How Leadership and Drive Create Commercial Innovations That Sweep the World

BREAKTHROUGHS!

NEWLY REVISED EDITION

Based on real-life stories of phenomenally successful products and services as uncovered by Arthur D. Little, Inc.

P. Ranganath Nayak & John M. Ketteringham

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From its earliest incarnation, this book has been the result of many people working together, most of them fitting this uncommon project into schedules already overcrowded. *Breakthroughs!* would have never been born without the commitment of Alma Triner, then Arthur D. Little's Vice President of Public Relations, who believed that the varied talents of Arthur D. Little's professional staff could be harnessed long enough to draw from them an interesting book. From the very first, writer David Benjamin immersed himself in this project and prodded both the corporation and the principal chapter investigators through the long months of research, travel, discussion, and composition. Kathleen Landis Lancaster, Corporate Creative Director, has given the book both substance and style; Jeff Bradley has helped us prune and polish this most recent edition.

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PREFACE TO THE NEW EDITION

In the nine years that have gone by since the seeds of this book first took root at Arthur D. Little, the fortunes of the breakthrough ideas profiled here have varied, as have the fortunes of the companies that nurtured them and gave them life. But the lessons to be learned from these breakthroughs remain as fresh and powerful today as they were when we gleaned them firsthand from the people who made them happen. We hope you will find these stories both useful and enjoyable.

Innovators, Inventors, and Facilitators

When a handpicked group of Arthur D. Little consultants began the process of choosing topics to include in a book about great commercial breakthroughs and how they grew, we were intrigued. For one hundred years, Arthur D. Little has been helping companies devise new products, new technologies, and new methods, and in this role has helped in the creation or re-creation of hundreds of enterprises. With such a heritage, it is a natural desire to want to analyze the successful concepts.

The drive to proceed with this book, which has involved a substantial investment of the company's time and money, also sprang from a need to examine the heart of the process that the company had so often encouraged. In 1886, a chemist named Arthur D. Little made a breakthrough by establishing the first business anywhere to devote its full energy to contract research, applying scientific inquiry to the needs of industry and government. From that beginning, contract research has become a multibillion-dollar industry with hundreds of profitable participants worldwide.

After Dr. Little's entrepreneurial breakthrough, his company turned its attention to other people's breakthrough ideas, lending to them technology, imagination, and direction. For one hundred years, the growing family of Arthur D. Little consultants has served as a touchstone to other inventors' ideas, as facilitators to the breakthrough process.

After a century of such service, it seemed fitting to return to the company's origins as curious, objective researchers. Some breakthroughs that Arthur D. Little had not assisted were explored, in the hopes that this exploration might indicate whether the right things were still being taught after all these years, whether there might yet be more to learn and pass on. It was already understood that when a client was helped to break a roadblock to a good idea, Arthur D. Little gained as much in new knowledge from the experience as the client gained in commercial success.

When in 1939, for example, the Cream of Wheat company saw the world passing their cereal by, they came to Arthur D. Little, who devised the first instant, fully enriched hot cereal—transforming breakfast for millions of Americans. In 1942 the government of Puerto Rico sought help in creating jobs for their people, Arthur D. Little invented the first multifaceted industrial development project, called Operation Bootstrap, creating an international model for economic recovery projects. In 1961 the Husky Oil Company asked Arthur D. Little to make a smokefree barbecue fuel from lignite. The outcome was the first charcoal briquette, and it helped to make cooking out a painless and convenient experience.

Companies have been helped to break through in far less evident ways—in developing industrial processes, restructuring management, mapping out distribution and communications systems, and more recently, managing information and exploring artificial intelligence.

Sometime in 1984 the idea of exploring the creativity that is at the heart of breakthroughs occupied the imagination of a small group of Arthur D. Little consultants. The discussion, as usual, ranged far and wide. Two of the members of that discussion group concluded that the best way to examine the issue of creativity would be to examine companies for whom the breakthrough experience occurred in the last one hundred years. The last ten years, they decided, would provide a fresher perspective; and rather than focusing presumptively on the qualities that characterize a breakthrough company, these two curious consultants, P. Ranganath Nayak and John Ketteringham, said, "Let's choose a number of products, services, and industrial processes that are widely acknowledged as breakthroughs. Let's make sure they represent a broad spectrum of industries and interests, and let's be as sure as possible that these breakthroughs reach the far corners of the world."

Nayak and Ketteringham, who became the coauthors of this book, assembled a team of a dozen people. The task for each team member was to serve as principal investigator of one or two breakthrough stories, then to return to the group to tell the tale and relate this new knowledge to the findings gathered by the others. Ideally, each principal investigator possessed an in-depth knowledge of the technologies, market dynamics, and business culture of the field in which the breakthrough occurred. But if the pursuit of insights into this hoary topic of invention was to succeed, more than just a technical specialist's insight into the final analyses was needed.

John Ketteringham lived to see this book widely acclaimed and translated into half a dozen languages. Tragically he died in 1989, at the age of 49, by then a senior vice president of Arthur D. Little.

P. Ranganath Nayak, a senior vice president and director of Arthur D. Little's worldwide operations management practice, led research on the development of the Walkman portable cassette player at Sony Corporation (Chapter 6) and the creation of the Toyota Production System (Chapter 9).

David Fishman led the investigation into the triumph of the VHS-format video cassette recorder (VCR) at JVC in Japan and RCA in the United States (Chapter 2).

Derek Till undertook the investigation of 3M Corporation's Post-it Notes™ (Chapter 3), first known as "those little yellow self-stick notes."

Elliott Wilbur led the examination of ChemLawn corporation's birth and growth (Chapter 4) as America's first national lawn-care provider.

Amram Shapiro led the research on the discovery and marketing of Tagamet (Chapter 5) by Smith Kline & French. .Tagamet, which heals ulcers in the human gastrointestinal tract, became the most successful prescription drug in history.

Richard F. Topping visited Raytheon and Amana Refrigeration in the United States and New Japan Radio corporation in Japan to explore the breakthrough of the microwave oven (Chapter 8).

Ellen Curtiss led the research effort on the explosive growth of Nike (Chapter 10) and its distinctive athletic footwear.

David Benjamin, the writer charged with assembling the varied investigations into a cohesive storybook, assisted in research on each chapter but also took as his own the examination of Nautilus (Chapter 11) and the exercise-machine boom that it launched.

Philip Roussel examined the emergence of a revolutionary high-yield catalyst for the ubiquitous plastic known in the industry as polypropylene (Chapter 12). Roussel's research embraced two companies who joined in the dramatic research effort, Montedison SpA. of Italy and Mitsui Petrochemical of Japan.

Richard Norris undertook the investigation of Federal Express (Chapter 13), researching its beginnings as a company and its creation of the overnight delivery industry in the United States.

Michel d'Halluin explored the origins and growth of the breakthrough vacation concept now known universally as Club Med (Chapter 14).

P. Ranganath Nayak and Martin van der Mandele looked into the development of the revolutionary compact disc technology at Philips (Chapter 15).

In each investigation, principal investigators returned to the *Breakthroughs!* team explaining that they had learned more than they had expected and discovered facts that defied their expectations. In almost every instance, the conventional wisdom about innovation diverged dramatically from the real-life stories of innovation.

More was learned for this book than by many others who went before, because the troops as well as the executives were interviewed. And in doing so, a healthy disrespect for overly tidy tales of spectacular success was reinforced. Scientific and business journal articles tend to depict discovery as a smooth progression, but the actual course of research inevitably is marked by detours, halts, and fits of pique that are excised in the retelling. *Because these detours, halts, and fits of pique are often vital to the outcome, they have been retained in the telling of each story*, many related here for the first time, as they really happened.

1

INTRODUCTION: STALKING THE BREAKTHROUGH

This book is about breakthroughs. Some are products, some are services, but all are commercial. It is devoted to things that sell, and sell, and keep on selling. It is about crackpot notions that broke the bank—about whole industries and markets that changed because someone figured out how to make something better, get it there faster, or met a need that people didn't know they had.

These are stories about individuals and companies who found big and little openings—and filled them. The stories reveal the creativity and the cussedness, the politics and the persistence, the determination and the dumb luck that took fourteen significant breakthroughs from conception to domination of markets that in some cases did not even exist, markets that breakthroughs created.

Before going any further, *breakthrough* should be defined. If advertisers are to be believed, breakthroughs in goods and services take place almost as frequently as Elvis sightings. As used here, however, a breakthrough is an idea that is so different that it cannot be compared to any existing practices or perceptions. It employs new technology and creates a new market. Breakthroughs are conceptual shifts that make history.

Many people, and not just advertising copywriters, confuse innovations with breakthroughs. Innovation is the art of doing the same thing you are doing now, but doing it better. Innovation may arise through the application of new technology to an existing product, process, or system, or through the introduction of existing technology into a new market.

The 3M company, (Chapter 3), offers a good example of distinguishing innovation from breakthrough. For decades 3M has provided periodic injections of money and constant encouragement to its researchers to enhance and adapt its existing product lines. Steady, incremental improvements in old products have resulted in better, new ones. The process of evolution from the first crude cellophane tape to Scotch tape to Magic Transparent Tape is just one example of 3M innovating effectively within its limitations. For people at 3M, there is no break in the progression of a product line; there is no relaxation of the focus on making their products and technologies incrementally better. This is innovation.

Those ubiquitous self-stick notepads that adorn desktops around the world—3M's Post-its—constitute a breakthrough. The unique Post-it adhesive, with no discernible applications to any previous 3M products, required not a step forward but a leap to an entirely different plane of consciousness. It was that special kind of innovation that made it a breakthrough.

This is not the first attempt to tackle the secrets of the commercial breakthrough. Because people have long regarded invention as the road to wealth and recognition, it has been intensely discussed, analyzed, and belabored. This fascination has given birth to countless nostrums ("Early to bed, early to rise ..."; "Build a better mousetrap ...)" and stocked libraries with earnest, mostly unread dissertations. Discussion of management of innovation, entrepreneurialism, and intrapreneurship are the focus of much of business writing today. John Jewkes, author of *The Sources of Invention* and an eloquent commentator on commercial breakthroughs, described this literature:

> The writings on invention, whilst vast and ever increasing, are of extraordinarily mixed quality. There seems to be no subject in which traditional and uncritical stories, casual rumors, sweeping generalizations, myths and conflicting records more widely abound.. .no one can hope entirely to escape the mild mesmerizing influence of the subject.[1]

From the start, "mesmerizing influence" transformed the Arthur D. Little team of consultants into storytellers, sharing anecdotes and oddities, talking about Archimedes' bathtub, Gutenberg's press, Fleming's mold, Land's camera, De Forest's vacuum tube, Shockley's transistor, and Diners Club's plastic card. Most importantly, the team moved past the stories and into how these breakthroughs came about, first by looking into the mind.

Defining Breakthroughs—Bisociative Thinking

The first operating definition of a breakthrough was that it must be something that visibly, dramatically changed the way society behaves. After the research was completed, the conviction that breakthroughs must begin with the urge to solve a problem was added. But the impulse to solve a problem isn't enough—it must be expressed properly. In many cases the proper *statement* of the problem was embodied in the idea of the *elegant concept.* Godfrey Hounsfield did not envision the CT scanner (a breakthrough that changed the way physicians can see into the body) in an instant. He displayed what Arthur Koestler in *The Act of Creation* called *bisociative thinking:*

> An escape—from boredom, stagnation, intellectual predicaments, and emotional frustration...signaled by

> the spontaneous flash of insight which shows a familiar situation or event in a new light, and elicits a new response to it. The bisociative act connects previously unconnected matrices of experience; it makes us understand what it is..."to be living on several planes at once."[2]

Once presented with a problem, Hounsfield could not rid himself of it; it plagued him persistently whenever other distractions receded from his consciousness. Koestler's example of the bisociative thinker is Archimedes, who was told to weigh the gold in a crown without melting it or separating the different metals. He fretted constantly with this first recorded problem of nondestructive testing and found it most intrusive when he was relaxed and resting. Unable to let go of his mental picture of the crown, even in his bath, Archimedes noticed his body displacing the water in his tub and shouted, "Eureka!" He had discovered the law of displacement of solids. Hounsfield, living with his incomplete image of the scanner, built it only after he "saw" it. Both men had experienced a flash of insight, but one that had been arduously cultivated by obsessive contemplation of the problem.

Not everyone can think the way that Archimedes and Hounsfield did. As many management analysts suggest, there is a certain type of person who behaves innovatively. Jewkes describes this person as "isolated; because he is engrossed with ideas that he believes to be new and therefore mark him out from other men...the world is against him, for it is normally against change."[3] Management expert Peter Drucker says that no breakthrough happens without the involvement of a "monomaniac with a mission."

Trying to firm up these subjective analyses, Bell Laboratories once tried to quantify the qualities of the creative type. Among the creative people studied, they found only two clearly common characteristics: an exceptional tolerance for messy work environments and a well-developed sense of humor.

According to Koestler, humor is the most basic form of bisociative thinking. A joke leads the listener along a particular plane of reference and then surprises him by shifting the plane of reference—by standing the listener's perceptions on end.

The story of the boastful Texan vacationing in the Scottish highlands provides an example: The Texan, surveying the small barley fields of a local farmer, explains that back home he can drive his pick-up all day without ever crossing his own property line. The Scotsman pauses to digest this thought and replies, "I had a lorry like that myself once."

The farmer is the bisociater; where the two lines of thinking—property and lorries—meet, he creates a whole new perception of events by following the less obvious direction. The farmer, seeing a connection in dissimilar things, bisociates them and produces something new. In this case, bisociation is funny. More seriously, as a *metaphor*—a bringing together of the likenesses of the dissimilar—the bisociative vision can be profound.

Thomas P. Hughes described the inventive person as a metaphor-maker and cited Aristotle, who wrote that the mastery of metaphor "is a sign of genius, since a good metaphor implies an intuitive perception of the similarity of the dissimilar." In this light, bisociation and metaphor are nearly identical. Hughes adds, "The inventor needs the intuition of the metaphor-maker, some of the insight of Newton, the imagination of the poet, and, perhaps, a touch of the irrational obsession of the schizophrenic. The myth of the inventor as mad genius is not without content."[4]

Making Breakthroughs Possible

These stories are interesting tales, all the more so if you own a Walkman, have taken Tagamet, or have had a CT scan.

Managers of companies, however, want to know how—or if—they can enable breakthroughs to take place in their companies. This is more fully addressed in the last chapter. As you read the fourteen stories here, pay particular attention to the varied environments in which breakthroughs took place, how they were spotted by management, and how the product or service was developed from there.

A magic bullet for commercial breakthroughs was not discovered in this survey. Such breakthrough developments happen in many ways, and the elements that many of them share form a frequently flawed, often confusing, but provocative pattern.

Similarities that connect these stories with one another are emphasized, but in the end, this investigation was more meaningful with lingering questions remaining than it would have been providing a pat answer. No certain elements that ensure commercial breakthroughs were found, but some elements can be identified that without which a breakthrough is almost certainly impossible.

This is a book, then, that will narrow your margin of error—but won't close it. Those who read simply for the pleasure of sharing these adventures probably will have the best time. Those who gain the most will be those who, though they began by seeking the key to the great commercial breakthrough, emerge satisfied with knowing where to find the lock.

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THE VCR: A MIRACLE AT JVC
BE VERY POLITE AND GENTLE

Aggressive, high-pressure, won't take no for an answer—these are the traits business uses to praise its salespeople. Gentility, politeness, and self-effacement are not high on the agendas of business schools or boardrooms in the West. But those are exactly the qualities a Japanese electronics executive recommended his employees use, and the remarkable success his company enjoyed as a result provides a surprising lesson.

The story really started in 1926, when inventor Kenjiro Takayanagi created one of the world's first television shows by forming the flickering image of a single Japanese ideogram inside a cathode-ray tube. Thus began an industry that would be reborn in other nations at other times and that, within thirty years, would become the most pervasive entertainment medium in human history.

However, when Takayanagi looked back in the early 1950s, he saw a medium and an industry that had not entirely lived up to their promise. On the one hand, he saw a remarkable commercial and technological breakthrough that had changed the very nature of family life throughout the world by providing instantaneous news and entertainment; but he also saw a medium controlled by a handful of broadcast networks, each holding almost unchecked sway over whole nations of people. Television as a mass medium too often seemed satisfied with mediocrity. Between moments of transcendent creativity and journalistic brilliance, television devoted vast blocks of time to intellectually barren, artistically crude, and commercially shrill programming.

Not content with this situation, Takayanagi dreamed that television might someday not only provide its users with a vast array of programs but also allow them to make their own. Takayanagi's dream was to offer everyone the thrill of that magic moment when he had seen the ideogram flicker to life.

In the early 1950s, this dream was shared by researchers in many electronics companies. Within JVC (the Japan Victor Company), Takayanagi shared it with a number of engineers young enough to carry the dream to fruition in the years to come. Their challenge was to develop a practical technology capable of storing images on some form of magnetic material, probably tape. But the tape would have to be very wide—much wider than that used for sound recording—and the electronic machinery to transfer images from tape to picture tube would have to be immense and very costly. How could they make this equipment so small and inexpensive that any family could use it to make their own TV programs? And how would JVC compete against such competitors as Matsushita, a corporation ten times its size, and Sony, a company whose reputation for research and innovation had made it a household word on three continents?

The three JVC leaders who realized the dream, despite stiff competition from far bigger Japanese electronics companies, and even the resistance of their own top management, were extraordinary men. Takayanagi was famous throughout Japan for his pioneering discoveries in television. Yuma Shiraishi was gifted not just as an electronics engineer but as a conceptual thinker. But the key member of the group was probably the late Shizuo Takano, an engineer with a talent for taking risks and rallying people to a common cause so passionately that they lost their fear of failure. JVC assigned Takano and Shiraishi the task of creating a workable home videotape recorder (VTR).

That objective seemed especially daunting for a company so small and ordinary as JVC, which had not been one of the companies to profit from Takayanagi's television breakthrough. As the postwar Japanese version of Victor Talking Machines Company, U.S.A., and later as an independent subsidiary of the electronics giant Matsushita, JVC emphasized phonograph records and hi-fi sets. Surely a videotape recorder for home use would eventually emerge as the brainchild of the giant corporations, companies with stables of technological wizards—not from JVC.

A Recorder the Size of a Jukebox

The first hint that the dream could come true at all appeared in America in 1954, when six engineers at Ampex Corporation built the first magnetic tape machine that recorded not only sound but pictures. Ampex's machine was a spectacular breakthrough, and its impact on the broadcast industry was historic. It meant that the days of live television were numbered. Now network affiliates could tape shows on the East Coast and then broadcast them in prime-time slots for all time zones.

Although the development brought a home video recorder closer, it did have drawbacks. Ampex's machine was a jukebox-sized behemoth that ran a two-inch-wide tape from reel to reel rather than within the cassettes that are common today. It employed four heads—the sensors that transfer sound and image to the eye and ear. An amazing, buzzing, whirring hulk, jammed with vacuum tubes, it was also so expensive that only large organizations could afford it.

Aware of the Ampex breakthrough almost from the start, Takayanagi set his engineers to work on devising a smaller, simpler video recorder. Five years later, JVC had built its first studio-quality, two-head, two-inch videotape recorder. But by then Ampex's four-head hulk was installed in studios all over the world, and a Sony version of the Ampex machine, introduced in 1958, had already claimed a major share of the Japanese market. JVC had created a technology simpler than its competitors' but incompatible with the industry standard. It failed to sell.

For JVC, that experience was both the beginning of a love affair with the home-use videotape recorder and a lesson. Shizuo Takano pointed to that failure as the last time that JVC entered the market without meeting technological standards that were shared by a number of original equipment manufacturers. The lesson would work to JVC's advantage almost two decades later, when the battle of standards between Sony's Beta and JVC's VHS would begin in Tokyo and swiftly sweep the globe.

Through the 1960s, JVC actively participated in the developing videotape recorder industry, but the equipment remained the tool of broadcast professionals. VTRs shrank dramatically in size and price, but not far enough to fit into the living room or the budget of the average household.

A Critical Meeting and a Crucial Breakthrough

The situation promised dramatic change in 1970, with the appearance at three Japanese companies of 3/4-inch VTR prototypes. The companies were Matsushita, Sony (then a medium-sized but aggressive young company), and JVC. At a trade show in Osaka, these three had a meeting. Although they treated it as happenstance, it was in fact long-awaited and carefully orchestrated. Japanese electronics companies, although they are intensely competitive, maintain an informal network of communication about the progress of one another's product research. So Matsushita, Sony, and JVC knew where they all stood. They knew that, taken separately, their paths to a marketable 3/4-inch VTR would be long and tortuous. But if they could agree to pool their findings, a shortcut that helped all three companies might be possible.

Sony's contribution to the meeting—a prototype of its U-Matic tape cassette—proved pivotal in the history of the home videocassette recorder (VCR). Although the three companies had been working on a "container" for magnetic tape since the first audiotape cassettes were introduced in 1964, all had trouble with certain technical features of their containers. Since Sony's U-Matic cassette seemed the most promising, the engineers from all three companies collaborated to iron out the kinks in it and achieved a significant breakthrough. Magnetic tape was no longer confined to loose, separate reels that had to be threaded through the heads of a tape machine. The self-contained cassette held a full hour of 3/4-inch tape, as well as the two spools that played out and reeled in the tape as it went through the machine. Sony's U-Matic technology placed the home-use VCR at last within reach. The cassette was so well devised, in fact, that it became the standard for many professional broadcast uses.

The three participants at the conference also signed a cross-licensing agreement giving each other free access to all the technical innovations they created throughout their research in videotape recorders. As a result, they shared each other's patented technologies not only for the 3/4-inch VCR but also for the enormously lucrative 1/2-inch home VCR that emerged first at Sony and then at JVC in the mid-1970s.

Because of the high stakes involved in the newer technology, however, the companies soon ceased to collaborate on VCR research in what Sony continues to call "the spirit of the cross-licensing agreement." Matsushita, Sony, and JVC went back to treating each other more as competitors than colleagues. For all three, the effort to sell a 3/4-inch product to the home-use market failed dismally. The machine was still too large, heavy, complicated, and expensive—more than $2,500 in US dollars—to sell to average consumers. The market that bought enough machines to make them profitable was institutional—corporate communications departments and schools, where Sony had always been a more popular supplier than Matsushita or JVC. Sony made a modest profit on the 3/4-inch VCR; the other two companies lost money.

The 3/4-inch setback should have discouraged JVC from pursuing the dream any further. In fact, after 1971, JVC's corporate leadership withdrew most of its support from the effort to develop a home-use VCR. Only the small team led by Yuma Shiraishi and Shizuo Takano hung on. The team's three-year struggle from 1971 to 1974 to keep pace with Sony, Matsushita, and the other big competitors was a combination of tenacity, deception, and luck.

JVC's failure with the 3/4-inch VCR as a home-use product had bitterly disappointed Shiraishi and Takano, not only in the sales failure for JVC but also because none of the companies had made anything that ordinary people could use. "We had made a very strong commitment to making a machine that could be used in the home. And a 3/4-inch was the original target," said Takano. "But then, when we agreed on standards and started manufacture, we realized that this can't be a home machine...we started to look back and ask ourselves what we had done wrong." Reflecting on their failures, they decided to forget all the work of the past and restart from scratch.

One significant result of this new outlook was the decision to require two hours of tape on the cassette. Since Sony had based its developmental concept on 3/4-inch tape, they never asked whether one hour was enough. Shiraishi added, "Sony was working faster than we were, which might explain why they didn't examine more closely the issue of whether the cassette should play for one hour or two. But that wasn't the only technical difference. Our first VCR was much lighter than Sony's—thirteen kilograms compared to twenty-one—and it fulfilled a goal that was very important to the companies who adopted our format: It was much easier to manufacture."

According to Shiraishi, improving the 3/4-inch tape machine "was perceived from a purely engineering point of view. If you compare all the previous machines, each one was a big improvement. But none ever became home-use equipment. We began to realize there might be some kind of conditions that had to be incorporated into a home-use machine that we hadn't thought of before. Because we had never met those conditions, we were never able to make equipment that people would want in their homes. So we sat down and started to think: 'What are those conditions?' "

Guided by this question, Shiraishi's team stopped thinking like engineers and started thinking like inventors; they ignored existing technology and tried to imagine everything that needed to be included in a home-use VCR.

Twelve Goals for a Home-Use VCR

The brainstormers were acting out what Thomas Edison once described as the essence of invention. According to Edison, in order for a system to operate properly and fulfill its purpose, each part of the system must be designed to operate in harmony with all other parts.

When this team in 1971 developed a list of twelve interconnected goals that came to be known simply as "the matrix," they intuitively applied Edison's credo to the creation of a videotape machine that people around the world could use to record birthdays, bar mitzvahs, and the bears in national parks. From that moment on, they never really were stumped. Every time they encountered an unexpected problem, they found the answer right there in the matrix.

JVC's research and development organization would not deliver the first home-use VCR, regardless of their management's impatience, until they had fulfilled each of twelve requirements.

The VCR should

- Connect to an ordinary television.
- Reproduce in quality the same image and sound as an ordinary television receiver.
- Have a minimum recording time of two hours.
- Be compatible with other manufacturers' VCRs so that the tape is interchangeable.
- Offer a wide range of functions—permit use of a video camera and allow recording of feature-length movies from television.

VCRs designed for homes should

- Not be too expensive.
- Be easy to operate.
- Have a low running cost (tape and so forth).

From a manufacturer's point of view, a VCR should

- Be reasonably easy to produce.
- Be designed so that parts can be used in a number of models.
- Be easy to service.

For society, VCRs should

- Serve as the transmitter of information and culture.

Shiraishi had envisioned the VCR three-dimensionally—as a device that must be intelligible to the people who make it, the people who buy it, and the people who have to fix it. Even before Shiraishi had assembled his engineers to write these rules, this matrix had already formed in his mind. The hardest thing was to go back to the very beginning, after the failures with the 3/4-inch tape recording. Shiraishi wasn't so disappointed that the 3/4-inch tape machine had not sold as he was saddened that it was wrong, that it hadn't done what it was intended to do.

To set aside nearly twenty years of work is almost impossible for anyone, but Shiraishi realized that if JVC were to move forward, he had to clear the workbench. He summoned the courage to trust his creativity and his colleagues' skill to find a path they had not seen before. The reason that the JVC matrix formed an elegant concept was that it was uncluttered by preconceptions. The entire horizon of challenges was seen as one whole before the researchers began to work.

The Inventor and the Enforcer Versus the Organization

When the work began in earnest, Yuma Shiraishi was the inventor, Shizuo Takano the enforcer. In personality, they must have seemed as different as yin and yang, but one common element kept them in harmony: total commitment to the project. Shiraishi was a reedy, scholarly man who appeared almost painfully shy. His manner was as honest and lucid as it was self-effacing. Takano was a striking contrast. He was small and gray-haired, with a piercingly direct, almost military bearing. This first impression concealed his lurking sense of mischief and a rasping laugh that seemed suddenly to overwhelm him in merriment. This sense of humor helped Takano endure repeated management suggestions to give up on home-use VCRs in a decade when television itself seemed to have stopped its technological advance to become a static household commodity like refrigerators and can openers.

Typical of Shizuo Takano's boldness was his 1977 opening of the VCR market in Europe. He literally went door-to-door with a team of engineers and a steamer trunk full of video equipment, which he demonstrated to the most important manufacturers of consumer electronics. No one at JVC today is entirely sure whether anyone ever authorized Takano to make these visits. But he persisted despite some disappointments and succeeded in establishing an impressive network—Thomson in France, Telefunken in Germany, and Thorn in the United Kingdom.

This kind of determination and attention to detail eventually proved to a host of Japanese television manufacturers that new things were indeed possible in their industry at a time when many opinion leaders said that video would never make it and many companies had lost interest in any sort of video. By communicating through an engineers' grapevine with others who shared his views, Takano stayed several steps ahead of his own top management for four years. Knowing that engineers in other companies believed in and were working on 1/2-inch tape home-use VCRs gave him hope. And hope was vital to the JVC team because strong pressure against the VCR project began to build within the company after the 3/4-inch tape market failure. In 1971 JVC reduced company expectations and cut the team of researchers from ninety people to ten, several of them working only part-time.

One organizational change that did seem positive at first was the creation of a video products division, but the real reason for separating it from the company's central research and development laboratories was to isolate its budget. Separate divisions at JVC must be self-supporting, and the video products division's 3/4-inch white elephant couldn't support even a small division. This marketing decision eliminated official research and development in hopes of insuring a profit on the 3/4-inch tape machine, but in practice it created conditions for secret, unobserved work on the VCR within JVC.

In a culture that, to the West, had always seemed dedicated to obedience and uniformity, a gentle spirit named Yuma Shiraishi and a bantamweight named Shizuo Takano were resolutely defying corporate policies. As a large group working at the main labs, Shiraishi said, "We had been constantly told to meet such-and-such goals within such-and-such period because we were going to have an announcement on such-and-such date. There was constant pressure on us. And, of course, top management always had deep interest and concern about us." When they moved into the new division, however, "we were an invisible team; nobody told us to do anything. We didn't have any pressure. No top management had any complaints because they didn't know we were doing things like this...We did have a hard time finding the money. But all in all, it was a good environment."

The Oil Embargo and an Important Figure

Eventually, red ink might have drowned Takano, Shiraishi, and their handful of corporate guerrillas. But an ill wind struck Japan—the Arab oil embargo—and it blew money into the video products division. The oil embargo brought an almost unprecedented phenomenon to the island nation: double-digit inflation. Prices skyrocketed, including costs of consumer and professional electronics. Meanwhile, the marketing people in JVC's video products division looked around and saw a large, dusty inventory of 3/4-inch VCRs priced at pre-oil-embargo rates.

While Sony and Matsushita raised prices on their new 3/4-inch equipment, JVC kept the old prices on its old machines and even claimed it was being patriotic by holding the line in the face of Middle Eastern blackmail. By undercutting the competition dramatically, JVC cleared out its inventory in a matter of months. Suddenly the video products division was the apple of JVC's eye.

This deft maneuver helped to preserve the division and save the VCR research project, but it still might not have survived without the support of some very imposing figures. One of them, of course, was Kenjiro Takayanagi. Another, as it turned out, was Konosuke Matsushita, the chairman of JVC's parent company. One day he visited the video products division facility in Yokohama and happened upon a fairly advanced, compact, 1/2-inch VCR prototype. Matsushita watched a tape that Takano had prepared for him. After all the technical nuances had been explained, Matsushita smiled. Then he leaned over, pressed his cheek against the recorder, and said, "It's marvelous. You have made something very nice."

Konosuke Matsushita never issued a directive or stated in any way his official support of the VCR development project, but in a company as familial as JVC, that fleeting incident was soon known to everyone in the organization.

Takano and Shiraishi had maintained a low profile for their project, neither confronting management when their research budget was eliminated nor complaining when their engineers were told to spend time in the field as retail salespeople, equipment repairmen, and maintenance troubleshooters. No indignity was too great to deter the team. And the team felt like a team. Many of its members were significantly younger than Takano, and he was sensitive to the risks they were taking.

In Japanese companies, an employee involved in a major failure almost never gets fired. But the assignments that follow often land him in outlying offices and dead-end positions with little advancement, small salary raises, and negligible prestige. "Not only myself, but everybody in our division felt threatened," recalled Takano. "It was such a bold decision to make, to go with our own system in direct competition with the giants. One day, I called all the managers in our division into one room. I asked them how they felt about doing the project, if they are prepared to commit suicide with me. We may not succeed, I told them, but if everybody agrees with going, then we go. If there is anybody who feels uneasy about it, please say so; you can leave." Only one member of the team decided to depart; everybody else agreed to "commit suicide" with Takano. "Without that moment," he said, "I don't think VHS could have succeeded."

The Sixty-Minute Difference

Takano had another dramatic opportunity to commit suicide on his own. In December 1974, Sony invited him and Shiraishi to examine Sony's new Betamax, a 1/2-inch, two-head VCR ready to hit the domestic market early the next year. Before the meeting, Takano knew only that the Betamax was small, light, and inexpensive enough to sell to individual customers. Recalling the failure of the 1970 cross-licensing agreement, Takano must have felt that history was repeating itself. He knew that JVC's format, called VHS (Video Home System), was still at least eighteen months from market readiness. The meeting would reveal the system that had the technological edge. If JVC could not work out a competitive advantage over Sony, there would be no point in introducing VHS as a separate format. No one but a handful of JVC engineers would ever see the beautiful machine they had fashioned.

Without a competitive advantage, JVC would have three options. It could concede Sony's victory, turn over its technology, and join Sony as a minor partner in opening the home VCR market; or it could step up development to . a panic pace and try to hit the market, if not simultaneously with Sony, then at least within a few months. This choice would mean postponing development of a video camera, an item both Takano and Shiraishi considered an inseparable element of the VCR concept. A third option would be just to quit altogether, a course that might please many in JVC management but would be unthinkable to the combative Takano and his proud cohort Shiraishi.

At the meeting, the Sony people demonstrated a VCR strikingly similar to prototypes JVC had built in its own laboratories. It had two heads and a cunningly small half-inch tape cassette—with a tape duration of one hour.

Just one hour.

For a scant second, Shiraishi and Takano each caught the other's eye. They were far too disciplined to reveal their relief and renewed ambition. It was probably the most significant moment in the careers of both men. They knew, although Sony did not, that JVC was already capable of producing cassettes of two hours—a length much more attractive to home users. Sony was indeed opening the door to the market, but it had yet to close it.

Sony suggested that the two companies join in an effort to build and market this appealing device as the world's first home-use VCR. It was offering standardization but at the same time issuing an ultimatum: Take it or leave it. During the demonstrations, a JVC engineer asked if Sony was planning another meeting of engineers like the collaboration of 1970, when the three companies had joined to standardize videotape technology. "This time," a Sony representative said, "we're not going to do things like that."

For their part, neither JVC nor Matsushita had any plans to "do things like that" either. Shiraishi and Takano bowed graciously, thanked the Sony representatives, and wished them the best of luck with their wonderful machine. The only sign that they were triumphantly unimpressed with Betamax might have been an extra spring in Takano's departing step and a calm in Shiraishi's eyes.

Although both men knew that little JVC still faced obstacles, they knew at least that Sony would neither overwhelm it technologically nor quickly dominate the market. From JVC's point of view, Sony's prototype was big where it should have been small, and small where it should have been big. The Betamax VCR deck that they saw was actually bigger than the VHS prototype then under development at JVC. More crucially, the one-hour tape failed to satisfy what JVC regarded as a basic consumer need.

After that Betamax demonstration, Sony persisted in seeking partnerships. It invited JVC and Matsushita to inspect the facilities already prepared for manufacturing the Betamax VCR. The JVC official who received the invitation was Shiraishi and Takano's boss; he refused the offer and told Sony that since JVC intended to proceed alone in its VCR development, it would be unfair to see any more of Sony's technology. Two Matsushita representatives, however, one of them the venerable Konosuke Matsushita himself, did go on the inspection tour in January 1975. Sony wanted his giant corporation as a partner to command the public's interest and confidence, but Matsushita was unconvinced that a one-hour tape could succeed in the market and was dismayed that Sony had committed itself to that limit before asking his opinion. Matsushita withheld his company's participation in Sony's "standard," leaving the field open for its own researchers and for those of JVC. Sony was left to go it alone.

A Payoff to the Long Wait

JVC had time to refine its own technology. The VHS cassette recorder that it introduced in September 1976 was a sophisticated package, complete because it had not been rushed to market and because Shiraishi's engineers had framed a full vision of what they needed before they embarked on solving the problem.

Moreover, between the meeting with Sony in 1974 and the introduction of VHS, Takano found an entry into the market. An engineer who knew very little about conventional marketing strategies, he simply followed his instincts and saw a way to the commercial success that other companies in the race had not seen. Sony's approach had been to reach the market first and establish Betamax as the standard so quickly and powerfully that no later format would have a chance. There was a certain wisdom in Sony's handing out its technical information, because it reasonably expected everybody to adopt its format eventually anyway. By late 1976, however, that strategy had not made Sony's format an invincible standard in the marketplace. Sales were encouraging but unspectacular. There was still room for another format, and Takano was ready to launch VHS.

Even in the early days, when Yuma Shiraishi was working with his engineers to form a fresh vision of the videocassette recorder, Takano was turning his eyes elsewhere. He was looking within JVC and outward at JVC's relationship to the marketplace. In size, prestige, and video experience, JVC was perhaps the least likely company in Japan to win the VCR race. The company was not known for creating markets in new technologies, and it had one of the smallest networks of company-owned retail outlets in Japan—one-tenth as many as Matsushita—a consideration that is all-important in new-product introductions. There was also the matter of style. Even today JVC's outlook on the world seems to face in the opposite direction from Madison Avenue. A sense of family pervades JVC's headquarters in Tokyo and its production facility in Yokohama. People seem to know and tolerate one another in ways that family members do. And, like a family, JVC seems more comfortable with its own patterns of thought and action than with those of the world outside. It may welcome strangers into *uchi* ("my company") with charm, assurance, and warmth, but its ventures out into the commercial world—notwithstanding Shizuo Takano's persistent storming of Western Europe—tend to have an air of polite timidity. JVC is a company known better for friendship than salesmanship.

An Unusual Sales Tool: Humility

Takano sensed, however, that this apparent weakness could be turned into strength. He knew from the grapevine that many companies in both Japan and America were struggling to devise an economically priced home-use VCR. He knew too the prevailing lack of self-confidence in the industry. If Takano could present leading manufacturers with the VHS format as a working model for development—and if he could make that presentation humbly, as a friend—he could, in one gesture, flatter their pride and reduce their risk. And he might convince them to adopt VHS rather than continue an expensive race to hit an uncertain market with a wave of different formats.

His approach to the market would be far different from Sony's; he would try humility. Humility seems an incongruous marketing tool, but Takano had the skill to use it like a scalpel. To Takano and JVC, market domination was neither practical nor rational. "Our basic policy was to spread information as well as the technology and the format," he said. "The market is large enough to hold everybody. One single company does not have to monopolize the whole profit."

When JVC was ready with its VHS prototype, the challenge was to convince at least four large manufacturers to abandon their own research and join up with JVC. JVC could not succeed without collaborators, because its production and retail forces were simply too small to handle the demand if consumers responded strongly to the VHS format. JVC then had only one factory capable of making 10,000 to 20,000 VCRs a year. A first-year demand of even 25,000 machines could be a disaster. Without help, JVC could be destroyed by its own success.

Sony, meanwhile, was developing relationships with Toshiba and Sanyo in Japan and Zenith in the United

States. JVC approached Japanese consumer electronics companies who had not committed to Sony with a series of VHS presentations made in a style that embodied the word of its president, Kokichi Matsuno. Matsuno and his successor, Ichiro Shinji, would later instill more risk-taking and aggressive attitudes into the company, but these were not what Matsuno had stressed in his first remarks to his employees.

To the Western ear, what he said was extraordinary: "The most important value for the people in our company is that you should be very polite and gentle." Gentleness as a business value is virtually unknown to the West, but Matsuno believed in a Japanese ethic most often applied to personal relationships—that each member of a relationship should strive to sense the other's feelings, even if he or she cannot or will not articulate them. Matsuno told his workers that "a JVC person should be one who can understand what your business partner is thinking."

Polite and Gentle, but Crafty

Realizing that it would not be easy for proud companies like Matsushita and Hitachi to concede a technological breakthrough to a minor company like JVC, Takano and Shiraishi appeared before them not as victors but as supplicants. Shiraishi recalled the typical VHS demonstration: "Mr. Takano said, 'Our dream has always been that each home has a videotape recorder, and we certainly believe that the videotape recorder will make our life much more enjoyable.' He showed the VHS prototype and told the other manufacturers, 'Well, JVC has been able to come up with this prototype, but I am sure everyone else in this room has also developed some sort of prototype by now. I don't really care which company's equipment or which format we go for, but let's go for the best system that we are all working on.'"

Takano emphasized to other manufacturers the necessity of having a standard. He was emphatic in telling the Japanese consumer electronics giants that little JVC would gladly stand aside and commit itself to another company's VCR standard if it was superior. For all his humility, Takano felt assured that no one else could top JVC's wonderful VHS product. And he knew that no one had answered all the aspects of the VCR problem as assiduously as Shiraishi had with his matrix of requirements.

Takano was polite and gentle, but he was also crafty. JVC's policy of very delicately bringing competitors into its confidence and then inviting them to help build, sell, and refine VHS technology was the stroke of genius that finally standardized a format for the home-use VCR and opened the marketplace. JVC's willingness to forgo monopoly allowed it to choose companies that would maintain the standards that the format required. By early 1977, JVC was stretched beyond its own production capacity in manufacturing VCRs, but partners like Matsushita, Hitachi, and Mitsubishi were hurrying to establish their production facilities under JVC's liberal licensing agreement.

The VHS format still had to clear one very high hurdle in Japan. The Ministry of International Trade and Industry (MITI), which wields substantial influence over such issues as national product standards, met with JVC in mid-1976 to suggest the abandonment of the VHS format in favor of a single national standard already on the market—Betamax. Part of MITI's request was based on the rather debatable contention that the Betamax picture quality was better than that of VHS. JVC countered that VHS offered comparable picture quality, a more convenient tape duration, and a fully functional video camera.

JVC and Sony engineers to this day argue over which format has the better picture. Each company has its technical advocates, but most consumers notice no appreciable difference in picture quality between Betamax and VHS. To most people choosing a VCR, this point has always been irrelevant. Although this was not really a technological discussion, it was political. MITI had to be convinced that there was sufficient economic might behind this late-to-the-market VHS format to make it viable. If JVC could not show the government that it had formed alliances with major manufacturers, MITI would use all of its considerable influence to force JVC to abandon VHS, while providing some compensation for their financial losses.

Takano's negotiations with other Japanese consumer electronics manufacturers had anticipated MITI's challenge. By the time JVC sought permission to compete with Sony, Takano was ready. He made all the technological arguments and then, very humbly, trotted out his allies: Matsushita, Hitachi, Mitsubishi, and Sharp—four powerful manufacturers who represented a substantial percentage of Japan's gross national product. When this coalition was arrayed against Sony's, the argument was over and MITI bowed out of the VCR standards discussion. This, MITI said diplomatically, is one of those decisions that we can leave to the marketplace.

So on September 9, 1976, Shizuo Takano and Yuma Shiraishi presented to a curious group of manufacturers and journalists the machine called VHS, a videocassette recorder so simple, small, and inexpensive that almost any family could possess one, take control of their video entertainment, and create their own television programming. The humblest company of them all, launched by Kenjiro Takayanagi's dream into a stormy sea, had finally reached the other side—almost.

Unexpectedly, within a year after JVC and its partners had filled their stores with VCRs and placed their ads, sales fell to a trickle. They had sold their equipment to all the gadget-conscious buyers who had to be the first with a new product; it proved much harder to sell the average, cautious consumer a product costing one thousand dollars or more. Such consumers had only a vague idea of what this machine was and what they could do with it.

Finding the Value of VCRs

Like salespeople in most small companies, JVC's sales force was accustomed to losing battles to big companies, especially since the larger manufacturers could afford to reduce their prices and keep them lower for longer periods of time than JVC could. As a result, it didn't take long for JVC's retailers to panic. Sales for VHS equipment began to level off only six months after the equipment had been introduced, and Shizuo Takano faced a sales force that was unanimous on one point: In order to compete with Sony, JVC had to reduce prices.

Takano didn't give an inch. Instead, to the surprise of the salespeople, he flew into a rage. He threatened to go back to his development team, add features to the original VCR, and raise the price. Faced with this crafty irrationality, the retailers went back to their stores, beat the bushes harder, and eventually found at their fingertips the answer to the VCR marketing problem. As with all things extraordinarily new, as Sony had realized with Betamax, the marketing problem was really an education problem. How could JVC teach the consumers the value of its VCR? The answer lay in the matrix, but for a while nobody focused on it.

Ten days after introducing the VHS tape deck in 1976, JVC had announced, with somewhat less fanfare, the first complete video camera for making VHS movies. Its cost, when combined with the tape deck, was prohibitive. But Shiraishi and Takano insisted that the camera was essential. Since the beginning of their research, they had focused on the idea that the VCR was a medium for individuals, capable of recording the ideas and memories of each of its users. In that sense it was different from every other television product ever invented; it was active rather than passive. The one ingredient that made it a truly individual medium was the camera, which was as much a piece of the whole concept as the tape deck. For Takano and Shiraishi, the concept could not be broken down into components.

Nevertheless, the video camera was initially treated as an extraneous appendage of the VCR, its main use in demonstrations that JVC salespeople conducted when they canvassed neighborhoods and showcased this brand-new technology. Normally, the salesperson simply posed the family, videotaped them, then replayed this vignette on the tape deck. But one day, a salesman in Osaka was demonstrating the system in an apartment that was literally so small that he couldn't back up far enough to take a picture. Casting about for alternatives, he seized the family photograph album from the coffee table, spread out a number of family snapshots, and quickly panned through the photographs. The effect he created—by zooming in and out, halting at each picture, and then quickly moving on—was a kinetic enhancement of the family's memory book. In that desperate salesman's makeshift approach, memories sprang to life. "Suddenly," said Shiraishi, "they realized that they could make the old times come alive. The customers could see themselves back in the 1940s and 1950s. It all came back."

Once a Kawasaki retailer had added a flourish—sound—and as a result enjoyed a month's sales in a single day, and thus a profitable sideline called the Video Album was introduced for JVC.

Only months later, in August 1977, RCA introduced the VHS tape deck in the United States in a dramatic national announcement. Worried that the market for television in the United States was declining, RCA had moved cautiously toward the VCR format. It had first declined Betamax, and it had avoided any commitment to manufacture VCRs in the U.S. RCA opened the VHS market in the United States by agreeing to sell only VCRs that were made by its Japanese supplier, Matsushita.

Jack Sauter, the RCA marketing executive credited with launching the VHS format in the United States, noted that while the television /video market was stirring very slowly in Japan, it had come to an almost complete halt in America. "It was an industry conclusion as early as 1969 that color television was at the point of maturity," Sauter said. "All we had to deal with was a replacement market, and we had to recognize that the life of an average television set was between seven and eleven years. Therefore, what future was there in this business other than just being a commodity supplier?"

Another reason for RCA to be cautious about adopting any VCR format was that the United States' television industry did not exactly spring to life when Sony introduced the Betamax. Said Sauter, "We had looked at the Sony, because that's all we had to look at. They were the first on the market. But we did not see a product that would capture the minds of the American consumer. And yet, instinctively, we knew that it had definite consumer possibilities." Sauter had another reason to turn away from

Betamax: RCA was too proud to serve as bridesmaid to another big-name brand name, Sony.

Early in 1977, RCA went to Japan to get a license to market VCRs in the United States. Its first visit was to JVC, but the company simply didn't have the production capacity to meet the figures suggested by RCA. Matsushita, JVC's partner in the introduction of VHS, was big enough to handle RCA's initial order of 40,000 VCRs for the first year (which ballooned to 60,000). But even with that commitment, Sauter was edgy. Betamax had slowed down in the American market, partly because of licensing problems between Sony and its American partner, Zenith. In addition, another technology was emerging almost simultaneously: RCA's SelectaVision. It was a prerecorded video on a disc, as simple as a record album, less expensive than a VCR, and with breathtaking image quality.

So when RCA committed to Matsushita and VHS in 1977, it was playing it safe. VCRs were, after all, a moderate success in Japan. Video discs might be the technology of tomorrow, but in the meantime, 40,000 VCRs didn't seem too big an inventory in a nation three times the size of Japan. Actually, RCA played it very safe. Licensed only to market but not manufacture VCRs, it would suffer a minimum loss in the case of a disaster.

RCA enjoyed spectacular sales through the Christmas season that year and part of January 1978. Then it appeared that disaster had struck. By February sales had virtually stopped, and the distributors panicked. Sauter responded with a marketing program reminiscent of the JVC recovery in Japan. Visiting retailers to find out why customers had stopped buying the VCRs, he learned that the VCR was still a "big city" product going to young, affluent professional people with a fondness for technology and a need to tape television programs to fit their schedules. The VCR was not yet a family-oriented, small-town item. Somehow RCA's retailers had to move the VCR market from the techno-experimenters in New York City to the average family in Toledo. Sauter thought, "Why don't we put on a good front? We'll just go out and tell the world it's a fabulous product."

A Triumph of Chutzpah

The "good front" put up by RCA was called SPRINT 78, which stood, rather ridiculously, for Selling Programs, Retail and Institutional, to Nudge store Traffic. The program was a triumph of chutzpah, a series of promotional schemes designed to educate and excite consumers about VCRs. Just as JVC's market in Japan had grown from a grass roots educational effort, so did RCA's. The American giant threw parties and made movies from people's photograph albums. Like JVC, RCA discovered that the VCR had to be presented one on one to average, everyday people. The VCR, as Shiraishi noted, is a device with the power to "touch your heart." Discovering this phenomenon was as gradual and remarkable to the salesperson as it was to the customer.

For JVC and its Japanese partners, RCA's contribution to the VHS breakthrough was enormous. As big and enthusiastic as the Japanese market was, it was the immense, affluent American market that sent the VCR into the commercial stratosphere and launched the proliferation of manufacturers, hardware features, software makers, retail and rental options, and a multibillion dollar network of industries that—by most experts' analyses—has yet to reach even half of its annual potential for making money.

Working through a network of powerful partners gently cultivated, JVC made VHS equal to Betamax in a remarkably short time and dramatically surpassed Sony's format in the early 1980s. By 1985, VHS accounted for more than 80 percent of all VCR sales in the world. In the US, Betamax owners looking for blank or prerecorded tapes in their format were relegated to the status of a disadvantaged minority. The VCR had become a worldwide social phenomenon that demonstrated more and more functions. In the US and Britain especially, the emergence of the rental industry (in tape players, prerecorded tapes, and even video cameras) spread the VCR fever among people who couldn't afford to purchase their own units. Jane Fonda's exercise tape became the most famous example of the educational potential of the VCR, which has swept through schools, colleges, and corporations and replaced the more expensive and less convenient 8mm and 16mm film.

Coming from humble and very uncertain beginnings, VCR technology is now present throughout the world. Sales in 1991 alone totaled 43.4 million units. Many experts believe that the VCR will approach the same sort of "necessity" status in Western society as the color television set and the refrigerator, possible largely because the VHS format recorder not only works dependably but also responds almost intuitively to the needs of users. JVC succeeded because it tried a little harder to understand the subtleties of both the device and the consumer before introducing its format. What should have happened, according to the usual business script, was a war among format inventors, eventually leading to suicidal escalations of competition, total consumer confusion, and a market fragmented and disillusioned for at least a decade. But the Great War of the VCR Formats was over before it started.

This exceptional peace was born because Shizuo Takano and Yuma Shiraishi realized that the problem of the home-use VCR was not just one of technological improvement; it was one of fundamental concept. To address it, they discarded everything they and others had done, even disregarding for the moment the miracle at Ampex and the genius of their mentor. They joined their fellow engineers and asked every question they could imagine. They prepared themselves for every unexpected reversal of fortune. At every step they considered themselves users, not inventors. Their concept was so finely examined that it contained within a dozen simple goals the answers to questions they hadn't even asked.

Politely, gently, the JVC people stepped outside their own experience and tried to anticipate what their business partners and customers thought. In doing so, they gave to their beloved teacher, Kenjiro Takayanagi, the fulfillment of a fifty-year vision. And they gave people all over the world a precious gift—the sights and sounds they cherish most, easily at hand and instantly recalled.

3

3M'S POST-IT NOTEPADS NEVER MIND. PEE DO IT MYSEEF.

Near the end of 1978, bleak reports came back to the headquarters of Minnesota Mining & Manufacturing (3M) Corporation in St. Paul from a four-city test market: This Post-it™ notepads idea was a real stinker. This came as no surprise, of course, to many of 3M's most astute observers of new product ideas; this one had smelled funny to them from the beginning. The company had ignored Post-it before it was a notepad, when the product-to-be was just an adhesive that didn't adhere very well. The first related product to reach the market was a sticky bulletin board whose sales were less than exciting. So why was it still around?

For five years this odd material kept turning up like a bad penny in the pocket of Spencer Silver, the chemist who had mixed it up in the first place. Even after the adhesive had evolved into a stickum-covered bulletin board, and then into notepad glue, the manufacturing department said they couldn't mass-produce the pads. The 3M marketing crew also said you could only sell these things if you gave them away, because who would pay a dollar for scratch paper?

So when the test market reports arrived, it seemed everyone who'd disparaged the Post-it notepad was right after all: 3M was finally going to do the merciful thing and bury the remains. Only one last try by two executives, Geoffrey Nicholson and Joseph Ramey, saved those little yellow self-stick notes from oblivion. Nicholson and Ramey knew 3M's marketing distribution network well, and they wondered why a product that they felt had obvious appeal had bombed. Had 3M's conventional marketing approach victimized an unconventional product? They were curious enough to fly to Richmond, Virginia, one of the test cities. Without that trip, 3M almost certainly would have ceased pilot production of Post-it Notes, retired the machinery they had designed for the job, and missed one of the all-time best-sellers among office products.

Always skilled at developing new variations on old products and then expanding their range of activities, 3M saw that Post-its were unique, a product entirely unlike anything else 3M had ever sold. Because Nicholson and Ramey recognized the unique properties of the Post-it Note and conveyed them to people in Richmond, the "little yellow self-stick notepads" are today proliferating in offices everywhere. They bristle from the margins of reports, speckle the surface of spreadsheet printouts, and insinuate reminders from typewriters, desk tops, bookcases, coffee cups, in-baskets and out-baskets, framed photos of families, computer screens, and copying machines. They seem to have a special affinity for the soles of shoes.

Post-it Notes are now ubiquitous in offices because they do something no product ever did before: They convey messages exactly where people want them, and then they leave no telltale sign that they were ever there. They don't make paper clip dents or staple holes. They can be moved from place to place, and their adhesive never gets tired. They come in various sizes for short, emphatic messages or long, contemplative ones; a small Post-it note can be stuck with understated reproach beside the tiniest error, and a big one can sprawl across the center of the perfect report, celebrating it in a single, boldly lettered word of praise without sullying the pristine surface beneath. The Post-it allows clerks and CEOs alike to do something always desired but rarely attained in the modern corporation: to be critical and equivocal at the same time.

Had they not engineered the market reversal in Richmond, Nicholson and Ramey would have had to eat their words—and several hundred thousand notepads besides. They made the extra effort because they had both used Post-it Notes and knew how irresistible they were. They also knew that their marketing people had approached the test markets in a traditional style that made for an exercise in futility. The tests relied heavily on advertising to generate enthusiasm in distributors who did not themselves use the product and who saw little sense in exerting sales efforts on a scratch pad with both an exorbitant price and a dubious profit margin. Nevertheless, Nicholson and Ramey took to Richmond a seemingly obvious bit of knowledge that had eluded all the marketers and distributors: You had to *use* Post-it Notes to appreciate them.

Putting Post-its in the Right Hands

Since they were ultimately responsible for the success or failure of Post-it Notes, Nicholson and Ramey stopped depending on their organization and just did it themselves. In so doing, they returned to two approaches that had already sold Post-it Notes more than once: Like Spencer Silver shuffling from division to division at 3M with his peculiar adhesive, they went door to door and they gave away the product, just as Nicholson had done within 3M for more than a year.

Up and down the business district of Richmond, Nicholson and Ramey handed out little yellow pads of Post-it Notes and said, "Here, try this." And they watched as receptionists, programmers, middle managers, and vice presidents did just that. People started sticking them everywhere—on papers, desks, phones, lapels, faces. In one day of contacts in Richmond, Nicholson and Ramey obtained valid assurance not only that people liked these things, but that they wanted more of them and were going to tell their family and friends about them. As was later proven more scientifically, people loved the Post-it Notes that they got for free, and if getting more meant they had to pay a dollar a pad, that was cheap. Post-it Notes spoil office people forever: Once you've used Post-it Notes, you can't go back to staples and paper clips.

For its next campaign, 3M diverted most of its office supply division sales force and a battalion of temporary employees to Boise, Idaho. The company had saturated test markets before with products and ads but had restricted the number of employees involved. A small fortune spent on advertising, promotions, and free Post-it Notes confirmed the appeal of the product and revealed that Post-it sales inevitably followed the distribution of free samples. Reorders came in at a rate of 90 percent—double the rate of any other wildly successful office product.

Boise notwithstanding, the key market breakthrough for Post-it Notes was Richmond, where Nicholson and Ramey had tempered their doubts and directly approached the end-users. "What made me go out into the market was the enthusiasm of Geoff Nicholson and Art Fry," said Ramey. "I just figured that for their morale I should get out and find out whether we ought to kill it once and for all.. .I didn't think frankly that it was a product that people would buy."[1] Nicholson called the trip "an act of desperation" and admitted, "a lot of the things were accidents."

There is an irony in Nicholson's description. The development of Post-it Notes has become one of the most studied and analyzed paradigms of the environment for innovation in modern business, despite Nicholson's contention that 3M's experience is not a model of innovation for other companies. Nevertheless, companies that want product breakthroughs are counseled to read about what 3M did and do the same thing. Retrospective writings about Post-it Notes refer effusively to the encouragement provided to creative people by champions and patrons in management. But Nicholson has rightly asked where all that encouragement was during the five years of Spencer Silver's struggle to be heard.

Bottom-up Support for a New Product

In fact, 3M does provide fertile soil for new ideas to grow, but until Nicholson listened to a presentation one day in 1973 given by Silver and his colleague Robert Oliveira, management at 3M had given no hint of support for what eventually became the Post-it Notes project. Until then, the flame was borne entirely by middle- and lower-echelon troops acting largely in solitude and, occasionally, in defiance of the organization's implicit desires. Silver's adhesive survived half a decade of cold shoulders only because the company has a tradition of internal selling; anyone with a product idea can carry it around to the company's divisions and seek support—both emotional and fiscal—to develop it for market. Inventors are never really stopped at 3M; no central overseer says "Cut that out and get back to work!" Instead, laboring in their spare time, inventors experience a mounting series of rejections from middle management functionaries, most of whom have neither the imagination nor the budget to take a serious look at the new idea. Product ideas die at 3M as they do at other places, but the death tends to be long and lingering.

Silver and Oliveira were among a host of company chemists working to develop variations on 3M chemical products. Like the others, they worked within specific programs set out by 3M to attain certain results, but they did get occasional encouragement to follow up on interesting, unexpected results. According to the company, 3M scientists "use up to 15 percent of their time pursuing interests outside their primary assignment. Their patrons on these projects are the successive layers of management to whom they report. While review of individual lab notebooks and oral presentations may not be met with wild enthusiasm, rarely do inventors get stopped." This 15 percent rule is common in many companies involved in research and development. But, in reality, no one at 3M really keeps track of it. In fact, 3M managers are wise *not* to monitor very carefully their scientists' use of this symbolic policy; if it were enforced rigidly, the rule would undermine its intent and inhibit the creative energy of researchers such as Silver and Oliveira.

The Post-it idea stayed alive for a remarkably long time, partly because Silver also kept busy with other assigned research tasks and did not devote himself entirely to his funny adhesive and partly because of his amazing tolerance for rejection. His adhesive made little sense, either scientifically or commercially; the 3M system had good reason and the strength to kill it. Post-it adhesive might have died simply because it had no noisy advocates: Silver was a model citizen of the corporation; he scrimped on equipment and chemicals; never asked for his office to be repainted; and never grabbed his boss by the lapels to talk about a new invention. Oliveira was more aggressive, but his most demonstrative moments were not the sort of tempests that could sway 3M's indifference. The worst thing about this impermanent adhesive, however, was that for five years it had no perceptible application—it was a solution looking for a problem. Of all the ways to devise new products, this was probably the most inefficient, especially when the goal is a product the company can sell successfully.

Monomers and Polymers

Silver's role in the development of Post-it notepads began in 1964 with the polymers for adhesives program in 3M's Central Research Laboratories. Since the time of William L. McKnight, a salesman who interviewed carpenters in 1912 to find ways for the company to make better sandpaper, 3M has had a tradition of periodically reexamining its own products to look for ways to improve them. This practice, at its best, results in incremental innovations that occasionally lead to new markets, new technologies, even whole new product lines. In the course of the new program, Silver learned about a new family of monomers developed by Archer-Daniels-Midland (ADM), which he thought had potential as ingredients for polymer-based adhesives. With the approval of 3M, he requested a number of samples from ADM. Silver's acquisition of the ADM monomers was the sort of open-ended exploration the company encouraged. "As long as you were producing new things, everybody was happy," said Silver. "Of course they had to be new patentable molecules."

Silver tried an experiment in which, on a whim, he put an unusually large amount of one of the monomers into the reaction mixture. He had used amounts before that corresponded to conventional wisdom. Silver had no particular expectation of what might occur; he just thought it might be interesting to see what would happen. By so doing, Silver was really venturing into the realm of the irrational. In the process of polymerization catalysis, scientists usually control the interacting ingredients in very tightly defined proportions, in accordance with prevailing theory and experience. Silver said with a certain measure of glee, "If I had sat down and factored it out beforehand and thought about it, I wouldn't have done the experiment. If I had really seriously gone through the literature, I would have stopped." Reliable published reports could have told him there was no point in doing what he did, but Silver understood that science is one part meticulous calculation and one part "fooling around."

"People like myself," said Silver, "get excited about looking for new properties in materials. I find that very satisfying, to perturb the structure slightly and just see what happens. I have a hard time talking people into doing that—people who are more highly trained. It's been my experience that people are reluctant just to try, to experiment—just to see what will happen!"

When Silver went ahead with the "wrong" proportions of the ADM monomers, he got a reaction that departed from the predictions of theory. He called it a *Eureka moment*—something Nicholson would refer to as an "accident." It was the moment for which scientists become scientists—the emergence of an unexpected, previously unobserved, but reproducible phenomenon. Every time Silver combined the chemicals, they fell into the same pattern.

Technically the material was what the research program called for—a new polymer with adhesive properties. Silver noticed that, among its other curious properties, this material was not "aggressively" adhesive—it would create what 3M scientists call *tack* between two surfaces, but it would not bond tightly to them. It also was more cohesive than adhesive; it clung to its own molecules better than to any others. If you sprayed it on a surface and then slapped a piece of paper on it, you might remove all or none of the adhesive when you lifted the paper. It might prefer one surface to another, but not stick well to either. Someone would have to invent a new coating if the adhesive were to work on paper, but Silver doubted the material's use on paper—and on this point, at least, everyone agreed.

The Search for a Purpose

Silver had achieved not a synthesis, the usual outcome in 3M's labs, but a discovery—the sort of thing one can put one's name on. Watching the reaction, Silver felt almost as though he were falling in love or becoming a father. Almost immediately, he personified the viscous goo: "It wanted to make Post-it adhesive," he said, and soon he came to call the stuff "my baby." It may not have been very sticky, but Silver got very attached to it.

Silver started presenting this discovery to people who shared none of his perceptions about the beauty of his glue. Interested in practical applications, they had only a passing appreciation for the science involved. More significantly, they were trapped by the notion that the ultimate adhesive is one that forms an unbreakable bond. The world in which they lived was looking for a better glue, not a worse one. Suddenly, here was Silver, circulating among the devotees of the constancy, touting the virtues of promiscuity. He couldn't say exactly what the glue was good for, "but it has to be good for something," he would tell them. "Aren't there times," Silver would ask, "when you want a glue to hold something for a while but not forever? Let's see if we can turn this adhesive into a product that will hold tight as long as people need it to, but then let go when they want."

From 1968 through 1973, however, company support systematically eluded him. First, the polymers for adhesives program ended. When the program's specified time and limited budget were used up, the researchers were reassigned. Some, like Silver, had become personally involved and were just starting to have fun. Left as a team, they might have fought together to keep alive a number of their odd little discoveries. But all those discoveries were shelved—with Silver's lone exception—and he got little assistance from his teammates in promoting the survival of his adhesive.

What Silver did next seems to happen frequently at 3M: He shrugged at the organization and did it himself. He had to battle to get the little money required to patent his unique polymer. Even then, Post-it adhesive was patented only in the United States, because it lacked apparent commercial potential. "It's kind of a shame," Silver said. "If you commit yourself to hundreds of thousands of dollars for research, you ought to follow it up with a ten-thousand-dollar patent."

Silver's advantage, as he quietly began the arduous struggle to capture the imagination of his colleagues and superiors, was that he was, after all, in love. "I was just absolutely convinced that this had some potential," Silver said. "There are some things that have a little spark to them—that are worth pursuing. You have to be almost a zealot at times in order to keep interest alive, because it will die off. In the fat times, we do a lot of interesting research; then the lean times come just about when you've developed your first goody. And then you've got to go out and try to sell it. Well, in the divisions everybody is so busy that they don't have time to look at new product ideas with no end product already in mind."

Silver went to every division at 3M that might be able to think up an application for an adhesive with the curious charm of hanging around without a commitment. The organization never protested; when he sought time at in-house technical seminars, he always received a bit of time to show off his now-it-works, now-it-doesn't adhesive. At every seminar someone said, "What can you do with a glue that doesn't glue?" But no one said, "Don't try. Stop wasting our time." In fact, to do so would have violated some very deeply felt principles of the 3M company.

Much is made of 3M's environment for innovation, but it really is more accurately one of nonintervention—of expecting people to fulfill their daily responsibilities without discernible pressure from above. Silver, no matter how much time he spent fooling around with the Post-it adhesive, never failed in his other duties, and so at 3M there was no overt reason to discourage his extracurricular activities. The positive side of this corporate ethic is the independence each worker experiences in doing a job. The disadvantage is that when you have a good idea that requires more than one person to share the work and get the credit, it can be hard to convince people to postpone their chores and help with yours.

As Silver pursued his quest, his best inspiration for applying his adhesive was on a bulletin board—a product that was not especially stimulating, even to its inventor. Silver got 3M to manufacture a number of them through a fairly low-tech, inexpensive process, and they were sent out to a predictable fate in the company's distribution and retail network. A few sold, but it was a slow-moving item in a sleepy market niche. Silver knew there had to be a better idea. Although Silver had overcome the trap of always striving for a stickier stickum, he, too, became trapped by the paradigm at the next stage of development. The bulletin board, the only product he could think of, was coated with adhesive—it was sticky everywhere. The model said that something is either sticky or not sticky; something partly sticky did not occur to him. More intellectually seductive was the fact that, until Silver's adhesive made it possible, there was no such thing as self-adhesive paper. Notepaper was cheap and trivial; fasteners were valuable. Silver was immersed in an organization whose lifeblood was Scotch brand tapes—cellophane tape, masking tape, duct tape, electrical tape, diaper tape, and surgical tape, to name only a few. In that atmosphere, imagining a piece of paper that eliminates the need for tape is almost heresy.

