# Some Memories of an HP Product Designer

By Bob DeVries

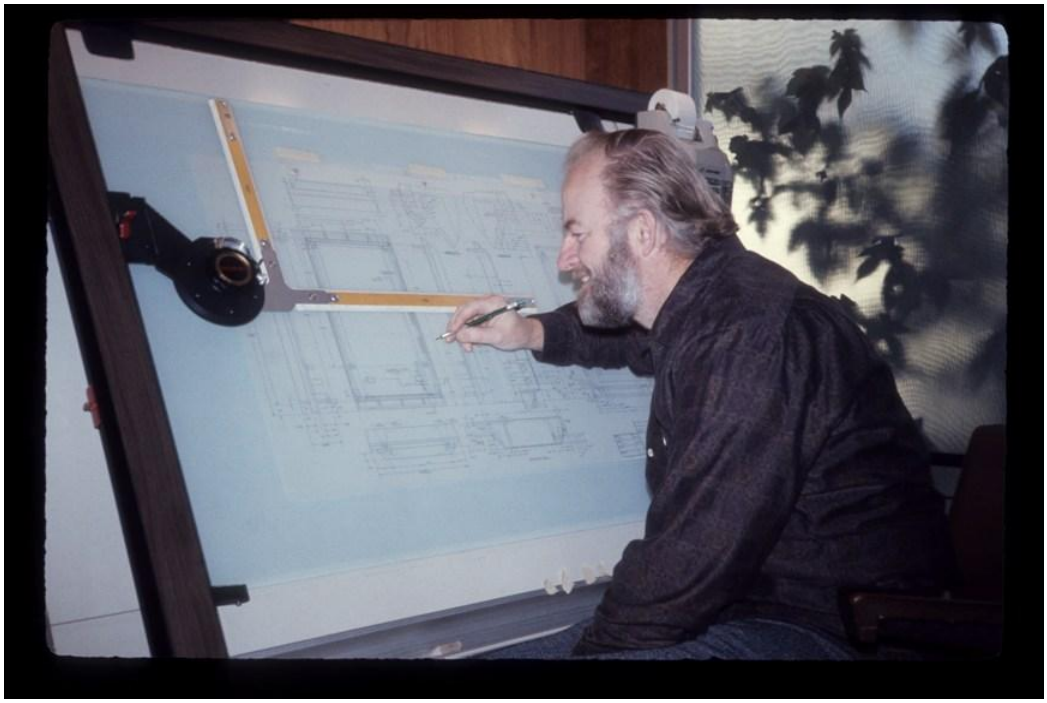
## *Foreword by John Minck*

## *PRODUCT DESIGN AT HP*

*You're a major manufacturer of high-tech electronics, say, Hewlett-Packard. You have more than one certified genius in your Advanced Research Labs. You have a world-class Industrial Design department to create dramatic product styling and the appearance of color excellence. You have bright, clever engineers and circuit designers all over your labs. You have a world class manufacturing facility, capable of fabricating everything from state-of-the-art semiconductors to precision plastic molded parts in any material, to the most intricate machined part. You have the world's best global marketing organization which compiles the new product specifications to precisely fit oncoming customer needs.*

*So what stands between you and a successful new product. It is a person that HP calls a Product Designer. Someone needs to take all of those above circuits and components and create a front panel control structure which makes customers VERY satisfied with its convenience and usability. You need someone to pack all those circuits and hot power supplies and mechanical controls into a small space. You need an internal layout that is easy and inexpensive to assemble, and yet, down the road, if it does hit a repair center, is easy to access failed parts deep inside. Someone needs to design and evaluate the air flow, whether fanned or convection, to assure that the Killer-of-Reliability, heat, is carried outside, even at +55° C (130 F).*

*One of HP's most clever and creative and accomplished Product Designers is Bob DeVries. His 38-year career in the Oscilloscope, Tape Recorder and Microwave Divisions boasts dozens of successful products which meet customer needs with reliable and easy to use instruments and accessories. Bob often said, "I've always felt the stuff I do is a major contribution to the product. The ME on a project can make a decided difference. The circuits can be tops, but if they're not held together right, the product won't work." Bob's memories of those products in the Golden Age of high-tech instrumentation makes interesting reading.*



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Computer control of HP instruments
11715 AM/FM test source
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# Some Memories of a Hewlett Packard Product Designer

**By Bob DeVries**

The Monroe Street Dam on the Spokane River.

## GROWING UP IN SPOKANE OF THE 1940s

The photo above is a downtown view across the Spokane River, in Eastern Washington State. It clearly shows the lovely waterfalls during spring runoff. To the right of the river is the Washington Water Power building. Within that building there was a large AC generator that, using river water, provided electricity to much of Spokane in the early days and still does today, I believe. When I was in grade school the Washington Water Power logo was Ready Kilowatt" a small electric looking man about 3" high, made of rubber, and could be used as an eraser for school children. "Ready Kilowatt" looked like a zigzag lightning strike with a small light bulb for a nose.

***Join HP…Donna gets the credit.***

Donna was born on 1/14/34 and Bob born 4/14/30. Both Donna and I were born and grew up in Spokane Washington. Even though our births were about four years apart, we both had Dr. Lawrence as our pediatrician. (My middle name is Lawrence and named after the fine doctor.) Both our fathers were in business in downtown Spokane. Donna's dad was in the wholesale and retail radio business selling radio tubes, ham gear, radio parts, table model and console radios and phonographs before World War II. The name of his business was the Inland Radio Co. My dad was in the auto parts and car repair business. Early on, dad called his business the Inland Battery Co. Later he changed the name to William DeVries Co.

***Who is Donna?***

If it wasn't for Donna and her mother I may never have applied at HP. The main reason is that her parents decided to move to Santa Cruz, CA for improved weather in their retirement years. And when we came from Spokane to visit, I give them both credit for giving me the incentive and support to apply. Donna's maiden name was Donna Lenzi, a good Swiss name. My folks knew Fred and Edna Lenzi from both a business and church standpoint. Donna's family and our family attended the same church. I was the

youngest in my family and Donna was youngest in her family. I would frequently hear my older brothers and sisters talk about Grace Marie, Donna's older sister and Edna Lenzi, Donna's mom but they never mentioned Donna. I know we all attended the same church. It seems I wasn't paying attention but, at my young age of 6-10, I just didn't know Donna existed. I was actually more interested in older women...ages 8-12. At that young age I was mostly interested in radios, radio parts and anything that looked like radio parts.

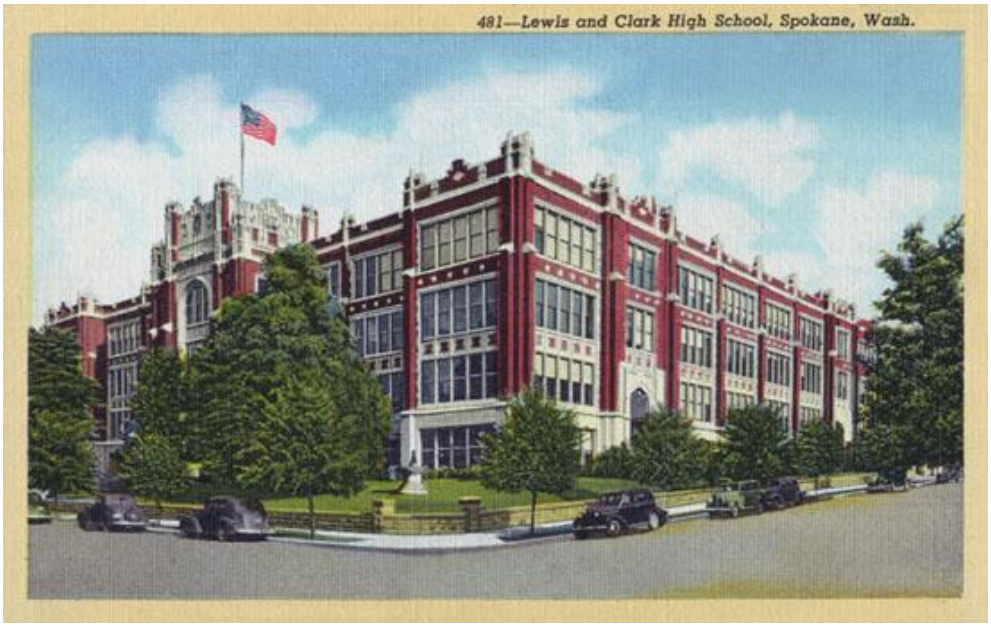
***My father's work ethic***

If I was to tell you the truth, my dad ran a tight ship. My mom passed away when I was about 8 years old. Dad never re-married. He had five kids to raise ages 8 to 18. Plus he had his business to run. My older brothers and sisters got married and went their way little by little until all that was left was dad and me. He wanted me to help him in his business and he insisted that when he turned in at night (at 9:30PM) he wanted me to either be home or I'd be locked out for the night. I'm telling you this because it really cramped any high school dating plans I might have had. Even though I had a lot of friend girls at high school, I really never had any girl friends during those high school years. I never dated anyone while in high school.

My dad kept me under his thumb by having me either in school or when school was out, I would help him in his auto parts and garage business. He had me sweep the floors, shovel the snow off the sidewalks, wash cars and trucks, wash windows in the business and keep up the window display. He really kept me busy and out of mischief. I would run errands all over Spokane either picking up parts he needed or paying bills here and there. Many of my trips across town would frequently cause me to pass Inland Radio Co. I would look in the window display or I'd go inside and just look around at all the beautiful new radios and electronic components that Fred had for sale. I got to know Fred pretty well but I still didn't know he had this daughter called "Donna".

***Schooling for this designer's future***

In later years, while attending Lewis & Clark high school, taking their traditional courses, I took some electronic courses at a nearby trade school. That would be 1944-1948. At the end of each school day my route from high school to my dad's business took me right past Inland Radio Co. Radio parts were hard to get because of the war but I'd still stop by Inland Radio and talk to Fred Lenzi. I learned a lot from Fred. In addition to electronic components I'd learn about business issues, stamps and coins and the Century brand of inboard speed boats. He was a fine man with a good sense of humor, a good stock of interesting stuff and had a good business sense. His radio/electronic inventory was much smaller at that time. During the war he actually sold the radio and radio repair part of his business and went into stamp and coin business. His hobby was stamp collecting and he turned that into a fine business for many years dealing in stamps and coins of the world. Well, I still didn't know about Donna.



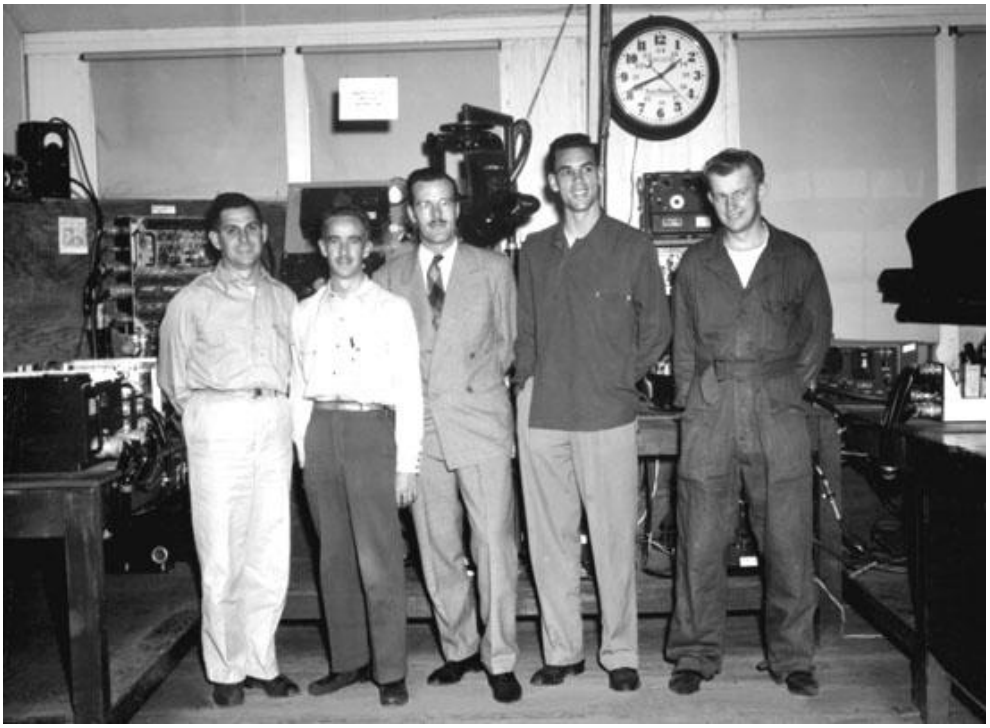
# JOINED THE U.S. AIR FORCE

***What'll I do in the Air Force?***

To get out from under dad's heavy thumb, in late 1948 I joined the Air Force, spent some time in Texas, England, Germany, and most of the time in Merced California, at Castle AFB. After basic training in Texas this PFC Robert DeVries was told to see the captain and get my assignment. He said that they needed a new guy in the mail room. I said, "Oh no please sir not the mail room. I'd really like to work in electronics." The fine captain said, "OK, go see Sgt. Heinz in building 25 and see if he can use you." Bldg 25 was the radio/radar shop. Well, Sgt Heinz and I talked for a few minutes and he said to see Mac in the radio shop. "Maybe he can use you."

***Assigned to the Radio Shop***

I saw Mac and he said, "Let's see what you can do. We have this intercom that doesn't work and hasn't for six months. We have no schematic. Our Philco Tech Rep, who is a civilian, has worked on it many times but can't seem to find its problem. See if you can make it work." I took the intercom aside, checked the vacuum tubes, poked around, saw where some wires were changed from their original location, traced the circuit, moved the wires back where they belonged, plugged it in and it worked. I fixed it in about a half hour. Mac and Sgt. Heinz were quite impressed. The Philco Tech Rep was annoyed that I fixed it so quickly and never spoke to me. He left shortly after. Needless to say…they let me join the radio shop and in about three weeks I was promoted to Corporal and moved into the Radar shop.



The APQ 24 mockup shop at Castle AFB, CA, and the folks involved in setting it up. L to R: Major Andrew J. Meyers, Dean Fuller, Tom Bonsack, Hank Zierenberg, PFC Bob DeVries

***Promoted to the Radar Shop***

Our Radar shop consisted of 4-5 GIs and one civilian, Hank Zierenberg. Hank was a delight to work with. He was a great mentor and I learned a lot from him as we worked together. One day he was working on a Synch unit for the APQ-13 radar. He caused quite a fuss when showed Major Myers in the front office his improvement in the Q-13 display. By changing the value of a mica capacitor, the display went from blurry to crisp. It was so much sharper it would improve bomb and navigation accuracy. I asked him how he knew what to change to make such an improvement? He said his contribution would differentiate (a mathematical term) the video waveform just a little resulting in a sharper display. It was in the video amplifiers for the intensity modulation of a PPI display. I wondered why the original designer of this amplifier hadn't thought of that. As a dumb lowly GI, I was in awe of Hank after that.

***Bombing Competition using Radar***
At that time our B-29s were all fitted with the APQ-13 ground-scanning radars. There were several major units within the aircraft and a rotating antenna facing toward the ground on the underside of the fuselage. Being in the Strategic Air Command, SAC, we would have bombing competition between various SAC bases. It was a big deal for a particular base to win the competition. In any case, I was told I was going along with our crews to analyze and repair any Radar failures. I had only been assigned to Radar repair for about a month. I'd never seen a Q-13 before this. It seemed that I was the only GI there and all others were officers. Well, in summary, Castle Air Force base won the competition. I (as well as others) got a letter of commendation from the base commander for a job well done. Fortunately for me, all the Q-13s worked and I really didn't do anything. It wasn't long after that we switched our SAC aircraft from B-29s to B-50s and a different radar set.

***The APQ-24 Radar mockup arrives***
One day I came to work and Hank was painting some new workbenches the traditional military olive drab color. He invited me to grab a paintbrush and help him.

I asked him what these benches were for and he said our shop was getting a new Radar to replace the old and obsolete Q-13. He said we'll have an actual Q-24 mockup in our shop to help repair and evaluate various plug-in modules. OK, that's cool…I pitched in and helped paint those lovely new benches.

