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interview

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BIOGRAPHY
1. You are often considered one of microprocessor (computer on a chip) creators. Could you tell how big part do you have in this event, what exactly have you done?

I was the originator of the initial concept realization, it had been postulated before but my design was the first actual implementation concept model (late 1967).
When I was 18, I designed a computer, based on the current newly announced Integrated Circuits from Fairchild Semiconductor. I diagrammed it in a 1-sheet block schematic with comments about function. It was based on the computer I had purchased a year earlier only 100 times smaller. I talked to Fairchild about the concept and they said I was crazy. (Early 1968)

Two years later (April 10, 1970), Dr. Robert Noyce called my parent's home with an invitation to come to INTEL. Upon arrival, he asked me "So what is it you want to do?" I replied "Place the control logic, timing, registers and Instruction decode logic of a computer on a chip" Dr. Noyce replied that "INTEL could not afford to invest in such a project at the moment, but if I could get along with the director of Research and Development, Marcian Hoff, I had a job. I became employee # 243 April 13, 1970 Computer Specialist, Research & Development. I was not required to sign a PATENT Agreement with INTEL.

At the time, INTEL was under contract with Busicom Corporation of Japan to create a custom calculator chip set.

Dr. Mashitoma Shima was Busicom's representative in the USA; Fedderico Fagin was hired to take control of creating the Calculator chip set. When Fedderico provided the calculator chip set cost estimates to Dr. Marcian Hoff, I was sitting with Ted (Marcian) in his office. He looked them over and then exclaimed "This will not work out, the cost is much too expensive". I replied you know the general-purpose computer-on-a -chip we have been discussing, programmed as a calculator, may work as a cheaper implementation. Ted looked thoughtful and then said he would go speak to Busicom about it. Ted went to the Busicom meeting which was a speaker phone conference call between Dr. Mashitoma Shima and Japan in Dr. Gordon Moore's Office. Ted came back from this meeting saying "They went for it"!

At that point, we set about defining the chips. Marcian Hoff, Stanley Mazor, Mashitoma Shima and I bandied back and forth about the instructions and layout. It was necessarily defined as a BCD (Binary Coded Decimal) application (Calculator) so the data was 1 BCD Digit or multiple digits. Four bits was settled upon because of this, also the number odd pins was limited so the data bus was also four wide and multiplexed.

I attempted to get an XOR (exclusive or) instruction included, but Shima could not and would not see it therefore it was dumped. After several, more rounds the instruction set and registers were defined.

I went to a PDP-8I that I had been assigned to use there at INTEL where I used the Macro-Assembler, which I then used to defined an assembler for the 4004. I also wrote a PDP-8 machine-language Binary-image to Hex format converter to derive a memory image of the code, then punch out a hex format tape to give to the production people to code the 4003 ROM devices.

I also teamed up with Dr. Phil Tai to research demonstration applications for the device. We began to design a demonstration board.

One day, I happened to walk into the Engineering Laboratory, actually intending to see Yung Feng, who worked for Fedderico, about the first 4004 chips which he was attempting to coax into life. I happened to walk near Dr. Dov Fhromman, a memory engineer. Dr Fhromman was very upset so I inquired as to his source of frustration. Dov was working on the INTEL 1103 memory cell, I knew. He had a test chip that was exhibiting a real problem. It seemed that when he wrote 0's into it this chip, it read back 0's, then, if he wrote a 1, it read back a 1, but if he then wrote a 0, it read back a 1! The only way he was able to program a 0 again was to remove power! I suggested we should go to lunch to discuss this weird phenomenon. We went to lunch where we talked it over. I never did catch up with Yung Feng that day, it was moot however, and the first 4004 chips were duds, same error to be exact!

During our discussion while at lunch, Dr. Fhromman decided to rent time at Fairchild which was next door to INTEL, he wanted to use their Electron Microscope to look under the aluminum contact layer.
When Dr. Fhromman returned, he was extremely angry. The Fabrication people had forgotten to run the acid etch after exposing the silicon dioxide passivation which is a silicon glass covering which is created by exposing the silicon surface at 1000 degrees Centigrade to pure Oxygen and water vapor. This passivation seals the Silicon beneath from atmospheric contamination.

To etch this silicon dioxide, a liquid photo-resist is placed over this glass layer and allowed to cure. The mask is then exposed to high intensity ultraviolet light to make a pattern for acid etching. The mask is then washed with deionized water to remove the exposed areas of the mask leaving a hole in the mask at these location(s). Etching the silicone-dioxide through the hole prepares a hole into the silicon for contact with the metal. The hydrochloric acid produces these holes in the silicon dioxide where the mask has been removed so the aluminum can get down to the silicon to make contact. Without this, electrons may be deposited through the silicon-dioxide with an effect called migration (electrons are easy to push (pressure from electrons behind them) and much more difficult to pull from something they have occupied (no pressure behind them to push them off)

After the effect was investigated it was found to be useful, of course properly done it worked much better, but you see the Girls in Fabrication did not get any credit at all for their goof/discovery!

