



Oral History of Clements E. (Ed) Pausa

Interviewed by:
Craig Addison

Recorded: June 17, 2004



© 2012 Semiconductor Equipment and Materials International (SEMI)

CHM Reference number: X6196.2011

Craig Addison: If we could start off going right back to the beginning and your first involvement in the semiconductor industry, can you tell us about that?

Ed Pausa: I joined Fairchild Semiconductor in 1959. I had gone to University of California, had done a graduate degree, worked part-time at the Institute Of Engineering Research there and that relates to how I got into the semiconductor industry. I went on active duty as a Naval officer for three years, came out, went to work for U.S. Steel in Pittsburg, California. I was working there for a couple of years as an engineer in both their tinplating and open hearth departments. A Leeds & Northrop sales representative, who I had worked with when I was working at University of California in one of my graduate programs, started telling me about the exciting things that were going on in what's now Silicon Valley, Mountain View, California. That got my interest up and then another fellow at U.S. Steel and myself both saw an ad, a very small ad in the local paper, a recruiting ad for Fairchild Semiconductor. We both went and interviewed. I got a job offer and I joined Fairchild in June of 1959. I was employee number 454, although I think at the time I joined there were only about 300 employees. I was hired by Frank Grady, who was the operations manager, vice president of operations.

Addison: So really before Fairchild, you didn't have any aspirations of joining the semiconductor industry?

Pausa: I didn't know anything about semiconductors prior to 1959. One of the things that may have made me attractive on their side was that I had done my master's degree in physical metallurgy. I had grown single crystals and I knew a little bit about the materials science.

Addison: What was the mood or feeling at Fairchild at that time, was it really exciting and a "change the world" kind of thinking?

Pausa: I don't know that you got the impression that we were going to change the world, and it may have depended upon what level you came in at. It certainly was exciting and it certainly was a brand new frontier. Everybody was trying to figure out how to do what they were doing. It was a relatively unscripted environment and everybody was encouraged to do more rather than less. There were very few boundaries...if something needed to be done and you couldn't [find] anyone else who was doing it, you were expected to go do it.

Addison: So what exactly did you do?

Pausa: I was brought in at what I think was called a production management trainee and there were about 4 or 5 of us. We ended up going into different routes. I ended up originally being, first a supervisor and then a general foreman of the transistor assembly line. Then Charlie Sporck joined the company and we reorganized into product lines and I became a product line manager for the first planar transistor product line. And sometime at that point, in that year and a half, we had moved from Charleston Road to the first plant in Mountain View [California].

Addison: At the time, the planar process was being developed and the IC was being developed, correct?

Pausa: We started out with a mesa process, so the first line I ran was a mesa production line. One of the things that I remember specifically about that was the way that you cut the mesa. Basically you used wax to mask off the area of the device that you wanted to save and then you etched the rest back to expose the mesa. That was really pretty crude now that you look at it.

Addison: What about the equipment, was it basically a case of build your own manufacturing and process equipment?

Pausa: A combination. Some of the equipment was scientific lab equipment. My impression is [that] the diffusion furnaces were [from] Thermco... similar to furnaces I'd worked with in one of the UC Institute of Engineering research projects, although maybe used for a different purpose. Some of the other equipment was out of the Beckman Lab catalog and some of the equipment was [home] made.

Addison: Was there any talk in the hallways about the IC, since it was being developed at that time?

Pausa: When you talked to the technologists, there was a lot of excitement about that. But if you think about it, when I joined it was mesa transistors, so the big activity was to go from the mesa transistor to the planar transistor and the discovery of the planar effect. How to do oxide protection was probably more of the discussion than the IC, particularly in 1960. After we built the first planar transistor, which I think was a 2N1613, we were trying to build PNP transistors. And then we wanted to get to what we referred to as a very small geometry transistor. So if I remember the different product lines, I had the NPN planar transistor line, somebody else had the PNP, and then there was the small geometry line, which was the one that was more experimental. At that time, we had our own crystal growing operation.

Addison: So what about Bob Noyce and Gordon Moore, did they talk to the people and say we've just had this breakthrough product and it's going to change everything, or there was nothing really said about it?

Pausa: There were things said about it, but I don't remember there being an enormous big announcement [about the IC]. There might have been, I just don't remember that. I'm trying to remember if there was an all hands meeting. It was very informal, so you talked to people like that almost every day, but I don't know there was a huge announcement.

Addison: How soon did you get into the assembly and packaging? Was that fairly soon after you joined?

Pausa: The first lines as a general foreman I had were assembly and test lines. Then I became product manager so that I had the whole product line, including the masking facilities, the diffusion line and a set of process and product engineers who worked for me. And then I got asked to set up and become the first manager of the South Portland, Maine plant. That was sometime in '61. I guess we first went to the site in about May or June of '61. We had selected a speculative building that was a shell, so the building had to be finished. We set up a plant in a former car dealership building in '61 while the final plant building was being completed. So from about June or July of '61 through probably the end of '61, we organized and established a plant and set up assembly and test activity, again for both the 1613 and the small geometry product. I think it was over the Christmas holidays in '61 we moved into the plant on Western Avenue in South Portland.