A few days later all the components came to our shop so we could put together the Q-24 radar. It was exactly like those in our B-50 aircraft but all circuits and housings were available for servicing and repair. The rotating antenna was mounted on the roof of our building and we could see targets out 150 miles or more. It had all the bells and whistles one would want. There were more than 150 vacuum tubes. There were lots of selsyns, servos, resolvers, tapped potentiometers, pots with special tapered windings, relays, motors, etc. It did a lot of math in the air and even allowed the pilot to release plane steering to the Radar officer who would control the plane, fly toward his target and release the bombs at the right time.

***Sequence of Repairs***
If, for some reason the radar operator thought his radar was inoperative, He would report the problem to the flight line radar service. Those guys would go out to the airplane, connect a motor generator to the plane, throw some switches on the Flight Engineer's panel, that applied the proper power to the Radar. Now the tech could operate the radar, find the black box that was inoperative and replace it with another black box. He would make sure it was all working and shut down. He would turn in the black box to our part supply stock room with a tag marked with the problem.

In our shop, one of us would go to the stock room, pick up the bad black box, plug it into our system, confirm that it truly was inoperative and proceed to fix it to the component level.

***Q-24 Training***
This Radar was designed and built by Western Electric. They sent out with the Radar a couple of Technical Representatives (Tech Reps) to help us get it all up and running and to answer any questions. Tom Bonsack and his partner, Dean Fuller, were there also to teach us all about the new radar. That course lasted about two weeks. They went over each schematic drawing and spent a lot of time on the operation of the electro-mechanical computer and how the radar would deal with pitch and roll, air speed, heading, winds, etc. This class was very interesting to me and I learned a lot of radar theory in class and practical airborne radar repair during my remaining Air Force years.

***An Extra Year*** in the ***Air Force …Then Discharge***
Because of the Korean Police Action, my enlistment was extended one more year. I got discharged from the Air Force on August 1, 1952 and moved back to Spokane and stayed with dad. Now Donna is 18 and I'm 22. I still didn't know about Donna so we never communicated during my four years in the Air Force. But, here is how Donna and I met.

## ON TO FIND HEWLETT PACKARD CO

***Television in Spokane***
This was 1952 in Spokane you recall. Spokane was a little slow getting television installed and working in the local radio stations. One station, KXLY, was installing a large TV antenna and transmitter on Mount Spokane. That was the tallest mountain nearby. My brother Adrian worked at radio station, KXLY, first, as a

radio announcer, newscaster, master of ceremonies, disc jockey and later as a TV host on local programming.

After the Air Force I worked at GE Supply. GE Supply was the local distributor for GE TV sets and other GE parts and appliances. Part of my job was to open each TV set box and make sure it worked and if it didn't, I would mark the carton for later set repair. Because I worked at GE Supply, I was able to get a fine new black & white GE TV for Fred at a discount. Fred was out of the radio business by this time and really appreciated getting a good deal on a new set.

***A traveling salesman for William DeVries Co.***

New opportunities come when least expected. I needed more income and my brother, Bill, worked for my dad selling service station supplies and auto accessories. Dad had several large trucks on the road selling to service stations within a two-hundred-mile radius of Spokane. Bill's territory was north to Canada and west to Coulee Dam. Bill had been on the road for several years and wanted a change. In March of 1953, Bill wanted to sell me his load of merchandise and dad would sell me the truck that Bill was using. Even though I'm not much of a salesman I decided to do it. I ended up with a truckload of spark plugs, fan belts, car polish, bug deflectors and a lot of other automobile supplies and a pretty good International one-ton truck. It was like a big bread truck with shelves full of stuff to sell to service stations. I received Bill's established route, good customers and quite a large debt.

The income from the truck and route was pretty good but the hours were long and I had to be away from home most of the week. I'd leave Monday morning and get back Friday afternoon and spend Saturday loading up the truck for next weeks route. We replaced most sold merchandise by buying it from dad at 50% off retail and sold it to service stations at 30-40% off. Each week I sold enough to pay expenses, to pay off my debts to dad and Bill and still have a little left over.

***I'm about to meet Donna***

I met Donna at a party at her parents' house where they were going to show the wedding movies for Donna's sister Grace Marie. I was also told that there was a pretty sister-in-law, Carolyn, who was attending and that I might be interested in meeting her. So, yes, I'll attend. About August 15th, I drove my 1942 BRIGHT RED Chrysler Convertible to Fred's home and met Fred again who I hadn't seen in more than four years. It was so good to see him. I met other mutual friends at their home that evening. I'm sure I met Donna right after entering their home but I just can't remember meeting her.

There must have been about 10-20 chairs set up also. It was time to sit down for the movie. Jim's sister, Carolyn, was toward the back of the room with an empty chair to her right and Donna was sitting toward the front of the room with an empty chair to her left. I wanted to sit in one of those two chairs but which one? There might have been other empty chairs but I didn't see them. So, at this crossroad in life, I decided to sit next to Donna.

While sitting and watching I was thinking it would be fun to get to know Donna better. What to do…what to do? The thought came to mind that she might like to see my bright red car. Anyhow, after the movie I asked her if she would like to see it. She agreed to come out front and see the car. She said she liked it. Then I asked if she would like to go for a ride. It was a lovely warm night and we'd have the top down. She agreed to go for a short ride. She wanted to get a wrap and scarf. She looked so cute with the scarf over her head and tied under her chin. I don't remember exactly where we went. We had a nice chat, I respected her wishes and kept the ride short and brought her home safe and sound.

After leaving her, I continued thinking about her more and more. I learned she worked at the AAA about a block from my dad's place of business. I stopped in to see her from time to time. We got to know each other better and started dating and spending more time together. You know how you feel when you are away from someone you really like? That's how I felt about Donna. I couldn't get her out of my mind. We had a memorable courtship, going on picnics, cooking and listening to 45 RPM records, spending time at Donna's parents cabin on the  Coeur d' Alene Lake or go to the Spokane Natatorium Park. Natatorium means, "Indoor swimming pool." With my father's 9:30 pm curfew, my sister, Dorothy, would help me by arranging for me to come back to her house after a late date.

***Bob & Donna marry on 5/2/53***

Before we got married and for about five weeks I had been on the road selling service station supplies and automobile accessories out of my truck. On the second of May Donna and I got married. After our wedding on that beautiful and memorable Saturday morning, we had a lovely wedding breakfast at the Desert Caravan Inn and later, an afternoon reception at our home. After the reception, we kissed everyone

goodbye and headed toward Idaho in my bright red Chrysler convertible. We stopped a few blocks from our home to remove the many tin cans and shoes tied to the rear of the car and we also removed the traditional "Just Married" sign from the car.

***A honeymoon to remember***

After about thirty miles, we stopped at Fowler's Café in downtown Couer d' Alene, Idaho for a delicious early dinner. Donna remembers she had French Fried Crab Legs for $1.60 and a piece of homemade pie at twenty cents. (Those were the good ol' days.) After dinner we headed toward the "Clark House" a fine resort hotel at lovely Hayden Lake in northern Idaho.

We stayed in the honeymoon suite in this beautiful hotel for only one night. We had the whole hotel to ourselves because it was early in the season and they had no other overnight guests. But, the Pacific Telephone Co. had a very large and noisy telephone company party that stayed half the night. I don't know how many folks attended but there were many and was quite loud. It went on and on into the night. Donna and I were snug in our room though. We ignored the party and had a fire in the fireplace and spent the evening hugging, kissing and reviewing the day. The next day we went hiking and sightseeing around the hotel grounds, just enjoying each other's company and the beauty of the area. We checked out of the Clark House late morning and headed home.

Clark House, a fine resort hotel at lovely Hayden Lake in northern Idaho.

As I said before, my dad was a no nonsense kind of guy. He encouraged (insisted) that I get back on my route on Monday morning after our overnight honeymoon. He said, "Bob your customers are depending on you to be there every two weeks." You must not let them down. Even though I was 23 at the time, and an adult, I continued to get constructive comments from my dad and I learned at an early age that it was best not to argue with him.

Donna and I figured out a way to extend our honeymoon. Donna could accompany me on my route (oh boy!) selling to service stations. She would get to meet many of my customers and friends, see a lot of Eastern Washington and up to Canada and we would be traveling together for four days and staying in several different motels. We would drive from town to town, I'd stop at 4 or 5 service stations in each town, talk to the proprietor and sell him the items he/she wanted then we'd drive to the next town. It wasn't a perfect honeymoon…not the kind that young ladies dream about but we were together and it was very nice having Donna with me. It made dad happy that we were taking care of these all-important customers.


"On the Road Again!"

***Selling service station supplies***

I'd like to tell you about some of my experiences as a traveling salesman. Keep in mind that my heart really wasn't into selling. My dad and brothers are fine salesmen but I'm not. I didn't like selling, I didn't really want to be on the road. I didn't like trying to talk someone into purchasing stuff they didn't want or need. My heart was really into electronics but there was nothing but radio or TV repair (which was new to the Spokane area) and the pay as a radio repair technician wasn't very good. I actually missed being in the Air Force fixing those fine Western Electric Radar sets. I didn't want to re-enlist. Air Force pay wasn't all that

good either. I considered going to college on the GI bill but now I had a wife to support. (I was eligible for the GI Bill because I was in the Air Force during the Korean conflict.) So a pretty good paying job had to be the answer.

My brother, Bill, sold a lot of stuff on his route because he was an excellent salesman and sometimes would promise the proprietor that he would take back the merchandise if it didn't sell. As you recall, I took over Bill's route. More than once I had to take back stuff that my brother sold to "Sam's Shell Station" or "Joe's Union." Usually this stuff, displays of key chains or spinner knobs, was partially sold and dull, faded or dirty from sitting in the window of the gas station for 10-15 months. Accepting back that stuff sure cut into the profit for the week. In addition it's hard to re-sell used faded merchandise. Plus most of the merchandise on our trucks was already quite shop-worn because of the dust and jostling as the truck went over rural and dusty roads. Our trucks were fitted with shelves so merchandise could be displayed in the truck and customers could enter the truck, see the various products and shop.

I don't want to sound too negative about these three years. There were several positive benefits being on the road. I was pretty much my own boss. I could earn as much as I wanted…I only had to work harder calling on more stations. I met a lot of very nice folks. I learned a lot about Northeastern Washington. The air was always fresh and clean along with beautiful scenery. I learned about profit and loss and being practical in investments and in the purchase and selling of merchandise. I got lots of exercise jumping in and out of the truck, moving stock, sorting stock and delivering stock. Looking back, I was quite physically fit.

***Big sales aren't everything***

An interesting side note…this same service station had been in business for several years. He was a moderately good customer. Generally items purchased from my brother, Bill, and me were paid for either by check or cash. Later, on another trip to Twisp, I stopped at this station and this time the proprietor was more than interested in purchasing lots of different items from me. I was so happy that I was making such a large sale. The total added up to several hundred dollars. Well, he asked me to charge the amount until my next trip up. That would be two weeks. That's not too bad…I could live with that. OK, let's do it. I charged all the stuff he bought. The next trip up, he was gone and out of business. He was nowhere and not available. All my merchandise was gone. My investment lost. I tried to find him to collect but got nowhere. I never did locate him and collect the money he owed me. We live and learn…don't we.

***From Spokane Trade School to finding Hewlett-Packard***

OK, I'm getting close to telling you about joining Hewlett-Packard. Actually, at this time, the only knowledge I had of HP was their new Audio Oscillator (the 200C) that we had in our electronics class at the Spokane Trade School. I didn't pay too much attention to it at the time (1948) but the instructors were pretty pleased with it and said it was easier to use and more accurate and stable than beating two RF frequencies together to get an audio frequency. While in the Air Force for four years, I didn't see or use any HP equipment. And being on the road for three years, I never gave HP any thought. We just can't jump directly into 1956 and how I learned more about HP. This story will all make sense in a few more pages.

HP 200C

Shortly after we married, Donna's folks moved to Santa Cruz, California. Her mom often dreamed about living in the warm California climate. They built a new home along the San Lorenzo river. It was close to where the river emptied into the ocean. Fred had his stamp and coin business in an office and show room adjacent to the street. On this same property was a small cottage where Donna's sister lived with her hubby, Jim Swartz. Donna's folks would come up to Spokane to visit us from time to time. It was always good to see them.

In 1954 Fred wanted to get a new Cadillac and he offered to sell me his '49 Cadillac for whatever I could get for my bright red '42 Chrysler. I'll have to admit, I was getting a good deal but we were really going from a pretty hot (and old) "young man's car" to a deluxe gun-metal gray "old man's car." With some parting sadness we sold my old red Chrysler car and got the Cad. We were driving in dependable luxury now. Donna's folks were very kind and generous to us. We appreciate all they did for us. Fred purchased a beautiful baby-blue 1954 Cadillac and was like a kid with a new toy.

Donna's mom (Gram) came to Spokane for a few days to help with the new baby. We were glad to have her help. Donna quit her job at Kaiser Aluminum and became a housewife and mother. Christmas of '55 Donna, JoDee and I went to Santa Cruz to visit her folks. One evening Donna's mom told us about her friends from church, Mr. and Mrs. Hanisch. They told Gram that their son, Bill, worked at Hewlett-Packard and said it was a fine place to work. They said that HP does a lot of work in electronics. Gram suggested that I drive to Palo Alto and check them out. I was semi-enthused. I really hadn't planned to do any job hunting while on this vacation visit. Before this Donna and I never discussed applying for a job and moving to California. I was sure I would be a traveling salesman the rest of my life, even though I didn't like it.

***My interview at Hewlett-Packard***

Over the weekend, I gave it some thought and the next Monday I drove over to HP at 275 Page Mill Road in Palo Alto, CA. I went to the front lobby and asked the telephone operator for Bill Hanisch whom I never met before now. Bill was a nice guy…I liked him right away. Bill was a circuit designer working in the lab at HP. I told him I was interested in getting into electronics and told him of my radio and radar experience in the Air Force. (I really didn't do my homework up front. At this time I had no Idea of all the products made by HP but I knew it was more than just an audio oscillator.) I had no idea if HP was hiring. I was very naive when it came to big business and interviewing. Maybe I should have called for an appointment or something? Why am I here? How did I get into this situation?

Bill introduced me to Anne Laudel who was the front office receptionist and telephone operator. He told her I wanted to fill out an application. She gave me a form to fill out. She told me that my timing was good and that HP is doing some hiring and expanding at this time. I told her I was down here on vacation from Spokane and would only be available today. After the form was complete, she introduced me to Don Peebles and Ray Demere' in the production department. Don gave me a written test of about 20 questions. I didn't do too badly on the test. I didn't know what VSWR was but I knew what SWR meant. I didn't remember all three leads of a transistor but I got two of them right and all the other questions answered correctly. Don didn't say they would hire me. He said they would let me know. I learned later Ray Demere' told Don, "I wouldn't hire him but you can if you want." Roger Early gave me a plant tour. I was quite impressed with HP by the time I left.

In the Air Force in our radar sets we used magnetrons and klystron tubes. Varian was in the klystron business. I was a little familiar with their products. I also had a Sylvania tube tester and bought and sold lots of Sylvania vacuum tubes when repairing radios while in high school. So, after my visit to Hewlett Packard, I checked with Varian Associates who were not hiring at this time. I drove to Sylvania and applied there. We talked for a while and I filled out an application. I really didn't know much about either Varian or Sylvania and wasn't sure how I'd fit in at either place. I just wanted to make the most of my trip to Palo Alto and get my application into any stable and interesting electronics firm.

***Hired by HP and quitting William DeVries Co.***

After our delightful and rewarding Christmas trip to California, Donna and I returned home. We got back into our daily routine of Donna being a wife and mother and my calling on service stations. About February '56 we got a letter from Sylvania with an offer to come work for them. A few days later I got a call from Don Peebles of HP asking why I wasn't there yet. He was telling me I had a job with HP. I was so excited and pleased. He said I would start in the test department. He asked how soon would I be there to punch in. I told him at least a couple months because I had to sell my truck and route. That would work for him, he said. I had nothing in writing that I was hired…just the call from Peebles but I didn't worry (very much).

Now you can see that this “Y” in the road of life brought me to HP. With the help of Donna, her Mother, Mrs Hanisch, and Bill Hanisch I may have missed this wonderful opportunity. It was meant to be.

Telling my dad that I was quitting the route and moving to California wasn't too much fun. He really wanted me to continue on the route. It was clear that he was quite upset with me. It took him a few days of advertising and some convincing of some candidates that running a service station supply route was a good way to make money. The buyer of my stock and route was financed by his well-to-do brother. I rode along with the new guy for a couple weeks to introduce him to the route and customers. Then we emptied the truck, washed it inside and out, inventoried all the supplies, re-stocked it and sold all the merchandise, truck and route to this new guy. He did object to including the few Ford Model "T" ignition coils that were in the inventory. Not much market for them in 1956. (I don't remember his name. I heard that several months later he ran the truck off a cliff and lost truck and all the stock, but he was insured.) I think he wanted off the route. I don't know who took it after that.