A New Leader of the R&D Team

In the early 1970s, 3M transferred Silver to a different research group, where he met Robert Oliveira, a biochemist who shared his interests. Silver and Oliveira kept each other from getting discouraged and eventually showed the adhesive to Geoff Nicholson. Nicholson, who has emphasized what he calls the accidental nature of the breakthroughs in Post-it technology, may have been the biggest accident of all. In 1973, he was appointed the leader of one of the open-ended research and development venture teams, formed when funds were available, to explore new directions in one of 3M's many lines of business and technology. Nicholson had been given a fresh budget and a free hand to develop new products in the company's Commercial Tape Division, whose new product development had grown sluggish.

Silver had been to see the people in the Commercial Tape Division at least twice before; both times they had rejected his adhesive. He and Oliveira were almost the first people in Nicholson's new office. "Here I am, brand-new to the division, and I don't know a lot about adhesives," Nicholson recalled. "I'm ripe for something new, different, and exciting." Silver explained his adhesive, his Eureka moment, for the umpteenth time, and Nicholson, who didn't understand half of what he was saying, loved it. "It sure sounded different and unique to me," he said. Finally, Silver's unloved, uncommitted adhesive had a home. Nicholson went about recruiting people for the new venture team; Silver hoped that one of them would arrive with a problem to match his solution. It turned out that there was one—a chemist, choir director, and amateur mechanic named Arthur Fry.

Fry ultimately took the baton from Silver and carried it over a jumble of discouraging hurdles. Fry, unlike Silver, had support from above, but the technological problems he dealt with were far more daunting than Silver's. Even before joining the new venture team, Fry had seen Silver show off his adhesive. Like Archimedes pondering the king's crown, Fry kept the idea turning slowly in the back of his mind. He agreed that this adhesive was special, but he wondered what to do with it. Then one day, singing in his church choir, he had one of those creative moments. "To make it easier to find the songs we were going to sing," Fry explained, "I used to mark the places with little slips of paper." Inevitably, something would divert his attention from the placement of his array of bookmarks: One unguarded move, and they fluttered to the floor or sank into the hymnal's binding. Suddenly, while Fry leafed for his place in the book, he thought, "If I had a little adhesive on these bookmarks, that would be just the ticket." Remembering Silver's adhesive, he decided to pursue his idea at work.

What had happened was what Arthur Koestler has called a *bisociation*—the simultaneous association of two unrelated ideas. After Fry mixed up some adhesive and paper, using different concentrations, he had invented what he called "the better bookmark." Encouraged by Silver's enthusiasm and Nicholson's push for new products, Fry began to realize the magnitude of his creative moment. "I knew I had made a much bigger discovery," said Fry. "I also now realized that the primary application for Silver's adhesive was not on a fixed surface, like the bulletin boards; the primary application concerned paper to paper." What Silver and the rest of 3M had not realized in five years, Fry realized in a flash. It was one of those ideas that contemplation doesn't seem to generate; it either pops into one's head or it doesn't happen at all.

After Silver had been insisting for five years that this adhesive must have a use, Fry provided the first truly affirmative response. But with his Eureka moment came an immediate problem: On the bulletin board, Silver's adhesive was attached to a favorable "substrate" or surface. It stuck to the bulletin board better than anything else. On paper, though, it peeled off onto everything it touched.

Two members of Nicholson's team, Henry Courtney and Roger Merrill, invented a paper coating that made the Post-it adhesive work. "Those guys actually made one of the most important contributions to the whole project, and they haven't got a lot of credit for it," Silver said. "If you put the adhesive down on something and pulled it apart, it could stay with either side. It had no memory of where it should be." Courtney and Merrill came up with a way to prime the substrate. "They're the ones who really made the breakthrough discovery, because once you've learned that, you can apply it to all sorts of different surfaces."

From Concept to Production

That contribution was the first in a series of actions that definitely were not accidents. Although there was still some organizational resistance, every action thenceforth, including Courtney and Merrill's research, was directed toward the development, production, and market success of the Post-it Note. Fry tenaciously advocated for the product through all phases from development to production scaleup.

While Silver's task had been simply to convince his corporation that his glue was worthwhile, the job Fry assumed was to help his division manufacture something that was (a) not sticky at all on one side, (b) only sticky on part of the other side, and (c) wasn't *very* sticky anywhere. It had to be produced in big sheets, not in rolls, and then these had to be laid together and cut into smaller sizes. The engineers in 3M's Commercial Tape Division were accustomed to tape that is sticky all over on one side and then gets packaged into rolls. To apply glue selectively to one side of the paper, and to move the product from rolls to sheets, the engineers would have to invent at least two new machines.

In war and politics, the best strategy is to divide and conquer; in production engineering, the reverse is true. Fry brought together the production people—designers, mechanical engineers, and machine operators—and let them describe the many reasons why something like that could not be done. He also encouraged them to speculate on ways that they might accomplish the impossible. A lifelong gadgeteer, Fry found himself offering his own suggestions. "Problems are wonderful things to have, especially early in the game, when you really should be looking for problems," said Fry.

People started thinking of places around 3M where they had seen machines and parts that they could use to assemble the machines they needed to build. And they thought of people who could help. "In a small company, if you had an idea that would incorporate a variety of technologies and you had to go out and buy the equipment to put those together, you probably couldn't afford it, or you'd have to go as inexpensively or as small as possible," said Fry. "At 3M, we've got so many experts and so much equipment scattered around that we can piece things together when we're starting off. We can make the adhesive and some of the raw materials here, and do one part over here, and another part over there, and convert a space there and make a few things that aren't available."

Then there was Arthur Fry's basement. He had argued with several engineers about a difficult phase of production, that is, applying adhesive to paper in a continuous roll. He said it could be done; they said it couldn't. He assembled a small-scale basic machine in his basement, then adapted it until he had solved the problem. The machine would work even better once the mechanical engineers had a chance to refine it. But to Fry's dismay, the new machine was too big to fit through his basement door. If he couldn't get it out of his cellar, he couldn't show it to the engineers. Fry accepted the consequences of his genius and did what he had to do. He cut a hole through his basement wall and delivered his machine by Cesarean section.

Within two years, Fry and 3M's mechanical engineers had tinkered their way to a series of machines that, among other things, coated the yellow paper with its substrate, applied adhesive, and cut the sticky paper into little square and rectangular notepads. All of the machines are unique and proprietary to the company; they are the key to the

Post-it Notes' consistency and dependability. The immense difficulty of duplicating 3M's machinery without knowing what Fry and the engineers did is part of the reason few competitors have marketed Post-it imitations.

From Production to Marketing

In a pilot plant attached to the lab, Fry and the engineers produced more than enough Post-it Note prototypes to supply all the company's offices. Early in the program, the senior managers' secretaries all received Post-it Notes and became hooked. But the personal enthusiasm of the secretaries did not impress the division's marketing organization. Fear of the unfamiliar repeatedly threatened to scuttle the program.

The marketing department had fallen out of the habit of dealing directly with consumers. By 1978 the Commercial Tape Division's marketing group had introduced half a dozen new products that met easily identified needs for clearly defined markets—products such as bookbinding tape for libraries and adhesives for the art market. The Post-it Note was just another new product, and not a high-priority one at that. Although the company's marketing people had become hooked on Post-it Notes in their own offices, they didn't recognize that other people would have to get hooked the same way, by actually using them. When marketers created materials to present the new product, they included no samples. Instead they wrote brochures describing it, then sent separate boxes of samples only if people got excited by the brochures. The 3M marketing group, too, was trapped by the model. It was their job to explain products, not to demonstrate them. As explainers, they hadn't overcome the "scratch paper" image. If they couldn't explain Post-its, they couldn't sell them.

Nicholson had only limited power to push the notes outside the company. When the four-city test failed, he alone might not have had the influence to keep the product alive. But by this time Nicholson had a heavyweight ally in Joe Ramey, general sales manager of the Commercial Tape Division and a marketing troubleshooter who knew that some market problems are too complicated to solve. He went to the test market in Richmond because he liked Nicholson, not because he liked Post-it Notes' chances. But the reactions, face-to-face, when people started "playing" with Post-it Notes, were so dramatic that Ramey had all the evidence he needed to throw all the artillery into Boise.

Cellophane tape and Post-it Notes—two of the company's greatest breakthroughs, 66 years apart—grew out of a similar faith in the wisdom of sitting down with customers and asking questions without any of the trappings of corporate protocol. According to most business analysts, that approach is part of what makes 3M a positive environment for innovation—something in 3M's style that tends to encourage individual ingenuity among workers.

One of 3M's corporate strengths has been its perpetual efforts to improve the product line. The development of cellophane tape in the 1930s was a breakthrough that came from 3M's work on insulation for railroad cars. From that point 3M sustained its interest in tape, always devising an improved product that left its imitators behind, and producing the Scotch brand Magic Tape revolution in the 1960s.

Whenever 3M's search for improvement led in a different direction, the company let a few people follow it. If the detour resulted in a product line of even modest profitability, 3M allowed the effort to proceed. The company operates on the simple principle *Forbes* magazine once noted, "that no market, no end product is so small as to be scorned; that with the proper organization, a myriad of small products can be as profitable, if not more so, than a few big ones. More firmly than most, 3M management appreciates that the beach is composed of grains of sand, the ocean of drops of water.[2]

This tolerance of the small scale certainly helped Spence Silver, and then Art Fry, to keep the company from stomping on the Post-it Notes project before it had developed a life of its own. But bigness also had benefits. Over the years, 3M has grown into a loosely integrated cluster of divisions, with senior management in St. Paul. One of the results of this corporate sprawl is that it permits clever researchers to hide in the crevices and carry out their own version of the 15 percent principle. Silver benefited more from this benign neglect than from anyone overtly encouraging him; Fry also enjoyed this freedom from scrutiny as he fostered the project through the touchy and costly work of product development.

A more provocative issue, though, is why people at 3M enjoy this unchecked opportunity to get away with things. One judgment, often delivered both within the company and outside, is that senior management has consciously decided to foster an orderly chaos as the rich fertilizer of innovative growth. But plenty of evidence challenges this assertion. The company tends to cast its most successfully creative people in bronze, rewarding them with conventional perks like private labs and creating new programs for innovation. Yet there seems to have been no desire for trophies among either the Post-it project principals or any of 3M's prior inventors. They were people obsessed with problems, not rewards, and they usually invented their own program in order to achieve solutions.

Incentives aren't the reason 3M gets creativity from its Silvers and Frys.

The Roots of 3M Innovation

A more credible explanation may be found in the company's origins. Since moving from Duluth in 1910, 3M has been inextricably linked with the city of St. Paul. Two-thirds of its employees are drawn from the upper Midwest. St. Paul has remained the company town for 3M, and 3M has been the town's company. Like other community-linked Midwestern companies, corporation and community have grown up together, and they generally know what to expect from each other. This bond creates trust, and with it an air of amiability. The ease and unpretentiousness of the highest officials at 3M contrasts with the formality and status-sensitivity of management in other regions, especially the East. Nicholson and Ramey, for example, did not need to overcome a lot of deep-seated conditioning in order to go out on the streets and behave like peddlers.

At 3M, it is simply not good form for management to watch too closely over the shoulders of its veteran employees. It is equally bad form for employees to violate the trust placed in them by a less than vigilant management. There is an honor system, and it works.

The source of this heartland ethos can be found in the farms that surround St. Paul. In this pioneer farming region, stretching from the Dakotas to Detroit, the lactation cycle of the Guernsey cow has for more than a century affected people's lives more than the daily fluctuations of the Dow Jones industrials. The ethic that has governed the farms around St. Paul has had some very explicit effects on the company style of 3M and other Midwestern companies that often are close to their communities but distant from their competition. There is a streak of stubborn independence in the management of these companies, and their managers tend to get that attitude from their employees rather than giving it to them.

On a farm, each worker is expected to complete his daily chores before sitting down to supper. Nobody ever watches him do his chores; if he doesn't do them, the disastrous evidence will become apparent by the next day's dawn. Nobody ever asks him if he did them, because he wouldn't be eating if he hadn't. In the Midwest, two or more separate farms have traditionally joined forces to do a job that's too big for any single household to handle, such as threshing the harvest of oats or rebuilding a barn. Although this pioneer spirit waned as farms became increasingly mechanized, the frame of mind and the ways of perceiving the world that grew from that spirit still hold on tenaciously within the region's people. Employees carry on at 3M because they are trustworthy, and they are trustworthy because trust is important to the larger culture that has surrounded and affected 3M for eighty-five years.

Even 3M's sprawling divisional structure has the appearance of a series of small farm towns spread throughout one of Minnesota's big, lake-strewn counties—each town (or division) fiercely independent yet alert to what is happening in every neighboring community. A sophisticated analysis of 3M's structure might find that management created radical decentralization in order to spread the entrepreneurial spirit. A simpler outlook might suggest that 3M grew according to the natural contours of its geography and its people.

One thing, however, that 3M has proven is that when it becomes self-conscious about managing its innovation, its innovation is not any better than that of any other company. As Nicholson said, "Post-it Notes came from accidents, not calculations." Each accident occurred after one person took an entirely independent course of action from the one assigned by the corporation, while at the same time carrying out his official responsibilities. Each time, the individual got frustrated by the indifference or the resistance of the organization. But even when the organization or management discouraged people from doing something, the cancellation orders didn't carry much conviction. The people creating things often have more room to express their egos than the people who are supposed to be running things. If there is an organizational key to breakthrough at 3M, a significant element of corporate culture, it is in the fact that people there do not believe in placing the values of the corporation above the values of the individual; instead, they keep the organization vital by not taking it too seriously.

As a result, when creative people inevitably run into the resistance of the organization, they feel the freedom to say, "Well, okay. Never mind. I'll do it myself." The organization simply does not have an equal measure of persistence in response; 3M yields to people who are sure of themselves. Just as important, everybody at 3M knows that if someone's pet project is a disaster, it isn't the end of the world. If Silver, Fry, or Nicholson had failed, they wouldn't have been dismissed or disgraced. As long as they had their chores done, they would always have a place at the table.

4

CHEMLAWN AND DICK DUKE'S LONELY BATTLE

When the first two tank trucks of a new company called ChemLawn rolled forth in Troy, Ohio, in 1968, even the company's employees harbored not grand expectations about its long-term prospects for success.[1] They enjoyed better pay and working conditions than they were accustomed to, but ChemLawn's first crews were composed of ordinary men whose ambitions and outlook generally did not extend beyond the next weekend. "We were all pretty uncomplicated people," one of them later said. Little did they realize that three of them would become executives in the new company, which in a startlingly short time would become the world's largest lawn-care service company. Within three years, the company's owner would entertain a buyout offer that would have made him and those original employees more than $1 million.

ChemLawn achieved that success and became the largest company in its industry by inventing the industry. Before ChemLawn, lawn care had been—to quote from the company's promotional copy—the province of "a shabby, unskilled worker with a dirty pickup truck." Instead, ChemLawn offered its customers a team trained to use specially developed equipment to spray a new type of liquid lawn food. In the vision of its founders, ChemLawn was to free American suburbanites from the most difficult and mystifying task associated with their property—lawn care.

Good Work and Fair Dealing

The company realized that vision beyond the wildest dreams of its founders or their first crew of so-called lawn-care specialists. That group comprised Richard Lyons, a Vietnam veteran who quit a $110-a-week newspaper advertising job to join up; Tom Grapner, a laborer who like the owners' reputation for good work and fair dealing; and John Wright, the owner of a landscaping business who kept his own equipment in storage—just in case. All of them felt ChemLawn offered better prospects, but they weren't exactly sure how. "We all thought the guy was going to have money coming in," said Lyons. "From where, we didn't know. Of course, as I look back now, I think, boy! Was that risky!"

"The guy" was Richard L. Duke, who with his father, Paul, co-founded ChemLawn. The two men began business in 1949 as proprietors of the Duke Garden Center, a modest operation whose only successful expansion was the purchase of a sod farm. The Dukes sold those interests and netted $40,000, which they invested in the pair of trucks and the other equipment (some of which they designed themselves) that they sent out with the first crew. What Duke expected from the men was the even application on customers' lawns of an ingenious liquid blend of fertilizer, weed killer, and bug killer. This mixture had the captivating effect of making a lawn uniformly green and healthy—very quickly. The ChemLawn truck, a custom-designed, six-wheel tanker with a huge lawn-green logo splashed across its sides, would come and go while the residents were at work and at school. The only sign of its passing was a notice on the door reminding people not to roll around in the grass until the chemicals had a chance to dry—about an hour.

The treatment didn't cost very much, and Duke ordered the lawn-care specialists to be extremely friendly to customers. That part wasn't hard; the crew was a pretty friendly bunch—friendlier, in fact, than the boss, who was nice to the paying public but tough now and then on friends, family, and employees. If there seemed to be a vaguely threatening air about Duke, there was also an electric intensity. It was that voltage, and Duke's great self-confidence, that compelled more timid souls like Wright to join up with this unlikely lawn-spraying outfit.

Wright didn't worry about believing in the company; he had believed, for several years, in Dick Duke. He had done business with the Dukes when they ran the sod farm, and while they loaded his pickup truck, the conversation would drift into aspirations that seemed to Wright both alluring and unattainable.

"I would invariably spend at least half a day when I'd go there," Wright said, "because Dick would start talking about this idea he had—an organization with the focus on the people. I found we had a lot of things in common philosophically and in reality, too. We both worked hard and we were starving to death, and we were sure that there had to be a better way to succeed."

I Don't Care What It Costs, Just Come and Do It

By late spring 1969, the ChemLawn crew was beginning to sense just how much better—and novel—their way was. At first, they were just doing their jobs. But one by one, they looked up from the grass and began to see untold possibilities.

"For one thing, all the checks cashed," Wright recalled. "When that is twice as much money as you've ever made in your life, and those checks do cash, that's a tremendous source of motivation. And the thing that really pulled the trigger was closing eight out of ten sales. I'd never been in a business like that. I'd been fighting for every dollar, and here these people were signing up for $50, $100 a year."

Not even the irrepressible Duke, who kept pumping his people with the assurance that "anything is possible," had expected ChemLawn's promise of suddenly green, lush, dandelion-free lawns to strike a resounding chord with the homeowners of Troy, Piqua, and Dayton—and soon, even Columbus.

"Saturday was a big sale day. People would come from blocks away to get in line at the truck and sign up," recalled Lyons. "You'd go back and they'd say, 'How come you didn't get any lawns sprayed?' You'd tell people, 'That's because I got these twelve new customers. I'll be down there as quick as I can.' And they'd say, T don't care what it costs. Just come and do it.' And that was routine."

In that first year, the growth of ChemLawn was extraordinary. After little discernible revenue in 1968, the company reached $218,000 in sales in 1969. That might not sound like much, but with a price structure that topped out at $100 for a very big lawn, the workload was sometimes overwhelming for the work force of five. The crew often worked from dawn until the late-falling summer darkness; then they would find Duke waiting back at the office with a case of beer.

The beer and the lingering conversations in the parking lot were comforting, but they were also a way for Dick Duke to push his people. And he never stopped pushing. He knew that the lines on Saturday mornings would not last forever. He knew he had to push to develop ChemLawn, to spread it beyond Ohio, and to push even harder to keep those homeowners coming back, year after year. Duke was still the only person in the company whose vision regularly extended beyond the weekend.

"He said we were going to be a multimillion-dollar company," said Lyons. "Probably inside, I laughed at him. He started talking about all the cities we'd be in." But within two years, ChemLawn was virtually a million-dollar company. Every year sales rose steeply: $981,000 in 1970, $2.3 million in 1971, $4.9 million in 1972, $141 million by 1980, and by 1991 well over $300 million.

A Leader Committed to His Employees

No one with any experience with ChemLawn credits the company's phenomenal success curve and the accompanying loyalty of hundreds of thousands of customers to anything but the personal qualities of Richard L. Duke—his magnetism, enthusiasm, perfectionism, and, above all, his almost fanatic devotion to his employees. Success gave Duke an opportunity to do something vitally important to him, to take care of a great number of people. His employees felt Duke's devotion, and for many of them he became an idol.

"Dick was the leader," said Wright. "He was my mentor, he inspired people. If Dick could think of it, the chances were we could probably do it. There was an attitude, particularly among the original group of people, which was—I have since found out—not terribly common in society. A lot of people look at things in terms of 'What's in it for me? How much security can you give me in return for this effort you want me to put forth?' I don't know if it was ignorance or integrity, but we weren't smart enough to ask that. We just tried to do the best we knew how to do."

To the people of ChemLawn in its first days, Duke conveyed a virtually messianic quality. Lyons, for example, was not simply hired away from the Piqua newspaper—he felt rescued. "There was something about him," Lyons recalled. "He had an air of confidence. I thought, 'I'm not sure what I want to do, but this guy acts like he knows what he's going to do, and it's going to be a success.' I was pretty much convinced that he had no doubt—you could believe in him."

Even the one person in his life who knew him best, his wife, Opal, found in Duke a presence that seemed, when he called upon it, to make him larger than life. "He was very good at planting an idea in people," she said, "and everybody would start talking and they'd think they came up with it. He was a master at doing that."

Easy Lawn Care for a Growing Market

Besides charisma, to start ChemLawn Duke also used a business concept that was virtually complete before the first day of operation. The elements of that concept had synthesized almost unconsciously over a twenty-year period, most of it in the unromantic occupations of backyard horticulture and sod farming. In this synthesis, Duke drew on his experience in combining chemicals to nurture healthy, verdant expanses of grass. Because he didn't like big companies—and because he was sure he was smarter than they were—Duke devised a service that provided an alternative to bagged, premixed products sold by big lawn food suppliers such as O.M. Scott and Ortho.

Duke also advanced a fairly new concept in the application of fertilizer. Applying liquid fertilizer had become common agricultural practice by the 1960s; the Dukes had found it a very efficient way to get a uniform application on their tracts of sod. At the same time, Dick had gradually developed a small clientele for whom he applied fertilizer. For a long time he used the old method, running a cart of dry fertilizer across the lawn. Eventually, Dick joined the speed and efficiency of liquid application on the farm to the same practice on people's lawns. After that, developing equipment such as tanks, spray nozzles, and chemical-resistant hoses represented a relatively small technological obstacle for Duke and Grapner.

An even more important element was Duke's realization that the market for this service was ripe and eager. By the mid-1960s, the post-World War II housing boom was settling down. The tracts of houses that had burgeoned across America were inhabited by affluent, middle-class families with a growing awareness of their image in the neighborhood. To some extent, the quality of construction in the average ranch-style home was less important to the householder than how the house looked to passersby. "Curb appeal" had come into its own, and Dick Duke had watched this market develop in Troy.

Since the Duke Garden Center's beginnings, customers had complained about uneven fertilizer application. Should they put it down just before it rains, just after, or when? How much did the average lawn need? When, what time of year? How many times a year? Faced with questions like these and possessed by an urge to help out, to do more, and to see the company grow, Duke eventually offered to do the job for them—to sell the fertilizer and then spread it for an extra dollar a bag. The next step was to realize that by buying the ingredients of commercial lawn food, mixing them himself, and applying the mixture for the customer, he could earn as much as he did by selling the premixed, marked-up, brand-name material.

Duke combined this extra effort with the homeowners' desire to compete with their neighbors and arrived at a service that answered a deep and persistent need. People weren't spending any more money, they didn't have to do any work, and suddenly they had the best-looking yard on the block. The neighbors could eat their hearts out!

The Essential Personal Touch

ChemLawn is a marvelous example of the successful exploitation of the competitive nature of the American suburbanite, but there was always more than that to the ChemLawn idea. The real product of a service industry is not so much what emerges at the end of the line, but rather the intangible feeling of care and concern. More important than its green grass, ChemLawn took good care of people—the same sort of care that had kept customers of the Duke Garden Center lingering at the counter after they had already paid for their fertilizer. Judging ChemLawn only by its product reveals only part of the story; its philosophy, however, reveals something more, a deep emotional response in customers who often feel a little lonely and forgotten by an impersonal society.

ChemLawn was hardly the first company in the lawn-care business. Generations of people like John Wright had scratched out a living in the trade. Huge corporations like O.M. Scott and Ortho continue to thrive, but none has succeeded like ChemLawn. Imitated in a dozen styles in a dozen locales, ChemLawn stands alone. In its formative years, Dick Duke was the irreplaceable ingredient.

Building a Process by Building People

To believers like Grapner, the Duke magic that summoned strength from ordinary people was something best left alone, a felicitous mystery. "I never second-guessed Dick. No matter how close a friend you were, you couldn't know everything that was going on in his mind," Grapner said. "A true entrepreneur is going to get beyond you so fast that you tune out certain parts. You don't dare to get too far out there."

Although he eventually served for a while as president of ChemLawn, Tom Grapner couldn't "get too far out there." In a way, he represents the ability of Dick Duke to build up not a concept or an enterprise, but people. In that building process, ChemLawn's founder could seem brutal.

Opal recalled, "He could really come down hard on a guy. Yet when he got done, the guy never held a grudge. And you'd go right back and work harder than ever for him, because you knew he was fair. He gave Tom Grapner responsibility that he didn't have the capacity to do. He would hit him hard, but yet he would come around again and be very compassionate. And Tom idolized him."

"He was tough but fair," Grapner said. "He would listen to you—even when he was dressing you down, he never left you feeling smaller. He might totally take you to the bone, but he would build you up."

The part of his personality that Duke harnessed to create ChemLawn filled people with boundless enthusiasm. He instantly and forcefully conveyed powerful self-confidence. Opal said, however, that it was a quality reserved for presenting to the world, that it existed "in business, not in his personal life."

Opal's portrait of her husband is that of a man driven—but not always by bright forces such as confidence, optimism, and the entrepreneurial spirit. In private he was a moody, often intimidating man who sometimes made his family walk on eggs until they could figure out his frame of mind. "The girls and I would get along fine when he'd be gone a week, but when he'd come back we'd all be [tense]," said Opal. "You just never knew what that mood was going to be."

There were times when Duke seemed to disappear from the face of the earth. Even when ChemLawn was facing the daily crises of starting up and dealing with growth that was doubling, tripling, quadrupling annually, often it had to face these crises without any counsel from its founder, chairman, and chief executive officer. Grapner said that Duke's disappearances were a strategy to force his subordinates to stand on their own two feet. Some thought Duke's mercurial wanderings were a master plan to decentralize the company and delegate responsibility to the branch managers, but the fact is that Duke was impulsive. Many times, instead of delegating responsibility, he was out in the field, interrogating lawn-care specialists and then grilling their branch managers about workers' complaints. Duke tended to trust the word of workers over that of management. It didn't matter to him if the branch manager had just been promoted, on Duke's recommendation, from the rank-and-file a month or two before. In Duke's eyes, people changed when they became management, and it was not a change for the better.

Jack Van Fossen, whom Duke chose to succeed himself as the leader of ChemLawn, said, "The last thing he would put up with was somebody abusing those he called 'the real people of the company,' the lawn-care specialists. For him, the customer came right after the people in the company. In some respects, he didn't consider management to be people."

The quality that typified Dick Duke was his faith in the integrity of working people, which only grew stronger as he grew older. For this reason, he placed enthusiastic trust in people as initially unpromising as Grapner, Wright, and Lyons. When he saw the need to hire an executive to administer a company bursting at its seams, he chose Van Fossen, who possessed all the tools but none of the pretensions of an MBA. And this is the reason, years later, Duke's company still conveys an air of simplicity, fellowship, and common purpose—a dedication to employee and customer welfare that almost suggests the zeal of a religious community.

"It's been our credo," explained Paul Duke, "if you take care of your people and then you take care of the customers, nothing's going to happen to the business but good." There is no clearer definition of an excellent service company. Paul left one thing out of his formula, however. As the family elder, he often had voiced this philosophy, but he had not put it into practice in business yet. The missing ingredient was a burning desire, Dick's desire, to apply this creed in business and prove that it could work.

A Poor Person in a Small Town

Before ChemLawn, the idea of either Paul or Dick Duke starting up any sort of going concern was not merely unlikely, it was actually silly. The consensus around Troy was that the Dukes wouldn't amount to much; they were good people and you could count on them to do a good job, but that's all. In a small town like Troy, a person's reputation is generally established fairly early in life.

Dick Duke's reputation was embodied in the garden center,, in his history, and in his debts. "It was hand-to-mouth," said Opal. "That's the way we lived for quite a while. No salaries, but nobody ever lost a penny on us. The milkman would wait, and the grocery man would wait, and when the season came in, we would pay all that back. They knew us."

Small-town poverty haunted Duke. Even after Chem-Lawn had passed a million dollars in revenue and was nearing ten million, Duke's fortune could not transcend his image. One reason that the ChemLawn headquarters is in Columbus is that Duke could not convince a contractor in Troy that he could afford to put up a building. Duke had been tied to the garden center since 1949, the year he dropped out of college. The store provided a living for the family, but it put no money in the bank. Outside the gardening season, things were tight. Christmas tree sales barely provided income into January. With the expansion into sod farming, the work got harder but the money did not increase. Dick tried to open a branch store, but that failed and almost wiped out the rest of the business.

The Dukes' hard business experience left them with crucial lessons. Dick Duke, for instance, learned to hate banks. After fifteen years in the same business in the same town, Duke went to a banker he had trusted for years and asked him for a loan extension on the store until the weather improved and business got rolling. The banker turned him down, not very diplomatically.

"The day he was turned down for a loan, he said he rode around for two hours. He didn't know whether to go down to the bridge and jump in the Miami River, or what to do," recalled Opal. "He had hit rock bottom. But he thought, 'Well, by God, I'll show 'em.' " This was the sort of thing Duke said frequently; it was part of his reputation. Even though he had never ceased to consider himself a creative entrepreneur, among the businessmen of Troy he was more commonly regarded as a big talker, the guy down at the garden shop with lots of dreams but nothing to back them.

Having a reputation as a blowhard is fairly commonplace among entrepreneurs; it is easily overcome if and when the entrepreneur can back up his claims. Duke had no money, however, and the entrepreneur who walks into banks with a chip on his shoulder usually can look forward to a brief business history. Duke reversed that experience and made it work to his advantage. His distrust of banks forced him to think of ways to manage without them.

Van Fossen described the company's first major effort at capitalization. A young banker unaware of Duke's hostility to banks dropped by the ChemLawn offices, where people were working almost around the clock to keep pace with demand. Van Fossen said, "He asked Dick, 'Anything I can do for you?' Dick said, 'Yeah, how much money you got?' The banker looked at the financial statements and said, 'We're sorry, but if you'll put $150,000 in capital into this business, then we'll match it with a $150,000 line of credit.' Well, Dick didn't have $150,000 in capital, so he just decided to sell some stock. He put together an intrastate offering circular and sold the stock door-to-door to customers and employees of the company. They oversubscribed the issue and raised $150,000; he said to the bank, 'We don't need your line of credit. We'll be back next year.' That basically established the borrowing relationship for the company. Except for stock sold to employees under option plans, that was the only outside equity put into the company until 1981." For most entrepreneurs, succeeding without banks would be very satisfying; for Dick Duke, it was revenge.

While Duke hated banks, he also believed that most people were basically good and trustworthy. He eventually gambled his future on that belief and, in doing so, instilled in his company the bond that a good service company must share with its customers.

Opal explained the evolution of that principle. "If Dick took a day off, he wouldn't let anybody see him. He wouldn't answer the door. He would just go away." But every day that Dick escaped, the garden center didn't do any business. "Finally he said, 'Just take what you want, and you can pay me later.' The same way with our Christmas trees. We used to rent a spot there at the fairgrounds. Dick tried sleeping in the car so people wouldn't steal our trees. It was very cold; the temperature that year went to eighteen below zero. Finally, he just decided well, if they steal, they steal. And it was funny. People would take a tree and leave a note, and then look him up later and pay. We were just amazed at the honesty of people."

What had begun as a matter of self-preservation became a matter of conviction. Dick Duke challenged people to cheat him. For all his apparent toughness, he put himself in a position from which he could not retaliate. This ingenuous, practical trust accomplished an unplanned purpose, instilling a reciprocal feeling in customers. As a matter of principle, Duke expected people to follow their best instincts.

This attitude puzzled Van Fossen when he started out as ChemLawn's corporate attorney. Duke insisted that he had no need for contracts. "The customer and I agree that I'm going to do the job, and if I don't do it he can cancel me," Duke maintained. "A contract isn't going to make any difference. Why do I need a contract if a customer who's not satisfied can quit?" Van Fossen countered that a contract would allow Duke to sue; without that, how could he be sure of being paid? "Ninety-nine point nine percent of the people will pay their bill," Duke answered. "That other percentage—there's nothing you can do about them anyway. Those people we just don't service anymore. Most customers you can trust."

ChemLawn and Federal Express

The experience of Duke before forming the ChemLawn corporation resembled that of Frederick W. Smith before his initial efforts to create Federal Express. Both men developed and refined the dominant ethic of their companies in times of personal crisis, literally in survival mode. Duke in more than fifteen years of marginal existence in business, Smith in three years as a combat officer in Vietnam, both men were forced to place their lives and livelihoods in the hands of people who just happened to be around them. As in a corporate organization, these were not people selected to serve in support roles commensurate with their qualifications. Both men had to depend absolutely on a totally random group. For Duke, these were customers, salesmen, acquaintances, creditors, farmers. For Smith, they were draftees, noncommissioned officers, pilots, medics, peasants, and enemies. Both men brought to these experiences an implicit faith in people. Dependability was the test, and both Duke and Smith concluded that the least complicated people were the most reliable. Both men emerged from the darkest personal episodes not with a negative outlook based on the worst in people but with a greater faith in ordinary people.

Both men built organizations that were incredibly nonselective in their choice of employees. In a way, both men—perhaps at the expense of their immediate families and friends (certainly this was true for Duke)—used their companies to demonstrate a completely noncommercial principle in which they both believed passionately: The majority of people are diligent, resourceful, and trustworthy. Duke and Smith believed that leadership begins with trust and that the common response to that is tireless effort and intense loyalty. Neither Duke nor Smith discovered this in abstract; they had both done their time in the trenches.

While Smith's ordeal was more dangerous, Duke's could very well have lasted a lifetime. Throughout the 1950s and 1960s, there was no visible evidence that the Duke family would ever manage to venture far from where they had begun. Almost two decades passed with no indication that Dick Duke had a single worthwhile idea in his head. For every inspiration, there was hesitation. His desk was full of diagrams and plans that "need only $500 of capital." Even when he had the $500, he would think twice, think again, and soon the money would be spent and the latest plan would be at the back of the drawer.

Necessary Chemistry

Dreamy and restless, Duke would spend hours sketching ads and diagrams for new lawn-care equipment. Sometimes he drove in his truck to hide at the nearby airport, where he would sit and watch the planes going out, leaving Ohio and all of its struggles behind. Of all possible times, 1968 was the least likely year for Duke to give birth to an empire. In that year his branch store was failing and steadily leading the Duke family toward bankruptcy; still he hesitated to give it up, because that would further prove to his neighbors that Dick Duke was a legend only in his own mind.

By 1968, however, all the pieces of the ChemLawn corporation had come together. With Grapner's help, Duke had devised methods and equipment to deliver lawn food in solution. Duke had become a master of the psychology of his customers, and he had developed a clientele of 400 households. The economics of a potential lawn-care business became not just a concept but an obsession. He talked to people about it all the time.

Oddly enough, Duke had envisioned this business and described it to people as early as 1964, but he didn't follow it through. After countless hat-in-hand trips to the bank, after years of developing a lawn-care concept and the basic technology to make it work, Dick Duke, now almost forty years old, still hesitated. Like Hamlet "sicklied o'er with the pale cast of thought," Duke clung to his dying businesses. Opal pressed him to close the branch before it drained away all their money. Swallowing his pride, Duke finally did so.

"Sometimes when you're a husband and you're out making a living, maybe your living isn't successful and you don't want to fail in the eyes of your family," Opal explained. "And it was just like he needed the support of his family."

Opal recalled a man who went to work for the Dukes in 1968 and listened every day on the sod truck to Dick talking ceaselessly about the great potential for the liquid application lawn-care business. "And this guy said, 'Well, if you really love the idea, why don't you do it?' So we really started talking about it. We had all the marketing ideas, and Dick came up with the brochure and the logo."

From that moment of commitment, ChemLawn grew from what John Wright described as "the available resources." Besides Dick's ideas, one of those resources was a one-man sales force—Paul Duke—who was uniquely suited to the marketplace. His contribution was as elusive as it was essential.

Paul Duke seems to be a man who would have been satisfied to have lived, made friends, paid his bills, and worked until the day he died. Yet at what would be beyond retirement age for most people, Paul went out and hit the neighborhoods as the ChemLawn company salesman. His salesmanship appeared to lack polish, making it perfect for Dayton, Ohio. Paul Duke is a kitchen-table, back-fence, driveway conversationalist, the kind who'll get you through a morning's leaf raking because he'll delay you for forty-five minutes between the front yard and the back.

The Thing Just Mushroomed

For all that easygoing simplicity, it should be remembered that ChemLawn had only about half a summer to turn its capital into enough revenue to support three families through the long Ohio winter. To succeed—to survive—they decided that they had to expand their range. "The fact that Dick and Tom agreed wholeheartedly on the idea of branching out sold me as much as anything else," said Paul. "The [first] five hundred customers were within a ten-mile range of here. We branched out immediately, into some of the better neighborhoods in Dayton, and came up with a brochure that we distributed ahead of time. And we got responses to it. We picked the exact right time to get into this thing. I went out and sold to beat the devil. I had a good time and put in hours you wouldn't believe—since so many people had to work during the day, I had to make evening calls. The boys then would follow up with the spraying, and inevitably they picked up customers while they were out doing that. A neighbor would say, 'Hey, do you want to do my lawn while you're here?' The thing just mushroomed."

Several things dramatically facilitated that mushroom effect. One was Dick's decision to hire Bill Copeland, who turned out to be a talented financial manager. Copeland's skill combined nicely with Duke's own budgeting abilities, which were as disciplined as his office hours were irregular. ChemLawn became a model of a small company that understood the value of growing as fast as possible, and it grew as close to the brink of its potential as Duke dared to go, which was always further than Copeland would have gone.

Still the foremost reason for the steady growth of ChemLawn was the independence and commitment of the lawn-care specialists. They were expected to get to know their customers, to listen to their problems, and to do something about them: They wouldn't stop working until the customer was satisfied. A specialist who did something wrong corrected it, replaced it, paid for it, or refunded the customer's money. Each was expected to be his own salesperson, expanding his customer base while he served his existing customers. He delivered and billed for the service, maintained his truck, mixed his own chemicals, scheduled and ran his own route every day. He was expected to prescribe for lawn problems on the spot or find someone who could, and to be a public relations expert as well—to keep himself professional in his behavior and appearance all the time.

The lawn-care specialist was rarely watched closely, because he was always alone and on the move. Established lawn food companies like O.M. Scott had always hesitated to enter the service business because they could think of no way to control all those truck drivers. Dick Duke's approach was unfathomable to them: He never tried to control anybody.

The responsibility, loyalty, and energy of the lawn-care specialists can't be emphasized enough. They made Duke's aspirations their own and never challenged the reasoning that he used to justify all their hard work. If anything characterized the first two years of ChemLawn's existence, it was a prevalence of people like Lyons who "never asked a question." They didn't inquire what anyone else thought about the prospects for the business. They didn't even reflect on why, or whether, anybody would allow strangers to spray chemicals on their property while no one was home.

Van Fossen described the way ChemLawn estimated the potential market. "You look around and see whether people are taking care of their lawns. If people had attractive lawns, that indicated that they had the interest. We figured we had a market. That was our sophisticated market research."

Very early it became bad form to ask, "What's in it for me?" Wright recalled an early planning meeting that was held because it was raining and no one could spray outside. "We discussed our growth plan, which was to go as far and fast as we possibly could and keep this thing glued together," he said. "Then we covered our benefits plan. Dick made it clear that we couldn't afford one. So the benefits plan was going to be that if anything happened to any of us, the rest of us would take care of the wives and families. Everybody said okay."

Southbound and Moving Up

By 1970 the ChemLawn growth curve had begun its steep upward progress. Even though the company was only in its second full year of operation, the Dukes had breathing room for the first time in their lives. ChemLawn was making strides toward becoming a structured corporation, but could Duke transform himself from entrepreneurial free spirit to manager? What he did next seemed to reveal the answer.

Duke disappeared with his family on a pilgrimage across the southern United States; when it was over, he announced that they were moving to Lake Lanier, Georgia. Dick thought of moving the whole ChemLawn headquarters to Atlanta, but was dissuaded by his father. It appeared, however, that ChemLawn had gotten too big and Duke had lost interest.

There wasn't a soul at the home office who knew how to run a corporation. For that matter, nobody really knew if Dick could do it, but he was the one most willing to try. No one could figure out how or why he was going to run it from a lake in Georgia.

"Dick Duke," suggested Copeland, "was a true Confederate. He hated the North and everything to do with it—particularly the snow." A strange explanation! A man struggles for twenty years, finally founds a promising business, and then throws it all into jeopardy because he doesn't like the weather.

There are at least two more logical explanations for Duke's swift exodus. The Dukes could finally afford to flee a town that held little for them but the reminders of their years of struggle and humiliation. Also, moving to Georgia actually made it easier for Duke to manage ChemLawn. If he had stayed in Ohio, he would have had to show up at the office every day at the same time, sit in the same place, say good morning to the same people. For him, that sort of routine would have been intolerable. "Dick didn't want to be president because he didn't like to go to work day in and day out," said Opal. "He worked better if he was on his own, and worked 'til two o'clock in the morning one day, or sitting on the beach. He could not stand to keep regular hours."

The mobility and unpredictability that had characterized his career before ChemLawn continued in his next incarnation. Duke had lost none of his passion for the people in his organization, and he started to make frequent flights between Atlanta and Columbus. After he moved, he proposed buying a bankrupt marina and converting it into a free vacation resort for the use of ChemLawn employees. Copeland, Grapner, and a few others spent about ten minutes reviewing the operating expenses of the marina and hurried to Lake Lanier to talk Dick out of the purchase. Not much later, Duke found a lovely little motel and beach in Florida. "How about buying this as an employee resort?" he asked his management team. Again, they talked him out of the idea. Duke did buy a luxury houseboat for vacationing ChemLawn employees, and when a number of lawn-care specialists won a sales contest, Duke chartered a Boeing 727 and flew them all to Washington, D.C., for a party.

Copeland, who enjoyed giving in to Duke's impulses more than he enjoyed talking him out of them, loved that idea. "I was writing the checks at that time, and I wasn't sure whether I was going to be able to cover it. But that one impulsive act was worth it," said Copeland. "The enthusiasm that he created was incredible. Most of those people had never been on a plane before. You should have seen their faces."

"He never gave a thought to how much it was costing him," said Van Fossen. "He always figured he'd get it back."

Had Duke's enthusiasm for his rapidly enlarging company genuinely waned, he had a golden opportunity to step away from it as a rich man. In 1971 several companies offered to absorb the fledgling lawn-care company at a price that would have returned him about $175 for every dollar he had originally invested. "He just had no concept of doing that," said Van Fossen. "He thought he could be a force in making this company grow a lot more. And besides, he didn't like those big company bastards."

Management by Bombshell

As a manager, Dick Duke surrendered a great deal of responsibility very early in the company's life, but he scrupulously oversaw the annual budget process and tirelessly monitored the morale of his work force. Everything he did reflected his sensitivity to working people. With a few tempestuous exceptions, he successfully scouted administrative talent, bringing in very good people to assume the white-collar duties he found distasteful. He demanded from these people an unqualified respect for "the real people of the company." And he operated on what Wright calls *management by bombshell.* When complacency threatened to take over the executive offices, a memorandum like the 1971 message excerpted here would arrive from Lake Lanier.

That memorandum began as an orderly presentation of a number of pressing management issues, then mounted into a polemic. Up to that point, Duke's dissertation progressed coherently without the use of an exclamation point; the remainder of the memo contains twenty-six exclamation points, usually in combinations of three.

> It is the responsibility of every man receiving this letter to recognize a problem promptly and openly! Next, it is equally important to analyze the problem—to find the cause, to the best of your, or our, ability. We solve nothing and we satisfy no one by waiting, by deferring action, by hesitating until we can arrive at a consensus. There are times when a consensus of one is the best consensus—even though it gets lonely for that one man. Then, after analysis, it's time to act!!! Do something!!! Call

> somebody!!! But stop this incessant stalling and buckpassing!!! If it's a problem today, take some action today!!!

Balancing bombast with guilt in a sort of instinctive rhythm, Duke continued:

> There's a lot of privilege and reward involved with being an officer or key manager in this company—but there's also a high degree of responsibility involved. Up to this point, I've heard a lot of discussion concerning the delegation of authority—but I've seen little willingness to accept responsibility in such a manner and to such a degree that authority comes naturally.

Duke expected everyone in the company to want to be in charge as much as he did. He assumed that hunger for leadership was part of everyone's makeup. Duke was disappointed when he realized that some people are satisfied with lower positions. When he told his employees that every person has the ability to "reach for the sun," he truly believed it and made them believe it.

Dick Duke died suddenly of a heart attack in 1977 at the age of forty-eight. For people who had grown personally dependent on Duke's leadership, his death was a terrible blow. Many were uncertain that they could cope with this loss and go on. For Duke's company, crisis seemed inevitable.

"When Dick died, for the immediate time afterward, I felt I was totally leaderless," said Lyons. "All of a sudden, this light goes out and you say, 'What the hell happened?'"

The predicted management crisis never materialized. Duke had instilled in his company's leaders an enormous measure of self-sufficiency and business savvy. Despite their initial fears, ChemLawn's management had learned how to get along without Dick Duke long before he died.

Keep Taking Care of People

There is a temptation to characterize ChemLawn's breakthrough as self-expression via entrepreneurialism because there is so much of Duke in the company, even today. One can also explain ChemLawn as the brainchild of a creative artist, but Dick Duke's creative talents remain articulated today by those who loved him deeply. Those who shared the birth of ChemLawn retain the sense of personal responsibility that first Duke and then his successors to company leadership felt for the well-being of the employees. In a 1976 promotional tape, Duke said: "If you will concern yourselves with improving the people with whom you work, if you'll be concerned about their welfare, their benefits, their advancement, to the almost total exclusion of your own, you'll almost inevitably advance."

Though this reads like a hackneyed rewrite of the Golden Rule, designed to keep employees in line and unions at bay, Duke held to his childlike ideal of trust. He believed that one could make a living, a business—maybe even a big business—out of taking care of people; but the only way it would work would be to take care of everybody (employees and customers) with tireless and unambiguous devotion. You had to be good to people, and *mean it*—not simply say it.

"Dick said these things, and he sounded like a goddamn hick who wouldn't last ten minutes in business," said Wright. "But he meant every word. And that's why it worked." Duke knew also that the only way to keep it working—even if it got bigger than he ever imagined—was to keep taking care and never give more attention to the business than to the people. At a celebration to mark the official launch of ChemLawn as a corporation, Duke said, "My God, what have we done? Where are we? We've got five families." "He took that responsibility very seriously," said Opal.

Paul Duke repeated an almost identical theme: "One of us would say, 'Hey, do you know that we're responsible for the welfare of hundreds of people on the payroll right now?' Now it's something over five thousand. To be responsible and concerned with the welfare of that many families, how much more satisfaction could you have in this world?"

For Dick Duke, creating ChemLawn was more than an act of free enterprise: It was parenthood. This helps to explain why his people so readily forgave his tendency to manage by bombshell. Again, from the 1971 memorandum:

> Finally, I want to make this point: For the balance of this year and continuing through 1972, we're going to supply this company with the hard-hitting, decisive, and positive leadership it deserves. That doesn't mean that we will stop being concerned about people or that we will abandon the philosophy and motives that we have held. It simply means that we will do whatever needs to be done—and that we are not going to be concerned about hurt feelings or tender toes, especially among this management group. I've already been accused, probably by one of you, of blowing .... smoke up some asses. Well, let me assure you that I'm prepared to do a lot more of that, if necessary, to keep this company moving.

Beneath Duke's apparent petulance and his roar, there was love. His patriarchal influence held sway in the days of the company's critical growth. Opal remembered, "I've seen business meetings where the officers would all be going at each other. He wouldn't say a word. Finally, after this had gone on for a couple of hours, he would just make a statement: 'This is the way I see it.' And everything would stop. He would really listen and think and then come out with a decision—the course we'll take. He had a lot of charisma."

"I've tried to discern how much of my values and priorities, particularly in regard to people, was there all along, and how much developed as a result of Dick Duke and ChemLawn," explained John Wright. "I feel reasonably sure that the desire to believe was there. It was inherent to my growing up; it was instilled in me. Dick is the guy who lit the match. We all want to believe in people—we want to believe that good overcomes evil, and all those lofty things that we're taught. Dick was the guy who made that happen. I remember one guy who came into the organization in the mid-1970s. He was a three-piece suiter when those guys weren't too common around our offices, and therefore they got a lot of attention. He was particularly interested in how this organization could expand the way it was expanding. And we told him, 'You decide what city you're going to open up. You call the guy you want to open it. You tell him to get a Ryder truck and be there Monday morning.' His point of view was, 'No, you can't do that, you have to plan this. You have to do market research.' This guy's conclusion, after talking to eight or ten of us, was that this wasn't a company. This was actually a religion. That was not the way you manage a business; that was they way you had religion."

Whether this unworldly air will prevail at ChemLawn into the next century is impossible to predict. If ChemLawn loses its still-thriving belief in people as its most important asset, however, it will have lost touch with its breakthrough. "It's the people difference that makes us what we are," Lyons said. "Every company that's tried to copy us is not even close to success or our size, because their philosophy is very different from ours. Unless that core is built or started by someone as dynamic as Dick, you can't buy it, you can't rent it, you can't copy it."

It might not be quite so simple. Certainly, the values that Dick Duke instilled in the company were a remarkable source of solidarity—family—that made the work easier to bear and made the vision seem possible. In his unembarrassed style of promotional overstatement, Duke called it "reaching for the sun." All the cherished values, though, would have been little more than personal convictions if he had not had that simple but crucial idea of mixing water with fertilizer and hauling it around on the back of a truck.

Even that idea might have lingered unpursued in Duke's mind if, like his father, he had been more content with his life in the hamlet of Troy. If Dick Duke hadn't wanted a ride out of Troy, he wouldn't have needed a ChemLawn truck.

5

TAGAMET: INSTEAD OF SURGERY

In 1963, when Dr. Edward Paget hired a former colleague, Dr. James Black, to take over the position as chief of pharmacology at the Welwyn Research Institute (WRI) in Welwyn Garden City, England, he quietly set in motion a fourteen-year research effort that eventually would bring to market the most successful prescription drug in history. The drug, which was developed at WRI for Smith Kline & French laboratories (SK&F), a Philadelphia-based pharmaceutical firm, is called Tagamet, and it changed forever the way patients and doctors cope with stomach distress. Tagamet heals ulcers quickly, simply, and painlessly. It became the first billion-dollar drug in pharmaceutical history, and it changed SK&F from what one source called "the senior citizen of the drug business" into a diversified international giant with the world's most modern pharmaceutical research and development facilities.

The idea for what eventually became Tagamet stirred for years in James Black's mind. In all likelihood, Tagamet never would have appeared if Black had not conceived and fought for it and if Paget had not given him a laboratory, a free hand to finance a research team, and a defender named Dr. William Duncan. All three men had left Imperial Chemical Industries (ICI) in Manchester, England, one of the world's great chemical and drug companies, for jobs at WRI.

For Paget, becoming managing director of WRI was an advancement, even if it meant going to work for a less than stellar company. In those days, Smith Kline & French (later to become SmithKline Beecham), the parent company of WRI, was widely regarded as an also-ran among the world's pharmaceutical companies. Part of the reason Paget had been brought to WRI was to upgrade the company's research reputation. By hiring Black, Paget instantly succeeded. Although Paget might have been expected to do a little discreet raiding of talent from his old firm, getting Black to come over was the unlikeliest of thefts. Black was one of ICI's stars. Only recently, Black had made pharmaceutical history by synthesizing drugs called *beta blockers.* To do this he created "false messengers" to infiltrate the messenger/receptor mechanism in human cells that triggers the release of adrenaline, thus calming the hearts of patients with high blood pressure. Beta blockers were not just a new drug; they represented a new class of drug and a revolutionary approach to pharmaceutical research. In the world of prescription drug development, Black was a celebrity. Bringing him to a research facility as insignificant as Welwyn marked a real coup.

Paget had two trump cards: his mandate to reorganize Welwyn's entire research organization and James Black's restlessness. Black had told the leadership of ICI that beta blockers were just the first in a series of potential discoveries that involved not merely finding new drugs in the conventional hunt-and-peck style of pharmaceutical research, but actually designing drugs according to a specific goal.

Gathering the Right People

What Black was proposing was revolutionary. It was against all odds. Major scientific breakthroughs are usually a once-in-a-lifetime event; with beta blockers, Black had used up his quota. He had earned the chance to administer research rather than continue to get his hands dirty doing it. However, neither Black nor his colleagues in beta blocker research were interested in taking a breather.

Commenting years later, Paget said, "We had just come through a most exciting period. We had all gotten quite wrapped up in it. But the great creative urge that we had shared—the enormous fun we had—was dying away."

Black, in fact, did not share many interests with ICI—or with most pharmaceutical companies. The company was interested in making drugs; Black was interested in proving a theory. The best way for him to prove his concept was to make drugs, but this remained simply the commercial justification that supported his greater goal. Black's complete loyalty was to his concept; if another company was more willing to support his conceptual pursuit, Black would leave ICI in a minute.

As a follow-up to beta blockers, Black proposed to develop something he called *H_2 antagonist* drugs, which would virtually wipe out most peptic ulcers by penetrating to their source. ICI told him no, and Black did not hesitate: He took Paget's offer to move.

Suddenly Welwyn was a different place. Until Paget's advent, WRI had consisted of a contented little group of Britons working frugally in their labs in the tranquil isolation of Hertfordshire. Suddenly Black was on the scene, assembling his H2 team with virtually no regard for existing practices and seniority. Duncan, who quickly followed Black to WRI, was accustomed to Black's aggressive manner; he knew, however, that people at Welwyn would need some, help in adjusting. From the moment he arrived, Duncan softened the impact of Black's personality on both the corporation far removed and on the small group at hand.

Nevertheless there were bruised egos and hurt feelings. Black drafted a number of his former colleagues into his new team, and he pointedly excluded several people regarded as stars at WRI—among them a chemist named Dr. Robin Ganellin, who nearly resigned when he was not invited to join the research group. Had he not been welcomed into the fold a little later, the Tagamet breakthrough might have been crucially delayed or even killed.

"Black had difficulty finding the right people to work with," said Ganellin. *"A* lot of senior people left because they couldn't understand what he was after. He's a very vexing man; he wants you to work in a particular way, and he always makes quick judgments."

The Philadelphia Story

Meanwhile, in Philadelphia, all this activity was viewed with approval. After years of dormancy, SK&F had a world-renowned scientist, and he obviously was making things happen in Welwyn. Actually, Paget and Duncan made certain that Philadelphia knew relatively little about Black's research plans. Philadelphia knew, for instance, that Black would be seeking a drug to inhibit the excess flow of gastric acid in the human gastrointestinal (GI) tract, a problem that causes ulcers. This was not the most promising line of research in terms of potential profits; the annual drug market for antiulcer compounds, mostly antacids, was only about $100 million. But SK&F was committed to the research; its main laboratories in Pennsylvania were seeking antisecretory agents, chemicals to reduce the excess acid that eats holes in people's stomachs.

What Welwyn did not tell Philadelphia was that Black's research was not antisecretory. Rather than trying to find something, Black believed he could create something, a compound that could change the chemistry of the GI tract. Had SK&F known what Black wanted to do, they probably would have followed ICI's example and told him to stop. No one in the practical business of pharmaceuticals could trust Black's renegade assumptions, but to people in the laboratory, they had irresistible appeal—especially as Black described them. Vexing in some ways, Black was hypnotic when he talked about science. Paget saw in Black's ideas an aesthetic quality that engaged the senses as well as the mind.

"The essence of it all is scientific taste," said Paget. "One can feel about science the way an artist feels about a painting or a musician feels about a piece of music. That's the way most of us felt about those days at the Research Institute."

Perhaps most appealing to corporate leadership was Black's speed. The main SK&F laboratories could not say when they would find an antiulcer compound and get it into development. In the summer of 1964, Black reported confidently to headquarters that he could present them an H_2 compound by Christmas. He wasn't kidding. His vision of the compound was clear, and his optimism was infectious.

Histamine and Antihistamine

Because he was such a convincing mentor, people believed Black was on the brink of a breakthrough despite data that said he was wrong. Black's colleagues knew that similar theories in the past had not proved valid. Three Swedish scientists, for example, had theorized the existence of a second receptor for histamine, a common chemical present in the human body. (Histamine's most apparent function is to trigger the flow of mucus in the sinuses. The most dramatic symptom of too much histamine is the stuffed-up nose.) Experiments seeking a different kind of histamine receptor in the GI tract to trigger the flow of gastric acid had proved to the satisfaction of most that you could not stop gastric acid by stopping histamine.

Black disagreed. He felt that the idea had not been explored sufficiently. Black hoped to find a way to interfere with the messenger/receptor mechanism between histamine and the cells that release acid into the stomach. He believed that the GI tract operated in the same way as the sinuses, where histamine carries a message to release mucus, which coats the passages of the sinuses, nose, and throat and protects them from drying out. These messages are conveyed to the cells only through the receptor sites located on the cells. Molecules of histamine enter the receptors and open the cell to the flow of mucus. When an imbalance in the chemistry of the body unnecessarily increases the level of histamine in the sinuses, however, suddenly all the cell receptors are flooded with histamine, mucus pours forth, and the host is afflicted with congestion. Enter antihistamine.

Antihistamine is an engineered chemical compound invented in a laboratory to look like histamine. It is the same size, the same shape, and almost exactly the same composition. It fits into the receptor site but cannot open the cell. So when antihistamine is added to the sinuses' messenger/receptor mucus system, it competes for receptor sites with the real histamine. Histamine wins some; antihistamine wins some. As a result, the body still gets enough mucus, but not too much. Congestion is relieved.

James Black advanced messenger/receptor chemistry significantly when he developed beta blockers. These are false messengers that interfere with the release of adrenaline. An excess of adrenaline can cause something far worse than sinus congestion: heart failure. Black believed that the next logical site for engineering chemical compounds to control messenger/receptor systems was in the GI tract and with histamine.

Black first had to prove that the GI tract operates on a messenger/receptor mechanism. In order to do that, however, he had to show that his putative second sort of histamine was the messenger. And in order to do that, he had to make something to antagonize the second sort of histamine. He could not proceed in gradual stages to unveil proofs of his theory. He had to start with the hardest part—to prevent something from happening that no one really knew was happening at all.

In light of established pharmaceutical procedures, Black's boldest gambit was that he was creating an entirely new direction for research. Until he changed the imagery of drug research with beta blockers, the word that motivated people in the laboratory was the "hunt." The microbe hunter would spot a new microbe in a microscope and then, largely through trial and error, search out a weapon that would kill, or at least affect, it.

Now Black was suggesting that researchers change from hunters to engineers, combining atoms to build novel compounds. The problem with this proposal was one of magnitude. The total number of possible combinations en route to what eventually would become Tagamet was thirty billion. If SK&F in Philadelphia was willing to support Black's research for four years, Black and his handful of researchers could synthesize several hundred of these possibilities. To explore all possible combinations in only four years would have required the efforts of eighteen million scientists.

Given these odds, it was very important to Black's research that his distant parent organization did not really understand what he was doing. In a major internal reorganization not long after the H_2 search began, Paget chose Duncan over Black as deputy director of research, which meant Duncan would run WRI when Paget relocated to Philadelphia. The choice kept Black in the laboratory and elevated Duncan to a position where he could battle against the nervous corporate finance managers.

Managing the Flow of Information

As time passed, it became more and more important that Duncan insert himself into every attempt by Philadelphia to determine how the H_2 project was progressing. Two Christmases came and went after the original deadline, and still SK&F received no word of a breakthrough. The budget for H_2 research, even though it averaged $2.5 million a year from 1964 through 1968, kept shrinking.

One of the major problems as the research rolled forward through some 700 unsuccessful experiments was to sustain optimism. Duncan had to keep people believing both in the goal of the project and in his ability to keep SK&F from giving up on it.

One of the synthetic compounds, for example, turned out to be an antiulcer and antisecretory—just the thing that the Philadelphia group was looking for. Duncan knew, however, that the antisecretory compounds could only be a partial solution. He feared that if Philadelphia knew Welwyn had found one, they might be satisfied and call off any further exploration for an H_2 antagonist. Duncan simply cut Philadelphia off from any knowledge of the discovery. For years after, none of the corporate leaders in the United States knew of the antisecretory agent engineered at Welwyn.

In 1966 three of Black's team—chemists John Emmett and Graham Durant and pharmacologist Michael Parsons—synthesized two compounds that stimulated acid flow at two different receptor sites. They were looking for a compound that did the opposite—inhibited acid flow—but this was still a good sign. Seeing the effect of these compounds strengthened the belief that the GI tract was a messenger/receptor mechanism. "This selectivity of action confirmed that we were on the right track and spurred us to go on," said Duncan.

Still, after two years and millions of dollars, such results were only vague hints of possible success, and they offered precious little encouragement for the corporation. And even when the group in Welwyn made a few halting steps of progress, Duncan didn't send much of the good news to the United States. Husbanding the trickle of resources from Philadelphia, he pushed the H_2 hunt to the top of WPI's agenda, forcing a number of other projects either into limbo or to their death. Duncan and Parsons later said that this maneuver "produced trauma" within the organization. But Duncan had the upper hand as research director—as well as a talent for politics, something lacking in many scientists.

"These were not happy times," Duncan wrote, "although every effort was made to isolate the scientists from the political and financial hardships of a company undergoing a major reorganization and a new-product famine." Still, Duncan and Ganellin, who perceived the political maelstrom that swirled about them, were probably in the minority. Parsons confessed to being oblivious of the whole mess. "There was a kind of tunnel vision," he said.

For his part, Black accepted Duncan's protection and rarely looked up to see what might be going on around his project. He had envisioned an idea, and for ten years his only interest was to prove that his idea was correct. His intensity became infectious.

"The best research is done by people who are really deeply committed to it," explained Paget, "who are passionately interested in the outcome. They'll argue you tooth and nail if you have opposing views. It could be frustrating as hell. Sometimes the chemists would come in and say, 'We cannot work with Black any longer.' And I would laugh. And then we all would go on."

Ganellin said, "Feelings were running very high. There were a lot of differences within the team. Some of them didn't see the value of Black's proposal. He found people he could not get on with. He's an emotional man and he generates emotion. But if you don't have emotion, you probably don't achieve anything."

Eventually, the team for the H_2 antagonist program sifted down to a core of five: pharmacologists Black and Parsons and chemists Ganellin, Durant, and Emmett. Ganellin admitted that they succeeded because they narrowed themselves to an almost fanatical focus. "One gets on this scientific high," he said. "You get wrapped up and believe in what you're doing."

The Same Mistake for Four Years

The value of that obsessive outlook came home to Duncan in a conversation several years later with Dr. Heinz Schild, one of the great pharmacologists of this century. "We were talking about some data," said Duncan, "and he suddenly said, 'It's amazing.' 'Oh, yes,' I said, 'these results surprised me as well.' 'Oh, I didn't mean that,' he said. 'I'm amazed that the H_2 program ever amounted to anything.' "

Schild should have been right. By 1968 the Welwyn team had got nowhere. Only a faint glimmer of hope appeared when Parsons noticed that he had been making the same basic mistake in his tests for four years. This might not have been a significant mistake, but it was worth correcting to see what might happen.

Parsons realized that every time he had tested a compound, he had introduced into the test medium much less histamine than might occur in a real stomach, only 30 to 40 percent of the maximum possible. He did this because that was the way he was supposed to work. He was going by the book, following established procedure that had been laid out by, among others, Dr. Schild. Even Black agreed with this method.

Parsons suddenly realized, though, how blinding the error in this method was. When only 40 percent of the histamine (the agonist) capable of filling every receptor in the system was matched with an equal amount of potential antagonist compound, the receptors received only 80 percent of their capacity. Both agonist and antagonist had lots of room to find receptors without changing the amount of acid that would enter the system. But if Parsons flooded the system with 100 percent of the possible histamine and sent in a possible antagonist to compete, acid levels might change.

This meant that everything he had done before—all 700 compounds—hadn't been given the right test. Another scientist might have been demoralized, but Parsons was enormously encouraged. The first six compounds that Black had theorized four years before as possible H_2 antagonists had possessed a logic that had excited Parsons at the beginning. He had been surprised that none of them had tested positive as an H_2 antagonist. Now, with the right test, they might work. So Parsons went back to the beginning, to the first half-dozen compounds synthesized.

And there it was.

The reaction was weak, but strong enough to prove the theory. The compound that tested positive acted as an H_2 agonist at lower levels and as an antagonist at the maximum level. The important fact was not what the specific reactions were, but that there was a reaction at all. The proof was there; Black had been right in 1964, and he had even proposed the right compounds to synthesize. With Parsons' discovery, things changed dramatically. Duncan informed Philadelphia that Black's theory had been proven correct: The GI tract was unquestionably a site for histamine receptors. This meant there might be a compound, and then a drug, that changed the way the GI tract secretes gastric acid—possibly a drug that didn't just clog up secretion, which was the common way to treat hyperacidity, but one that could make the GI tract behave differently.

Philadelphia's attitude began to change, but only gradually. At first, management remained unenthusiastic. Parsons' discovery was hardly the culmination of the research project. If a drug was going to emerge, it would still mean the creation of a much stronger H_2 antagonist, a stable compound that inhibited gastric acid without halting it. Most important, it must create no other side effects on the human body. The search, after all, required engineering molecules unknown to nature. No one would know this compound's effects until it had been tested on people. The clinical testing procedure would require hundreds of doctors, thousands of patients, and years of use under strict controls. Parsons' discovery of his mistake might have seemed like the end of the road to many people at WRI, but it was barely a beginning for SK&F. **The** company still had ample reason to be pessimistic.

A Company Waiting for a New Drug

In the late 1960s, SK&F was in an advanced stage of recession. Its most successful product, a psychotropic drug called Thorazine (a tranquilizer that calmed even the most violent manifestations of mental illness) was in decline and about to lose its patent protection. No new products were on the immediate horizon, and however hopeful this H_2 project might have seemed, it was no quick cure for the company's troubles. Thomas M. Rauch, president and chief executive officer in those days, recalled, "I was convinced things couldn't get any worse. We were at rock bottom."

That sense of desperation, according to Rauch, gave SK&F "the courage to take risks." But what was there to take a risk on? SK&F's leaders were ready to grasp at straws, but there were barely any straws to grasp.

Among those leaders was Henry Wendt. Today he is chairman of the board of SmithKline Beecham, but in the 1960s Wendt commanded a much less lofty outlook as chief of commercial drug development for SK&F's modest international division. He was one of the first to tell Philadelphia that a new product emerging at WRI might be worth a major investment.