Addison: Once again, what sort of equipment did you have secure for that? Was it homemade or did you buy it commercially?

Pausa: It was a mix. In thinking about equipment items, these were almost all metal can, T05, T018 transistors, so one of the equipments that I remember we used was Taylor and Winfield dual ram welders that we basically built dry boxes for and bought vacuum chambers for the final seal equipment. There was a company called EMB, Engineering Machine Builders, who got into the bonder business, so we bought wire bonders from them. Die attach equipment at that point in time I think was pretty much homemade. I don't remember who made the scribes at the time. Originally the process had a welding operation as well as a bonding operation, because we couldn't do stitch bonding. We used Fairchild testers from Fairchild Camera and Instrument. Well going back a bit, we used Tektronix curve tracers. The first line of testing, which is probably what now would be called die sort, was all done with curve tracers. And then for final test, I believe we were using Fairchild Camera and Instrument built testers. And later we went to Teradyne testers.

Addison: So this was pretty heavily labor intensive?

Pausa: Very definitely it was labor intensive. The wire bonders...the number of one hundred units an hour is a number I recall, but I think that was three or four years later. I think we were doing less than a hundred units an hour. The pictures I have show a number of people on bench rows with about 30 to 36 inch centers, all next to each other, all looking through American Optical microscopes. Die attach was all hand aligned, wire bonding was all hand aligned.

Addison: How long were you involved with the South Portland plant?

Pausa: I left the South Portland plant at the end of '64. I think by that time we'd grown to about a thousand people.

Addison: When you set up that plant was there any discussion about going offshore at that stage, or there was no choice at the time?

Pausa: No, there was no choice. I don't think the company had any thoughts at that time about going offshore. Fairchild, after setting up the plant in Mountain View, set up a diode operation, which they put in San Rafael [California]. So if we moved to Mountain View in say 1960, they probably by the end of '60 or early '61 had set up a San Rafael plant and then mid-'61 set up the South Portland plant.

Addison: And South Portland was selected for what reason?

Pausa: A series of reasons. One, we wanted a labor base. We wanted to be on the East Coast because we had a number of East Coast customers and we thought that would be helpful. The criteria was that we wanted a place that did not have a heavy union activity. We wanted reasonable access to transportation, which meant airports, and we wanted reasonable access to education, universities. Portland became attractive because it had the spec building and it had a development agency that went out of the way to make it easy for us to go there. In Maine, there had been a transistor plant in Lewiston. It was an old

Raytheon plant and Lewiston was 90 miles away, so there were some technologists already there, a pool of labor to start hiring technologists from as well.

Addison: After '64 when you left South Portland, where did you go?

Pausa: I went to Hong Kong in December of 1964 to what was a Fairchild Hong Kong plant. The Fairchild Hong Kong plant I guess had been started in maybe '62 or '63, and they were building a different kind of transistor that was built using a ceramic bead and individual lead posts, if you would, and they were all assembled and then encapsulated by "globbing" them with epoxy. They were called the T0105 and 106 epoxy transistors. I had mentioned at some point in time to Charlie Sporck...that if there were ever an opportunity, I might be interested in going to Hong Kong. I had visited Hong Kong a few times while I was on active duty in the Navy. I just thought it might be interesting to do that.

Addison: Are you aware of the decision making behind going to Hong Kong? I mean, they had the South Portland plant and then they thought, we need to go offshore?

Pausa: I know some of the story. Bob Noyce had some investment in a small radio company that was running in Hong Kong. I don't know which one. I don't think it was Atlas, it may have been one of the other ones. He asked a couple of people who were traveling to Asia to look at the [radio] company. At one point in time, the fellow who ran that plant, a guy named John Baldwin, came to Mountain View. As a consequence of Bob [Noyce's] interest and people visiting, people became interested in the opportunity to set up an operation [in Hong Kong]. The TO 105, 106 were probably even a little bit more labor intensive than the T05, T018 transistors, and they were aimed at a much more commodity marketplace. They were not aimed to be military devices, they were aimed to be consumer and commercial devices and a lot of the products went into radios. So I think the sensitivity to labor and labor costs became a consideration in making that decision.

Addison: John Baldwin was the head of the radio factory, not the Fairchild factory?

Pausa: That's right, he was the head of the radio factory. Norm Peterson was the head of the [Fairchild] plant when it was started. Norm had been in the silicon materials operation at Fairchild.

Addison: So you put your hand up and said you'd be interested in going to Hong Kong. So what opportunity arose?

Pausa: I was asked to replace Norm Peterson. I went there one day, I guess I arrived on a Friday, he and I met on a Saturday, and I took over on Monday.

Addison: Is there a story behind that? Did he come back to Fairchild in Mountain View?