# TEST DEPARTMENT 1956-59

***First day at HP with more to follow***

On April 16th, I went to HP and asked for Don Peebles. He introduced me to Jim Hobson who was a line leader in the test department. Jim was a great guy and my boss for several months. The test department was fun and interesting. I didn't realize all the instruments being built and tested. Lots to learn here. After a tour of the facilities we got down to business and I was introduce to the 212A Pulse Generator. I was shown how to test them, what to look for, adjustments to make, test card to fill out, and where to put the tested ones. I thought I had maybe four or five to test but production runs were usually 25, 50, or 100 instruments. Maybe we had 25 of the 212A to test. Actually they all tested pretty well. I got through my first run OK with no rejects.

HP just finished designing the 211A Square Wave Generator. I was assigned to test this first or second run of 100 units. As new instruments were tested one would check operation at high and low line, calibrate the output to match dial readings, make sure it has the proper output, etc. Well, The 211A has a Symmetry control that changes the frequency output depending on the setting of that control. I had about 25 units rejected because I didn't know the Symmetry affected frequency. I was told that the symmetry of the square wave should be set for a symmetrical output before the frequency was calibrated. I had to re-test and re-calibrate about 25 Square Wave generators. That wasn't too bad and about the biggest mistake I ever made in the test department.

I was truly enjoying my work at HP. Its So much different and better than being on the road. I can be with Donna and JoDee every night. No long lonely trips trying to sell stuff to people. I have no uncomfortable truck and no truck problems to deal with. I'm so happy that Donna's mom suggested looking up Bill Hanisch.

I had lots to be thankful for. I had this wonderful new job doing what I love to do. Every Friday afternoon auctions of rejected parts were held at Don's desk. During the week there were lots of parts and vacuum tubes rejected for one reason or another. On Fridays Don Peebles would auction off this good stuff. The first thing I purchased was a bag of 6BH6 vacuum tubes that didn't meet spec. There were more than 50 tubes in the bag that I got for twenty-five cents. I actually never used any of them but what a good deal. Many times there were AC-4A decade counter modules that were auctioned off for $0.50. Lots of components and hardware were available free or for nearly nothing. Incorrectly wired transformers were cheap. For folks interested in building electronic stuff…this was as close to heaven as one can get.

The money Don got for these items went to the entertainment fund for the Harmony Plotters, a social HP group. Frequently there were beer busts and celebrations for one thing and another. The free coffee and doughnuts every morning was far more than I ever expected. I couldn't believe they would have an open stock room with all kinds of parts and components available. Everyone was knowledgeable, kind, helpful, polite and fun to work with. There was so much to learn. I know I was a extremely lucky guy to be hired by this fine company.

HP-4A Decade Counter

I spent a few short years in the test department but later I was really fortunate to be selected to become an engineer/product designer in the lab. About 35 years later I retired from HP.

***Recalling many early details***

I'll just continue on from April 16, 1956 (the day I started at HP). One must realize that recalling happenings of fifty years ago is quite a challenge. That is especially true for a slow learner/fast forgetter like me. This section will cover some of my home and work activities and learning experiences, as a "Test Engineer" in the test department at HP

My test department activities covers a little over three years. When I joined HP, I think they had about 600 employees. I was quite sure I'd be working in test for my working career. I had no idea what the future would bring. I was quite naive and never worked for a large company like this before. I didn't know the history of HP and its potential for growth. I was just very happy to be off the road, living in California and have this fine new job working in electronics again.

***A place for home projects***
When we moved to Palo Alto we purchased a home at 3417 Cowper St. Our new home was almost within walking distance of my new job. I walked it a few times and biked many times. We moved to Palo Alto with our 14 months old daughter, JoDee. Our new home was more of a cracker box and built by Stern and Price builders. It had a wall furnace, two small bedrooms, a bathroom, kitchen, dining/family room and living room. It had no garage but a small shed attached to the front of the home and at the end of a short driveway. I had a lot of hand tools, power plane, router, drill press and table saw that I brought from Spokane. That shed worked quite well for my tool storage and workshop. This shop was about 10' wide and 6' deep and was a little crowded but not too bad. Any table saw work was done out on the driveway. Within a week I was putting all those tools to good use.

***Reporting for work at HP***
I was hired into HP test department for $1.80 per hour (plus 35% bonus). I reported to Jim Hobson who reported to Don Peebles. I think Don reported to Ray Demere or Ed Porter…I'm just not sure. I started in Test in building 7B at 275 Page Mill Road in Palo Alto, CA. A couple years later some of the assembly and test lines moved to new buildings up the hill at 1501 Page Mill Road at Stanford Park. I was then on Test line 6 in building 2-Upper. Bob Schauer was the Line Leader for assembly. I was the line leader for test.

The first products I tested were the 211A Square Wave Generator, The 212A Pulse Generator and the 712A Variable Voltage Power Supply. A little later I was involved in testing our new 130A Oscilloscope. And at that time I was selected to be a line leader on the scope test line.


HP 211A

My first testing of an unfamiliar product was a learning experience. There was a written test procedure to follow. But, usually there was another technician that would take me, the new guy, through the test procedure and discuss the schematic and how the circuit works. Some things had to work properly and be set before other circuits could be tested and calibrated. For example, the power supplies had to be set and tested at high and low line for voltage stability and regulation before any amplifiers or oscillators could be tested and calibrated. Many times the product would be smacked on the side or lifted off the bench and dropped just to ensure there were no intermittent problems.

***Jumping small hurdles and learning new things***
I don't remember why, but one day, shortly after I was hired, I needed to make a copy of a drawing. I learned that in the office area there was a room that had all the drawing masters filed in logical order. There was a Brunning copy machine against the wall. Someone helped me find the drawing master I needed but I had no idea how to run the Bruning blue-line machine. There were lots of knobs and switches on the machine. Then there was the print paper that had one good side. Then what goes on top, the vellum or the print paper? Is the good side up or down? What print speed? I didn't know and I just didn't want to screw things up. So I asked one of the nice ladies near by and she showed me the copy procedure. Since then, I'm sure I've made a million blue-line copies of drawings but that first one was a memorable experience that scared me. I was so green and timid at first. I just didn't want to do something stupid.

***General routine for a test guy***
My general routine as a test guy went something like this. The new instruments were assembled and wired then placed on a four-shelved dolly. The dolly could hold about 16 or so large instruments waiting to be tested. There was a pre-printed test card accompanying each instrument with the instrument serial number noted on the card. The card acted as a guide and reminder to the test tech, to set and calibrate all the instrument's parameters for long-term reliable service. After the dolly was loaded it was rolled near my workstation. These instruments have just been assembled but had never been turned on. I lifted one off the dolly and set it at my workstation.

For a test tech, this is the exciting part. I'd look the product over for any obvious wiring errors or assembly problems. Are all the tubes in the correct location? If that all looked good, I'd plug it into a Variable voltage AC source called a Variac. I'd slowly bring up the AC to the product while monitoring the DC voltages in the instrument. I'd be on the alert for anything getting too hot or funny smells. If all that went well, I'd continue

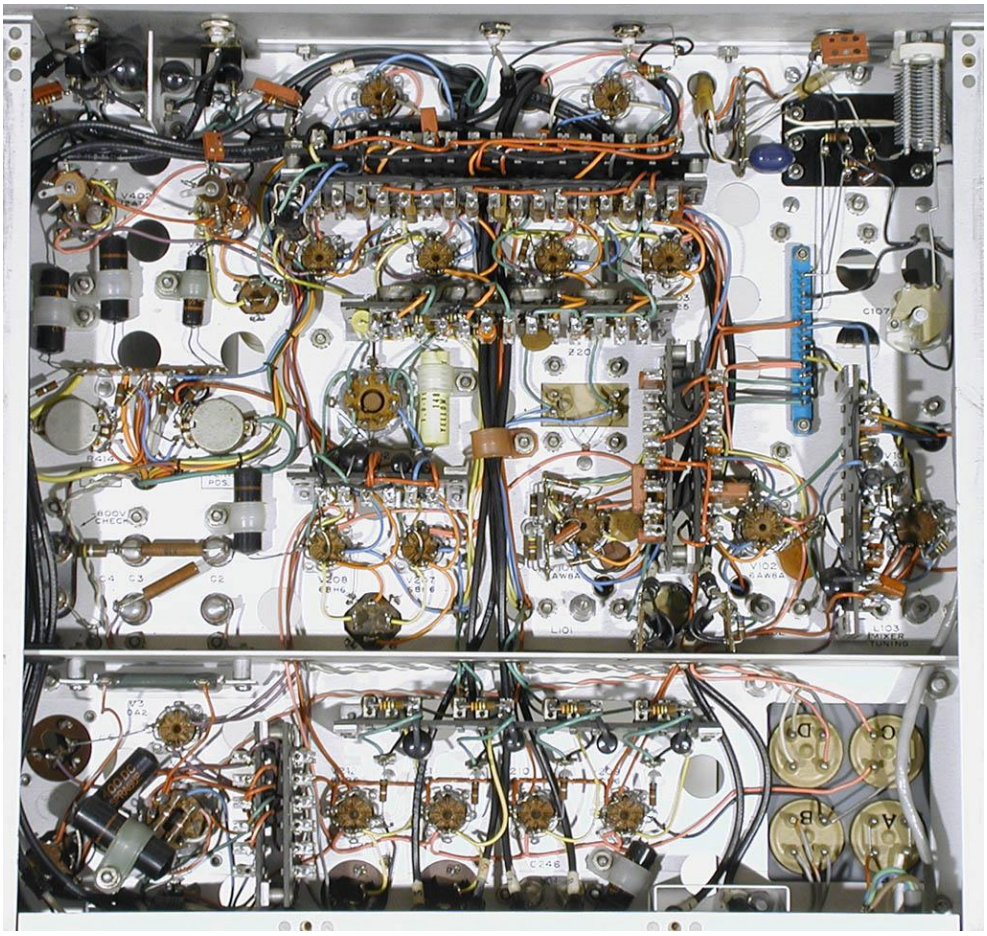
on with the test and calibration procedure. As the various parameters were tested the results were noted on the test card.

It didn't take long to become familiar with the new instrument, especially after testing several dozen of them. Sometimes an error was made in the wiring of the product. Maybe it would be a consistent error and the wiring/assembly line leader was called over to check for the error in other instruments waiting to be tested. Many times the wiring ladies would be asked to make the repair because their soldering technique was more professional looking than the technicians.

Sometimes wiring errors caused Allan-Bradley carbon resistors to overheat and they had a distinctive smell when they burned. So finding a wiring error or problem just amounted to following your nose and checking that part of the circuit that has the black or charred Allen-Bradley resistor. Sometimes the plate of a vacuum tube would glow red because it was overloaded due to a wrong or defective component or wiring error. That red glow caused the tech to focus on that part of the circuit for wiring errors or component problems.

Back then, there were no transistors and few semiconductor diodes in our products. Nearly all our products used vacuum tubes. Tubes run quite hot so many instruments required fans to keep the unit cool and air filters to keep out the dust. When changing tubes to solve an operation problem one could easily burn fingertips. All the tubes required high voltages to operate. Usually 200-400 Volts DC. When trouble-shooting for problems the tech had to be careful to respect those high voltages. It really shakes one up to get across 400 Volts DC.

There were some occasions where a couple of wires in a cable harness would short and that would cause the wires to get hot which would cause the plastic insulation on the wires to melt resulting in a ruined wiring harness. Some harnesses had more than 100 wires (200 ends) that had to be carefully disconnected. Then the new harness is re-installed and re-soldered in place. It was a very big job and a costly wiring problem to correct.



Typical Point-to-Point Wiring, circa the 1950s

Most of the HP products of that time were point-to-point wired. One of the early HP instruments using the new technology of printed or etched circuit boards was the 523A Electronic Counter. And later HP came out with the 150A and 130A Oscilloscope. Otherwise all other products were interconnected the traditional way using tube sockets, cable harnesses, jumper wires, tie points and terminal boards.

***A new baby, a new home and home projects***

Much to my surprise about June of '56 Donna tells me she is expecting another little baby. Oh, my…that is good news! Now what'll we do? About July I got my first raise of 10 cents/hr. Boy, that'll help a lot!

While walking one evening, we passed some new tract homes being constructed in our neighborhood. They were called Eichler homes. They are of modern design, single level, slab floor with a lot of windows. We both fell in love with them and considered purchasing one if we could afford it. We realized that our present home would be a little too small with the new baby coming. A few days later, while on a drive in Palo Alto we passed another tract of new Eichler homes on Edgewood Drive. We stopped in at the sales office, talked to the Eichler folks, got a home tour and found the perfect home for us at 2047 Edgewood. It was a single level, fenced yard, three bedrooms, two bath, family room/dining room, Kitchen, two car garage and radiant heating. All this for just $18,950.00. On 9/15/56 we sold our 3417 Cowper home for a little more than we paid for it and purchased this new Eichler. A few days later I got another ten cents/hr raise from HP. Things are really looking good.

***New 130A Oscilloscope with problems***

About January '57 our production line built 10 lab prototype 130A Oscilloscopes. They went together pretty well but had lots of aesthetic problems as well as some technical problems. This design was essentially rejected by production and sent back into the lab for further design. (I was surprised to note the production folks have a big input on new designs coming out of the lab. This was a good example and eye-opener for me. But, I had to agree. The interior design of the scope and wiring looked pretty bad.)

HP 130A

HP was continuing to grow and production quantities were larger. It wasn't too long before HP installed several roller skate lines at bench height, to move the instruments from station to station. The instruments were placed on a sheet of Masonite or plywood that rested on the rollers and processed down the line as they were assembled and tested. The 150A Oscilloscope, the 608A Signal Generator, the 524 Electronic Counter and some other products were too large and heavy for the assembly ladies to lift. The rollers allowed us to just push the instrument down the line rather than carry it from station to station.

In a few short weeks the redesigned 130A was ready to be assembled and tested by our production department. I was made the test line leader of the low frequency scope line. Our test line included about 8 others testing, inspecting and shipping oscilloscopes. After assembly, the scopes would be sent to test.

The test stations are as follows:

1. Turn on the scopes and set power supplies. Then heat-run for 24 hrs.
2. Test and calibrate the Vertical Amplifier
3. Test and calibrate the Horizontal Amplifier
4. Test and calibrate the Sweep Circuits
5. Do an overall test and check amplifier stability. Run a one-hour amplifier drift check on both vertical and horizontal amplifiers on the most sensitive range.
6. Do a mechanical inspection, approve and send to shipping
7. Do a spot mechanical and electrical check of scopes picked at random
8. If there were no problems, the instrument would be packaged and shipped to a waiting customer

Item five above has an interesting side note. In order to accomplish this drift check I had two Varian Strip-chart Recorders. For the drift test, they were connected to the vertical and horizontal deflection plates of the oscilloscope under test. The scope sensitivity switches were set to the most sensitive range of one millivolt/cm. The spot was centered on the scope screen. The scope was allowed to warm up for 10 minutes with the cabinet on. After the warm up the spot couldn't drift off center more than a couple centimeters in an hour. The vertical and horizontal sensitivity switches were set to maximum sensitivity of 1 mv/cm. Before the drift test I would smack the scope on the sides and lift the front and let it drop on the

bench to check for microphonic  input tubes. The paper chart recorded the spot drift in both the horizontal and vertical direction. If it drifted, tubes had to be changed and the scope re-calibrated. I would always pray for minimum drift.

