GENERAL MICRO-ELECTRONICS, INC.

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General Micro-electronics, Inc. (GM-e) was a fabbed semiconductor company established in 1963 and sold to Ford Motor Co. in 1966.

Financial backing for the company was provided by the Pyle National, Co., a Chicago manufacturer of electrical components. Pyle National was formed in the 1880's and grew slowly over many years. Locomotive headlights were an important product for Pyle in the early years. Apparently, the American Indians shot out many of the headlights on the "iron horses" that were invading their territory, so Pyle enjoyed a strong replacement market and prospered accordingly.

In the 1950's Pyle became a prominent supplier of umbilical connectors for the Minuteman missile and thereby accumulated a sizeable sum of cash. At the same time Pyle became concerned about the rapidly increasing market for semiconductors and wondered if the emergence of this market might threaten Pyle's product line. Pyle, headed by its CEO, Bill Croft, hired Arthur D. Little to do a study of the possible impact of semiconductors on Pyle's interests.

The study concluded that semiconductors did not threaten Pyle's interests but made the comment that it might be a good place to invest some of Pyle's retained earnings. The study further stated that, in the course of collecting information for the study, the Arthur D. Little personnel had met a man who might be a good leader for any new company Pyle might back financially.

The man Arthur D. Little had interviewed was Col. Arthur Lowell of the U. S. Marines. Col. Lowell at the time was head of the Microelectronics Branch of the Bureau of Weapons of the Navy Department in Washington, D. C.

Electronics were becoming a larger and larger factor in new military weapons at the time and the weight, volume, power consumption and reliability of the new electronic equipment was becoming a burden for equipment designers, especially for airframe designers. Hence, there was a strong effort to advance microelectronic technology to alleviate these problems.

Pyle National contacted Col. Lowell and he expressed an interest in retiring from the Marines and become the leader of a new microelectronics company.

Col. Lowell, in turn, was acquainted with two employees of Fairchild Semiconductor, Howard Bobb and Bob Norman. Howard Bobb was a salesman for Fairchild and Bob Norman was the manager of part of the Fairchild circuit design department. They visited Col. Lowell frequently as representatives of Fairchild in its effort to sell semiconductors to the federal government.

Col. Lowell contacted Howard Bobb and Bob Norman and they expressed interest in being part of a start-up company. They later brought into the discussion Phil Ferguson, the head of the new processes and new products development group in Fairchild's R & D labs.

An agreement was signed and GM-e was formed in the summer of 1963 with facilities established in Santa Clara, CA. GM-e was the seventh spin-off from Fairchild Semiconductor. In total, there were said to be forty-three spin-offs from Fairchild Semiconductor, and GM-e had the dubious honor to be the only one Fairchild

Semiconductor sued.

The lawsuit claimed any number of underhanded and devious actions by the GM-e founders, but the real problem was the number of Fairchild employees that GM-e hired. GM-e management didn't have a good handle on how many Fairchild employees were being hired but it was excessive by any standard. The lawsuit was later dropped as being without merit.

The initial business plan envisioned that the first product line would be epitaxial bipolar integrated circuits (ICs) using resistor-transistor logic (RTL). This technology was to be used to generate initial revenues and reach profitability. However, the company's long- term interest was in metal-oxide-semiconductors (MOS). The MOS was just starting to be discussed with some preliminary R & D work in progress.

The first known reference to the MOS structure was, apparently, in an issue of the RCA Technical Journal in the late 1950's or early 1960's. This basic technology has gone on to dominate today's digital semiconductor product lines. The MOS device is a field-effect transistor. Interestingly, a field-effect device was the initial objective of the Bell Labs team that discovered the transistor.

The advantage of MOS structures over bipolar structures is obvious and massive. A bi-polar transistor is three-dimensional and a MOS transistor is two-dimensional. This fundamentally eases the manufacturing problems. From the beginning, MOS structures could be successfully produced with ten or more times the device density of an equivalent bipolar device.

The basic MOS physics was poorly understood at the time GM-e was organized. There were some odd things happening at the oxide-semiconductor interface that resulted in some devices turning "on" when they were supposed to be "off" and vice versa. It turned out later that the culprit was sodium ions that were mobile and were collecting at the oxide-semiconductor interface.

The immaturity of MOS technology was the reason that GM-e chose to use epitaxial bi-polar integrated circuit technology as its first product line.

The advent of epitaxial bipolar integrated circuits in early 1963 proved to be the solution to the yield problem associated with the early bipolar integrated circuits. The first bipolar integrated circuits were triple-diffused, a process that formed the collector region of the circuit with a long, high-temperature diffusion. This diffusion caused the insulating oxide layer to be compromised and that, in turn, resulted in flaws and unacceptably low yields, i.e., unacceptably low survival rates for the circuits be processed. The epitaxial process eliminated the long, high-temperature collector diffusion and instantly increased manufacturing yields by about a factor of fifty.

A serious, and perhaps fatal, error was made by GM-e in the selection of resistor-transistor logic (RTL) as the circuit design technique on which all of the early GM-e bipolar integrated circuits were based. Well before GM-e was founded, the world was moving away from RTL circuit design in favor of diode-transistor (DTL) logic and transistor-transistor (TTL) logic. The perceived advantage of DTL and TTL circuit design was a superior "noise-immunity", i.e., a superior ability of DTL and TTL circuits to withstand the presence of electrical noise without malfunction.

A preceding Fairchild Semiconductor spin-out, Signetics, Inc., chose DTL circuit design for their products and enjoyed considerable success in the market.