Pausa: No, he ended up going to work for another company, I think it was Teledyne, setting up another plant in Hong Kong. He tried to recruit people from us, and probably recruited some successfully. We occupied the house he had been living in when my family moved in, [and] he hired both of the amahs (maids) away.

Addison: Were there any problems in the plant? Did you go in there and put out fires?

Pausa: There were concerns about the fact that it wasn't meeting its production schedule, it seemed to have a lot of yield problems.

Addison: At that stage were there many other, OK, you mentioned Teledyne, but were there many other assembly plants in Hong Kong?

Pausa: We were the first, and probably we were the first of the semiconductor companies to go away from their home country, to go, if you would, overseas. I say that because the Japanese didn't come to Southeast Asia until later. Norm [Peterson] brought Teledyne [to Hong Kong] and that was probably a year later. The only other similar activity that I can recall was General Instruments building TV components, not semiconductors, but flybacks and yolks and so on in Taiwan at that time.

Addison: Somebody told me that Fairchild actually had something in Mexico before Hong Kong.

Pausa: I don't think it was before. I think it started later. When I came back from Hong Kong, I ran a group of companies and either the Tijuana plant and the Mexico City plant worked for me at one point in time or another. It was after I came back, which was after '67. So they were started a little bit after the Hong Kong plant. The plants [that] I remember after Hong Kong, we basically started a plant in South Korea, which was probably in '66. [There was] one other Fairchild plant that was started about the time I was in Hong Kong -- so it must have been '65, '66 -- they started a plant in Shiprock, New Mexico.

Addison: So really the Fairchild Hong Kong plant was pretty much the first semiconductor factory that went offshore?

Pausa: Yes.

Addison: Did you call it assembly, packaging and test back then?

Pausa: We started out by calling it Semiconductor Limited. Did we call it assembly and test? I don't know. For another reason, I've gotten into researching when the term semiconductor packaging, assembly, and test, or other names started to get used, [and it] probably was more in the '70s.

Addison: After building the Hong Kong plant, how did things go in terms of getting the equipment installed and ramped up?

Pausa: We did pretty well. By the time I left, we had 6,000 employees. When I got there, there were I think 1,200.

Addison: In that one building?

Pausa: We were working three shifts, but Hong Kong subscribed to an international labor organization rule that basically said women and young people could not work between midnight and four o'clock. So basically we had to hire men, and that made the third shift a relatively small shift that primarily did test

operations. So if we had 6,000 employees, we basically had 3,000 employees on day shift, 2,500 on swing shift, and about 500 at the most, on graveyard shift.

Addison: Did the Hong Kong factory exceed the productivity of the U.S. factories? How did they compare?

Pausa: If you mean productivity, units per labor hour, probably they were fairly comparable. In my experience in most of the plants, if you do a good job of working with the people and motivating them, the productivity will be relatively the same. The things that will get involved are maintenance, uptime on equipment, yields. One of the difficulties that we had ...Hong Kong when I moved there had 4 million people. It had less than 200,000 motor vehicles, so that the vast majority of people really had no, and particularly the men, had no experience with mechanical things and mechanical tolerances. So we had a lot of effort to teach people how to be sensitive to mechanical tolerances. Another thing, if you were hiring people who had gone to college or university, there was a cultural characteristic that basically said they preferred not to get their hands dirty. They wanted to not be heavily involved with the operational aspects of it. So we ended up starting a day release program. We hired people from the trade schools who came in as technicians, and we gave them one day off so they could go and get further advanced education with the idea we could train them to become better supervisors, start developing a cadre of people who could both work with the people and work with the process and have technical knowledge.

The other thing, in Hong Kong the workers were very, very wage sensitive. They would change jobs for a 5 percent increase in pay, and the turnover rate was very high.

Addison: So they were changing jobs to other assembly and test factories?

Pausa: No, the garment industry was very big at that point in time. Across the street from us was a big garment factory. Hong Kong, at that point in time, was a heavily industrialized manufacturing center.

Addison: Once again, when you were equipping the new factory in Hong Kong, was that similar to what you were doing in Portland, or was there more off-the-shelf equipment available?

Pausa: There wasn't much more...well, we were running the T105, 106 epoxy transistors. The bonders [in Hong Kong] were the same, the die attachers were probably initially hand built. Some of the other equipment was purchased. The epoxy was put in by hand, so there were "glob tops". We used a lot of ovens to cure the epoxy. The testers were commercially purchased testers. I can't remember whose testers they were. I don't think they were Fairchild, they may have been Teradyne. We used a lot of Syntron bowl-fed handling equipment. I know in South Portland we were using Daymark. I can't remember whose handlers we were using there. We had a diode line. The diode line was equipped with Dix sealers, which was a particular kind of equipment manufacturer that specialized in diode equipment. We had the same T105, 106 transistor line that we had in South Portland, and then similar packaging was used to build [those devices]. We were there making some integrated circuits as well, and header type packages.