***Meeting Mr. William (Bill) Hewlett***

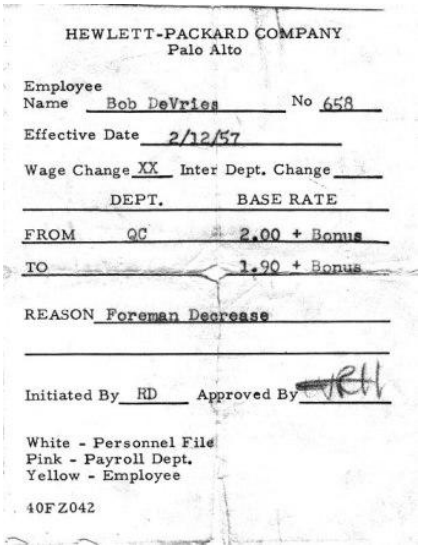
I was still a new kid on the block and one morning this engineer looking guy (along with another fellow) came to my workstation and said he wanted to borrow one of my Varian recorders. He acted like he owned the place. Coincidentally, at that particular time, I had no instruments being drifted. The recorders were not being used nor connected to anything. I said "No, I'm sorry, but I use these all day every day!" I couldn't tell the man that it's in use but I did tell him that I use both recorders to run these important 130A drift tests. "Can't ship the scope without the drift test," I said. Well, I looked around and saw that most of my co-workers mouths just dropped. The other man standing there couldn't believe what I said. I couldn't figure why all these folks looked so dumbfounded. Then I said to the short stocky engineer looking fellow, "If you really need one and my boss, Harvey Kellogg says it's OK, I'll let you have one." Everyone looked at me like I'd lost it. Then the engineer looking guy said, "Oh that's OK, I think I'll be able to find one somewhere else." Then both fellows left. Well, in just a couple microseconds my co-workers told me that I turned down Bill Hewlett and wouldn't let him use his own recorder. They couldn't believe I'd do that.

Actually that was the first time I met or saw Bill. Before this encounter I didn't know what he looked like. I didn't get fired nor promoted for turning him down. I just continued doing my final electrical evaluations and drift tests. It was an experience I'd never forget nor would my co-workers. Months later at a Christmas party, I told Bill that I was very sorry I'd turned him down. He was very gracious and told me that if I'm using something he needs, and I turn him down, that is just fine with him.

***Raises are given and taken away and Rick is born 3/5/57***

In early March '57 our son, Rick, was born at the Palo Alto Hospital. Our new home is ready for him. We all have separate bedrooms for all of us and lots of space. My work at HP continued to go very well. I kept getting raises about every 3-6 months.

Speaking of raises. As you recall I was made test line leader and had several folks working for me on the test line. One young man stood out above the rest. Any assignment he would tackle with vigor and complete it rapidly and without error. He was just excellent. I was totally impressed with his performance. I told my bosses about Fred and suggested they consider him for a raise. He certainly deserved it. He did the work of two people. I told by bosses that, "I would take a cut in pay if you would give Fred Buckingham a raise." Well, when the raise slips came out the next week I was handed one. Mine read: "From $2.00 + Bonus…To $1.90 + Bonus." I was dumfounded! Yes, Fred got his raise. My slip looked just like the others but the raise was negative. It was signed by Ray Demere and approved by Bill Hewlett. I didn't know what to say or do. What'll I tell Donna? I went back to Larry and Don and asked them is this real? Well, they let me believe it was real all day. That was the longest day of my career at HP. At the end of the day, Larry told me it was a joke. That day I learned I must be a little more careful what I say but actually I was very happy that Fred got his well-earned raise.



HEWLETT-PACKARD COMPANY
Palo Alto

Employee Name Bob DeVries No 658

Effective Date 2/12/57

Wage Change XX Inter Dept. Change ____

| DEPT. | BASE RATE |
|---|---|
| FROM QC | 2.00 + Bonus |
| TO | 1.90 + Bonus |

REASON Foreman Decrease

Initiated By RD Approved By RH

White - Personnel File
Pink - Payroll Dept.
Yellow - Employee

40FZ042

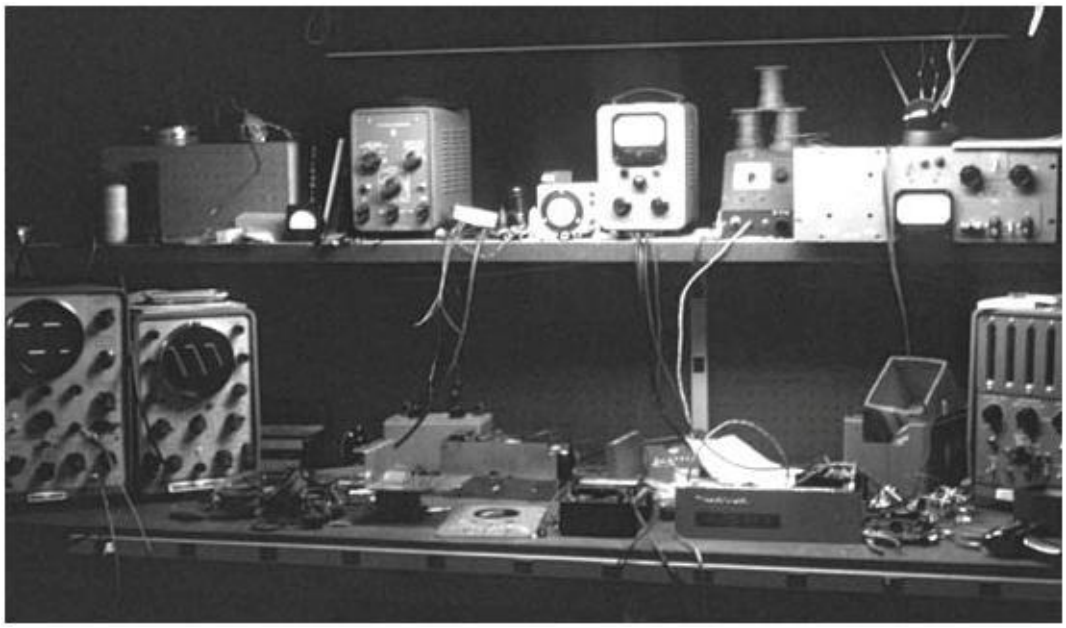
The fake wage decrease voucher

***I loved working at HP for many reasons***

Compared to a lot of jobs, I was just in heaven working in test at HP. All our instruments were clean and new. It wasn't like fixing old radios and TV sets. All the co-workers were friendly, helpful and smart. The environment was extremely stimulating. There were interesting things going on in adjacent HP buildings. Every chance I could, I would go for a walk around the plant. We had a casting shop, a machine shop, a plastic molding shop, a sheet metal fabrication shop, a paint and drying oven area, an engraving department, a machine assembly department, a tube aging area, and the various wiring and assembly lines. We had a fine library of technical books, a customer service department and a test equipment maintenance and calibration area for our own test equipment. We had the lab where new products were being invented, an environmental test area along with shake table and screen room for electromagnetic interference tests. We had a publication department for service manuals and advertisements. There were lots of folks in the offices processing orders, paying bills, doing bookkeeping and others working on mysterious things. As a new kid on the block I had a lot to learn, no doubt about it.

I haven't mentioned the beer busts that would occur more frequently than one would even desire. I attended a few but I really didn't care too much for lots of free beer and Donna and the kiddies were home waiting for me. They were always fun though with a lot of social interaction and camaraderie.
Missing or needed parts could be purchased from HP for cost plus ten percent. Sometimes the auctioned parts needed repair.

***Useful instruments from rejected parts***
I mentioned earlier the Friday auctions of junk and rejected parts that Don Peebles conducted. The HP quality standards were very high and many times parts were rejected because of a minor flaw. It wouldn't take long to collect all or most of the parts to build a fine HP instrument (with a few flaws) for home use. Early on I built a 211A Square Wave Generator and a 521A counter at very little cost. The fifty-cent decade dividers for the counter didn't work at first try but with a little trouble-shooting I was able to make them work just fine. How lucky could I be to own these expensive HP instruments for just a few dollars and a little work. The photo above is of my electronic work bench at 2047 Edgewood about1959. Shown there are several instruments built from auctioned parts that I assembled and worked well. The photo includes a HP-150 and 130 oscilloscope, a sawtooth generator, a couple meters, a signal tracer (brought from home), a frequency/voltage standard and a 523 electronic counter. What fun to have such swell equipment.



My Electronic Work Bench about 1959

As I became more familiar with the company and while on my lunchtime walks around the plant, I'd look in the trash cans for any useful items that were rejected for one reason or another. I'm a little embarrassed to write about it now but it happened. These parts were too poor to even be included in Don's auctions but with a little work could be made to work or be used for something entirely different. At the end of the week, I'd just ask Don for a property pass to take the junk home. I always had one electronic project or another going on at home in addition to important home activities.

***The Harmony Plotters***
HP had a social group called the Harmony Plotters (HP). There were representatives from each department. I was asked to represent the Test Department. Don's junk auctions brought funds into the Harmony Plotters treasury. The treasury was used to fund social events for the HP employees. Even the Harmony Plotters had their own annual auctions of obsolete instruments and hardware. More funds for the treasury. I was asked to be the auctioneer for one of their auctions. What fun that was. We sold lots of good stuff and I even purchased some good junk for myself.

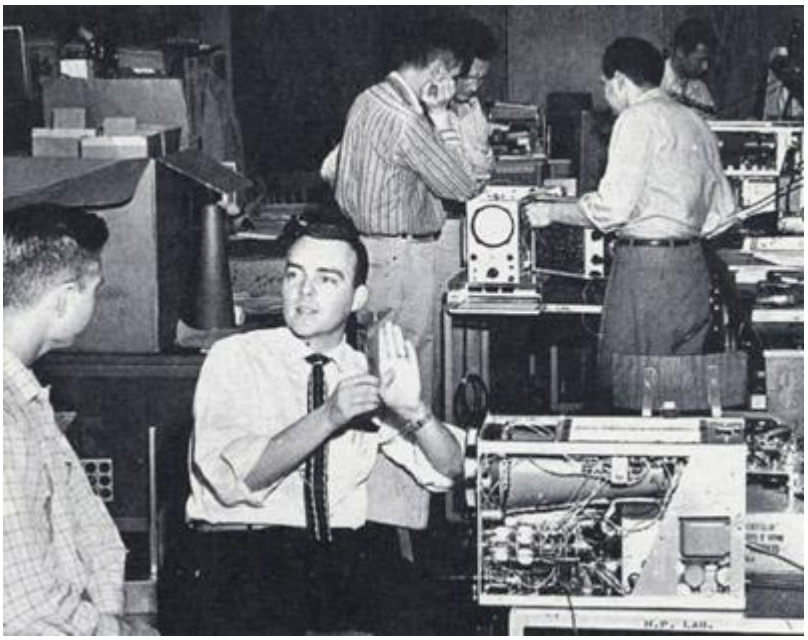
Things were continuing to go along well at HP. During this period HP continued to grow, they leased some land at 1501 Page Mill Road on Stanford property and built several new buildings. To celebrate the completion of the first new building on Stanford land, the Harmony plotters proposed a lovely 1958 Christmas party on the upper floor of the new building. The floor was an acre in size. Lots of room for lots

of people. I took an active part in food preparation and serving of drinks. We had live music, dancing and happy conversation. The party was a complete success and memorable in many ways.

***Oscilloscopes, 130A, 130B, and the new 120A***

After the big party, many assembly and test operations were transferred to the "Hill." Our line continued to build and test the 130A and 130B. Because of warranty problems using printed circuit boards, Dave Packard said that there would be no new products designed using PC Boards until we can make them more reliable. In the meantime, the lab was designing a new Oscilloscope called a 120A. It was released to production using point-to-point wiring.

It's interesting to note that Duane Dunwoodie was the project leader on the new 120A scope. Bill Jarvis was the marketing manager for the scope group of HP. It wasn't too long after the release to production of the 120A that Duane along with a couple other HP engineers (Bill Jarvis and Pete Lacy) left HP and started up a new company call Wiltron Electronics. Wiltron was purchased much later by Anritsu of Japan and became Anritsu Company in Morgan Hill CA.



Some of the people behind the HP scope program in 1955 Left to right: Duane Dunwoodie, Dick Reynolds, Brunton Bauer, Jim Cheseborough, and Norm Schrock. From Watt's Current, December 1955

My friend, Eric Hammerquist was the product designer on the 120A. Over a few months he and I became good friends. I would frequently go up to the lab and have lunch with Eric and discuss product design and other subjects of the day. I owe a lot that I learned about product design to Eric. A few years later he moved to Fluke Electronics in Seattle.

***PC Board reliability problems and solutions***

The 130A, 130B, 150A oscilloscopes and 523A counter were still being built and shipped using PC boards. But, there were warranty problems, especially on the 523A and 150A. Both had very large PC boards. HP tried two things to help solve their reliability problems. First, someone got the bright idea of using steel wool to clean the PC board surface before loading the components and dip soldering. That was a disaster. The steel wool cut through the copper traces with a microscopic fine line and the solder didn't jump the line so there was an open circuit in many places on some boards. Trouble shooting the open circuits was very difficult. As I said, the break (or cut) was microscopic so one couldn't see it with the naked eye. In addition, the steel wool left minute shreds of steel on the board surface and when the boards were dip-soldered, the circuits were shorted by the steel shreds making trouble shooting even more difficult.

Inside View of a HP 150A Oscilloscope

Also to ensure vacuum tube reliability and to weed out the marginal ones, they put 100 tubes at a time on the shake table and would vibrate them for several minutes. That helped detect early failures in some but actually did more harm than good for long term reliability of the tubes.

The technique that really helped PC board reliability was to put an eyelet (hollow rivet) at each through-hole on the board. This would require several hundred eyelets per board. The eyelet made a good mechanical connection to the board traces and helped hold down the copper traces to the phenolic PC board substrate. Using thicker copper helped and using no steel wool for cleaning was the answer. Years later PC board technology improved and the component holes were plated through which eliminated the need for eyelets

***Semi-automated testing of oscilloscopes***

While testing these oscilloscopes one used several required instruments at his test station. Throughout the test procedure it was necessary to connect various signals from these instruments to the input connectors of the scope. One was always moving the connector from one test device to the next. I thought of a simple test fixture to connect all the cables from the various instruments to a switch box then used only two cables from the switch-box to the scope inputs. Now the technician just rotates a switch to select the various required signal sources to calibrate and test our oscilloscopes. This proved to be very helpful in speeding up and simplifying the test procedure.

***Redesigning the 120A for better profit***

We accepted the 120A oscilloscope into production and built and shipped many of them. The only problem was that this oscilloscope was labor intensive because it had tube sockets mounted on a fairly deep and narrow aluminum chassis and used jumper wires, tie points and terminal strips to mount and interconnect all the components. Trouble shooting and repair was difficult because the many components were hard to access. It was good looking and well made but it was expensive to build and repair. As test line leader I figured there must be a better way. I attended a meeting with the appropriate production engineers, production managers, engineering folks and even Dave Packard. I presented my observations as the test line leader, the things that made testing this product difficult. We came up with some small items to implement to make assembly and test easier but I was convinced that bigger improvements could be made.

In early '59 I was talking to Bill Bohnett, my friend in the PC fabrication department. During the past few months, PC fabrication and PC reliability had improved a great deal. Bill and I agreed that we could redesign the 120A put it on PC boards and really lower the assembly & test costs. We did it "under the counter" without management's permission or knowledge. Looking back, that might have been a dumb Idea. I'm sure management would like to know when and where they were spending their resources.

An instrument redesign is a big project for any individual and usually would be done in the lab. But for us to sell the redesign idea to the lab would be even more difficult than just doing the redesign ourselves. There were no circuit design changes but only mechanical design changes required. Bill and his department had all the facilities to fabricate any PC boards that we required. He had access to the dark room for photographing tape masters. He could make silkscreens to print circuit layouts on copper PC laminate. He could etch away the unwanted copper and drill and eyelet the through holes. He could load and dip-solder the PC boards. Bill asked Betty Downs to help us create the tape masters of each of the five circuit boards. So Bill and I agreed to build a PC version of the 120A. We informally called it the 120B.

Since I was familiar with the performance testing of the120A, I would know if the 120B performed properly and met specifications. I wanted it to work as well or better than the 120A. This redesign job was a little more difficult than just re-designing one product. The 120A had two versions. One was a cabinet model and the other was a rack mount. So I really had two products to think about. Throughout this project our scope line continued building and shipping various oscilloscopes. But, for several nights and weekends I worked on the new PC board blanks, chassis design, and switch layouts. I worked with Betty on the board layouts. I worked with Bill on PC board fabrication, board shape and mounting details. I worked with the sheet metal shop on the new board supports, front panel, side gussets and rear panel parts.

I was somewhat a fish out of water because I didn't have a drawing board nor the design knowledge of our experienced product designers in the lab. Again, Eric Hammerquist helped me on some of the documentation details. Looking back, there was so much I didn't know that I'm surprised we were able to get it all together with me as the project leader. I was making informal free-hand drawings and submitting them to the model shop for chassis part fabrication.