Unfortunately, some of the circuit design management at GM-e had what can only be described, in retrospect, as an unhealthy allegiance to RTL circuit design, an allegiance bordering on zealotry. If the world thought poorly

of RTL it would be GM-e's job to change their minds. GM-e couldn't and didn't. RTL really was inferior.

The problems stemming from the RTL decision were compounded by the initial markets selected for penetration. The GM-e sale force had a strong relationship with some of the engineers at the National Security Agency (NSA) in Washington, D. C., and GM-e focused its early sales efforts at equipment to be built for NSA by private contractors. The market potential for integrated circuits for this NSA equipment was gigantic, but, as is so often with government programs, the development cycle stretched out and no production buys were forthcoming. All this time GM-e was burning money.

After about eighteen months of low revenues and high expenses, relations between Col. Lowell and Pyle National started breaking down. Pyle National was a relatively small company with limited resources and the spending at GM-e was causing the lights to dim in Chicago. Col. Lowell was relieved by Pyle National and left the company. Phil Ferguson became the second, and last, CEO of GM-e.

The problem generating revenues from the company's bipolar circuits forced GM-e to accelerate its efforts to develop MOS products and bring them to market.

As a demonstration vehicle for the advantages of MOS, the company developed an electronic calculator prototype that generated a great deal of interest. It was not the first electronic calculator; that distinction went to Friden, a subsidiary of the Singer Sewing Machine Co. Friden had designed an electronic calculator using bipolar ICs but it was rather large, heavy and expensive with limited capability. The GM-e machine was more powerful, smaller and lighter.

Among those expressing interest in the GM-e calculator was Victor Comptometer, a Chicago supplier of electro-mechanical calculating machines. Victor saw the GM-e machine as a useful product to be placed at the very top of their calculator line, and awarded GM-e a contract to design and manufacture a private-label machine for Victor.

During 1965 the GM-e continued to have perhaps the best capability in the world to manufacture epitaxial bipolar integrated circuits but was unable to attract volume buyers.

At the same time, the design of the Victor electronic calculator progressed with a couple of major problems.

One problem was that Victor kept coming up with good ideas to improve the machine.
The new features all increased the complexity of the MOS circuitry required to implement them. The calculator case form factor froze the number of MOS integrated circuits at thirty circuits. The added features meant that each of the thirty circuits became more complex so that the initial limit of forty devices per chip ended up to be two hundred devices per chip. Hence, the MOS technology was being asked to place many more devices on each of the thirty chips than had ever been done before.

The second problem was that MOS technology was still immature with the identification of the source of the surface state instability still in the future.

Another problem was that Pyle National was running out of cash to support GM-e.

At this inauspicious moment, the 7th Cavalry appeared on the horizon in the form of the Ford Motor Co. Philco had been purchased by Ford Motor Co. a few years before GM-e arrived on the scene. Ford had anticipated that electronics would be of growing importance to the automobile industry and hoped that Philco could inject some electronic expertise into the Ford organization.

Philco had semiconductor operations at Lansdale and Spring City, Pennsylvania. The management of these facilities mentioned to the CEO of Philco that GM-e was doing some interesting things. It turned out that the Philco CEO was a member of the Board of Directors of the Elgin Watch Co. Another member of the Elgin board was Bill Croft, the CEO of Pyle National. At an Elgin Watch Co. board meeting they got to talking about GM-e and the Philco CEO asked Bill Croft if Pyle would be willing to sell GM-e to Ford. Bill Croft said he would check with the Pyle board and with GM-e.

These events were quietly related to GM-e by Pyle over the telephone and its opinion requested. The immediate and fervent response from the GM-e CEO was the Pyle should sell GM-e to Ford "in about a New York minute". A sale price of $10 million was agreed to by the parties.

Part of the agreement was that Ford would pay for GM-e in cash. The GM-e CEO made a special trip to Dearborn to try to talk to Ford about the problems associated with buying all the GM-e stock. Ford had no concept of the fact that in Silicon Valley people work for stock and would go away if the stock went away.

Dealing with Ford was much like approaching the Wizard of Oz. You are talking to a disembodied voice coming from somewhere behind a curtain. When the GM-e CEO suggested that Ford consider buying control but not all of the GM-e stock, the voice behind the curtain responded that Ford had once bought less than all of a company and that purchase had not worked out well. Ford would only buy GM-e if it was the entire company and was paid for in cash. Okay, that's clear.

The sale transaction was completed and one day a large check arrived from Ford. A new bank account was established and that Ford check became the only deposit ever made to that bank account. A few days later GM-e set up tables at the company and started buying back all the stock from GM-e employees. It was like payday in the Army.

With all the stock options gone, GM-e exploded like a bomb. Three successive managers of the NSA program resigned in the same week. Sadly, a number of marriages of company personnel also exploded as couples got their hands on substantial amounts of money for the first time and apparently decided that they didn't much like each other any more.

Ford/Philco continued to operate GM-e (now the Philco Microelectronics Div.) for about a year before moving it back to Lansdale, Pennsylvania. One ex-GM-e engineer moved back in the facility transfer and stayed for a few months before returning to California.

The Victor Comptometer program was canceled after a time. The NSA RTL programs finally reached production a number of years after the demise of GM-e; Motorola was the main beneficiary of production volume from the NSA programs.

GM-e was not a successful venture. It did, however, demonstrate the potential of the MOS structure both as an IC and at the system level.