Wendt attended a research and development seminar conducted at Welwyn in 1969 to inform corporate leadership of ongoing projects. Wendt recalled, "I sat next to the medical director of our international division, Dr. David Ovedoff. Suddenly, he grabbed my elbow and said, 'You've got to watch this one! This is the main chance!' I probably didn't understand much else of what was being said, but I certainly understood that." Ovedoff was a confirmed skeptic; Wendt trusted him to look at new ideas with cold-blooded realism. To see Ovedoff excited was unusual and a sign that the H_2 project held great potential.

Wendt carried that excitement back to Philadelphia. He conveyed to Robert Dee, then SK&F's chief operating officer, that H_2 might be the main chance for a big drug in the 1970s. SK&F had not had a big drug since they introduced Thorazine.

The idea that an H_2 antagonist could be as big a drug as Thorazine was odd; the numbers simply did not support it. Market estimates were critical to a decision to invest in an H_2 antagonist, but throughout the early 1970s no one at SK&F could demonstrate that there would be a big market—or even a medium-sized one. Even years later, after SK&F had committed millions to priming the market for Tagamet, there was no solid sense of how much of this product they could sell.

While Philadelphia pondered the mysteries of the market, the H_2 team pieced together a compound. Because of Parsons' critical assay, the group focused on a few promising molecules. The team was close, but they still had nothing more than that one faintly antagonistic compound. The nearness of the goal created an intensity of feeling that was both exhilarating and exhausting. Any slight intrusion created spasms of frustration for the team, and then spurred them on to even longer hours and harder work.

From 1968 to 1970 Black's team synthesized compounds that competed aggressively and selectively with histamine. Philadelphia, eager to get out of the laboratory and start development, pressured them repeatedly to move one of these compounds along for human studies. But the chemists felt that they had not yet found a compound that would be safe in human beings. They kept looking, selling delay to SK&F's uneasy leaders.

In 1969, things looked bleak. Black went to the United States and made an impassioned plea to continue the program. Rauch and Dee were so impressed by his almost religious fervor that they gave him another year.

Burimamide and Metiamide

Black determined finally, in 1970, that a compound called burimamide was pharmacologically clean enough to test in humans. It had some drawbacks, including the fact that it would not be very potent if taken orally, but it was a major step: Burimamide was the first H_2 compound that could legitimately be called a drug. Within minutes of Black's decision, Duncan was contacting hospitals to see if they would be interested in testing it and seeking volunteers within Welwyn to be the first guinea pigs. Ganellin and Duncan himself were the first volunteers in line. When they tested their own stomachs and found a reduction in gastric acid, they shouted with triumph. They were sure their search was over.

When Duncan informed Philadelphia that burimamide had tested positive on himself, Ganellin, and several others, the reaction was restrained. SK&F replied with a memo asking, "Did you check with corporate personnel about the insurance before you did it?"

Duncan's response is unprintable.

Burimamide acted only as a transition. With a year of its discovery, the researchers had synthesized and distributed to every clinician who wanted it a much more promising compound called metiamide. This compound had no discernible side effects and was strong enough to use orally, either as a pill or a liquid. Metiamide was the drug SK&F had been waiting for.

As metiamide emerged, Duncan reversed the secretive style that had shielded the H_2 project. Now it was ready for the world to see. Duncan went out of his way to seize the attention of the scientific and medical communities. In April 1972, the scientific journal *Nature* published a complete description of burimamide, written by Black, Duncan, Durant, et al.

It was highly unusual for a research facility to release information in such meticulous detail while a compound was still in the relatively early stages of development. But Duncan's strategy served two important purposes. First, it gave fair warning to other researchers that SK&F did indeed have a huge head start (and a patent) in a field that most scientists had viewed as a dry hole; second, it piqued the curiosity of clinicians, who began to clamor for samples of burimamide—and then metiamide—to test on ulcer patients. Full disclosure actually proved a most effective premarketing campaign. Moreover, the flood of voluntary clinical tests provided volumes of information for the research team. Sharing prolonged and painstaking test procedures with hundreds of clinicians prevented countless mistakes and hastened the development of Tagamet.

Black, the Absent-Minded Professor

Between 1968 and 1972, the emphasis of research shifted from pharmacology to chemistry, and then even further afield to clinical experimentation and the dynamics of pharmaceutical market development. All of this activity held little allure for James Black. His theory had been proved true, and he was getting restless again. In 1972, even before clinical tests had begun on metiamide, Black was gone. With the Tagamet job literally half-finished, Black accepted the position of professor of pharmacology at University Hospital, King's College, London.

Some felt Black left to attain an intellectual respect to which few industrial researchers in England ever dare aspire. "In the academic world in the U.K. it was almost considered dirty to be working in industry," Douglas said. "It was remarkable for an academic institution of preeminence in histamine pharmacology to call a Jim Black to be a professor. How could he resist that?"

An easy conclusion might be that Black was able to focus now and then on some great vision that might someday bring him fame and glory, but he otherwise remained a bumbling, blustering quixotic fellow—an absent-minded professor.

Rather than being disorderly, however, Black's thinking had been marked by a clarity and orderliness greater than that of anyone else. He knew precisely what he hoped to find and precisely how to recognize it when he found it. He had a certain vision of the unseen that kept a stubborn group in England and an impatient American corporation committed, beyond reason, for four years.

One thing that Black, the lab visionary, rarely ever saw—or cared to see—was the pharmaceuticals market. But as the Welwyn team worked toward the synthesis of burimamide and then the promise of metiamide, SK&F's marketing organization struggled to assess how much they could sell of a genuine antiulcer compound. Every discussion saw a conflict between the vision held by a few and the more realistic probabilities. Again, the vision won out.

While Welwyn was still synthesizing new compounds, SK&F's senior management made a do-or-die commitment to the H_2 project. To some extent, wishful thinking triggered that commitment. The senior executives of the 1970s had been the Thorazine salesmen of the 1950s. They had felt the excitement of selling a drug that improved human lives almost miraculously. They had felt the rare thrill of hearing people clamor for their product; they had seen mental institutions transformed from jails into treatment centers. They had also seen SK&F's disorganized marketing of Thorazine. One of their standard laments was, "We did well with Thorazine, but if we'd been ready, we could have done a lot better."

Eager Salespeople and a Huge Market

Those former salesmen had been waiting and wishing for another main chance like Thorazine. When they started to hear from their researchers that the H_2 compound had a similarly dramatic medical potential, statistical measurements of the market fell short. They wanted a chance to do it again; they wanted to be ready this time.

There was also a hint of desperation. The company's research wing had generated few promising drugs in two decades. Tagamet represented a low risk for SK&F. Even if they poured resources into Tagamet and failed, they would feel vindicated by an all-out effort. If they went down, at least they would go down fighting.

Something else, though, drew the company closer to commitment. When they considered the H_2 project, many at SK&F shared an intuition that there were more people in the world coping with ulcers than medical statistics had revealed. Thomas Collins, head of Tagamet's U.S. marketing effort, recalled gearing up to sell Jim Black's brainchild based on his guess about his own success-driven, hyperacidic friends.

"In my age group," said Collins, "I can remember all sorts of people with ulcers. But they weren't under active treatment. They did whatever they had to. They stopped drinking. They stopped whatever it was that agitated them. But they didn't change the environment at all. So I didn't think anybody knew the size of this market. How many would at last go to their physician and say, T haven't been feeling well. Would this drug help me?' "

Collins couldn't answer that question; neither could anyone else. Gambling on hunches, SK&F decided early on to take the chance. By 1970 they had begun a series of acquisitions and expansions that changed forever the face of the company.

Before Tagamet, SK&F did not own a major, fine chemicals plant. To manufacture enough drug to match the marketing push, the company committed to construct a chemical plant in Cork, Ireland. It represented a major risk—$10 million in 1973, when the company had a total capital investment budget of only $16 million.

Even more significant was that SK&F, notwithstanding a certain fiscal shakiness, was using Tagamet's potential to create something else it lacked—a company-controlled international sales organization. Dee saw Tagamet as a world drug, and a world drug couldn't be sold by a domestic pill company with an inadequate marketing apparatus. SK&F acquired drug companies in Germany and France to expedite swift distribution of its big drug and then signed a joint agreement with Fujisawa Pharmaceutical Company, Ltd., for its distribution in Japan. Eventually the company created a network that would allow a fast distribution of Tagamet, beginning in the United Kingdom in 1976, reaching sixty countries by 1978.

Metiamide Crashes; Enter Cimetidine

While Dee and Philadelphia were opening distribution and sales organizations throughout the world, Welwyn was flooding its own network of hospitals and clinics with samples of metiamide. All this momentum and the tremendous buildup of optimism in SK&F stopped suddenly in 1974, when metiamide crashed.

In June 1974 clinical studies revealed a case of a patient with agranulocytosis (a loss of infection-fighting white blood cells) directly connected with metiamide. One incident might have been overlooked, but this was the second. Agranulocytosis is a rare condition to which only a few patients are susceptible, but the British Committee on Safety in Medicine was extraordinarily swift and harsh in response: It halted all clinical tests with metiamide and abruptly buried it as a potential H_2 antagonist. The next month the CSM reinstated it for limited use on seriously ill patients who showed no sign of reduced blood count. The message to SK&F was clear: If you don't have an H_2 antagonist that avoids this problem, you don't have an H_2 antagonist.

The news went through SK&F like a knife through the heart.

Duncan told Ganellin that work had to stop. "It was as if the ground had opened up." said Ganellin. "Like I was falling down through a rushing hole."

The product manager for Tagamet was in Amsterdam the day of the metiamide crash, attending a meeting in which SK&F's international marketing leaders were building excitement and strategies for the metiamide launch. He recalled, "We got this phone call. They said metiamide had been suspended. After that, we had to walk hand in hand over the bridges because of the fear somebody might jump. Everybody was very depressed."

Although Welwyn had other compounds in the pipeline, most were markedly inferior to metiamide. Only one of them held nearly as much promise as metiamide: the newly synthesized cimetidine. SK&F, whose wishful thinking had been reinforced by millions of dollars in investment, was irreversibly committed to cimetidine—even though they barely knew it existed or if it was any good.

Wendt recalled, "We reviewed proposals to construct the plant to produce metiamide. Cimetidine wasn't up yet, although it was a prospect. We said, 'One of these compounds is going to work. Odds are we're going to be able to make it in this plant. If we don't have the plant, we're going to wish we did. If we have the plant but don't have the compounds, we'll think of something else. We'd better build it.' So we did. And along came cimetidine."

In 1973 Dee had noticed the agranulocytosis problem in laboratory animals and had asked Duncan to look for a compound to back up metiamide. Duncan always had concerns about the presence of something called a "thiourea group" in the compound, so he insisted researchers begin developing one without it. He had added cimetidine to the pipeline just to be on the safe side, even as SK&F was shouting "metiamide" from the rooftops.

To provide some measure of how critical the success of cimetidine was, it should be noted that in the entire decade that followed the synthesis of cimetidine, only one other effective H_2 antagonist was synthesized and approved by anyone, including SK&F. They might not have realized it in 1974, but for SK&F it was cimetidine or nothing.

As soon as the shock had passed from the metiamide failure, SK&F moved aggressively to begin clinical development of cimetidine. However, the first clinical trial came almost too soon.

Dr. William Burland had joined Welwyn shortly before the metiamide crash. In 1974, with the suspension still fresh, a clinician phoned Welwyn demanding cimetidine for a critically ill patient who had developed agranulocytosis in metiamide treatment. "Clearly, if you have the first compound of a new class in the clinic, where it appears to be effective, and its usefulness is suddenly limited by discovery of untoward effects, then any second agent has to be even more intensely scrutinized. A single mistake could result in a decision to kill the whole program," explained Burland. In other words, he would have been crazy to send cimetidine to the doctor, but when the call came in, Burland was in favor of helping the patient. He tracked down Duncan in the United States and received concurring opinion.

The patient's ulcer not only improved, but he got better from his agranulocytosis. In very short order SK&F had some tantalizing evidence that they could make H_2 antagonists that didn't kill white blood cells. Burland admitted that had he not reached Duncan, he probably would have released the medicine anyway, and he would have done so without informing Philadelphia. The risk was that the patient would die, and if he did, the innocent compound (cimetidine) would be indistinguishable from the guilty (metiamide). Both might well be banned forever from human use. Burland decided that, whatever the danger inherent in turning over an untested drug to a doctor with a critically ill patient, there was a corresponding opportunity to find out immediately whether cimetidine possessed the same flaw as metiamide. It was an all-or-nothing step in which corporate headquarters would likely see only the nothing and none of the all. Subjected to the usual hours of organizational hesitation, the opportunity might be lost. With that in mind, Burland and Duncan risked handing out their mystery vial of cimetidine.

The advance of Tagamet depended on a series of these critical decisions, made not by corporate chiefs measuring their options but by middle managers close to the action, who trusted the quality of their peers' work and carefully regulated the amount of information that reached the company's senior management. The unheralded players who made these decisions included Burland and Duncan; Paget also, whose motives in hiring Black at the outset were partly concealed from Philadelphia; and even Parsons, who set aside the authority of the most prestigious pharmacologist in Great Britain when he changed the proportions of histamine in the test. None of these unauthorized decisions was carried out in defiance; all were made by men who believed they knew what was good for the company in a special situation better than the people who were supposed to be running it.

Tagamet at Last

In 1976 SK&F finally launched Tagamet (the product name for cimetidine) in Great Britain. Careful market preparation resulted in immediate sales success and intensified interest in countries that could not yet get it. The United States and world launch came in 1977—as soon as the U.S. Food and Drug Administration had found Tagamet to be without serious side effects in the treatment of duodenal ulcers. Since then Tagamet has been prescribed by doctors for a host of other ailments, including prevention of hangovers, but its FDA approvals still officially cover only a few human ailments.

Within a year, Tagamet had sold more in the United States than the company's wildly optimistic peak forecast, more than $100 million. Sales astounded even the most experienced marketing people at SK&F. There was intensive worldwide demand for the drug despite its then-astonishing cost, almost $20 per hundred tablets. Doctors called SK&F salesmen and insisted on more of it. Strangers approached officials of SK&F, thanking them for their wonderful drug. SK&F was trying to figure out ways to make four times as much Tagamet as they had ever thought they would sell.

Tagamet burst so spectacularly onto the scene largely because it was such a dramatic improvement over the ulcer treatments of the time. The available therapies worked poorly and seldom permanently. Furthermore, they were unpleasant to use. Antacids, the most commonly available remedy, are inexpensive, chalky-tasting substances that coat the stomach lining and prevent it from being attacked by its own secretions. The other inexpensive antisecretory drugs available caused dry mouth.

Without drugs, the results were more severe: life-threatening ulcers and eventually surgery. In the 1970s, ulcer surgery cost thousands of dollars, along with days—or weeks—of physician visits, hospitalization, and income loss. Ulcers were costing people a fortune.

Tagamet was like magic. It healed ulcers, little ulcers and big ulcers. It did not just replace antacids, it replaced scalpels. People finally could heal one of the most widespread, uncomfortable, and dangerous ills of modern life without drinking chalk or getting cut open. It didn't matter that the pills cost $20; if they were ten times as much, they still beat surgery.

The unexpected popularity of Tagamet hit hard at SK&F headquarters, but it hit even harder in Cork. For two years Declan Scott, plant manager of the only manufacturing source for the fastest-growing prescription drug on earth, lived and worked on the brink of catastrophe. When SK&F's leaders decided to build the Cork plant, it had seemed huge. Most of them wondered how they would ever sell enough drugs to justify the staggering capital investment. No one even brought up the absurd question of whether the plant might not be big enough to meet demand.

By 1978 the absurdity of five years earlier had become reality. Wendt found himself thrilled by the popularity of Tagamet and terrified by the fact that the only place in the world where it could be made was that little chemical plant in Cork. Almost every day for two years, he looked at a list of countries that would stop getting shipments of Tagamet if Scott could not sustain production. Each time Wendt contemplated the idea of rationing Tagamet, his blood ran cold.

The Cost of Success

To mar the dream come true by denying treatment to whole nations, to favor one country while denying another, would permanently stain SK&F's image and damage its business. Wendt lived in fear that a failure in the flow of supply would label his company permanently as a second-class operation, unworthy of the magnitude of its greatest drug discovery.

Every week Wendt called Scott three or four times. He checked to see if a consignment of ingredients had arrived from Switzerland, or America, or the Bahamas. "Here was the chief operating officer calling me," Scott recalled, "asking me about individual shipments of drug. 'Has it arrived yet?' 'How soon can you get it processed?' Believe me, I haven't got many calls from Philadelphia since then!"

Scott treated the entire crisis as a pleasant surprise that provided him with ceaseless entertainment. He was expected, with a work force of about 200 (all of whom went on twelve-hour shifts early in 1978) to generate twice the amount of cimetidine (350 tons a year) that the plant was designed to produce. SK&F's next production facility, in Puerto Rico, would not be in full operation for a year or more. Wendt's instructions to Scott were remarkable: " 'Money is no issue," he told me," Scott recalled. " 'Make as much as you can. As much as you can!' "

At the same time, Scott was consciously soft-pedaling a crisis that repeatedly threatened to shut down the plant at the peak of its production. Scott was producing a chemical whose full nature had yet to be understood by almost anyone. Normally when a new drug goes from laboratory to chemical plant, it passes through a pilot-plant stage, where production people find out if it has any strange qualities that only emerge when a lot of it is synthesized. But cimetidine had been pushed straight from the lab to the production, without going through a pilot plant. The distressing result was a smell that drifted unpleasantly into the nicer neighborhoods of Cork.

Cork is one of Ireland's industrial centers, and people there are accustomed to an occasional whiff of industrial effluvium, but cimetidine strained the limits of Cork's tolerance. Tagamet was good for the economy but bad for the atmosphere.

As Scott's engineers sought the solution to the odor problem, he found himself meeting ever more frequently with the governing councils for both the city and county of Cork to explain his progress, if any, in eliminating the stench. In 1979 Scott entered a council meeting under threat of a court injunction—brought by a neighborhood activist—and possible immediate cessation of industrial activity. In the meantime, Scott had assured Wendt that he was making swift progress in solving a minor environmental problem.

When Scott went into that critical meeting, he did so with barely any of the legal support that Philadelphia might have provided. Scott's only ace was one that he knew had higher value in Cork than anything SK&F could deal from across the Atlantic: He went into the council meeting as a fellow citizen and businessman, and he reminded them that he shared their hopes and concerns for the revival of a city that had slipped into a prolonged economic recession. Scott presented a plan that would result in a steady, gradual cleanup of the Tagamet pollution problem without stanching the flow of drugs from the plant. As only a fellow citizen can do, Scott impressed the council with the fact that they were the vital link in a commercial breakthrough that reached around the world and touched the lives of millions of people. Through this neighborly appeal, the council understood the importance of the product to the marketplace and the importance of a livable Cork to the leadership of SK&F.

These negotiations were a face-saving tour-de-force. The council imposed a series of strict deadlines for environmental compliance (all of them proposed by Scott), and Scott was able to go back to work. Scott's tap dance with the council was one more spontaneous decision that kept a Tagamet crisis safely in the hands of a wise mediator who knew the territory.

To characterize the breakthrough at SK&F solely as the crafty work of middle management mediators, however, is to minimize the importance of the series of courageous moves by others. Robert Dee drastically enlarged SK&F in anticipation of the emergence of Tagamet and put the company onto the world stage. Scott performed heroically in squeezing out double production and in staying open in the political crisis, but it was Philadelphia that had the foresight to build the Cork plant. And the enormous demand for Tagamet, right from the start, was the product of masterful international marketing planning.

For the world at large, the most dramatic implications of the Tagamet discovery are not in the interplay between top management and the underground of key players. Nor is it most important that SK&F gave the world a drug that spares people from surgery. In the long term, the most profound impact of the tagamet story is in the concept conceived by James Black and brought to term by the Welwyn, Philadelphia, and Cork organizations.

The Birth of Bioengineering

The house that Jack Black built encompasses the entire community of pharmaceutical research. In proving his concept, Black changed permanently the way scientists seek new drugs. He expanded the limits of human possibility.

The key of the H_2 accomplishment is that none of the three compounds that led to a final product called Tagamet exists in nature. Burimamide, metiamide, and cimetidine all were created by chemists who assembled them from atoms. Black imagined and then built a molecule that ameliorates a destructive effect within a natural system but doesn't change anything else in the system. Because of the huge impact of Tagamet on the practice of medicine and on the course of human lives, Black's concept revealed the potential of what is now known as *bioengineering.*

Before Black, pharmaceutical researchers labored doggedly among a tangle of nameless solutions in hopes of matching one of them, sooner or later, to an important problem. Because of Black, pharmacology is now moving away from that wasteful level of trial and error. Researchers can now specify the problem they wish to solve and design combinations of atoms they believe will solve it. Now problems that through guesswork might have taken centuries to solve will perhaps take only decades; problems otherwise decades from solution may be conquered in years.

This promise lies today at the fingertips of most scientists largely because James Black, in defiance of the stated interests of most of the institutions for whom he worked, pressed on stubbornly with his unique view of science. Black, however, could not have moved science forward so dramatically on his own; the world's medical and scientific establishment would not have so swiftly embraced, or even noticed, Black's vision if not for a handful of believers who barely missed a beat after their mentor had proved his point and ascended to academia. Quietly, diligently, they picked up Black's concept where he had left it and turned it into a common presence in medicine cabinets worldwide.

6

THE WALKMAN: NOT SUCH A DUMB PRODUCT

They were disappointed at first, but it wasn't going to keep them awake nights. In 1978, Mitsuro Ida and a group of electronics engineers in Sony Corporation's tape recorder division tried to redesign a small portable tape recorder called "Pressman," which they had invented a year or so earlier. A wonderfully compact machine, ideal for use by journalists, Pressman had sold very well.

The sound of the original model was monaural, so the next challenge for Sony was to make a portable machine just as small, but with stereo. The first stereo Pressman, however, didn't succeed: putting stereo circuits in its chassis (5.25 by 3.46 inches, and only 1.14 inches deep) left no space for the recording mechanism. It was a stereo tape recorder that couldn't record anything. Ida regarded this as a good try but a useless product. Since the stereo Pressman was a nice little music machine, the engineers didn't throw it away but played cassettes on it while they worked. Meanwhile, Ida looked for a way to fit both stereo playback and recording into the tiny box.

A year later, Kozo Ohsone, the general manager for the division, became the heir to Ida's failed music box. To the company's surprise, Sony suddenly needed millions of the machines, and Ohsone was charged with transforming an electronic production facility to manufacture them. By early 1980 the new devices, dubbed "Walkman" by Sony's marketing people, were the most popular tape machine ever. Everybody seemed to want one. Electronics stores throughout Japan could not stock them fast enough. Tourists and business travelers from the United States and Europe were buying them by the armful and smuggling them through customs to give away and sell at home. Half a dozen Japanese electronics competitors were pouring resources into production of their own versions.

The reason Ida's machine became the best-selling electronic device in the world for several years was one simple addition to the design: headphones. But these were not just any headphones, certainly not the immense headphones of the 1970s that tied audiophiles to stereo systems. The Walkman headphones were small, light, loose-fitting—and portable. Because of those headphones, most people today know what a Walkman is—and how it sounds. Even though the Walkman is Sony's trade name for their product, most people call any personal portable stereo a Walkman. And most households have one.

But in 1978 and throughout much of 1979, few people at Sony envisioned any potential in this accidental product. When the Walkman I was introduced, senior management of the tape recorder division made sure the minimum of money and personnel went into the product launch. Sony thought of it as a toy, designed to attract young people and exploit their impulsive spending habits.

Some at Sony remained rather ambivalent about the Walkman even years later. When Sony Chairman Akio Morita was interviewed in 1985 on the Walkman's genesis, he diverted the conversation to a newer technology. "You should be asking me about compact discs," Morita said. "This is the true breakthrough! A great technology developed here at Sony!" Despite this disclaimer, the Walkman is a source of great pride for Morita, who rightly claims a major role in its development.

The Walkman is actually typical of Sony. The company emerged from the postwar struggle of the Japanese electronics industry partly by its manufacture of little things that anticipated people's needs. Its first successful product was a tape recorder, the first in a long line of innovations in recording technology. In 1954, Sony was the first company to find a simple use for the transistor, a phenomenal invention of Bell Laboratories. In fact, through its tiny, ubiquitous radios, Sony made *transistor* part of the world's vocabulary.

Breathtaking Sound in Privacy

Like the transistor radio, the Walkman conceals technological sophistication within outward simplicity. It is possible, for a few thousand dollars, to get extraordinary stereo music by assembling electronic components in a room acoustically designed for such a purpose and organizing an array of high-fidelity speakers in perfect juxtaposition to a listener. It is also possible to achieve the same goal by strapping on a fifty-dollar Walkman and flipping the switch. Like the transistor radio, the Walkman fulfills a basic need in human life: entertainment. Transistor radios were the first product to exploit the desire to take a personal world of sound and sensation wherever one went. The Walkman took this concept a step further.

The Walkman is a minimal item of apparel, silent and barely noticeable. Yet it wraps the user in a cocoon, closing off the external sounds of a crowded, hurrying, tense environment. It extends privacy into a new personal dimension by separating the individual from the surroundings without being physically removed to another place. Besides its power to remove people from the distractions of urban society, the Walkman can also bring the benefits of that society to those who don't otherwise receive them.

"Years ago in Hong Kong," said Morita, "I saw many people living on small boats. They had no entertainment, but each boat had a transistor radio. The radio was their first chance to get outside entertainment. I hope to put the Walkman into the jungle, so that people there can enjoy stereo."

Even to reach Morita's attention, however, the Walkman had to catch the eye of another authority at Sony—Honorary Chairman Masaru Ibuka, the company's founder. Ibuka discovered the Walkman prototype, made and then rejected by Ida's team of researchers. Even after turning their stereo Pressman into background music, Ida and his group of problem-solvers remained intrigued by the complexity of fitting the stereo function and recorder into such a small box. Their focus on the stereo Pressman blinded them to the solution—to a different problem—that was in their hands.

The Critical Connection

It is the province of honorary chairmen everywhere, because their status is almost invariably ceremonial, to putter around the plant looking in on this group and that, nodding over the latest gadget. To this mundane task, Masaru Ibuka brought an undiminished intelligence and an active imagination. When he happened into the tape recorder division and saw Ida's incomplete tape recorder, he admired the quality of its stereo sound. He also remembered an entirely unrelated project where engineers were working to develop lightweight portable headphones.

What if you combined them? asked Ibuka. At the very least, the headphones would use battery power much more efficiently than stereo speakers. But another idea began to form in his mind. If you added the headphones, wouldn't you dramatically increase the quality of what the listener hears? Couldn't you leave out the recorder and make a successful product that just plays music?

In the world of tape recorders, Ibuka's thought was heresy. He was mixing up functions. Headphones traditionally were supposed to extend the usefulness of tape recorders, not to be essential to their success. This idea was so well established that if Ibuka had not made an association between a defective tape recorder design and an unfinished headphone design, the Walkman may well have never appeared at all. Design groups within Sony tend to be very close-knit and remain focused on short-term task completion. Ordinarily there was no reason for tape recorder people ever to communicate with headphone people. They had nothing to do with each other. Even without this insularity, there is no assurance that someone else at Sony would have made the connection that Ibuka did. Today, the relationship between a cassette player and a set of headphones is self-evident. Yet in 1978, at Sony and every other consumer electronics company, that connection was invisible.

Ibuka got a predictable response from the researchers in both the tape recorder and the headphone divisions: polite but noncommittal. Ibuka might be right that the headphones would improve Pressman's efficiency, but nobody knew how much. No one wanted to tell him that the idea of removing the speaker in favor of headphones was crazy. But it was! What if the owner of the device wanted to play a tape so that someone else could listen? When Ibuka ventured further into illogic by suggesting a player with no speaker or recorder, he lost everybody. Who would want to buy such a thing? Who at Sony would support development of such a harebrained scheme?

In a way, they were right and Ibuka was wrong. His idea violated most industries' well-established, basic criterion for judging product development: The prototype of a new product should be better than that of the previous generation. Ida's nonrecording prototype seemed worse. The idea had no support from those who eventually would be responsible for funding its development, carrying out the research, and selling it to consumers.

Although he was revered at Sony, Ibuka had no authority to order a project undertaken against the wishes of the division's leaders. It was clear that the only way to sell a dubious idea to a group of cautious, overly reasonable businessmen was to find an ally. So his next step was straight to the office of his partner and friend, Akio Morita. The interplay between the two was a fascinating drama and a critical step in the survival of the idea that eventually would be called the Walkman.

The Chairman Who Loved Gadgets

Ibuka was taking advantage of a fundamental quirk in Morita's personality: Morita loved new gadgets, and he often exercised dubious judgment about which ones had solid commercial potential and which didn't. At Sony, anyone with the nerve to barge into Morita's office with an idea, however strange, actually had a good chance of selling it.

One other impulse, however, also motivated Ibuka to visit Morita. For more than thirty years, the two men had shared—in the same workshops, offices, and laboratories—a common purpose. They had formed Sony from the rubble of Tokyo after World War II, and they granted to each other a trust that springs not from logic but from love. In expressing that passion, Morita has said, "Even to this day, Sony is a company of compatriots gathered together for the sole purpose of realizing Masaru Ibuka's dreams."

Even then, Morita might have bowed and thanked his friend profusely and then slipped the idea into a bottom drawer—some dreams are more worthy of respect than of capital investment. Ibuka had prepared for this possibility. He said, "Let's put together one of these things and try it. Let's see how it sounds." This was a harmless request. The ingredients were available. So Ida's machine was combined with a set of conventional, heavy headphones.

According to popular legend, Morita and Ibuka then went out into the world to test the infant Walkman; they wore it in airports, on tennis courts, and on golf courses. The story is nice but not accurate. Morita smiles mischievously at the fabric of legends he has created among gullible journalists. "There were many stories that came out. Many rumors spread. All these couldn't have occurred," he said. "A journalist would say, 'You developed the Walkman for playing tennis.' I would say, 'Yes, that's right.' Another would say, 'You developed the Walkman for playing golf.' I would say, 'Yes.' Such an interesting story is good for promotion."

The most important result of his trial was Morita's discovery of sounds he had never heard before. The stereo that burst from that little box was wonderful. He and Ibuka had done what none of the more sensible people in the tape recorder division had done: They had tried it.

And they loved it.

Morita's immediate decision to push the development of a nonrecording cassette player shocked the tape recorder division. How could the Honorary Chairman and now

Chairman Morita *both* support this departure from rational product development?

At Sony, partly because of the personality of its chairman, the idea for being a market creator is far more important than for other Japanese companies. The Sony philosophy—to lead competitors from the beginning, from development to marketing—sounds, in fact, more American than Japanese. The philosophy is that of Ibuka, who wrote the company charter, and Morita, who enforces it: "Do what others have not done." The Walkman provided Sony with another possibility—however remote—of creating a market.

Virtually alone among chief executives in Japan, Morita is outspoken and provocative. Contrary to the unobtrusive style expected of businessmen, he charges into the public eye, makes bold predictions, and challenges conventional ideas. He also provides vast entertainment to a journalistic community bored by the standard Japanese corporate style. Morita admits bravely to his failures, justly claims more victories than defeats, and enjoys the limelight.

Morita's passion is to ensure that Sony is the first with the newest. While he creates the impression that Sony's employees are helpless captives of a quixotic and autocratic leader, Morita is in fact only one member of a management group that shares in making the major decisions. The Japanese word *uchi* is used interchangeably to mean "my company" or "my home." For many Japanese, especially men, relationships with colleagues at work are the focus of life; the company is home. In the rapid cultural change now pervading Japanese society this relationship may erode, but Morita used it with his generation to create a remarkably efficient organization.

A Pervasive Skepticism

Morita not only said, "Let's try this"; he also said that he would be watching closely. If the people in the tape recorder division had sensed that Morita was not taking this product seriously, they might have set it aside. Early on, the Walkman project was for them mainly a drain on the division's money and manpower.

In that period, there was little feeling of pressure, even though the orders in February were that the product must be developed, advertised, and introduced by midsummer. There was a prevailing devil-may-care attitude about the creation of the Walkman I, which stemmed partly from the ongoing belief that it would fail. Another reason was the influence of Yasuo Kuroki, whom Morita had charged with shepherding the Walkman's development. Kuroki is an animated man who can seem simultaneously overwhelmed and delighted by any situation, and his presence lent a lighthearted contrast when pressure did begin to flow increasingly from Morita's office.

Of course, according to most reports, neither Kuroki nor Kozo Ohsone served as chief product manager for the Walkman; rather, Morita adopted it as his own and drove it through with unstinting energy and constant attention. Kuroki smiles skeptically at this suggestion. "Mr. Morita liked to think of himself as the project manager," said Kuroki, "but do you think on something like this, the chairman of the board would really be able to serve as the project boss?"

Appropriately, Morita left the day-to-day details to Kuroki and Ohsone. But he understood one thing very clearly: Everybody had to believe that this was his pet project. Most of Kuroki's team still obviously lacked enthusiasm. No one had yet convinced them that a nonrecording tape player made sense. Nevertheless, they followed orders and began to move things around in the maddeningly small space of the Pressman.

By late February 1979, a few prototypes had been built. Ambivalent tape recorder division executives knew they couldn't afford to launch this new product, regardless of its good design, unless it could make money. It looked as though they had a costly loser, a nonrecording tape player that would retail for at least ¥50,000 ($249), which was more than people were paying for tape *recorders.* The marketing people were blunt in their assessment: "This is a dumb product."

The Chairman Versus the Engineers

With this sort of attitude prevalent, Kuroki decided it was time for a pep rally. He arranged a meeting between the young engineers and Morita. This was the first time that these engineers had ever faced the chairman without being in trouble. "To be invited to the chairman's room is something extraordinary," one of them recalled. "For most of us it's a once-in-a-lifetime experience."

Aware of the nervousness that the visit could instill, Kuroki gave the young engineers a briefing. It backfired. "I told them, 'Please, if you disagree with Mr. Morita, feel free to say no,' " said Kuroki. "But they were so obedient that they kept saying 'No. No.' Toward the end of the meeting, I was very troubled, and I regretted my words."

At the meeting, the engineers would not give in to Morita on the issue of price. "The division has a right to refuse," said Kuroki. The gap between a price that would attract youthful buyers (about ¥35,000, or $170) and the break-even price (¥49,800, or $249) was huge. Based on that disparity, Morita should have been forced to respect the division's refusal.

He didn't. Morita had visualized a supportive market for this playback-only device, and he wanted to explore it. He promoted the idea that this playback/headphone machine was not a tape recorder but a new concept in entertainment, one that dovetailed with the growing market in prerecorded cassettes. Morita believed that it would strike an immediate chord with teenagers, a social group that he said could not live without music. He observed that teenagers carry music to school, to the beach, to athletic events, even to musical performances. The Walkman would allow them to easily carry their music anywhere at all; it would break down the last barriers.

The result of Morita's eagerness was that Kuroki called another meeting to change the engineers' minds. "It was not because the chairman instructed us," he insisted. "It was not a command. We were very aware of Mr. Morita's enthusiasm and emotion. We responded emotionally. We sympathized."

As they haggled over the price, the engineers conceded that by trimming costs and praying for incredible sales, they could justify a price somewhere around ¥40,000 ($200). Given an inch, Morita declared that the price would be ¥33,000 ($165)—a number chosen to commemorate Sony's thirty-third anniversary that year. And it was conceivably affordable for Japanese youth. Morita used the occasion to set a product launch date of July 1—only four months away.

For many companies, a four-month deadline would have been absurd. For the design and engineering staff of Sony, however, the pressure was barely noticeable. Outwardly, Sony's structure is rigid, orderly, and specialized; yet, sparked suddenly by the chairman's whim, a team formed to respond to the challenge. Morita knew that he had more than the technological pieces to put together a

Walkman; he had an entire network of people who thrived on doing odd jobs on the spur of the moment.

For this spontaneous network, the biggest immediate problem was Morita's crazy price. At $165, they could sell out the entire first production run of 60,000 units, which most people regarded as the most wildly optimistic outlook imaginable, and still lose $35 on each. The more they would produce, the more they would lose.

Kozo Ohsone could see that a failure of this magnitude could diminish his reputation. When Kuroki told him to prepare an initial run of 60,000 units, Ohsone, a pragmatist, made a deal. He would acquire enough parts for 60,000 Walkmans, but he would make only 30,000. If that first batch was selling briskly, he would have time to produce the remainder with little or no delay; if it died on the market, Sony would be spared the expense of making 30,000 additional unwanted units. Kuroki and Ohsone agreed and made sure Morita didn't know a thing about it.

Ohsone's production budget for the Walkman I was frugal, but it was lavish compared to the money given the marketing group. They received $100,000 for advertising; for promotion they got almost nothing. Most of their budget consisted of Walkman samples, which they used creatively. Aiming their efforts at the youth market, they got maximum promotion for minimum outlay. Their free samples went to celebrities in music and show business—several to foreign pop stars who were touring Japan that summer. The Walkman press announcement went out on cassettes rather than paper. On the day of the product release, Sony bused members of the press (each wearing a brand-new Walkman) to a park in Tokyo, where a throng of teenagers, all listening to Walkmans, roller-skated circles around them.

The Japanese press found this introduction delightful and gave it extraordinary coverage the next day and throughout the ensuing weeks. The tape recorder division seemingly had taken a risk with an unconventional market introduction and had succeeded. While the press had been excited, Japan's youth was not infected with that excitement. Teenagers didn't buy the Walkman in numbers that even approached Sony's expectations. Why didn't young people, who supposedly couldn't live without music, eagerly buy this novel way to listen to it? Part of the explanation was found in their intrinsic conformity: Japanese and American cultures often credit teenagers with starting fashion trends, but teenagers aren't leaders; they are among the most lockstep trend-followers in consumer societies. They will consume almost anything, but they wait until they see others consuming it first.

Despite little response from teenagers, Walkman sales finally began to pick up. August was a good month, and then suddenly sales exploded. By the first week in September, supplies had vanished. There wasn't a Walkman to be found in any retail outlet.

The Mysterious Market

Chairman Morita fumed and demanded why supplies had run out at 30,000 units, when the production level had been set at 60,000. Ohsone was in trouble for holding back on the second 30,000 units; the Walkman would not be back on the market until almost October. Kuroki stepped between Morita and Ohsone and took some of the responsibility for the decision, reminding Morita that Ohsone's caution was justified, having been based on the original dubious outlook for a product that didn't make sense to experienced people in the business.

The market didn't make much sense either. Who was buying the Walkman? Without a teenage market, the marketing group wondered why the Walkman was selling at all. Later market studies showed that Sony had discovered the demographic group that came to be known as young urban professionals (yuppies). The Walkman was an ideal accessory for members of the young professional class (average age twenty-eight), who led affluent, active lives. For this group, recorded music had been a pervasive presence all their lives. Most of them already owned other cassette players and many prerecorded cassettes. The price of the Walkman, designed to fit teenagers' tight budgets, presented no cost barrier at all to this older, wealthier class, who enjoyed their role as conspicuous consumers and were not self-conscious about breaking new ground in society. Now they could jog, commute on the subway, or play golf while enjoying perfect stereo sound.

Sony quickly identified this market and aimed ensuing marketing campaigns at these heavy users, concentrating on lifestyle, quality of sound, and technological innovation. It wasn't until eighteen months later that Sony saw the Walkman finally penetrate the youth market.

Sony had a fad on their hands, and other consumer electronics companies rushed to make copies. To stay ahead of the competition, Sony had to make a better Walkman. Sony needed another breakthrough, and the Walkman II was on the drawing board by October 1979.

That month also brought a marketing crisis that took seven months to resolve. At an international sales meeting in Tokyo, Morita introduced the Walkman to Sony representatives from America, Europe, and Australia. Within two months, the Walkman was introduced in the United States under the name "Soundabout"; two months later, it was on sale in the United Kingdom as "Stowaway." Sony in Japan had consented to the name changes because their English-speaking marketing groups had told them the name "Walkman" sounded funny in English. Nevertheless, with tourists importing the Walkman from Japan and spreading the original name faster than any advertising could have done, Walkman became the name most people used when they asked for the product in a store. Thus, Sony found themselves losing sales because they had three different names for the same item. Morita settled the issue at Sony's United States national sales convention in May 1980 by declaring that, funny or not, Walkman was the name everybody had to use.

Staying Ahead of the Pack

Regardless of what they called it, Sony had to follow up with the Walkman II quickly or lose the advantage of introducing a product that was both exceptionally new and exceptionally easy for other manufacturers to imitate.

Walkman II was the reason the so-called "headphone culture" took root. In deciding at last to commit fully, Sony did a number of extraordinary things. A first critical step was to reduce the size of the Walkman dramatically, to only slightly larger than the cassette itself. With this reduction came improvements in stereo function, headphone design, and energy use. Morita and Kuroki also knew that they had to take advantage of worldwide interest in the Walkman with a flood of products. If they could not manufacture to meet demand, the moment might either pass or be seized by competitors. Suddenly, the mood went from devil-may-care to deadly serious. With that change in atmosphere, the job of orchestration went from Kuroki to Ohsone's production group.

Judged by the Western stereotype, Ohsone seems the archetypal Japanese manager who rose by virtue of his conformity and acquiescence to the homogeneous norm. But his awareness of people's capabilities and feelings—especially their frustrations—made him an exceptional leader. He needed all that skill to deal with Morita's rapidly growing expectations for the Walkman II.

The task was frightening. Sony had reached a monthly production peak of over 30,000 units of the Walkman I per month early in 1980. But Morita already planned to replace the Walkman I with the Walkman II within eight months, setting a monthly production target of 200,000 units by midyear.

Ohsone smiled when asked whether that goal made him feel pressured. Like Kuroki, Ohsone responded obediently to the expectations of Sony's chairman, but he also had learned the difference between Morita's bark and his bite. "Ask a woman to give birth in three months. Does she feel pressure?" said Ohsone. "No, because she knows it's impossible." In fact, before the Walkman II project was underway, a new target date of January 1, 1981, had already been set.

Ohsone knew that his most important contribution to the success of the Walkman II would be selecting the right people for the development group. "This team consisted of rare individuals. They had to be cohesive, because this was a challenge like mountain climbing. Teamwork is critical. Some only go as far as the base camp. Some go to the peak, but they would not get there without the support of the others," Ohsone explained.

Ohsone recruited his team by interrogating managers in Sony's tape recorder and headphone divisions about their people. He wanted to know how well they responded to working with another division and how they would interact with one another. After he had formed the team, Ohsone stood back and did his best to protect it from Morita's demands. One of his most important decisions was the selection of Kenji Sano to implement production of the Walkman II.

Sano's job was overwhelming. Pointing to his silvery hair, he said, "Before Walkman II, my hair was black!" More than anything else, the warmth of his handshake—two hands enveloping one hand of his interviewer—expresses a fellowship that must have made it easier for him to push a crew of harried engineers, mechanics, assembly trainees, and suppliers through the ordeal of setting up in months a production system that reasonably should have taken years.

The challenge of restructuring the mechanics and electronics of the Walkman II to fit into a space little more than half the size of the Walkman I required cunning solutions, many coming from Mitsuro Ida. "The problem with Mr. Ida is that his ideas are so creative," said Sano. "He would give me designs that nobody knows how to manufacture, and they are so clever that nobody—including Mr. Ida—knows how to modify them. This was one of the worst years of my life." Besides dealing with internal issues, Sano coped with parts suppliers, none of whom at the beginning of 1980 could turn out parts at a rate of almost one quarter of a million a month.

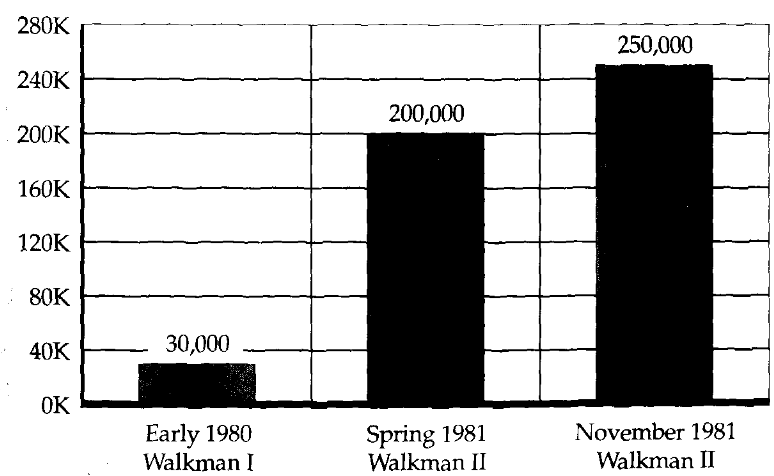
Whiskey, Sake, and Three Days at the Beach

At the team's breaking point, Ohsone would appear as though he had felt their building frustration. He would supply the team members with bottles of sake and whiskey and dispatch them to the beach for a few days. For two days they would relax; on the third day, they would begin to feel uneasy about taking time off in the middle of the crisis. On the fourth day, Ohsone would show up and say, "So, got any ideas how we can do this?"

Although Ohsone's ploys were never subtle, they were always welcome. Besides providing rest and recreation, he kept the chemistry of the Walkman team under control. Under tremendous pressure, it bubbled furiously but never exploded.

By November 1980 the production line was ready to run; with a blend of manual and automated assembly, the Walkman II went into production. By February 1981 inventory was large enough for Sony to begin selling the new product. Sano's fully automated assembly line began operation that month, and production levels reached 200,000 per month by spring and 250,000 by November. Sano had earned the right to plant the flag atop his Everest.

Sano's achievement is acknowledged throughout Sony, and he receives a measure of special respect from those aware of his two-year ordeal. Yet his role has been lost in the abbreviated Walkman story circulated among



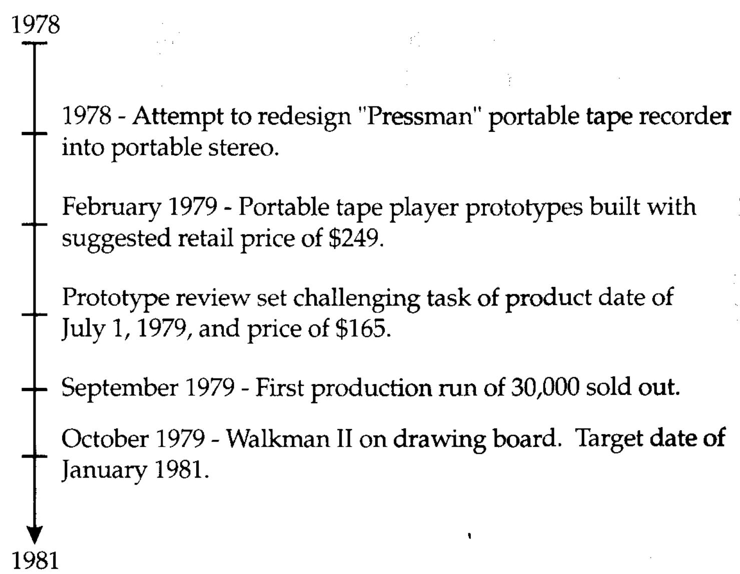
Monthly Production Rate Increase from Walkman I to Walkman II the business press. Absent also are such key players as designer Ida and production chief Ohsone. "Product Manager" Morita is the simplified hero of these popular stories. This emphasis on Morita's leadership, however, is not entirely misplaced, because it was his personal interest that gave the Walkman a special place within Sony. Sony is, after all, a busy corporation where people tend to concentrate on well-defined assignments. They are reluctant to divert their attention toward notions that are less concrete than the task at hand. They need a good reason to break from the familiar circle of a few intimate coworkers.

Morita's involvement in the Walkman made it possible and psychologically acceptable for engineers from two separate divisions to communicate and work together. In this light, it is clear that the Walkman breakthrough was attained substantially through the intervention of Akio Morita. The question can be asked whether normal organizational inertia would prevent any similar breakthrough without his intervention again.

The answer is, not necessarily. It wasn't Morita, after all, who transformed the Pressman into the Walkman. It wasn't he who made the critical link between the cassette player and lightweight headphones. It wasn't his negotiating magic that compelled the tape recorder division to risk a major financial loss on an unproven device that they had disliked from the beginning. Nor did he personally create the Walkman team or the unprecedented production capacity. When the need arose to overcome customary structures and to complete an extraordinary project, a network of special people emerged: Ida, the inventor; Kuroki, the negotiator; Ohsone, the psychologist; Sano, the builder. All the key people were long-established at Sony. None seemed troubled by the unstructured style of the Walkman project; each adapted quickly to the flying-squad approach to product development. None was visibly awed by Chairman Morita.

An Amazing Feat of Product Development

From the heart of a company, which to the world appears to be a tightly ordered series of cubicles where drones meekly labor away for the common good under a charismatic leader, a host of unique performances suddenly burst forth and guided Sony to an exceptional success. Akio Morita, that charismatic leader, injected the initial energy that the Walkman project needed, but the sudden turns and spot decisions that followed were too quick and intuitive to await his approval. The most exceptional feature of the Walkman breakthrough was its speed; while the majority of significant commercial breakthroughs are years in the making, Sony's breakthrough ran its full course—from concept to market fireworks—in less than a year.



Walkman Product Development Timeline

This is true partly because of the Walkman's technical heritage. Sony had all the necessary technology present when the opportunity emerged. It helped too that the Walkman was a relatively simple product. But these facts alone cannot explain the coordination within Sony that fleshed out Honorary Chairman Ibuka's idea and created the headphone culture all within a few months.

Somehow, exactly when the need arose, the special skills, talent, and ingenuity needed emerged within Sony. A similar phenomenon occurred, though more slowly, in the Post-it Note breakthrough at 3M. There also, ordinary people emerged from a small circle of colleagues and contributed to an extraordinary product. In 3M's sprawling network of divisions, the members of the Post-it group had to search for each other; they formed their team by volunteer enlistment. At Sony, the Walkman team got drafted. The project leaders knew the abilities of a number of people in several departments who might be able to contribute.

In the Japanese industrial ideal of lifetime employment, a great deal of experimentation goes on. Employees are moved around, sometimes arbitrarily, among a number of jobs and departments. The purpose of this shuffling is to allow managers to discover workers' talents and fit them into the spot where they eventually will remain and contribute the most. When this system is abused or misused, it turns the workers into chattel; it provides no benefit to the company and gives play to the worst impulses of manipulative managers. In the hands of good managers, however, it identifies special talents. Kuroki and Ohsone at Sony, like Geoff Nicholson at 3M, perceived their cadre of lifetime workers as a wealth of diversity and creativity.

When the Walkman became his responsibility, Ohsone recognized that the most critical task he faced was the selection of his working group. If he chose the right people, their talent and personal character would carry the effort forward. Sony is, after all, a delicately (and not accidentally) balanced organization. Within a year it could muster teamwork to turn a raw concept into a perceived necessity in consumer society. It is remarkable that this happened without a what Peter Drucker once called a *monomaniac with a mission*—one person who kicked the organization to make it move and then kept pushing, with unreasonable passion, all the way through the process. Rather than heroes, there was a series of quiet leaders who passed the baton gracefully because they understood each others' needs as clearly as they understood the expectations of the chairman.

No Monomaniacs at Sony

One lesson that emerges from both the Walkman and Post-its is that an organization can do new things without the outward appearance of creative ferment. To do so, it must provide its employees with job security and appreciation for their individual talents. It must recognize and cherish its vital players.

There were no monomaniacs at Sony—not even Akio Morita. Although he recognized the need for his involvement, Morita also understood how important it was that he stand slightly removed from the action, to do his other work and to shield from possible failure the corporate prestige that he had become so closely attached to himself. Sony had intimacy, which was far more important than Morita's watchfulness. Weaving down through the structure of the company was an unbroken fabric woven of people who trusted one another. They knew one another intimately, so that when a great opportunity emerged and cried out for rare individuals, they were easy to find. They had been there all along. They were willing to help and perfectly willing to let Akio Morita finish the climb and stand on the mountaintop.

7

THE CAT SCANNER: EXPLORATORY SURGERY'S REPLACEMENT

The scene at the Rochester, Minnesota, airport one day in 1971 might have been staged by a film director as a sequel to *Frankenstein.* At a routine security checkpoint, guards halted a man carrying a suspicious-looking container. When they passed it through the x-ray machine, the display screen revealed the unmistakable contours of a human skull. Opening the container, they saw that this was neither a skull nor a preserved head, but an actual, recently severed human head.

This was the first time the discoverers of this grisly luggage had ever apprehended anyone trying to transport a detached head. What were they going to do with this traveler? The man said that he was on his way to London, that he wanted the head for *scanning,* whatever that meant. They let him make a phone call, to someone in England named Hounsfield. "Godfrey," the man said, "I'm at the airport in Rochester. The head went through the x-ray machine!"

Sensitive negotiations followed. The man traveling with the head, with help from the dignified-sounding Mr. Hounsfield, explained that the head had been obtained legitimately at the Mayo Clinic in Rochester, as a call to the clinic confirmed. The head was intended for medical research; it was to be subjected to a new type of x-ray at the

Central Research Laboratories (CRL) of EMI Ltd., in Hayes, Middlesex, England. Airport officials eventually released the traveler, with a stern warning that they would not again permit this sort of thing unless someone first called ahead to warn them.

Godfrey Hounsfield, unlike Frankenstein, was not a mad scientist, even though many in his parent company and in medicine certainly regarded him as pretty odd. Hounsfield in 1972 presented to a skeptical medical community and then to the world at large the CT scanner, often referred to as the *CAT scanner,* a device intricate in conception and execution but compellingly simple in its results. Hounsfield's computerized tomographic (CT) scanning technology allowed radiologists to take much clearer pictures inside the human body than are possible through traditional x-ray photography. CAT scans show tissues that are too soft for an x-ray. Furthermore, they overcome the obscuring effect of dense materials, such as bone, that in conventional x-ray pictures mask tissues behind them. CAT scans often replace exploratory surgery with a swift, painless, and safe computerized probe. Through Hounsfield's efforts between 1968 and 1975, medical imaging moved permanently from the limited technology of photographic film to the vast possibilities of computer science.

Since Hounsfield did indeed launch a revolution in radiology, surgery, and computer technology, one would expect that huge resources and legions of well-trained technicians had supported his breakthrough, but Hounsfield invented the CAT scanner with a grant of less than $44,400* from the British Department of Health and Social Security. His staff comprised two research assistants who were still completing their training. Substantially by himself, he built a prototype with original computer software and within that budget. That prototype, still on display at

*Figures are based on 1993 conversion rate of £/$1.48.

EMI, has a rustic appearance, to put it kindly. It was the simplest possible device created to perform the most sophisticated possible function. For many reasons, however, that primitive approach was the only one possible. Hounsfield's idea was widely considered unworthy of financial investment because, by consensus, it was impossible.

Told to Go Away and Think

Hounsfield came across the idea of computerized tomography by chance. After earlier occupations as a cinema operator, radio repairman, and builders' draftsman, he became a skilled radar technician in the Royal Air Force during World War II. After the war, he finished his formal education in electrical engineering and joined EMI. A pioneer in television and high-fidelity phonograph technology, EMI was by the 1960s mostly a manufacturer of records, record players, TVs, and radios. The company remained actively interested in new electronic technologies, however, and it was in this area that Hounsfield exercised his creativity. He proved himself a brilliant innovator in the newborn specialty of computer memory storage, discovering ways to keep huge amounts of information on small bits of magnetized nickel iron for fast computer access.

EMI decided not to support development of this breakthrough. The company's early interest in computers diminished when management saw the intense competition that had emerged so quickly. EMI didn't want to take on IBM and its crowd of imitators. This frustrated Hounsfield, but it served him well in the long run. His intellectual energy at least had gained recognition within CRL, whose director, Dr. Leonard Broadway, realized that Hounsfield needed no prompting to tackle new problems. Hounsfield was capable of generating his own projects and was practical enough to make them adaptable to commercial development. Broadway offered Hounsfield condolences for the death of the memory storage project and told him to look for another new idea.

"I was told to go away and see what I could think of to do," said Hounsfield. "There were four or five ideas I'd had in the past, and CAT was one of them. When I was talking to somebody about computing, we made the observation that if you took readings that could detect the presence of material from all angles through a box, in three dimensions, then you would have enough information, without opening the box, to tell what was inside." This field is called *pattern recognition*, a highly theoretical science at that time. Mathematicians and engineers looked for ways for computers to recognize and identify images as swiftly as the human brain and then to respond accordingly.

Hounsfield's idea surpassed all the efforts up to that time. He envisioned a mathematical puzzle so vastly complex that it seemed beyond the ability of human persistence to solve it. He kept thinking of that object inside the box. How could you identify it without opening the box? If the object were reduced to picture points—the tiny dots that compose a photograph—then all of them could be assigned a mathematical value. Each view through the box could be expressed mathematically. If you could collect all the expressions outside the box and teach a computer how to reassemble them just as they had been inside the box, you could display the reconstructed object on a computer screen—see what's inside the box.

The idea was pure science fiction. Hounsfield was almost proposing a real-life application of the phenomenon called *beaming* in the television series "Star Trek," where someone stood under a "transporter beam," which reduced the matter in one's body to a stream of molecules, directed the stream at a distant point, and then reassembled the molecules there, presumably losing no parts in transit. Hounsfield's notion was to take a picture of each molecule, transport those pictures on an x-ray into a computer memory, then have it reassemble all the pictures on a monitor in exactly their original order.

Seeing Beyond X-rays

Hounsfield doesn't remember when he stopped thinking about boxes and started thinking about human bodies. Suddenly, though, he had associated his knowledge of computerized pattern recognition with his knowledge of medical radiology. Hounsfield didn't even consider as yet the immense task of assembling and reassembling all the picture points in the human body in three dimensions. What occurred to him was that he could make pictures of "slices" of the human body. Instead of blasting the body with x-rays as in conventional radiography and then catching them on a photo plate, you could penetrate a specific point with a slender shaft of radiation. What you would capture on the other side would be x-rays whose intensity would give information about the tissue in the plane that the shaft had passed through. This intensity could be accurately recorded. Repeatedly irradiating this slice, or plane, would yield sufficient information about all points in it to reassemble and create an image of that slice of tissue—the object in the box.

It was a wonderful theory, the physicists told him, but he would need a mechanism that would uniformly and quickly obtain all those pieces of information. Live humans move and breathe; their hearts beat and their fluids flow. And all these things tend to make computer photos blur just the way regular photos blur when people move. Moreover, Hounsfield would need a medium to collect and to reproduce the many thousands of mathematical photo points. Besides that, he would need some sort of algorithm (a problem-solving software code) to unscramble all the narrow snapshots.

Hounsfield was undaunted by these formidable, practical implications. As soon as the idea occurred to him, it made such vivid sense that he knew it would work. He couldn't be certain of the value of his idea to medical science, because he knew nothing about medicine. But he had a practical understanding of radiology, and he was intimate with the ability of a computer to perform the vast, complicated, and tedious task of information storage, assembly, and reassembly. In a 1979 interview, Hounsfield revealed that his confidence, even as he began to devise his CAT scanner, was unshakable. "It became rather obvious," he said, "once I realized that my method was considerably more efficient than conventional x-rays; I hoped to see things they could not possibly see. I must win in the end, was my general feeling."[1]

While Hounsfield was making these associations, he had no idea whether medicine would want or need the device that had already formed in his mind. He only thought doctors might like to have it.

Almost a decade earlier, the urgent need for some sort of tomographic x-ray machine was expressed by Dr. William H. Oldendorf, a neurologist and psychiatrist and one of the first real pioneers to attempt building one. Oldendorf built a model of a tomographic scanner in 1961 and patented it in 1963. He made his models without computers—there none then capable of handling the amount of data that would be generated by a scan.

Oldendorf's model was a heroic effort, undertaken because of his sense of the need in radiology to progress beyond the limited images available in standard x-rays. He declared with greater emotion than is customary at a symposium on biomedical electronics, "As a practicing clinical neurologist, I am daily confronted with the necessity of performing traumatic tests because the information is so vital to intelligent case management. These tests were introduced between thirty and forty years ago, and neither has changed basically since then. Each time I perform these primitive procedures, I wonder why no more pressing need is felt by the clinical neurological world to seek some technique that would yield direct information about brain structure without traumatizing it."[2]

Preparing the Soil and Planting the Seed

Hounsfield laid the groundwork for his computerized tomographic scanner and submitted the idea to his superiors in 1968 without knowledge of Oldendorf's work. They agreed to patent "a method and apparatus for examination of a body by radiation such as gamma radiation." Beyond that, EMI was hesitant to attempt any development of Hounsfield's idea. They would be competing with companies in the x-ray industry that had laboratory technology, manufacturing facilities, and vital access to hospitals.

Broadway was Hounsfield's boss for the first two years of the CAT project, but he had a difficult balancing act. He was expected to encourage research that would provide EMI with new marketable products, but he believed that real freedom of inquiry requires researchers to ignore commercial considerations at the outset and simply explore ideas that provoke their curiosity. Broadway indulged Hounsfield, his best explorer, as much as he could without incurring the displeasure of EMI's results-oriented management.

Broadway had enough background in the field of radiography to know that Hounsfield's idea had merit—as well as to foresee a mountain of technological problems. He also knew that Hounsfield, given time and money, could weave his dogged, ingenious way through any number of technical problems; Hounsfield is happy only when he has something to solve. "He worked on these problems with enormous dedication," Broadway said.

Broadway solved Hounsfield's initial money problem by acquiring an innovative research grant from a fund established by Sir John Read, EMI's chief executive officer. He also provided him with two key pieces of technology: a computer terminal for processing equations and an industrial radiography machine for generating signals. Equipment purchases and a few experiments used up the grant very quickly; EMI told Broadway to prove that Hounsfield could make a machine they could sell or else Hounsfield would have to go on to something else.

Hounsfield's biggest dilemma, after theory and technology had been worked out in his mind, was finding an audience that could even partly grasp what he was talking about and also see that it served some necessary purpose. Doctors, who needed this technology, didn't understand it. Physicists, who could understand it, didn't need it.

In the British medical establishment, the idea of moving another quantum leap forward from x-ray technology into computerized tomography unnerved many and appalled some. Hounsfield recalled, "A colleague and I visited several hospitals armed with our first laboratory test pictures, to assess likely sales possibilities. Some were mildly interested, but some of the teaching radiological hospitals were very conservative. Possibly because they were wedded to conventional x-ray technologies, some in the medical profession didn't see any advantages in the system. Despite the poor reaction, I maintained that we could sell at least twenty-five machines—because of the greater sensitivity it offered."

Dr. John Alfred Powell, the executive who eventually brought the CAT scanner to market, described one common reaction to his efforts to promote it among doctors in the U.K.: "One medical professor asked me, 'What's all this computer nonsense you're trying to bring into medicine? I've got no confidence at all in computers and I want nothing whatsoever to do with them!' He was seventy-four years old and retired, yet he consulted to several hospitals on technology." In essence, resistance to Hounsfield's notion was so pervasive in some quarters that only a shoestring-and-sealing-wax effort, as Hounsfield termed it, could have brought about the first CAT scanner.

The only possible outside source of financial support was the British Department of Health and Social Security (DHSS), an organization that contained both physicians and physicists. The first step was for Hounsfield to talk to Cliff Gregory, the DHSS official in charge of spending for experimental medicine. Hounsfield was poorly equipped to sell his idea to the skeptical Gregory.

Although Hounsfield could communicate with—and inspire—those with whom he worked closely, he was not a salesman by training or temperament, nor was he impressively pompous and professorial. "To meet him, you'd never classify him as a brilliant academic. He'd be the first to admit it," explained Powell. "He's extremely humble, but he has that certain genius touch to see problems before they arise. Many innovators are loners and have great difficulty communicating. It was frequently very difficult to extract all the information from someone like Godfrey and get it down on paper so that one could communicate effectively with others."

Dr. James Ambrose, the clinical radiologist who later teamed with Hounsfield to make the first CAT scans of the human brain, was astonished and outraged that DHSS was so generously subsidizing research ($2,220 a month) at a wealthy private corporation such as EMI. Ambrose, like many British doctors, had waged a lifelong war to get money from the tight-fisted DHSS.

In November 1972, Ambrose presented a paper on clinical experience with the first head scanner to a gathering of the Radiological Society of North America. The demonstration of the scanner's operation at the convention provided EMI with a breakthrough into the huge and wealthy American medical market. The moment was historic for EMI and for the future of medical computing. But for Hounsfield, the necessity of going to Chicago was a profound annoyance. Hounsfield intensely disliked going anywhere outside the Greenwich time zone. Powell recalled, "He wouldn't change the time on his watch. He wouldn't change his habits. In Chicago, he was seven hours ahead of everyone else."

After he had become a Nobel laureate for his CAT invention, Hounsfield received numerous invitations to hobnob with VIPs. He never adjusted to the stardom that his achievement thrust upon him, seemingly embarrassed by the acclaim. To characterize Hounsfield as an absent-minded professor is misleading, however. When he made his presentation to Gregory, he had already formed an intellectually unassailable image of his CAT concept. Through the network of medical specialists and physicists assembled by DHSS, Hounsfield had a wealth of precise, articulate responses to every challenge, every question. "Godfrey would look upon a problem from a practical point of view of how to solve it," Powell said. "He had what most people lack—an intuitive, practical mind, which he would apply to problem-solving."

An Intellect and Intuition Working in Harmony

Dr. Frank Doyle, a bone radiology specialist, was appointed by DHSS to review the concept before the department committed itself. Looking for flaws in his theory, Doyle discovered in Hounsfield a scientist whose intellect and intuition worked in harmony.

"Godfrey Hounsfield was a knight's move ahead of me at every turn," Doyle said. "Any objection I raised he had already thought about and had satisfied himself by calculations that it was not a serious problem. I reported that I could not fault any of Godfrey Hounsfield's ideas and could find no flaw in anything he said. His notion of computerized tomography was very much worth backing."[3]

Each of the DHSS examiners in turn found Hounsfield's idea almost impossible to understand and equally impossible to dismiss. Ambrose said, "What Hounsfield brought to DHSS was so revolutionary that I don't think anybody understood it. Gregory sent him along to a radiologist, Dr. Evan Lennon, who rang me up and said, 'I don't know what he's talking about. He's either a crackpot or a genius. Will you see him and listen to what he has to say?' "

In the course of his meetings, Hounsfield instilled in everyone a feeling that he could make a much better image than an x-ray. When Gregory suggested that Hounsfield should first concentrate on the brain, he seized on the idea eagerly. The head could be held steady for an indefinite period, and that solved the problem of the extended time exposure needed for the CAT scanner series of pictures.

"Hounsfield used to say to me, 'Problems! We've got to have problems! We thrive on problems!' " recalled Ambrose. The quality that inspired first the support of Broadway and then DHSS was this dauntless eagerness to tackle tribulation. Even with a destination clearly in view, Hounsfield would not be happy unless he got to travel every inch of every detour to get there.

For Hounsfield the theoretical conception of computerized tomography was indivisible from his mechanical vision of how to make it work. As he was building a hypothesis on one side of his brain, he was building a gadget on the other side. But his vision was not of some glistening steel and chrome and silicon marvel, because he could not afford steel, chrome, or silicon. He was limited to available resources, and when he started, those available resources—not counting his ingenuity and his persistence—added up to zero. He actually went ahead with construction before he got any money from DHSS to finance the first machine.