Little by little, our chassis parts were being made, the PC boards were ready to mount and test, the front panels were engraved, painted and filled, the chassis parts went together well and all the components fit and mounted as intended. I stayed late one evening and interconnected all the individual board assemblies, applied power, turned on the new 120B and completed the test and calibration procedure. It really looked clean, easy to build and it worked to specification. Bill and I couldn't have been happier.

With much excitement and some informality we showed this new oscilloscope design to our supervisors and managers who were all quite impressed. Even Packard, Hewlett, Ed Porter, Ralph Lee and Stan Selby came down to see this new product. Management accepted this PC 120A scope (120B) as a project they wanted to pursue. About that same time I was promoted from "Shop" to "Salary" on the pay system. That means I will be paid by the month rather than punch a time clock and be paid by the hour.

***Transferred to the lab to finish 120B design***

In a few days, I was told that I would be transferred to the lab to do the final design and formal documentation of this new 120B. I would be assigned to Norm Schrock's scope lab. I quickly learned that building a working prototype instrument is just the first step. In a new product there is lots more work to do. Create clean and readable documentation including a bill of material, assign part numbers, create material lists, create new test procedures, create new operating and service manuals. Design and build new production tooling for this new product. Build a pilot run of 10 rack mount and 10 cabinet mount versions, go through and pass all environmental tests. I had lots on my plate now. We asked one of my test line technicians, Bill Miller, to take over as scope test line leader.

Actually my transfer to the lab was supposed to be a temporary assignment but lasted thirty-one years. This was a big feather in my cap. Here I am, a young guy who had some basic electronics training in high school. I could fix most any AM tube-type home or car radio. I had four years of radar repair in the Air Force, I sold service stations supplies for my dad for three years and now I'm working in the lab of one of the finest electronics companies in the world. I'm helping to invent and develop fine new products. I've no degree. I've attended no college and I'm working elbow to elbow with many brilliant cream-of-the-crop degreed engineers of one type or another. I couldn't be in a better learning environment. Early on I made up my mind to keep my ears and eyes open and work as smart and hard as I could to do as well or better than those around me. This focused work ethic paid off in many ways over the years.

Throughout these three years Donna and I made numerous trips to Santa Cruz to bring the kiddies to visit with Donna's mom and dad. They would visit us from time to time also. Our yard continued to grow, I mowed the lawn and washed the car as required, life went on and every day was a new experience. There are lots of details that I've skimmed over. I hope you haven't found this too boring. That's pretty much what I did as a test guy at HP. After these few short years in test, I was really fortunate to be selected to become an engineer/product designer in the lab. My design experience and contributions in Norm's scope group

continued on for about five years and is somewhat interesting. So the next segment will cover those activities.

## OSCILLOSCOPE LAB 1959-64

***My experiences in the "Scope Lab" at HP.***
This section might be a little easier to recall because I have some reference material that I've kept for these many years. I'll include some of my home and scope lab activities and learning experiences in the lab at HP. Because of the scope division move to Colorado Springs in mid '64, I left scopes on August 15, 1964 and joined the Magnetic Recording group. I'll write about that later.

***Consulting, moonlighting, extra income***
On the home front, during '59 I spent a little more time moonlighting for Coopertronics. I was continuing to drill and mount components in his power supply chassis. I really wasn't tooled up to do a good job for Andy Cooper. I drilled the holes using either a hand drill or drill press and, if necessary, the holes were enlarged with various Greenlee punches. It helped the income a little though. Looking back, I believe a better use of my time would be to spend it with the wife and kiddies. As I re-read this, it looks like I spent all my time either at work or in my home shop, it really didn't work out that way. We did enjoy visiting Donna's folks at Santa Cruz and spending time on the beach and boardwalk. We visited my sister in Moraga, and went on trips and picnics to local or distant places. We even spent a few days at Disneyland when the kiddies got a little older.

A few times in 1960 I had to get after the lady who bought our previous Palo Alto home at 3417 Cowper. Once in a while she would pay the house payment with a check but had no money in the bank to cover it. I had to remind her in a few letters about paying on time and how banks and checking accounts work.

***Oscilloscope redesigned 120A = 120BX, then 120B***
I better focus on my scope activities. I'll try to perk this up as best I can but reading about working in a lab can be pretty dull. It can be confusing unless the reader is really interested and pays close attention to some details.

The main area of confusion is calling my new repackaged scope a 120B for the cabinet model and 120BR for the rack mount version. For this summary let's call my redesigned 120A a "120BX." You'll see that later, we created another 120B oscilloscope packaged in the Clement "System One" instrument cabinet so, in the interest of clarity, we'll call the System One redesign of the 120A oscilloscope a "120B". Carl Clement was an industrial designer working at HP and came up with a completely new cabinet design. You'll see later where my 120 BX was redesigned into the Clement cabinet.

***Environmental tests on new designs***
We certainly didn't waste any time getting started on a thorough examination of the new 120BX by everyone (it seemed). Even before I was assigned to the lab we started environmental tests on this new product. Actually at this early time in my career I didn't know there was such a thing as environmental tests and that department played such an important part in the development of a new product.

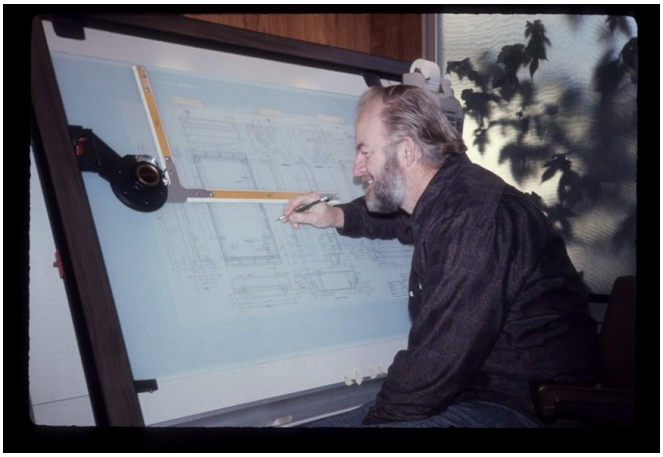
I'm sure you know this but environmental tests include several rigorous tests on a new product. The goal is to assure management and customers that the new product will work (hopefully within spec) under severe environmental (temperature and humidity) conditions. We want to be assured that the new product doesn't radiate unwanted frequencies or isn't compromised in its operation by unwanted and unknown frequencies. We also want to be assured that it will pass a reasonable shock, shake and package drop tests with no resulting damage to any components or chassis parts and will operate normally after these tests. These tests are like finals before graduation. It evaluates the designs and thoroughness of product and circuit designers and clearly reveals any weaknesses in the electrical and mechanical design and/or selected parts. I've often said, "Environmental tests separate the men from the boys." Later, as I designed new products I always had in the back of my mind, "How will this design survive in our environmental tests?

My oscilloscope activity covers a little less than five years. During those five years I was involved in several new scope designs. During my many years at HP as a product designer, it became clear that some projects took from one to five years to complete depending on the complexity of the product, the number of engineers on the design and changes made throughout the development cycle. Actually my 120B wasn't released to production until 10/26/61. (2.2 years after I entered the lab.) I soon learned that it was possible to juggle more than one project by carefully budgeting time and focusing on project "B" while there were

parts being made in the shop for project "A." There were times later on when I was designing 3-4 products at one time. But in the beginning redesigning the 120A was a full time job for this amateur engineer.

***Designing with pencil, paper & drafting board***

It surprised me, as a new kid in the lab, how poor my drawings were. I really hadn't done any mechanical drawing since my first semester of high school. That was 15 years earlier back in 1944. So my drawings were somewhere between poor to bad. No one fussed about them but this was my own assessment. The lettering wasn't consistent, the line weight was too light and wasn't uniform and the arrowheads looked just awful. I worked on them to clean them up and make the lettering uniform, readable and handsome. I've always admired well-done drawings.



Designing before computers

At this time in the industry there was no such thing as computer aided design which came on the scene about 25 years later. Also all (or most all) of our fabrication drawings were dimensioned in fractions of an inch. Decimal dimensions and metric dimensions were not recommended at that time. Decimal dimensioning came a couple years later and millimeter (mm) dimensions came much later.

Dimensioning our drawings in inches and fractions of inches made fit and interface calculations a little difficult. Calculations were done using pencil and paper. A slide rule doesn't work for adding dimensions in fractions. We had no handheld calculators nor computers to use. They weren't invented yet. The accounting folks had adding machines but they were not available for us lowly product designers to use. Besides adding 1 1/2 + 3 23/32 on an adding machine would be of some help but awkward. (Actually, 1 1/2 + 3 23/32 = 5 7/32.) It wasn't until a couple years later, when we started using decimal inches, that I purchased an adding machine from Sears to help me with my design calculations.

(I'm digressing here. But, when HP went metric (about 1982), all drawings had to be dimensioned in millimeters. We included a chart on the drawing giving the mm dimension and its inch equivalent dimension in decimal inches. Since every mm dimension on the drawing had to show the inch equivalent it resulted in a big conversion chart as part of the drawing. In addition, the conversion chart took up precious space that could be devoted to drawing details. And creating the chart was a big job as some drawings had several hundred dimensions. As a result drawings ended up on larger sheets of paper.)

***Designing the 120BX***

When Bill Bohnett and I worked on the 120BX in test, we had the help of Betty Downs to help create the tape masters for the PC Boards. Now that I'm in the lab it's my responsibility to clean up the PC boards, adjusting the spacing for proper component insertion and make sure the circuit is laid out correctly. In the beginning I did all my own board layouts. In general the PC Board tape masters are created two-times size and photo reduced to a 1:1 size. We generally used sheets of .010" thick Mylar. One sheet per PC board layer. Usually my boards were two layers, a circuit side and a component side. That infers two tape masters. We used special red plastic tape stuck to the Mylar for component pads and traces. Lots of errors can be made laying out PC Boards. One common error was connecting to a 7 or 9 pin tube socket and remembering if you are laying out the board looking at the circuit side of the board or component side. Many times when boards were fabricated and loaded the designer realized the tube had to mount on the wrong side of the board to work electrically due to layout errors. Boards got scrapped and a new corrected layout started. It amused me that the once head Printed Circuit Engineer laid out a PC board design and got the tubes in upside down and backwards. That proves the "Know-it-alls" don't actually know it all!

Later on and as time permitted I was called on to train various young ladies how to read a schematic and lay out PC boards. Some got very skilled at doing board layout and were an asset to product design and the lab. Later each lab had PC Departments that did that difficult and important task. Some of our more complicated instruments had 20 to 40 PC boards.

I was surprised how quickly many resources of HP focused on this new 120BX project and how much I had

to learn. Looking back, I was treated as just another engineer and got wonderful cooperation everywhere I went. I was actually at an advantage because I had worked in production, knew lots of people and knew the location of different departments. Much to my surprise, many engineers stayed close to their lab bench and never ventured out of the lab. Everyone, both engineering and production, was very helpful. I was assigned a K&E 4-post drafting table, a tall stool to sit on and, I think initially, I shared a lab bench that contained space to store drawings and a working surface to build prototypes. I was back in the far corner of the lab, next to the back door, next to the windows and next to the library. I had a fine view of the hills looking up Page Mill Road in Palo Alto. My friend and sounding board, Eric Hammerquist, was just a work bench away.

I was weak on considering part costs. Initially, I gave part cost no thought at. When working on the 120A redesign in test, my goal was to just use the same parts but mount them differently. Actually my goal was to reduce assembly and test cost by the use of Etched Circuit Boards. The 120A was a very competitive product. We wanted to keep the costs low but still make a profit.

In developing a new product everyone gets into the act. The accounting folks got involved in a cost analysis. The production folks and production engineers passed my prototypes around offering constructive criticism for one thing or another to improve its appearance or ease of assembly. The marketing folks got involved by questioning the addition and/or deletion of various features. The material engineers got involved in component applications and sometimes suggested alternate, lower cost, components or even circuit changes. The tooling folks got involved in designing tooling for making chassis parts using steel-rule dies for cutting out the flat sheet-metal blanks and pad-form dies for folding the sheet metal. All these good suggestions (and some not-so-good) tended to complicate my day and many of those suggestions impacted the design. What have I gotten myself into, I wondered?

***120BX environmental tests***

Even before I entered the lab we evaluated our first environmental test results. I joined the scope lab on September 15, 1959 but before that on August 21st I received back the results of the 120BRX environmental tests. It wasn't too bad but I didn't win any prizes. I remember during the shake test the vibrating heavy power transformer flexed the deck it was mounted on to such an extent that it caused a fracture in the metal deck. The fracture was from a sharp inside corner cutout for the transformer to the edge of the deck. During shake the operator looks for instrument resonances and shakes the instrument several minutes at resonance to see if there will be any failures. I was discussing this failure with Bill Myers who was the boss of Bill Thormahlen who was in charge of the environmental tests. Bill Myers suggested a radius corner in the transformer cutout to relieve stresses in that area. That was an excellent suggestion that worked over and over on other products I designed. Radius corners are good in both internal and external corners in sheet metal. They relieve stress concentrations and eliminate cuts and snags for the service folks. Every day I learned many new things.

We all know we like the external appearance of a product to be attractive to the customer. We had industrial designers hired to ensure good looking and human engineered products. I've always felt strongly about a handsome internal appearance of an electronic product. Being intimately familiar with military radar sets and other pricey equipment I gained an appreciation for neat wiring, laced cables clearly marked circuit boards and sub assemblies. It makes servicing the product so much easier. I wanted my 120BX to be clean open and easy to service. I received lots of compliments on the open clean design of the 120BX.

***Tektronix competition***

During this period the Tektronix Oscilloscopes were built as stated above. In addition to their easy-access cabinets and user-friendly front panels and well-designed circuitry, they had a handsome internal appearance, neat wiring, laced cables, clearly marked components and sub assemblies. They used their handsome white ceramic standoff component supports using silver solder to hold components in place. Their designs and workmanship was tough to match. But, fortunately for HP, at that time they had no low frequency oscilloscopes in their product line.

***120BX design used in other products***

The 120BX design was modular and partitioned in a logical manner of several major sub assemblies consisting of: a Vertical Amplifier, Horizontal Amplifier, Sweep Circuit, Low Voltage Power Supply, and High Voltage Power Supply. Those along with the power transformer, Cathode Ray Tube (CRT) and chassis would result in a complete oscilloscope. The 120A was just one large chassis with all the circuits interconnected. It would have been difficult to sub-divide it into several sub assemblies.

This modular approach got our marketing folks quite excited about creating several other oscilloscope

configurations to satisfy customer needs just by combining the right circuits and changing the size and shape of the instrument cabinet and CRT.

I was focusing on the 120BX and trying to complete the documentation including all part drawings, PC board tape master, material lists, test procedures, etc. I was working toward the completion of our pilot run of 5 ea 120BX and 5 ea 120BRX instruments. We built the pilot run and they went together well. There was a lot of enthusiasm and inertia regarding these new products. Some of the pilot run instruments went through environmental test again and passed without any great problems.

I soon realized there was a lot going on behind the scenes in other parts of the lab that would impact these products more than I ever dreamed. I worked diligently to take care of any environmental problems, correct any errors in documentation, and to be certain the tooling was coming along on schedule. I was ready to release the new instruments to production. But, much to my dismay, the whole project slowly came to a halt. I couldn't understand what was happening. Why were we holding on the release of the 120BX and 120BRX? In late January 1961, I wrote multi-page notes to important management folks like Ed Porter, Ralph Lee, Norm Schrock, Wally Klingman and others about the current status of documentation and tooling. We were ready to go! Why aren't we going? That answer is coming up later.

***Designing plug-ins for the 160A oscilloscope***

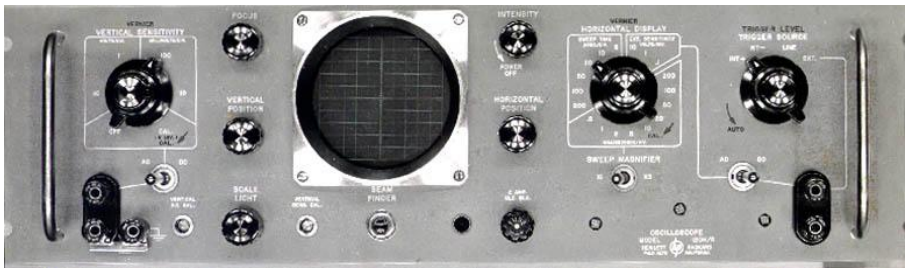
In our scope lab there were about 30 engineers working on other scope projects during this period. One major project was the 160A scope. It was militarized, big, heavy, and designed to have a much higher frequency response. It had a mainframe designed to accommodate separate vertical and horizontal plug-ins. During pauses in my 120BX activities I was asked to help product design some of the horizontal plug-ins for the 160A. I was happy to help. Being involved in other designs indicated that I'm more permanent in the lab and maybe they'll let me stay? Maybe they'll forget to send me back to test? I took on new projects with enthusiastic vigor and did the best I could to satisfy the project goals. I was really happy to be working in such a stimulating environment and with such great engineers.