Addison: Were there any kind of disasters or problems after the factory was up and running? Anything that went wrong?

Pausa: Well, we had one labor disturbance walkout that lasted a week. The day shift walked out because they thought the second shift was getting a preferential wage increase. That was a very stressful week. We got absolutely vilified in the Chinese language press, I mean absolutely vilified in the press. We ultimately caved in one way or the other and gave the day shift a slight increase in pay and everybody came back to work. What was very interesting was we were a relatively large employer at the time, we probably were already at 3,500 or 4,000 [people]. When the strike started, the local police were there within 30 minutes, because they had an informer, an agent in the plant so they could keep track of that large a body of people.

Addison: Was there any trouble, any demonstrating?

Pausa: There were demonstrations, but there was no physical violence, although you wondered about it at the time.

Addison: So these numbers of people, 3,000 to 4,000, and eventually 6,000...did the garment industry have similar numbers of people?

Pausa: We were one of the largest employers. But the garment factories had 2,000, 4,000 people.

Addison: Did the Hong Kong government encourage Fairchild to go over there in the first place? Were there any sort of incentives in place?

Pausa: There were no incentives per se. The government was encouraging everything because there's a very low income tax rate. It's a free port, so there were no questions about duty, import, customs and the like. The stamp tax was very low, so it was just a very easy place to do business. So it was encouraging from that standpoint, but they didn't particularly have incentive programs like other communities around there did. They just made doing business relatively easy. Contrasted with today's environment, the one thing now that I look at, communications were very limited. When I first went there, I guess there was one trans-Pacific cable for telephones. I got about one telephone call, maybe two telephone calls a week for messages and a few telex messages. Contrast that with today's environment where everybody's online constantly. So it was just dramatically different from that standpoint.

Addison: Compared to other locations in Asia, like Korea or Singapore, was Hong Kong relatively advanced in terms of the infrastructure?

Pausa: In terms of infrastructure to support manufacturing activities, certainly compared to Southeast Asia, Hong Kong was about as advanced as you got. Looking at the operations that were in Taiwan, Taiwan probably would be next in terms of their development, but that was about it.

Addison: Was there ever a discussion about language being a problem? You said you went to Korea shortly after [Hong Kong]. I guess back then, and even now, not many people in Korea speak English. Was that a consideration, the language barrier?

Pausa: It wasn't high on our list of check offs. Obviously you had to be able to hire mid-level managers who could speak the language. And at that point in time, there wasn't much interaction between the

plants and customer service. So you didn't have that requirement. And because communications were so relatively limited, you didn't have the requirements you have today, the constant e-mail traffic going back and forth. But we expected all our general foremen and all of our process engineers to have a reasonable knowledge of being able to read English. I can't remember where, it may not have been the Hong Kong plant, but I know at some point in time, I basically insisted that all of the specifications be parallel translated. So on every page you saw the process specification in both English and the native language so that when customers went through and they were looking at an operation and they would look for a spec, they could see the exact same spec the operator had. You could almost point to numbers and be sure that both parties were talking about the same thing.

Addison: Hong Kong fell out of favor to the Southeast Asian countries as a site for IC assembly. Can you talk about that? Were wages too high in Hong Kong, or what happened that caused that shift out of Hong Kong?

Pausa: Well, the other locations offered incentives and they had more area and the operations gradually became less labor intensive, and the wages in Hong Kong went up so that they ended up being less competitive compared with the Southeast Asia countries. I left Fairchild Hong Kong and returned to Fairchild headquarters at the end of '67, ran a group of plants that included Hong Kong, Korea, the Tijuana plant. We also had a small operation in Toronto for a while, and at one point in time San Rafael and Shiprock worked for me. The very last thing I did for Fairchild was I helped negotiate and start up the Fairchild Singapore plant.

Addison: So these plants, the one in Korea and Mexico and then Singapore, they were all adding capacity, it wasn't replacing another plant.

Pausa: No, they were all adding capacity. Shiprock was adding capacity and was in the Indian reservation because there was incentive for being in the Indian reservation. Korea was definitely adding capacity. Korea had some incentives and I know we looked at both Taiwan and Korea and chose Korea over Taiwan. Korea was a couple of years, in terms of its economic development, behind Taiwan. There was a U.S. agency, US AID (Agency for International Development), that worked with both the Taiwanese government and then the Korean government to help their industrialization.

Addison: In choosing Korea over Taiwan, what was the main thing that worked against Taiwan?

Pausa: I can't remember for sure. It may have been that the wages were a little higher, it may have been the incentives were not as easy, it may have been that it was a little bit more difficult to work with their free trade zones. I just don't know.

Addison: What about Singapore? You said that was the last project you did at Fairchild.