The basic ingredients of Hounsfield's first CAT scanner suggested the results of an expedition to a rummage sale. The foundation of the machine was an industrial lathe bed. He removed most of its moving parts, and in the center he mounted a rotating ten-inch plastic box. He filled the box with water and placed in it a number of metal fragments. On one side of the box he positioned a source that shot mildly radioactive gamma rays. On the other side he positioned a device to catch the radioactive rays—a simple scintillation counter. Hounsfield then harnessed the simple mechanics of the lathe to move the source and the scintillation counter back and forth in tiny steps past the box, which was rotated one degree each time the source passed it. As the scanner moved, the slender shafts of radiation were beamed through the **box,** giving readings at a succession of different angles.

Every time a gamma ray was released—always at a constant level—it was altered by the contents of the box, and that alteration became the reading on the scintillation counter. The counter was attached to a computer, which registered the radiation level that emerged in each exposure. By reading the radiation level from the counter, the computer recorded the change in radiation. The readings were stored until there were enough to produce a picture; only then could the computer calculate all the values and form them into a whole picture. The hoped-for result was a photograph of what the gamma rays had encountered in the box.

To form the whole picture, Hounsfield's first machine had to make 28,800 exposures, from which 24,000 picture points could be calculated. The gamma ray was a weak radiation source, and the machine ran slowly; each exposure lasted several seconds. Hounsfield's first scans—from the moment he began until the last reading was punched onto a paper tape—took nine days each. In comparison, the current generation of scanners can complete more than 115,000 picture points in less than a minute.

Still, Hounsfield had assembled from spare parts a system of memory storage and electronic computation so new that most computer experts were still catching up to it. It was a laughable contraption which no sensible person

	First-Generation CAT Scanner	**Today's CAT Scanner**
Image Absorption Volume	24,000 picture points	115,000 picture points
Rate	9 days	less than 1 minute

A Technological Leap

would have expected to work. Hounsfield, who had some pretensions to sensibleness himself, kept his own hopes in check. "It pays to be cautious," Hounsfield said. "You've got to be all the time not expecting success, so when it doesn't come, you don't get all depressed and in the dumps."

Once the nine days of scanning were over, another two and a half hours passed while the computer processed the readings and then assembled them as a picture on a monitor screen. A Polaroid photograph of the screen image became a permanent CAT scan record. It showed a visual slice of what was inside the box, exactly as Hounsfield had imagined it would. Variations in the density of the contents were shown as shades of white, black, and gray, which would not have been visible in normal x-ray photographs.

From that point, Hounsfield stayed always "a knight's move ahead." The problems that emerged had nothing to do with his concept: They were practical. For example, Hounsfield began to scan pig abdomens, which would decompose over the nine days. "Things rather deteriorated, and that changed the picture, of course," said Hounsfield. "But I was satisfied that I hadn't made a mistake."

Throughout 1970 Hounsfield reported exciting results, and he spent the carefully monitored money improving his prototype, switching from gamma to x-ray radiation. When he scanned heads of cattle, however, images of tissue were almost indistinguishable. Something was wrong. As it turned out, the first samples, obtained from a nonkosher slaughterhouse, had been killed by electric jolts or bullets to the head, and their brains had been scrambled—literally. Once kosher cattle, which are killed with a knife, were substituted, the brain scans came through vividly.

Scanning a Live Person

After Hounsfield's machine had seen through an array of inanimate objects and various animal brains, and had even reproduced in stunning detail a preserved slice of human brain, the only question remaining was whether it would succeed on a living person.

The location for the test was Atkinson Morley's Hospital, where Ambrose practiced neuroradiology out of a dimly lit office adjoining a cramped examination room, most of which was occupied by a CAT scanner. An almost instinctive kinship developed between the two men as they refined both the engineering and the medical integrity of the machine. Each became a student of the other's specialty. Oblivious and sometimes hostile to the concerns of the world around them, they focused in harmony on their singular invention.

About this time, Dr. Broadway retired and was succeeded by William Ingham, who was an enthusiastic supporter of Hounsfield's work and played a crucial role in helping it through the next phases of its evolution.

By the summer of 1971, DHSS was deeply committed to the CAT project. That year virtually the entire DHSS research and development budget (about $370,000) had gone to Hounsfield and Ambrose. To keep the project , going—even before the new prototype had been built and tested on a human subject—DHSS agreed to purchase the first five machines that EMI could build.

If the machines failed, both participants would lose a bundle. EMI, which after all was the record company for the Beatles, could cope with a setback of that magnitude if the company built the five machines by hand in Hounsfield's lab. DHSS officials like Gregory, accountable to politicians and taxpayers, faced far darker consequences if Hounsfield failed.

Hounsfield remained supremely confident. Finally, in the autumn of 1971, he and Ambrose had reduced the time to scan a human brain to several minutes. They were ready for a patient. The first was a woman who had been diagnosed as having a brain tumor. "We hoped to use the image," said Ambrose, "to determine whether the tumor was solid, cystic, necrotic, well-defined, or not." The woman had to lie on a flat couch. The circular scanning path of the machine surrounded her head, which was immobilized by a water bag through which the x-rays could pass without obstruction. When EMI publicist Colin Woodley was asked to describe this process, he compared it to "putting your head inside a washing machine."

Although that first scan took only a few minutes, the processing consumed the rest of the day and lingered into the night. The transfer of information from x-rays to magnetic tape, then from that to computer and back to tape again, to a tape deck and onto an oscilloscope screen, and finally to Polaroid film, was tedious.

When Hounsfield returned to Atkinson Morley's Hospital with the pictures for review by Ambrose and a group of surgeons, the reaction was explosive. "It was clear!" said Ambrose. "Her set of images told us there was a cystic tumor in the left frontal lobe. We couldn't have known that without surgery. Ambrose and Hounsfield "jumped up and down like football players who had just scored a winning goal."

The Prototype Was the Paradigm

Hounsfield was "rather pleased" but confessed, "My first reaction was that I was very worried, because I had this awful fear that we just happened to be lucky with that particular patient." Although Hounsfield fretted then whether the machine ever would work again and immediately began to think about the next, better CAT scanner, actually very little of the basic design has been improved since that prototype. One significant change was brought about by the advent of minicomputers. Within a year, they dramatically reduced the steps and the time required and also brought the information processing technology directly into the hospital beside the scanner.

Hounsfield had imagined the CAT as a whole before even picking up a screwdriver. He later applied a physician's openness to the medical contingencies and an engineer's practicality to the mechanics when he encountered problems in building it. Built in just fifteen months, Hounsfield's prototype left very little for him or a successor to fix. When EMI began to manufacture CAT scanners, they made almost exact copies of that screwed-and-glued-together first machine. The prototype was the paradigm. Recognizing that he couldn't build a better head machine, Hounsfield switched to a different part of the human subject—the body.

Head scans kept getting better and better, and it was clear that the five machines ordered by DHSS would perform as expected. Then Hounsfield expressed the nagging question: "I knew that somebody would want this," he said. "But how many? And who?"

At this point, EMI might have been expected to fade from the scene. The company had a sorry record of failing to exploit their own technological breakthroughs. EMI failed to pursue an early, superior television technology and profited little from the postwar TV explosion. Their researchers, with Hounsfield leading, built the first large, all-transistor computer in 1955, years ahead of any other company's technology. EMI built twenty-four large machines selling at $370,000 each. They were very successful until faster transistors curtailed their design life. But EMI hesitated to follow through to the next generation and so missed out on the computer revolution of the 1960s and 1970s.

American Attitudes Build a British Legacy

John Powell is a Briton with American attitudes. A physicist trained at Oxford, Powell came to EMI under the powerful wing of CEO Sir John Read. Powell had acquired an American style of aggressive management as director of Northern European Operations for Texas Instruments (TI). It was clear to the people at EMI that Read had given him authority to make waves. "One of my first assignments was to audit the technical resources and form some strategy of what to do with them," recalled Powell. "There was a tremendous amount of technology and talent at EMI, but it never went anywhere. It was devoted to too many things and dedicated to too few."

Powell sensed that managers at the top had indulged inventors—especially truly creative geniuses like Hounsfield—but had carried this indulgence only as far as the completion of a research goal. When the time came to get a broad corporate commitment to a new idea, the research director had no power to overrule senior managers loath to risk the company's profits on unproven technology. Indeed, if Broadway had not found outside help, the CAT scanner project would have been a memory before Powell arrived at EMI.

"EMI history was strewn with a lot of good ideas that never really got to the marketplace, or from which EMI never really profited," said Powell. "These bright ideas weren't properly supported or resourced, and no one seemed to have the drive, the enthusiasm to push forward."

Unlike Broadway, Powell had the clear support of Read; he also had a philosophy of technology management. TI's early success in the semiconductor industry inspired him. Powell hoped to find at least one technology that was new, one that he could build from obscurity and use as EMI's foundation for technological dominance. The CAT scanner was made to order for Powell's master plan, and Hounsfield was the sort of driven personality whom Powell had learned early in his career to admire—the sort of person he could bet his shirt on.

"If the CAT scanner was successful, here was an opportunity of building up electronics," said Powell. "Above all else, medical or what have you, it was an electronics business. I was looking for ideas to rejuvenate electronics at EMI."

One of Powell's first perceptions was that the CAT market was much larger than anyone had imagined. An American salesman at heart, he knew he could make it even bigger. Without that aggressive approach, CAT technology would have gone to other companies much earlier. Because of the potential fortune to be made, competing companies much bigger than EMI would have launched major research efforts and within several years would have had their own machines on the market. It would not matter to them that these might violate a patent, because by the time litigation was ended, the competition would have driven EMI from the market. The financial penalty eventually paid for patent infringements would be a pittance compared to the interim financial gain.

Powell was EMI's best, last hope, but even he might have passed over the technology if he had not seen it in the fulfillment of a personal goal. Hounsfield was the problemsolver in the breakthrough, Powell the legacy-builder. He had been happy at TI, and he left only because he saw an opportunity to build a new organization in his own image. Powell wanted to leave his mark.

"To be absolutely frank," said Powell, "management at EMI was appalling. I had come from a company where management was a culture throughout the organization. TI rarely went outside for managers—they bred their own. There was no such thing at EMI. Everybody seemed to be on the defensive, concerned with protecting what they had rather than branching out to make something of it. I tried to inculcate the same culture I had seen at TI. I thought the only way to do this was with a new product, building up a management team with that, and gradually convert the whole electronics group and eventually other operations. The major evolutionary vehicle was going to be the CAT scanner."

Powell succeeded and then failed. "To do what I wanted to do, you need disciples. I didn't have enough disciples."

Resistance from Managers, Enthusiasm from Physicians

The resistance of EMI managers who were not sympathetic to this Texanized go-getter left him fending for himself when the CAT scanner faced a crisis in the marketplace late in the 1970s. Nevertheless, at the very moment that the machine was emerging from its first successful trial, Powell gave Hounsfield precisely what he needed—someplace to go. That someplace had always been a mystery to the marketing executives in EMI electronics. To the benefit of both Hounsfield and EMI, Powell managed the two functions that the company typically ruined—marketing and manufacturing.

As research director, Broadway had proposed a cautious marketing approach. He said that EMI should spread this new technology among a number of original equipment manufacturers and reap the benefits from license fees and rapid, widespread production by those companies. "I advised granting nonexclusive patent licenses to overseas companies such as General Electric, Westinghouse, and Varian Associates," Broadway said, "since I felt that EMI would find it difficult to compete with the enormous technical and commercial resources available to them."[4]

It seemed sensible in light of EMI's weak manufacturing base, but this course failed to fulfill a key criterion for Powell: establishing EMI's name as an international leader in medical electronics. Without that infusion of prestige, Powell's agenda of assembling disciples and rebuilding the management structure would remain unrealized. Powell convinced EMI's board that this was an opportunity too big to ignore. The size of EMI's competitors, he maintained, was as much a hindrance to their successful development of the CAT scanner as it was an advantage.

"What do these big ones have that gives them this so-called virtue of being able to seize on breakthroughs and make them commercially successful?" asked Powell. "There's nothing that suggests they will succeed—the probability is that the right small company will be far more successful. My experiences with Texas Instruments persuaded me that EMI ought to be able to do this."

He counseled going it alone, and EMI did what they were unaccustomed to doing: they took a chance. The financial commitment was astounding for EMI—£6 million (about $9 million).

Powell got his way, but some held grudges that would haunt him for more than a decade. In the meantime, his gamble worked, although not as well as he had hoped. The most efficient aspect was the marketing of the CAT scanner, which rested on Powell's belief that, unlike the conservative British medical establishment, U.S. doctors, who can always be confident that private medical insurers will foot the bill, would welcome the new technology.

Powell understood America. Of the first five scanners ordered by DHSS, Powell made certain that two went to prestigious American hospitals: the Mayo Clinic in Rochester and Massachusetts General Hospital in Boston.

"It was after the scanners had been installed at Mayo and Mass General that the message started creeping across the U.S. of what it was all about," Powell recalled. "I went to New York and asked a group of consultants and radiologists, 'How many of these do you think we could sell in the States over the next couple of years?' The first guess was five every year. Someone else said, 'Oh, more than that!' And the numbers just went up and up and up. In the last guess, it exceeded a thousand per year."

The marketing campaign, managed by Woodley, began with a press conference in April 1972, following a presentation by Ambrose and Hounsfield at the British Radiological Society. "They were flabbergasted," said Ambrose. The presentation created an international grapevine tremor among radiologists, so when Hounsfield went to New York that summer for a series of neuroradiology lectures, participants there were in a state of tense anticipation. Few had seen either his astonishing results or the scanners' technical specifications, which Powell and Woodley did not release until August.

Hounsfield was overwhelmed. "I more or less sold the first dozen machines that day," he recalled, his voice conveying disbelief at such a hero's reception. "Just for showing pictures! Then they began coming all the way to England, to see pictures."

The stage was set for the biggest radiological event of the year, the Radiological Society of North America's annual meeting in Chicago that November. Orders for scanners proliferated with the publication of the technical specifications. There was a year's worth of clinical experience to draw on and hundreds of pictures to show—and Woodley's advance publicity work had excited everyone's interest. Ambrose presented his paper and brought the house down. They cheered, they stood, and they applauded; they loved it.

Laboratories Become Factories

Hospitals throughout North America, as well as in Japan and Germany and a handful of other nations, wanted scanners as soon as possible. It was not easy to get one, since EMI was going to build them on its own. EMI took orders, demanded big down payments to finance work in progress, and told customers to wait six months, none of which deterred them. Meanwhile, a makeshift assembly operation lurched into being. "The laboratories had to become, in part, a factory," said Woodley. "It was totally alien to their normal function, but it had to be done that way. We were still fixing little things here and there."

Powell complains to this day that the shortage of industrial engineers hindered the assembly setup. But the functions of the plant evolved as a number of assemblers, each working on several machines—with different bugs in each machine—attained a highly erratic but ongoing output. As more orders came in, more assemblers joined the team, and the engineers learned by doing. In the midst of all this, Hounsfield ranged about like a worried teacher at a kindergarten class show.

"The plant had to be close to CRL so we could tap the brain of Godfrey Hounsfield," said Powell. "He was absolutely essential. No one else understood it in its entirety. This unavoidably had its drawbacks. Godfrey could get terribly frustrated when simple mistakes were not immediately spotted and rectified. He'd complain to me. I'd say, 'Godfrey, you've been working on this for years and you know it inside out. But what about this poor guy? He's never seen one before.' "

Whatever the difficulties, Powell's go-it-alone approach was unquestionably an enormous short-term success. In five years the medical electronics group went from a net loss to producing 20 percent of EMI's total £75 million (about $113 million) profit for 1977. From 1972 through 1977, EMI sold 704 CAT scanners, at prices between $300,000 and $1 million each; by 1977 there were 1,130 scanners in the world. "There was a feeling around here that it could not lose money," said Woodley. "But it really would have been beyond peoples' wildest dreams at that time to forecast this sort of success."

Dropping the Baton

Success lasted through much of the 1970s, then dramatically reversed. In 1975, in another demonstration before an audience of radiologists, Hounsfield showed the first pictures produced in a whole-body CAT scan. This was intended to trigger EMI's production of body scan machines, and Powell pushed for production facilities in the United States, where the market would be greater than the rest of the world combined.

But Powell's plans ran into a series of troubles, each magnifying the previous one. In five years EMI went from being a profitable manufacturer of scanning equipment to a company that was losing so much money on its considerably expanded medical electronics activities that it had to stop because it couldn't generate the funds necessary to continue essential development. By coincidence, a worldwide recession in the recorded music business cut off any possibility of help from that usually healthy sector of the company's operations.

Many of the problems with the American facility were beyond Powell's control. A medical cost-containment drive by the Carter Administration used the costly body scanner as a symbolic whipping boy. Design problems also delayed the start of U.S. production more than a year. EMI was feeling twin pressures—losses from the drastic downturn in the music industry and the expensive creation of the American plant with no projections of when production could start. Now the company was truly alone.

And within EMI Powell was alone. His U.S. production plan had followed logically on his successful marketing focus. To supervise American production, he hired his former TI mentor, Norman Provost. Sure that Provost would be the ideal leader, Powell pinned all his hopes for the North American strategy on him. But in May 1976, as Powell and Provost were drawing up plans for the U.S. facility, Powell had a call from the hotel saying that Provost was dead of a heart attack. "That really set us back an awful lot," said Powell, "it took us ages to find anybody with comparable experience and caliber to go forward with the programs we had set.

"We suffered many delays, and I could find no way of overcoming them rapidly. The whole growing-up of the scanner business and the organization was a hothouse.

There weren't enough people in EMI to do this, so we had to recruit outside since we were spreading all over the world. It was as if one had grown in a hothouse a long slender stalk whose roots were not properly developed. It was bound to be fragile, in terms of human relationships, organizations, culture—everything. Consequently, a setback like that is pretty devastating."[5]

In 1980, after three years of losses, EMI announced its complete withdrawal from the medical electronics industry. All its interests outside the U.S. went to General Electric. In the last year of operations, EMI medical electronics lost £13 million (more than $19 million).

One observation expresses a more positive result. It goes back to the ambition for less traumatic x-ray technology. "Later on, visiting hospitals and seeing kids at the age of mine diagnosed by a technique infinitely less intrusive than would have been the case otherwise—that was the greatest satisfaction for me," said Woodley. "I hoped I might become involved again in something which is technologically as much a breakthrough, but also would have the same terrific social advantage. I'd be very lucky to find . that lightning striking again."

In analyzing EMI's dramatic rise and fall with the CAT scanner, it is easy to forget the impact of Hounsfield's breakthrough. Hounsfield had turned an almost unbelievable theory into practice, and had done so on the first try. The theory of tomography—seeing inside the body in two-dimensional slices—dated all the way back to 1917 and the work of an Austrian mathematician named Johann Radon. Oldendorf followed with his work in the 1960s, and a decade later, physicist Allan McLod Cormack was pursuing parallel research. When the 1979 Nobel prize for Physiology/Medicine was handed out for the CAT scanner, Hounsfield and Cormack shared the award.

However, Ambrose was both loyal and correct when he said that Hounsfield was the prime mover. The breakthrough for computer tomography was not the statement of a theory, not the development of mathematical computations that verified the possibilities. The breakthrough was, in Hounsfield's plain words, the creation of a product, a thing that worked. "I had a lot of experience before I came into research, on the practical side," he explained. "Designing computers, I'd already got the idea that if you are in research, you're here to eventually produce a product. You may do research to understand things, but this is wasted commercially if you don't come up with a useful product."

Just One More Thing

That attitude sets Hounsfield apart from theoreticians who might have understood the idea of tomography better than he did. Hounsfield was neither a physicist nor a radiologist, but a computer designer more practically advanced in the abstruse realm of pattern recognitions than most people. The creation of the machine itself required, above all, a gifted engineer unhindered by preconceptions. Hounsfield was expert in computer design, development of complex software algorithms, and x-ray detection devices. He possessed an intuition that led him, with an economy of effort, directly to the source of problems. Because he was also an expert mechanic, Hounsfield never felt that a machine was complete—there was always something one could do to improve it. This sense of the unfinished conveyed both intensity and humility.

Powell was in attendance when Hounsfield presented the first results of his work on a whole-body scanner. The occasion—which Powell described as "typical Hounsfield"—was an exercise in self-deprecation. To the world's foremost radiologists, Hounsfield was showing the first CAT "slices" exposed fast enough to see inside the human body without blurring. The body on display was his own. In order to get the photos, he had lain perfectly still, holding his breath and working the scanner's controls. Photo after photo, as the crowd murmured with amazement at the clarity of the images, Hounsfield kept saying, "Well, this one isn't very good."

Finally, after a series of "not very good" pictures, which nevertheless awed the radiologists, Hounsfield put his *piece de resistance* onto the screen: It was a perfectly exposed brightly contrasted portrait of his internal organs—a slice of the inventor. "Now this one," he said, "I'm rather pleased with."

"It was brilliant!" recalled Powell. "People couldn't control themselves any longer. They stood up and began to cheer. He absolutely shattered the place. People had never seen anything like this—they had never expected to see anything like this."

Hounsfield's self-deprecation, his dissatisfaction with those pictures, was genuine. There was too much yet to do with the body scanner for him to be satisfied. It nagged at him, an unfinished problem turning constantly in his mind. There was always "just one more little thing" before he could declare the job finished.

Today, Hounsfield is described as semiretired, but he does not accept the description. He has certainly not settled into tranquil, laureled repose.

If Hounsfield had not opened people's eyes to the union of computer pattern recognition and medical imaging, the leap from x-ray negatives probably might never have been made. In him alone were combined the mind of a mathematician, the wits of a puzzle-player, and the hands of a builder. Woodley noted that "Hounsfield's unique experience" contained all the ingredients necessary to give birth to CAT-scanner technology. But to keep it going all the way to the marketplace, there were two other keys to the breakthrough. One was Powell's ego, the force that moved the CAT scanner from the scrutiny of a handful of researchers and doctors to the broad gaze of the market-place. The other element was a chronic restlessness that Powell saw in Hounsfield; he knew that, however far-fetched the technology, here was someone who would tinker with something until it worked. And every time the thing seemed to work well enough to please almost every-one else, Hounsfield could always find a reason to keep on tinkering.

Woodley recalled the triumphant moment for the the-ory of computer tomography. EMI had stunned the Radio-logical Society of North America with Hounsfield's head scan. The company's hospitality suite was a traffic jam. EMI representatives received repeated toasts and tributes from the world's foremost radiologists. Sales were prom-ised, phone numbers exchanged. In all the noise and cele-bration, Woodley hadn't noticed Hounsfield at all.

"Finally," said Woodley, "I found him in a corner, scribbling away on the back of an envelope. I asked what he was up to. He said he was working. I said, 'What in the world could you be working on?' Hounsfield said, 'On the body scanner, of course.' "

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THE MICROWAVE OVEN: 'TIS BLACK MAGIC!

The last chance for the world to see the microwave oven as an American invention came at a 1965 meeting at the headquarters of the Raytheon Company in Lexington, Massachusetts. No one at that meeting knew that a number of Japanese companies were on the verge of breakthroughs that would move the sluggish microwave-oven industry from a limited professional market into millions of middle-class kitchens.

Raytheon had given birth to the microwave oven in 1946, then within a few years had all but orphaned it. The microwave oven was a consumer product trapped within a company that didn't make consumer products. Raytheon was a member in excellent standing of what U.S. President Dwight D. Eisenhower called the *military-industrial complex;* its lifeblood was government contracts. Compared to Raytheon's two proudest products at the time, the Hawk and the Sparrow guided missiles, the Radarange oven was a comic oddity.

Similarly, the key person in that meeting must have seemed a comic oddity to the managers of Raytheon: George Foerstner, the manager and founder of Amana Refrigeration, Inc., of Amana, Iowa, was a perplexing blend of traits. Scoffing openly at the costly, impractical ways of Raytheon, Foerstner attended only because

Raytheon's President, Thomas L. Phillips, had cajoled him for weeks, but Foerstner was really a captive audience. Raytheon had recently bought Amana, largely to revive the dying microwave project. After almost twenty years of fiddling around with microwave ovens at Raytheon, Chairman Charles F. Adams had laid out an ultimatum: "We'd give it one shot," he said, "and if it didn't work, then we'd forget it once and for all."

For Adams, that was a difficult ultimatum. Because consumer products presented such a contrast to Raytheon's stock in trade, they held a soft spot in his heart. Raytheon wanted a consumer success, but so far all of its efforts had failed. "We had to prove we knew how to make something out of this technology," said Adams. The company had tried time and again to crack the consumer market, but they had failed with transistor radios and television sets. Their microwave oven—with losses of more than $5 million—threatened to become the biggest consumer failure in their history.

Foerstner had been strongly inclined to put an end to it before he got involved in "one last shot," but he had agreed to consider the machine's potential. Palmer Derby, a Raytheon vice president, related that when he asked what the oven should cost, "George said, 'It's about the same size as an air conditioner. It weighs about the same. It should sell for the same—$499.' Now you think that's silly, but stop and think about it. He really didn't understand technology, but there is about the same amount of copper and steel as in an air conditioner. It didn't make a lot of difference how the final products work—they're both boxes made out of sheet metal, and they both require some kind of trim." Foerstner had reduced microwave radar—one of the greatest military secrets of World War II, a technology twenty years in development by armies of researchers—to the level of an air conditioner. But he had seen something all the researchers had failed to see: The microwave oven had to compete with other household appliances.

Besides Amana's impeccable reputation for quality in the appliance industry, Foerstner brought to the project his own personality. He had elevated salesmanship to the level of genius: Any product Foerstner decided to take under his wing was guaranteed to sell. Amana's Radarange was destined to cook as Raytheon's never had.

Frontlines to the Home Front

Microwave technology had been developed in Great Britain. A group of British scientists devised the pulsed-type microwave magnetron for radar use in 1939, and radar eventually turned the Battle of Britain against Germany. Until radar began to spot German aircraft crossing the English Channel, the Royal Air Force had to depend on human ground spotters. Night attacks were devastating; without radar to see through the darkness and launch an early counterattack, England might have succumbed. Among the American firms the British government invited to help produce the vital and ultrasecret magnetrons was Raytheon.

After the end of the war, most companies stopped making magnetrons because of the sudden cutback in military orders; but at Raytheon, an old-fashioned inventor named Percy Spencer kept fooling around with them, thinking of other uses.

When he came to Raytheon, Spencer had no more formal education than the average nomadic laborer looking for a job. Hired as an inspector in 1925, he did not have an aura of genius. No matter how many times he impressed people with bursts of brilliance, each time they would look at him in disbelief. Otto Scott recorded a typical Spencer encounter with the academic world:

> One day, while Spencer was lunching with several Raytheon scientists, a mathematical question arose. Several men, in a familiar reflex, pulled out their slide rules, but before any could complete the equation, Spencer gave the answer. "How did you do that?" he was asked. "The root," said Spencer. "I learned cube roots and squares by using blocks as a boy. Since then, all I have to do is visualize them placed together."[1]

Similarly, within a few months of his association with the technology, Spencer had imagined using microwaves for cooking.

Restless and vigilant, Spencer prowled Raytheon's Waltham, Massachusetts, plant; it was a huge room where women with sons and husbands overseas assembled magnetrons. Raytheon managers remembered him as a cauldron of curiosity, a wild-eyed inventor whose mind always bubbled with mechanical ingenuity. But Spencer also carried the insecurity of a rank-and-file worker who had uneasily moved into management, so he applied a fanatical intensity to the oversight of his assembly workers. He was the first person to arrive at the plant and one of the last to leave, proving a point to his blue-collar peers that probably few of them appreciated, that hard work and discipline were more important to advancement than genius, education, or talent. His combination of genius and hard work attracted the attention of Charles Adams, first as a colleague and then as a good friend.

To some extent, his devotion to that philosophy diverted him from his own talent. By the early 1960s, as a vice president, he departed from the assembly floor forever. Although he often performed brilliantly as a leader, unquestionably he had left behind a greater brilliance. Had

Spencer remained closer to the workbench, he would have very likely worked to improve the microwave oven. The reinvention of the magnetron would have to await a jigsaw genius thousands of miles from Waltham.

Today, given the health concerns about microwave radiation and the volumes of Occupational Safety and Health Administration regulations, microwave cooking would never have been envisioned. "In those days we weren't concerned about microwave radiation," said Derby, who recalled that workers warmed their hands on magnetrons in the chilly plant. "In testing the bulbs, it was quite obvious that your hands got hot. I don't know when Percy really thought of the microwave oven, but he mentioned frequently at that time that this would be a good device for cooking."

In the corporate push for production, the cooking idea could only linger in casual conversation. But it became much more feasible, and tempting, in 1944, when Derby found a way to make a continuous-power magnetron to replace the older pulsing type. Spencer knew then that cooking with magnetrons was possible, but when he broached the idea, he was told it would have to wait until the war was over.

With the end of the war, however, the American magnetron industry suddenly ceased to exist. "The day the war ended, the factory closed. Boom! That was it," Derby remembered. For Spencer, Derby, and other engineers at Raytheon, that meant that they finally had time to tinker with cooking.

They set up a fairly strong power tube (300-500 watts), and one of them held a bag of popcorn in front of the wave guide. "The popcorn began to jump all over hell," said Derby. The engineers next tried a pork chop. Not only did it cook, but someone even had the courage to eat it. After a few dozen more tests, it was time to show off the thing to the board of directors. Spencer could have chosen any number of demonstration foods, but he opted for one that would leave an indelible impression: an egg.

"Percy put an egg on the pedestal," Derby recalled. "Then the wave guide pumped a kilowatt of energy into it. There's only one thing that could have happened—all over everybody!" Spencer had won his point. After they cleaned themselves off, the board agreed to put some money into microwave cooking. Although it was a pittance compared to what they might spend on a guided missile, $5 million over seven to ten years was an extravagant sum for Raytheon to spend on a consumer product.

Money Down a Rat Hole

After the first patent in 1949, the technology evolved with painful slowness. By 1953, Raytheon had a Radarange oven on the market, and they soon licensed the technology to two other companies whose names have since become more closely identified with microwave cooking: Tappan and Litton. In 1955, Tappan began selling a home-use microwave oven for $1,295, which was more than the cost of several models of automobiles then.

Aside from the price, those early microwave ovens had other glaring flaws. Most were almost as large and heavy as a refrigerator; operating at 220 volts, they couldn't be plugged into most American wall outlets without the help of an electrician. They also required a plumber, because the power tube was water-cooled to keep it from overheating: installation required an entire new set of pipes.

Between 1953 and 1967, fewer than 10,000 microwave ovens were sold in the United States. Almost all went to such institutional users as restaurants and airlines. The biggest customer for the technology was not in America at all; it was the Japanese National Railroad, which installed in its trains 2,500 microwave ovens made by Toshiba. Today almost everyone at Raytheon who remembers that time admits that the company's efforts to market microwave cooking were thoroughly incompetent. One Raytheon physicist was blunt: "We didn't have the foggiest idea of how to market them and we knew it. We were pouring money into a rat hole."

By the end of the 1950s, Raytheon's continued support of the Radarange was obviously senseless; without the support of Charles Adams, the project might have died. The technology had diverged drastically from Raytheon's mainstream business. The cooking magnetron had become so specialized that it could not be adapted to any other use. It was a dead end that for years failed to make money, an oddball item that clashed with the Raytheon image. Yet as things looked worse and worse for the Radarange, Adams, a responsible corporate official, seemed ever more devoted.

While Adams continued to indulge the Radarange, a different microwave technology that was also developed at Raytheon lived and died without a ripple of interest from either industry or the public. Adams failed to heed that warning, too. Meanwhile, microwave research at MIT, Columbia, and Bell Laboratories also died out. When microwave cooking first appeared in Japan, however, Japanese consumer electronics companies seized on it as a promising area of development. While America slept, the sun was dawning in the East.

A New Beginning in Japan

In Japan, as in the United States, the main problem for microwave oven development was finding a magnetron source. By 1960, the only one left was New Japan Radio Company (NJRC). In modest ways, NJRC had made greater progress in developing nonmilitary uses for magnetrons than Raytheon. Since NJRC had been banned by American occupation laws from military work, the focus of their research was on civilian communications and medical heat therapy. Shortages of raw materials, especially metals, had forced them to look for ways to make magnetrons from cheaper materials.

After Raytheon demonstrated a restaurant model oven at a 1960 trade show, Japanese companies began building copies, using NJRC's magnetrons as the heat source. But that original NJRC oven tube was not primarily designed for cooking. The problem that everyone always had, from Raytheon to Litton to NJRC, was the intricacy of that power tube. To make one at all was a technological challenge beyond the powers of many electronics laboratories and far beyond the capacity of most. To make one cheaply was regarded as impossible.

NJRC, however, needed to do it. Yoshihiko Sato, manager of NJRC's operation, recalled, "We believed that if the size of the microwave oven stayed the same, it wouldn't be well accepted by the Japanese people. But then Sanyo decided to invest in manufacturing microwave ovens for the Japanese market, and they came to an agreement that we do research here and develop low-cost magnetrons."

One critical element also accelerated Japanese interest in the microwave oven while it languished in America. Adams plainly expressed the problem: "Everyone in the United States wants to eat steak, and steak was the only thing you couldn't do in a microwave oven."

Researchers at Toshiba noted that by comparison two staples of the Japanese diet, rice and sake, are ideally suited to reheating in the microwave oven. If both could be heated perfectly in single servings, without stealing time and cooking surfaces from other more complicated foods, the crowded, hectic nature of Japanese life would be reduced dramatically. Based on heating those basic items, Japanese appliance makers felt that microwave cooking would have an immediate appeal. They suffered few of the marked misgivings that had plagued America and Raytheon.

Toshiba had no more talent available to redesign the power tube than any other electronics company. No one knew magnetrons better than Raytheon and NJRC, and by 1961 those two companies were linked. In a series of international acquisitions, Raytheon obtained a one-third interest in NJRC. From this merger, NJRC got complete access to Raytheon's designs, and Raytheon would eventually reap the genius of Keishi Ogura.

A Fresh Approach

NJRC assigned Ogura the intimidating job of improving Raytheon's magnetron. To make an affordable cooking model, he had to do what Spencer had done with the military version: disregard the elements of the past to focus on the functions of the present. He must try to make the first magnetron in history that contained no memory of the Battle of Britain.

Before he began, Ogura paused to envision every problem that had been built into the Raytheon magnetron. Most observers had not regarded these as problems at all, but as features. They saw a final achievement to which only incremental improvements might be made, but Ogura saw a web of problems that required him to start afresh at the very beginning.

"The magnetron was poorly understood, despite the academics," said John Osepchuk, a Raytheon engineer. "Most manufacturers made the things work by hook or by crook. Fairly often, the professors from MIT and Stanford couldn't answer the question, 'What's causing this?' New Japan Radio found ways that minimized a lot of these problems. They came up with a design that turned out to be almost ideal, in terms of performance. All microwave ovens today still have the same basic design parameters as that [New] Japan Radio tube."

Ogura said, "The policy we had then was to design a low-cost product that was easy to make. So the design had to be as simple as possible and at the same time achieve high-efficiency, stable performance. These objectives to some extent may contradict each other. My biggest goal was to try to fit all these characteristics into one system. A lot of trade-offs had to be made."

Ogura responded to Edison's admonition: "All parts of the system must be constructed with reference to all other parts of the system." In one "magnificent design," as Sato called it, Ogura accomplished the following:

- Higher technical sophistication than ever before
- Design simplicity for easy service
- Ease of manufacture
- No improvements in technology that would add cost
- Greater performance stability
- A reduction in material costs (because of entirely different materials that were cheaper but better)
- Longer tube life
- Instantaneous heating

- An electric voltage requirement suitable to the average home, both in Japan and in the United States
- Much greater energy efficiency.

Ogura never wrote down this list of requirements. He shared a special kind of creative perception with many other inventors—an awareness that standard practice and accepted theory would only hinder his work—so he gave them little attention. Ogura understood his goal and saw it three-dimensionally without writing everything down in advance; he resolved the details of assembly as he built the prototype.

Behind it all, Ogura (like Edison) focused not only on understanding how things work but also on the product that must emerge from that understanding. Sato expressed this purpose: "We all, especially Mr. Ogura, felt strongly that we had to bring the technology down to an ordinary level, in order to popularize microwave ovens."

Curiously, Ogura's breakthrough was not greeted with shouts of exultation in the United States. Although Raytheon had never expressly asked their Japanese partner to work on a new cooking magnetron, by 1964 Ogura's product was finished, and Japanese manufacturers began development of a compact microwave oven for home use two years before Tom Phillips of Raytheon talked George Foerstner into doing it at Amana. No one knew it yet, but time was running out in the United States.

Strange Bedfellows

Technically, Raytheon and Amana were an ideal match. Raytheon brought to the appliance company an advanced technology—a working oven already tested, proven, and sold, with several remarkable elements that would never have emerged from an appliance company. In 1965

Raytheon could also add Ogura's magnetron design to the concept. Amana provided the military contractor an intimate familiarity with consumer attitudes and a distribution capability foreign to Raytheon. Culturally speaking, however, these were two very strange bedfellows.

Raytheon was Eastern establishment; Amana was a Midwestern outsider. And Amana's differences from Raytheon were more than just regional. Founded in 1934, Amana Refrigeration is the largest employer in a cluster of seven Iowa villages which make up the Amana Colonies, a community which until 1931 was entirely controlled by its church. Members belonged to the Society of True Inspiration, a religious sect born in the seventeenth century as a splinter group of the Lutheran Church. People were expected to worship long and hard every day, aside from doing work dedicated to a doctrinaire communalist ideal. Children were educated to the age of thirteen and then put to work. The theocracy of the Amana Colonies did not substantially erode until social pressures cracked their isolation. People wanted possessions of their own; they wanted time away from work and worship. Some wanted electricity, radios, and an advanced education. Also, with a community debt of almost $500,000, the Amana Colonies were almost broke by 1931. The church restricted its control to religious matters, and Amana edged toward the mainstream.[2]

What remained was an intense sense of community and purpose—an atmosphere that defined the character of George Foerstner. As a salesman for his father's auto accessory business, Foerstner often tinkered with machines; his interest turned to refrigeration, an almost nonexistent technology in the 1930s. He realized that rather than fixing iceboxes, he could build a better one from scratch, which he did.

By 1934 he was selling his own line of hand-built beer coolers. In 1936 Foerstner sold that business to the managers of the Amana Society, who had the good sense to tell him to keep running it. Foerstner and a consortium of eastern Iowa business people bought back the firm in 1949; fifteen years later, with sales at $25 million, Foerstner had Amana Refrigeration primed for another merger, this time with Raytheon. For Thomas Phillips, the central purpose of the merger was the microwave oven. Foerstner, who knew the oven's pathetic history and was also concerned about his company's suitability to manufacture a cooking rather than refrigeration appliance, played hard to get.

Meeting the Price

Nevertheless, from the moment that Foerstner, "in that dictatorial voice that knew the answer to everything," announced the shape and price of the microwave oven, the technology shifted from New England to Iowa and the new Radarange oven took shape. But the people involved in magnetron production at Raytheon faced a difficult demand. To meet Foerstner's recommended price, they needed a magnetron that cost less than $25 to make. In more than ten years, the cheapest magnetron Raytheon had made cost $125.

Raytheon never resolved that dilemma; what they did was buy enough of Ogura's newly designed magnetrons and copy them at the old Waltham plant. American development nevertheless continued to trail that of the Japanese, and by the 1980s, no U.S. company was making cooking magnetrons—all were imported from Japan or Korea. Ironically, NJRC also halted cooking magnetron production by 1980. They were unable to compete with volume producers like Toshiba, who had pulled the price down to as low as $7.

The job of handling the transition of the Radarange from Raytheon to Amana went to George Foerstner's son Richard, a mechanical engineer who created an inexpensive, compact chassis. After the intricacies of refrigeration, this little oven seemed terrifyingly simple. The key to the fast development of the countertop microwave oven at Amana was born out of the mechanic's imperative that Foerstner shared with Ogura; making it work was more important than simply understanding how it worked.

While his son was recreating the design and the Amana manufacturing facilities were gearing up, Foerstner expressed the real challenge facing the Radarange: "No matter how technologically exciting a thing is, it's not going to sell until you can convince consumers that they need it. And if you can't find or produce that market need, you'd better throw the damn thing away," he said.

First, You Get the Mule's Attention

Finding that market need was Foerstner's favorite sport. When he demanded a $500 price ceiling, he didn't know or care that it was impossible technologically. He didn't pay much attention to his son's design work, except to complain about how slow it was. George Foerstner saw the market, and he wanted to get at it.

Two years passed before Amana was ready to test the new Radarange in the market. By then—although this was essentially unknown in America—Sharp had introduced in Japan the first functional countertop microwave oven for home use. Like the Radarange, it was based on Ogura's magnetron design.

If anyone had told George Foerstner about the Sharp oven, he would have said he didn't give a damn. Anyone with the temerity to suggest that Amana had no evidence of its market would have received the same answer. Foerstner had little respect for the science of marketing; he believed in his gut feeling, not in demographics and research. "George is one of the most stubborn men who's ever lived," Charles Adams said. "It's a little hard to talk to George in his field."

Once Amana consented to develop Raytheon's Radarange, the program relied on Foerstner's confidence. And George knew how to sell. Years before, Amana had pioneered the market for home freezers, eventually wiping out the cold-storage-locker industry, not by selling freezers (big, dull, and expensive), but by selling wholesale food door-to-door. Once people bought the food, at prices that were cheaper and in amounts that were larger than they'd ever experienced before, they needed someplace to store it.

Besides the idea of how to approach an untested market, Foerstner possessed the unmitigated gall that typifies the true salesman: He knew that sometimes the best approach is to make the presentation impossible to ignore. Foerstner's fundamental marketing principle is, "First, you get the mule's attention." Wayne Giddings, one of the people responsible for the Radarange market push, recalled one of Foerstner's performances at a trade show. "He said, 'we build 'em strong!' and he walked up to the freezer and climbed onto the top of the door—like a ladder. We were afraid the whole unit was going to topple forward and kill him. So we ran over and grabbed it."

Testing the Market

With the microwave oven, Amana was again going to sell a function, not a product, and by 1967 they were better equipped to do this than they had been for the freezer campaign. Still, everyone knew that it was not going to be easy. "We knew by talking to our distributors and dealers, even talking to people in the company, that the educational job we had to do was absolutely astronomical," said Amana Chairman Alex Meyer. "We had to educate people on how to change their way of cooking. And when you go into a home and try to tell people to change their way of cooking, you have a problem."

Foerstner's response was an all-out push in Chicago as a one-year test market for the Radarange. The features of the campaign were a combination of showmanship, impeccable organization, and relentless education. The first thing Foerstner did was educate wholesalers and retailers to the full range of the Radarange oven's capabilities. Everyone who sold one had to be able to demonstrate it; Foerstner made it clear that if they couldn't do that, they weren't going to sell any of them.

Although Foerstner talks a great deal about housewives, it is clear that they were a secondary market in the Radarange push; the primary market was appliance distributors. "Distributors," Foerstner said, "are the first line of defense. The secret in obtaining and keeping good distributors is to appeal to their selfishness. They must be able to make enough money handling your appliances to abandon everyone else's line and switch to yours. Any other appeal is a waste of time."[3]

Foerstner's troops told the distributors that the most important element of their program was to understand housewives, calm their fears, and simplify the instruction manual. "The housewife didn't understand it," said Meyer. "It was too technical. She didn't understand that we were stirring these molecules 2,450 times per second. She didn't understand that the friction of the molecules was the source of heat. There are no flames. There is no electric heating element. It was a little scary. So we had to eliminate that aspect and make it very practical. Cook a steak, pop popcorn, do the coffee, take a plastic pouch of vegetables from the freezer to the microwave and prepare a meal. Make it convenient; reheat meals when everybody's in a hurry and eating at three or four different times."

After the distributors had been exhaustively grounded in microwave cooking and in the psychology of homemakers, and then pep-talked into a mercantile frenzy, Amana turned up the emotional heat with an impressive press party, making sure all the distributors, retailers, and salesmen were in attendance. Demonstrations were perpetual and amusing. "One of the great things in our presentations," said Meyer, "was that we kept their attention by giving them popcorn. They would wait for the popcorn to pop. They'd watch the molecular disturbance and the bursting of the popcorn. They would smell and hear it popping. Finally, we'd give them some, and then they'd stand around and say, This thing really does work!'"

The *piece de resistance* for the introduction was the train. "In Chicago, we rode around in a train and picked up the press," said Meyer. "We were cooking on the train and we had balloons and bands—we did the thing up properly. We had housewives and church groups. We gave them coupons to buy the product at a discount. At every stop we had some new group of people."

Educating Fears Away

After sales were consummated, the Foerstner touch was especially evident. George Foerstner was an old-fashioned man, comfortable with the idea of putting women on a pedestal and demanding enough to make them stay where they've been put. His perception of housewives was that the technology of the microwave oven might not be merely strange; it might be frightening to them. Even then, when *microwave radiation* was a meaningless term to most people, fears about it had already come into circulation.

"Even then we were worried about safety," said Giddings. "We used to talk about real weird, gruesome things—they used to be afraid that some kid was going to take the family cat and cook him in the microwave." Foerstner refused to let fear or ignorance hinder the march of the microwave. So, with every delivery of a new oven in the Chicago push, an Amana home economist, a woman specially trained in microwave oven use, arrived to help the housewife install it in her kitchen, cook her first microwave meal, and learn how to use all three buttons on the front. That home economist was on twenty-four-hour call for each of her clients, and there was a serviceman also on call, guaranteed to show up within an hour.

Few products have ever been introduced into any market with the level of handholding, babysitting, and fatherly solicitude that Foerstner applied to the Chicago Radarange campaign. And as Amana expanded the product throughout the nation, he made sure that the distribution network acted as a sort of a housewife's polytechnic institute, teaching safe microwave oven use wherever the product was sold.

After the product had been on the market a few years, the teaching became more systematic. "One of the basic criteria was that the distributor have a home economist or another qualified person to conduct schools," said Meyer. "We wrote the script: We told them what to cook, what their shopping list was, how much money they could spend. We told them how much we would participate—that was like signing the franchise. If they didn't do the whole thing it wouldn't work."

In fact, the misgivings that Foerstner had about housewives proved true of all microwave oven customers. It was perceived as a strange, new thing, and by concentrating on education, Amana obliterated the cloud of mystery and shortened the time that America might otherwise have needed to adapt to the microwave oven. And time had become critical: By 1968, Japanese manufacturers were exporting microwave ovens to the United States at an appealing price, and by the 1980s, Japan had the dominant share of the American market.

Quality-of-Life Improvement

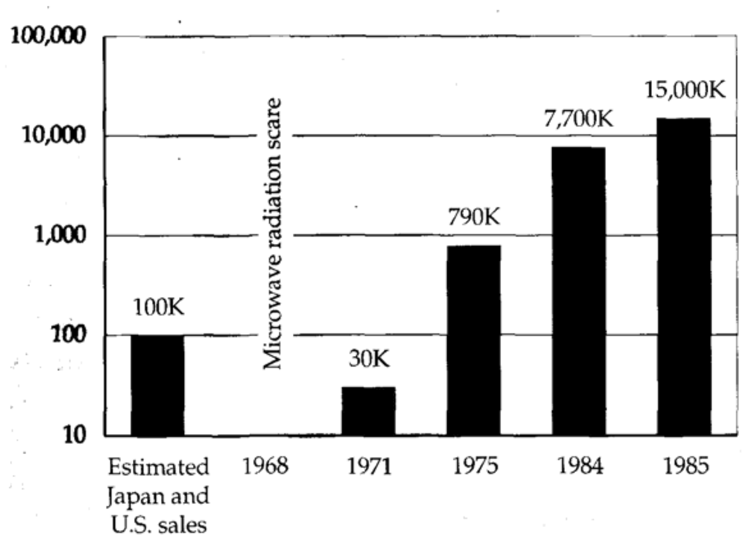
There is a small irony in the fact that, in Japan, the microwave oven is the tool of the full-time homemaker. It allows the housewife to prepare several courses of a meal at once—some of it cold, some hot from the stove top, some heated in the microwave. It is a marvelous addition to the traditional Japanese style of food preparation. In the United States, the microwave actually served a contrasting purpose. It freed housewives from the kitchen, allowed them to work outside the home and still prepare meals (or have their families do so), but in much less time than in the traditional kitchen.

Rose Rennekamp, vice president of product planning and marketing at Amana, summarized the change in her own life: "What we've done with the microwave oven has contributed to the quality of people's lives. We've given them more time to spend with their families. The microwave gives me probably thirty minutes more a day to spend with my kids. And it's given that to every working woman in America who's got a microwave oven."

Following the spectacular success of the Chicago campaign, George Foerstner enjoyed one of the great triumphs of his life—the national introduction of the Radarange oven "back East" in Raytheon territory. Even then, however, neither he nor anyone else in America, nor any of the Japanese manufacturers, had any conception of the spectacular magnitude of the market.

Growth at first was manageable but steady. The break-even point came in Amana's second year of manufacture. Keishi Ogura, who studied markets as well as technology, had estimated peak production for the Japanese market would come to fewer than 100,000 units a year. Wayne Giddings estimated the U.S. market would peak at about the same number. But in less than four years, in spite of a dramatic microwave radiation scare in 1968, world sales reached 30,000 units annually. In 1975, the number was 790,000; by 1984, *7.7* million microwave oven units were sold internationally; 1985 sales were twice that much; and in 1990 *Appliance Magazine* reported that Japan alone produced 155,636,000 microwave ovens. Many experts in the appliance industry believe that by the turn of the century, the microwave oven will become, like the refrigerator and the kitchen range, a "basic appliance" in industrialized nations. Everyone will have one.

It is easy to identify a number of keys to the development of the microwave oven. The technology was "sophisticated and simple." Although its complexity created the demand for real scientific ingenuity at the stage of invention, it emerged as a very simple device in the hands of the consumer. Foerstner's decisions on design and price were vital to the breakthrough into the American marketplace. Because the microwave oven was something entirely new to the consumer, the emphasis on education was a critical marketing springboard, as was Amana's concentration on



Estimated Versus Actual World Microwave Sales

its intermediate market—the distributors. Not coincidentally, Toshiba followed the same marketing strategy in introducing microwave ovens to the Japanese domestic market.

Why So Long?

All these keys, however, leave unanswered the question of why it took so long for a technology of such obvious potential to be developed. Part of the answer is found in the fact that all of the companies originally involved in microwave development were technical enclaves working for the government; none was a consumer products company, even in a broad definition of the term. Part of the answer is that microwave technology was so unfamiliar that it took years for its developers to find a way to explain it (or to realize that it doesn't have to be explained) to people who just want to cook dinner.

Charles Adams provided a vivid example of the public education problem. Early in the development, he had turned his home kitchen into the proving ground for each successive generation of Raytheon ovens. Eventually the forefront of technology collided with the resistance of culture, as embodied by the family cook. Adams recalled, "Our cook, a rather old Irish lady, walked into the kitchen while I was experimenting with it. 'Oh!' she said. " 'Tis black magic!' And she went upstairs and packed her bags, and she was never heard from again."

However, neither the consumer marketing incompetence of technology companies nor the set ways of professional cooks adequately explains a quarter century of failure of a product of such compelling value for the average middle-class household.

Affordability

Unquestionably, if Raytheon or one of its partners had been able to launch into the market a compact, affordable microwave oven in the 1950s, the success of this product would not have had to wait for George Foerstner to march into Chicago with a locomotive and an army of culinary crusaders. A fundamental technological obstacle was that nobody could make affordable the basic element of the microwave oven; nobody could make a cheap magnetron.

Time has clouded the significance of this problem, but it was crippling. John Osepchuk stated it flatly: "They had to be on the countertop, and they had to be under five hundred bucks. As long as Raytheon was selling something for $1,500—in the 1950s, that's ridiculous! I don't care if it was a sex machine. They still couldn't sell it!" Technological perfection doesn't mean a thing if it costs too much. For the middle-class breadwinner, cooking faster is not worth a $1,300 to $1,500 investment—not today, and certainly not thirty years ago, when the dollar was worth more. Foerstner was right in identifying $500 as the ideal price, but his audience for that statement was a research and development team that had been trying to reduce costs for twenty years, and they had yet to get within $1,000 of the magic number. Everyone assumed that Foerstner was expressing a goal with that price, but what he might have been doing was stating that if Raytheon couldn't meet that figure, then Amana could not be expected to pursue development. Amana would be spared losses to the "rat hole" that had already wasted millions of Raytheon's dollars.

The pertinent question, then, is not why it took so long to make the microwave oven a successful product, but rather how an imperfect technology nevertheless survived all that time. The magnetron should have passed through several development generations—all of them grossly expensive—and then fallen under the cold, unsentimental review of corporate leadership. The company's leaders should then have reached several conclusions: (a) This thing is still far too costly to make; (b) We don't know how to mass-produce it, and even if we knew, we'd be mass-producing something too expensive for people to buy; and (c) Besides being too expensive, our product is something we can't sell to people—we can't even explain it.

The Savior of Radarange

Someone at Raytheon should have killed the product. As with a number of other breakthroughs, a rational, sensible system of product review broke down at Raytheon. When the company claims it poured $5 million into the Radarange between 1949 and 1960, it is providing a rather self-protective underestimate: The figures were larger, and the period extended for at least five more years. There was no reason to assume that more years and more money would achieve any better results. At Raytheon, a company with a reputation for cost control and accountability, an out of control effort was running up bills and messing up the ledgers.

Robert Decareau, one of the food technologists who worked on the microwave oven throughout the 1950s, identified the reason the project survived. "It is extremely doubtful if the microwave business came even close to breaking even during those first ten to fifteen years," Decareau wrote. "Certainly, it would not have survived to give birth to the tremendous consumer microwave oven market that exists today if it were not for someone with vision and faith in the potential of microwave cooking. That someone was Charles Adams."[4]

As an executive vice president and eventually as Chairman of Raytheon, Adams carried out a series of actions—all of them costly and several of them risky—that might have been justifiable as reasonable corporate moves if taken separately. The establishment of the Raytheon food . laboratory and the hiring of a team of scientists to develop microwave cooking techniques are obvious offspring of the magnetron development effort, as are the licensing agreements with Tappan and Litton.

New Japan Radio was an obscure company. Since acquiring NJRC in 1961, Raytheon has consistently owned one-third of the Japanese firm but has done almost nothing in partnership with it. Few people at Raytheon even know that it is still a part of their company. The only thing that NJRC ever did for Raytheon, apparently, was Keishi Ogura making a brand-new power tube. When Raytheon planned more acquisitions, somehow Adams and Phillips got an Iowa appliance company onto the list of candidates.

Behind Adams' actions and in the back of his mind was a tireless desire for—even an obsession with—the microwave oven. Every time he entered his kitchen, the latest prototype stared at him accusingly. Each one seemed to say, "I'm too big, too expensive, too heavy, too strange, too dangerous. Stop me before I spend again!"

Adams ignored even the nagging voice of an overweight prototype. He stuck with it. His reason might have been the same sort of intuition that infected Spencer, Ogura, and Foerstner. At each turn there was an intuitive flash: Spencer and Derby warming their hands in a wave guide and saying, "There might be something here!"; Ogura holding the Raytheon magnetron in his hands, turning it over and seeing the things that must be changed; and Foerstner looking at Raytheon's behemoth Radarange oven and seeing a whole new metaphor, the air conditioner.

If Adams shared an intuition with these three, his sense of the potential for microwave cooking was not as direct. He said, "I felt that somehow this kind of cooking was going to break out someday. Don't say I'm the great genius who saw where it was going to end up, because that's not true. But I knew that some day, if we kept trying, it would eventually break through."

When he encountered George Foerstner, Adams sensed that finally he had found someone with the right style to carry the torch to its destination. Perhaps more than anyone else at Raytheon, Adams possessed a (well-concealed) love for adventure. A member of a historic New England family, Adams left a cushy post provided for him by blood and training at a brokerage firm. Coming to Raytheon was an adventure for him, and because of that, his view of the company has always been through rose-colored glasses. To other observers, Raytheon is a bastion of ivory-tower technocrats, favored by and feasting on government largesse. But to Adams, Raytheon is a blend of straightforward, sound business people and a few unconventional personalities. "This company, like a lot of companies, wouldn't be what it is without a certain number of eccentric geniuses," Adams said.

Adams' dilemma has always been to convey this inventive force and strain of adventure to a wider audience. When its "eccentric geniuses" had succeeded in the past, the company bungled the product in the marketplace. In Adams' view, the best chance for the world to know about the Raytheon knack for nurturing eccentric genius was to make the microwave oven succeed.

Adams is not an egoist; he is a man who is engagingly comfortable with himself. Had he seen the microwave oven as a personal crusade, he probably would have recognized its hopelessness by the end of the 1960s: He would have been embarrassed by his own obstinacy, come to his senses, and killed it. He would never have acquired overseas interests or ventured into an Iowa community. But Adams wasn't doing it for himself. Percy Spencer was his friend and his hero. For Adams, Spencer embodied the very best of what Raytheon stands for as a community. It was easy for Adams to persist in the microwave oven project, beyond reason and with untiring devotion—he was doing it for his old friend.

This is not as crazy as it sounds, or unusual. Like the mentors who fostered other breakthroughs, Charles Adams had taken an emotional step that could not be reversed—he had embraced the microwave oven project and, in so doing, had embraced the people in his company whom he most admired, whose talents he most cherished.

Today, after a remarkably long and twisted path, the microwave oven is one of the most pervasive products in the world, acknowledged as a technological marvel, a middle-class staple, and a commercial breakthrough. To make it this far, the product needed a series of advocates, experts, and tinkerers who picked it up and advanced it at critical moments. At its turning point, it needed an inventor who, in a single coherent perception, could sort through the knowledge gained and errors committed of a decade of research. The effort needed a great deal of creativity, corporate commitment, persistence, and luck. And it needed—holding together all these elements that made the modern microwave oven possible—a tenacious strand of faith, kept unbroken by Charles Adams.

9

TOYOTA: A SUPERMARKET FOR CARS

The oil embargoes imposed on the industrial world by the Organization of Petroleum Exporting Countries (OPEC) in 1974 and 1978 had many significant implications for the world economy, but none was more dramatic than the swift shift of U.S. consumer respect from Detroit to Japan. Americans discovered that foreign automobile makers could transport them comfortably and economically in a four-cylinder "roller skate" that cruised forty miles or more before it dipped into its second gallon of fuel. By the mid-1970s, Japan, not the United States, became the leading exporter of automobiles. By 1983, Japanese auto manufacture exceeded 11.1 million cars, compared to 9.2 million cars made and sold by the U.S. companies. In 1991, of the 8.2 million cars sold in the United States, only 5.4 million were produced by domestic manufacturers. Most of the others came from Japan.

American automakers belatedly awoke to a reality they had been ignoring for three decades. They were getting whipped by these little cars from Japan, and not just on the basis of price. They were getting beaten by Japanese engineers, Japanese production technology, and Japanese quality. The American automobile had slipped to the status of second-rate, and the message was coming through to the American carmakers from the most embarrassing source: American drivers. The speed with which the U.S. automobile companies sought out Japanese know-how on the building of small cars had the sweaty scent of panic. In their rush to learn something, anything, the Americans studying the Japanese suddenly understood one thing clearly: Toyota Motor Corporation, located in a bustling company town called Toyota-Shi (Toyota City), had transformed the automobile industry. To their chagrin, they soon discovered that the Toyota Production System might be not only one of the greatest breakthroughs of the 1970s, but also the hardest to understand.

Exceptional Efficiency

The Toyota Production System is an interplay of production concepts that, taken separately, are simple and revolutionary. Taken together, these concepts are inextricable from the personal commitment and efficiency of each member of the Toyota work force. The Toyota Production System, under the leadership of one man, a former machinist and union member named Taiichi Ohno (who died in 1990), took thirty years to develop to its current level of productivity. The exceptional efficiency of the Toyota Production System is reflected in the fact that the productivity of Japanese-owned plants in Japan remains, on average, about one-third higher than that of U.S.-owned plants in the United States.

And today, notwithstanding Detroit's recent efforts to reverse this perception, many, if not most, Americans believe that the less expensive Japanese import is not merely a better deal but a much better car. In fact, it was quality more than price that drove automakers first in Japan, then in Detroit, to begin trying to figure out why Toyota's system was so effective. Most manufacturers found ways to hurry their versions of smaller, more fuel-efficient cars into production. Toyota's fellow Japanese carmakers had been doing it almost as long as Toyota, but no one could do it nearly as well as Toyota. The sudden influx of competitors studying the Toyota Production System struck Toyota's leaders with a triumphant sense of irony.

Fujio Cho, general manager of Toyota's Transportation Administration Office, who worked in auto plants for much of his career in the company, recalled that Toyota was traditionally an oddball among Japan's carmakers. Toyota-Shi, a rural village far from Japan's larger industrial centers, was thought to be populated by bumpkins unable to understand modern production technology.

To a significant extent, Toyota was doing things backward from the standard approach to auto manufacturing. One of the most imitated features of the Toyota Production System is called *just-in-time,* and Ohno said that it emerged literally when "we reversed our thinking and considered the production process in terms of backward flow." Just-in-time and a system called *kanban* are the two most broadly studied and discussed aspects of the Toyota Production System. Each is simple.

Just-in-time means that parts are not kept in warehouses waiting to be moved to the production line. Each process on the line receives the parts it needs in the necessary quantity at exactly the right time from the preceding station on the production line. This idea is widely accepted today, but implementing it took more than fifty years of automotive history and a quaint group of production revolutionaries at Toyota.

A key to the realization of this revolution was *kanban,* an "information-carrying device," actually a colored-paper card that travels the line with the actual parts and indicates such details as where the parts should go, how many there are, and what time they must arrive at their next destination. *Kanban* circulation times are adjusted as the cards travel, according to the number of parts being used. Thus, if parts are being depleted more slowly, the *kanban card* tells the production people to delay ordering replacement parts. If parts are going fast, *kanban* is the automatic, nontechnological device that alerts the crew to call for more parts at just the right time. Toyota has installed *kanban* not only in its own plants, but in the plants run by its outside parts suppliers, literally infiltrating this parade of colored cards throughout the Aichi prefecture of Japan.

Kanban limits the buildup of inventory provided from outside suppliers and eliminates any buildup of partly finished products between stations on the production line. Almost empty of any waiting stacks of half-built parts, a Toyota production line has an empty look, but it is fiendishly efficient.

In most automobile manufacturing plants, Ohno explained, "Managers don't want workers or machines to be idle, so they keep on producing parts whether they need them in the assembly stage or not. But if they do that in the . just-in-time system, there is no place to stack them. If the workers have the materials to make parts but no place to stack them, they have to stop producing. When that happens the supervisor knows he has too many people working on that production stage, and the workers realize there are more people on the job than necessary."

In this brief explanation Ohno implies one of the most complex results of using just-in-time. While solving one defect in a manufacturing process, the system exposes a host of additional defects. It can, in fact, reveal a network of problems—waste of money, waste of time, and waste of people.

Nevertheless, because of the outward simplicity of just-in-time and *kanban,* these concepts began to spring up in auto plants all over the world, along with a third Toyota idea called *quality circles.* In fact, quality circles were most thoroughly described in the 1950s by an American named Edward Deming, who celebrated Toyota very early as a prime example. A quality circle, in simple terms, is a group of workers who discuss ways to do their work better and make better cars. Quality circles work at Toyota because management does (more than 90 percent of the time) what the workers tell them to do.

Although many companies faithfully imitated just-in-time, *kanban,* and quality circles, none did it as well as Toyota. In many cases, other companies' quality circles were simply mechanisms set up to pacify workers. With all three concepts, other companies mimicked Toyota without understanding the ideas that bred and nurtured the unique web of people and automation that makes the Toyota Production System. To try to duplicate Toyota's attainment by installing just-in-time and *kanban* is like trying to visualize *Swan Lake* by reading Tchaikovsky's score and Balanchine's choreography; it is notes without music, dance without dancers.

Just-in-Time

To grasp even something as ostensibly simple but so effective as just-in-time, it is crucial to know its origins. By now, the story has achieved the stature of legend; but the basic facts remain true.

The founder of Toyota Motor Works was Kiichiro Toyoda, the son of one of Japan's great inventors and industrial heroes, Sakichi Toyoda, who had invented, among other things, an automatic loom that transformed textile production.

In 1935, two years before the first Toyota car was produced, Kiichiro Toyoda compared the automobile assembly line to an American supermarket. He noticed that in an American market, great quantities of food, much of it perishable, are gathered. It can'tbe stored on site, because the store doesn't have space and can't afford the cost of storage; besides, much of the food would spoil in storage. So, as shelves empty in the store, the staff notes the need for more supplies, the supplier is informed, and the bread or chicken legs or fresh peaches arrive just in time. If this system could somehow be translated to auto production, Kiichiro thought, the elimination of waste, the elimination of parts warehouses, and the greater coordination of all production stages could reduce costs dramatically. It would give the company that made it work a significant competitive advantage.

Kiichiro's concept was sound; it was intriguing. However, it would be twenty years—two years after Kiichiro Toyoda's death—before Toyota Motor Works would begin to practice this "supermarket system" of operation.

The supermarket in Kiichiro Toyoda's vision was a key analogy in the development of what is called the Toyota Production System, which in truth is no system at all. It is a philosophy, formed by Kiichiro Toyoda, Taiichi Ohno, and a network of Toyota leaders who adopted the ideas of Toyoda and Ohno. The Toyota Production System is just a jumble of flow charts and technocracy until one comes to some understanding of Ohno, who poured his heart into the expression of this philosophy. Among Toyota people of every corporate rank, Ohno is known by the reverent title *sensei* (literally "teacher and master," but it is far more difficult to translate the emotion).

Toyota's Towering Sertsei

Taiichi Ohno was a perplexing figure at Toyota. Toyota is a company where, as with most Japanese firms, the homogeneity of the Japanese people is professed to be the source of the company's spirit of teamwork. Yet Ohno had no place in any philosophy of sameness. In a rumbling voice that growled louder than everyone else's, his remarks were bold, straightforward. His ego bespoke a man who knew most of the answers and was impatient with the rest of the crowd for not getting around to the questions more quickly. His description of himself was "rebel." He laughed with none of the reserve that marked the humor of the people around him; he seemed to take pride in being the one guy in the room who knew a good joke when he heard one. Unlike many Japanese men who professed total devotion to their work at the expense of their families, Ohno said that he was glad to get away from the job and spend time close to his family. He drew a sharp distinction between Toyota's time and his own time.

Yet clearly, for thirty years of his life, the Toyota Production System was never far from Taiichi Ohno's mind. It became his obsession; it became his legacy to Toyota Motor Works. He created an army of company executives who called themselves "Ohno's Apostles." To know about Taiichi Ohno is to know why the Toyota Production System has become the standard of automobile production for the 1980s and beyond.