The first plug-in project for the 160 Oscilloscope was the 166A Dummy Plug-in. This had no controls and basically filled the space if the user didn't need any of the other horizontal plug-ins offered. The next one was the 166B Time Mark Plug-in that provided intensity modulated markers on the scope trace so the user could measure frequency accurately. This plug-in provided several various microseconds between markers. The circuit designer was Scott McClendon. The next one was the166C Display Scanner Plug-in that allowed the user to plot the displayed waveform on an X-Y pen recorder. John Strathman was the circuit designer on this one. And the last one was the 166D Sweep Delay Plug-in. Floyd Siegel was the circuit designer. I think Floyd got a patent on this sweep delay idea and also on his beam finder idea. Sweep delay allowed the user to closely examine the horizontal scope trace and any portion of the trace expanded and magnified for thorough analysis. All these plug-ins had to be invented, created, designed, documented, tested, tested again and ultimately released to production.

***Additional oscilloscope designs***

While time was passing and plug-ins were being invented and designed there were four things happening that impacted my future product design activities. They were:

- The corporate industrial design folks were creating a new modular cabinet packaging system for the Hewlett-Packard Co.
- The company purchased and set up a CRT design lab and production area on level one just below the scope lab that was on level two.
- The CRT lab was developing a new and unique internal graticule CRT.
- Our marketing folks were talking to customers and getting feedback about their low frequency scope needs.



HP 120H for Hughes Aircraft

Marketing came back to the lab with some proposals and wondered if it was possible to create the scopes that follow. George Fredricks in our marketing department was most active in coming up with new scope proposals.

His first proposal was a scope we called the 120H Oscilloscope. This utilized a 3" cathode ray tube (rather than 5") and was in a custom designed cabinet. It was a standard rack width, 5" high panel by 11" deep housing. Hughes Aircraft wanted this 3" version for a test equipment system they were working on. It didn't take long to take the PC boards designed for the 120BX and find a way to position them in this smaller case with the 3" CRT. I got everything to fit in the box. It had an attractive and logical front panel layout. Cooling was accomplished by perforating both top and bottom covers and depending on convection cooling. It was a fun project that looked and worked well. We built two prototypes, one to show Hughes and the other to go through environmental.

Another scope proposal was a special scope for the U. S. Navy. They wanted a 120BRX equivalent only they wanted it less than 14" deep. They wanted a 7" high panel and standard rack width. I had no problem fitting the 120BRX PC boards in that cabinet size. Burt Squier and our CRT lab designed and made a special short 5" diameter CRT for this scope. Because the tube was shorter, the trace on the front could not fill the whole screen but the navy would accept that. I built a couple prototypes that worked well also. I sent one through environmental test. We soon learned the navy wanted it to withstand some military environmental specifications. We called this new scope the 120N. This project was turned over to John Tatum to complete. A year later he released it to production.

A third scope proposal was to make just an X - Y scope using two vertical amplifiers with no sweep circuits. This would use the same parts as the 120BRX but no sweep board and a vertical amplifier in place of the horizontal amplifier. Of course, the panel was changed to accommodate the different functions. This was easy to accomplish and another usage of the 120BX circuit boards. I think I built a couple of these but can't remember.

A fourth scope proposal was to make a special dual monitor scope for Sperry Gyroscope. They wanted a scope with two 3" CRTs and the appropriate circuits from the 120BRX to drive the CRTs. This project never got off the ground. It was really a special special. But these few paragraphs illustrate the interest and additional business the 120BX generated.

***Modular cabinet: "System-one" or "Clement Cabinet"***

Our corporate industrial design folks (Carl Clement and Tom Lauhon) were creating a new modular cabinet packaging system for the HP company-wide product line. This was a totally new cabinet design that was called "Clement Cabinet System" or later, "System One Cabinets." This cabinet system was about ready to be introduced. All they needed was an instrument to be designed into it. Also, the timing was such that the "Internal Graticule" CRT was about ready to be introduced. And, as you know, the 120BX is still waiting on the sidelines to be introduced. Our corporate folks thought it would be a good plan to introduce the new 120B with the new internal graticule CRT and in the new Clement Cabinet. That's a very good idea except the 120BX was not designed to fit in the Clement Cabinet.

I should digress here. What is an internal graticule, you might ask and who needs it? Using a calibrated oscilloscope one can measure voltage amplitude and frequency just by looking at both the trace on the oscilloscope screen and switch sensitivity settings. If you know how many centimeters or millimeters the trace is deflected and you know how many volts per division your range switch is set to, you can calculate volts of deflection. An example: the trace is deflected 3.0 cm. You are on the 10 Volts/cm range. Your signal voltage is 30 Volts peak to peak. In all earlier scopes, the centimeter scale was outside the tube face, etched or scribed on a piece of plastic in front of the CRT screen.

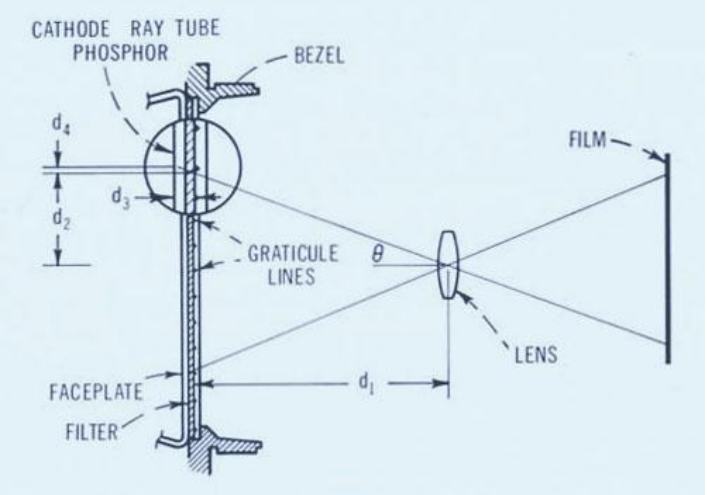



Diagram illustrating source of parallax error $d_4$ in oscilloscopes. Since phosphor and graticule inside the crt are located in same plane, parallax error is eliminated, for the eye or cameras. From the Hewlett Packard Journal, July-August 1961

There was always a parallax error in reading the trace amplitude. One had to be very careful taking data. The internal graticule was developed to be in the same plane as the phosphor of the CRT so there could be no reading error due to parallax. It was an ingenuous oscilloscope improvement.

***Charlie Reis and his projects***

Several years earlier, I met Charlie Reis who was an engineer in the lab in building 8A. He was knowledgeable in chemistry, physics and electronics. He was a strange engineer always working on some new and wonderful invention or other. One of his major investigations was a method of electronically displaying numbers. I actually don't know of anything that he invented or designed that was significant or memorable. One day he came to me in the Scope lab and discussed silicon controlled rectifiers (SCR) that were quite new then. He talked about light dimmers and how they worked. He talked me into designing and building a light dimmer assembly for some project he was working on. I wasn't assigned to help Charlie but I just helped him get this hardware together for his project. In the meantime I learned more about SCRs and how they worked. I was able to integrate that work along with my oscilloscope design activities. In addition, and at a later date, Charlie had an idea about a digital clock that used Nixie tube readouts, neon bulbs for the colon and rotary PC switches for the numeric switching. An electric clock motor drove the four PC switches.

Nixie tubes were quite new then and were used in counters and voltmeters for a digital readout. Well this design was far more complicated and required some PC board layouts and hardware to hold it all together plus a case to put it into. I'm not really sure if this was a home project for Charlie or a work related project but we got it together and it worked quite well. Later he was after me to do more stuff for him but I turned him down since his requests had nothing to do with my assignments, goals and career. I was spending too much time on his projects and needed to focus more on the oscilloscope projects at hand. I don't know whatever happened to Charlie.

***Oscilloscope redesigned becomes the 120B***

Guess who was assigned to repackage the 120BRX into the Clement Cabinet? Yes, it was about February 1961 when I started on the new 120B design. The 120B was the first HP instrument to use this new cabinet system. Dozens of various instruments followed later. This was a whole new ball game but an exciting challenge. Most mounting holes, front and rear panel sizes and shapes were pre-determined by the side castings in this new cabinet design. The product designer had the flexibility of determining how to use the interior space but the exterior was off limits for any changes! It was written that no product designers would dare make external changes on the Clement Cabinet system!

For an oscilloscope to fit in the Clement Cabinet, one critical problem had to be solved. The CRT was 16.75" long and the cabinet was only 16.00" deep. We had our CRT lab design a new internal graticule CRT that was about 15.75" long so it would fit within this shorter cabinet. For additional clearance it was necessary to put a small protrusion in the rear panel behind the CRT socket. The other problem was trace alignment with the internal graticule. It was necessary to create an adjustable magnetic field that would rotate the scope beam within the CRT so we could align it precisely with the internal graticule. This was accomplished by including a coil of wire around the CRT, after the deflection plates and inside the CRT shield. By causing a current to flow in the coil it created a magnetic field within the CRT that rotated the electron beam for precise alignment. That was an ingenious solution to an otherwise difficult mechanical problem.

In addition to these solutions we made some improvements in the 120A circuit design to allow the vertical amplifier to display a wider bandwidth and to enable the power supply to operate at lower power. We reduced the power dissipated by the DC Filament supply by using a 12V zener diode and series transistor regulator rather than a vacuum tube regulator. We added a Beam Finder, Sweep Expand switch and Trigger Level to the front panel controls.

There continued to be a lot of discussion about the Clement Cabinets over the years. Clement and his styling team insisted there will be no holes in the top nor side covers in his new cabinet design. I agree, the cabinets looked nicer without ventilation holes to enhance cooling. But it wasn't the real world. The cabinets were designed as a thermos bottle with a bright aluminum interior and a vinyl covered exterior. As a result, the temperature would rise to a maximum because there was no place for the hot air to go. We considered a fan in the 120B but there was no room for it. We compromised and the final instrument had a solid top cover, perforated bottom and side covers. We also had vent holes in the rear panel.

Our goal was to have clean prototypes ready by August '61 so this product could be introduced at Wescon (Western Electronics Conference), a very important trade show. With some design help from Barney Oliver

and Carl Nale we were able to reduce wasted power that lowered the temperature rise of the instrument even further. We passed our environmental tests and we achieved all our goals.

In July/August '61 there was an HP Journal article devoted to the new 120B, internal graticule CRT and the new Clement cabinet. In October '61 this product was released to pilot run of 10 instruments. Then to production for first delivery scheduled for 1/15/62. The 120B was slow in coming but well worth the wait and was a sales success.

***Designing the 130C with John Strathman***

About this time, HP was breaking up into several different divisions. We had the Scope Division, F&T (Frequency & Time), Microwave and Audio division. The Scope Division moved back down to Building 7 at 275 Page Mill Road. Several more scopes were designed into the Clement cabinet. I got involved in a couple of them. In addition I was asked to help with some design details for the 175A and 185A Sampling Scope.

I can remember like it was yesterday working with John Strathman on the 130C. John was a fine circuit design engineer. We had mutual respect for each other and got along well. There was another fellow assigned to design the Power Supply design for the 130C but I can't remember his name. The 130C design was a hybrid. It utilized both vacuum tubes and transistors. More and more we were seeing transistors appear in some circuits in all our HP products. This project progressed well and was working well.

We were passing tests and reviews one after another. We were getting close to a pilot run release when one evening, long after quitting time, John was working late on his prototype 130C. He had this serious and worried look on his face. One could easily tell when John was upset.

The HP 130C

I asked what was bothering him. He told me that his 130C amplifier was oscillating and he just couldn't figure out the reason for it. (An oscillator is really an amplifier with positive feedback that causes it to oscillate.) John's amplifier had lots of gain, and covered the band from DC to 600 KHz. He had been working on this problem for a couple days. He said he had tried everything to get it to stop. I asked him to show me how he knew it was oscillating. Now, I'm not a circuit designer but I know a little about circuits and interpreting oscilloscope displays. So John showed me the problem. I sat and looked at it for a couple minutes. I adjusted the sweep time switch and trigger level setting and said to John, "John, here is the solution to your problem, your amplifier is not oscillating, it is picking up KGO the local radio station." It was clear to me, and true too, that the high frequency that we were seeing was being amplitude modulated and if John had put a speaker in place of the CRT, he could be listing to music or news of the day.

I went to lab stock, got a coil and variable capacitor and made a tuned circuit, hooked an antenna to it, plugged it into the vertical input of his scope and we tuned in a very large signal of this same radio station. John was so relieved. His problem was solved. He had no oscillation nor amplifier problem. The amplifier was very sensitive and just picking up local signals. It was doing what it was designed to do.

This 130C project continued forward with ease, it passed all our tests and reviews and was well received by our customers. I still have a working one on my bench here at home. It's 41 years old and still works and looks like new.

***My last oscilloscope design, the 132A***

My next and last scope project is the 132A. Sometime after getting started on this project the company decided to move the scope division to Colorado Springs. Oh my, no more scopes in Palo Alto. What should we do? I really loved all the scope projects and the folks I worked with. I couldn't have been happier working with scopes. HP offered to send many scope supervisors, engineers and spouses to Colorado

Springs to see if they would want to stay with the division, move there and continue designing scopes for HP. So in May '64 Donna and I got a flight to Colorado Springs and spent a week looking at the new plant, homes and environment. Not a bad place to live but Palo Alto isn't too bad either. After much anguish and soul searching we decided not to move. We just had too many good reasons to stay in Palo Alto. The kiddies were in school by now, Donna's folks lived nearby, we had a nice home and lived close to work

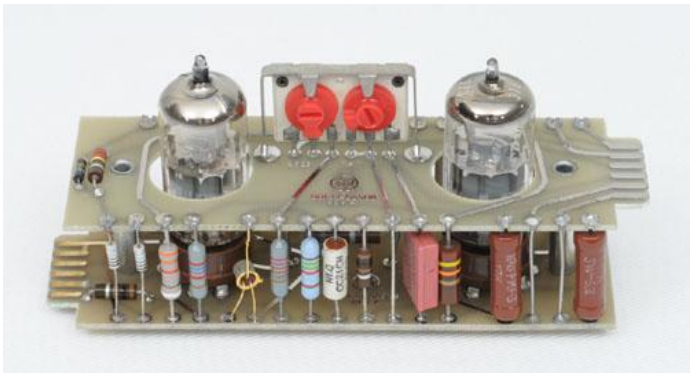
I continued designing the 132A. This scope was unique in that it had a CRT with two electron guns. It was exactly like two 130C scopes in one box but with only one display. Since I was intimately familiar with the 130C I was asked to make the few circuit design changes as well as complete the product design for this dual beam project. Later, Dick Monnier was asked to be the project leader, to create a block diagram of the 132, design a couple amplifiers, monitor progress and make suggestions. We had a couple summer students help us too. One was a Stanford student, Roger Williams and an exchange student from Berlin Germany, Eckhard Kienscherf. They all helped a lot getting this product together and keeping it moving.


HP 132A

It's interesting to note that when I was test line leader, Dick Monnier was a new engineer in the lab. HP had a rotation program for new engineers and many of them worked for a week or two each in the shops, assembly and test. Dick was an excellent test technician for the few days he worked on my line. He worked the turn-on position for the 130A and I remember him to this day focusing on a stubborn inoperative power supply problem. He finally found the problem and fixed it.

***Sandwich circuit packaging and the 132A***

The 132A was designed using a unique packaging scheme that came to mind one day. It was so unique that Packard came to see it and said, "This is the best idea I've seen come out of this lab in years." It also was featured in a publication called Electrical Design News. It got a lot of press in HP publications. It was called "Cordwood" or "Sandwich Circuit Packaging."



A two tube sandwich package

The package is made up of two PC boards parallel to each other and spaced about one inch apart. Both boards have traces on both surfaces. The lower board accepts and supports the tube sockets. The upper board has cutouts for the tubes to protrude through.