The EPROM was created within four weeks. The 4004 demo board was altered to use the EPROM, immediately. Dr. Hoff busied himself designing an EPROM programmer board and a program to run the board. When I got the first 4004 board, we were just about to move to the new building in Santa Clara. We continued the development and proceeded to other interfaces like RS-232, video and Sound.

Dr. Hoff, invited me to his home for dinner. The discussion there was varied, but the 4004 were brought up more than once. The Hoff's were convinced that Society would reject the computer's entry into their lives. I of course, was sure that at least the engineering society would gobble it up like candy. Dr. Hoff's daughter asked me if I had a girlfriend. They presented me with a sighed copy of "Future Shock" which expresses societies resistance to change.

When the Demo was fully working a vote was taken to determine whether to show the device at Las Vegas, Fall Joint Computer Conference. I voted 'aye' everyone else voted 'nay'! I exploded, I slammed my fist on the conference table, called them all "Blithering Idiots" then I stormed out of the room.

Late in the afternoon, I approached Dr. Noyce's Secretary, Ms. Jean Jones; I told her I wished to have a meeting with Dr. Noyce. She checked his appointment schedule then told me that 4:30 was open. I said I would take that appointment. At 4:30 I arrived to see Dr. Noyce, we had a discussion concerning the 4004 and its announcement. Dr. Noyce finally said, "all right, you can take the 4004 to Las Vegas, if everything works out ok, you do not have a problem, if everything does not work out, You and it can stay in Las Vegas!" I replied that I would happily accept those terms, the rest is history.

Except for the rescue of three young Mexican ladies, during my return trip from Las Vegas.

2. When you have started working for Intel, you were very young; you were not much over 20 years old. How could it be that in such tender age you did so much?

At age 12, I entered a drawing contest, to draw a horse's head. The horse was named Trigger, from the Roy Rogers show. I won the contest, then was disqualified because the minimum age of a contestee was 16!

I began studying electronics at age 13, whereupon by age 15 I was beginning to design.

Since when have you been interesting in electronics and computers? How did your childhood look like?

I can remember back to when I was about 1.5 years old. I was very curious, and explorative. I was born in Illinois, but I can only remember after we arrived in California. We lived at 357 N. 19th Street San Jose, California.

Initially I began to read at age 3, My Father gave me a picture Bible and told me he wanted me to report on what I read to him. I had an electric train; the neighbor had 15 electric trains in his basement.

I had exotic neighbors, the Archiletters next door, were Spanish, they had a Granddaughter Nina, the same age as me. The Daley's an older couple lived slightly across the street, they were very friendly and invited me over many times. Down the street two houses was an older Gentleman who created ceramic figures. I visited him quite often, also. Butch, who lived across the street, was not friendly after the first two days of our meeting at age four. I got a new red wagon for Christmas. Butch came over and we had a good time. Butch went home, the next morning I invited Butch to come over and play, Butch began to throw rocks at me. The next day we had a rock fight, Butch lost; my Dad had shown me how to throw rocks the night before, and made me practice. The Marcos family lived across the street, next to Butch, they were friendly, and they had a Loquat tree in their front yard. You have to taste the loquat fruit, it is ambitious! There were five brothers in this family; two were near my age.

My family, which included four Girls, and myself, traveled every summer to the National Parks, to visit relatives. We went to San Francisco, Oakland, Los Angeles and many other cities, and states. My youngest Sister is 13 years older than I am. My oldest Sister has Children 5 years younger than me. I began to sleep less at a young age; I did not want to miss anything! At five I got a parakeet as a pet, the parakeet's name was Joey. I also received two sets of books for Christmas 1955, the Book of Knowledge, and books of Lands, and Peoples. I read all of them, several times.

When I was seven, my parents bought a Gentleman farm in San Martin, 20 miles south of San Jose, California. On this farm, I had room to explore as well as keep large and small pets. I had chores, but sleeping 4 hours per night gives you extra time. When you are infatuated with something, working does not seem like work at all but play. I am infatuated with invention, creation, making and doing things.

3. You had to have some support. Could you specify persons, who have helped in your education and workings?

Initially these people came about in my life after the first six months of High School. Everything before that was on my own. I am very good at self-education. In High School, I met Mr. Earl Rice. He was the Wood Shop instructor. He was also a Ham Radio operator. Mr. Rice introduced me to Mr. George Keller. I knew more than basic electronic theory when I met Mr. Rice, it was more of a place to hide when I wanted to work on special projects at school. It was also Mr. Rice's keys I had borrowed that allowed me into the Principles outer office, to see that Monrobot 9, which, was the first computer I ever touched.