Taiichi Ohno was an engineer by profession. His career began at the oldest of the Toyoda family's companies, Toyoda Spinning and Weaving Company, founded by Kiichiro's father, Sakichi Toyoda. Occupation notwithstanding, Ohno was a teacher by inclination, by vocation.

Ohno believed the Toyota organization would support his progress wherever it might lead. Sakichi Toyoda, the entrepreneur of the fourteen companies that now make up the Toyota Group, had taken his employees at the turn of the century from the drudgery of the Industrial Revolution by reasserting the greater value of human beings over machines. As important as the invention of his revolutionary automatic loom, Sakichi Toyoda incorporated his faith in the worker into the atmosphere of Toyoda Automatic Loom Works. He expected more from workers than they often expected from themselves. He established the Toyota tradition of finding the best minds in the work force and keeping them as long as possible "on the shop floor," where they could examine the way things are done and think of ways to make them better. He insisted that people can meet challenges that at first glance clearly appear impossible, but those people must have a catalyst—a leader, a teacher—to show them the depth of their own inner strength.

Takumi Mishima, general counselor of Toyota's Production Control Department, expressed in a few words the effect of Taiichi Ohno, the catalyst, who arrived at work early every day, armed with Sakichi Toyoda's demanding legacy. "We were frightened," said Mishima, "because we were afraid we weren't living up to his expectations."

Before Ohno, the various pieces of the Toyota Production System, such as the idea of just-in-time, existed separately at Toyota. These concepts had emerged at different times, in different places within the growing group of family-owned companies, and they had no discernible interrelationship. Ohno, in a progressive series of connections, fit them into one whole. In even making these connections, Ohno was violating an iron-clad law of modern manufacturing, that the more of a thing you manufacture, the lower each unit will cost. "It's a wrong notion to believe that mass production will guarantee you less cost. That was true in the 1960s when there was a high demand/' said Ohno. "But that notion has become a myth that no longer applies in the 1980s. Now production capacity exceeds demand. For some reason, many people in the world still believe in this myth and they will still take for granted that if they increase mass production they can reduce costs."

Fujio Cho called Ohno the "interpreter." Ohno was the man who seemed to see ahead to a change in the very foundation of manufacturing. Already in the 1950s, Taiichi Ohno was saying to his colleagues at Toyota that, in the future, auto companies would be unable to dictate to car buyers a limited range of models and body styles and then gear their production schedules to that self-imposed system of supply and demand. Ohno foresaw the need to eliminate the production schedule entirely and produce cars according to customer preferences, even though some models, colors, and optional features would be demanded by relatively small numbers of customers.

"We cannot be dependent upon a production schedule to produce autos," Ohno said. "It's very important to have an extremely flexible system so that we can manufacture certain models regardless of which models sell the most." For the next twenty years, such thinking was sheer heresy in automobile production circles. Ohno looked within Toyota to find the elements necessary to prepare the company for the great change to come.

Taiichi Ohno's active role in developing the Toyota Production System began as early as 1955, a decade after Kiichiro Toyoda had introduced him to the supermarket metaphor. Ohno was also greatly influenced by a concept that Sakichi Toyoda incorporated in the automatic loom business: that "work" refers to the production of perfect goods only. "If a machine is not producing perfect goods," said Ohno, "it is not 'working.' In the Toyota way of thinking, mechanisms for stopping production of defective goods must be fitted into automatic machines." At Toyota, these mechanisms form a central part of the powerful idea known as *jidoka.*

The Importance of Jidoka

In the very infancy of automation, Sakichi Toyoda had made the rare observation that automatic machines can be broken without appearing to be broken and can go on making bad things indefinitely without anyone noticing the problem. Born before the twentieth century, the idea at Toyota that counteracts this flaw in automation is called *jidoka.* Perhaps more important to the Toyota Production System than just-in-time, *kanban,* or quality circles is *jidoka.*

In Japanese, *jidoka* can be translated simply as "automation," but at Toyota, *jidoka* means much more. It implies faith in the worker, as a human being and as a thinker. "What is the difference about human beings?" asked Cho. "How can we differentiate a human being from an animal? Man can *think.* He has brains. Then we thought we should respect those capabilities in human beings, promote their creativity. Good products, good thoughts, good ideas. It was a tradition for the Toyota Production System to think together, put all our wisdom together to improve the company, the product."

To Ohno, *jidoka* is important because it demands so much on the assembly floor from each worker, each of Ohno's pupils. Because it requires workers to respond decisively with each automatic stoppage of any of dozens of auto assembly machines, at Toyota *jidoka* assumes a respect for the worker's intelligence. At the time of crisis in the mid-1950s, it revived the Toyota tradition of putting bright people on the shop floor in the middle of the action to keep the line moving.

Ohno redefined *jidoka* to express Toyota tradition. He used it as a means of restoring the dignity of the rank-and-file worker. When Toyota's management gave him an ambiguous mandate to improve production methods, Ohno's first problem was to deal with the array of automatic machines. These were machines produced by other companies, mostly American, and they were supposedly "ready-made" to produce cars.

Fujio Cho recalled Ohno's thoughts about the new wave of production automation. "When management first decided to buy automated machines," said Fujio Cho, "they thought they would be able to replace people. Instead of using three people, the machines would work by themselves. But, in reality, they realized they still needed people to avoid defective items."

Management's solution was to park one person beside each machine. That person would watch the machine until it broke down, and then tell someone. Ohno regarded this as a pretty stupid way to use people on the assembly floor.

"Mr. Ohno, our *sensei*, asked us to think together, to find a way to add Toyota intelligence to these machines," said Cho.

"Left on their own, machines continue to produce items even though a problem has occurred," said Ohno. "So they produce defective items. To solve that, we installed a very simple sensor."

It did not happen on all the machines at once. But gradually, over time, each production machine was given the ability to sense its own disorders. When the sensors recognized a malfunction in the machine, a light attached to the machine began to glow, and the machine stopped itself. Because the sensor anticipated breakdown, the machine could be repaired *before* it broke.

Never Trust a Machine

As more and more sensor lights appeared on machines in a single production line, the managers who hurried from problem to problem became more and more pressured. Ohno responded with a new system called *andon*—a central "switchboard" connected with every machine. A manager monitoring problems in production could tell at a glance by looking at the *andon* board where a problem was happening. For Taiichi Ohno, *andon* was the fulfillment of a goal to dramatically reduce the number of employees assigned to solve production problems. Because of the efficiency of the *andon* system, one manager assigned to the "improvement staff" on the production floor was able to cover the same ground once covered by ten people.

"There was an attitude change," recalled Fujio Cho. "Before *andon,* the improvement staff came in to work, and they didn't want to know about any problems. With *andon,* the improvement staff was able to collect information and gather complaints about problems before they actually happened. They collected everybody's troubles and corrected them. People stopped worrying about who was to blame for a problem, and the feeling of unity between the production workers and the improvement staff managers grew."

Andon meant, in fact, that the Toyota improvement staff manager and, to a lesser extent, the production worker had to be multifunctional. He must eventually learn every machine and every station on the assembly line, or he could not respond to the full range of expectations that *jidoka* implied. And it meant that each worker would, almost instinctively, begin to see ways to make the system, the interplay of machines and people, work better. It meant he would be virtually unable to resist telling someone else his ideas for making it work better. It meant that each Toyota production worker had to keep *learning* from the day he began his career until the day he retired.

Jidoka, as Taiichi Ohno quietly fit its elements together at Toyota, had one fundamental tenet, a requirement that made it work. Ohno's perception was that, in order to react to every problem or opportunity as soon as it emerged, each worker had to be able to *see* everything operating. Ohno stripped all the sheet metal away from machines; he redesigned machines so that every moving part was visible. "Mr. Ohno said if a production line cannot be understood with your own eyes, then it's not a good production line," explained Cho. "You should be able to see everything with your own eyes."

This "never trust a machine" philosophy is part of official company policy. With *jidoka,* Taiichi Ohno made sure that it wasn't just managers who had the privilege of using their heads. Ohno created a system for employee suggestions, which has since been institutionalized as quality circles. He perpetuated Toyota's "low technology" approach to manufacturing; he refused to allow the concealment of needed information inside machines and computers. He wanted all workers to learn every function. He gave every worker the responsibility to halt the entire production line whenever the worker saw a problem, small or large, that could become worse if not corrected immediately.

"In the United States [and other nations], stopping a production line is something wrong—evil!" said Ohno. "The Japanese approach is the other way around. *Jidoka* encourages people to stop the line when there is any trouble. If you don't stop the line when there is trouble, you are doing the wrong thing."

The Quiet Assembly Line

A visit to a Toyota line today—at Takaoka, for example—is a profoundly disappointing experience. It lacks the grandeur of great industry. Automobiles in various stages of assembly weave along a serpentine conveyor. There are many cars in process, and there are many workers. But there is no sense of magnitude here, no glistening engines of industrial might. Because inventory buildups are forbidden here, areas on either side of the production line are relatively clear. Machinery is stark, stripped down, visible. Some sections of the line are almost unpeopled; one worker roams a wide area, observing the *andon* lights of a number of robotized production stages. Other areas contain a series of workers bustling through four or five assembly functions as cars inch along.

Each of these work stations, however, has a sort of stylistic flair. Most stages are carpeted. The floor rises and falls along the line, allowing each worker the most comfort-* able position for each task. Workbenches are scrubbed and neat; each tool, once used, goes back to exactly the same spot, often right next to a flower vase or a family picture. It is a *quiet* assembly line, perhaps because each machine is only turned on for as long as it is needed, then shut off again. The Japanese imperative "eliminate waste" applies here to energy, movement, noise, space—and even bosses wandering around giving orders.

And the line does stop, repeatedly. Red lights go on, a bell sounds. There is a pause of perhaps ten seconds, perhaps as long as thirty seconds, and then it moves again. Regarded in most factories as subversion, these perpetual line stoppages at Toyota, these brave little acts of *jidoka*, seem terribly, disappointingly, trivial. And they seem to *accelerate* the pace.

Andon, the system of warning lights and bells, means that a worker is free, as Cho noted, "to do other things." This is called *ijo kanri*, the control and management of only the emergency. It was, of course, Ohno's belief that the other things workers would do would be to think about ways to make the system work better.

Even under Ohno, this sense of worker involvement, this vigilance for improvement, did not occur immediately. The Toyota Production System was truly an evolution, almost twenty years in the making. Ohno had, at the beginning, no more authority than the average *kacho*, or section manager. In 1955 he was not yet regarded as senior management. He did his first experiments with the idea of *jidoka* and just-in-time inside the machine shop, with the experimental assembly of automobile transmissions.

"I gave the authority to myself and was a self-appointed manager," said Ohno. "I wasn't really self-appointed, of course. I didn't have the authority. I did it on my own responsibility, and I was ready to take the blame if it failed. For some reason, I'm still alive."

When Ohno's experiment worked in the machine shop, his system took its first big step. His transmission assembly process was installed on the regular assembly line. Then he started to restructure other sections of the line to work the same way. His pupils began to multiply.

"What I recall is that he would come to the plant, to the floor, and he would personally instruct the workers as to what to do," said Mishima. "We had then six thousand to eight thousand workers on the assembly line of Toyota. I thought it was remarkable that Mr. Ohno met all the shop floor people one by one."

One of Ohno's pupils recalled a familiar Ohno tactic. At the beginning of the workday, Ohno appeared at a particular section of the assembly line, and he would stay there. He observed all day, pacing, watching, but never speaking. All day, he didn't say a word. But the improvement staff responsible for that production area were concerned. They understood something was wrong. "Poppa Ohno" had seen some way to do this job better. "All day, we wondered what it could be. We looked at everything. We whispered to each other. We studied every movement, because we knew if we didn't find it that day, he would come back in the morning and start screaming at us. He gave you one day; that was all!"

"When we see him nearby," said one worker, "we start to sweat."

Ohno recalled, "I was wearing more and more hats. I would be in charge of the final assembly line as well as the rough shop, the machine shop. When you have an idea, you have to have the people on the floor try it.. .to prove it can be worked out, before it can be further developed."

A Progressive, Logical Reinvention

Piece by piece, Ohno's ideas prevailed. Insidiously, Ohno's "authority" superseded other authorities who thought they ran the manufacturing process. Machines were changed to fit Ohno's specifications; management, unable to understand this drastically transformed environment, had to become pupils of Ohno in order to understand their own factory. Ohno had applied to this creation not so much a vision of how a perfect assembly line should appear, but a set of principles of how people should work together and treat one another in order to manufacture things. Ohno conformed to no plan or blueprint. As Godfrey Hounsfield applied a *mechanic's imperative* to inventing the CAT scanner at EMI, Taiichi Ohno applied it to the reinvention of the assembly line. He introduced elements to it in a progressive, logical sequence, threw away those that didn't fit, and worked with only the materials that were at hand and affordable—he made adjustments as the need arose.

The most telling example of this principle in application can be seen in the company's production through much of the 1950s. Replacement parts for assembly machines, all of them manufactured overseas, were not available to Japanese carmakers. At Toyota, this meant that, in order to stay in production, the company had to repair what was already there. Ohno simply told people they could not let any machine reach a point of failure. Workers began to watch for subtleties, to seek the root causes of problems. A sensor light might flicker on, indicating that something was wrong with a production machine. "Why is that light on?" Ohno would ask. "Well," someone would reply, "maybe there is a defective part in the machine." "How do we find that defective part?" Ohno would ask. And this question would send the improvement staff poring over the machines for symptoms until they found, perhaps, a seepage of oil, ever so slight.

"Explain the oil leak," Ohno insisted. The improvement staff finally discovered that the seams in the oil pipes were loose. "Why are the seams loose?" Ohno demanded to know. The answer came back that the machine's vibration made the seams weaken. "Stop the vibration," Ohno would say. "It can't be stopped," would be the reply. "Then," Ohno would say, "how can we protect that point from vibration?" And the answer emerged! The problem part had been secured to the machine at two points. Secure it at *four* points and it will not come loose.

"We said you should really find out the exact cause of a breakdown," explained Cho. "If it takes time to do that, eventually you are able to *transfer* the time. *Jidoka,* on one end, means an effort to avoid the recurrence of this type of breakdown."

For a manager who perceives his responsibility as having the "big picture," for whom stability and a hierarchy of authority is vital, the Toyota production line of the 1950s and 1960s had all the characteristics of a Monty Python comedy routine. To a conventional manager, the constant atmosphere of shortages and deprivation, the attention paid to trivial matters like replacing two screws with four screws, the perpetual cycle of setting things up, then tearing them apart and setting them up all over again, would have been madness. For Ohno, however, this was the perfect teaching environment. As things went along, everyone learned, and Ohno had to stay a step ahead of the class all the time. If he could not, if he faltered even once, he was not a worthy *sensei.*

Always Think Ahead

Perhaps Ohno's greatest challenge with the Toyota Production System was implementing the elements of just-in-time and *kanban,* because these required the cooperation of outside suppliers. Ohno had two advantages, and one was simple: All of the suppliers to Toyota Motor Works are located close to Toyota City, in the prefecture of Aichi, and many are members of the Toyota family of companies. Ohno's visits to these companies, to teach and preach his system, became frequent. The other advantage Ohno had was psychological. All these companies shared with Toyota the trauma of near failure and deprivation that had gripped Japanese business after the defeat in World War

II. There was, therefore, a fundamental logic in Ohno's explanation of working "just-in-time."

Inventory, he told the suppliers, is simply the institutionalization of waste and inefficiency. If you pile up parts before assembly, and if you pile up partly assembled products between each stage of assembly, then you never have to improve the quality of the production line itself. You can allow things to break, and even with prolonged periods of failure you can keep putting out products from the accumulation of partly built things. Furthermore, Ohno explained, if you accumulate extra cars at the end of the assembly line, some will never get sold; they will go to waste.

In the 1950s and 1960s, most experts were talking about *mathematically optimal inventory control,* matching the amounts of stored material with the anticipated average duration of breakdowns in production. Ohno was talking about "no inventory," "no breakdowns," and "just-in-time." You can make the assembly line work as fast as people are buying Toyota cars, he said, and you don't *have* to work any faster than that. If you can work at the right speed, you don't need to stack up parts in expensive warehouses and you don't need to park extra finished cars in expensive parking lots. The opposite realization, of course, is that you can't afford to make Toyota cars more slowly than people are buying them. You can't afford for the assembly line to break down. Ever!

Here was Ohno's triumph. With *jidoka,* the assembly line *never* breaks down. It never has broken down, because, rather than consisting of machines operating automatically, it consists of people and machines working together intelligently.

Ohno emphasized that the effectiveness of the Toyota Production System goes to the very definition of the worker. The word *rodosha* (laborer) is forbidden in Toyota. People are called *gino-in*, or "skilled persons." In each of these skilled persons there is an ingrained awareness not only of his or her own task on the assembly line but of how that task blends into the one before it and the next step beyond it. Ultimately, *each gino-in* knows all the tasks that go into a finished car and has a sense of the whole process. The *gino-in* must know this because he or she is equally responsible along with every other worker for sensing changes in the flow that might become problems if left unnoticed. There is a harmony, created by Ohno, that can only be attained when people understand each other's jobs as well as they understand their own jobs.

"Mr. Ohno said that a person should not think that he has done his job if he has just done what he is told," said Mishima. "We should always try to think ahead, and only that way can we make improvements."

A Timeless Method of Learning

"Mr. Ohno says" was a phrase that was almost a mantra for hundreds of people at Toyota. For thirty years, he was the spirit and essence of the Toyota Production System. The system became as individual as a style of painting that is visualized by a single, gifted artist and then conveyed through patient instruction to a group of disciples. As the *sensei*, "Poppa Ohno" was omnipresent at the constantly changing production lines at Toyota. He was an unfathomable presence to those who worked for him, sometimes seemingly on the verge of explosion, other times apparently about to embrace his "sons." People became dependent on Ohno for approval, partly because they believed he was interested in them individually. "One generation of us claims to be the students, the apostles of Mr. Ohno," said

Cho. "That group of people is the core of the Toyota Production System."

As important as it is to know *what* Ohno taught people, the emergence of the Toyota Production System, as a system of *faith*, happened because of *how* Ohno taught. Ohno, the teacher, achieved his remarkable, gentle dominion over this mass of diverse individuals through a teaching method that is almost as old as mankind but never has been very popular. As demonstrated in his silent scrutiny over those nervous workers, his teaching contained a minimum of direct explanation. He taught by inference and inquiry. He expected his pupils to figure things out by clues and hints, by thinking. Ohno's approach could be frustrating. In another culture, his "pupils" might have rejected him as an unreasonable eccentric who expected people to be mind readers.

Ohno's style has an ancient tradition in Japan, although it appears to be dying as Japanese education systems become more Westernized. Today his teaching style is primarily associated traditional arts and crafts in Japan—painting, dance, martial arts, sumo, pottery. One of Ohno's "apostles" compared Ohno to Musashi, the great archetypal *samurai* invented by one of Japan's greatest writers, Eiji Yoshikawa. But Ohno's method precedes even the feudal hero Musashi. Two legendary teachers in Western culture taught through inquiry and parables: Socrates, who interrogated his pupils to near distraction, and Jesus Christ, who preached in fables and symbols. Both glorified the tradition of the teacher who hints at answers and demands perception from his followers.

Ohno taught the Toyota Production System in this style. If Detroit or Nissan has difficulty adopting the Toyota Production System, it is because they lack the *sensei* to whom people are so devoted that they will in every moment of their work probe to determine the meaning of his gestures and inferences, study him to understand what he expects of them, and wrack their brains to see what it is he sees.

Fujio Cho recalled an incident in which he tried to please Ohno. Cho was on the improvement staff for a section of the Toyota production line. He was concerned that his section's productivity was low. He couldn't determine the reason for the problem merely by watching the work so, although he was a manager of the operation, he threw himself into manual labor on a section of the assembly line. For eight hours, Cho operated a stamping machine, working with unstinting energy and concentration. His results exceeded the section's production average. The normal production rate on the stamping machine was less than 240 an hour; Cho produced at a rate of 250 an hour.

Ohno heard of this incident and called Cho into his office. "Mr. Ohno told me that I seemed to have improved the efficiency of production by producing two hundred and fifty parts an hour. But, said Mr. Ohno, if I, as an inexperienced person, could do two hundred and fifty an hour, wasn't it reasonable to expect skilled workers to do two hundred and eighty an hour? 'Don't you think so?' asked Mr. Ohno. I said yes."

" 'But then,' Mr. Ohno said, 'if you think so, you're forcing the workers to work harder without making any real improvement in the production line. Our mission is to increase efficiency and produce more *rationally* by streamlining, not by mere hard work!' "

Ohno gave Cho a book entitled *Respect for Humanity* and instructed him to read it carefully. "I read the book ten times," said Cho. Then he returned to Ohno's office. He was asked to return each day for four days to discuss the ideas in *Respect for Humanity*.

"Eventually," said Cho, "I realized that what I did was in contradiction to respect for humanity. I was an amateur, unaccustomed to how it feels to do that kind of work every day. Mr. Ohno said, 'That's a terrible thing to do, to make people work harder and faster for no good reason.' "

Cho was deeply chastised, but in private. However, the story does not end there. Cho noted that Ohno never praised people directly. "He feels that if you praise too much, that will be the end of improvement. Although he will not praise you directly, he will convey his goodwill to you through other people," said Cho. In the case of Cho, the praise came when Ohno was conducting tours for Toyota board members visiting the production facilities. "We have a member of our improvement staff named Cho," Ohno told one group of board members. "Cho is a manager, not an engineer. But since it was hard for him, from that vantage point, to understand how improvements in machines bring about improvements in production, Cho one day spent all day operating machines. That will and devotion to understanding is necessary for everyone who wants to improve the Toyota Production System." Ohno's praise for Cho spread quickly throughout the Toyota family. It was a recognition as public as Cho's chastisement had been confidential.

As indirect as Ohno's teaching was, and as indirect his praise, it never waned or faltered, and it carried an emotion that was almost palpable. The apostles of Mr. Ohno are an emotional group of people. Each lesson of Ohno reinforced the last and each conquered challenge expanded the team's sense of what could be done. Ohno had an intuitive grasp of how far he could push. Sometimes the distance was astonishing.

"We weren't sure if we were good enough. We tried to think of more things we could do, but we weren't sure what we were doing was enough," said Mishima. "It was not enough just to complete the first step, but he told us we were required to think ahead and be prepared. He was strict, with love. He made the workers feel that he cared for them."

The Die Is Recast

The most dramatic example of his teaching style was the development at Toyota of what has come to be called *Single Minute Exchange of Dies (SMED).* The dies in question are huge stamping machines that, in one resounding motion, shape metal into whole sections of car chassis. Well into the 1970s, one of the basic tenets of auto manufacture was that a single production line has to make identical cars for long stretches of time, because the exchange of dies was a process of disassembly, reassembly, adjustment, and fine-tuning that took as long as sixteen hours. During that time, production would be at a standstill.

"But then," said Cho, "Mr. Ohno began to insist that the flexible production demands of the future require very fast die exchange." Thus began the great quest. For a frantic period of six months, the apostles of Mr. Ohno tirelessly studied ways to take all the labor of die exchange away from the stamping line, creating "modular" dies that could be restructured and adjusted *outside* the machine and then simply fitted into the machine, similar to the way a film cartridge fits into a camera. There was a moment of great triumph at Toyota when the team had cut their die exchange time from three hours to less than ten minutes. Ohno's only response was, "Well, we can probably do it faster!"

And they cut the time again, to five minutes, and again, to three minutes. And still Ohno was not satisfied. Later, Toyota exchanged dies in a little more than sixty seconds; and Ohno with a cold twinkle in his eye said, "If we can do it in a minute, we can do it in thirty seconds."

No one today at Toyota disagrees with that expectation; they know Ohno does not deal in fantasies. Though Taiichi Ohno never drew up a plan or submitted a proposal for anything, the people of the company came to believe in his vision and hearken to his words. That was not always so. In the 1950s he simply had to proceed, without permission, with only an ambiguous blessing from the late Kiichiro Toyoda. For years, his blend of ideas—elimination of waste, respect for humanity, *jidoka, kanban,* just-in-time—made sense only to him. The only way it was expressed or justified was in people's efforts and in the increasing quality of the Toyota automobile. For years, the Toyota Production System grew because Taiichi Ohno didn't bother to discuss the issue with the boss.

"No matter how knowledgeable or concerned management is, unless you have the support of the workers, it won't work. I thought it would be more important, more urgent, to have the people in the shop understand it and implement it," explained Ohno. "The workers would not necessarily understand what they are doing theoretically. They might not know what they are doing; they would just give it a try. After they've given it a try and succeeded, they would develop understanding. As they try, they gain confidence and see the visible results."

How Life Should Be

This remarkable description by Ohno explains vividly why the Toyota Production System attained productivity and quality and variety unimagined in other world outposts of the auto industry. This was not *what* Ohno taught; it was not *how* he taught. This was *why* he taught.

It was never Ohno's foremost goal to make better cars. Teachers don't make products. Ohno's goal was to make better people. The cars were the means to reach that goal. The Toyota Production System was Ohno's tenacious statement of how life should be, ever-learning, ever-growing, ever-directed toward fresh attainment.

Not more, but better! This is a concept that receives lip service from senior management everywhere; it is easily and often compromised; but in Taiichi Ohno the spirit of compromise had no room.

The system he created was an expression of his beliefs. When he began his creation, there was, it must be stressed, no need for a system that so intricately focused on quality, on the elimination of waste, and on the interplay of every element of the production line: people with machines, machines with machines, people with people, sections with other sections, pieces with the whole. In that era, with demand for cars vastly greater than production capacity, numbers were the only established goal, and almost any * system was good enough. For the individual, for the *sensei*, to say "good enough" is impossible. The vision of that one man was focused not on things but on people. And thus, from its birth, the Toyota Production System was governed not by a market, but by pride!

"I worked so hard for Mr. Ohno because he was a very inspiring, wonderful person. But that's not the only reason," explained Cho. "He demonstrated that what he gave us was intended for our greater happiness. He was very fair. He tried to show that we are doing this not for his sake but for our own sake."

Like ChemLawn's Dick Duke creating "an organization in which the people were the focus," Ohno focused on making the process better in order to get the very best from each person. Ohno might have been just as satisfied improving the process of textile manufacture at Toyoda Gosei (which was his job, in what he slyly called "retirement") or even lawn spraying. As long as he could *teach*, advancing the *science* rather than the business, Ohno was heeding his own calling.

Ohno's sense of mission eventually pervaded all areas of Toyota. His presence lingers today, teaching, berating, peering over people's shoulders with the spirit of Toyota. People absorbed the presence of Taiichi Ohno. They began to teach themselves after the same fashion in which they had learned from their *sensei*. Learning and inquiry have become a way of life. Each person, to some imperfect degree, became an Ohno.

Because Ohno haunts Toyota, the system works, and people continue to depict the Toyota Production System as "still incomplete. We're still building the system."

"Because the expectations of customers change constantly, our production system has to change all the time," said Toyota President Shoichiro Toyoda. So Toyota continues to look for things to fix. In 1984, Toyota received 2.15 million suggestions for improvements in the production system from employees, and the company implemented 96 percent of those suggestions.

Today, even though it is possible to study the Toyota Production System and reproduce all of its features, it is something that cannot be copied. Technologies and concepts are insufficient to the task. When observers look upon Ohno's system, they see a variety of automobiles produced to match the level of consumer demand and produced with such meticulous quality that *recall* is an almost unknown word at Toyota.

A General Motors executive, commenting on Detroit's struggle to catch up with the productivity of Toyota, made this remark: "The Japanese are a very simple people. They believe in, and constantly strive for, perfection."

He was almost right. Ohno shrugged at the notion of perfection. Perfection is an *end*, a sort of death. He didn't believe people ever can be finished with the goal of finding greater things deeper within themselves. More accurately, what the *sensei* in Japan sought was not perfection, but harmony. Repeatedly, Soichiro Toyoda, the company's current leader, depicts the Toyota Production System as "harmony and communication."

When Ohno once had a disagreement with a Toyota manager about the quality of the cars produced in the factory, he didn't settle for a resolution between the two men that henceforth they would stop making defective cars and would be "perfect" from that day on. Ohno would have heard such a promise as lip service to an impossible dream. Instead, he abruptly ended the long argument when the manager stopped making excuses and offered to go to the shipping port to retrieve a defective vehicle.

Then Ohno knew that the man shared with him, at last, the sense of urgency that he felt about the shipment of a defective product containing the work and pride of Toyota workers. The two men had attained *harmony;* they felt the same feeling. They would never reach perfection, but they would move toward it side by side. That striving for harmony expressed in hours of Ohno's silent, unnerving stare and in his bursts of shouting was Ohno's highest objective as *sensei*. His final testament—a blend that includes *jidoka*, "respect for humanity," just-in-time, *kanban*, and a network of machines that literally tell their troubles to people—was finally more than harmony. The Toyota Production System became a symphony that when people grew quiet enough to listen changed the very rhythms of industry.

10

NIKE: THE COMPETITIVE RESPONSE

Athletes and foot trouble probably date back to the training rooms of the first Olympic Games. For most of the intervening millennia, very little was done to improve the shoes that go on athletes' feet. Two German companies, Adidas and Puma, first specialized in athletic shoes in the 1920s, but for many athletes the results were less than ideal. Because these companies had little competition, they were often unresponsive to requests for design changes. Moreover, through the 1950s, no one made comfortable running shoes for joggers.

As pervasive as joggers are today, as recently as the mid-1950s they were almost nonexistent. Jogging in the shoes then available hurt too much for the average person. It might still hurt too much today if not for one stubborn man in Eugene, Oregon—Bill Bowerman, the head coach of the University of Oregon track and field team. He invented the modern-day running shoe—more specifically, he fashioned the first of those ubiquitous staples of popular footwear called *Nikes.*

Mostly because of Bowerman, today's athletic shoes are so well designed and so varied that they have the power to transform an athlete's performance. They are also so comfortable and attractive that they are an accepted item of daily wear. When actor Jimmy Stewart appeared on "The Tonight Show" dressed in evening clothes and a pair of Nike shoes, he was the object not of amazement but of envy. And today's athletic shoes have opened the door to a myriad of commercial cousins ranging from running bras and nylon sweatsuits to the multimillion dollar endorsement contracts. Sneakers, once the province of athletes and children, have conquered the globe.

In 1952, Bowerman was working to build a winning program at the University of Oregon. He was looking for every advantage he could find against such glamour teams as UCLA and USC, whose athletes trained in fancier facilities and sunnier climes. As a former athlete, infantryman, and high school coach, Bowerman had seen more sore feet than he cared to remember. He knew that the shoes many athletes wore were not very good. Shoes designed much the same one way were worn by every athlete, even though different sports required different movements and placed vastly different kinds of stress on the foot. Considering different uses and designs, Bowerman decided that even a basic single-design shoe could have a sole that was lighter and provided better support, stability, and traction than was then available.

Bowerman drew his own designs for a better shoe and sent them to American sporting goods companies. They all turned him down, indicating that they were happy with their shoes and were not about to take a chance on making something that might be too expensive to sell. "We don't tell you how to coach," they told Bowerman, "so don't tell us how to make shoes."

Coach to Cobbler

Those rejections brought Bowerman face to face with a test of his own personal philosophy. Bowerman had come more and more to describe himself not as a track coach but as a *teacher of competitive response.* He taught athletes to value competition not so much for its prizes and victories as for its intellectual and spiritual demands. His athletes came to regard athletic contests as a different kind of challenge: If you won, there was no problem; if you lost, you gained information that would help you the next time.

Sometimes the competitive response to defeat was simply a matter of conditioning—become stronger and you will win the next time. More often, however, the response required more information, such as better race tactics, more knowledge of the opposition, better equipment. Bowerman taught his athletes that their resources to win were almost limitless if they applied themselves to knowing and exploiting those resources fully. His teams had exceptional self-esteem; they believed in their ability to summon up internal resources, not only as athletes but as people.

Bowerman's athletes absorbed a measure of his intensity. At heart, he was a teacher. Instinctively, he tests each person he meets; if the results are satisfactory, instruction commences. To the disciplines of track and field, Bowerman was a natural. Track is a team sport in which members work and compete, for the most part, in isolation from each other. Their greatest bond to each other is through their teacher, the teacher's management of their training, juggling of personnel to create winning combinations, and instillation of common beliefs in each of them. The track and field athlete often depends upon the coach more than on any teammate. Track teams commonly exhibit a symbiosis that flows directly from and to the coach. They seem separate from their peers and inseparable from each other.

Bowerman created that solidarity among the Oregon track men. He had long understood that emotion could make the difference in competition, because differences in physical advantage were often small. Not requiring much equipment, track and field events depend more on the body itself than do most sports. Athletes competing in a particular event usually share similar physical characteristics, because they are specialists. Differences between competitors are measurable in small increments and subtle advantages; a successful coach discovers those subtle advantages and uses them.

In shoes, Bowerman saw the potential for advantages that were far from subtle. He knew that shoes could be greatly improved, but he could convince no one to make them. Bowerman knew the response he would have given to one of his athletes: "If you can't find someone to do it for you, learn to do it yourself."

So Bowerman became a shoemaker. He acquired his ability by trial and error. A cobbler taught him the basic skills and then sent him to an expert who made custom boots for lumberjacks. The bootmaker taught Bowerman that the "lasts," or patterns, for shoe soles and uppers don't have to be fancy or durable; he could make them from grocery bags and keep redrawing, cutting, and shaping until he got the best design. From that insight, and a series of return trips to the bootmaker, Bowerman progressed from paper bags to leather. Bowerman designed his first pair of track shoes for a middle-distance runner. Today that first pair looks fragile and ragged at the edges, but also sleek, light, and purposeful. This was a shoe that would do its job.

Summoning his new talents, Bowerman began to outfit more and more of his athletes with his own custom-made shoes. Each pair was an experiment, but each got better. And each suited its use and its user like a glove. "A good racing shoe," says Bowerman, "should be built to last the distance and then self-destruct." To his athletes, those shoes were the tangible embodiment of the competitive response. The athletes won races—wearing those shoes—because their coach had found a way to solve a problem that every other coach had simply ignored.

Just Do It

Most of Bowerman's athletes graduated and transferred their newly learned competitive persistence to other pursuits. But one of them, Philip Knight, a fairly good miler who had grown into a superior athlete under Bowerman's teaching, saw in those custom shoes not just an example but an industry. They solved problems that persistently plagued runners. Knight believed athletes would embrace these new shoes if he could only find a manufacturer willing to make them. But who? Established American companies were not interested; their customers, like it or not, would have to choose among existing sneakers.

The first articulation of what would eventually become Nike, Inc., was a graduate school paper Knight wrote for his master's degree in business administration at Stanford University. He suggested that an American company could open new markets for athletic shoes by *sourcing* the products (buying finished goods and importing them) in Japan, then distributing them in America directly to athletes and teams. The key was that these must be shoes of a superior design. Knight's concept was more than theoretical. In Bowerman's shoes, he already had the design; all he needed was a Japanese manufacturer and a U.S. distributor. To this problem, Knight applied Bowerman's principle: If you can't find someone else to do it, do it yourself.

On a 1962 trip to Asia, Knight decided to explore the possibilities for sourcing athletic shoes. He called on Onitsuka Tiger, Japan's best manufacturer of athletic shoes. At that time, very little business information crossed the Pacific Ocean; Onitsuka and Knight were equally unknown to each other. Knight, however, conveyed an air of authenticity to the Japanese. His athleticism, his youth, and his urgent manner made him seem like the typical go-getter American marketing representative Japanese executives frequently read about.

Unexpectedly presented by Tiger with an opportunity to begin a business relationship on the spot, Knight didn't even have a name for the company he was supposed to be representing. He invented one on the spot—Blue Ribbon Sports, Inc. (BRS). Knight offered a simple arrangement: Tiger would ship their shoes to Blue Ribbon Sports, which would be their sole distributor in the United States.

With little hesitancy, Onitsuka agreed to this golden opportunity to be the first in the American marketplace; he set a nominal fee of $1,000 for the exclusive rights. With that unexpected promise, Knight hurried back to America desperately in need of two things—a thousand dollars and a company.

The company came together when he told his idea to Bowerman, who responded warmly. Both men knew that if they successfully marketed Tigers in America, Onitsuka would probably agree to manufacture Bowerman's shoe designs. Bowerman had already seen beyond the needs of track athletes to those of other people who ran for health and exercise. More and more he believed that running was a failure as a popular sport in America because the shoes were so bad.

Also participating in the discussion was John Jaqua, Bowerman's attorney. After Jaqua told them how to form a corporation, Bowerman and Knight became Blue Ribbon Sports, Inc., split the expense of the distribution rights, and sent Tiger one of Bowerman's designs. Over the subsequent months, Onitsuka Tiger transformed their production facility to accommodate this design and developed mass-production methods for the shoe. Less than one year later, a shipment of two hundred factory-made Bowerman shoes arrived in Oregon.

A Blueprint for Chaos

Blue Ribbon Sports was, in its first few years, a shaky enterprise. Both heads of the company worked part-time. Bowerman coached for eight more years, winning three National Collegiate Athletic Association championships and becoming in 1972 the world's most controversial Olympic track and field coach.

Bowerman overshadowed his athletes during much of the 1972 Munich Olympics by criticizing the structure of the International Olympic Committee and the facilities provided by the German government—including security. His complaints were tragically vindicated when Palestinian terrorists breached the perimeters of the Olympic Village and murdered eleven Israeli athletes. Bowerman continued his criticism, boycotting the memorial service for the athletes and calling the International Olympic Committee "people using a tragedy to heighten their own sense of immortality."

Knight was less public, but no less busy; he worked as an accountant and as an accounting professor. The style of operation for BRS was a blueprint for chaos. Tiger wouldn't send shoes until BRS sent money, so the company was always in the hole, waiting months to sell products they had already paid for. In essence, the more they sold, the more they owed. Shipments didn't always arrive as quickly as promised. Sometimes demand exceeded supply, and when Tiger made choices on which market to serve first, they invariably favored their domestic distributors over BRS.

To sell their shoes, Knight's small sales force worked out of the trunks of cars. At first, this was a matter of necessity—Knight couldn't afford to pay rent. But even after BRS (eventually renamed Nike) had stores, this mobility became a company trademark.

Jeff Johnson is recognized as the first employee of Nike. A former part-time salesman for Adidas and an athlete who had competed against Knight and Bowerman, Johnson knew that they understood the athlete. Though their company was small and their product lacked Adidas's packaging sophistication, Johnson felt more comfortable with BRS because they were close to the people who wore the shoes. "I believed in Knight," he said. "I knew I could sell those shoes, and I knew exactly how I was going to do it."

The other original salesman was Geoff Hollister, who got his start working weekends while he was on Bowerman's college team. Eventually Johnson and Hollister perceived the need for a normal retail outlet; too often, traffic caused them to miss appointments. Hollister became the proprietor of one of the first BRS stores, in Eugene, Oregon. Johnson's was in Los Angeles, and a warehouse sprang up in Wellesley, Massachusetts.

The Eugene store, founded in 1968, cost the company $75 a month to rent, $25 more than the corporate headquarters. Every time trash collectors came through the neighborhood, Hollister had to dust off his entire stock. "You could see the dust coming through the walls," he said. "It wasn't a real stable place."

The Nike Mystique

Although they were to increase in number five years later, retail outlets remained a minor element in Nike sales and the Nike mystique, which grew steadily among the cognoscenti of the running world. Nelson Farris, a track athlete who joined Nike on impulse because he "liked these shoes," described the company approach: "We were the right people with the right product at the right place and the right time with the right attitude. We made inroads against Adidas and the others because by going to high schools and selling shoes to coaches and athletes, we brought them the personal touch. We made friends of those who bought our product. The stuff was good-looking and light; it felt good. We worked hard to deliver."

The idea of "authenticity" recurs repeatedly among the "older guys" at Nike. As the 1960s turned into the 1970s, BRS—by then renamed Nike, Inc., after the Greek goddess of victory—emerged more and more as the authentic shoe company serving runners. Although other companies served every sport, they were also rigid. So if there was a flaw in their court shoe, for example, it didn't get corrected, because they had no one in touch with the athletes it troubled. Their products were developed in laboratories, not on playing fields. Their distributors stayed in their offices, talked on the telephone, wore suits, drank at lunch, and got fat. At least this was the impression shared by most athletes. The established companies were out of touch.

"Every aspect of the athletic shoe business was open and waiting. I think other companies didn't take us seriously—they didn't think running was going to become popular in America. But we believed it was—with a passion! Because of that, once we were going, you couldn't stop us," said Farris. "We had an authentic presence. Our guys didn't look like salesmen. All of them were skinny, they were all runners or had some running background, and they knew what they were talking about. If our guy talked to a racer or a coach about shin splints, he knew what he was talking about. It wasn't a fraud. We were accepted into the running community instantly."

That acceptance was vital. When Johnson, Farris, or Hollister put on a clinic or a race or gave away shoes to teams of high school athletes, they helped to make up for the fact that BRS was not making the high-quality shoe that Knight and Bowerman had envisioned. The company was at the mercy of Onitsuka Tiger, which took greater and greater advantage of their wildcat distributor in America. Sometimes sales were so good in Japan that factory seconds were shipped to Oregon.

Hollister and Nike financial officer Del Hayes recalled a typical crisis: "One year we got our load of basketball shoes," Hollister said. "There was a heat-activated glue for the soles and they forgot to run them through the activator. These shoes would last a couple of weeks and then fall apart. I had to replace one team's shoes three or four times. We lost a lot of money, yet we were able to sell shoes to the same people later." "We didn't hesitate," Hayes added. "We just replaced the shoes."

A Revolutionary Crusade

Even though product failures were expensive and embarrassing and the marketing scheme resembled an amateur fund-raising campaign, three forces were guiding BRS toward their eventual breakthrough. First, Bowerman's shoe technology was growing more sophisticated and was oriented more toward a market beyond athletic specialties. Second, the competitive response was taking over among

BRS workers, turning what had started out as a hopeful pastime into a crusade. "Those guys went out into the field like believers in the true faith," said Mary Marckx, Nike's public information manager. Third, Knight proved to be a leader with an intuitive grasp of when people should be left alone and when they needed to be reined in; Rob Strasser, leader of Nike's new product development group, described Knight: "He has vision and faith. He's a great competitor who inspires loyalty in a lot of people. I'd follow him anywhere."

Even great leadership needs a good product. If its product lacked technological integrity, Nike would have remained little more than a minor participant in a specialty market. "Our product at the beginning was not that great," said Hollister, "but we listened well. Our competition had a twenty-year head start on us. We'd worn their shoes, and we'd hurt. Bowerman was coming up with neat ideas, good experiments. He began with a few small things; as you look back you don't think they're very innovative, but then they were pretty revolutionary."

One of Bowerman's dreams was to expand the sport of running to average people as an avenue to fitness and health. Running, or jogging, is a logical method of lifetime conditioning, and the world itself is the playing field. Yet people didn't run, especially in the United States. "You forget what it was like back then," said Knight. "It was a little strange. If you ran in the streets, people thought you were weird."

One of the ironies of Bowerman's wish to popularize running is that most people didn't realize how uncomfortable most sneakers really were. People tended to believe that sneakers were the most comfortable shoes and that they gave them up in adulthood because of social convention. In reality, for average adults, traditional sneakers were an assault on the muscles of the leg. People who spent their workdays in shoes with heels and mid-sole supports gave up those supports when they put on sneakers and went out running. Their feet and legs hurt; they got shin splints, leg cramps, back pain, damaged knees, twisted ankles. "We had to design a shoe to fit the unfit adult," said Bowerman, "because they couldn't exercise in any existing shoe and enjoy it."

A New Industry Standard

In 1966 Bowerman designed a shoe called the Cortez, with a heel wedge and a mid-sole support—the first technological advances in general-purpose sneakers since the 1920s. The Cortez made it possible for average adults to run without pain. From then on, Bowerman kept blending athletes' advice with his own vision of good shoes. He had retained a whole, elegant concept almost as long as he had been a coach and teacher, but it had taken him more than twenty years to gather the resources and technical skills to synthesize it all into one shoe.

By the mid-1970s, four elements had become basic in athletic shoes; Bowerman had introduced them all. Virtually every running shoe now sold for "unfit adults" has them: (1) the heel wedge—for heel support and protection against shock; (2) the cushioned mid-sole—to soften the impact of running; (3) the waffle sole—which provides better traction with less sole weight; and (4) the nylon upper, which is lighter and more "breathable" than canvas or leather.

With these changes, Bowerman provided the superior product that Knight's quixotic enterprise needed to survive beyond the stage of nervous energy and novelty. Just as important was the mounting sense of true faith among the BRS crusaders. The resourcefulness of many of the early employees came partly from their naturally competitive response and also from their sense of shared ordeal and triumph. Many things reminded them of being back on the team, of gutting out a third-place finish to add one point to the total.

"This sounds corny but I think it's true," Hollister said. "Along with collaboration, you had definite feelings about the people you were working with, because you were going through this struggle. It wasn't pretty at times; it was hard. You can look back now and say it was a great success, but back then, I don't know that we considered ourselves successful. You really had a feeling—I have to call it love—for other people in the company who were winning small battles."

Another element that deepened that unity was a growing animosity toward competitors, especially Adidas. Nike found out that being an overwhelming underdog had advantages that touched both the retailers and the distributors, as well as the athletes. Many dealers were angry because they had been forced to buy the product that Adidas wanted them to, at the company's prices. Nike listened to dealers and developed the same relationship with them they had with athletes. "A lot of people were really excited about us being competitive with Adidas," Hollister recalled. Every team needs an opponent; Adidas was the perfect one for Nike.

Resisting a Takeover and Regrouping

It was not Adidas who literally closed down BRS with one sudden announcement. One day in 1971, five representatives of Onitsuka Tiger marched into Jaqua's office and announced that Tiger had cut off supplies to BRS. Tiger had given an indication of what was coming, when they proposed a takeover earlier. BRS had surprised Tiger by approaching $2 million in annual revenues. As long as it was only the manufacturer, Tiger earned a relatively small fraction of that growing revenue; the temptation to get it all became too much. Tiger made a rather unattractive offer to buy 51 percent of the company's assets, control two of the five seats on its board, and let Knight and Bowerman stay on the payroll. When Knight resisted, the total cutoff of supplies came very quickly. Jaqua, however, was the only one who really understood the crisis.

"I don't think Knight and Bowerman realized the finality of what Tiger had done," recalled Jaqua. "I think they thought the source would slowly dry up and give them time to reorganize. But what was going to happen was an absolute ban on shoes to us, and I'm convinced that Tiger's own distributors had already been set up."

In fact, as revealed in the inevitable court case, Tiger had established a separate distribution organization in the United States. They were ready to switch shipments of Bowerman-designed shoes to other U.S. retailers without a break in the flow of products. By controlling supplies with no other source available, Tiger could win the war even if they lost the initial legal skirmishes. "For a small company like this to have a hiatus in its distribution would have been fatal," said Jaqua.

Within twenty-four hours, Knight was on a plane to Japan. Jaqua began to file legal papers to prevent Tiger from taking over Bowerman's designs; he had Charles Robinson, an international banker, meet Knight in Tokyo. With Robinson's help, Knight accomplished in thirty days what should have taken eighteen months. Robinson introduced him to the leaders of Nissho-Iwai, a large Japanese trading company. Nissho agreed to serve as the financial middleman between BRS and their Japanese shoe manufacturer. Since BRS no longer had a Japanese manufacturer, Nissho introduced Knight to two. When they agreed to make the shoes, Knight produced copies of Bowerman's designs and offered to stay in Japan to help get them into production.

Spurred by Nissho-Iwai's influence and Knight's persistent presence, the new Japanese shoe suppliers had products off the production line in weeks. A month later, Knight flew back to the United States with boxes of shoes for his distributors in America. Jaqua was astounded at how quickly Knight was able to switch manufacturers and still keep the products flowing. Bowerman was amazed at how quickly Jaqua had sized up the threat to the company. "John Jaqua was almost a seer," said Bowerman. "Chuck Robinson, through Jaqua, saved our bacon."

"The trouble with Knight and Bowerman," Jaqua recalled, "is that they just trusted everybody. I don't think that either of them envisioned the infighting that could take place."

By keeping open the lines of distribution with even a few boxes of shoes, Knight broke Tiger's back before the court actions began. Legal victory was relatively easy for BRS, and Tiger virtually disappeared from the U.S. market. They had tried to kill the goose that laid the golden egg, but instead they only made that goose self-sufficient.

A New Name, a New Focus

From 1971 to 1973, the strength of Nike shifted from Bowerman's inventiveness to Knight's organization. Bowerman continued to design shoes, but soon it became important for this new product to achieve national market recognition.

Knight developed for his distributors a *Futures Program*, which allowed them to predict a certain level of sales of shoes and finance that amount. Distributors could have shoes made according to orders received, rather than be forced to keep a large and costly inventory. The Futures Program was a riskier way of operating than that of established shoe companies, but it served Nike's peripatetic, part-time distributors better.

Nike also benefited from aggressive efforts to associate its footwear with celebrity athletes. The first of these, in 1973, was distance runner and world record-holder Steve Prefontaine. Tennis star Ilie Nastase and Boston Marathon winner Jon Anderson soon followed, as did Wimbledon and U.S. Open titlist Jimmy Connors.

In 1975, Rob Strasser—Nike's overweight, unathletic marketing leader—changed the face of professional basketball by giving a handful of National Basketball Association (NBA) players $2,000 a year plus a share of royalties to wear Nikes. By 1981, Nike had 65 percent of NBA players under contract to wear its shoes. The "shoe wars" among Nike, Adidas, Converse, and Pony escalated until, just a few years later, every NBA player had a shoe contract, with the biggest stars' contracts approaching $1 million. Strasser's small original group had grown into a monster.

After Nike had survived the takeover try, there was a sense that the company could grow to as big as ten to twenty million dollars a year by the end of the 1970s. "Knight thought he'd have a successful national distribution," Jaqua said, "but I don't think he envisioned anything more than a five or six million dollar company. He felt that if he could find somebody with innovative ideas, they could not only siphon off some of the market but also enhance it. He thought he could make a comfortable living; he wouldn't have to teach."

Competing intelligently against the bigger shoe companies, Nike might have advanced beyond even the ten to twenty million dollars that seemed beyond Knight's wildest dreams. How much farther they could have climbed—in a normal atmosphere—is hard to judge.

Riding the Wave of the "Me Decade"

By the second half of the *1970s,* the United States was in the midst of an era that has been described as the *Me Decade,* in which a generation of young Americans, wealthier and better educated than their predecessors, became possessed by an almost religious self-absorption. It was an era in which conformity and rebellion seemed insolubly confused, in which conservation of resources and conspicuous consumption became the weirdest of bedfellows. Young people began expressing themselves in new ways that were intentionally self-centered. Among the most tenacious trends was the so-called *fitness movement.*

With the sudden emergence of that movement, an idiosyncratic, antiestablishment shoe company was in position to be the touchstone for a generation. Suddenly, veteran runners found themselves amidst a mass of strangers in electric-blue nylon designer ensembles. Often the old runners encountered this crowd at a run sponsored by a Nike retail store.

By then, Nike was everywhere real runners were. The company had established a network of retail stores, each responsible for sponsoring one run ranging in distance from two miles to a marathon. Now, besides the runners whom they'd been seeing for years, store proprietors were listening to a growing host of dilettantes and amateurs.

"Runners searched out the best stuff," said Farris. "People would ride fifty miles to buy a pair of Nikes, because our stores were authentic. Guys there knew what they were talking about. Then the real runners would run the race, and all the novices would see them in Nikes. The concern with health and good food and all that was starting to grow. And we were there—the guys with the good stuff."

Hollister added, "We were concerned about serious runners, and they bought our product. People saw them running races, looking fit. They wore these shoes. Lots of people wanted to follow their example." The Nike work ethic met not only the broadening product need but also the psychic need. When the fitness movement struck America, Nike was the best-prepared shoe company to take advantage.

Of course Nike enjoyed a prime location. They were well established in California, the source of many trends in American culture. Farris mentions Culver City as having the best claim to being the birthplace of the fitness movement; it was there that Nike held one of their first public product promotions, at the Western Hemisphere Marathon. Having a strong base in California was a matter of lucky geography, and it might be that Nike's rise happened to coincide historically with a rising tide that lifted all boats. But this explanation disregards the dizzying speed of Nike's growth—from under $29 million in 1976 to close to $3 billion in 1991.

Farris recalled, "In the 1976 Olympics, we sent nine promotional people to take care of the handful of guys who had our products. Adidas had 300 people—an entire wing of the hotel. Their power and prestige were absolutely overwhelming." While Nike spent $75,000 on that Olympics, Adidas's promotional expenses were estimated at $6-9 million. Adidas fielded a host of medal winners.

Nike's only potential medalist—marathoner Frank Shorter—at the last minute, on the last day, suddenly overwhelmed by superstition, changed his shoes. In stunned silence, Nike people watched their Olympian, on national television for more than two hours, run the marathon in somebody else's shoes. "After that happened," recalled Hollister, "I stayed in bed for eight or nine days."

Grass-Roots Advertising

However crushing such disappointments, Nike had never really depended on celebrity endorsements or medals. Their strength was in the grass roots, serving the core of the running movement. From that basic approach, Athletics West, the first company-sponsored running club, sprang up the year after the 1976 Olympics. Nike was becoming, as Strasser noted, "famous by word-of-foot advertising."

The novices were seeking—among experienced runners, among fitness experts—the most "authentic" products. Believers in craftsmanship, they were looking for new names and salesmen to counsel them. Nike's focus on serving the needs of the runner, Bowerman's constant improvements of the basic shoe, the company's obsession with shoe comfort—all these factors appeared to fitness-conscious consumers not merely as product features but as personal values. Nikes were something people could buy and display as symbols of their fitness, individuality, and resistance to the big business establishment that had brought the world to such a sorry pass.

Nike's values developed in a time when millions of people were looking for integrity in the things they touched every day. "By being involved with athletes at the grass roots, we had an invitation to the party in virtually all sports," said Strasser. "We belonged, and people recognized us as belonging. Winning or losing is not a popular way to label values, but that's what we like to do—not winning at any cost, but just trying to be excellent." Nike exuded a wholesomeness that struck a responsive chord.

As the 1980s began, that chord rang in for Nike an era of spectacular revenues and expenditures, an era in which they expanded into new facilities, production sites, countries, and development methods. And Nike became far more structured.

It is difficult to look at the Nike of today and see any vestige of its origins. At the beginning, among a collection of part-time workers with a grab bag of degrees ranging from English to art, Knight had been the rare exception with a business degree. The people at Nike, for the most part, were more interested in life's pastimes—sports and games—than in its serious pursuits. Neither they nor their oddly scattered commercial centers seemed to have the makings of a long-term enterprise.

The outward appearance, however, of Knight's "old guys"—and what he insisted on more and more in his "new guys"—is as deceptive as Bowerman's inscrutable stoicism. Formed in the competitive crucible of Bowerman's tutelage, and inspired by the confidence of his foremost disciple Knight, Nike people never were isolated in their work, no matter how far they were from headquarters. Like former college athletes, they were instinctively conscious of the value of each individual's effort to the success of the team.

Bowerman, even *in absentia,* influenced everyone in the early years at Nike. "They were all loyal to him because he was like a godfather to them," said Jaqua. "Some people think he's a little rigid, because he has a very set, consistent moral code. He doesn't bend for expediency when some people think he should. But that's what made him great in the eyes of people who worked for him, ran for him."

"From the beginning," said Hollister, "Bowerman really taught you that competing was very important. If you didn't compete, you shouldn't be playing the game. It was more from example than from talking about it. We wanted to win. We covered some distance in a very short period of time. A lot of that had to do with our competitiveness." "If you had to say in one word what made Nike, it's 'Bowerman,' " said Knight. "Here was a whole bunch of guys who grew up under one system, who came here with a common view of the world." Mary Marckx added, "It was like what we're doing is right, and it's going to make a better world."

Like Bowerman, the people who built Nike rarely, if ever, contemplated total defeat. As Del Hayes noted, no one ever worried about having to do it all by himself. Bowerman taught that a shared commitment returns to each individual more than he puts into it, even if his contribution is a lot bigger than everybody else's. By his teams' consistent success, Bowerman proved that this could be true. Knight, in turn, showed people at Nike—most of whom believed it anyway—that this could apply even in business.

To most people, this notion of excellence without ego remains a fairy tale. Even most athletes don't live up to it. Ned Frederick, a researcher with Nike, adds, "If your ambition is to be someone, you're going to have to go somewhere else, because you don't succeed at Nike by climbing the ladder. I don't think there is a ladder. There are just a bunch of jobs out there that need to get done.Your satisfaction is the approval of your peers and that sense of a job well done, not the big promotion with the raise, not the bigger office and all that. I think four simple principles explain how people feel about Nike. When we're feeling good, it's because we feel a part of it, feel we are getting a fair deal, have a way to keep score, and get a chance to show our stuff."

People Who Like Being Together

By 1984, Nike's fairy tale—probably to the delight of so-called realists everywhere—was on the skids. Returning after a year's sabbatical, Knight found a company that had begun to hire people the way most American companies do, by fitting the person's qualifications to the job. The team had broken up, and a business had taken its place. Hayes (ironically, one of the few "old guys" to come from an established corporation) was most emphatic in his complaints to Knight about the changed atmosphere: "...people sitting around worrying about their career paths, titles, and job descriptions."

"I've learned at Nike that I hate big business," said Hayes. "And when you start pushing on a billion dollars you become a big business. But I think that lately, in spite of the numbers, we've become a little smaller, reverted a bit to some of the old practices, which in spite of everything were fairly successful. You never go back to when there were fifty people on the payroll. But I think that some of the principles that were embraced during that time you can still embrace."

Knight's response to Hayes's complaints included imposing a tight discipline on finances to phase out some of the wild expenditures on entertainment and celebrity contracts and bringing the product development group under more control. His main focus was on personnel. He had a discordant team, and he moved aggressively to get rid of people who wanted to do the same thing all the time, who didn't enjoy arguing or telling jokes, who got dressed up for work and expected their secretaries to have *The Wall Street Journal* on their desks every day at 9:00 A.M. sharp. Knight applied to Nike's recovery the principle that once you've got the right people, you're probably going to make out all right.

"We grew so fast that we brought a lot of people in, and some of them aren't as much fun to work with as the old guys," Knight said. "As we regroup, we go back to the old guard and the new guys who have worked well together—regardless of their talents. I increasingly respect the Japanese style of managing. You major in the business; you don't major in the discipline. You work toward a common goal. It sounds simple, but I think it's almost an educational process."

People at Nike, explained Hayes, had stopped measuring success in terms of each other and started measuring it in terms of the image from outside. Nike faltered until Knight, who is thoroughly unconcerned with how the world perceives his success, returned to reimpose his image of how Nike people should behave. He reminded them that it matters less what you do in your job or the way you go about doing it than how you feel about the people with whom you work. If people value each other more than they value themselves, the organization tends to find a way.

Nelson Farris, looking back on a sixteen-year Nike roller coaster ride, assessed his feelings. "Two-thirds of the people I know—a stunning amount—don't like what they do. It's hard for us here to believe—sticking with a job that you really dislike. The most exciting thing about being part of this has been working in a place where you like what you're doing—to be able to go home and have laughs about your job. We were a bunch of people with individual achievements and team victories. It was a place and time to do your best and have a lot of fun. We could never duplicate that. They were the best of times."

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NAUTILUS: THE UNFINISHED BREAKTHROUGH

In an atmosphere dominated by dozens of men dressed only in strips of Day-Glo bikini—their rippling musculature tanned, shaved, and oiled to a wet-marble sheen—diverting people's attention would seem impossible. But at the 1970 Mr. America Contest, the most attention-getting individual amid that sea of glistening glutes and pulsating pecs was a short, balding man in his fifties, standing fully dressed in front of a big blue steel machine.

The machine, nicknamed the *Blue Monster* by Arthur Jones, its proud inventor, was large and complicated enough to be mistaken for something used to crush automobiles. Jones explained to anyone who ventured near that it represented a revolution in exercise physiology, the first exercise machine ever devised with an understanding of the way the human body uses and increases muscle.

Most of the people who paused to listen left smiling nervously, nodding and backing away carefully from his provocative but hard-to-believe pitch. Most of them were lifelong devotees of bodybuilding—a grim, slavish procedure often described as sculpture from the inside out. Bodybuilding requires men and women to sacrifice normal lives, to submit religiously to exhausting, mind-numbing repetitive weightlifting routines for four to six hours a day in dark, dingy gyms. It is the pursuit of physical beauty through an endless cycle of trivial but brutish agonies.

Here was Arthur Jones, however, talking about great strength and bigger muscles developed almost overnight, insisting that by applying resistance correctly, his machine could outperform all the free weights traditional to bodybuilding by twofold, threefold, tenfold. It could turn a year's work into a few weeks' worth. "I am not the best exercise physiologist in the world," he would say. "I am the *only* exercise physiologist in the world."

Few of those people knew Jones—his tendency to make apparently outrageous claims and to back them up with performance—how an obsession could drive him relentlessly for days, years, even decades. Had they known, they would have realized that he was telling the truth. Within the Blue Monster was contained almost forty years of irritation, ego, study, and labor. Used properly, the machine would do what he said. It would build muscle more quickly, evenly, and effectively than any bodybuilder or athlete had ever dreamed possible.

A Move to Fitness

A four-station, multiexercise behemoth that required the help of two people for anyone to use, the Blue Monster was not the ultimate exercise machine. Although it was the father of several advanced single-station machines, each focused on one complete human muscular movement, that together were called *Nautilus.* Once associated only with seashells, Jules Verne, and nuclear submarines, the word *Nautilus* became a shibboleth in professional athletics and a linchpin of the fitness movement in the 1970s.

Athletes trained with Nautilus to get bigger and stronger, hit more home rims, drive golf balls farther, serve more aces, tackle more quarterbacks, and stuff more baskets. Nautilus had become, as Arthur Jones had promised that skeptical crowd, the ultimate exercise machine. The excitement of television sports announcers spread word of its wonders, and by 1980 anyone involved in physical training, muscular development, aerobics, rehabilitation—or even natural foods and yoga—was certain eventually to encounter the question: "Do you do Nautilus?"

By the early 1980s, with the fitness movement in full swing, no image was more prevalent than that of a bronzed woman in a satin leotard, drawing together the padded chrome arms of a Nautilus chest machine. Frequently that chest belonged to Terri Jones, Arthur's fifth wife, whom he found in a teen beauty contest when she was fifteen, married when she was eighteen, and turned into *the Nautilus Woman.*

No economic measure of the connection between Nautilus and the fitness movement is possible, because Nautilus has refused to make public any figures for the privately held company. Estimates for national revenues from health clubs, fitness spas, aerobics centers, and other outposts of the fitness movement where Nautilus machines are essential items, either for serious use or merely for interior decoration, run as high as $250 million. Annual sales for Nautilus in 1992 were estimated at $26.9 million. Conservative estimates of the number of Nautilus machines in the United States—virtually all of them in good working condition because they were built to last—range upward from 500,000.

The impact of the explosion can be seen in its effects on Arthur Jones. In 1970, in order to get the Blue Monster to California from his porch in Lake Helen, Florida, Jones had to borrow money to rent a car and a trailer. He had been unemployed for more than a year and lived mainly on money borrowed from his sister and from odd jobs that his fourth wife, Liza, and son Gary could scrounge up in the depressed employment market.

By 1985, Jones was the proprietor of a vast headquarters in Lake Helen, the most remarkable feature of which was a $20 million television studio large and elaborate enough to rival most network facilities. He acquired *Jumbo Lair*, a six-hundred-acre estate in Ocala, Florida, big enough to accommodate a 7,550-foot jetport, where he kept three Boeing 707 jets and a few smaller aircraft. Jumbo Lair gets its name from the herd of sixty-three baby elephants that Jones airlifted from Zimbabwe to save from a government herd-thinning program. Among the other exotica that lived at the estate were three rhinoceroses, hundreds of rattlesnakes, thousands of alligators, four hundred crocodiles, and a gorilla—all of which Jones professed to like more than the people he knew. Arthur and Terri were guests on "The Tonight Show," "Lifestyles of the Rich and Famous," and "America Talks Back."

Away from the cameras, however, he was working on his next project: applying his knowledge of muscles and machines to relieving chronic lower back pain—an ailment estimated to cost the United States over $40 billion a year in treatment.

In 1986 Jones sold Nautilus for $38 million to Travis Ward, a Dallas businessman. Four years later, following a change in management and increasing debt and overhead, the company filed for bankruptcy. Dan Baldwin, a former Nautilus president, headed the investment firm that bought the company in February 1991 for $15 million. The company refuses to release sales figures, but an independent source estimated annual sales of $26.9 million.

Nautilus machines changed Jones's life, but his private style has remained unchanged. The driven, hard-sell inventor is the real man. By the time he unveiled a working Blue Monster, Jones had pondered, built, and rebuilt exercise machines for most of his life.

A Lifelong Passion

Jones assembled his first machine in 1948 after achieving what he regarded as inadequate results lifting free weights to build muscles and get bigger. In the 1930s he had begun to lift weights. He was one of millions of teenage boys for whom physical strength was a way to wrestle the ambiguities of life into submission. But Jones brought a uniquely anomalous intellect to weight training. By the ninth grade he had abandoned formal education forever, disappointing his parents, both of whom were physicians. "All that school was ever capable of doing was weeding out incompetents," he said. "We learn only from experience, and then only from our mistakes. Our successes only reinforce our superstitions."

Despite his refusal to "be educated," Jones dedicated his life to a constant regimen of learning—not just how to do things, but how and why they work. He evolved into a teacher who was contemptuous of his pupils' ignorance and unable to resist the urge to teach them anyway. "You put people into a situation where they can make mistakes," he said. "Eventually, the guy blunders through that. Then you put him over his head a little further, and if he blunders through that, you throw him in even deeper. At some level, he'll fail. Then you know his level—but in the meantime, he's learned from the experience."

However he teaches, it inspires. "With Arthur," said Inge Cook, who has labored as a photographer, machine-scraper, elephant caretaker, and all-purpose assistant for Jones for decades, "I found myself. Before I started to work for him, I didn't think for myself. I didn't think about why I did something, why I felt the way I felt about things. I learned that after I started working for Arthur. He would ask, 'Why? What do you think? How do you feel about that?' He made me stop and think: How do I feel? What do I think? I grew up. I became a person."

Asking why has been a lifelong passion for Jones. When lifting barbells didn't make him as big as he thought it should he was annoyed, but he also started to wonder why. He could not rest until he knew the reasons for this problem, and then the solution. "I eventually began to suspect that there was something wrong with the tool," recalled Jones, "because it produced good results in some portions of your anatomy and much lesser results in others. I assumed that by training with different weights, by training more, by training with different exercises or more or faster repetitions, at some point I would achieve good results everywhere. Initially, I didn't blame it on the tool, I blamed it on a lack of knowledge. So I sought out the 'experts.'"