Pausa: By then we had been in Korea, and we were joined in Korea by Signetics, which became Philips Signetics, and Motorola was in Korea, and RCA was in Taiwan. Probably Motorola and Texas Instruments were in Taiwan. National had started an operation in Singapore before Fairchild by about six months, and Singapore was just very attractive. The Singapore government had changed recently. The British had pulled out...and Lee Kuan Yew brought in the government, changed all of the labor

regulations, and effectively improved the industrial relations department. Singapore used to have an enormous number of strikes. We would not have gone to Singapore in the years before then. They were primarily strikes aimed at the major employer, who was the British military establishment. The numbers of days of work lost for strikes was very high in Singapore. Ultimately, when the British military pulled out, Lee Kuan Yew recognized that they had to do something to improve their economics, so they changed that. The Singapore Economic Development Board was being run by a U.N. assignee, I.F. Tang, and they were very effective in making attractive arrangements. There we started out in either the auditorium of a school or the auditorium of a community center if I remember correctly. We got land, we were going to build a plant in Toa Payoh, but we wanted to get started before we did that so we started in another temporary facility.

Addison: So really, after the British pulled out of Singapore, that's when you started looking at it seriously.

Pausa: Yes.

Addison: So by the time National was building a factory in Singapore you were still at Fairchild?

Pausa: No. In the middle of '69 I joined National Semiconductor. They had started an operation in another temporary facility in Singapore sometime earlier in '69, maybe late '68...in a place called River Valley Road. I joined them [and] my first assignment was basically to find a new plant manager for that plant. So I went to the River Valley Road and acted as plant manager for four months until we found a new plant manager.

Addison: Any particular reason why you left Fairchild to join National?

Pausa: Charlie Sporck and Fred Bialek and a number of people had gone to National and National was very promising. Fairchild, after Noyce and [Gordon] Moore left, had a lot of organizational problems. [Les] Hogan came in '68 and brought in a whole new management team so I was attracted to join the people I had used to work for. Frankly I had two choices. I could have gone to Intel and I could have gone to National. I ended up going to National.

Addison: Did Charlie Sporck actually say, come over and join us?

Pausa: Yes.

Addison: So within a couple of years they built this plant in Singapore?

Pausa: Yes.

Addison: Was that the first offshore plant for National?

Pausa: Well, they did two things almost simultaneously because the plant in Singapore was aimed at their integrated circuit business. They had set up a small plant in Hong Kong to run their discrete business, and it used a number of contractors. So it basically managed the contractors and tested the devices the contractors made.

Addison: Backing up a bit, did Charlie Sporck have a big say in choosing Hong Kong as the site for Fairchild? I know you said Bob Noyce had investments there.

Pausa: I'm sure that [Charlie] and Julie Blank, who had all of the facilities responsibilities, they visited Hong Kong before they said, yes, we can go to Hong Kong. So yes, he had a say. He certainly had a say on every one of the location decisions, both at Fairchild and National.

Addison: At National, were there any U.S. based assembly and test facilities before the Singapore one?

Pausa: Not very much. They had a plant in [Danbury], which was the original National plant, which was primarily a transistor operation and some hybrid devices. So when they saw they had devices that they wanted to manufacture in a reasonable quantity, they decided to go overseas and set up an assembly plant.

Addison: Any particular reason why they would have gone to Singapore, given the comfort level of operating in Hong Kong. Was it just because of the wages?

Pausa: I think it was because of the wage difference. Singapore... gave you an incentive package. It gave you a tax holiday that was quite attractive. I'm sure that made a difference.

Addison: I heard a story, I don't know if it's true, that Charlie Sporck had looked around Asia and he went to the Philippines and saw a sign on a bar door saying, "Leave your guns at the door," and he said, "This place is too wild." Then he went on to Singapore. Is there any truth in that?

Pausa: I am sure the sign was on the door in the Philippines (laughs), because it certainly was when I was on active duty in the Philippines. While I was in Hong Kong, because I was also a reserve officer, I spent some time with the Navy in the Philippines and I know that was the circumstance in '66 and '67 in Manila, absolutely. You checked your gun. People carried side arms and checked their gun everywhere. Frank Yee, who had left Fairchild Hong Kong to set up another company, Microelectronics in Hong Kong, and then left to set up another company, GME in Kaoshiung in Taiwan, had told Charlie that he ought to look at Singapore and I think Charlie went to see Singapore because of what Frank Yee had said.

Addison: So Frank was ex Fairchild in the packaging area?

Pausa: Both packaging and process engineering. He had been at Fairchild Hong Kong as the process engineering manager.

Addison: Were you in Singapore when the new plant was being built?

Pausa: We hadn't started construction on the new facility for National when I was in Singapore running the National plant. We knew we had to do it, I think we had gotten the property because I remember reviewing the plans, I remember working with the architect, but I don't think we started construction at that point. But very shortly thereafter, we started construction.

Addison: Was it pretty smooth? Were there any incidents?

Pausa: No, construction was pretty smooth. They did a pretty good job.

Addison: Before you said there were a lot of strikes but once that finished, what was the labor force like in Singapore?