All the required components of the circuit are mounted between the lower and upper boards. The advantages of all of this is good utilization of instrument volume, good air flow between components, good isolation of troublesome components, ease of trouble shooting of circuits, and ease of mounting this modular circuit assembly.

The 132A used this packaging technique on its various assemblies. They all plugged into a large mother board spanning the instrument from side to side and top to bottom. There was very little wiring required because the mother board did most of the interconnecting. The instrument was convection cooled. Air came in the perforated bottom cover and exited through a rear perforated top cover. (Sorry, Mr. Clement.)

As long as vacuum tubes were used in our products, this new packaging idea made sense. But my timing was such that tubes were on their way out. Future scopes were mostly all transistor. The 132A was the only scope that used "Sandwich" PC boards.

***Guards are protecting HP's property***

One weekend I just had a lot at work to accomplish. On Friday evening I discussed it with Donna. We had several things planned for the weekend and I didn't want to disappoint Donna nor the kiddies. I suggested that on Sunday morning I would get up really early, about 2:30 AM and go to the lab and work till about 7:00AM and come home and have breakfast and a normal Sunday. She agreed that could work OK.

It was a lovely warm summer night. Not much traffic at that time of the morning. At about 2:45AM I entered the front lobby of HP at 275 Page Mill Road. Both front doors were wide open. Much to my surprise both security guards were fast asleep on the lobby furniture. Several thoughts entered my mind. Who is guarding these premises? Should I sign in without waking these sleepyheads? Should I call Ed Porter and report them? Should I wake them and sign in? Maybe I should go back home and let them sleep. I made a little noise and one of the guys woke up and stomped his feet and walked around the lobby trying to get his head together. He scolded me for coming to work at this ungodly hour. I took his scolding like a man but didn't want to argue with him. I signed in, did my work and went home about 7:00AM.

On Monday I told my dear friend Mary Elledge about my security guard experience who told her hubby, Keith. Keith worked in the front office. To make a long story short, the guards(?) were relieved of their HP duties. I've often wondered how many other nights have these folks snoozed on the job? It is certain that some security guards are better than others are. I could tell more security guard stories, but not now.

This 132A project went well through all the tests and evaluations. We built several prototypes here in Palo Alto. The pilot run and production runs were to be built in Colorado Springs. On 8/6/64 I went to Colorado Springs for a week to teach a class on the 132A design and transfer the design, documentation and wiring samples to Dave Davidson.

***New York Machine Design show and the 132A***

I was asked by marketing to take the 132A to the Machine Design show in New York City. I had booth duty each day and demonstrated the operation of both the 132A and a multi-channel strip-chart paper recorder we called the "Bandsaw" recorder. This Bandsaw recorder got lots of attention, especially by the Brush Company representatives. The Brush Company made several different models of paper recorders and wanted to see and study the competition. It turns out that our Bandsaw recorder never got very far off the ground. That project was discontinued after the pilot run of ten instruments and after the show. But, the 132A became a success. This New York trip was memorable in many ways but convinced me that I wouldn't want to be in marketing as a career.

This was my first trip to New York and I wanted to see as much of it as I could during the few days of the show. Every spare minute I would either be walking by myself or with other HP folks up and down the streets of New York. You really can't get the feel of a new city by riding in a taxi, bus or subway so everywhere I went, I walked. I was standing at booth duty every day. Also at night we wandered up and down the streets and enjoyed the sights. More than once were propositioned by ladies of the night, but turned them down. Sipping a short one in a bar a lady came over and made some interesting proposals …sorry lady.

Anyhow, the point of this paragraph is not the ladies of the night but I was on my feet so much and in uncomfortable tight fitting dress shoes by the fifth day, I just couldn't stand. I'll never forget that last morning in my hotel room. I jumped out of bed, landed on my feet and my ankles gave way. I couldn't stand. That never happened before or since. Holy-cow, what'll I do now? I couldn't stand! I had to stand. I had to get dressed and get to the last day of the show and get on a plane and go home. I couldn't stand! I

really didn't know what to do. I was too embarrassed to tell anyone or call for help. I sat on the edge of the bed thinking about it. I've got to stand! I've got to get dressed and walk out of here! I somehow got it all together and accomplished that task. Maybe just moving the ankles a little and rubbing them fixed the problem. I'll admit that I didn't walk very fast for the first couple blocks but later I was OK. Maybe it was the combination of tight fitting, leather dress shoes on hard concrete for several days in a row that caused the problem. Give me the comfort of casual dress product design, sitting on my duffer any day over the dressy discomfort of a tie-wearing marketing guy.

***Aids to engineering***

As time passed and HP was growing we developed more tools and aids for both the circuit designers and product designers. Two of my favorite aids to excellent and consistent engineering that come to mind are the "HP Manufacturing Engineering Manual" and the "HP Preferred Parts Manual." Both of these books were invaluable as we developed new products. The Manufacturing Engineering Manual was most useful as an aid to practical mechanical engineering practices at HP. It provided engineering information such as: standard hole sizes, standard fold radius for sheet metal, standard casting practices, standards for plastic molding practices and later standards for extrusions and semi-rigid coax fabrication. (I wrote the sections on semi-rigid coax and extrusion later in my career. The preferred parts manual was precious in that it provided part numbers and descriptions of corporate approved parts to use in our new designs. The parts were preferred because they did the job well and were lower in cost due to large purchases. Later, about 1985 we had "Colossus" on the computer. That program listed nearly all purchased parts that HP had and was a convenient method of finding the part number of most any item you might need for a new design. It used cross indexing so you could enter the database with part's specs.

That's pretty much what I did in the Scope Lab at HP. They never did send me back to test. In fact, the scope folks gave me seven raises during these past five years. So I think I'll be in the lab for good. It's pretty wonderful being paid for doing something you really enjoy. After these few short years in Scopes, and the group moved to Colorado Springs, I was really fortunate to be permitted to join Walt Selsted's Magnetic Recording Group. My design experiences and contributions in Walt's tape group continued on for another five years.

## MAGNETIC RECORDING LAB 1964-68

***My experiences in the "Magnetic Recording Lab" at HP.***

These pages will be a continuation of my previous section of "Working in the Scope Lab." I left scopes on August 15, 1964 and joined the Magnetic Recording group. The time spent in Magnetic Recording was about 4.5 years.

***My New 1964 Pepper Red Mustang***

Meantime, before I get in too deep telling you about my magnetic recording activities, I must tell you that this year, 1964, is the year Ford came out with the original Mustang automobile. The only car I ever really fell in love with at first sight was the Mustang. I had to have one. I loved the sporty look, body style and color choices. My first choice was a bright red convertible. We didn't really need another car, and the Mustang was a little small for a family of four but it was so beautiful and hot. Fortunately for me, Donna's dad loved cars. On Father's day her folks were visiting us from Santa Cruz and Fred suggested the two of us go to the Ford store in San Jose and see if they had any new Mustangs.

My Pepper Red Mustang

Mustangs were just introduced a month earlier and selling so fast there were very few available in the bay area. Fortunately for us they had one on the floor. A bright pepper red hard top. It was actually used for about a week, purchased in Detroit and driven out here so had about 3000 miles on it. It was for sale as new and had a new guarantee. It was my dream to own this car. Good ol' Fred pulled out his check book and we bought it on the spot. I paid him back later but that was a memorable day for me. Donna and I enjoyed it for many years and later gave it to daughter JoDee when she entered college. She is still using it

to this day. She had it repainted and engine replaced but 42 years later it still looks and runs like new. My friend, Larry Johnson, took the above photograph.

***A "Y" in the road of life & Walter Selsted***

As we go through life there is sometimes a "Y" in the road. We are forced to take one branch or the other. You just can't stop and wait at the junction of the "Y", you must continue forward. I've often thought, what if I took a different branch? In general I've been very happy with the career choices I've made. This next branch in the "Y" was rewarding in more ways than one. Meeting, knowing and working with Walt Selsted has been a big part of my life. If I took a different path…who knows what life would bring?

This may be a long introduction to our dear friend, Walter Selsted. I would guess it was about May-June of '64 that I attended a scope lab lunch and meeting. The guest speaker was new to me and a fairly new guy hired by Bill Hewlett. Walt was a nerdy looking guy. When Walt joined HP, he was initially assigned to Advanced Research and Development and he reported to Barney Oliver. Before coming to HP, Walt was head of Ampex R&D. Ampex was founded and started developing tape recorders right after WW-2 and Walt was one of their first employees. He made technical contributions to many recorder developments as well as their development of the rotating head video recorder. He had been awarded many patents. Walt was a Vice President of Ampex Instrumentation Recording Division when he left. He left Ampex to help HP develop a multi-channel instrumentation tape recorder. Our eastern medical division (Sanborn), needed these recorders as part of their patient monitoring systems. Walt Selsted and Bill Girdner, an old-timer HP Mechanical Engineer, developed a new 10" reel-to-reel instrumentation recorder for Sanborn. Walt was going to tell us about its design and why they designed it the way they did.

Walt's talk was interesting and memorable in many ways. His approach was to give an electrical analogy to mechanical functions. He was knowledgeable in both electrical circuits and mechanical devices. He was just brilliant and his lecture was captivating.

Our Microwave Division had all the fine CNC mills and lathes that money could buy. Those tools were used to machine castings, housings and turned parts for our microwave assemblies. It just made sense to locate Magnetic Recording in the Microwave Division. The large cast aluminum housings for the tape transports used in our Instrumentation Magnetic Recording devices and other machined parts required sophisticated and capable machine tools. It wasn't long until management made Walt's group part of our Microwave Division. When that occurred, Walter reported to John Young the Microwave Division Manager.

Because scopes were moving to Colorado Springs, and after much pondering, Donna and I decided to stay in Palo Alto so I had to find someone who would have me. The next most interesting place that I would like to work would be in the tape group. I was very interested in audio tape recording and I know I'd learn a lot by working in that group and for a brilliant guy like Walt.

From when I was a little boy I've been interested in audio recording from cutting phonograph records and later, recording on wire and tape. My brother, Adrian, demonstrated a wire recorder to me back in 1946 when he worked at KFPY, a radio station in Spokane Washington. I couldn't believe what I was seeing. How do you record sound on a very small wire or thin length of plastic tape, I wondered? It makes no sense and seemed like black magic. I had to learn more about that. There was no training in wire or tape recorder theory at my trade school. We were studying Ohm's law and simple circuits most of the time. There was no training about tape recording in the Air Force. Their training was mostly about radio communication and radar navigation and bombing. And while on the road for my dad, I learned nothing about tape recorders. With that background, it makes you wonder why they would even let me near our new magnetic recording group.

***Seeking a new lab assignment***

Starting about June '64 every time I had a chance I'd walk by Bill Girdner's desk and chat with Bill about working in their small recording group consisting of Bill and Walt. (It was a very small group. If it had one less person it wouldn't be a group at all.) I didn't know Walt at the time. He seemed too busy and consumed with his important tape transport design to be interrupted by me seeking my next job. Walt has lots of nervous energy and seems always on the go and even a little impatient. After working with him I learned that he was never too busy to explain or help analyze a technical problem or crack a joke. He was a hands-on manager. He has a fun sense of humor. But, not knowing him, I didn't want to bug him so I picked on Bill. At the time I had no idea what their plans for the future were. Fortunately for me they did have future plans. HP was just getting into the tape transport business and had plans for more and better instrumentation tape recorders and systems. To help move that plan forward, Walt soon hired a fine circuit designer, Jerry Ainsworth.

One day I was chatting with Bill Girdner when Walt came over and said, "Bill tells me you would like to be part of our group. Very soon we will be working on a wide-band tape system and we need some good product design help." He then introduced me to Jerry. He told me, "If Jerry gives the OK, you would be welcome to join our group." My interview with Jerry went well so, as soon as I finished my scope obligations, I would be part of Magnetic Recording.

One thing I learned and admired about Jerry is that he is one of few circuit designers that did the complete design of his circuits on paper including detailed operation and circuit compensation at high and low temperatures. Then he created a complete and detailed schematic. Then he and I designed and built a prototype of the circuit to confirm that it worked as intended. Jerry's prototypes always worked perfectly. (Jerry later had the aid of a fine technician, Wally Overton, to take data, make measurements and check system performance.) Many circuit designers design by trial and error. They make prototype after prototype and still don't get it right. Jerry knew what he was doing and did it well. Another fine engineer, Russ Riley, designed the same way. Fortunately for me I was able to product design for both Jerry and Russ during my HP career.

As a product designer, working elbow to elbow with various circuit designers, we get calibrated quite quickly on the circuit designer's skill level. A good measure might be the number of PC board iterations one must go through to a final design. Or product design changes required because of missing features or capabilities. Many folks get into the act and influence the final product but working with various engineers, I've learned that some are better than others. Some really have their act together…some don't even have an act.

As time went on, Walt's tape group expanded and we later merged with a small Digital Tape Instrumentation Company HP purchased called Datamec located in Mountain View, just south of Palo Alto, which became the Mountain View division. I'll discuss the Microwave Division tape projects first, then a product I helped developed at Mountain View Division.

***Working with Walt and loving it***

One lovable thing about Walt is that he was very personable. At coffee breaks, morning and afternoon, our group of guys would gather at the coffee table and discuss various issues of the day. One day the subject was quite technical and Walt was explaining how a circuit worked. He needed to draw a picture on some scratch paper but there was none available right there and then. Rather than leave the coffee stand and get some paper, Walt picked up a sugar cube from the box provided and with a ball-point pen drew the schematic on the lump of sugar. That brought a lot of laughs and conveyed his technical message. Walt was always a very quick thinker, innovator and I later learned he could immediately find the weaknesses in any electrical or mechanical design.

We had one memorable engineer who was loud, somewhat obnoxious and not too much fun to be around. He usually came later to coffee breaks but would always elbow his way through the crowd so he could stand face to face with Walt. Now, Walt could notice and be impressed by him. Were we jealous? Were we offended? No, I think we were more amused than anything. Were we annoyed? Yes! He was so obvious. It takes all kinds of people to make up a lab. He was a good electrical engineer but not the best I've seen and his personality needed some work.

This photo (L-R) shows Girdner, DeVries, Overton, 3950 System, Selsted and Ainsworth.

***Our magnetic tape systems***

Describing my tape system activities gets a little complicated. I'll try to keep it simple. While at the Microwave Division we developed two major tape systems. Our first system was a high frequency (1.5MHz) system called a 3950 Series. The second one was a low frequency (300KHz) system called a 3955 Series. These were large systems mounted in cabinets seven feet high by a couple feet wide and deep. A typical system was made up of tape decks that could accommodate either 1/2" or 1.0" wide tape. Tape 1/2" wide enables a record/reproduce capability of 7 channels and 1.0" wide tape has the capability 14 Channels. We could accommodate reels of tape either 10" or 14" diameter.

The systems included a special housing mounted in the transport for pre-amplifiers and below the transport

we had cabinet/s for plug-in record and reproduce electronics. These electronics could either be FM Record and Reproduce and Direct Record and Reproduce as required. Even these Record and Reproduce electronics had little equalizer plug-ins that were designed to match the selected tape recorder speed. The transports could run at 1.75, 3.5, 7.0, 15.0, 30.0, 60.0, and 120.0 inches per second tape speed. We had equalizers for each speed and for each channel. The system was designed to be very versatile, interchangeable and custom built to satisfy the customer's needs. Our pilot run of the 3950 system included 13 each record and reproduce mainframes, 88 each record and reproduce plug-ins and bunches of equalizers. I don't know how many transports but would guess 13 also.

An impressive example of the 1.5 MHz system is that at a tape speed of 120"/Sec the bandwidth of the system was flat from 400 Hz to 1.5MHz. That means that the entire AM broadcast band could be recorded all at one time on each of seven or fourteen tracks. The AM broadcast band could be recorded by connecting an antenna to the input connector of Channel One. To later listen to it in playback one could use an AM radio connected to the output of Channel one and just tune to the AM station of choice. That experiment only used the bandwidth from 500kHz to 1.5MHz of that channel. The band below 500kHz could be used for something else. That experiment uses only one channel of the seven or fourteen channels available. These systems could record and store a lot of data.