Real Experts Understand

The experts to whom Jones harkened were the dedicated power lifters who labored in isolation in cellars, gyms, YMCAs. He asked them the correct way of using barbells to get uniform results, but he found out that they had come to accept the inconsistency of muscle development as a fact of life. "I found out they didn't know," said Jones. "Oh, they believed they knew. They had opinions. They had answers, except the answers didn't work."

Jones wasn't just perplexed; he was angry. These men supposedly possessed the most advanced knowledge in their field. They should have been capable not only of showing him a better way, but of explaining the reasons for it. But they didn't know. Worse, they had never bothered to ask why not. Their expertise was based not on superior technique or higher intellect, but on a congenital predisposition toward big muscles. In Jones's view, these so-called experts were frauds. An issue of curiosity became for him a matter of principle—people who do not understand something should not be telling others how to do it.

Jones determined then to learn everything he needed to know to understand weightlifting and how it could be done better. At first, Jones focused on the tool itself, but he also started to learn the sciences—physics, physiology, kinesiology—that would reveal the *why* that lay beneath the *how.* He didn't think then that in the end his rational barbell would become a commercial product leading to a spectacularly successful business. "My motivation was really just curiosity," he said. "I didn't set out to achieve financial glory or fame or adulation. I was simply curious. I set out to try to solve the problem myself."

"I started modifying the barbell," Jones said. "It was obvious to me that you're stronger in some positions than in others. Now, if you are three times as strong in one position of a movement as you are in another, how much weight can you use? Obviously, only what you can manage in your weakest position. The weight must vary during the movement or else you are stimulating yourself only in the weakest position. During the late 1930s, I added chains to barbells, so as you lifted the barbell more and more of the chain was lifted, thereby adding weight."

With that addition (at that time an unheard-of innovation) Jones was on his way to the Blue Monster. "Step by step," he said, "I became aware of the problems. Step by step, I solved them."

Refusing Limits

More than thirty years intervened. For most of that time, Jones was too busy with other challenges to concentrate fully on the creation of the ultimate exercise machine. The details of Jones's biography remain murky, mainly because he prefers it that way. He still refuses to reveal his age. But among the certain details is personal hardship during the Depression, made worse by the fact that he had virtually disowned his own family. From the beginning, Jones embarked on a life of fanatical romanticism. He insisted on doing almost everything himself. His religion was self-sufficiency, and he carried into every enterprise a passion for doing everything the hard way.

In 1939 Jones took up flying. Within a year he was a pilot, and his livelihood through two decades of alternating affluence and destitution came largely from airplanes. He built up businesses flying in South America and importing animals to the United States from South America and Africa. He also holds the distinction of being the first man to capture live adult crocodiles. This was a typical Arthur Jones attainment. No one in the whole world needed live adult crocodiles; even in the crocodile market, such as it was, buyers had always been happy to accept juveniles, which are easier and less dangerous to catch, and then to raise them to adulthood.

Somewhere along the line, Jones heard that no one had ever caught a live adult crocodile. That was all he needed to know. Within a few months, he was crating up live adult crocodiles by the dozen, setting up his own crocodile farm in Louisiana, and finding occasional crocodile buyers.

By the mid-1950s, Jones yearned to immortalize one of his animal captures on film. When he couldn't find a cameraman on whom he could rely, Jones took up filmmaking. He became good enough to make a handsome living as a producer of television shows that featured the capture of exotic beasts. The most successful of them was a series called "Wild Cargo."

In 1968, Jones was in Rhodesia making wildlife films. His experience there contained many elements that recur repeatedly in his life. Around him was a small but intensely loyal entourage. Included in the Jones colony were the peculiar basics of his life—a herd of pet elephants, several airplanes, lots of film equipment, a few crocodiles, and yes, an exercise machine.

Starting Over

Then Shangri-La caved in. Jones left Rhodesia, and while he was gone, all of his belongings, from aircraft to children's clothing, were seized. "They said they were 'protecting my creditors,' " recalled Jones. "But I had no creditors." He, Liza, and Inge Cook came to rest in Liza's home state of Florida, where Jones was flat broke. He had no income, no job. But Jones never looked for jobs; instead, he borrowed $2,500 from his sister, sent Liza and Inge out to forage for spare change, and found himself at last with the leisure to bring together thirty years of thinking about the ultimate exercise machine.

"In Africa, I had built an exercise machine," Jones said. "I had an idea for a component to be added to it; I called one of my employees at 2:15 A.M. and told him to get a piece of paper and a pencil. I drew it over the phone: 'Go to the upper left-hand corner of the page; now go four inches to the right,' and so on. I told him to make those components and bring them to my house later that morning. It didn't work, but it failed so dramatically that I knew what it would take to redesign the machine so it would not fail. I suddenly understood the problem."

A Rotational Animal

What he had understood was a matter of physics. The combination of gravity and the variations in leverage in the human body create disparities in a weight's resistance, and thus in its benefits to the weightlifter. Jones conceived a more effective way to replicate his chains-on-barbells idea—a way to make resistance vary according to the strength available at each point in the curve of a muscular movement. "Man is a rotational animal," Jones said. "You don't move in straight lines; even if you move your hand in a straight line, that involves three rotations—around the shoulder axis, the elbow axis, and the wrist axis."

Soon Jones was assembling the necessities for the construction of his machine. Many of his concepts by themselves were not profound or revolutionary—to a physicist, they were high school material—but combined and applied they formed an exceptional synthesis. His machine would use the human body as the leading technology in weight training. Jones had fretted over the physics of the body and weights long enough to devise a machine that did not move in straight lines—it forced resistance to rotate on the axis of the body. It freed the body but stabilized both the weights and the forces of gravity.

The pulley that Jones eventually created is not round, like most pulleys. It is more accurately a cam, a wheel that has been stretched and bent. This shape occurs in nature in the bean and the kidney and, more appealingly, in the beautiful mollusk called the chambered nautilus. In 1972, Jones changed the name of his company from Arthur Jones Productions to Nautilus Sports Medical Industries, in tribute to the form that was at the heart of his invention and would be the foundation of his fortune.

The uneven surface of the Nautilus cam conforms to variations in strength of muscular movements. For example, at the moment that the arm is strongest, the cam forces it to lift the weight the longest distance; it encounters greater resistance. As the arm reaches a weaker position in its range of movement, the cam demands a shorter pull—less resistance, but resistance that nevertheless taxes the muscle to its limit at this point in the movement. Jones's device also increases the body's flexibility by extending resistance through the complete range of a movement—it stretches as it strengthens, which free weights do not.

The result is dramatic. The body encounters measured, almost intelligent resistance from the Nautilus and draws from it the maximum benefit to achieve growth. This is simple; it makes sense. Before Arthur Jones, no one had ever effectively applied that intuition to create a tool that could make the body uniformly stronger.

Measurable, Adjustable Results

Paul Katz, an entrepreneur who met Jones in 1970 and became one of the first proprietors of a Nautilus fitness center, expressed the impact of the invention on fitness. "I thought, this guy is a genius," he said. "He's got the full range of motion. He's got flexibility, which athletes need more than strength. He revolutionized the whole field!"

Jones made a machine in which improvement could be measured, because the machine could be adjusted upward with improvements in strength or maintained at a constant level. Users could continue to get bigger and stronger or settle for a happy medium. They would be in control. Because its model is the human body and not weights, Nautilus will not cause injury if properly used. It works with incredible speed and efficiency, especially at the early stages when weak muscle groups have much to gain. In fact, it has always been Jones's contention, supported by a series of studies conducted under his supervision, that the optimal use of a Nautilus machine is thirty minutes every forty-eight hours.

Clay Steffee, a twenty-year employee of Jones, explained, "You'd train thirty minutes a day, three times a week, but it is a brutally hard workout if it's done properly. It takes a couple of months to build up to where you can stand it. But that's all you do. That makes it more popular, because a lot of people can afford thirty minutes a day three times a week, but not many can afford six hours a day six days a week. Nautilus enables you to get very good results in very little time."

To a bodybuilder, Jones's notion is heresy. To make muscle the old-fashioned way, you had to put in four to six hours a day, repeating identical lifts hundreds of times, increasing the weights eventually to gigantic levels. But Jones was saying it didn't matter how you lifted a weight; it didn't even matter how much it weighed. The important thing was to lift it until you couldn't do it again—to the point of failure—and then quit.

Jones believes that muscles grow not as a response to work but to overload. If a muscle is capable of doing work, no matter how long or how hard, then it doesn't have to grow; but if it experiences a shocking burst of work in which it fails, then the body will eventually respond, in a period of forty-eight hours, by enlarging muscle cells. "Exercise can pull a muscle; it can break a bone," Jones maintained. "It can cause exhaustion; it can cause all kinds of problems you don't want. The body will respond if it is stimulated. Exercise provides stimulation. If other physiological factors are right, you will grow. Stimulus comes from overload. No overload, no stimulus. No stimulus, no results."

The Nautilus machine can also provide aerobic stimulation by working short of the point of failure. It has helped athletes and people who are disabled or injured both prevent and rehabilitate muscular injuries. Its market embraces athletes, trainers, physicians, physical therapists, and all people for whom fitness is important to the quality of life. In fact, Nautilus incorporates most results that can be obtained from sensibly exercising muscles. The Nautilus cam and Jones's theories of resistance are so thorough and efficient that virtually all exercise technology now takes them as benchmarks.

Risky, Hard Work

That success did not come overnight, however, or easily. The suffering that Jones endured during the genesis of his first machine would have crushed a less tenacious person. He began by making plywood models, which he designed by making crude drawings as he paced through sleepless nights. Inge Cook recalled, "He would sit in a fast food place and mull things over. He would get out a pencil and doodle on the paper napkins. That's how he developed the machine. The next morning he would say: 'This came into my head. See what you can do with it.' But he was—and is—the only person who actually developed the machine."

When his designs were ready for a steel prototype, Jones had very little money and only a few hand tools. He found the equipment and working space he needed at a nearby welding shop, where he also met the man he would eventually hire as a prototype developer, Don Stevens.

Jones worked odd hours, but they suited a man too nervous to sleep. "I went in after they closed, and I rented the space and the tools," he recalled. "They didn't build them for me. I worked all night every night and, if I wasn't in the way, sometimes during the day. And on weekends.

From Friday evening I worked straight until Monday morning."

In the daytime, Jones would rest and Inge Cook would labor on the porch of the bungalow in Lake Helen, filing and sanding the welds. More than Jones, she felt the isolation of those penniless days of dispiriting work: "The worst was the beginning, living on borrowed money and no guarantee at all of success," Cook recalled. "We were working so hard. Because of what I was doing, my arms and back got very big—which made me a bit unhappy. Hard work outdoors, in the summer, hot and humid, sweat dripping in my eyes and salt itching all over. I painted at first in the open air with the wind blowing sand on my fresh paint, making a mess of it. It took several months before I got a covered shed to paint in—and then it was tin, which was very hot."

The result was the Blue Monster and the trip which became a pilgrimage to survival for Jones and his entourage. They held no expectations of wealth or triumph, just a faint hope that they could build these machines and make a living. Ironically, the least promising market was among those so-called experts in the bodybuilding world. Although their ignorance had spurred Jones's original quest, they remain stubbornly unconvinced even today that Nautilus is superior to free weights. In a way, the bodybuilders are right. Their goal is "bigness," just as Jones's goal had been when he was a teenager. If bigness is more important than flexibility—and as long as the illegal use of anabolic steroids, testosterone, and human growth hormones are part of the formula—then Nautilus machines will be superfluous to them.

Nevertheless, what secured Jones's future was their curiosity. So hungry are they for a competitive edge, in a sport judged by almost invisible subtleties in muscular conformation, that they will try anything once. Jones's Blue Monster and his several days of standing in front of it, haranguing people, stirred interest. He got an order.

Mr. America Means Nothing

A more important ripple of interest came from a man named Perry Rader, editor of a muscle magazine called *Iron Man*. Delighted by Jones's articulate and controversial prose, Rader cut a deal in which Jones would get free advertising in *Iron Man* if he would agree to write a series of unpaid articles describing his theories of exercise technology. That agreement was more critical than Jones could have realized. Although a good salesman and theorist, he had neither the patience nor the experience to market a product. In the next five years, Jones repeatedly struggled to gain a substantial following among bodybuilders. One of his greatest triumphs was when he took a young body-builder named Casey Viator as his protege, trained him intensely on his first machines, and saw him win the Mr. America title. It was a hollow victory, however; bodybuilders still could not be convinced, and Mr. America titles mean nothing to the real world.

Far more significant was that through *Iron Man* and a grapevine that extended into other forms of weight training, word about Jones's devices slowly spread. Among the first callers was Don Shula, coach of the National Football League's Miami Dolphins. In the first year Jones made twice as many machines as he expected—perhaps as many as 200—and obtained the vital assurance that he would make a living. All of those first machines were assembled, filed, and painted by hand.

While the tin building in Lake Helen buzzed with production, James Flanagan, one of Jones's employees, took several machines home and set them up in his garage for his own workouts. Flanagan met Paul Katz, then a real estate developer, while both were jogging. Katz, who played handball as a pastime, had just participated in a lengthy tournament and was suffering the usual painful aftermath, a stiff back.

Flanagan led Katz to his garage full of Nautilus machines. Within minutes he had loosened Katz's back and relieved the pain on a back machine. Like Jones, Katz was a lifelong student of exercise physiology who constantly sought intelligent ways to exercise more effectively and safely. Katz said, "When I saw Jim's setup, I said, 'This is for every average man and woman.' I knew that, under supervision, no one could ever get hurt on this stuff. You couldn't tear muscles. Jim started getting a lot of people coming into his garage. It started as just a little neighborhood thing. He asked, 'If I open up a center, do you think it will go?' and I said, 'Of course it will go.' "

It is almost certain that Flanagan's center, equipped with machines barely out of the prototype stage, was the first Nautilus training center. By 1972 other centers began to spring up in other places, first in California. Because Jones's machines cost relatively little and he applied no additional financial burdens, such as license fees to use the Nautilus name or franchise costs, it was remarkably inexpensive to equip a gym with a complete array of ten Nautilus machines—as little as $33,000. It didn't take a great leap of imagination to figure the advantages of opening a center. A bodybuilder could open a Nautilus center, serve athletes in a number of sports, spend his own days in the gym, and make a comfortable living. These entrepreneurs were frequently still devoted to free weights, and most had never learned how to use Nautilus properly. But they provided enough service—machines, showers, and towels in clean, carpeted surroundings—to make users feel comfortable and welcome.

By chance rather than design, the market had been primed for the fitness explosion. Not only was Nautilus authentic, having emerged gradually from the ranks of committed athletes, it was a shortcut to fitness that required significantly less time and none of the gritty masochism of bodybuilding. In the past, gyms generally had been dingy and unattractive. The Nautilus atmosphere allowed sociability to blend with conditioning. Indeed, as much as the technology, it was the cleanliness and brightness of Nautilus centers that sold weight conditioning to the huge new market of fitness-conscious people in the late 1970s. Most of the time, these people did not use the equipment to more than a fraction of its potential. Like a neighborhood tavern, the fitness center turned out to be a nice place to drop in, meet people, and work off a day's tensions. Nautilus, the new social lubricant, moved weightlifting from the boiler room to the living room.

A Blessing and a Curse

This evolution occurred regardless of—almost in spite of—Arthur Jones. Although Jones was far too bright not to perceive the fitness and medical potential in his machine, he exploited it only halfheartedly. When celebrity athletes began to endorse Nautilus training on television, it was not because he had contacted them. Celebrity endorsements were a consequence of Nautilus's success, not a cause. Jones overcame the lack of marketing savvy accidentally, because Nautilus sold itself. The technology was so thorough and compelling that those who found it couldn't help but talk about it.

Jones had done four things that successful inventors must do. First, he had followed Edison's dictum that the whole project must be envisioned, its problems and its solutions blended into a single image, before the work begins.

Second, he had the insight and courage to scrap all previous assumptions and go back to the very beginning. As Jones said, "The fact that something has been done in a particular way is no proof that that's a good way. In fact, the result that you are producing may be in spite of what you are doing."

Third, he took on the job of mechanic, making seat-of-the-pants adjustments with available materials to solve delays and minor problems that occurred during development. "I've used a drafting board," Jones remarked, "but I've learned that's not necessary in the early stages. You can use a drafting board until you're blue in the face. Build the son of a bitch. Strap it on your ass, run down the runway, and see if it will fly. And if it will, then make the improvements."

Fourth, he had penetrated the basic science of how things work in order to make them work better.

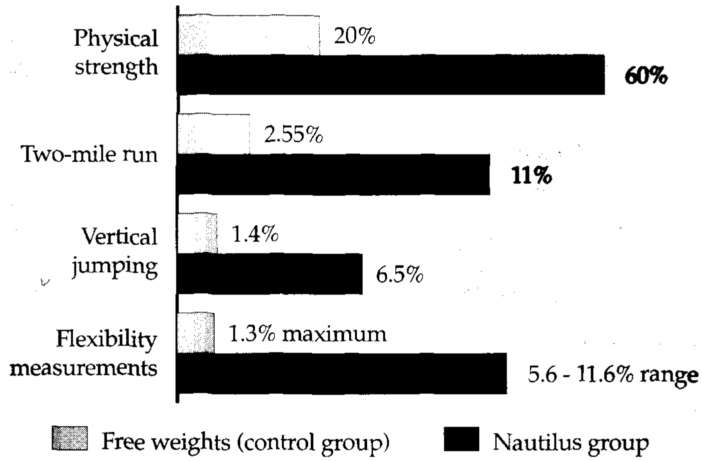
Jones also broke through by remaining on top of the explosive demand that pushed production for more than seven years. Though Nautilus Sports Medical Industries operated with only the Lake Helen facility until 1980, the longest delay any buyer had to tolerate between order and delivery was three months. And the quality of the machines was never an issue—even today, Nautilus's new machines face some of their stiffest competition from used Nautiluses that won't even begin to wear out for ten years.

Indeed, Jones discovered something with more applications than he foresaw. The most significant breakthrough for Nautilus has yet to happen because many of its potential benefits have barely been touched. It remains, in the majority of its installations, misused and misunderstood.

The Undeveloped Potential

Some of that varied potential was shown in a study done jointly by Nautilus and the United States Military Academy. In a comparison of two groups of Army football players—one group using Nautilus and the other free weights—differences in strength and flexibility improvement were extraordinary. The Nautilus group, in six weeks, increased physical strength by an average of 60 percent, while the control group improved less than 20 percent. The Nautilus group had an 11 percent improvement in its two-mile run, the other group a 2.55 percent improvement. The Nautilus group increased its vertical jumping ability by 6.5 percent, the other group 1.4 percent. While the control group did not improve its flexibility measurements by more than 1.3 percent in any of three categories, the Nautilus group had improvements ranging from 5.6 percent to 11.6 percent.

Paul Katz, who eventually served for several years as a strength coach in the National Football League, made some additional discoveries. He found that proper Nautilus use relieved some muscle injuries almost instantly and prevented the occurrence of pulled muscles, and he also developed a Nautilus aerobic routine. Nevertheless, Katz asserts, Nautilus technology is not easy to understand, and the available books do not provide the information necessary to use it to its full potential. He maintains that few people—especially specialists in rehabilitation, neurology,



Nautilus/USMA Study Comparing Performance Improvements of Two Groups of Football Players

orthopedics, and gerontology—have had enough exposure to grasp its capacity. The deceptive popularity of Jones's machines has prevented their effective implementation.

Katz today is out of the Nautilus business largely because he tried to use the machines properly. "My center closed because Arthur Jones was selling equipment to people across the street from me, nineteen-year-old kids just out of high school who didn't know the first thing about using it," said Katz. "They got their equipment on a 5-percent-down deal with a leasing company. They sold $80,000 to $90,000 worth of memberships at $100 or so, then went out of business. Then the leasing company resold the equipment to somebody else, and the cycle went on. In the meantime, I'm competing against them. I'm asking for three times as much money, I'm making people go for a physical before they sign up, I'm putting them through a killer of a routine for a half hour or forty-five minutes, three times a week. To use this equipment right is like dancing.

You have to maintain your discipline, your form. Once you break form, you're not doing yourself any good."

Katz's disciplined approach, complete with individual instruction and personal programs, was what Jones had envisioned from the early days. It represented a less lucrative, longer-term approach and the creation of a service industry that would parallel and augment the manufacture of the equipment. But the flood of popular response that struck Jones never motivated him to create a long-term service network, and it might have been too hard for him to rely on other people to help him create one.

"Would he have made more?" asked Katz. "I believe he would have made more and would have taken a lot more people with him to make a lot more. He's a tough, tough son of a gun. He just barreled ahead. He could have been a giant among giants. He could have been another Einstein."

Dumb as Einstein

Katz also describes business potential in terms of compassion, which seems odd. Yet for Nautilus that simply meant the ability of someone in the organization to perceive what the equipment could do for all sorts of people who needed it, then helping them understand and use it. "He should have had a training program for these people," said Katz.

"My compassion," Jones responded, "is what has gotten me into trouble all my life. I've gotten kicked in the head every time—and who the hell would want to be as dumb as Einstein?"

"I could write you an exact formula which would make you a millionaire in three or four years, from scratch, with no resources to start," he insisted. "Follow this pattern. Do not deviate from it. Don't modify it. But you wouldn't follow it. You'd change it—because you're stupid, opinionated, lazy, because you have biases and an empty head, not an open mind. You'd like parts of it, and you'd concentrate on those. Some you wouldn't, so you'd rationalize that those were unimportant. For whatever reason, you'd change it. You would not follow the instructions, you'd fail, and you'd blame it on me."

Enemies Everywhere

Jones also regards people as fundamentally felonious, attracted to men of his exceptional gifts and wealth in order to steal it. This sense of perpetual threat comes not just from Jones, but from everyone around him. His wife Terri explained: "Sometimes I get a view like he has—a cynical, hard view. But I've been exposed to a lot of dishonesty, a lot of theft, a lot of people trying to take advantage because you've got something they want, and they want to steal it. Very few people are honest. You've got to spend so much time babysitting, motivating, watching so that they don't steal. I hate so much that everybody wants to steal from you."

Harry Lafconski, Jones's longtime camera operator, stresses Jones's insistence on absolute loyalty—a loyalty he refused to acknowledge until Lafconski had worked through a four-year probation. "He was very jittery when he first started Nautilus," recalled Lafconski, "because of people trying to steal his ideas. He had something he knew was going to work. He had the fortitude, the confidence, the drive. He had everything going for him. I'm not trying to say he stepped on people—the only people he stepped on were the people that were trying to do him in, to steal his ideas. You'd do the same thing, because that idea created a multimillion-dollar industry."

Under the constraint of such profound mistrust, it is almost impossible for Jones to allow any aspect of his business outside his personal control or that of one of a tiny handful of loyalists. He promised fitness center proprietors the latest generation of computerized Nautilus machines by 1977, but they were not available until 1987—largely because Jones insisted that "it just wasn't ready." "I understand there are people who will take advantage of people," said Don Stevens. "I appreciate Arthur's feelings about what he wants done, and I understand it's hard to get people to do something exactly the way you want them to do it."

"Arthur developed the idea," recalled Lafconski. "He'd work on a project for hours and days at a time. Then he would delegate it to a person he had confidence in and say, 'Do it exactly the way I have it. When you do it that way, bring it back to me, so I can look at it, and then I'll revise it and I'll give it back to you.' It would go back and forth. As far as the idea itself, he was it."

Jones responds this way: "I hire good people, pay them well, treat them well, and leave them entirely alone. When they tell me they have something to show me, I look at it."

"Depending on other people is difficult for him," said his wife, "because he's done everything in the past himself. He would sweep out the office, design the equipment, answer the phone. It's really difficult for him now to extend responsibility. He won't allow anyone to open his mail—if you go into our kitchen, we have stacks of mail on the table and counters. He won't allow a secretary to open it. He wants to do it himself, because she may make the wrong decision or throw something away that's important."

The Next Generation

As much as anyone who ever has attained a commercial product breakthrough, Jones has done it by creating a company in his own image—an image that was an extraordinary reflection of technical ingenuity and unstinting hard work. His ability to express his concepts in a product and to instill in others that passion for work opened a huge, unexpected market.

For Dick Duke, founder of ChemLawn Corporation, it was also important to "show 'em"—to demonstrate his aptitude to a world that had underestimated him. But Duke fought that evaluation because, more than anything else, he wanted to be involved with people, to help and lead them. He perceived business as a dialogue, something better because it's shared. To Jones, on the other hand, sharing is an invitation to theft.

Or at least that was so during the Nautilus years.

Jones is now focused on the next generation of body machines—a generation that took a long time to emerge. Jones explains it this way: "If you told me back then what I'm about to tell you, it would have been the end of the conversation and the beginning of a fight." In the early 1970s, Jones was annoyed by the claims of a rival exercise machine named Cybex, whose makers he says asserted their device could accurately measure torque by forcing muscles to lift weights at a set speed. "In January of 1972," said Jones, "I wrote an article that pointed out the problems with the Cybex machine and furthermore said that I would take $200,000 and six months to build a machine that would do what theirs claimed to do. Privately, I thought it would take three weeks and $10,000.

"That machine wound up taking fourteen years and forty million dollars," he stated. "We built, tested, and rejected 3,000 prototypes. The first machine we worked on was to test knee functions. It turned out to be so complicated that it was the last one developed."

This new generation of machines make up Jones's latest enterprise—the MedX company, the focus of which is testing and exercise equipment for the lower back, the neck, and the knee. These areas of the body have been very hard to work with because of the difficulty involved in isolating the specific muscles surrounding them.

"Back problems cause more pain, more loss of work, and greater medical costs than any other physical problem," explained Jones. His new machines—an assortment of belts, pads, levers, counterweights, and a computer—are far more complicated than any Nautilus apparatus, and have been tested on hundreds of thousands of patients in the United States and ten other countries. According to Jones, patients using his machine can improve lower-back strength by 200 percent to 300 percent in just ten weeks.

The machines of MedX have only started to make a huge impact on the market, but the confidence that sustained Arthur Jones throughout the Nautilus saga remains utterly undiminished. Asked about the future success of his latest, he answers without hesitation: "We ought to win the Nobel prize in medicine for this thing."

12

MODERN POLYPROPYLENE: DREAMS DEFERRED

Life gave Italo Trapasso a gift that few people ever get: a childhood dream fulfilled. Trapasso's dream was to be a research chemist, to spend his life hunting for solutions to the mysteries that elude all but a handful of exceptional detectives, and to find an answer no one had ever found. His dream went unrealized, however, for more than twenty years.

Thousands of miles away in Japan, another youthful dream was approaching belated fruition for another man toughened by the harshness of circumstances and the resistance of employers. Like Trapasso, Yasuji Torii was an idealist who believed in the potential of chemistry.

Each man battled his company and won a victory for himself and for all scientists working in corporate laboratories. Torii's battle and victory came in the 1950s and 1960s with Mitsui Petrochemical, his lifelong employer; Trapasso's came in the 1970s at Montedison SpA., Italy's largest chemical company.

While both men were still dreaming and deferring their hopes, they met and became friends, sharing the kinship and uncertainty of dreamers in an unromantic industrial world. Partly because of their friendship, each man created an unforeseen commercial triumph. What turned them from friends to business partners was a substance called *polypropylene*, known to almost **no one** by name but to almost everyone by its prevalence.

Manufactured polypropylene is a nondescript, colorless polymer, a plastic so stable and flexible that it adapts to thousands of uses, so valuable that it is produced worldwide at a rate of fourteen billion pounds a year. It can be found in automobiles, in clothes and carpets, in upholstery and furniture, in sterile disposable medical items, in coating films for packages, in computers and television sets, in pipes and gears, and in a hundred other things that ease our daily routine.

Neither Trapasso nor Torii invented polypropylene; that was done in 1954 by Italian chemist Giulio Natta. His discovery of the process for polymerizing polypropylene was adapted for manufacturing by Montecatini, a chemical company whose 1966 merger with the giant utility company Edison created Montedison.

Though polypropylene was a breakthrough worthy of the Nobel prize, over the years it gradually lost its luster. For it to become a breakthrough again would require the wits and courage of Trapasso and Torii and the brilliance of the researchers who worked for them. Working on the same chemical process thousands of miles apart, Trapasso's and Torii's people slowly came together. Still, for the two groups to weave together a new polypropylene breakthrough required a seemingly impossible journey across time and geography. A Chinese proverb says, "The journey of a thousand miles begins with a single step." Strangely, in this case, that step was taken neither in Italy nor Japan, but rather in Germany in 1953 by a chemist named Karl Ziegler.

An Explosion of Research

Until Ziegler began to work on them, plastics were still crude and brittle, laden with impurities. A material called *polystyrene* was the best of them, and it was restricted to uses that required bearing little weight or stress. When Ziegler discovered a new, far more flexible substance called *polyethylene*, chemists in every industrial nation responded with an explosion of research.

Ziegler found that, in the chemical soup that reacts to synthesize polymers, certain metallic salts often encourage the formation of molecules which, under very high magnification, appear as clusters of chemical *pearls.* His breakthrough came when he created a *catalyst system* through which the pearls formed chains. He coaxed similar molecules to gather in a reaction that separated them from the surrounding substances. Significantly, he formed something new and useful from a lot of old, not-very-useful things. Today polyethylene is ubiquitous as the ingredient in food wraps and containers, garbage bags, toys, furniture—everything from badminton nets to gasoline filters. It is durable, flexible, and easy to make and mold. And it is the forebear of polypropylene, an even more promising substance.

Giulio Natta used Ziegler's discovery as a launching point for the discovery of polypropylene. Chemists describe Natta's achievement as the equivalent of training pearls to make themselves without oysters—and then getting the pearls to string themselves together. At Montecatini's lab in Ferrara, he led a research team that turned polypropylene into an industry within three years.

Ambition Postponed

In those same days, Trapasso enviously watched the excitement that Ziegler and Natta had started. Trapasso had been preparing for this kind of excitement since he was a boy. He loved chemistry devoutly, equipping his own laboratory when he was fourteen by working as a tutor. Throughout secondary school and college, he tutored until late at night, then hurried home to run his experiments into the early morning, oblivious of time or fatigue. "I consider study one of the biggest satisfactions in my life," said Trapasso. "I expected to continue studying all my life. It was my dream to be a chemist in polymer research."

At the University of Genoa, he focused more and more on polymers and began to blend his chemical study with a philosophical concept of Gottfried Leibniz called *monady*—the idea that all the processes of life are simple and comprehensible to humanity. Trapasso believed that knowing chemical processes as deeply as possible was the key to harnessing them.

His dream of a life of research seemed at hand when the university offered him a permanent position as a teacher and researcher in polymer science. But on the same day that he learned of the offer, Trapasso was drafted for military service. The teaching post would not wait: It went to someone else, and Trapasso saw his dream abruptly stifled. When he finished his service he was a stranger at the university; there were no opportunities and he had scant credentials to do research.

Trapasso had missed out on his dream, but he refused to feel sorry for himself. He kept informed on polymer research during a career as a manager in the chemicals industry. He was probably the only executive in Italy whose greatest heroes were Ziegler, Natta, and Torii.

A New Japanese Enterprise

While Ziegler and Natta were creating new polymers in Europe, Torii was among the engineers in the large Mitsui group of companies who insisted that to recover from World War II, the company had to diversify, to expand from coal into petroleum-based chemical processes. In 1955, Mitsui spun off a new company called Mitsui Petrochemical Industries (MPC) to pursue that idea. Torii was put in charge of its research. Already in middle age, he had patiently toiled through the step-by-step promotion process common in Japanese companies. Like Trapasso, Torii was passionate about research. He was sure that a company committed to understanding the basic processes of science could bypass its competitors.

The first act of MPC's president, Takeshi Ishida, was to convince Mitsui to buy a process for synthesizing *higher alcohols* from their German patent holders. When Ishida got to Germany, however, he encountered the excitement over Ziegler's polyethylene discovery and recognized immediately that, if Ziegler's concept could be translated into a practical manufacturing process, it would be far more valuable than synthesizing alcohols. But buying the polyethylene process was a major risk. It was still only a laboratory discovery; Ziegler had neither an industrial process nor any interest in helping to develop one.

"Ziegler said it was not his responsibility to establish know-how for commercialization," Torii recalled. "That was up to private enterprise. Mr. Ishida believed that though MPC had acquired only the patent, we could develop a manufacturing technology." Ishida was right; under his and Torii's guidance, Mitsui had it within a year. While they were vigorously promoting the production of high-density polyethylene and the development of its applications, Ishida and Torii saw other Japanese companies flock to Montecatini in quest of Natta's polypropylene discovery.

Two things kept MPC from following the Japanese supplicants. One was pride. Ishida had not enjoyed traveling to a fellow defeated nation to beg technology from an autocrat. He and Torii knew that Japan's recovery must eventually grow from creating its own technologies, rather than buying them from others. By 1955, the Japanese Ministry of International Trade and Industry (MITI) was enforcing the same philosophy. To save foreign currency, MITI began strictly limiting Japanese companies' acquisitions of foreign technology. Already in possession of one European polymerization process, MPC was unlikely to receive MITI's permission to buy another.

Torii had another idea. He suggested that MPC could make a polypropylene discovery similar to Natta's by discovering a catalyst system based on Ziegler's. Ishida said no, and with good reason. Natta had made an epochal discovery in catalysis to convert a simple gas, propylene, into polypropylene; it was absurd to believe MPC's researchers could duplicate that feat without infringing on Montecatini's patent.

Torii believed polypropylene was even more promising than polyethylene, that it was crucial to the success of MPC and the prestige of Japanese research. He shrugged at Ishida's refusal and told his researchers to go ahead. Torii persisted in his research and kept asking if it was okay to do it. Ishida kept refusing.

After five years, it looked as though Ishida was right. Torii's researchers were spinning their wheels. They had devised a polypropylene process, but they would have had trouble differentiating it from Natta's if it were challenged as a patent infringement. They needed a more dramatic difference, and they seemed unable to find one.

Torii quietly relented in his resistance to buying a foreign process and, entirely on his own, went to Italy to seek patent rights to the Natta catalyst in 1960. But Montecatini refused him. They had enough licensees, they said: In fact, four Japanese companies had already been licensed to make polypropylene by Natta's process. Torii's choice was simple: He could either admit that Ishida was right and abandon polypropylene research or he could find another way to do it.

Pathfinding

The choice was even simpler than that. If Torii gave up, he would have to listen to Ishida saying, "I told you so." For Torii, even the thought was unbearable. A career in the coal chemical industry had given him a healthy perspective on the meaning of danger. He had crawled through and survived enough dark pits in the earth that the prospect of losing face in a well-lit office held few terrors. So, unafraid of that potential humiliation, Torii stubbornly rededicated his team. The difficulty of the challenge was, in a way, greater than Natta's. Natta had found the most accessible route; Torii had to find another, less apparent way that would not cross in any way the previous path.

Torii's quest for a polypropylene catalyst was complicated in yet another way. His duties at MPC did not allow him to focus entirely on chemical research, since he also served in a more mundane role, as technical director of MPC's manufacturing plant. In 1959, that job led him to seek a license from a British company for a process to develop chemicals called *cumenphenols.* Torii met another man seeking a cumenphenol license—an Italian named Italo Trapasso.

The two developed the relationship of a talented student, Trapasso, learning under the guidance of a maestro, Torii. Over the next five years, they took turns visiting each other's chemical plants. More important, they became friends, sharing hospitality and troubles. Each knew what it was to dream of scientific discovery but to see the dream forestalled by practical considerations. Each believed in the simplicity of natural processes and in humanity's ability to understand them. Each loved research more than anything, far more than the management of chemical plants. "We shared knowledge; we shared trust," said Trapasso.

In the early 1960s Torii could share little of the knowledge that was emerging slowly from his researchers' work on polypropylene, and Trapasso was still a manager and, in a sense, in exile from research. Both men might have dreamed of working together toward a discovery as scientists and friends, but realized that was unlikely. The closest they would probably ever come was to discuss it over a pitcher of sake.

Not long after Torii tried to buy Natta's process, his research group broke through, discovering a titanium-based polypropylene catalyst that could be patented separately. In 1965, Torii was able to tell Ishida triumphantly that MPC could make its own polypropylene and need not seek permission to do so from any other company. "Mr. Ishida thought about it and said, T shall not oppose MPC manufacturing polypropylene any longer,' " said Torii. The cat-and-mouse game was over; they had both won. Torii believed that Ishida intended his opposition from the outset not to stop research, but to motivate it. "Our researchers were disappointed when MPC did not have anything while all our competitors had obtained polypropylene licenses from Montecatini," Torii said. "But Mr. Ishida had a firm belief that, if this challenge were left to MPC researchers, eventually they would succeed in developing a catalyst of our own."

The Dark Age

While the period from 1960 through 1965 brought great ferment to MPC, it was a time of gradual decline in research at Montecatini. Even though Natta had become head of research and shared with Ziegler the 1963 Nobel prize in Chemistry, Montecatini's researchers made no new discoveries. The worst thing that happened in that period was that Natta declared polypropylene research complete. Montecatini ceased its efforts to refine further their patented process, while other companies continued trying to improve it. And the other companies succeeded; Montecatini licensees devised ways to make purer polypropylene at less cost, using less energy. Eventually, most polypropylene makers were using a second-generation process, while Montecatini remained in the first generation.

The best thing that happened in that period was the arrival in 1961 of a brilliant young chemist named Paolo Galli, who came to Montecatini's Ferrara Research Center after winning a national competition among doctoral graduates in industrial chemistry. Still a young man, he established himself with extraordinary rapidity as one of the research center's leaders.

Beneath his successes, Paolo Galli was frustrated. One of the reasons he had joined Montecatini was the company's Nobel prize reputation in polypropylene research. But when he arrived, he found it gathering dust on the shelf; he found a research group entering what he calls the Dark Age—simply working on product improvement. Galli and his researchers yearned to explore the nature of things and to make discoveries, but mostly all they did was talk about discovery. .

The consistent feature of the Dark Age (1965-1975) was the diversion of talent to less fertile realms of polymer research. Galli's group made substantial advances with ethylene propylene rubber, a favorite product for Montecatini. In another mundane product improvement Galli helped develop a better form of synthetic paper from the base chemicals for polyethylene and polypropylene. Even in this period his reputation grew as a versatile, talented, and engaging professional.

Paolo Galli is a man with the looks and demeanor of an Italian matinee idol. Impeccably dressed, ingenuously warm and hospitable, his sophistication and good looks conceal what is more visible in Trapasso—that both men have been seduced by the lust for discovery. They hunger to understand not just the shape and form of what they see, but the secrets in what they cannot—wondrous things that lurk behind, beneath, and within the outer shell of appearance. Both enjoy the labor of examination more than the thrill of promotion or the triumph of a whopping profit margin. Galli's passion for discovery shows even in his favorite pastime: scuba diving to hunt for remnants of ancient civilizations.

For Galli, the Dark Age was a maddening standstill. "By the end of the 1960s, Montedison was one of the last-place companies in the production of polypropylene," said Galli. "We lost our leadership completely. America and most Japanese companies, continuing their research, became the best producers in the world." The company was a ward of the Italian government, top-heavy with executives appointed by political allies and often inexperienced in the industries they were chosen to direct. One business historian called the Montedison of the period "little more than a bloated political football...dedicated more to the furtherance of state social policies than to profitable operations."[1]

The real life of the company took place in small groups and individuals who had the initiative to forge a course of action that served their own personal goals while helping the giant company. As Galli and Trapasso swiftly learned, the aggressiveness of a few individuals tended to confuse company leadership. Top management often opposed the actions of the committed few but then spent months—or years—contemplating what to do about their rebellion.

Polypropylene and the undiscovered secrets of its synthesis were more important than the projects assigned to the Ferrara researchers by headquarters in Milan, but Galli and his researchers were prohibited from working on polypropylene. A team of researchers was assembled and ready but standing idle because company management had no awareness of the talent available in Ferrara. Galli was emerging as the leader of this group, which included Adolfo Mayer, a meticulous researcher; Camillo Barbe, a key man in the synthesis of the new polypropylene catalyst; and Tonino Simonazzi, a maestro in his own right at assaying and testing new laboratory results for the polypropylene catalyst. Galli had the right people. He had an Olympic-class team, but the owners had taken away his equipment. As the corporation's budget faltered in the 1960s, the Ferrara Research Center became a bottom-line concern and the company's dedication to research weakened even further.

Montecatini's merger with Edison resulted in an even greater threat to the center's survival. When the agreements had been signed and the details ironed out, it became clear that Edison people dominated the new management. Montecatini had been a company proud of its accomplishments and reputation in original industrial research and development. Edison, on the other hand, had established a corporate practice of minimizing research and development costs by buying technologies from others. When the Edison clique emerged on top, the implications for the research center were dire. Galli realized that every day was going to bring a fresh battle to keep top management in Milan from pulling the plug. "The new managers of Montedison did not trust research. They were against the people of Montecatini," he said. "There was the strong tendency in all of them to eliminate us and keep only Edison people in management."

Catalysts

In such a negative atmosphere, scientific breakthrough should have been impossible. Montedison should have collapsed under its own weight and the pressure of internal conflict—as it nearly did. But hardship only seemed to fire the imagination and steel the determination of the researchers. Amidst the confusion, Galli waged an under-equipped guerrilla war to combat the decline of research. His group achieved enough to force Montedison to keep Ferrara alive and managed to avoid catastrophe until the eleventh-hour arrival of a savior—Italo Trapasso.

Shortly after the merger, Galli began to exhibit an uncanny knack for turning rebukes into opportunities. The new management decided to buy from Phillips Petroleum a second-generation version of Ziegler's synthesizing process. Galli was appalled; here was the greatest polymer research company in the world ignoring its own polymer research laboratory. He knew that if he allowed Montedison management to bypass their researchers in this fashion, Ferrara was as good as closed. Galli recalled, "Our commercial sales department asked for immediate entrance into the field of polyethylene and said that we don't like to lose time researching—to avoid losing time, we will buy the know-how."

So if there was money to buy the technology, there was also money for research: Montedison's first postmerger profit margin was an impressive 9 percent. Since Galli knew that the negotiations to buy the process would be long and expensive, he played his ace in the hole. Galli and his men entered a race against time, against the plans of their own management. This is the company of Giulio Natta, Italy's greatest researcher, he told his bosses. Let us try to develop our own catalyst while you court Phillips. Why settle for a second-generation process when you have the forces to develop a third generation? Give me a year, he assured them, and we can do it.

The Ferrara research group had another adversary—Japan—in the race to a new polyethylene catalyst. Polyethylene was, after all, the special strength of the researchers at MPC who had already begun looking for a third-generation polyethylene. The leader of the Mitsui team was a brilliant young chemist named Norio Kashiwa, but the spirit that guided them was that of the elder statesman of MPC research, Yasuji Torii. They faced little resistance from management; Kashiwa had a mandate to keep the company on the forefront of research in polymerization catalysis. So while Kashiwa and his team were launched into the mainstream of corporate aspirations, Galli and his team in Italy, seeking the same result, were swimming against the corporate current.

By the time Galli's year was almost up, very early in 1968, he had created a dilemma for Montedison. Ferrara's polyethylene work had already shown dramatic progress—too much to call it quits. Galli and Mayer invested heavily, equipping laboratories and building a pilot plant for the anticipated catalyst to move directly from laboratory to mass production. They had made the investment too big to abandon.

Montedison responded with indecision. Management issued no order to stop, but neither did they offer any encouragement. The implicit threat that Ferrara might be cut off at any time remained in the air. A reprieve of sorts came in mid-1968 that permitted the research group to intensify its efforts: The entire management group went on vacation for two months. "We were alone at last," said Galli, "so we had the opportunity of working steadily. Their holiday gave us the freedom we needed. In those two months, we found the catalyst."

Left to their own devices, the researchers made the greatest advance in polymer catalysis since Natta's discovery of polypropylene. The discovery of a new catalyst for polyethylene not only made Montedison an important licenser and supplier of polyethylene to the world market; it also saved the tarnished reputation of the research center, keeping it alive for at least another eight years, and created the scientific basis for the Montedison/Mitsui polypropylene discoveries of 1975. The Dark Age was far from over, but Galli and his men had lit a defiant light.

The discovery affected Western chemical industries dramatically. As quickly as they could, European and American manufacturers were studying the new process and adapting their operations to incorporate it. Meanwhile, within weeks, there was an almost identical breakthrough at Mitsui Petrochemical. Kashiwa's research team also devised a new high-yield catalyst for polyethylene.

Galli and Kashiwa had never met; they didn't even know each other's names. They'd never read the other's papers and knew little of the other's companies. Yet each led a team to the same discovery, starting almost simultaneously and finishing in a virtual dead heat. Adding to the coincidence was the fact that their work in polyethylene catalysis was the first new science in that polymer since Ziegler's discovery. There had been a lull of more than a decade, and then simultaneous bursts of activity thousands of miles apart in two different cultures. The discoveries were in fact so similar that they could not be patented separately. A clash between Montedison and Mitsui was inevitable—as soon as each found out what the other had done.

In the meantime, Montedison's leaders first had to deal with the fact that a division they didn't really want had engineered the greatest breakthrough in polymer science in a decade. Their eventual response was to form new plans to eliminate the division. This polyethylene discovery was probably just a fluke. Certainly, Galli couldn't keep it up, and if he tried to, his work would be too costly to support over the long term.

Galli, however, was also making plans. Knowing that the door had opened to a family of catalysts that could change the nature of polymer science and the billion-dollar industries that relied on it, he took as much advantage as possible of his short-term reprieve and pushed Montedison into the next level of research—a polypropylene catalyst based on the same principle.

Every oyster needs an irritant (usually a grain of sand) around which it can build its pearl. For the creation of polypropylene molecules from a propylene soup, Ziegler and Natta each discovered that the best irritant, or catalyst, was titanium chloride, $TiCl_3$ (the Japanese call it "ticklethree"). When they used that catalyst, it was as though they were pouring many grains of sand into an oyster bed and suddenly finding the water to be filled with strings of pearls—or, in this case, *stereospecific polymers.*

There was a problem with this miracle. For nearly twenty years, petrochemical manufacturers had been forced to get all those grains of sand back out of the water because, once it made its pearls, titanium chloride became a pollutant. Manufacturers had to put the polymer through a time-consuming and expensive waste-removal process.

What Galli in Italy and Kashiwa in Japan discovered was a way to polymerize polyethylene with *hollow* grains of sand, or empty irritants. They realized that another metallic salt, magnesium chloride, could work as a partner with titanium, and that they could create molecules of catalyst made up of titanium chloride on the outside but magnesium chloride on the inside. Suddenly the amount of $TiCl_3$ available to pollute the polymer was reduced by 90 percent. The need to purify it had disappeared, because little of the new catalyst was required and the magnesium chloride was so benign it could be left in the product. Both salts could now blend undetectably into the polymer.

When the two companies realized they had both done the same thing and were both trying to license the same basic catalyst under two different patents, the inevitable lawsuit followed. The ensuing patent battle, which was settled in 1982 in Montedison's favor, was good reason for the two companies not to see eye-to-eye in the 1970s. But research leaders at both companies understood they had found something special when they discovered a *catalyst support* for polyethylene. They saw that what had improved polyethylene synthesis could also eventually do the same for polypropylene. And if they could do it with polypropylene, a much more important polymer, the impact on industry would be staggering.

A Brief Reprieve

"The polyethylene discovery became a flag in our hand. We had demonstrated to management that we could discover, in a short time, a new catalyst and a new revolutionary process," said Galli. "So we said, 'We have strengthened the technology of polyethylene, which can be adapted. Please give us one, two years and you will have a possibility of a new process and a new product.' "

While Galli pleaded his case, Montedison's manufacturing process had already grown outdated. Every other polypropylene company had a better, faster, second-generation process, and the company had to buy it from one of their licensees. For Galli, the irony was cruel: The laboratory that had taught the world was forced to buy notes from one of its students.

In selecting polypropylene as the next project for research, Galli was pointing in the most logical direction, but he was also pointing toward one of his company's crying needs. By the late 1960s, polypropylene was still key in the manufacture of hundreds of products, but it was also starting to decline in popularity because of its wasteful manufacturing process. Shortages of petroleum were beginning to loom, and a supply crisis could be disastrous to companies such as Montedison that were already making only minimum profits on tons of polypropylene.

Through Galli's efforts, the research center briefly enjoyed a rejuvenated reputation. It was working on a process that Montedison needed very much, so plans to close the facility had to wait a while, but not for long. When research dragged on longer than two years, management support collapsed entirely. Incredibly, Montedison grew concerned that Ferrara might be developing another breakthrough; if that happened, they might never be able to close it. Management's solution was to shift official approval for new research projects—including the new catalyst—to another research center. Ferrara was left with odds and ends. In 1972 Ferrara lost autonomy and was placed under a general research budget; Galli got no money at all for polypropylene research and was told again to work just on problems specified by the company. He and his group were expected to report to plant management, an even worse organizational condition for creative researchers.

They never stopped working, however, and they never ceased to believe in their work. "We just ignored their orders," said Galli. Aware that they were being watched ever more closely by Milan (who, Galli said, "understood nothing and controlled everything"), they took their research into the closet. "We were very excited, but we had to pretend we were working on plants. By 1975 we had isolated a high-yield catalyst using magnesium chloride. We did it on our own, with no big boss showing any interest. In fact, they were against us."

No Bureaucrat

The isolation of that catalyst was a dramatic breakthrough for Galli and his team, but an even more important breakthrough occurred in, of all places, Milan. Montedison named Italo Trapasso to head a new plastics division, which included the laboratory in Ferrara. At last Trapasso had his own lab again. The dream so long deferred was restored to this man who believed in research more passionately than anything else.

To Ferrara's researchers, the news was just another pronouncement from the accountants. Nothing in Trapasso's past or demeanor suggested that he could be their liberator. Because of the course of his career, Trapasso was comfortable among engineers, mechanics, and foremen—he was used to standing in the sun, shouting orders and trading insults with men driving heavy machinery.

Trapasso's populist credentials didn't impress Galli and his group. Trapasso had been a member in good standing of the Edison management structure for years, and Galli's people believed that if someone was from Edison, he was the enemy. But Trapasso was nobody's company man. And, whatever his experience in life, in his heart he remained a chemist. Trapasso embraced the research complex in Ferrara like a parent would a living child who had been given up for dead.

Surveying for the first time the Ferrara Research Center, Trapasso saw the repository of his dreams—a group of scientists who could, with his support, restore Montedison's tarnished reputation in scientific inquiry. Though corporate leadership had failed to see the importance of the group's discovery of the polyethylene process, Trapasso recognized it as historic. He began a series of sweeping changes in the structure of his division—battling with Milan, embracing the stunned researchers in Ferrara, calling them family, telling them he trusted them to come up with great discoveries. "I want to develop things," said Trapasso. "I'm not a bureaucrat. I don't like people who don't trust workers."

Trapasso found himself balanced between a threat and a triumph. If he paused even briefly, other laboratories in other companies would take Montedison's secret and the glory of its great scientific breakthrough; but if he seized the moment, he might inspire a true discovery, a new and entirely different generation of polypropylene. "When I arrived, the research laboratory was reporting to the plant manager of the manufacturing facility. Can you imagine? Reporting to a plant manager busy following other kinds of things. Not technology! Not research!" said Trapasso. "My task was to get top management to change its idea of research. I spent nine hours explaining that I wanted the Ferrara Research Center independent, to recreate it as a true research lab."

Trapasso acted with a speed and decisiveness that shocked the deliberate world of Montedison management. In less than a year, he restructured his division so separate deputy general managers were in charge of plant operations, engineering, technology, and research. Galli was made deputy general manager of research. "I attacked very strongly Montedison's reluctance to support research," recalled Trapasso. "I had full confidence in my people. I would have signed a blank check and given it to them." Galli said, "Dr. Trapasso saved us. He was the only Edison executive I knew who had scientific training and vision. We made the discoveries; he made an industry. He is a saint!"

A Union and a Reunion

Trapasso recognized that if Galli's team already had a new high-yield catalyst, then Mitsui, their Japanese rival, might be almost as close—perhaps even ahead. So while he restructured his division and Montedison management worried, Trapasso fulfilled another of his dreams. In 1975, Trapasso got in touch with the man he calls maestro, Yasuji Torii. Suddenly these two men, who years earlier had sat up nights drinking and talking earnestly like university students obsessed with the dream of discovery, were coming together. They had waited patiently. Finally they seized their chance to design together their great experiment. Not only did they have the same goal, but each man had a team of the world's best polymer scientists.

Trapasso told Torii it was time for their two teams of researchers to start working in unison. Torii had admired and watched attentively the brilliant advances that had been made in Ferrara since the mid-1960s, and he knew that his company and Trapasso's were in a race to synthesize a manufacturable high-yield polypropylene catalyst. Like Montedison, Torii did not relish the prospect of another long patent suit. And Torii had a classically Japanese view of the competition: He knew that the catalyst would generate spectacular wealth for the company or companies that discovered it. There would be enough to go around.

Once Torii told Trapasso that a deal was possible, negotiations followed very quickly, and in August 1975 Mitsui and Montedison signed an agreement that combined their research knowledge and precluded the possibility of another court battle over patent rights.

The results of agreement came amazingly quickly. On its own, each laboratory had made huge strides in adapting the polyethylene discovery into a high-yield catalyst for polypropylene. When they shared their notes and repeated each other's experiments, it was relatively easy to repair the other's minor miscalculations. If they had undertaken this process independently, refining the catalyst would have taken years; instead, it took three months. "Eventually MPC by itself would have succeeded, but it would have taken much longer," said Kashiwa. "Even when the agreement was executed, neither company expected such speed."

In November 1975 researchers at both companies saw, in the images recorded by an electron microscope, long strings of molecules so perfect that they could go directly into use, without purification. Since they were to be used as building blocks for crystallized solids, their uniformity was important; they had to fit together without distortion or flaws. But that was no problem—these polypropylene molecules were the most flawless strings the chemists had ever seen.

Bigger Problem, Bigger Advantage

Although these remarkable pearls emerged through the efforts of both laboratories on an almost identical timetable, there were vast differences in the environments that produced them. Mitsui researchers had followed a smooth course of scientific inquiry and development, while the Ferrara group had faced an almost constant series of halts, threats, and misdirections. With polyethylene and then with polypropylene, Mitsui had started sooner than Montedison. The Mitsui researchers worked under a mandate issued by senior management and under benevolent leadership. Torii's triumphant duel of wills with Ishida had established fundamental research as a necessity at MPC; the corporation supported its research team with praise and money. Research is a religion at Mitsui. By contrast, by 1966 at Montedison, fundamental research had become heresy, and it remained so throughout Ferrara's greatest burst of creativity.

The paradox of successful research as a virtual heresy is not limited to the discovery of a high-yield catalyst for polypropylene. In many breakthroughs, the company that began inventive efforts from a disadvantage, or from the position of the underdog, emerged at the end more swiftly with a better solution. The Italian researchers at Montedison kept pace with their more fortunate Japanese peers because they shared with them a belief in basic science, but they also prevailed because they made up for the organizational support they lacked by greater emotional involvement.

"Galli told us that our success would come in dedicating our research to basic physical chemistry—not kitchen chemistry," said Camillo Barbe, who coauthored the scientific papers with Galli. "When you understand, you can make changes in a rational way."

"When you have an experimental problem, you don't try first to solve it practically," said Galli. "First you understand the basic phenomena. You interpret, look for laws, and then go to the solution. Not trial and error, but interpretation. That is absolutely the key. You must have deep knowledge of theoretical phenomena."

Galli also kept one eye focused ahead, on the next steps to be taken, beyond laboratory results. At the beginning of the polypropylene research in 1970, he emphasized the importance of turning lab results into industrial process. In a way, by looking ahead to manufacturing, Galli turned Montedison's worst disadvantage into an advantage. He knew that MPC already had sophisticated second-generation manufacturing facilities in Japan making both polypropylene and polyethylene, while Montedison lagged dramatically behind. As problem-solvers, the Montedison group thus had an ironic advantage over MPC: They had a bigger problem. MPC, whose laboratory goals were logically similar to those at Ferrara, had an excellent research plan; but, under the gun, Galli's group had added to that a number of subtleties. With more to worry about, they thought more broadly and more imaginatively.

As a result, the Ferrara research team paused, assembled all the details of the problem, and outlined a series of goals that covered virtually every contingency. Four goals that Galli listed for Ferrara's proposed high-yield catalyst seemed to deal solely with characteristics of the catalyst itself: (1) high activity, (2) excellent stereospecificity,

(3) good molecular weight distribution, and (4) superior and unique polymer morphology.

These goals were defined and attained as the result of a systematic, scientific approach based on physical chemistry studies carried out during the darkest period of the Dark Age, "when we were completely abandoned," said Galli. But as they developed these goals, the Ferrara team matched each with its effect on pilot plant testing, gearing up for full manufacturing, marketing appeal, and advantages for manufacturers whom Montedison hoped to license to use the process.

Pilot to Production

Nevertheless, Galli's well-formed plan would have failed without MPC. Money for Ferrara, despite the relentless Trapasso, ran out in early 1977. Montedison would not risk converting one of their industrial plants to mass-produce polypropylene by a process that had never been used industrially. "We needed a catalyst right away, and we developed it here and tested it in our pilot plant," recalled Galli. "At the same time, Mitsui reached the same result in their pilot plant, and immediately they brought it to their industrial plant, because they had much more advanced industrial polypropylene technology."

What Mitsui did was to modify its own manufacturing equipment, essentially bypassing many of the purification stages built into the old catalyst process. Within months, MPC's factory had synthesized tons of a polypropylene that was cleaner and simpler than the chemical world could have imagined a few years earlier. With proof of the feasibility of the new process, Trapasso began a dramatic push to establish a dominant world presence for the new polypropylene. The first step was the $4 million conversion of an old Montedison first-generation polypropylene plant in Brindisi, Italy. The changeover was costly and risky, but it was within Montedison's means: Even if this new polypropylene failed, the company could absorb the conversion of one aging chemical plant.

The second step, if Montedison took it and stumbled, could have caused irreparable damage. Trapasso told the directors of Montedison that one plant was not enough. "We had to expand our presence in polypropylene in the biggest potential market, in the United States," he said. "We had to decide to build a new plant there, and we had to decide then, in 1977." The ideal site was in LaPorte, Texas, close to a plant that produced propylene. Trapasso insisted that Montedison acquire the site and begin building immediately.

The decision to go ahead with the U.S. plant was complicated by lingering doubts in the scientific community as to whether the new catalyst really was new at all. Montedison was still the only company with even so much as a pilot plant dedicated to the new polypropylene; Mitsui would not complete a manufacturing plant until 1984. Trapasso had driven Montedison forward so fast into industrial development that he was left almost alone, standing on a plant site in Texas, waiting for the world to catch up. Trapasso remembered, "Many people were against it. Only the chairman was willing to back me up. Even some of the senior Montedison research people said that this catalyst was a common one."

No Sleep for Two Years

Eventually the corporate leaders at Montedison deferred a decision, leaving the go-ahead on a multimillion-dollar overseas manufacturing plant to an impetuous division head. "They told me to decide. I decided, we go ahead—and I did not sleep for two years." Trapasso stormed through the Brindisi conversion in less than a year and had the first new polypropylene on the market in 1978. It then became clear to the scientific and manufacturing communities that this clean, simple, cheap, and versatile polypropylene was nothing like the old stuff.

The product that began to flow from Montedison's plants looked drab. Most polypropylene leaves the factory as little white pellets of plastic *foam.* To someone not a chemist it looks like the stuff used as packing material for shipping fragile items, but to manufacturers, this polypropylene opened worlds of opportunity. Every major petrochemical company began to search feverishly for new ways to use it. This material could be molded, extruded, stretched, and bent unlike any previous polymer.

Manufacturers began to find new applications within months that infused polypropylene into everyday life pervasively and invisibly. It is virtually impossible to move in any direction in a modern house or automobile without touching or being surrounded by it. If the building you are in is less than ten years old, it is likely that there is polypropylene above you in the roofing material; below you in the carpeting; around you in the upholstery and webbing of chairs and sofas; and in the pipes and the electrical system. It is part of the mattress and box spring. It is the agitator in the washing machine and the plastic fixtures inside the dishwasher. It is in the refrigerator, both in the shelves and in food containers.

Polypropylene might be in your underwear and your ski outfit, and it is certainly in your baby's disposable diapers. If your car is new, its bumpers, floor, dashboard, and most of its plastic interior trim are all polypropylene. The outer casing for every videocassette is made of high-impact polypropylene. Because the substance is more flexible and easier to make than any previous form of plastic, it is inevitable that more of it will move unseen into every person's environment. Things will be lighter, stronger, more durable, and safer.

A Still Happier Ending

The ending was happy for Montedison. A strategy born in Paolo Galli's elegant matrix of goals was carried resolutely forth on the shoulders of Italo Trapasso. The world learned of the new polypropylene mainly because Trapasso goaded Montedison into making a lot of it. The happy ending also came about more easily, however, when in 1977 Montedison stepped from their Dark Age to their Renaissance with the appointment of a new vice president named Mario Schimberni. Over the next seven years, Montedison focused their business. Schimberni became president and chairman of the board in 1980, and he led efforts to divest the sprawling company of a plethora of competing interests. He began aggressively to weed out the layers of management that had grown into the body of the company like a fungus. This was not an easy task. Things were financially bleak until 1984, when Montedison finally broke even. In 1985 the company made a significant profit and convinced a long-skeptical business community that they would no longer ignore their most promising projects—like those of the research group in Ferrara.

In 1984 Schimberni said, "The biggest problems are past. Montedison has a new structure. We have selected our business portfolio; we have clear strategic goals. We are a diversified company with strengths in primary and specialty chemicals, energy, and services. We know where we want to go. Our management is now innovative, flexible, open-minded, and accepts the challenge of change." In 1983 Montedison formed a new company called Himont, Inc., in partnership with Hercules, Inc., the world leader in polypropylene production by the second-generation process. The new company was staggeringly successful, showing first-year revenues of $600 million and earnings of $73 million. Unlike Montecatini in 1956, Montedison kept a tight rein on their patent rights. Montedison and Mitsui estimated that within eight years almost three-quarters of the polypropylene manufactured in the world will be under their joint patent.

Finding the Best People

The most impressive demonstration, however, that Montedison had finally changed for the better was the return in 1986 of Trapasso, who not long after he had brought the Texas plant into production had grown frustrated with company bureaucracy and quit.

He stayed away for several years.

Today, the Ferrara Research Center, renamed in honor of Giulio Natta, continues to refine the process of polymer catalysis, to seek what Trapasso calls *monady*. "Nature is composed of single elements," Trapasso said. "I feel that all chemical processes will be simplified." The formation of Himont gave Montedison the opportunity to call Trapasso back into the company, and he came willingly, encouraged by the new respect for research. His return was welcomed warmly by Galli, who became the new company's vice president of technology.

Reminiscing about the discovery of the high-yield polypropylene catalyst, he conveys an ambivalent blend of pride and modesty. "To be honest, I had not too much time. I had to support the good people. My work experience allowed me to understand who they were. If you do not have the best people doing research, you are not doing research." Trapasso's emphasis on having the right people is one way of shaking his fist at the system, but it is also a compelling insight into what happened in Ferrara. "All I did," he said, "was to recognize the merit of the Ferrara people. I was a kind of servant of them. I was their assistant."

Trapasso believes that a manager's most important supervisory function is choosing the best people for the job; once that's done, his foremost value is in protecting them from senior management's interference. Trapasso directed all of his energy, all of his aggressiveness, not at the research center but at his superiors. It was his bosses whom Trapasso "managed." He left the Ferrara Research Center to themselves. To him they were family. "In research," he said, "you don't need a boss or an executive. Research is so much satisfaction that it is enough." Trapasso uses the word *enough* as though it means "everything."

By itself, Trapasso's ideal of research possesses a fragile aestheticism. Simonazzi called the research team at Ferrara "a very little group that tried to maintain something living." Trapasso, in his ideal picture of life, would have been one of that group all along, but he had compromised with life. Perhaps Trapasso always felt that he would get another chance. Perhaps that is why when at last his path crossed that of the researchers he admired and envied, he became immediately what Galli and his group needed to complete their scientific odyssey. Trapasso knew that it is good to be a researcher, but even better when the world knows what you have discovered. And to make sure of that, what you have to do—what Trapasso did—is sell it.

Trapasso didn't rest until he had raised the Montedison/Mitsui catalyst discovery to a mature product that had captured the attention of the world.

"Would it have survived without me?" Trapasso wondered. Then he answered his own question with a shrug and a smile. "Probably not."

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FEDERAL EXPRESS: KNIGHTS ON THE LAST WHITE HORSE

If American companies followed a system that allowed no breakdowns or surprises, it is likely that the breakthrough of an air freight company named Federal Express (sometimes referred to as "FedEx") would never have happened. Federal Express redefined the air freight industry because its founder, Frederick W. Smith, *expected* that American companies would break down incessantly, unexpectedly, and at the worst possible moment.

Founded in 1971, when Smith was only twenty-seven years old, Federal Express spent years on the brink of catastrophe. Between 1971 and 1975, Smith fell $30 million in debt, was indicted for bank fraud, got sued by his own family, saw his investors replace him—then recovered it all months later.

Through a special kinship Smith shared with a loyal corps of executives, pilots, and rank-and-file couriers, Federal Express survived crisis upon crisis with a sort of John Wayne bravado and became the standard for air freight operations for the future. In 1991, the company exceeded $7.6 million in annual revenue. American businesses have elevated nationwide delivery of packages to the level of a necessity—a staple like computers, photocopiers, and telephones. And that speedy delivery became synonymous with the name Federal Express.

Fred Smith has offered many retrospective analyses of the astonishing success of Federal Express. He cites most often the emergence of high-technology industries that require safe delivery of tiny but critical electronic components or tiny vials of perishable biotechnological specimens on extremely short notice. "In the past/' Smith explained, "if you ran a big factory and a lathe broke down, you always had a couple of craftsmen who went in and welded it back together and did whatever was necessary to solve the problem. In first-generation industries, the cost of production delays wasn't very significant; but in the 1960s, electronic machines started to become prevalent. When a computer broke down, there was no way to extract the data from inside it. You couldn't get at it. You were just out of business. The people who supplied these electronic machines had a terrible logistics problem in providing timely repair and parts replacement because the entire country had become one market."

More Work, No More Time

As logical as the market explanation is, it isn't enough. It doesn't explain why printers, architects, and wholesalers of plumbing fixtures depend on Federal Express for daily economic survival. If its success depended on high tech and biotech, Federal Express would have become only a modest commercial success. The fact is that when Federal Express's *Super Hub* sorting complex in the Memphis, Tennessee, International Airport topped the 400,000-packages-per-night plateau in 1985, barely one in ten of those parcels contained electronics parts or biotech specimens. Most of the packages were plain, ordinary, business mail packages. It was paper, the stuff that computers were supposed to make obsolete. High technology might have inspired Federal Express, but paper made it a roaring success.