Pausa: Remember I said the labor force in Hong Kong was very money motivated. The labor force in Singapore was much more family oriented, much more amenable to team activities and "pull together" kind of relationships, so much more relationship building. Unions were pretty much outlawed by Lee Kuan Yew...they did have a state union and TI ultimately got unionized. To the best of my knowledge, we never got unionized. It was a very benign arrangement so we never had any work stoppages.

Addison: By that stage, was the back-end manufacturing still very heavily labor intensive, or had any automation crept in?

Pausa: When we started out it was very heavily labor intensive. Automation really didn't start until about '74, '75. I can't remember whether we started with them, but very soon the bonder of choice was the Kulicke & Soffa 478...we had hundreds and hundreds of them. So compared to what we had been using before, the EMB bonders, they were a step up in terms of automation. Even though originally they still were pretty much manual target and aiming, over about a three year period I think there were a couple of improvements made to them that improved their productivity. But it wasn't until people applied microprocessors to semiconductor assembly equipment that you basically really got any degree of significant automation.

Addison: That happened in the mid-'70s?

Pausa: Yes.

Addison: Were there other plants built in Singapore after the first one?

Pausa: I can't remember if National was the first or not, but there were certainly other semiconductor companies in Singapore. There was Fairchild, there was National, there was Texas Instruments. If I'm not mistaken, Intersil had a plant. Some of the people from National ultimately left, got hired away and [built] a plant about 60 miles away in Muar, Malaysia for SGS. There were a couple of passive manufacturers there that I remember going to plant openings for and there may have been one or two Japanese companies that set up within the first couple of years in Singapore. Oh, I forgot an important player that you normally wouldn't think of in semiconductors; HP set up and they were making optoelectronic devices [in Singapore].

At the end of the '60s and beginning of the 70s, it was [still] a very labor intensive kind of operation, so we ended up pretty much doing a new plant every year. So we had Singapore, then in '71 we put a plant in Penang, Malaysia. Obviously that area had become an enormous center. We were followed by AMD, by Intel, by what is now Infineon [formerly Siemens]. The Penang State Governor, called the Chief Minister, was very actively involved in promoting the whole area and he has been able to live to see his vision realized. That's really very touching.

We went from there to Malacca. In Malacca...we started the plant on the stage of the political organization's community center. I guess Malacca was about '72. In '73 we did a plant in Bangkok. I guess in '74 we did a plant in Bandung, Indonesia. And then somewhere along the line we started a machine tool company in Penang. We were making molds, primarily mold tooling and an outgrowth of that is a company called Gallant Precision Tooling, which is now probably a SEMI member...in Taiwan and China. I can't remember when we set up the first Dynacraft plating operation in Asia, but we set up the Dynacraft operation in Singapore probably around '72 or '73, which was a frame plating operation. Then we set up the Dynacraft operation in Penang, and ultimately grew that into a frame stamping operation. So we had a reasonable semiconductor related equipment and materials operation. Then we acquired Swiss Plating, which was a frame plating operation in Hong Kong, in about 1980 if I remember correctly, as part of the Dynacraft operation.

As I said, it really was our own [semiconductor] products that facilitated the productivity improvement. The microprocessor made improvements of productivity possible because they basically began to use microprocessors to drive the semiconductor assembly equipment. Then you married that with technology that had been developed for the intelligence, photo reconnaissance, activity which is basically view technology and you had developed pattern recognition technology. Then you made significant improvements in the productivity of the equipment over the years. Some of it was very painful. There were a number of times when equipment would come in and it would be months before we got it to work to the expectations that it was supposed to. A lot of people who worked at National did an awful lot of work in terms of improving the equipment for various equipment vendors, from that standpoint.

Addison: That was my next question. Was there any technology transfer from the IDMs to the equipment suppliers, or did the equipment guys come to you and say we have this new machine?

Pausa: They went both ways. They would come and say, here's this new machine, sometimes they'd work and sometimes they wouldn't work and we'd have to make changes to make them work and they would pick up the changes and incorporate them in their new design.

Addison: When you said sometimes it took months to get the machines to work, was it really because the equipment companies were brand new and they were pioneering?

Pausa: They were on the edge of technology and sometimes they did not do an adequate job in terms of proving it out before they sold it. They have certainly gotten a lot better.

Addison: But I guess in those days, the only way to test them was on the factory floor.

Pausa: Yes, but they didn't tell you that, and we bought a number of them.

Addison: Before you said you built a plant a year to add capacity. Did that change with automation?

Pausa: Yes it did. Units per number of employees skyrocketed. So your space requirement went up but you didn't need as many employees, so we ended up expanding in some facilities and contracting and ultimately closing some of the other facilities. We added one more, we added a plant in Seremban, Malaysia, after all the ones that I mentioned. For National, that was the last of the plant additions. Then

with the improvement of productivity, we began to concentrate in the larger facilities in fewer locations because we didn't need as many people, but we needed other economies of scale. And the infrastructure cost got to be important. We recognized that low labor cost didn't necessarily mean the lowest cost of production. There were other things that got in the way of making certain locations better than certain other locations. We closed or sold off some of the facilities in the middle '80s.