4. Intel Corp. is today one of the biggest company in the microprocessor (not only) market.

How did it look like at the beginning, when you worked there? Intel began in a small building in Mountain View, California. The address was 365 Middlefield Road, Mountain View. There were about 160 people working at INTEL in two shifts when I joined.

5. Before you started work at Intel, you worked for IBM some time.
I worked for IBM for the summer of 1968, the project was the Winchester Disk Drive which style is now included in every PC.

You even have a proposal for paying for your education. You didn't accept it, why?

They demanded that I sign a contract to work for them for five years once I completed college. At eighteen, I felt I was too young to make such a commitment. I had also witnessed two failures of equipment design that were caused by the laxidaistcal attitude of the engineers there. I felt I could not work around such attitudes.

6. Your youth wasn't only work, education, fascination of electronics and robotics, it was also many adventures. Could you tell something about it, describe some situation?

I learned to drive at age 7; I had fun reading the manuals for the cars to figure out all the features.
I visited many places and many people.
I played a musical instrument.
I hiked in the Wilderness, enjoyed the trees and smells of fern.
I have climbed a couple of mountains.
I have driven fast cars.
I have dated beautiful women.
I have done some tricks with a car that some people in the movies have not quite done.
I have been severely injured and have fully recovered over time.

Most of those stories are a minor book into themselves.
If you have a specific item, I could expound.

7. In 1975, you left Intel. What was the reason for this?

Politics, and greed. In addition, I had previously dated a young lady who worked at INTEL, whom they were threatening to affect me.

8. What have you done later and what are you doing now? What are your plans for the future?

I have continued to develop the Robot, and also
to make money I have worked as a Systems Analyst, Network Specialist,

Engineer, and Software Engineer and lately as a Manager. I have developed other products; I plan to bring them out in the near future.

I do not trust the US Patent office, since I have kept everything secret. I have not had any more problems.

COMPUTER HISTORY
9. How do you evaluate an invention of a computer and its rapid growth?
The computer is a very handy tool.

What influence had it on the human's life in your opinion? I think where it is not abused; the computer has had a positive effect on people's lives. Take e-mail, it has brought not only the World but also Families much closer.

10. Which event, do you think, was the most important in the computer history? I think all the inventors that helped computers develop deserve accolades. Of course, the major events, initial Creation, Transistorization, and then Integration are the major steps for hardware, so far.
I think software wise; we are still in the infancy.

11. Who is the person, which had the greatest impact on this field in your opinion? As far as personal computers goes, Bill Gates has it easily. As far as computer usage, I believe the expansion of the computer into the gaming industry was not socially proactive.

12. How do you evaluate an invention and a growth of the Internet?
The Internet was around in 1970; it just only existed between several Universities and three National Laboratories. What happened again was that ole American greed machine. Everyone attempts to jump on the bandwagon, the wagon becomes overloaded, and a wheel departs the wagon tips and only the strongest are able to hold on.

TODAY'S COMPUTER INDUSTRY
13. Computers in today's world are occupying very important position. They are almost everywhere: in a refrigerator, in a washer, in a telephone or even in a human's body. What do you think about it?
As far as computers in the body, I am all for it. My ex-boss at INTEL, Ted Hoff was one of the first recipreiants of this. Last time I spoke to him, about a little over a year ago, we spent more than an hour on the telephone together.
In the mechanical devices I am all for it, in fact one of the devices I have been working on is a totally integrated home.

In what way and how often do you use them?

The computer is my file cabinet, drafting board and communication device. I am never too far away from one.

14. How do you look at a growth of microprocessors and a race between the two giants: Intel and AMD. Do you look at the first one with some sentiment?

I interviewed at AMD before I interviewed at INTEL; AMD did not hire me. I look upon them as Johnny come Laties. INTEL gave me the chance to prove I was not crazy.

15. How do you think will be the future look like, both near and far?

I want to introduce my Robots and some other inventions, some of my friends have asked me to help INTEL, get their stock up. I would
give them one more, if asked.

I want to change society, increase the general knowledge.

I can see us in the Stars very soon if that change occurs, technological jumps could be reduced to 5 years or less.

I see computers growing; I see communication becoming full, with video and sound.

Society has to change, become more conscious of the environment and each other as individuals.

I know more has to be done for 3rd World countries, I look to the Robots to help there a tremendous amount.

I hope to be in shape to visit the moon and maybe Mars, before I die.