Federal Express was and is a triumph of Parkinson's law that work expands to fill the time available for its completion. America once wrapped up its important business documents two or three days before deadlines because it would take an air freight service using commercial flights that long to get documents to the client. Federal Express made it possible to put off until the last minute and still get it there on time—overnight.

"Absolutely, positively overnight!" Arthur Bass, who was chief operating officer at Federal Express from 1976 to 1978 and one of a handful of devoted people who kept the company alive through its first four years, explained, "Before Federal Express, everybody was satisfied with what you would call the 'as-soon-as-possible.' When we changed that to 'overnight,' Federal Express in itself became the time machine."

In the 1970s, businesses in America started paying $10 and more to send a one-page letter 1,000 miles from Hartford, Connecticut, to Memphis, Tennessee, in order to be sure it would arrive in Manhattan, 100 miles south of Hartford, by noon the next day. If this was madness, it was madness that worked.

In the Trenches Together

Like many breakthroughs, Federal Express boiled irrepressibly from within an individual who grew surer of his idea the more the experts told him it was silly. Like other breakthroughs, it emerged intact from a crisis early in its existence because its originator was able to combine a clear vision of his goals with a flexible response to obstacles he would not see until they appeared. Most important, the

Federal Express breakthrough, like so many others, happened because the originator rallied around him individuals who found in themselves talents that had lain fallow through a lifetime of more ordinary attainments.

Tucker Taylor, a former Navy pilot who looks and talks like an all-American boy from Yale, was one of Federal Express's early leaders. In 1974, Smith assigned him the task of keeping happy a sporadically paid and overworked labor force. Taylor explained why everyone felt so good when things were so bad: "One thing that kept morale so high was the fact that Federal Express was losing money. There was a 'we're all in the trenches together' feeling. We prided ourselves on being like the Viet Cong, not really knowing what 'convertible debenture' meant, wearing cheap suits and talking about investment bankers like they were the 'jackals of Wall Street,' and that kind of stuff. We were going to succeed without playing the game."

Bass added, "It was a crusade. It was my chance to prove everything I knew about business in an environment that would allow it to happen." That crusading spirit was not just a feeling among the leadership; it spread with equal passion among even the package handlers in the gaudy orange and purple courier vans that became the company trademark. The egalitarianism that existed at Federal Express was—more perhaps than any of his corporate strategies and financial triumphs—the creation of Fred Smith. He made people believe he felt the same thing they felt.

For Smith to achieve this kinship among the people of his company seems inconsistent with his roots. His father built a fortune running bus lines through the South; he left Fred, Fred's half-sister, and his adopted sister more than $3 million each, partly in the form of stock in a family holding company worth more than $15 million. Fred went to the best schools and then to Yale University without a worry about cost. He was popular, handsome, gifted, and schooled in the manners of the Old South. Taylor, who was at Yale a couple of years behind Smith, said, "He's the guy you hated worst at college. Not only does he have an IQ that's twice yours, he stays up late and studies."

Roots of a Revolution

At Yale, Smith began to use his exceptional intellect to synthesize a number of ideas and interests, articulating one in particular in a junior-year business paper. The concept, the teacher told him, was interesting, but in order to earn better than a "C," it must be feasible. The teacher was not convinced that Smith's imaginary enterprise could exist in the real world.

Smith's concept was guaranteed overnight package delivery. At the heart of his idea was a *hub-and-spokes* system. Smith suggested that a freight-forwarding company could draw a circle around an airport, which would act as a hub; a number of truck routes inside the circle would be the spokes. All day, trucks would gather parcels from businesses that wanted the packages sent quickly someplace else in the United States. At the end of the day, all spokes would lead back to one airplane. The truck drivers and pilot would fill the airplane with the packages; the loaded plane would fly to a bigger hub somewhere in the center of America—Memphis would be perfect. Airplane routes to Memphis—from Chicago, Los Angeles, New York, Miami, wherever—would be the big spokes. The planes would be emptied in Memphis, the packages sorted, and the planes reloaded with packages destined for only their city, to which they would return. Before the sun was up, that city's fleet of trucks would deliver the packages inside the circle and gather another batch for delivery the next day.

Keep doing that every day, said Smith, and you could make a lot of money. The idea was not even new, as Smith made clear to his doubting professor. "American Airlines tried to set up a hub-and-spokes system for air freight in 1948 in Topeka, Kansas," said Smith. "The Indian Postal Service and the French Aero Postal operated this way. The best way to ship things was to gather them all at a central point, clear them at a clearinghouse, and ship them back to their destinations. I recognized the solution by observing the banking industry—they send all their canceled checks to a central location, swap them around, and return them."

In the Real World

But Smith's skeptics, beginning with his professor, responded that even though banks and other organizations had used the hub-and-spokes system, none tried it overnight. Big freight forwarders such as United Parcel Service (UPS), Emery, and the U.S. Postal Service had already thought of the idea and rejected it. The cost of all those airplanes, trucks, pilots, couriers, and the hub facility itself - would be enormous. Besides, none of the big companies had ever heard of a customer who wanted overnight delivery. Nobody expected it; nobody ever asked for it.

Still, Smith knew that if people had overnight delivery available they would like it, and they would begin to depend on it. Americans increasingly expected instant and sophisticated services, and the proliferation of high-tech industries would make overnight delivery increasingly desirable. "If I get only one percent of the current air freight market," Smith insisted, "I can support this service."

Smith's certainty notwithstanding, the idea seemed fatally flawed. For one thing, this overnight delivery had to be a national service on the very first day: The network, which would cost tens of millions of dollars to build, had to be in place at the outset. Although he was a millionaire, Smith didn't have that much money. In order to start the company, Smith would need the largest infusion of venture capital in history. He would need investors of enormous wealth—none of whom at that point had heard of him—who were very likely to think he was insane.

Furthermore, at age twenty-one, Smith was not good enough or experienced enough to pull this thing off. He was bright, confident, charming, even courageous, but he still lacked the personal tools necessary to pull together and motivate an enterprise composed of diverse and socially incompatible people. The key to activate his concept could not emerge until he had one more life experience.

Baptism by Fire

The Vietnam War was that life experience that forged an element within Smith to become the burning ember of his energy—his leadership. Smith calls himself a manager because he can balance books, explain tactics, and formulate strategy, but he created Federal Express because he loved people. The one thing a leader must do is to make people believe he cares more for them than he does for himself and the bottom line. Smith would have come to this understanding eventually, because he always cared for people. But in Vietnam, where everything was desperate, his learning was accelerated. Smith's deep idealism was baptized by fire.

Smith joined the United States Marines in 1966, right after graduation. His choice was almost devoid of political interest: He simply regarded military service as a matter of duty. He felt a high sense of responsibility for others; since he had gifts others lacked, he must use them on other people's behalf. Taylor explained: "Fred Smith is a mixture of egomania and a tremendously overblown sense of responsibility—I say overblown to a fault. That's a conflict in him. He has a sense of responsibility to whatever he embraces."

Smith served two tours of duty in Vietnam, first as a company commander, then as a forward air controller, spotter, and reconnaissance flier in the bloody and tragic Quang Tri Province. Captain Smith received six medals for bravery, including a Silver Star and two Purple Hearts. Smith was lucky to come out of it alive, but he gained an outlook that could not have emerged without that searing experience.

Smith went to war as a matter of personal duty. He did not judge the merits of the particular war, and he feels guiltless about participating in it. He did, however, return with the desire to fix something he thought was wrong. Smith had gained a sense of how the efforts and abilities of those soldiers to whom he grew so close had been so wasted. He saw lives wasted not merely in sudden death, but in their future living. He realized that the managerial class who would hire these working-class men would expect far too little of them—and receive far too little in return. In Vietnam, Smith discovered the intelligence and character of men he might once have described as merely average.

"Most folks who run companies or large organizations are very snobbish, and they really look down on the people who work on the factory floor," Smith said. "They have a disdain for the average person, and even though that person may be making them zillions of dollars, they just don't like him."

In the face of death, Smith learned the emotional foundations of leadership. The war was as overwhelming to him as to everyone else. Smith was stripped of his individuality in a way that shrank his ego. For the first time in his life, the institutions that surrounded him regarded him as a nonentity and would crush him without remorse. From this crash course in humility, Smith learned that the powerless demand only one thing from life and their fellows: respect. He also learned that the imperative of leadership is to take care of your people. The only goal worth pursuing, in war or in peace, is to get them from where they are now to a better, safer place. You do not lead people into danger unless you can lead them out again, into safety.

In Vietnam, Smith discovered that people are more than they seem and he turned that discovery into a mission. He was determined that average people would be the builders, the mainstay, and the crusaders of his idea for overnight delivery. He would employ them, set them loose, and trust them to the very end.

Testing the Waters

After his discharge, Smith owned and ran a business buying and selling used corporate jets, but this was merely a means to establish himself, to create contacts, capital, and resources. In June 1971 he created a spin-off corporation called Federal Express. Almost immediately, he lost his first customer: the U.S. Federal Reserve had been interested in contracting with one company to transfer its canceled checks among its many branch banks, but the branches killed the idea.

Smith moved quickly to a new strategy. Since his idea had first been dismissed, Smith had understood that the people to whom he had to sell his air freight service were those least likely to believe in him—not the shippers and secretaries who would eventually depend on Federal Express, but the banks and the corporations that would finance him. He knew that these were conservative people, unwilling to part with a penny unless they saw proof that his idea would make a profit in the end.

Smith's first stroke of ingenuity was to hire two market research companies to test the waters for overnight delivery. Both were in New York City: A. T. Kearney, Inc., an old respected Wall Street firm, where an account executive named Roger Frock led Federal Express's research; and Aerospace Advance Planning Group (AAPG), a used-airplane business consisting entirely of three men—Tucker Taylor, Arthur Bass, and Vincent Fagan.

The trio had met Smith a few months before in Little Rock, Arkansas. "Because of our mutual understanding of airplanes and the corporate airplane business, we ended up down there making a presentation to Fred. He described this dumb idea of buying a bunch of corporate Falcons, cutting big doors in the sides, and flying them all over the place and meeting at Little Rock," recalled Taylor. "He wanted to hire us as consultants to take a look at that idea. It was crazy, but he had money. So Art, Vince, and I decided 'We can talk this guy out of this, but why should we? He's going to pay us while we are doing it.' We started the research, and it turned out that it became the means to help him raise the money."

During early 1972, Smith traveled frequently to New York for discussions and updates on the research. Taylor was amused when he realized Smith had hired two companies to conduct the same research. Both companies were surprised when the research turned out in Smith's favor. The more shippers, freight handlers, and managers they contacted, the more they heard the same response: "Sure, I would use a service like that, but I will believe it when I see it." The conclusion was that Smith needed to invest, up front, about $20 million, and for that he could eventually attain what Taylor called "a nice little business. He could make some money. But it would never be anything big."

A Sense of Urgency

Almost everything the researchers said turned out to be wrong. That $20 million grew into $72 million. Federal Express would indeed eventually become big; Smith claims that he always knew both the cost and the eventual size of the enterprise. Whether he did or not, he got his money's worth out of his market research. A. T. Kearney and AAPG had said, in writing for investors to read, what Smith already knew: There was a market waiting for overnight delivery and the business could make money.

Frock explained what eventually led him to commit his future to Smith's risky and unlikely company: "There was this urgency to it all." Whether Smith's urgency was part of his nature or something he cultivated in Vietnam, it was real. He had to broaden his financial base very quickly; he was already depending too much on family money. All that Federal Express owned, thanks to loans from the Enterprise Company and the National Bank of Commerce of Memphis, were two used, French-built jets. Smith could not have proceeded very far without the numbers to convince bankers he wasn't a crackpot. But more than numbers, Smith needed people. He had a perception common in breakthrough stories: The personnel choices made at the beginning of a project are arucial. Nothing is more important.

Flexibility and Finding the Right People

Smith didn't expect to find the right people in established companies, and he didn't want to. "Fred wanted innovators," said Taylor, "and he wanted people without any preconceived notions, people who were a little bit wild. It's a good thing that's what he wanted, because if he had wanted someone from Emery, he couldn't have gotten him."

In Vietnam, Smith had come to value flexibility. He had seen men die because commanders could not or would not deviate from a plan, even in the face of the unexpected. And he had seen common soldiers respond spontaneously to a crisis, guiding others away from a threat that had emerged seconds before. Smith wanted people like that—alert, resourceful, indifferent toward structured planning, and able to move forward with only the tools at hand. He knew that when Federal Express was in crisis, he would not be available to scout the terrain and lead the way through all the details. He would have to depend on other • people, and he needed the right people more than money or airplanes.

"Fred has a very clear view of the future," said Bass. "And he has a single-mindedness. He uses a lot of brain power to manipulate things to accomplish his ends, but he is not a tactician. Fortunately, he surrounded himself with doers who did not give a damn, who were not inhibited by worrying about anything except simply, 'Let's get this job done.' "

Smith explained, "I have never seen many successful endeavors where somebody goes out and hires a great resume. That person, to build that resume, knows all the reasons you can't do something. It has always been my experience that you are better off developing your own. It was the same with Art, Vince, and Tucker. They had a philosophy of life, they weren't afraid to make decisions, they understood the game, they liked this proposition. They just fit."

Smith's technique for getting qualified people was a mixture of showmanship and boyish enthusiasm. "Fred gave me a commitment that if Federal Express succeeded, I would get stock," said Frock. "There was nothing written and I didn't expect anything. I took a big pay cut, but I was thirty-five, and I wanted to take the plunge in a risk venture."

In 1974 Smith added perhaps the most unlikely of the group—Peter Willmott, who served several years as Federal Express's chief financial officer. Coming from International Telephone & Telegraph (ITT), perhaps America's most conservative company, he admits that the culture shock almost killed him, but the excitement that followed was the greatest of his life. "The four years we were trying to set up any sort of financial structure was the longest and shortest time of my life," he said. "It was a very emotional, very profound experience. I can't describe it; no one can understand it unless they felt it."

"I am not sure what ingredients make a good cake, but the one that fell off the shelf was a good one. This assemblage of creative talent at the outset is what distinguished Federal Express from many contemporary companies," said Bass. "We were the last of the gunslingers."

By 1973, the spirit of Federal Express had been born. The people were in place. There was a camaraderie among pilots, drivers, mechanics, and executives reminiscent of that displayed by multiethnic squads in movies about

World War II. Then, and only then, did Smith take off his flak jacket, don his pinstripe suit, and begin to romance the "jackals of Wall Street."

Opening Night Fiasco

Smith's fund-raising campaign culminated in a $52 million venture capital investment—the biggest ever made. The dynamics of his eighteen months of financial dealing are almost impossible to grasp. From May 1972 through November 1973, the company lost a fortune. Any sensible investor should have foreseen no better future. The company could have folded on "opening night," March 12, 1973, when its airplanes flew to Memphis from all over the eastern United States—with a total of six packages. After that fiasco, it was a month before Federal Express flew again, and the count then (186 packages) was hardly more encouraging. At the end of April the end-of-fiscal-year report showed an accumulated loss of $4.4 million.

In order to keep the cash flow going, Smith secured a $2 million loan from Union Bank of Little Rock. He pledged his own shares of the privately held Frederick Smith Enterprise Company to the bank. Even for so large a sum, Smith felt this authorization was routine since he was one of the company's five directors and its president, and a similar provision had been used by other family members. "The bank needed a take-out, since Enterprise was not listed on the stock exchange," he said. "I simply dictated a resolution of the board of directors that would permit the company to buy into my shares. Then I made a very bad mistake, which was characteristic of the loose, familial way we ran the company. I signed my lawyer's name."

In September 1973 a series of multimillion-dollar loans, secured by using the promising AAPG and Kearney reports, fell due and then into default. A memorandum to employees, signed by Smith, read in part, "With the most profound regret, we would like to request from each of you that you do not cash or deposit your payroll check until next Monday at the very earliest. Naturally, for those of you whose sustenance depends on immediate use of these funds, please feel free to do so.... As you know, we have made every effort to see that every payroll has been made, and were it not for circumstances completely beyond our control, we would not be asking for a sacrifice such as this." Part of the reason Federal Express survived this catastrophe (and more besides) was that, as Taylor noted, Smith was just so charming. In the gray world of bankers and investment counselors, this aviator, this Southern gentleman from Little Rock via Quang Tri, was a peacock—or perhaps the better term is *chameleon.* "He's got a high degree of charisma when he wants to," said Taylor. "He can be what he has to be. Talking to New York bankers he could sound like he just fell off the turnip wagon from Little Rock. He'd talk with a southern accent—'Gee, I'm just so naive and if you guys could just help me on this thing. I'm just a good old boy.' Or he could just as suddenly be David Rockefeller. And he's got a very good sense of when to do what he is supposed to do."

Guerilla Tactics

Federal Express survived because of another exceptional thing about Smith: While everyone in the business world around him was behaving like a general, Smith was moving like a platoon leader. While his investors were thoughtful and deliberate, Smith's movements were sudden and impulsive. After the positive market reports in spring 1972, he escalated a series of exceptionally large loans from banks in Little Rock and Memphis based on the Smith family's standing in those communities, the solvency of the family's Enterprise Company, and the positive market outlook for Smith's new company. These loans allowed him to buy rather than lease from Pan American World Airways almost all the used Dassault jets available in the United States—thirty-three of them—for $56.1 million, a bargain. But Smith would not have the money in his hands when Pan Am came to collect in 1973 and 1974. Seduced by Smith's charm, the banks went in as deep as he was.

By July 1973 Federal Express was an exciting little entrepreneurial outfit with a split personality. Even as the president of the company was jetting off to meet with the legendary chairman of General Dynamics, Colonel Henry Crown, to toss around figures like $16 million, the folks back in Memphis were eking out their payrolls by ignoring their couriers' expense vouchers and their withholding tax payments to the Internal Revenue Service. The news Smith got from General Dynamics was that the giant company would back, for a while, a $23.7 million loan package for Federal Express.

This wasn't really such good news, because the loans would start falling due heavily in September, and Smith knew he would not have the cash to pay them back then. Even this help did not come without conditions: Colonel Crown, then in his mid-eighties, was uneasy with committing money to a company run by a whippersnapper still two or three years shy of thirty. "To him," recalled Smith, "I was barely out of the crib." Crown insisted that Smith, at least for the sake of appearances, find an older executive to serve as chief executive officer of Federal Express for a while. Smith agreed and began seeking the right person.

More Bad News

Meanwhile, the bad news from General Dynamics was awful. They had also been considering purchasing a controlling interest in Federal Express for $16 million. That would have put the company in the black and given Smith the time and money he needed to prove that overnight delivery could succeed beyond anyone's wildest dreams. When they declined, Smith had to go back to the payroll ordeals, the clamor of impatient creditors, and the legal disputes in Memphis without any real hope that the company would survive. He was as close to despair as a habitual optimist could be. "I went to the airport to go back to Memphis," Smith said, "and saw a flight to Las Vegas. I won $27,000, starting with just a couple of hundred, and sent it back to Memphis. The $27,000 wasn't decisive, but it was an omen that things would get better."

Smith had never gambled before and has not gambled since—at least not with cards or dice. But the encouragement of that strange moment of luck lifted him and sent him exploring another option—his relationship with two executives of a New York company called New Court Securities, which was funded by the Rothschild banking dynasty. The two men, Charles Lea and Richard Stowe, had concluded that Federal Express might indeed be able to live up to Smith's predictions of volume and revenue; they began to work with him on a financial package to save Federal Express from default before Christmas. Besides having a lot of couriers holding their paychecks, by then the Enterprise Company was on the hook for $7.9 million, Chase Manhattan Bank had $24 million in outstanding loans to Federal Express, and one bank in Little Rock—which had a loan ceiling of $2 million—had $9 million outstanding.

At the memory of that 1973 crisis, Smith smiles like a platoon leader who has outflanked and cornered a superior, better-equipped enemy. "In the first couple of years of operation, we lost a total of $29 million. But we learned a very important principle," said Smith. "Don't ever borrow a little bit of money, because when you borrow a little bit of money, you have a serious creditor if you run short. If you borrow a lot of money, you have a partner when you get into trouble."

In October 1973, with almost daily foreclosure threats at Federal Express, New Court Securities assembled a galaxy of investors in New York. Among them were Prudential Insurance, Allstate Insurance, General Dynamics, Heizer Corporation, Citicorp, the Bank of America, and the First National Bank of Chicago. After negotiations, Smith emerged with $52 million in backing. Federal Express could now afford to lose money for years—which it did.

Even with all those partners and all that money, things got worse before they got better. By March 1974 relations within the Smith family had deteriorated. An attorney for Smith's two sisters advised them to disavow his pledging , his shares and, believing Federal Express would not be successful, to attempt to bankrupt it and recoup much of the investment through tax refunds. That lawyer wrote Federal Express attorneys in Little Rock and Memphis, and the result was an indictment against Smith for exceeding his legal authority as president of the Enterprise Company. Smith was not officially charged with fraud until the following January, but the possibility of the company's founder and leader going to jail did not comfort its board of directors or its investors.

A Conflict of Leadership

In June 1974, the chairmanship of Federal Express was turned over to retired Air Force General Howell Estes, in accord with Smith's agreement with General Dynamics. For the first time since Vietnam, the platoon leader was answering to a general again. To many others at Federal Express, the authoritarian Estes was a terrible shock. Tucker Taylor, who had to report directly to him, almost abandoned the company on the spot. "What the company needed in that period was Mao Tse-tung, and they gave us Metternich," said Taylor. "He made pompous announcements like a general does. He was the only one who had a parking place with his name on it. We were all driving Volkswagens—Smith was parking eight blocks away and walking in the rain—and here was this reserved parking space."

Taylor might have left the company had he not got a reading from Smith of what the future held. "I asked Fred just one question: 'If it comes down to a fight between you and General Estes, who's gonna win?' And he said, I will.' And I never talked to him about it again."

As resistant as the workforce was to Estes, Smith bore the change with relative calm. Drawing an analogy to a different pair of contrasting commanders, Smith recalled, "It was Ho Chi Minh versus Bismarck." Smith gave Estes respect and kept his distance, but he also saw that Estes' devotion to rigid lines of command was inconsistent with the trust and freedom Federal Express's people had come to expect. Estes and the workers drifted farther and farther apart. The company developed a dual leadership, with people paying lip service to Estes but checking with Smith before acting. When the eventual conflict between the two came eight months later, Estes resigned and Smith was reinstated as CEO. The board began a search for a replacement, but no one took the effort seriously.

At the end of 1975, a Federal Express jury exonerated Smith of illegally authorizing his own loan documents, ruling that he had acted basically for the best interests of a company largely under his personal control. The decision of the court came rather quickly. Smith's sisters had second thoughts about prosecuting their brother and refused to testify against him. The attorney whose signature Smith had borrowed told the judge that the nature of the company and his relationship with Smith were such that he had signed Smith's income tax forms for him. "It was like trying to prosecute somebody for borrowing the family car," said John Patterson, one of the former brothers-in-law, in his testimony.

Perspective

Throughout the long personal ordeal, Smith retained his composure. He insists today that the crises of litigation and finance are fearful only for those who have never faced the sort of terror he faced in Vietnam. "You ought to get into a goddamn firefight and see what it's like," said Smith. "Nothing of the things that happened to me in those two years were particularly traumatic at all, considering where I've been. If you want to get the hell scared out of you, have about two thousand guys trying to overrun you. That's scary!"

The strength of Federal Express through the desperate period from 1973 to 1975 was that "we were all in this together." The company was largely a hand-to-mouth group—daredevils and barnstormers without much regard for risk or the future. Smith's troubles with investors, his sisters, and the presence of Estes all strengthened the kinship he shared with his work force. "The most fun I had was when the pressure was the most," recalled Taylor. "I thought that was wonderful. The fact that the company didn't have any money wasn't really important—this was the great experiment! We were going to prove it could be done anyway."

Foreclosure threatened everybody, the boss as well as the working stiff. When everybody had to deal it, it didn't seem so awful. Everybody at Federal Express was an entrepreneur: One person's idea about starting a new office was as good as anybody else's. "For the first three years, we didn't know what we were doing," said Taylor. "We didn't have any market data. When you opened a station in Miami, you found the best kid you could, gave him a map of Miami, and told him to call you if he had any problems."

Individual style became sacred in those early days. Once a courier set out, he was as independent as a pony express rider. Each driver was expected to pick up all of his packages on time and get them to the airport any way he could; no one ever asked questions as long as the driver made it. There are stories of couriers so committed that they pawned their watches to buy gas.

As bad as finances got, Smith insisted that the law of the platoon must prevail. Smith's loyalty to his people came back to him in equal measure. "Federal Express never laid anybody off," said Taylor. "One of our convictions was that, even if the sheriff was about to take the airplane, we never laid anybody off. We would take pilots and make them managers when we opened a new station. We had pilots all over the place. Then as the company grew, we would take them and put them back out flying."

As crazy as Federal Express's people liked to be, they were neat. From the first day, Smith emphasized that the image of air freight must be changed. "The public isn't impressed when they have to deal with a gruff, sloppily dressed character chomping on a cigar in some seedy shed near an airport or on the back of some loading dock," he said. "If the opportunities were going to be fully exploited, the public image had to be changed."

Bass was one of the keepers of the image. "The company's schedule was good. Its reliability was good. The people were knowledgeable, clean, and well shaven, and every truck was washed every day," he explained. "Woe betide he who didn't have the truck washed, because that was our logo—even when we didn't have enough money to do a lot of things. I couldn't tell you the number of times somebody said, 'We don't have enough money. We can't wash trucks.' And I said, 'You're telling me we can't afford water? Is that what I am hearing?' "

No one at Federal Express, not even Smith, ever had run a service company. There was no instruction manual, but caring about and taking care of each other was an ethic that pervaded their work. The feeling also infected customers. "We found that in a start-up company in a service business, customers respond to people," recalled Taylor. "One example: Every quarter we would ask one-fourth of our customers what they liked about Federal Express. The questionnaires would come back with little notes like, 'Say hello to Ginny in Wichita for me.' It finally occurred to us that customers were giving their packages to people, not to Federal Express. They didn't care about the airplanes, but they knew Ginny had never let them down."

Bass recalled, "Plenty of people called me during the early days to say, 'Your company is just as screwed up as the competition. I wanted to tell you because I don't have the heart to tell your courier—that kid is busting his ass out here for you, and we are going to be sure that you still get the packages. But if you ever screw up again, that's going to be it.' The kids had built this unbelievable feeling in the company."

The chaos began to subside a little. By early 1976 the hub in Memphis was handling thousands of packages smoothly every night, and the fleet of Falcons was often flying fully loaded. The fear of foreclosure began to fade. But, in the great scheme of things, Federal Express was still a tiny company. Two things worked to keep them small—public recognition and Federal Express regulation. In 1978 two breakthroughs occurred to overcome these problems.

Owning the Market

Smith spent most of his time from 1976 to 1978 in Washington, D.C., learning legislative and regulatory intricacies. His mission was to change the laws that allowed carriers to move freight over any route they chose but under severe weight limits—laws that dated back to the building of commercial aviation. As long as weight limits existed, the biggest plane Federal Express could fly was a Falcon, with a payload of about 6,000 pounds.

By 1977 Federal Express had as many as five Falcons flying in formation on some of their heaviest routes. The image was wonderfully romantic, but it also demonstrated graphically the limits to company growth, especially with the dramatic rise in fuel prices following Federal Express's inception. If the company were free to fly bigger airplanes, the older freight handlers—who used cargo space on commercial airlines—would lose freight, money, and customers. The battle lines were clear, but Smith had two advantages over his competition: One was his tenacity; the other was the administration of President Carter, which was strongly in favor of deregulating the industry.

"The people who make decisions in Washington are not the senators and the congressmen, but the staffers," said Smith. "So we lobbied the staff. We knew we had right on our side, and the forces of history. A question that remained was, 'How do we topple the big guys?' " That struggle began to close with the passage of an amendment called the "Federal Express Bill." By the fall of 1976, Smith had obtained considerable support in both Houses of Congress for a special dispensation on payload limits. That was killed by Congressman Glenn Anderson, who refused to support what he felt was "preferential treatment" for Federal Express. Disappointed but undeterred, Smith responded with another Vietnam analogy: "If you keep working at it, in the last analysis, you win," said Smith. "We're like Ho Chi Minh. They've got to kill us a hundred times. We just have to kill them once."

In 1977 Congressman Anderson introduced the bill for complete reform of the air freight industry. The infighting between a group of upstart carriers and a powerful lobby of older, bigger, regular air carriers continued to the last minute. But in the 1970s, the forty-year-old restrictions made little sense to the Administration or to Congress. Deregulation was favored so overwhelmingly that it passed both houses by voice vote.

The impact on the future of Federal Express was historic. Within six weeks, Smith had begun to change Federal Express's fleet to Boeing 727s with ten times the payload of Falcons. Today, many of Federal Express's fleet are DC-lOs with a payload of more than 120,000 pounds each. Business historian Robert Sigafoos expressed the impact of deregulation: "Without the freedom provided by air cargo deregulation, Federal Express would have faced a flattening of its growth curve within a year or two, and it probably would have remained a small, moderately profitable company. The growth limitations imposed by continued reliance on the Falcon fleet would have negated continued interest by investors and lenders. Talented staff and technical people would have abandoned the company in droves. But with deregulation, Smith and his bright, entrepreneurially oriented colleagues were given new motivation to try to take Federal Express to unprecedented heights."

Along with Smith, Bass, and others, Taylor knew that if the company seized the opportunity, it could become immense. "When Jimmy Carter signed the Air Cargo Deregulation Act, I knew it was not a matter of whether or not I would get rich, but how rich," he said. "And not how well Federal Express was going to succeed, but how big the success was going to be. We owned the market."

Hello-o-o Federal

Federal Express did own the market, but they could have lost it without one more major step: People had to know Federal Express as well as UPS and Emery. Vincent Fagan began working feverishly with a couple of New York advertising men. They took a while to understand the unconventionality of Federal Express, as did many observers. At first all they could see was the technology—the airplanes and the hub system. Air freight did not normally advertise on television at all, but Smith and Fagan agreed that the gap between them and the big companies required a little daring.

The campaign focused on the difference between Federal Express and their competition. Ads used a survey that showed that their overnight packages arrived before noon at twice the success rate of the next-fastest company. The reason for the difference was simple: Federal Express was flying its own fleet, while Emery still depended on commercial flights. Federal Express's slogan became, "Twice as good as the best in the business." That got real attention from shippers and irritated the archrival. Emery eventually followed Federal Express into overnight delivery in 1977, while Federal Express was still well in the shadow of their huge competitors. "Emery brought fear into the hearts of a lot of our employees," said Bass. "I would tell this story—which we used in pamphlets, papers, everything—about the bear and the alligator. In a fight between a bear and an alligator, the winner is determined not by the skill of the combatant as much as by the terrain. In 1975, if Emery had really caught on to what we were doing, they could have pulled us out of the swamp and killed us. In 1977, they jumped in the swamp. And it was a whole different battle."

When it was time for Federal Express to undertake a fresh advertising initiative, to hit television hard in the wake of deregulation, Fagan's staff focused first on the hub and spokes and the great melee that occurred every night in Memphis. There, packages poured from airplanes and flew along a multistory racetrack of conveyor belts, while cargo trucks and forklifts buzzed down long, concrete alleys. The hub was already hypnotic. Today it has 200 miles of conveyors on 600 acres of land. With almost 6,000 employees handling 800,000 packages in about 2 hours, it is a kind of mechanical Fantasyland.

"The advertising men thought the hub was so unique that it should be our story," recalled Bass. "Fagan had to convince them otherwise. All people cared about was that it got there—all they knew was it had to be in Boston tomorrow. If somebody convinced them that it was going from New York to Memphis to Boston, because we were so proud of our system, we would be killing ourselves."

Years before, Smith had an intuition that people wanted overnight delivery; now Fagan had an idea of why they wanted it. He found a researcher who verified what Fagan had suspected all along: "People didn't care about speed or price," said Bass. "What they really cared about was peace of mind. The advertisers wouldn't accept it until Fagan took the agency's president to the guy who did the research and told him, 'Listen to what this guy is telling you!' "

The result was a series of television ads that for a time became part of American culture. If any one of them could be said to sum up the difference Federal Express aimed to communicate, it was one depicting a small businessman in a store that specialized in electric light bulbs. He is on the phone to "Dingbat Air Freight," insisting, "If those bulbs aren't here tomorrow morning, I am out of business!" The second scene shows the Dingbat Air Freight courier arriving "two days later" and gaping at a sign across the front of the store that reads, "Out of Business."

Selling Peace of Mind

All of Federal Express's television ads focused on the individual who will get in trouble if the package doesn't arrive on time. Smith had given his company a working-class bias that resulted in working-class commercials. The charm of the commercials, however, was that the "working-class" people who identified with the people in the spots went all the way up the ladder to the outskirts of corporate power. Fagan uncovered the fear and injustice that people feel when they take the blame for someone else's mistake.

"Hello, Federal!"—spoken thousands of times to millions of viewers in those irreverent, unforgettable commercials—became a punch line and an alibi. It even implied a certain defiance of authority. In one commercial, a series of self-important executives parade into a corporate shipping room, handing packages to a harried clerk, insisting that he send the packages overnight via Federal Express's various competitors. They threaten him with loss of his job if he fails. With all the packages stacked beside him, the clerk picks up the phone, an impish, confident smile playing across his face, and says, "Hello-o-o, Federal!" Fagan said, "We put everyday people into these ads so that they could see themselves and the forces aligned against them."

"The problems of moving something in an organization don't just happen on the shipping dock," explained Taylor. "But the farther you move down in an organization, the more the needs become personal, as opposed to corporate. All the chairman of the board of a company cares about is the bottom line. But you go down to the secretaries, what they care about is their own well-being. That's where 'Hello, Federal!' came in. The whole issue is moving down an organization and saying, 'Forget what this is going to do for your company. This is going to make your life easier.' The sales proposition is not that the package will get there overnight, because that person doesn't really care . whether it does or not. The issue is, if you send it Federal Express, who can get mad at you? You've done the best you can. The breakthrough was when we figured out we were really selling peace of mind."

Since the late 1970s, Federal Express's growth has barely hesitated. Whatever the future, Smith's legend is safe. If anything bothers him, it is the fact that there is a legend at all. Smith is uncomfortable with his image as a hero of industry, a genius of strategic management, and a one-man show. Smith wisely aimed, at the beginning, at finding the right people, because he could not do it alone.

He explains that his greatest attainments were to give each of his employees a mission, to challenge the employees without overwhelming them, and to conceal from everyone else how overwhelmed he himself sometimes felt.

Smith began the Federal Express breakthrough as others began theirs—as a guide and teacher, articulating a vision more clearly to others than he could truly see it for himself. He set things in motion and stepped back. "People will rise to the occasion if you give them a chance, whether it's a delivery guy or Tucker designing a new telephone system or Vince coming up with new advertising or Art coming up with a new control network," said Smith. "People have the basic intelligence and outlook to do it."

The enormous energy that poured from Federal Express from the very first was built not as much on what Smith could do as what he couldn't do. From the outset, he entrusted ordinary people with extraordinary responsibility. He expected from them decisions that touched the company's very survival. And he never looked back. He had seen people like this make wise survival decisions under fire. More than anything else, even financial success, Smith wanted his people to become the very best they could be. Because he had learned in Vietnam to depend on others, he understood that trust is the thing you give first.

"I don't think I would have done anything like this without that experience; I don't think I would have had the same perspective," Smith said. "I felt a tremendous responsibility. There was no way I was going to let things go down the tubes if I could possibly help it. I had gotten all these people who believed in me and I just couldn't turn back."

In a way, Federal Express came about not through the vision of Fred Smith, but through the thankless heroism of the grunts in the Marines. With Federal Express, Smith in spirit gave those comrades in arms almost everything he hadn't been able to give them in Vietnam—a purpose, a worthy job, a chance to grow, a sense of dignity, respect, and hope. He also wishes he could give them the credit. Smith wishes he could surrender to his workers all the recognition that has fallen to him. However, the troops understand that his recognition is their triumph. He made possible feelings that they might never have known otherwise. Federal Express was something worth fighting for, something to believe in, and something that was fun.

"At Federal Express, we delivered on the promise," said Art Bass. "I don't mean for customers. I mean we brought together people who were proud of what they were doing, who had few other opportunities in their lives to be proud of anything. We all remembered the story of the knight on the white horse who went off to fight the dragon, not knowing whether he was going to get any support. He was on his own. That's the way we all felt, in a truck or in a plane or in the hub. You were all alone out there, but everybody was depending on you. You had to come through."

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CLUB MEDITERRANEE: DREAMERS, ACCOUNTANTS, AND ENTERTAINERS

The scene beneath the oven-hot sun of Agadir, Morocco, seems identical to that at any other resort. The atmosphere at the enormous swimming pool is one of torpid luxury. One hundred or so vacationers—French, Belgian, German, Canadian, even an American or two—have stripped down to little more than narrow bands of lycra and are shiny with oil, browning themselves beside cool drinks.

This resort, however, is different. Founded on a reputation and a magazine article in 1950, Club Mediterranee created a fashion that the travel industry aches to imitate. Flanking this Club Med are two copycat resorts, each with a stretch of the wondrous beach—a 400-meter strip of gold sand that curves along 10 kilometers of dazzling blue ocean. The neighbors have many of the same facilities as Club Med: tennis, golf, riding, and *petanque;* magnificent pools; nightclubs; and dining halls serving immense buffet feasts. But the copycats do not thrive, even here; they do not burst with the number of clients or the enthusiasm of Club Med.

Worldwide, the comparison is the same. No other vacation company boasts Club Med's 139 villages on 5 continents in 35 countries. No other company approaches the millions of clients (Club Med served two million clients in 1991). No competitor can claim to be a household word—a synonym for *vacation* in every industrialized nation.

Like other breakthroughs, Club Med began with an effort by one man: the late athlete/philosopher Gerard Blitz and his desire to solve a problem. The clarity of his understanding of the problem, the elegance of his proposed solution, his tenacity in nurturing it, his basic lack of interest in financial reward, and his astonishment at the unanticipated and overwhelming popularity of his idea all typified the breakthrough experience. Similarly, Club Med evoked in its founders intense emotion.

Millions of clients, called *gentils membres (GMs),* have also responded over the years to the Club in intensely personal ways. "Half the people who went to that first village were furious because of the absence of comforts," recalled Blitz. "The other half were unbelievably enthusiastic."

Today people continue to evaluate Club Med on the basis not of cost and services but of emotional experience, often encounters with other people. "You're certain to rub some people the wrong way," said Alexis Agnello, executive vice president. "The relationships are very personal, very passionate."

To some, Club Med means sun and beaches; to others, it means sex and the mating rituals of the singles scene. To some it means uninterrupted skiing, golf, tennis, bridge, or just sunning; to others, nights of feasting, floor shows, dancing, flirting, and talk—hours and hours of talk, usually between people who began as strangers.

To the dissatisfied, Club Med means regimentation and forced camaraderie, tight two-bed bungalows shared with an incompatible stranger, dinner tables shared with strangers who yammer endlessly about their bridge games, tennis tournaments, or problems with a hairdresser. To some, it means a vacation without the blessing of solitude; an artificial, intense isolation (no television, no news, no phones); and a dearth of intellectual stimulation on a Third-World oasis populated by the leisure class.

The Gentils Organisateurs (GOs)

The dissatisfied don't return, but the majority who love it and come back find Club Med differs from all the others. To understand why, just linger by the pool at Agadir. Before long, something will happen. An hour or so before lunchtime, three or four bronzed young people, in their twenties, burst onto the pool deck. These are Club Med's *gentils organisateurs (GOs),* a cadre of "always beautiful, always young," elves who infect each Club village with ceaseless energy and goodwill. There are so many GOs at each village that it is virtually impossible to sneak off to the bathroom without a hearty "bon voyage" from a GO.

Four GOs arrive and begin to frolic boisterously, even a little dangerously, with a pogo stick and a unicycle. At another resort, this loud intrusion into the lazy enclave would be viewed dimly—reason enough for at least one disgruntled sunbather to stalk off in search of the management. At Club Med, however, this sort of romp is on the bill of fare. The crowd smiles as a GO masterfully maneuvers the pogo stick within inches of people's toes. These people know the intruders: Rashid, handsome, muscular, effervescent, equally comfortable among the Muslims of North Africa and Parisians; Georgia, a French girl whose beauty recalls Gina Lollabrigida; Jean-Pierre, a fine-boned blond of great beauty who delights the crowd by doing pratfalls; and Michel, nicknamed "Cassoulet," the Club comedian. Inevitably, Rashid lures a curious man to try the pogo stick. For the next half hour the whole poolside crowd is captivated by this casual entertainment; more and more of them are lured by the challenge of the unicycle and pogo stick. And the long hour before lunch has flown by.

Lunch is spectacular: a feast vast in its delights, pleasing to the eye and palate, fit for a Roman emperor. No wonder the prospect of each meal draws the entire village from its other pursuits.

The *Chef de Village*

When the second of the daily feasts is over, the poolside repopulates; many of those who spend the morning in sports spend the afternoon in repose. Soon a courtyard off the pool deck becomes the stage for another amusement. The *chef de village* (village chief), Eric Voyer, introduces Cassoulet, sadfaced, costumed in a red dinner jacket and mustache, and accompanied by another male GO dressed in drag as a slatternly housewife. Her wig is a blonde rat's nest, and she lumbers along with a load of laundry and a huge bucket. As Cassoulet begins to emote in the tones of , a world-weary rake, the burly housewife—grown disgusted with his self-indulgent monologue—lifts him bodily and dunks him in the laundry bucket. Cassoulet continues despite the submersions. The scene is raw slapstick, but with studied practice and exceptional timing. The crowd enjoys the diversion immensely.

A day later at the same poolside, Club Med stages an apparently impromptu fashion show, stocked from the village's luxurious boutique. Among the models is Rossana Sessa, who appears in the village's nightly stage shows. She is the best singer in the village, but before joining Club Med she had barely sung a note. An Italian who earned her degree in English literature at Cambridge, she sought a year as a GO as a break before beginning a teaching career. Now in her fifth year and eighth village as a GO, she has become more specialized—as a singer and as a mature leader for the younger GOs. Should Rossana leave Club Med, she will have doubled the options she had five years ago, with credentials not only as a teacher but as a performer. However, her instinct for gentle and subtle leadership is the sort of strength Club Med prefers to keep.

Watch GOs carefully and you notice them helping a lady to a seat before the nightly show, stopping by GMs beside the pool to offer assistance, or giving lessons. They coach GMs in tennis, golf, horsemanship—with almost superhuman patience and careful discipline that produce swift and exhilarating results. The job does not pay well when you consider that it entails being on call twenty-four hours a day. On the other hand, food and lodgings come with the job—as well as the eternal vacation. Perhaps gentil organisateur is the ideal job for young people with enormous energy, a superior education, and great potential, but without much purpose in life. The demands of the job—the ceaseless contact with people and the six-month cycle of total change in job location, language, culture, responsibilities, boss, colleagues—create unparalleled conditions for growing and maturing. In the average GO there is an exceptional blend of youth and maturity. "Club Med holds a unique place," explained Michel Villemejane, director of the Club's Belgian office, "because the GOs are totally integrated into the world of their clients."

If the Club's values of service are embodied by the GOs, they are magnified in the chefs de village. At first, the chef de village was like the pastor of a congregation of celebrants that had been willingly cast into the wilderness. He was the one person who not only assured everyone's survival but convinced them they were having fun. This role was particularly vital in the earliest days of Club Med when the fun consisted of little more than sun, beaches, snorkels, tents, volleyball, and talking. Today, the confidence and versatility of the chef de village as he manages a rich variety of options is the lifeblood of Club Med. Michel Perchet, a former GO and chef de village, explained: "The chef is everywhere at once; he is the soul of the village."

A modern chef de village like Eric Voyer is responsible for property of several hundred acres and a small city of buildings valued in the tens of millions of dollars. He manages a staff of 100 GOs, as well as several hundred support workers drawn from the nearby community. He caters to a paying population of more than 500 GMs. And above all, he is an entertainer.

One might first see Voyer performing in a spoof of "WrestleMania," with Cassoulet refereeing a comedy match and Voyer bounding through an exhausting tag-team performance. He may sing in the next show and later appear in the discotheque. And every day he is master of ceremonies of a game that has elements of "Name That Tune" and musical chairs. When offstage, Voyer handles problems with luggage, transportation, medical needs, and incompatible roommates. Every day he does a circuit of the sports sites, doing everything from playing tennis to kibitzing over bridge. Every evening, in several languages, he is the greeter at the dining room. His eyes sparkle; his handshake is firm; he is an iron man who never sleeps.

The importance of the chef de village cannot be overstated. Jacques Benacin, who left IBM to work for Club Med, recalled attending a Club Med resort with two other executives. "We had enormous job responsibilities," he said. "But we were like children in the hands of the chef de village and the GOs. If there had been an earthquake, all of us would have obeyed the chef de village, just as if this were the army and he were the general!"

If Benacin's earthquake had occurred, the ability of the chef de village to take charge would have been taken for granted not only by the GMs but also by headquarters in Paris. When Alexis Agnello sends a chef off to a site, he gives him little more than a crew and a budget. "When the village is working, its life is just the GMs and GOs. It's not necessary for us to intrude," he said. "Our role is to select the people and turn the operations over to them."

Marc Tombez, once Club Med's director of training and now general manager of the Italian villages, expressed this management style as a philosophy: "Our only guarantee of success is that everybody in the company must be free and autonomous. Freedom is our goal, in every element of the company, because we cannot control quality. In a service business, what you produce is immediately consumed by the customer. So each person in the company represents the product, the image, the name of Club Med." Because of this extraordinary independence, the Club places a high value on graciousness and spontaneity. "When we hire a GO, our main criterion is that person's capacity for relationships—not only under ideal conditions, but under high pressure," said Tombez.

The measure to which a GO is gracious and spontaneous ultimately determines his or her potential for advancement. The GO must sense people's needs, even as they develop, and respond to them before they can be articulated. This idea (to care for people more than they expect) is the basis of Club Med.

A Holiday More Remote, More Natural

In 1950, Gerard Blitz was a diamond cutter—a profession unexpected in a man with his history and inclinations. A member of the Belgian national swim and water-polo teams, Blitz served three years in the Resistance during World War II and was decorated six times for bravery. After the war, Blitz felt caged by the gray and cold of Paris, by clocks, money, and the pressures of everyday commerce. He spent his summer vacations in the South, but because of his war experience, he wanted a holiday more remote and *natural* than most others wanted. His escape was to a desolate stretch of beach in Corsica, with a few friends.

Those vacations replenished and restored Blitz. To his friends, he wondered, "Why can't we make this available to everyone?" It became clear that organizing and capitalizing vacation camps in remote Mediterranean villages, at least for a small group of people, would not be difficult. The idea was practical, but it was also more than that: It was a way to express things he had always believed.

Blitz, who died in 1990, talked about the creation of Club Med on a gray spring day in Paris, early in the sixtieth year of his life. His vitality belied his age. He leaned forward to speak, his voice was deep, clear, and as certain as his memory. His serenity was the product of a lifetime of studying yoga and twenty-five years as a Zen monk. "I felt then, and even more today," he said, "that in their daily lives people are unaware of habits that limit their capacity for life. They fall into a repetition of automatic cycles and movements. They become prisoners of a style of life in which there is no freedom, no possibility for real relationships, no hope to enjoy the simplest things."

Blitz's response to this perception was to prepare an *inventory of obstacles to the capacity for life.* Blitz's manifesto led directly to the elegant concept so characteristic of breakthroughs. "I proposed, for the holiday period, a way of life that breaks those limits," said Blitz. "First of all, space is needed. Look around you; all that you see are walls. We need to see space unobstructed by human construction. We proposed the sea, the mountains, the desert, the snow, and the sand. Instead of gray skies, luminosity. I proposed to bring people into the light. I'm not talking about the sun; we were attracted by the sort of light that is the source of our civilization. There is a special quality in this luminosity of the Mediterranean—the light of Greece, Rome, Jerusalem. It was no accident that our civilization happened there."

Also on Blitz's inventory was the insidious pressure of money. As he formed the concept of Club Med, he avoided this problem as much as possible. First, he determined that the Club would be a group of amateurs running a nonprofit organization. The price of a vacation would simply cover expenses. (In fact, for the first twelve years neither he nor anyone else bothered to calculate whether fees were actually covering expenses.) The result was a singular liberation within Club Med villages, where currency is largely banned. "We took away money not because of the money itself, but because of the worries that come with it, especially when you're in a foreign country and worried about making it to the end of your vacation."

Along with the disappearance of money came the disappearance of comforts customary to modern society. At first there was no running water, no electricity, no communication with the outside world. "The absence of comfort was also part of the formula," said Blitz. "Without money, walls, or limits, you achieve an enormous sense of well-being. Suspicion disappeared when there was no money. It was easy for people to speak from the heart. There were no barriers."

This breaking down of social barriers came as a surprise, but even more surprising was the spontaneous appeal of Club Med to a broad spectrum of people. Like most breakthrough leaders, Blitz never anticipated the enormous market response to his idea.

First, however, he had to set up camp. Blitz was literally without a centime to buy the supplies necessary to make camp on his chosen site in Majorca, so he called in a few old chips. Before World War II, his athletic exploits were chronicled in the sports journal *L'Equipe*. He asked its editors to consider an article about his new holiday concept; the three features that followed were Club Med's only advertising for more than a decade. Within weeks, Blitz had signed up 6,200 eager vacationers. He had to turn down hundreds because his first village had already been filled to capacity.

His concern then shifted to the matter of tents. Since the war, there were millions of tents in Europe, most of them left behind by the U.S. Army. Looking through a list of suppliers that sold surplus tents, Blitz stopped at the name of Raymond Trigano. The choice was purely accidental. Blitz had met neither Trigano nor his son Gilbert, who answered the phone when Blitz called. That conversation began a lifelong friendship between Blitz the dreamer and Trigano, whom one of his colleagues, Michel Villemejane, calls "a dreamer who can count." It would be four years before Gilbert Trigano was more than just a tent supplier to Club Med, but in those years he developed a passion for the Club that rivaled Blitz's own. Blitz and Trigano, only eight years apart in age, had many things in common. Both Jewish, they had both fought in the Resistance, and they had both enjoyed youths of nomadism and free expression.

Protocol

In the Club's first years, details of protocol sprang up the way ideas bubble up among friends sharing a bottle and having a good time. The use of the adjective *gentil* (usually translated as "gentle") was adopted as an honorific for both customers and employees. In 1954, Blitz realized that management of his Club, which had grown to four villages with more than 10,000 clients, had gotten out of hand. Blitz had no idea whether he was making money. Bills got paid, but since the government didn't tax nonprofit clubs, he did no accounting. It was not part of his duty or in his nature.

Gilbert Trigano, however, was an accountant. His significant contribution was not only financial but organizational. He formalized Blitz's concepts of keeping currency out of the villages, institutionalized the GO system, and elevated the responsibilities of the chef de village. In the twelve years that Club Med remained nonprofit, he and Blitz established four basic rules, the four taboos, which helped create the Club's legend.

- No money
- No formal *vous* (the use of the familiar *tu* in all conversations)
- No locks on doors
- No isolation, especially at meals, where group seatings are mandatory

A fifth, unwritten taboo also prevailed for much of Club Med's early years, though it has largely perished since: no clothes. This meant not so much that people went naked (though such behavior was indulged), but that people were essentially free of luggage. A bathing suit and casual togs were supplemented by the *pareo* (sarong) that Club Med provided to GMs on arrival. This rudimentary wardrobe was deemed sufficient for a stay of two weeks.

Nomadism and No Money

Trigano and Blitz also crystallized the concept of nomadism for Club Med employees. They decided that after a season in one village, everyone who had worked there would start fresh in some other village. As a result, Club Med tends not to attract homebodies who like steady, familiar surroundings from month to month, year to year. The policy cost fortunes in travel expenses and resulted in at least one extra level of bureaucracy dedicated to the complexities of visas, passports, and diplomatic sensibilities. But nomadism, intended to prevent the creation of fiefdoms within the Club and fend off psychic stagnation among employees, has attained its purpose.

A Club Med village is like a tidal pool. It has as its only constant a handful of immovable objects—rocks, structures, the occasional stubborn crustacean. Other creatures, however, sweep into a pool—or a village—in wild variety with every cycle, bringing enrichment, color, and rejuvenating change. Agadir today is totally unlike what it will be six months from now. The resulting ferment is infectious. The energy generated by the GOs makes them seem able to do anything, able to manufacture fun in infinite variety from thin air. This expectation grows in GMs as they return to Club Med; they expect new magic every time. The effect on the GOs is a redoubling of their efforts to make the magic, to share ideas, to try anything. Even an idea that fails still succeeds in occupying the GOs and the village for a while, increasing the GMs' affection for the hardworking GOs.

Alexis Agnello smiled at the idea that nomadism and client pressure represent a methodology for innovation. "Even if someone comes up with an idea that seems terrible, we let them do what they want," he said. "Out of ten ideas that people try, two really work, and then we tell other villages about them."

Money did not, in fact, become even moderately important until the end of the 1962 season, when the company had no money to pay bills. "The only bad surprise," said Blitz, "was that we lost control. We were being pushed by more and more people wanting to join, and we kept trying to grow fast enough to fit them in. We didn't pay enough attention to the accounts. We took the anxiety of money away from our clients, but we also refused to face reality." It was time for Trigano to carry out that long-delayed audit of Club Med's nonexistent books. He spent several months piecing together fiscal shreds while Blitz sailed to Tahiti to examine sites for yet another village—if they found they could afford it.

Too Much Success

The situation was strange. By 1962, Blitz and Trigano were managing a nonprofit organization with more than 70,000 members using facilities on a dozen sites throughout the Mediterranean. The cult had exploded in 1958 when *Life* magazine published a thirteen-page photo feature on Club Med, identifying it as the trendiest new vacation concept. Letters poured into Club Med offices, "but we couldn't even answer them," said Blitz. "We were pushed, pushed, pushed. Every year we built a new village, and we didn't have the means that we have now—no telex, no telephones. We operated in underdeveloped countries; we had no way of controlling the situation. It was an adventure from the beginning."

By the end of the 1950s, Club Med winter meetings had outgrown virtually all the available assembly halls in Paris. Not long before Blitz and Trigano had faced their financial bungling, a meeting of Club members had to be located in a hangar at Orly Airport, where thousands of enthusiasts created a traffic jam of historic proportion.

Club Med's problems were typified by the fact that in 1962 they had to turn away more than 100,000 applicants. The Club was suffocating under the weight of its own success. Blitz recalled, "In Tahiti, I got a telegram from Gilbert with the result of his audit. We were in debt for billions of francs and couldn't pay even one of the previous year's bills...We refused 100,000 people and we lost money! On the one hand, we had developed an enormous potential market; on the other, a total absence of operational control."

Blitz and Trigano agreed to meet as soon as possible in Los Angeles. That meeting was the turning point for the future of Club Mediterranee. Two choices were clear. The . first, said Blitz, was "to disappear. Bankrupt. *Finis.* That was impossible, though, because we were, in the eyes of people and the media, so successful. It would be impossible to explain." Choice number two was no easier for this pair of idealists who—in philosophy and instincts—recoiled at the thought of accumulating money for its own sake. They had clung to nonprofit status not only for its freedom from taxation, but for the purity it gave to their service to people. "The second choice," Blitz said, "was to make a company with capital, equity, and money—to go into business in an orthodox manner."

They decided to form a company, but the problem remained of finding a venture capitalist who would shoulder the enormous debt and fund reformation of the company. Recent news reports had informed Blitz and Trigano that one of the gentils membres possessed one of the largest, if not the largest, family fortunes in the Western world—Edmond de Rothschild, who was a frequent visitor to Club Med's village in Israel. So Blitz went to see Rothschild. It was not so difficult, because in him Club Med had a true fan. Like many Europeans who were squeezed by the pressures of daily life and frustrated by the sameness of mass-produced culture, Rothschild found in the rugged simplicity of a Club Med village a physical and intellectual liberation.

Blitz recalled, "I explained that holidays will become more and more important. We had created a concept, and we already had the market. Club Med was to holidays what Frigidaire was to refrigerators and Kodak was to photography. But now we had overbooking, we had refused thousands of people, and we had lost a billion francs...I also told him, 'Your cousins are in mining and oil. You are starting with money but no business prospects. I am proposing to you a gamble, a very big gamble.' After that, I could give him no more information. We had no bookkeeping. .. I told him, 'If you want to join us, it will cost you one billion francs.' "

After Blitz's brazen offer, two months passed. In that time, Rothschild's accountants did their best to rummage through Club Med's chaotic finances to determine the condition and potential of the "Club of amateurs." The delay was unfortunate. Early in 1963 Blitz and Trigano began to fold their tents. Blitz feared that he had overplayed his hand. "We had lost all hope," said Blitz. "But Rothschild came back and said, 'OK, I'm coming into the business.' "

Rothschild's involvement was extraordinarily generous. For approximately a one-third interest in the business, he paid off Club Med's outstanding debt but did not impose any management restrictions on the founders. He is currently on the board of directors. Whether Rothschild's trust was canny or naive, it saved Club Med as certainly as did his money. To have built a structure over the two entrepreneurs whose emotions were the Club's heart would have been like dropping a net over a butterfly.

Blitz, whose name then was more famous and more representative of Club Med's image, became the new company's first president. After two years, he turned the leadership over to Trigano. Blitz had become the ambassador of Club Med, but the energetic, visionary Trigano had become the leader. It was apparent to both that the business community, the press, and the membership of Club Med had come to identify Trigano as the guiding spirit of the company. Thus it was up to him to manage the business, for better or worse.

Michel Villemejane described Trigano as "a dreamer who seems to be acting on impulse, but at the same time he can add it all up and show you how much it will cost. And he's always right. He seems to make a snap decision, but he has all the figures in his head."

Marc Tombez offered a similar assessment. "He has a remarkable vision of how we can become the biggest and best, and what people will like and need, not only now but ten years from now," he said. "But, in an instant, he can turn his attention to a GO's suggestion for improving the design of beach chairs. He has a colossal imagination, but he can become interested immediately in a banal detail. And he never gets lost either way."

One of the first things that happened under Trigano's leadership was that the Club built its first permanent village—at Agadir. This was no so much strategy as evolution. Club Med had become big enough to create a more permanent atmosphere. They owned the land; they could finally afford it. With an annual membership in excess of 100,000 vacationers, Club Mediterranee moved out of tents and straw huts and into the hotel business.

The American Adventure

The Club's leaders had long realized that they must penetrate the American market, not only because of its wealth but because of the potential length of the vacation season in the constant summer of the West Indies. Club Med operated most villages for four months—slightly longer in North Africa—but in Guadeloupe or Martinique they could operate year-round, closing only for one month for repairs and refurbishing.

The problem in 1965, though, was familiar: The Club had money to operate and build bungalows in Morocco but not enough for the enormous investment needed to expand to the Caribbean. Blitz flew to America to court potential investors, many of whom had vacationed at villages in Europe and Africa. His goodwill tour had generated no significant results by the time he had reached the West Coast and prepared to fly back to Paris.

As he talked to members of the press at his last gathering, someone asked about a recent decision by President Lyndon Johnson to impose a tax on Americans who travel overseas. Blitz, with a talent for taking advantage when the spotlight happened to pause briefly on him, seized the question. "This is not the image I have of the United States," said Blitz. "This is a restriction of people's freedom." Pressed by the reporter, Blitz said that he would have expanded American tourism rather than restricting overseas tourism. "The United States is a very hospitable country. Only in Greece is hospitality equal to that in the United

States—but your budget for the development of tourism is smaller than the budget of Greece!"

Blitz's timing could not have been better; he had offered a straightforward response to Johnson's travel tax at the very moment that it was in the public consciousness. Overnight, Blitz found himself deluged with calls, most from reporters but one from the President of American Express, Howard Clark. Blitz appeared on network news—"I talked for two minutes on Mr. Johnson and eighteen minutes on Club Med"—and met with Clark. Impressed by Blitz's vision as well as the growing reputation of Club Med, and concerned by the conservative image of American Express, Clark suggested an alliance with Club Med. "It was my lucky day," said Blitz.

In fact, Blitz had made his own luck. Presented with the opportunity to team up with the world's biggest name in travel, Blitz negotiated until he had obtained not only an alliance but a check for $3 million—a big risk for American Express—that would allow Club Med to start the first Caribbean village. Business in the Caribbean and Mexico took four years to show a profit, but it transformed Club Med from a regional to an international company that became a symbol of vacation to a generation of adults for whom leisure had become an avocation.

In America, Club Med also grew beyond a seasonal enterprise into a year-round company with a constant flow of money, customers, and GOs dashing all over the globe. Trigano stressed during development of the Western villages that they should attract a mostly American and Canadian clientele, just as the Mediterranean villages were mostly European. The difference in atmosphere between a village in Morocco and one in the Bahamas is a barometer of the difference between French and American cultures. French GMs who have worked in both regions claim that

American villages are "not really Club Med at all." Americans experience the same culture shock when they first visit a village in the Alps or North Africa. "Language," said Blitz, "remains the chief barrier to communication."

Antoine Cachin, Club Med's secretary general, expressed pride in the Club's ability to appear comfortable to people of vastly different cultures, ages, and backgrounds. "The only way to expand around the world is to adapt, hiring people who speak the language and understand the culture of the GMs," he said. "You must not only adapt to the culture of each client, but also help individuals from different countries adapt and live peacefully together. We found a way, because these people realize they are not in their country, or in any country. They are in Club Med, which is another place."

Thanks to this adaptation and the success of expansion, Club Med's membership rose dramatically. They were finally able to accommodate the backlog of applicants—membership more than quadrupled, reaching 300,00 by 1970, and that number doubled again in 1980.

Clubs Today and Tomorrow

Today it is hard to imagine that the roots of Club Med lay in the used tents from Europe's bloodiest war. Each year the comfort of Club Med grows greater and the old taboos grow weaker. Some of the hotels are as plush as the competition's. Where once it was considered gauche to wear anything more than a bathing suit and *pareo*, GMs now dress in a rainbow of fashionable sportswear. The *pareo* has gone from a staple to a souvenir, available in the village boutique but rarely used.

With the disappearance of the petty discomforts of the old days, many GMs fear the loss of the communal spirit that pervaded a Club Med village like no other vacation site. "Club Med wasn't born from a business plan; rather it was created as a reflection of its founders' tastes. It was a new kind of holiday. People didn't even realize, until it was offered, that they needed this type of holiday," said Michel Villemejane. "The key to the success of Club Med was that Blitz and Trigano had a good feel for the era they were living in, and they wanted to do something they liked to do themselves."

In the mid-1980s, a GM as young as twenty-one-year-old Serge Levi, who has been visiting Club Med villages since he was a child, laments the passage of the hardier days: "Things were simpler when I was a kid. You came for the sun and the sports—and to eat! Now the Club is filled with rich people showing off their money." Defiantly attired in blue jeans, sneakers, and a T-shirt, Levi is an oddity in a sea of high-fashion clothing. Demographics have shifted from socialism to conspicuous consumption.

The change might be a tactical adaptation—a response to new clientele. Trigano described life in the early villages as "a kind of voluptuousness, an immersion into a faraway world where nothing is real." In that light, not much has changed, except that the voluptuousness has spread to costumes and makeup.

Today Trigano, known for his talent for articulating customers' needs before the competition does, foresees the next generation of Club villages as *life workshops* where "the goal is professional training, to improve members' professional skills and to prepare a place for children and older people to gain school training."

Improvement of professional skills? School training on vacation? At first glance this vision appears a complete reversal of Blitz's principles of setting people free, tearing down the walls of familiar routine, and plunging people into structureless space and inspirational light. To Trigano, however, the exploration of new horizons for the human intellect represents not a departure from that original vision but an extension of it, based on intellectual and philosophical values rather than the pursuit of pure leisure.

Trigano's son Serge, the Club's director general, must sustain Club Med's basic ideals while continuing to respond to the evolving market. For several years vacation patterns have been changing, with people taking more frequent but shorter stays instead of a single, unbroken stay. Families make up a growing segment of Club Med clients. In the U.S. branch of Club Med, 40 percent of visitors have children.

Club Med entered the cruise business in 1990 with the launch of Club Med I, billed as the world's largest and most technologically advanced sailing ship. Club Med II, a sister ship, began sailing in December of 1992.

At the same time, Club Med is going after convention and conference business, offering rooms that feature color television and telephones along with full convention facilities—a far cry from the original tents-on-the-beach concept. These Clubs will be open for conventions and seminars as well as to vacationers. To Serge Trigano, the concept represents a continuation of Club Med's philosophy and an innovative response to people's actual needs.

Keeping the Spirit

Club Med has always offered people what they wanted, from transcendental meditation to disco dancing, as well as what they needed: light, space, pleasure, and refuge—the simplicity of life so dear to Blitz. Those things will always summon people from the classroom into the open. "The main originality of Club Med," said Cachin, "is that it's a true resort, where you can do everything you want. It has a special atmosphere. It's difficult to explain to people who don't know Club Med. They think it's garbage—but they are wrong."

"The foundation of the company was a bunch of friends," said Tombez. "It was born a social and cultural concept—a concept of love. The financial rationale came later with Gilbert Trigano. But always, he also had the imagination to keep as his top priority this human objective. He adapted all the financial tools of the organization to the concept."

Tombez recalled a meeting that showed the two sides of Trigano. On one side Trigano has mastered the language of business that appeals to shareholders and satisfies boards of directors, but when he gathered his gang of GOs and his team of managers, he expressed his understanding of the simplicity of his product and his unerring awareness of what Club Med must do to "keep the spirit."

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PHILIPS''S COMPACT DISC: THE DUTCH GIANT THINKS SMALL

Perhaps no consumer product of our time better represents the breakthrough experience than the little silver platter called the compact disc (CD) at N.V. Philips's Gloeilampenfabrieken (known worldwide as "Philips") in the 1970s. That Philips would create a revolutionary consumer electronics technology and hold a strong position in the market after its introduction astounded both the company and experts elsewhere in the industry. The impressive technology helped rejuvenate a depressed industry. No one predicted the swiftness and magnitude of the revolution, or that it would come from a European company when Japan had cornered the market on new ideas in consumer electronics. Indeed, Japan was involved: Sony Corporation joined in the development of compact disc technology—on an invitation from Philips—as part of a series of connections that kept Philips in the competition to the end.

Compact disc technology began as an orphan in a huge, vastly diversified company that was mainly interested in manufacturing lighting products, household appliances, television sets, stereo equipment, and dozens of other consumer and industrial products. Philips is an international giant, employing 272,800 people in factories and offices in 150 countries worldwide, with $32.3 billion in annual sales. ' ,

An Unlikely Explosion

Philips also has one of the world's most respected electronics research laboratories. It was there that researchers spawned an unlikely means of recording visual images—and the idea didn't work. But because their leader, Peter Kramer, didn't give up, they found a way to make it work and then found others up the corporate ladder whose curiosity somehow got the better of their good judgment. The baton finally dropped into the hands of Cornelius Van der Klugt, of Philips's powerful Board of Management. But even his enthusiasm and alliance with as powerful a partner as Sony did not diminish the skepticism of a company that didn't think much of the potential of CDs.