Then in 1987, we acquired Fairchild and we got a plant in Cebu [Philippines], a plant in Singapore, we got a plant in Korea, a plant in Nagasaki [Japan]. From a productivity standpoint, the one other thing that was very significant, at least for the National product line for almost 10 years, was that they did a lot of very good work in conjunction with 3M Corporation and Jade in terms of applying tape automated bonding to standard logic devices...which they called Flow 10. It was developed to be very effective and it was very productive until the wire bonding caught up with it. Flow 10 ran for 10 years as a much more productive approach to a high volume, low mix kind of logic devices. And that was all concentrated in Penang.

Addison: So this 10 year period was roughly from when to when?

Pausa: Probably late '70s to the late '80s I think they closed Flow 10 down in probably '89.

Addison: Was it a proprietary thing that they did with 3M, or was it an industry standard?

Pausa: Other people had a lot of trouble applying it, so it never became a heavy industry standard.

Addison: Did National make the equipment for that?

Pausa: No, the original equipment was all made by Jade. There was a follow on version called, if I remember correctly, Flow 70 and there Shinkawa also got into the equipment business.

Addison: Just talking a little bit more about Penang. Did the government there have strong incentive programs to encourage device makers to invest?

Pausa: Malaysia had a program of incentives very similar to Singapore, in terms of tax holidays and the state of Penang had an industrial zone, and the state of Penang was just very easy to work with. They had their own industrial commission who were very helpful in making sure you got all the permits and very helpful if you had any problems. And we occasionally had some minor problems. The greatest problem was Penang is an island [and] the power generation was on the mainland and every now and then a ship would drag an anchor and cut the power cable. So we'd be short of power and they absolutely made sure that the companies were able to keep going by rationing the power sensibly and shutting off power to some of the domestic users for certain hours just to keep the industrial activity going. The government was very easy to deal with and very responsive.

Addison: What about the labor there? Pretty much the same as Singapore in terms of its cultural attitudes?

Pausa: Yeah, the culture was quite similar, particularly because Penang... was not ruled by a Sultan. So it was more similar to Singapore than Malacca was, but in both cases it worked.

Addison: At the height of the situation how many factories did National have all over the world for assembly and test?

Pausa: Eight or 10 for assembly and test plus another four or five for the Dynacraft operations I think we grew to have over 24,000 employees by about 1984 or 85. We had more than 50 percent of National's labor force in the assembly and test area.

Addison: And most of those were in Asia?

Pausa: Yes. So other than the ones in Southeast Asia, National had a couple of small plants that they started in the Caribbean for awhile, Puerto Rico with a small plant in Haiti. They had a small plant for another reason in Australia for a while. They had a small plant in Bello Horizonte, Brazil for a while.

Addison: And in Penang, it was a similar situation in the early days that you were one of the largest employers?

Pausa: Yes, although within five years there was such a concentration of electronics and semiconductor companies. We may have been one of the larger employers, but there were just a large number of companies. I'm thinking about Intel, thinking about AMD, thinking about Monolithic Memories. There was [Siemens], Nortel was there, just a large number of people.

Addison: And again there was a lot of job hopping in Penang?

Pausa: Certainly not like Hong Kong. Hong Kong was unique. Again it was more of a team atmosphere. Certainly there was job changing, but there was more of a team atmosphere in all of those plants compared to Hong Kong. Hong Kong was unique in that people changed at a moments notice.

Addison: What impact did some of the industry downturns have on the factories in Southeast Asia?

Pausa: They were pretty severe. We laid off numbers of people. We tried to make arrangements with the governments and in some cases they would carry us where we could go to a short work week and basically reduce pay. But many times we basically had to lay off. We'd have a 3,000 or 4,000 workforce and we'd lay off 1,000 people. It was not necessarily pleasant. Then a year later, you'd hire back, or hire equivalent numbers back.

Addison: So the local economies were pretty dramatically affected?

Pausa: It clearly had a noticeable impact on the economy.

Addison: I guess that's why Singapore started expanding into other areas like disk drives and foundries and such.

Pausa: Yeah, their grand strategy was to basically move up the food chain and they've done a nice job of it.

Addison: These days the packaging is developed by the contractors and the IDMs in Asia, but back then I guess it was all done in the head office and transferred.

Pausa: Yes.

Addison: How did that work? Was there a lot of shuffling back and forth?

Pausa: There was a reasonable amount of that. Most of the plants operated with a couple thousand employees and maybe two or three expatriates. We had a program where basically we would take qualified mid-managers and bring them to the U.S. for a couple years to work and sponsor them for an advance degree. I think we gave about 15 of those opportunities every year. So we always had about 30 people on that program concept.