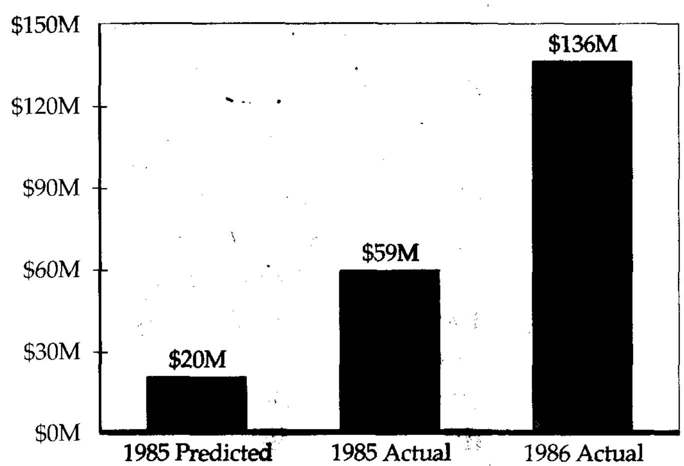
Even the advocates of the CD had to endure the failure of its parent technology, the Laser Vision video disc. It had features no one wanted and the price of a competing technology, videocassette recorders, declined rapidly. For these reasons and more, the intensity of the researchers, marketers, and managers who kept the CD alive seemed incongruous. At almost every turn, they confronted overwhelming indifference.

Because they didn't give up, they were the fathers of a product that entered worldwide markets even more explosively than the VCR had only a few years before. In 1982, Philips and Sony launched the CD player and five-inch (twelve-centimeter) digitally mastered discs (all made by PolyGram Records, which is controlled by Philips). There were only 20,000 CD players ready to be sold, about 300,000 discs, and only 150 music titles—almost all of them classical. Because classical music listeners tend to be more fastidious about sound quality than others, Jan Timmer, PolyGram's chief, aimed a disproportionate part of the first CDs at them.

Classical music, however, represented less than 5 percent of the music market. If Bach lovers didn't buy quickly, the whole project would be at risk. Furthermore, there was concern that the very people most likely to buy CDs, serious audiophiles, had the most to lose in existing equipment and music libraries.

Today such misgivings seem preposterous. Compact discs and players sold beyond the limits of Philips and its partners to produce them, and production raced against demand for the first three years of CDs' existence. At times, consumers seemed almost indifferent to what the music was; if it was on CD, they wanted to hear it.

The market outstripped all predictions. As Philips's and Sony's research, manufacturing, and marketing forces prepared to introduce the CD, they compared estimates of sales three years ahead. Philips's and PolyGram's conservative estimate was that in 1985 worldwide sales would be 10.6 million discs. Within one year, PolyGram revised their estimate to fifteen million and ventured that four million CD players might be sold in 1986. Sony's wildly optimistic estimate was that 1985 sales would hit twenty million. In fact, disc sales went from 59 million in 1985 to 136 million a year later, with predictions up to 800 million in annual sales by 1990. CD player sales—three million in 1985—reached nine million in 1986; Philips's prediction of nine million players sold in 1990 was surpassed in 1986. In the United Kingdom, sales of CDs jumped 55 percent from 1988 to 1989, and in 1991 an astonishing 333.3 million CDs were sold in the United States (a 16.34 percent increase from the previous year), and these figures include music discs only.



Actual Versus Predicted Sony CD Sales

The Proof Is in the Hearing

Numbers do not explain why CDs struck the market with such force. In CDs, consumers found a simplicity in handling recorded sound that they had never before encountered. To play this simple disc, one drops it into a tray and pushes one button. The player's solid-state electronics are almost infallible. The disc is the most durable sound carrier ever mass-produced, almost unscratchable and nearly impervious to enemies of vinyl LPs such as fingerprints and dust. On one side a CD contains 25 percent more sound than two sides of an LP. And the durability of the clear plastic "jewel box" package, conceived by PolyGram's Senior Director Hans Gout, contrasts favorably with the eventually dog-eared cardboard that surrounds LPs. CDs also have advantages over tape: They cannot stretch, flake, or flutter, nor are they in danger of being tangled or accidentally erased.

All of these external features are nothing compared to what CDs do for the human ear. The disc is a spiral of billions of micron-sized pits, which are read by a laser beam attached to a computer. At high volume on very sensitive equipment the familiar trace of "hiss" lingers, but it is only the sound of the laser machinery; nothing ever touches the music sealed within the disc.

Both Gout and Timmer scoffed at the idea of studying the market to see if people might like better sound from a noncontact technology. "People had to *hear* it," said Timmer. One of the first to do so was Herbert von Karajan, then conductor of the Berlin Philharmonic Orchestra and one of the world's most respected classical musicians. His advocacy of CDs was a keystone of the technology's swift emergence. His assessment of CDs' sound quality became a motto that Philips and PolyGram used as their calling card to the music industry: "After this," said Karajan, "all else is gaslight."

So shockingly crystal clear was the sound from even the first CD players and discs that it brought strangely resentful reviews from a handful of music critics. They represent what Timmer calls "high-end users," audiophiles who invest large sums of money in sound systems in order to hear music of fidelity as high as traditional recording technology can attain. "What CD did to hi-fi buffs was to take an illusion away," said Timmer. "They believed you could achieve spectacular sound only by buying spectacular equipment at spectacular expense. But with CDs, you take them home, you plug a simple machine into a mediocre sound system, and there's a miracle—absolutely marvelous sound!"

Eventually, many of those audiophiles followed the stampede to the CD, even as Philips began to look for new uses of digital disc technology—as a video carrier, as a data storage medium of colossal capacity, and in microcomputers serving both home and office with a host of interactive functions that combine sound and images with immediate access.

Optical Beginnings

The man who found the solution to the first successful CD was Lou Ottens, technical director of Philips's audio division in the 1970s. But, as Peter Kramer pointed out, calling Ottens a "technical director" was a misnomer. "He wasn't a technician," said Kramer. "He was a product man." Being a "product man" made all the difference. From the moment Kramer and his fellow scientists began working on optically readable discs in 1969, the disc was intended as a visual medium. The Philips product that came from that research was LaserVision, movies on a silver disc the size of an LP. Even as early as 1976, however, the prospects for LaserVision were beginning to sour. At least two Japanese companies, JVC and Matsushita, were working on a competitive format, as was Teldec in Germany; a video disc system was also emerging from the American giant RCA. But the real obstacle was the film industry. Though all the companies, including Philips, had signed up studios to provide movies on disc, the agreements were, in Timmer's words, "passive cooperation for a fee." No studio invested the sort of money that would prevent them from backing out if sales were weak. None made a commitment to video discs.

Despite this lack of enthusiasm, Lou Ottens, a veteran of the electronic product wars, became the man with the metaphor. Philips had been trapped by the word *optical.* The disc's most innovative aspect was the use of lasers to record and read visual images from a transparent, luminous medium. But Ottens said no, arguing that people had grown accustomed to the idea that images are stored on skinny strips of film or tape. To accept video discs, people would have to be taught to understand a new technology, to embrace a totally unfamiliar metaphor.

Ottens took the optical metaphor out of the lab, placed it in the perspective of the consumer, and said, "Since this thing looks like a phonograph record, why don't we make it into a phonograph record?" He had found the key to consumer acceptance of optical discs.

While LaserVision struggled in the marketplace and Philips was losing its battle with cautious suppliers, Ottens's audio team was refining the metaphor of a disc that could be heard but not seen. Ironically, now consumers are stuck on the audio metaphor while manufacturers are ready to take them into a new era of disc applications that will transform their lives with a variety of new applications—CD-ROM (read-only memory), CD-V (video), CD-I (interactive), and even CD-E (erasable). Philips has yet to hit upon the metaphor that will free the consumer's imagination. This is why the audio CD is only the first, overwhelmingly popular phase of a breakthrough still in progress.

It began in 1968 when Kees Wols, in charge of Philips's electronic educational products, approached Peter Kramer to propose a new medium that could combine still pictures, motion pictures, and sound, so that all parts of the program could be called up quickly. Kramer and his fellow researchers were drawn to the idea, rather innocently, by Wols. They were never really interested in a new "educational" medium. For almost twenty years, Philips's researchers had been wondering why the picture quality of home movies was so poor. Since the 1940s, they had experimented to improve amateur and commercial films that people could watch at home. Wols's interest combined with recent advances in technology to prod the researchers back to the problem.

Though Kramer realized that a disc would solve the problem of where to place the images, the research group went through several failed experiments before they hit upon making little holes—*dimples*—in a transparent material, then reading them as electronic signals. "If we used dimples, we were back to what you do with a phonograph record, and you can press them for mass production," he said. The group had quickly solved the conceptual problem, but they could envision the time and expense necessary for a working prototype of this transparent disc as well as a machine that would read dimples and show images.

Kramer told Wols that the idea would require a lot of work for only an educational product, but that this technology could evolve into a successful product. Kramer wasn't really sure what the product would be or whether consumers would want it; he was more interested in pursuing the problem than selling the solution. Convinced he had a potential consumer product stirring, Wols encouraged Kramer.

"It took two years to solve the problem of following the track and making those first records," said Kramer. In those days, the concept of turning analog signals—sound, words, pictures—into digital or numerical codes to be read by computer was still in its infancy. As a result, early video discs contained tightly packed, frequency-modulated signals with color information included. The complexities of fitting all the components—a transparent disc read with an optical sensor, controlled by photoresistor electronics and integrated circuits—were enormous and intriguing.

The research involved a steady stream of borrowed and unauthorized scientists from other Philips projects who would step in long enough to solve a conundrum and depart, but who then kept an eye on ensuing progress. "We got the good experts from all over the laboratory," said Kramer. "It relied more on enthusiasm of people than on the organization. It was a very friendly development."

One day in 1970, it was ready. "We made a disc, put all the electronics and optics around it, and tried to look at the signal/' said Kramer. "We saw nothing but noise. That was a big surprise. Why did we see only noise? We had the best incandescent lamp Philips made illuminating it and a very good detector. We got an even better detector and staged the same test...noise!"

What was wrong?

The researchers figured that an incandescent lamp, no matter how good, could not get enough photons through this small area—about a micron—to carry the signal to the sensor. They needed a brighter light source. The obvious choice was a laser, which Philips also made; the problem was the cost. The standard laser of the era was a helium-neon model that wholesaled for $5,000. Installing that in a home movie machine would make a consumer product for Donald Trump and the Aga Khan but not many other people. But Kramer went to Philips's laser people, got one of the $5,000 lasers, and put it into the optical disc prototype anyway.

This time the noise disappeared, and they had the image of a black-and-white checkerboard that shone clear and steady on the screen. As for the laser's expense, Kramer's team assumed that it was only a matter of time before Philips found a way to make a cheap one. While the group celebrated their success they faced an internal problem: proving that they deserved the time and staff to proceed with development of this invention into a product. Thus far what they had was a raw technology whose price, size, and complexity were immense and whose practical application had yet to be fathomed.

A demonstration in November 1971 greatly impressed Philips's Board of Management. "We showed them a black-and-white picture and said we'd have color in three or four months," said Kramer. That was wishful thinking, but the bold promise paid off. The Board upgraded the optical disc from experiment to product, engaged the product division, and added five technical experts to Kramer's team. "That was a lot," said Kramer. "We had color by March 1972."

The next fall, partly to show off but mainly to head off a parallel system that Teldec was developing, Kramer's group showed the prototype of the Philips system to the consumer electronics press. The move established Philips as the research leader in optical disc technology; no other company had a system as sophisticated as that developed in Kramer's laboratory. But as far as Philips had come, they were still six years from getting a product to market—and its failure. Pictures on disc remained the flawed metaphor that kept Philips going.

Adapting to an Existing Market

The Board of Management's decision brought into the project the vital imagination of Lou Ottens, who oversaw Philips's audio products. Official development plans included an affordable video disc player, a similarly affordable disc (for which they teamed up with MCA in the United States), and, at Ottens's insistence, an audio-only disc system. Kramer explained why Ottens pushed for a system with only sound when, with the same technology, Philips could give consumers both sound and pictures. "Mr. Ottens said video disc is a new market, but in audio, we have an existing market. We can add a lot of quality, and we have this beautiful small dimension!"

This idea of shrinking the disc for audio was another dramatic metaphor that lay right before the inventors' eyes. The logical idea was to make the new optical discs the same size as LPs: twelve inches in diameter. This was done with LaserVision and with the discs devised by Philips's main competitors in that area, RCA and JVC. Sony applied the same assumption to their audio disc development. When Philips and Sony joined in 1979 to develop a standard for optical audio discs, Sony had only recently decided to reduce their audio disc to a diameter smaller than a 45 rpm single. And it was seeing Philips's CD that awakened Sony to the virtues of thinking small. Why didn't a Japanese company—especially one with a reputation for small televisions, tiny radios, and miniature tape recorders—think of making discs smaller too? "What seems obvious today," said Francois Dierckx, product manager for Philips's CD audio player development, "wasn't so obvious then." It was logical to shrink the audio disc because recording sound requires fewer dimples than sound plus pictures. But the standard of long-playing records had been twelve inches (30 cm) since they appeared in 1953; reducing that size risked consumer skepticism.

Ottens and the group, however, saw many advantages in the much smaller disc and foresaw delight overcoming doubt for a record buyer who could buy a record smaller than a single but that offered clearer sound than the best LP. The small, high-quality products from Japan had convinced Western consumers that smaller is better. They were ready for CDs.

For two years the audio and video disc developments advanced side-by-side, with video receiving the company's greater attention. But in 1976, Ottens learned that an optical audio player using digital technology (which would sound better than even the best available AM and FM techniques) could be sold for less than $200, the threshold he had set for commercial viability. This was a breakthrough that Ottens had longed for, the last piece of the intricate puzzle. Philips' engineers set about incorporating digital encoding into a disc machine that was now advanced to the prototype stage.

When the prototype appeared before Ottens, it was about the size and shape of an old television set—the kind with vacuum tubes and rabbit ears. He hated it. "It was too big," said Dierckx. "He refused to accept it. He said it could and *must be* smaller—it must have the size and convenience of a cassette player." The Philips team began downsizing the audio player and introducing digital coding, conquering the technical details as they had steadily and methodically done from the beginning.

Meanwhile, Philips entered the consumer optical disc market with LaserVision in 1978. A laser in a box read twelve-inch optical discs, on which visual images were encoded by FM signals—Philips's best optical disc technology was still analog, not digital—and electronically transformed them into vivid moving pictures on a television screen. According to all their promotional assertions, Philips had brought home entertainment into a new era.

Yet there was trouble. Philips's collaboration with its software supplier, MCA, had been tense at best. Other suppliers remained hesitant about the new technology's prospects. Movie companies almost unanimously agreed that home cinema might destroy their richest market, consumers who go to movie theaters. Meanwhile, two other manufacturers were preparing to enter the market: In 1980 RCA in the United States introduced SelectaVision. JVC, with support from Matsushita, showed VHD video discs in Japan the next year. Of the three, VHD had the most success, though it was hardly spectacular.

RCA and JVC also experienced hesitancy from software suppliers and the distraction of developing yet another medium, videocassette recorders. VCRs were developed separately by Philips, RCA, Sony, JVC, Matsushita, and several other companies. The battle for dominance was bitter and destructive. JVC's Video Home System (VHS) won out because its strategy for luring other companies to its format was better than anyone else's, but even JVC lost something in the struggle. By the time JVC introduced the VHD video disc system, the VHS VCR had already taken hold as an international home video standard. All other systems eventually fell before it—including Philips's long-awaited LaserVision.

However, while VCRs cooled the electronics industry's enthusiasm for video discs, the interest in audio discs—especially with the new potential for digital coding—was heating up. Philips had a prototype, but it was no longer alone in the competition. After a year's hiatus, when it lost faith in laser-disc technology, Sony was back to work. If Sony had made the connection between digital coding and optical discs, Philips would have to struggle to retain their technological lead.

Selling International Standards

Ottens understood, perhaps better than anyone else at Philips, the importance of *standards* in consumer electronics. If ten companies invent a new technology and introduce prototypes that appear identical, all ten versions can still be totally incompatible in a host of technical details. If the ten inventors do not resolve those differences, then the market—first manufacturers, then consumers—makes the choice. When the market chooses among ten, there are nine losers and one winner. Sometimes there is no winner at all.

Ottens had overcome that danger in the 1960s when Philips invented the audiocassette, now present in billions of units and the preferred medium for nonprofessional recording. Ottens avoided a race to produce a dominant format by boldly proposing that other manufacturers have license rights to Philips's cassette at no charge, no royalty. Given the opportunity to forego the expense of continued research and development and the difficulty of catching up to Philips, other companies eagerly accepted. Philips's cassette worked as well as anybody's ever would, so the race was canceled.

The lack of an agreed-upon standard for VCRs produced a lengthy and expensive battle. It was clear to Ottens that a standard was necessary for what Philips was now calling compact disc. But as only a division head, he had no power to bring Philips into an arena that was really more political than technological.

Enter Cornelius Van der Klugt.

Van der Klugt had been promoted to Philips's Board of Management in 1978. One of the first things handed to him was a list of products in advanced development, among them the CD. He felt the prototype was a wonderful device—with problems.

One problem was size. The actual disc player and disc were smaller than a shoe box, but they were accompanied by a cubic meter of electronics. Van der Klugt agreed with the Philips development team that in time that could become a cubic centimeter—as it did four years later.

Van der Klugt, like Ottens, saw Philips losing a competition with Japanese companies unless there was a standard for compact audio discs. By 1978, the phenomenon that

Van der Klugt called "the Japanese hurricane" was blowing full force. The hurricane had driven every major American company out of the electronics portion of the hi-fi audio business, and Japanese companies controlled more than 90 percent of the hi-fi audio business worldwide. Except for a stronghold that Philips maintained in Europe, when the rest of the world wanted a stereo, a radio, a tape recorder, or a boom box, it went to Japan. In the face of that staggering Japanese dominance, both in market and quality, Philips might win the race to the market, might have the best CD technology in the world, but could still lose to a lesser Japanese technology, because the world would refuse to believe that a hi-fi audio breakthrough was possible anywhere but Tokyo.

Van der Klugt's first priority was the same as Ottens's: a standard! That standard must come even before the research was finished, before a prototype, before a marketing plan. And Van der Klugt, unlike Ottens, had the power to launch the offensive for standardization.

It was as simple and as complicated as a political campaign. Van der Klugt began the campaign inside Philips, working to convince them that digital-optical audio-disc technology was unlike anything else Philips had ever done and unlike anything the market had ever seen. He sold his colleagues on the promise of introducing an entirely new system into the established audio market, and he warned them of the dangers. His object was to get them excited, to make them believe, as he and Ottens did, that the eventual rewards were worth the risk.

Van der Klugt had a special advantage. As the new guy on the Board of Management, he held no chips. He was gambling without encumbrances, but he did have friends throughout Philips. "I asked them how we should go about things," he said. "Philips is not bound by hierarchy. It's easy to have a frank, open conversation with your friends. We concluded that to market this product successfully, we would have to change our philosophy. We were not talking about a new product; we were talking about a system. It was not competing with any existing technology. You would not just have to convince your competitors to make this type of machine; you would also have to convince record companies to use it. This was a totally different challenge than we'd ever faced—to prepare, realize, and introduce a totally new system in which many independent components had to get together." It was the sort of vision upon which empires are built—not only for corporations but for the individuals who launch the initiative.

A Catalog of Problems

The first stage of Van der Klugt's campaign was to identify the team that would carry the cause inside Philips while he campaigned in the industry. The team included Joop van Tilburg, who took over the audio division, as well as Ottens, Dierckx, and Gaston Bastiaens, who forced Philips' sluggish manufacturing capacity up to a pace that had been unthinkable in any nation but Japan. On the software side were Jan Timmer, assigned the presidency of PolyGram specifically to drag the record industry into the new world of CDs, and Hans Gout, Timmer's marketing genius.

With his team, Van der Klugt assembled a catalog of the problems Philips must solve and a clear perception of how consumers would respond to a whole system designed to make their expensive collections of records and tapes obsolete.

- CD technology will be a new system, and must be introduced as a system, with both hardware and software in place.

- The CD must be launched in a market—United States or Japan—where Philips is weak, not in Europe—because the high price, at first, will not make it an appealing product to the generally middle-class, price-conscious European market.
- CDs will be for an elite consumer for at least several years, because the majority of consumers willing to pay a premium price for high quality in sound have been classical music listeners.
- Philips's CD technology must have a large and growing partnership with the software industry—but who would agree to make the records? And could record makers adopt the new and demanding technologies that go into the manufacture of optical discs?

Van der Klugt said that above all it was important for Philips's people to stop thinking like inventors and start thinking like consumers. All consumers wanted was something smooth on the outside, unbreakable, and interchangeable with other similar machines. It had to have the personality of a television. "Imagine," said Van der Klugt. "The manufacturer goes to the dealer and says, 'This is what you have to buy.' The dealer offers it to the public, who says, 'Who else makes it? Is there a price difference? Can I have a simple one? A complicated one? Does it play records? What kind of music is there? What choice is there?' We decided that everybody in the audio industry should be able to make this player—otherwise, incompatibility would kill it. This was a hard decision for Philips because, even with the free licensing we did with audiocassettes, we had never before launched a system with components that we didn't have under our control."

Except for his friends, Van der Klugt had few allies in Philips. Hi-fi, a mature market that depended on old technologies, in the late 1970s was entering its worst crisis in history. Few market experts at Philips or elsewhere had hope for its revival. "We had to make a fundamental decision," he said. "Do we believe in the potential of the hi-fi market? In those days very few people did. There was a general feeling that people were going video, that there was no future for a dramatic step ahead just for audio. You have to counter that feeling with solid arguments. But in the preparatory stages of a new product, there are no solid arguments. You have to go by opinions."

Jan Timmer, who encountered even stiffer resistance when he led the record industry into adopting CDs, echoed that dependence on intuition. He didn't really know that people would want CDs until he saw them fall in love with the very first sounds they heard. "No market research could have given us that information," he said. "Our business is about emotions—how excited people get about what they see and hear. People are always astonished that such a major thing was done based not on research but intuition and gut feel. But all you have at the start is gut feel!"

Feeding the Dragon

Whether with power or charm, Van der Klugt pushed Philips away from its fear of market death and undertook the next phase of his campaign to make the CD a world product and a world standard. The next phase was to sign up a Japanese partner.

"We were going out to tackle a giant," said Van der Klugt. "Japan had over 90 percent of the marketplace and were known as having top quality products. We thought we should not only be in that market, but help them get stronger. Many people shook their heads and said, 'You must be crazy! How could you feed the dragon?' But we saw there was no other way. Either we sell the patents—lock, stock, and barrel—to Japan, or we would fail. Because the public must be able to choose."

The question of which Japanese company Philips should choose was not difficult. Matsushita, the biggest, most powerful company in consumer electronics, was tied to its subsidiary, JVC, and to JVC's disc technologies, VHD in video and AHD (audio high definition) in audio. Van der Klugt's preference was Sony, because of its reputation for quality and marketing muscle, and because of his friendship—or friendly rivalry—with Sony Chairman Akio Morita. Van der Klugt knew that Morita, once he became convinced of the potential for a new product, tended to become obsessive, and he wanted that obsession on his side. He also knew that he dared not show his hand to Morita; if he indicated in any way that Philips needed Sony as much as Sony needed Philips, he would be operating at a disadvantage from the beginning.

Van der Klugt knew from the outset exactly what Sony could provide. Besides the Sony name and Morita's enthusiasm, Sony was strong in digital encoding, in particular, digital error correction, which would become a key to the purity of CD sound. The rest of the technology—the electronics and optics, even the idea of making the disc smaller than a single—all was developed at Philips. For once, a European company had a dramatic technical advantage over a Japanese competitor, and Van der Klugt didn't want to surrender that edge through a tactical misstep.

Calling Morita on the telephone would be just such a mistake. So Van der Klugt did a little Zen-like politicking. He called on Morita by *not* calling on him. "We organized a chance meeting with Morita. He didn't know that we had decided to approach Sony and that I should be the one to talk to him. But if I made a direct overture and asked for something, I would lose my bargaining advantage. The moment I showed that I needed something, it would cost money. So we were not going to show we needed anything.

"In those days, Morita had the habit of dropping in on our managers in New York, London, Paris, Milan. So I said, 'Anyone who hears that Morita's coming, tell me, and I'll be there to have a cup of coffee, by chance, in your office.' One Friday morning, my New York manager called and said, 'Are you ready? Morita's coming on Monday.' So I flew to New York, and I was sitting there on Monday when Morita walked into the room. We had an almost instant contact, because he said, 'I'm tired. I just flew in from Brazil'

"So I said, 'What were you doing in Brazil?'

"He said, T visited our plant there and played golf with a very good friend at the Sao Paulo Golf Club, of which I am a member.'

"And I said, 'That must have been Manubu Mabe.' You see, Manubu Mabe is one of the most famous of the 400,000 *Nisei* (foreign-born Japanese) in Brazil and one of the most famous painters in Latin America. There is only one Japanese I know of in Brazil who plays golf and is also famous—and unless he's famous, Morita wouldn't even look at him—so I guessed right, and Morita fell off his chair discovering that I knew who Manubu Mabe was!"

Van der Klugt thus cordially sidestepped the obligatory sparring match with the Sony chairman and broke the ice for discussions of CD standardization. Further meetings followed, but the first had been the key, because it was now possible for Philips to send a technical delegation to

Japan to present their technology and to seek a partner without arriving in a posture of weakness.

That delegation demonstrated their player—still laden with an enormous collection of transistors, resistors, hand-wired circuits, and lots of wire—to both Sony and Matsushita. Both companies showed fascination but made no commitment—yet. However, Van der Klugt's courtship was working, and Sony's commitment was only a matter of time.

Sony joined forces in 1979, several months after Philips had made another preemptive strike on the market by unveiling its CD audio system to the international press in a classic display of showmanship. Atop the display table, on a white tablecloth, was a box that looked very much like a cassette player. Into that box Philips's demonstrators slipped a silvery compact optical disc. Beneath the tablecloth, carefully adjusted before anyone had arrived, was that old cubic meter of electronics. Marino Carrasso, who headed the negotiations with Sony, explained that such "deception" is common practice. "We do that to all the electronics that we are integrating and making smaller. We want to show our commercial people how small it can be, so we simply put everything that will eventually be integrated below the table."

Technical Difficulties and Secrets Shared

Once Philips and Sony decided to join in developing a standard for CDs, the propagation of that standard remained in doubt for another year, because of the creation in Japan of a powerful group called the Digital Audio Disc (DAD) Committee, a subcommittee of the government's ruling body on issues of international trade, the Ministry of International Trade and Industry (MITI). Any standard

MITI set in the audio industry would probably end discussion.

Theoretically, the race included ten Japanese companies, plus Philips and Telefunken. In fact, the real competition pitted Philips/Sony against JVC, a respected company with a reputation for very high quality in consumer electronics. JVC's engineers had attained higher information density (more dimples) on their AHD disc than Philips/Sony, and the result, in the view of many industry experts, was slightly better sound quality. Also, JVC's special relationship with mighty Matsushita, and Matsushita's unparalleled market power, never did JVC any harm.

Because JVC was such a serious rival, Sony and Philips were under pressure before a pivotal DAD demonstration in May 1980 to make tremendous strides toward a standard in less than a year. The two companies' standardization meetings usually involved eight or nine engineers from each. Whenever the two teams met, topics such as "bit error," "medium pit size," "sampling frequency," "pit shape precision," and "jitter" filled conference rooms, in Dutch and Japanese, for hours and days. Because of the degree of detail demanded, each engineer focused exclusively on the appropriate specialty.

The work of the engineers throughout this period was extraordinarily open and intense. Both companies shared all their technical information, opening up what had been company secrets to full inspection by the competition. It was agreed that all patents associated with the joint standard would include the names of inventors from both companies. Once they had each others' designs, each built and tested the others' technology. "Sony would have a proposal, we would have a proposal," said Marino Carrasso.

"We each investigated the others' proposal and compared measurements."

Among the key issues settled was the decision to increase the power load of the machine from Philips's preference for fourteen bits to Sony's sixteen bits. The increase would retain for both companies the option of combining images with sound on discs. Another issue that Sony won was the increase in the diameter of the disc from 11.5 to 12 cm. This increased the playing time from about one hour, equivalent to one LP, to 75 minutes. The reason for that change was, according to legend, the fondness of Sony Vice President Norio Ohga for Beethoven's Ninth Symphony, which runs at its slowest version by Karajan approximately 74 minutes.

In order to get a precious standard, Philips shared technical leadership in a number of areas to which, if left to their own devices, Sony would have been hard pressed to catch up; some issues remained unresolved. "What was not standardized," said Carrasso, "were things that were not important to a standard: How do you solve the optical box? How do you connect the servo (motor) system? On the other hand, considerable know-how was shared with Sony, because you have to know what's possible and what others can do. At that time we were more advanced than Sony in the player servo system, so we had to share it to a certain extent, because we said this information density was possible and they doubted us." Separately, the two companies might have worked for years more to design a system that approached the sophistication of the one they designed together. The modulation system (now standard) began with Philips the leader but ended, according to Carrasso, a fifty-fifty split.

The work of the engineers was not complete when MITI convened the crucial meeting of the DAD Committee in May 1980. But the demonstration that they gave was strong enough to swing the committee in favor of CD over JVC's AHD. It was a moment of quiet triumph for Sony. A few years before, MITI had staged a similar comparison between the two VCR formats, Sony's Betamax and JVC's VHS, and MITI had stepped out of the disagreement without a judgment, foiling a Sony strategy to preempt the JVC technology. That had left the market to decide the winner and to create its own standard. The market's decision, in that case, was VHS.

Convincing Record Makers

While the Philips/Sony standards group pressed on with its work, Van der Klugt contemplated the next phase of introducing this new system. If Philips could not get record companies to put music on discs, there would be nothing to play and CD would become an obscure acronym. Convincing four of the world's five biggest record companies—CBS, Warner (WEA), RCA, and EMI—to join up seemed almost impossible. The record industry, not naturally inclined to change its ways, was even less inclined to do so in the beginning of the 1980s. In those days, it was an industry in disarray.

Into this breach, in September 1981, Van der Klugt threw Jan Timmer, who found himself suddenly but gladly elevated to the presidency of PolyGram, the world's fourth-largest record company and the world leader in classical music repertoire. He arrived after the enterprise had already begun. In January 1981, PolyGram's board of directors had agreed to support Philips's development of CD hardware by renovating a section of the original Deutsche Grammophon record factory in Hanover, West Germany, at a cost of $35 million. Under the leadership of technical chief Hermann Franz, that project was given only 500 days for completion—from investment to the production of the first disc.

This meant that Franz had to do more than just fix up a factory. He and his engineers had to invent a way to make a disc that, until then, had been made only one at a time in a laboratory. They had to create manufacturing conditions that were entirely free of dust and static electricity, conditions that had been reserved for the manufacture of sensitive electronics. They had to experiment with plastics they had never used before, because the old vinyl (polyvinyl chloride) was not good for CDs. And they had to meet a production quota of 500,000 discs by January 1983.

If anyone had an even tougher job, it was Jan Timmer. While Franz struggled with materials and machines, Timmer had to cope with people. It was his job to convince people first at PolyGram, then in other companies in the music industry, that CDs were worth the investment of millions of dollars. And he was behind schedule. Franz had started work in January 1981; Timmer wasn't at PolyGram until September. "By the end of 1981, the technical preparations were certainly far ahead of the marketing preparations. I started an internal program in PolyGram, telling everyone that this is the future," he said. "I didn't tell them we had to do it because the shareholders had given us a lot of money to build a factory." I said, 'We need it. It's good for us.' "

Timmer began an even more concerted effort to win converts among other record companies. "The rest of the industry was very skeptical of this technology, and they were waiting passively on the sidelines," he said. In fact, that skepticism amounted to open hostility on the part of many people in the industry. They were going through hard times, and here was PolyGram, the next-to-smallest record company in the big five, telling them their records and tapes were going to obsolete and that they had to build new factories. Resistance was obvious at an annual meeting of the music industry sponsored by *Billboard* magazine in May 1982: "Before we demonstrated the CD, we thought we had a very good story. We thought they would applaud," said Timmer. "But they shot us down."

Many individuals told Timmer that CD technology seemed to be a very promising development, but a few quiet assurances didn't help much in the face of solid opposition from the leading companies who made the records and controlled the rights to the artists who made the music. They were not joining up. "They were not," said Timmer, "enthusiastic."

Sales in 1978 were excellent. "By 1979, that industry was in the doldrums," said Van der Klugt. "There was no new musical trend visible. Profits were going down, and in some cases turning into losses. Then here comes the hardware industry talking about technology! Well they don't care about technology. Their priority is intellectual property—composers, musicians, trends, songs. They're not interested in a new sound carrier. Their industry is antiquated; nothing technologically revolutionary has happened in their industry for seventy years." The almost unanimous resistance of the record industry threatened to become organized several months before Philips's and Sony's 1982 product launch.

Averting a Conspiracy

One morning Van der Klugt received a nervous call from Akio Morita. Through Walter Yernikoff, president of CBS Records (who manufacture records in Japan through a joint venture with Sony) Morita had got wind of a meeting, scheduled for the next week in New York, of leaders of all the major U.S. record companies. The key to this meeting was not whether the companies discussed CD technology, but whether they met and *didn't* discuss it. Morita, with huge sums of money invested, was concerned about the danger of a freeze-out, an unstated resolve among record companies to let this troublesome and costly new technology die of neglect.

For companies who control more than three-fourths of the industry to meet and openly agree to oppose any involvement in CD technology would have amounted to a boycott that might have violated U.S. antitrust laws. But there were ways for companies to get together, talk amiably of many things, and emerge with a united front—even though they had never said anything directly about concerted action. Morita expressed his anxiety that this might happen.

The central issue was a royalty that Philips and Sony were demanding as a license fee for the right to make and sell discs. It amounted to only three cents per disc, on discs whose initial retail prices often exceeded $20, but if millions were sold every year, that three cents would represent a king's ransom for both Philips and Sony, as well as a considerable annoyance to record companies.

Morita proposed to tell the companies that the patent holders would drop the demand for the royalty, that they would give a free license to the record industry. He said that he was preparing to dispatch Norio Ohga to New York to meet with the record company moguls and renounce Sony's interest in royalties. He asked Van der Klugt to do the same.

Van der Klugt recalled the unnerving conversation. "If you don't do this/ he told me, 'everybody will stop preparing and the product is dead; we'll publish in the newspapers that you killed your own product.' Well, that's quite something to hear just before going to a golf match on Sunday morning."

Van der Klugt responded by telling Morita to delay twenty-four hours. Morita grudgingly agreed to hold Ohga back until he had heard again from Van der Klugt. Van der Klugt began calling other people within his organization. He never got to the golf course, but "after six hours," he said, "we had a solution."

"I phoned Morita and said, 'Don't go to New York. Don't meddle in that business. Leave it to us.' " Morita, protesting mildly against Van der Klugt's vague assurances that he had things under control, nevertheless hung up the phone—but only long enough to call Van der Klugt's boss, Philips's CEO Wisse Dekker. Dekker phoned Van der Klugt immediately and asked what Van der Klugt was going to do against the apparent stone wall being erected by the record industry. Van der Klugt's reply was the sort of defiance that could only occur between two people who had "grown up together."

"I said, 'If I tell you what is happening, then you decide; from then on, this is your baby,' " Van der Klugt recalled. " 'Either that, or I don't tell you, and I decide. If you want to take over the decisions, put down the telephone and you fix it. But I wouldn't do it if I were you—it's too dangerous.' " Dekker's reply was immediate. He told Van der Klugt to go ahead, then he hung up, and waited for the drama to unfold.

Van der Klugt called Morita back, told him he had Dekker's support, and, still without revealing his plan, extracted an agreement for Sony to go ahead and renounce the royalty. Morita, still concerned about the power of the record companies and mystified about the strategy, agreed—leaving Philips as the sole recipient of patent royalties on CDs.

Van der Klugt recalled, "He asked what I was going to do; I said I'd call him back. I didn't tell him then because I had to make my play in such a way that he would call his crony Yetnikoff. They would know what we were going to do and that would head off the American companies, but just in time, so they couldn't take any other measures. Morita is nine hours ahead, and Yetnikoff is nine hours behind; I was sitting in the middle, playing the chronometer."

Van der Klugt's strategy was risky but necessary. He wanted both Morita and Yetnikoff to believe that whatever they did, Philips still held an unknown, unbeatable trump card. After all the preparatory calls had been made and all the concerned parties were aware that Van der Klugt had something up his sleeve, he revealed his strategy to Morita. It was, in fact, a simple game known as "hardball," and its effectiveness was infallible.

Van der Klugt told Morita, "PolyGram will join the meeting of the record makers. They will bring along two lawyers. Anyone who suggests a boycott can be subpoenaed. He will be under arrest as soon as he steps out of the hall because in the United States for industries to pronounce a boycott is a criminal act." Van der Klugt triumphed in this battle of wits because he timed it perfectly, at the last minute, so that no one else had time to contemplate an effective countermove and because he did it with such unshakable confidence. Whatever threat might have lain in the New York meeting was defused, the record companies' united resistance was broken, and the "every-man-for-himself" policy that had prevailed before was restored.

General acceptance came with painful slowness. If Timmer and Gout had had to wait for the record companies on their own initiative to join with Poly Gram, they would have failed. Their ace in the hole was the magic of sound.

The Critics Convinced

In a meticulous and thorough plan that he had written in 1981, Gout focused the marketing of CDs on listeners. His program was a series of demonstrations in living-room settings that would show people how, under normal conditions, the sound of music soars to unimagined heights on the CD. The inspiration for this strategy had occurred at the 1981 Salzburg Easter Music Festival.

One of the first musicians to hear his own music on CD was one of PolyGram's stars, Herbert von Karajan. Karajan, transfixed by the clarity of what he heard, embraced CD technology with enthusiasm. "Why? Because he's a technology freak!" said Van der Klugt. "Karajan is an absolute master at grabbing everything in technology that will help his art. So he goes for an electric piano, for amplified sound—as long as what comes out enhances his art. He was convinced immediately by laser disc because it gave such good digital sound."

Karajan's part in the drama occurred at the Salzburg Festival, an intensive week of music in which Wednesday is reserved for the classical music critics of the world to rest and mix with musicians. That year, however, Karajan canceled the day of rest. "To convince the critics," said Van der Klugt, "he ordered them to the theater and demonstrated CD all day. He let them hear what it is like."

Karajan's act was a turning point for the CD. It convinced many critics that CD sound had extraordinary clarity, even at levels of amplification that would fill a concert hall. And it told them that musicians would be part of the lobby that was going to push the record industry toward CDs. It also showed Gout where to go with his marketing plan, which went on an extended road show to audio fairs from Dusseldorf to Chicago to Tokyo. There, passersby both from the industry and the public not only heard how much better music can sound, but they saw a flashy little disc in a shiny plastic box. People had to be taught how to open the box, to be encouraged to touch the surface of the record. "People had to see the product," said Timmer, "how it was packaged, the crystal clear sound, the absence of any scratches or anything. It had a lot of sex appeal. People got excited!"

Unexpected Demand

As more and more artists, from Luciano Pavarotti to Mick Jagger, began to demand that their music be recorded on CD, and as public excitement built, the Hanover CD plant made its deadline, largely, said Gout, because the record makers there were more obsessed with sound quality and more technologically astute than most record makers. They didn't resist the new knowledge; they solved frightening problems, including the flatness of the disc, the new plastics required, the discovery that fingerprints on a disc confused the laser. By June 1982, perfect discs were rolling off the production line.

All of those discs (300,000 by autumn, with a small but serviceable repertoire of 150 mostly classical titles) went to Japan for the CD unveiling at the Tokyo Audio Fair. Philips was also producing CD players in Belgium, but those stayed mainly in Europe in anticipation of the second launch, in Holland, in the spring.

Thirty-seven companies, mostly in Japan, had already signed up with Philips and Sony to build CD players, but only ten companies had signed licenses to manufacture discs. For the next year, the only places CDs were made were in that overtaxed plant in Hanover and at CBS/Sony in Japan.

Meanwhile, Timmer watched in amazement as the CD was embraced not only by classical music listeners but by rock 'n' roll fans and even by diehard jazz collectors. "We underestimated the popular music audience," said Gout. "Apart from a small group of classical music lovers, we didn't know about the thirty- to sixty-year-olds who started to come back into record shops—where they hadn't been for years—to replace those beloved old jazz records that were too scratched and worn."

All this popularity frightened Timmer, because he knew Philips and the whole record industry were depending on PolyGram's plant to get them through the supply crunch that followed successful product launches in Japan, Europe, and the United States. Nobody else would build disc-making facilities until they were sure people would buy discs. "This all happened when the industry was in the worst period it had ever experienced," said Timmer. "It's good management theory to invest in new facilities when times are bad, to be ready for the upturn. But nobody really does that—it's against human nature to start spending on an unproven technology when your bottom line is under stress. That's what we did, of course, but the others didn't follow us very quickly. So we just made it with CDs. If we had aroused all that interest and disappointed consumers who couldn't find the discs they wanted, we would have had a serious problem with general acceptance of the CD format."

In fact, Timmer had to fight to keep Japanese player manufacturers on schedule with the phased introductions in Japan first and the United States last—the United States was everybody's biggest market. "We kept holding them back," he said, "cautioning against a too-early introduction in the States—if we can't keep pace with the supply of hardware, we told them, you'll ruin the image of the system. You'll endanger the launch if you fill the shops with hardware and people cannot find, right next to it, the software they need to play on the machine."

By late 1983 the numbers were already gratifying. Even with a repertoire of less than 1,000 titles, the growth astounded everyone at Philips and throughout the music industry. At that point Philips's leaders might have leaned back and contemplated the skill with which they managed the greatest hi-fi innovation in thirty years. Like many others involved in breakthroughs, Philips's people have taken a distinctly humble view of their success.

"We stumbled into the process. At every turn we had a champion who took over the next role," said Dierckx. "But we never knew in advance who it would be. We were lucky. We never understood how we did it." As each new crisis materialized in Philips's empire, a fresh guide emerged to shepherd the project through it.

Breaking Tradition

Philips's next crisis developed in Belgium. The production of CD players in the first year of full operation surpassed predictions several times. First-generation CD players were not the problem. In 1983, Gaston Bastiaens visited Japan and realized that Japanese makers were already eighteen months ahead of Philips in the development of new types of lasers, lenses, servos, and integrated circuits;

that is, new machines, better and cheaper, to replace the old ones.

Bastiaens calculated that within three years, a Japanese CD player that cost 800 Dutch guilders on the day the product was introduced would cost only 250 guilders, and it would be a much better machine. At the current rate of development, he estimated that it would take Philips five years to reach that price level. By then the market would have fled Philips for Japan, and Philips would be a minor player in an industry that it had created. Bastiaens returned to Philips and, as he put it, "rang the fire alarm."

Bastiaens's solution was to break tradition at Philips, to end the company's informal sharing of knowledge and do it in a formal, "military, Japanese" style. He convened a meeting of ninety people from throughout the company—engineers, product designers, manufacturing experts—and told them to think of ways of doing things better, faster, and cheaper. The meeting, which surprised almost everyone, evolved into a kind of epic brainstorming. Based on technical specialties, small groups broke off and began discussing the restructuring of the subassemblies within CD players—without adding size or substantial cost.

Having rallied the troops, Bastiaens next lobbied the Board of Management for the money he would need to fund constant product innovation and the streamlining of production facilities. Fear of Japan was the velvet hammer he took to his meeting with the Board. He got his money, with an order: Report on progress every three months. He reversed the order and applied it to his plant and laboratories: Any ideas that were implemented had to be carried out exactly according to plan even if someone thought of a better way in the meantime. Regulating the flow of creativity caused it to increase.

"Once we made a consolidation, in a very military way we stuck to the plan," said Bastiaens. "A lot of innovative people got frustrated because they'd think of something and we'd say, 'Hands off.' After three months, we'd adapt the plan and let them add the idea. But we went step by step to reach the goal. These were hard times; we were trying to increase our output seven times in a year."

An example of this intensive, phased approach to shrinking and improving the product was the *light pen,* the laser that read the dimples on a disc. In 1983, that light pen had 17 components and cost 100 guilders to build. Four years later, the light pen had 6 components and cost 25 guilders. The number of components in a basic Philips CD player was reduced from 850 to 250 during that time. In 1986, three years after Philips's lowest-priced CD player cost 800 guilders, Bastiaens had one for less than 250 guilders. Japan was on schedule with cost reductions, too; they reached Bastiaens's predicted goal of 250 guilders by 1987. For once, Philips hadn't just kept pace, they had led the way.

The difference for Philips because of Bastiaens's "iron rule" shows in figures released in 1986, when worldwide sales of CD players reached $1 billion: The three top producers each earned a fifth of that total. They were Sony, Matsushita, and Philips. Had Bastiaens not realized that Philips had fallen behind Japan even before they had finished introducing their product, and had he not begun his Herculean catch-up effort, Philips would have almost certainly been listed among "others" on that 1986 market report.

A Favorable Echo

Because of the breakneck pace of product refinement and cost-cutting, however, no one among CD manufacturers can afford to be content. CDs have become the standard in music; the focus now is to expand their use in other applications, such as CD-ROM. Compact disc read-only memory is an excellent medium for computer storage; the space available on one single-sided, five-inch CD-ROM disc can hold 250,000 pages of text, or more than 7,000 pictures or graphics, or more than an hour of video. The entire telephone directory of most nations can be stored on one disc. The disadvantage of CD-ROM is, of course, its "read-only" stipulation—users cannot add or change information on the disc—yet they can interact with that information in a variety of ways.

This disadvantage has not halted a torrent of offerings of CD-ROMs. Books from the Bible to the *Oxford English Dictionary are* available on CD, as are vast amounts of data that would otherwise occupy stacks of computer discs. These technological breakthroughs are changing scholarship and education, from kindergarten to college. With a CD player, a Shakespearean scholar can quickly see how many times, and where, a particular word occurs in all of the Bard's writings; a six-year-old can type in t-i-g-e-r then watch a color video of a Bengal tiger stalking its prey, see a colorful map of tiger habitats, and listen to an expert talk about efforts being made to prevent their extinction. Other nonacademic applications include multimedia instructions for amateur photographers or armchair visits to far-off countries.

Apple Computer has introduced a personal computer that comes equipped with a CD-ROM player, and photo processing centers in the United States will soon offer customers the chance to have their pictures put on a CD. Family photos can then be inflicted on friends and relatives from the television set or a computer monitor where, to heighten the experience, the photos can be cropped or otherwise altered.

Van der Klugt is a realist. Though determined to carry Philips forward into the full-flower of CD technology, he is realistic about the variations on CDs that will prosper. "The marketplace will decide," he said. "We can add features, but we don't know their value to consumers, or how much consumers will pay for them. What we do know is that CD technology has had a fertile beginning. The system is no longer a mystery. The echo is favorable."

16

MESSAGE TO MANAGERS

Creativity is an elusive quarry, even for those who can afford to fund a big hunting party. Nonetheless, in exploring fourteen of the most significant commercial breakthroughs of the past twenty years, creativity appears to be hardier and more prevalent than most people imagine. The evidence of these breakthroughs is that new, extraordinary ideas can emerge from any environment. In this series of stories, breakthroughs have been found that grew from rich soil, but also from barren soil, rocky soil, or no soil at all. Breakthroughs have come from organizations that foster creativity as well as those with poor records of innovation—from creative teams that were joined by their management, ignored by their management, supported only belatedly by their management, misunderstood by their management, and castigated by their management. Breakthroughs can emerge just as readily from no organization at all.

As a manager or as an organization, you can experience a creative breakthrough whether you deserve it or not. The reason for this is that breakthroughs are children not of the milieu but of the mind. A breakthrough, because it is something new, something unheard of, transcends the culture and the environment from which it springs. A breakthrough is so often unrelated to its surroundings because it comes first from an independent individual and then from a group of people who have been changed, torn from their surroundings, by that individual. Breakthroughs are not organizational creations, although they may be catalyzed or inhibited by organizations, and once successful they are eagerly claimed by organizations. They are more like works of art than works of commerce. Teams of people who accomplish breakthroughs behave more like disciples emerging from the tutelage of a great visionary than like the graduates of a prestigious management curriculum.

Disciples of a great visionary? Breakthroughs that aren't organizational creations? These sentences almost suggest that there is no hope for managers who want to encourage breakthroughs in their organization. That, fortunately, is not true. What follows is a discussion of how to set up the best possible environment for a breakthrough and how to nurture one if it comes along.

Organizations, through good personnel practices and some fairly traditional incentives, can foster research and development that is genuinely innovative. Managers who do this, however, must first get past a very well-entrenched set of myths.

Myths and Realities About Breakthroughs

In the preceding discussions and in the literature alike, a confusion exists between the origins of a breakthrough and its process. People have often hurried to state a how-to formula before understanding exactly how a breakthrough occurred. Commentators have been willing to accept breakthrough stories secondhand, but a professional mistrust of secondhand stories prevails. The many intangible elements that affect a breakthrough make it impossible to extrapolate an infallible success formula. The obsession with the process of "innovation experts," who are often wrong and frequently misinformed by a vast mythology, is avoided here. A sampling of the most firmly and erroneously cherished of these myths is offered.

The Myth: Commercial breakthroughs come from ideas that no one ever had before.

The Reality: Often what seems new is something that others have thought of but never figured out how to do. Before Sir James Black discovered the second histamine receptor in the human body, which led to the development of Tagamet (Chapter 5), he had read about the same concept in scientific journals, but those authors had given up on the idea.

And Sir Godfrey Hounsfield, who invented the CAT-scan machine (Chapter 7), was not the first to imagine an x-ray that produces three-dimensional scans of the body. What Black and Hounsfield had that others lacked was an *elegant concept* (a virtually complete image of the breakthrough). Though in both cases the journey from concept to realization was long and difficult, both men knew exactly what they were looking for when they began. Fred Smith, founder of Federal Express, also had seen examples of his concept; Federal Express's hub-and-spokes system was used by at least three air freight services as early as the 1930s. What was new in Smith's concept was its enormous scale. From the beginning, Smith had seen something very big. It was an old concept turned "elegant" in the mind of a breakthrough individual.

The Myth: Breakthroughs occur through "genius inventors."

The Reality: Invention is a step, not an end in itself. Once conceived or invented, a concept must become manufacturable, marketable, and competitive. Inventors need help. So do marketers. To be commercially successful, a concept requires organizational cohesion—teamwork. Sometimes it requires the contributions of people in a series of organizations. The microwave oven (Chapter 8) very likely never would have existed without the imagination of Raytheon Corporation's Percy Spencer, who is credited as its inventor. But the breakthrough into the marketplace occurred twenty years after Spencer's invention; it required redesign by a second inventive genius, Keishi Ogura of New Japan Radio Corporation, and it needed, finally, the help of a marketing genius, George Foerstner of Amana.

The Myth: If you build a better mousetrap, the world will beat a path to your doorstep.

The Reality: Ideally, any time you dramatically improve existing technology you should have a breakthrough product that makes you dominant in that market. But state-of-the-art technology alone is not enough. A fast-moving competitor who can match your technological ingenuity and whose technology achieves a closer fit with market needs may pave the path to his door more quickly.

Sony got to the market first with the Betamax format of the videocassette recorder (VCR) (Chapter 2), but a smaller company, JVC, not only independently produced a comparable technology a few months later but enlisted the collaboration of most consumer electronics companies in Japan to help manufacture and market the new VHS format. JVC's technology may not have been superior to Sony's per se, but it offered a significant advantage to consumers: the ability to record and play entire movies. In the end, because JVC used better bait for the same mousetrap, the smaller company got most of the mice.

The Myth: All the great ideas come from little guys.

The Reality: Certain innovations, especially those that require relatively small investments of capital but a large commitment of individual labor, tend to come from independent entrepreneurs. But innovations that require substantial financial investment and teamwork often emerge within big organizations. In this collection, the big/small ratio splits almost evenly. The grain of truth in this myth lies in the fact that when a breakthrough emerges from a big company, it tends to begin within a handful of people who break off small branches of the big corporate tree and bend them to their own will.

Tagamet emerged at Smith Kline & French, a large Philadelphia pharmaceuticals company, partly because an obstinate group refused to stop working on it in the company's small English research laboratory. The drug went to market because, once aware of the breakthrough brewing in Britain, the company's management reversed direction, built a $4 million chemical plant, and assembled an international distribution network that gave the company the sales capacity to turn a mere success into a record-breaker.

The Myth: Big success requires big resources.

The Reality: At each stage of development, a concept requires a balance of human and financial commitment, which depends to a great extent on the concept itself. The key is not big resources, but the right resources at the right time. Sometimes these must be large, as in the capitalization of Federal Express, but often—as in Sony's tight-fisted approach to the Walkman (Chapter 6)—money is almost entirely unavailable.

By the same token, the value of *bootlegging* (a popular term that refers to the illicit expropriation of money within a large company to carry on unauthorized research) has been significantly overstated. Only two or three arguable instances of bootlegging were uncovered, and there was little indication that a shortage or secrecy of funds provides more encouragement to innovation than does budgeted money with corporate approval.

The Myth: Breakthroughs always respond to an unfulfilled need.

The Reality: It is true that no breakthrough becomes commercial unless the people developing it see a market for it, but it is untrue that the bulk of successful commercial innovation results from *market pull* rather than *technology push.* That is a topsy-turvy analysis—it expresses the outcome of an idea as its origin.

In discussions with sixteen companies involved in a dozen breakthroughs, researchers asked what the motivating force was—what really got the idea going—focusing not on the beginning of product development, but on the concept that preceded it. In every case, it was curiosity that lit the fire. Neither financial need nor market intelligence played a major role. When "experts" assert the predominance of some notion like "market pull," they reveal that they identify more with administrators of research than with creators of it. By descending from the upper echelons to explore the sometimes remarkably humble and irrational beginnings of a breakthrough, people best described as problem-solvers were found in the dungeons of research. Sometimes what they devised solved a technical problem that had been nagging at them for a long time. Sometimes it was the solution for a personal problem, a need unfulfilled, or a mixture of technological curiosity and creative impulse. It always was a problem, however, to be solved, not a fortune to be made or a market to be exploited.

Certainly the search for a market often followed quickly. In some cases it was a parallel phenomenon, but there was no instance of a market demanding a breakthrough before the inventor had found it lurking in the depths of his subconscience.

The Myth: The commercial breakthrough requires a special sort of environment.

The Reality: As a rule, employees are happier and more productive working in organizations that try to create an environment for creativity, but this environment does not necessarily nurture latent ingenuity in researchers. Also widely believed is that *corporate culture* can either generate or stifle the innovative spirit. The stories in this book do not support this idea. The variety, complexity, and flexibility of people—and organizations composed of people—dwarf attempts to categorize them.

A wide range of environments were investigated: a compartmentalized Japanese corporation that seems to discourage interdepartmental communications; a small town in Ohio; a demoralized research center in Italy scheduled for phase-out; a porch in Lake Helen, Florida; a reconnaissance plane somewhere over Vietnam; an understaffed Tokyo electronics lab where researchers were required to spend part of every week doing field repairs; and a large, structured corporation in Minnesota, which requires that each new idea be "sold" by its inventor to the manufacturing and marketing staffs in separate divisions.

Eliminating Barriers to Breakthroughs

While it is true that breakthroughs can occur in any environment, one should not conclude that the environment does not make a difference. Some environments may be more conducive to breakthroughs than others. A more conducive environment—one in which the barriers are fewer or lower—might permit breakthroughs by people less dogged or mighty than the heroes in these stories. Of course, even where the barriers are few and low, they can be discouraging. And companies are often unaware of their existence.

Barriers to breakthroughs appear in many guises, but the three most important are lack of specific financial rewards for innovators, gaps between what managers say and what actually happens, and communication problems.

Lack of Specific Rewards

Almost none of the fourteen stories mention financial or other gains of the individuals who masterminded breakthroughs. Arthur Jones of Nautilus is one exception—anyone who shares his estate with three rhinoceroses, hundreds of rattlesnakes, thousands of alligators, 400 crocodiles, and a gorilla can't be ignored—but many of the people were not driven by a desire to achieve power, bask in glory, or make money.

As a manager, however, you cannot assume that your employees are similarly disinterested in rewards. Companies need to have in place reward systems that provide adequate recognition and compensation for innovation. They should also clearly demonstrate a willingness to pay out much more if a breakthrough occurs. Managers who do not come up with such a policy sometimes find their prize individuals defecting to other companies or, as is very common in the United States, starting their own companies and reaping all the rewards.

How does one set up such a policy? Many companies offer prestigious awards and year-end bonuses for innovation; others write agreements offering a percentage of the profits earned by new products or services. Promotions are also widely used, but these have the risk of taking the creative person out of the laboratory or other setting most likely to produce further innovation.

One American manager said that his technical people wanted good salaries but were even more motivated by opportunities to work with the latest—and, of course, the most expensive—supercomputers. His successful technique for keeping his key people is centered on providing them with tools that few other companies could offer.

While very creative people appreciate recognition and monetary rewards, they often feel that the highest reward of all is the opportunity to work on a more important problem. Whatever policy a company develops, it is important to check from time to time to see whether it is being implemented as planned and—more importantly—whether the creative people think it is working, which leads into the second barrier to breakthroughs.

Gaps Between What Managers Say and What Really Happens

"Yes, we do all we can to facilitate innovation," "This company values long-term R&D and protects it," "We are committed to state-of-the-art R&D."

These are the kinds of responses senior managers give when asked about their policies regarding innovation and breakthroughs. The big question is, Do these statements accurately reflect what goes on in the company?

Often senior management may have the best intentions, but a lack of vision on R&D matters prevents them from converting their intentions into actions. For instance, they may ask the R&D manager to keep the other people current in their fields but to turn down requests for funds for travel to important conferences or for up-to-date lab equipment. Similarly, they may give the green light to a high-risk R&D project and then when it fails to produce the desired result berate, demote, or even fire the people in charge. To encourage innovation, management must demonstrate a willingness to tolerate failure.

Lack of Communication

Two kinds of communication problems can prove to be formidable barriers to innovation in general and breakthroughs in particular. The first is personal; the second is corporate.

Dick Duke of ChemLawn, a prime example of an extrovert, liked to talk to people, enjoyed working with his employees, and, if he needed to, could write memos that would almost smolder on the paper.

Other individuals who are just as capable as Duke of producing a breakthrough, particularly those in the depths of a large organization, may not be willing to trumpet their ideas or to do battle with anyone who causes them trouble. Even if they are brilliant extroverts, they may be utterly inept at the political gamesmanship that afflicts many companies today.

A breakthrough concept almost never springs forth fully formed. If a vaguely stated notion emerges in a company where people move up by constantly proving they are smarter than others, it will not last long. One of the easiest ways to make yourself look smart is to attack ideas that are unfamiliar and unproven. Deviant notions are the cannon fodder of corporate ladder-climbing. Fred Smith of Federal Express said that a great corporate resume is usually assembled by someone "who knows all the reasons you can't do something." Unchecked, that kind of person will shoot down one possible breakthrough after another. It takes many people saying "yes" to a breakthrough idea to make it happen, but often just one "no" can kill it.

Among the people saying "yes," there are often three kinds of champions: the technical champion, the business champion, and the executive champion.

One of the great ironies of the breakthrough stories is that the breakthrough teams themselves did not have the vision of the great commercial success that was to come. They had no ammunition to protect them from management analysis. The breakthrough concept is something new, something no consumer has ever bought. And if no one has ever bought it, how do you know anybody is going to buy it? Creative forces within structured organizations eventually discover the Catch-22 of new product marketing: People can't buy it until we sell it, but we don't dare sell it until somebody has bought it.

Almost always, a breakthrough doesn't expand a market—it gives birth to a market. With no comparison to a status quo, a breakthrough cannot grow from a market perception. It grows, rather, from largely unformulated needs.

The second communication problem, simply put, involves getting people who have needs together with people who know how to fulfill them. R&D people should circulate among the company's customers and, thus, see firsthand what is bothering them. What do customers need that the company could supply? Is there some technology that the R&D people know about that has an application to the customer? Where is the need?

This kind of thinking flies in the face of traditional corporate structure, in which marketing is separated from technology development. Traditional ways of operating create huge barriers in communicating information, to the extent that the customers' needs and wants are never truly understood by those who know what it takes to meet those needs. The problem can be solved to some extent by creating multifunctional teams in which marketing and product development people can talk to each other, but a better solution is to send innovators out into marketplace, where they can meet the customers and listen to them.

The goal is to make possible the leap to a new bisociative idea. And to do that, you need to bring together two spheres of expertise: problem-solvers such as engineers and scientists, who know what is possible, and customers, who are uniquely positioned to know (or at least to recognize) what they want. The trick is to get the engineers to listen to the customers.

Listening to customers means more than just asking conventional marketing research questions, however. ("How are we doing? How did you like our last product/service? What would you like to improve about our product/service?") Effective listening is more akin to what an anthropologist would use to talk to a group of people. In such a setting, an anthropologist would try to approach the study group with no preconceived notions in order to truly hear what the people are saying.

This takes time, but it can work. With patience and a bit of luck, customers may open up and tell the questioner what sort of problems they are really having—things for which the customers want solutions. If the questioners are technical people, they can then ask leading questions based on what is possible. The answers to these questions will shape the direction of the solutions. Then the R&D people have something to work on that is different from the usual suggestions for incremental improvements that come back from marketing.

Spotting Breakthroughs and Nurturing Them

At talks given by the Arthur D. Little researchers, one of the inevitable questions is "For every breakthrough there are 999 ideas that won't work. How do you know which one to back?" That's a good question, and it's very much like the kinds of questions that are put to venture capitalists: How do you know what companies to support?

There are four key questions to ask of a possible breakthrough idea:

How strong is the idea?

If a wacky-sounding idea is a real breakthrough, it will prove remarkably sturdy. When you examine it dispassionately, you won't find anything wrong with it. The objections people raise will themselves sound weak and subjective.

An important consideration here is the choice of people examining ideas. You need the standard hard-nosed analysts, to be sure, but you also need some "soft-nosed" analysts as well—people who are willing to play around with an idea, to think of possible modifications, and to give it a chance. As we saw in the section on communication, it's never hard to find a cadre of people who can shoot down anything. It takes a sensitive, knowledgeable, dispassionate judge to spot a potential breakthrough—and then to champion it ardently. Are there people like this in your organization?

How enthusiastic is the idea's originator?

Lots of people come up with notions that "we ought to have someone look into." When you have a person who is wildly enthusiastic about an idea, who is willing to drop everything else to work on it, and who tells everyone he or she meets about this great project, you have a good indication that something might work. Men and women want to hitch their wagons to real stars. Your creative people may not, as Shizuo Takano of JVC (Chapter 2) ask their associates if they are willing to commit suicide for the effort, but such enthusiasm is a good indicator of success.

What are the qualifications of the originator?

One of the problems in research universities today is the extreme degree of specialization. An East Asian expert may know everything there is to know about the Hmong people of Cambodia and yet not be able to locate Sri Lanka on a map.

When an individual in a company comes forth with a potential breakthrough, look to see if this person has both the depth and enough breadth to communicate the new ideas to others. If the breakthrough is so arcane that it can be understood only by a handful of people, the chances of it succeeding on a large scale are diminished.

What is the track record of the innovator?

When Dr. Edward Paget hired James Black, whose work eventually led to Tagamet (Chapter 5), he was bringing in a man who had a great background as a drug researcher. Here was someone who had experienced both failure and success and whose judgment was worthy of respect. Such a person had already demonstrated the ability to motivate others and the dogged determination to succeed that are essential ingredients of breakthroughs.

Investing to Get Information

What do you do if you have a promising idea and all four questions seem to give the project a green light? The answer is to invest in it—judiciously. This is not the time to fully fund the project and plunge ahead, but rather to invest just enough to reach the point of certainty. If the potential breakthrough is a chemical process, as in the case of polypropylene (Chapter 12), one point of certainty might be whether or not the process is patentable.

For many products, the first level of investment might be development of an early commercial version to test market reactions. To determine this, the company would fund the project only until that question is resolved. Then managers could decide whether to proceed to the next point of certainty. This incremental, step-by-step approach is the most cost-effective. Each phase thus doesn't seem to cost too much at any given time, and the aspiring breakthrough can be nurtured along until one is sure that its aspirations will or will not be fulfilled. In this way, one can avoid the two deadly sins of innovation: killing a good idea and spending too much time on a bad one.

Sometimes a company has to await developments outside the firm to enable a breakthrough to take place. Sony was not the first company to attempt to make a portable audio device (Chapter 6). The same thing had been tried in the 1920s, but the heavy weight of batteries, headphones, and other components doomed this proto-Walkman to use only by weightlifters. Sony—or any company making such a device—could not have done it until the proper materials were available. A small, steady stream of funding can keep a project vital enough to be prepared for or to wait for the right conditions to come along.

Managing for Innovation

To repeat, you can get a breakthrough whether you deserve it or not. Following these ideas, however, will at the very least lead to a higher level of incremental innovation, which has served a great many companies very well over the years. And, if you are lucky, if you have the right people in place and surround them with a receptive environment, your company may be one of the ones that hits the jackpot, that is studied by business schools all over the world and makes it to the next edition of *Breakthroughs!*

ENDNOTES

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Chapter 4

NOTE: In the years since this chapter was researched, ChemLawn has gone through some significant changes, including acquisition by Escolab and a subsequent divestment. Perhaps the greatest testimony to the power of the original ChemLawn breakthrough—besides its initial dazzling success—is the plethora of ChemLawn clones now tending the lawns of suburban America. Whatever the future of ChemLawn, its story remains well worth retelling.

Chapter 7

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Chapter 8

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Information derived largely from Diane L. Barlhel, *Amana: From Pietist Sect to American Community,* Lincoln, Nebraska: University of Nebraska Press, 1984.

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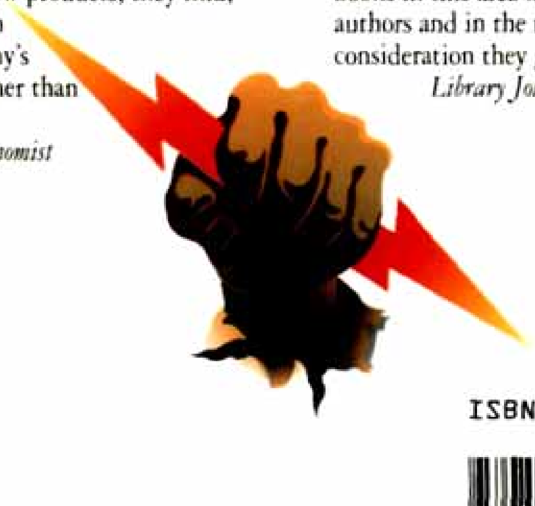

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