Addison: How critical for the competitiveness of a company were the assembly and test operations? In terms of the overall productivity, were they a key factor?

Pausa: For standard logic devices, yes, because basically they're a relatively small die product, so package cost was a significant component of the cost. Whereas for high-end microprocessors it would be exactly the opposite.

Addison: If I could take the last 10 minutes to talk about the rest of your career at National, what happened and when did you leave? What are some of the highlights?

Pausa: I retired in 1990. We haven't mentioned, but we did a number of other interesting things. I guess this started in '77, and this was during one of the downturns, but we ran a program where we were a subcontractor to GTE for a project to build a fully integrated consumer products operation for the government of Algeria, or for the Algerian state company. So we built a semiconductor factory in Algeria over a period of about five years and trained about 30 Algerians [in the U.S.] for a year and a half. Up until 1990 it was in operation, I know that because some friends of mine have gone back and seen it. That was a very challenging set of circumstance.

Addison: So how did GTE come in, did they commission National?

Pausa: They basically had the consumer products which were radios and TVs...and this was a million square feet under roof, it was a big plant. We had about 40,000 square feet for a small semiconductor operation, small fab, small mask making, small assembly line. And then we entered into a joint venture with, I guess it was Saint Gobain, to build a memory company called Eurotechnique in France. We built a [5-inch] wafer fab in Rousset France for Eurotechnique and got it up so that we were about to do the first wafer start and the French government changed. They nationalized the plant. They certainly compensated National. National didn't lose anything out of it and the plant was given to Thomson. Thomson merged with SGS so it became the ST plant in Rousset and it's still there.

Addison: Did you ever get anything out of it before it was nationalized?

Pausa: They gave us one “sou” for it. They paid all the expenses and they paid one “sou” for the company [and] we got preferential market rights in France and so on. National has no complaints. I think they may have gotten some license fees for the technology.

Addison: Was this the beginning of Thomson the semiconductor company?

Pausa: Well, Thomson had other operations, but from the best of my knowledge, France basically assigned this operation to be part of Thomson and then Thomson merged with SGS. I should digress and go all the way back. At one point in time, Fairchild had a share in SGS, and I don’t know how they got the share in SGS, it may have been the result of the Noyce patents. I visited and helped set up a couple of SGS plants, one in Scotland, one somewhere else.

Addison: What year was the French plant built?

Pausa: I think we started construction about ’79 and the government change occurred late ’81 or the beginning of ’82.

Addison: After that, what did you do?

Pausa: I was running the whole group of plants called international manufacturing. When we took over Fairchild, there was a lot of consolidation work with the Fairchild operations. Some interesting side activities; we had a large package development program with Delco, called TapePak, that Delco continued for a number of years.

Addison: The last thing I wanted to ask you about is the emergence of the independent contract assembly houses. Did you notice that during your period in Asia?

Pausa: Absolutely, and we used them. National, in Hong Kong, used contractors to build transistors. We set up a couple of contract operations manufacturing the gem transistor package. One of the operations [National] set up was with Lucky Gold Star. As best I remember it was their first step into the semiconductor world, so this must have been ’69, ’70 that we set up with Lucky Gold Star. We set up with another company called Singapore Semiconductor that ultimately got closed and we had a small operation that was sponsored by the Dollar Investment Trust in Indonesia that ultimately didn’t survive. We used Stanford Micro...we used both Dynetics and Stanford, we used OSE. National was late in the ceramic package, so we started off by saying we’ll contract out the ceramic packages and we used OSE is our first contractor. And for optoelectronic devices we used Amkor in Korea early on. I guess I could go even one step further on a historical basis. Back when I was at Fairchild in Hong Kong, the facilities manager was Roy Pitman. Roy Pitman left, and with the backing of John Carter’s son, John Carter Jr., started a company called Carter Semiconductor, which later became Carsem. So Carsem Malaysia basically traces its roots back to Roy Pitman. They had an operation in Hong Kong first, then they went to Malaysia and the Philippines, and the Malaysia company survived.

Addison: The Lucky Gold Star in Korea, do you recall the name of that operation?

Pausa: It was just part of Lucky Gold Star. They didn't give it a separate name. They started out just building discrete devices for us on a contract basis.

Addison: Did National give them the technology?

Pausa: We gave them the packaging technology. I don't know where they were in setting up their wafer fab technology. I don't think it had started yet, I may be wrong.

Addison: So you were happy to use these guys for overflow capacity needs.

Pausa: Well in the case of gem [transistor], they did all of it. We didn't build that package ourselves. This was a unique transistor package that we were using. I guess it had been developed in Danbury, but we didn't do it.

Addison: OK, that's it. Thanks very much Ed.

Pausa: Before I finish I would like to take this opportunity to express my thanks and appreciation to all the thousands of people who worked with us over the past four decades. Working together, we have helped build a very significant global industry. Overall I found it to be a grand adventure and a truly life enriching experience and I hope that they found it to be the same.

END OF INTERVIEW