***Industrial design and new part development***

On any new product, we product designers work very closely with the corporate industrial design department. As you know, the industrial design folks consider front panel human engineering, customer interface, ease of use, panel colors, knob sizes, logical panel layouts, etc. Their proposals greatly effect what occurs behind the panel. Sometimes their ideas and proposals aren't practical or the interior design is affected by the front panel layout. So, it's really necessary for us product designers to work closely together with the Industrial Designer and either of us can effect the project schedule if we drag our feet on an issue.

The industrial designer assigned to the tape system project was Tom Lauhon. I've worked with him on other projects before and after. We had a good working relationship. He was a fine and skilled industrial designer. But, he drove Walt nuts. He spent nearly a year selecting a general design and colors for the tape systems. Walt was frustrated because Tom was becoming the critical path and parts couldn't be designed, tooled and ordered until he settled on the color scheme and design that made good sense. Walt's frustration level was so high that he went to Young, Barney, and finally Packard to get some firm decisions out of the industrial design department.

They finally came up with a handsome system and we were able to move forward. Lead-time can be quite long when designing and ordering parts for new products. We didn't want the industrial design folks to delay our introduction unnecessarily. Production tooling can be a serious lead-time problem getting tools designed and fabricated to make extruded, cast or plastic molded parts. The product design or part design process has several steps. Each step takes a certain amount of time.

The steps for developing a new part might be:

1. Realizing a need for the part,
2. The initial concept of the part,
3. The design and documentation of the part,
4. The making the first prototype of the part,
5. Evaluation of the prototype part,
6. The tooling design required to manufacture the part,
7. The making the tool required to manufacture the part,
8. The ordering and building of production quantities of the part.

This new tape system design utilized sand castings, die cast parts, plastic molded parts and extrusions. By this time I was quite knowledgeable about sheet-metal design but the other fabrication technologies were foreign to me. All my previous designs utilized sheet metal, pems, rivets and circuit boards. I knew very little about magnetic recording and even less about designing extrusions, castings and plastic moldings. This magnetic recording job will be a good learning experience in more ways than one. I spent a lot of time reading our manufacturing manual and discussing designs with various machinists and tool makers in our shops. Too learn more, I visited several extruders and casting shops in the Bay Area.

***Adding to my record library***

I mentioned earlier that my brother, Adrian, was in the radio broadcasting business. Several years earlier he purchased a radio station in Colfax Washington. The call letters were KCLX. Radio broadcasters were able to purchase record libraries for broadcasting from record companies at a low cost. While 33 1/3 RPM

LP records were selling for $4.00 to $6.00 at that time it was possible to subscribe to 100 record set of RCA Red Seal records released during the year. The cost was about 80 cents each. Since I had a small library of LPs I asked my brother to sign me up for a subscription. During '65, '66, and '67 I got quite a library of long playing records. My friend Marve Wilrodt shared costs and received quite a library too. The only problem with this method of buying records is that you don't get to choose the record. They are only what the company publishes that year but the new released records were good and of high quality.

***Tape system design details***

I had nothing to do with the design of the tape transports. The mechanical engineers were Bill Girdner and Mike Verdone. Walt Selsted supervised their activities. I was involved in the design of a pre-amp housing that mounted in the transports. The pre-amps take the signal directly off the reproduce heads, amplify those signals and send them to the reproduce amplifiers. This housing would accommodate 14 pre-amps. Each pre-amp was about the size of a deck of playing cards. It was a fairly large housing and well shielded from outside signals and signals between pre-amps.

I took a very active part in the design of the 3513A Record Mainframe and the 3514A Reproduce Mainframe design. Both of these housings were 7" high X 16"wide X 16"deep. Each mainframe had its own power supply in the rear of the box and had room for seven plug-ins each plug-in being 2.5" wide X 5" high X 12" Deep approx.

In all my projects to date, my main task was to package the product. In this mainframe design there was no one available to design the regulated power supplies for the mainframes. Walt gave me the responsibility of designing the supplies. I'm no circuit designer but fortunately I had some experience with power supplies in my scope and hobby activities. So, I basically copied a scope power supply but adjusted the voltage and current requirements to accommodate the needs of our mainframes. The supplies worked well and passed all the tests.

We designed several different types of record and reproduce plug-ins. Each plug-in was designed to work at any selected tape speed. Each plug-in could accommodate three equalizers. The front of each equalizer was shaped like a wide pushbutton. Generally the transport tape speed was selected first then the equalizer that matched the selected tape speed needed to be activated by depressing it. Depressing any equalizer caused the unwanted equalizer to partially eject. It worked much like a push-button radio. Also any equalizer could be removed just by pulling on its front edge and a different one, marked with a different tape speed, installed in its place. The equalizer was a small printed circuit board with components mounted on it and a handle on the front.

***The "connector switch" and patent***

There was no connector on the market available to connect the edges of the equalizer plug-ins to the plug-in mother board. When the equalizer was fully depressed we wanted it to make up to 16 connections and when partially ejected we wanted it to disconnect all connections. We wanted low insertion force but didn't want the equalizers to fall out. I designed a connector that satisfied those goals. The board entered the connector from the end rather than from the side which is the traditional method. The connector had contacts specially shaped and the mating contacts on the equalizer board edge were designed for easy insertion, board switching and board retention. On 1/13/65 I wrote a patent disclosure on this new connector idea. On 7/26/65 we applied for a patent and on 9/26/67 the patent #3,344,243 was issued on that special connector-switch design.

3950 System, Pre-amplifier Plug-in

***Extrusions and other fabricated parts***

While in the tape group I surprised myself on the number of extrusions and plastic molded parts that I designed. The extruded parts were the mainframe top, meter insert, equalizer door, plug-in frame and bottom trim. Molded parts were the equalizer push-buttons, equalizer ejector levers, adjustment rod, and connector switch housing. The die-cast part was the plug-in front. After designing, building, evaluating,

observing and working with model shop folks and tooling engineers on these parts, and learning about these various processes, I knew a lot more than when I started.

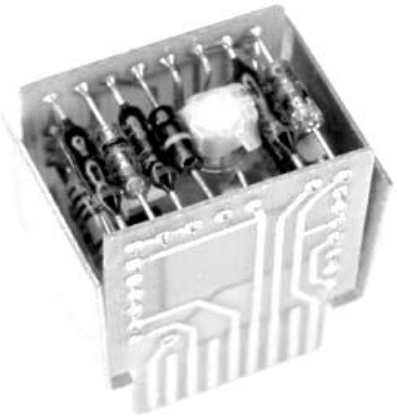
I'll digress a moment. I was most amazed and interested in the extrusion processes. I took a tour of Pacific Extrusion plant in Watsonville CA. In general extrusions should have a uniform wall thickness throughout the part but can be most any shape. The tool maker cuts a hole, the shape of your desired extrusion, in a piece of steel about 7" in diameter and 1.5" thick. The steel is hardened, inserted in a press and backed up with additional steel for non-interfering die support.

There is a billet of aluminum that is 7" in diameter and about 3' long that is inserted behind the steel die. The billet and die is heated to just the softening point of the aluminum. A hydraulic ram in a huge press then pushes the billet against the die and the softened aluminum flows through the die and retains the shape of the die opening. The thing that surprised me is that as the aluminum squeezes out of the die, a worker grips the hot extruding aluminum with a pair of vice-grip pliers as it leaves the die. He then pulls on the extrusion and runs along 100' or more of rollers to keep the extruded metal straight and under control until it cools. Without this control, the extrusion would bow, bend and be all over the place. It won't necessarily come out of the die straight and true. This process is repeated over and over depending on the quantity of extruded metal desired. While still warm, the extrusion is then clamped on each end. The clamps, which are 100' apart, are pulled away from each other to straighten the extrusion, then it's cut to manageable lengths. Extruding is a fairly crude process but it's surprising how closely that process will hold manufacturing tolerances.

***Oscillator oven drift investigation***

For servicing our plug-ins it was necessary to have connector extenders and module support. I designed a plug-in and equalizer extender. With these extenders in place we could have the complete tape system operating and be able to service any appropriate inoperative circuit.

Our 3535A FM Record plug-in design had a voltage controlled oscillator which was the heart of the record circuit (operating as high as 216 kHz). It was a critical circuit so we designed it to operate in a temperature controlled oven within the plug-in. In our first prototypes this circuit worked flawlessly. Hans Westerby, an Electrical Engineer from Norway, and his leader, Joe Rolf, designed the electronics. I did the product design. We then built a pilot run of about 21 plug-ins and much to our surprise, some of the oven circuits started losing control and caused the ovens to turn full on. That made the circuit boards overheat and turn brown and some components failed from being too hot. When we discovered this, Joe was on vacation and Hans was on another important project so Walt told me to investigate the reason for this loss of oven control. I was both surprised and pleased. In my opinion, it was a circuit design problem. What do I know about oscillators, and oven controllers? I went forward as though I knew what I was doing.



The critical FM oscillator…a sandwich board design.

I started an investigation and it didn't take long to discover that an overloaded transistor was experiencing thermal runaway. That happens when a transistor gets a signal to turn up the heat and in doing so, it makes the transistor hotter which causes the transistor to turn up the heat more so the transistor gets hotter, etc. The cure for this problem was to use a better transistor and heat-sink for the controlling transistor so it would run cooler. When Joe returned from vacation he was quite surprised and annoyed that his oven controller design had this problem but pleased that we found a solution.

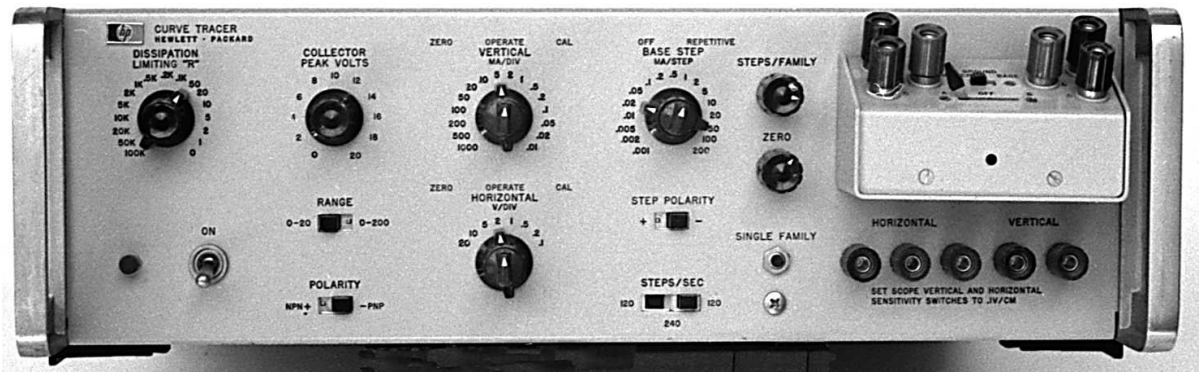
While working on the oven heater problem, Walt suggested that I run some additional tests on this plug-in to see what it would do in temperature extremes. I started with a 7-channel mainframe, just at room temperature. I ran turn-on and time tests on seven different plug-ins, taking data every ten minutes, recording the data and plotting graphs. I even took the instruments home over the weekend to continue running the tests. After running the tests over the weekend, I showed the plots to Walt the next Monday morning. He said, "You know what I think?" I said, "No Walt, what?" He said, "Your garage is drafty!" He was right. The plots were all over the place. Those tests were taken before we had a really good oven design.

I set up the experiment on my lab bench using a small environmental chamber that could be set to go to temperature extremes from 0 to 55 degrees Centigrade. I made thousands of measurements of voltage and frequency over the next four months while making adjustments in the design of our plug-in oven and the internal circuit board. Each set of measurements took the better part of a day. When temperature is involved it takes time to cool the chamber to 0º C and let it stabilize. Then take appropriate readings. Then heat up the chamber to 50º C, stabilize and take readings. Again taking readings at ten-minute intervals, then 30-minute intervals at various temperatures.

With Walt's help, we made a temperature controlled oscillator that varied only a small percentage (about 0.00125%) over that temperature extreme and we had no more thermal runaway problems. It was a lot of work, a memorable investigation and a rewarding learning experience for me.

***A redesign of the Tektronix Curve Tracer***

There was one project that was another learning experience for me and I pursued it to broaden my knowledge of transistors and various semi-conductors. In the early 1960s Tektronix came out with a curve tracer for vacuum tubes. The Tektronix folks later designed and sold a semi-conductor curve tracer. We had a couple in our Microwave lab. As time went on and semi-conductors became more popular in new designs, I wanted to learn more about them.




Never Seen Elsewhere - Bob's Transistor/Diode Curve Tracer

I was quite taken by the curve tracer for vacuum tubes and the transistor/diode curve tracer. Both instruments were very useful to circuit designers and anyone wishing to analyze those components. To be able to see a family of transistor curves on the face of a cathode ray tube was just great. I had to learn more about those instruments. As a special project, I decided to build one. I thought that maybe HP could use a few curve tracers too. I discussed it with my friend Larry Johnson, a fine materials engineer, and he discussed it with his boss, Bill Myers, and they provided me with a number to charge part fabrication and purchases to. In between my tape system responsibilities I studied the Tektronix Transistor Curve Tracer manual. I soon realized that I only had to build about half of the Tek circuit because I'd be using an HP oscilloscope for the display.

I decided to build it into a 5" high by 16" deep Clement cabinet. Using that approach one could use either a 120B, 130C or 132A oscilloscope and it would fit right on top of this lower transistor test control box. For my special project, I designed a rear panel, main deck and front panel. I laid out the circuit boards that were designed using the "Sandwich" technology that I used in the 132A oscilloscope. I designed several different plug-in "front porches" that could accommodate different types of transistors. Two sockets on each porch for comparative transistor testing. I gathered all the parts together, assembled and wired two units. They both worked well. One was used in environmental test for component analysis and the other remained with me. It has been a useful instrument for characterizing transistors, diodes, neon bulbs, incandescent bulbs, resistors, capacitors and many unknown components.

***Various completed Tape Group projects***

There were a few product designs that I accomplished (shown in Appendix) but some were not too exciting and pretty dull to write about. For the tape systems, I designed a Reproduce Track Selector. It was a quite simple product that would allow the user to select anyone of 14 tracks from the tape reproduce heads and feed the signal to anyone of seven different reproduce plug-ins. Its advantage is that a customer could

purchase that lower cost unit rather than a second reproduce mainframe and seven more reproduce amplifiers with equalizers.

I was the product designer on a voice channel for the tape system. In addition to the 7 or 14 record/reproduce heads there was an additional head at the edge of the tape for a voice track. In running data logging experiments its beneficial to have voice annotation to narrate the experiment in progress. These tape guys think of everything. They sometimes would record a tone on the tape, using that audio track, and had a motor drive amplifier that would drive the capstan motor based on the frequency of the tone. That compensated for any variation in tape movement. Constant tape speed in recording was important but playing back the tape at the same speed it was recorded was more important. Any variation in tape speed, especially in FM recording and playback, resulted in changes in signals and measurements. These were really precise systems.

***Designing tape systems at Datamec***

The Mountain View Division was another world. The HP merger with Datamec went quite well. They made digital tape systems and we made analog tape systems. In the lab there were about 20 digital guys and we had about 15 analog guys. At Mountain View the lab was located in the back corner of a large warehouse structure. The ceilings were about 20 feet high and had a cement slab floor. Most of us had lab benches, desks, filing cabinets and product designers had a drawing board. There were no tall walls separating different functions but there were short, 6' high walls. Adjacent to the lab was the shipping department. And then were the assembly folks, sheet metal fabrication and warehouse activities. Toward the front was marketing and office staff. One would hope that our lab environment could be mature, peaceful and quite for deep thinking. This lab was not quiet! One very disturbing occurrence was that each time the shipping department packaged up a digital tape system to ship to a customer, they sounded an air horn. This horn was from a diesel truck and operated from compressed air. It was an abrupt, long loud and unexpected blast that shook the building and made me jump out of my skin. It was just awful. It was good for manufacturing morale but a disaster for us lab guys and our nerves.

***My lab assistant, Erma Rhinehart***

Throughout my tape recorder activities I was blessed with the able assistance of a dear lady, Erma Rhinehart. She was the most helpful and enthusiastic helper one could ever want. No task was too small or too large for Erma. As we worked together before the Datamec move I taught her how to lay out PC Boards, how to take drift data on the FM system, how to keep good notes and plot graphs. She could assemble, wire and solder as well as anyone. She was extremely helpful and pleasant to work with. She had been my assistant these several years. Upon the move to Mountain View, management decided to assign her to someone else. That, and some other issues, caused me to lose interest in magnetic recording.

HP 3960A Portable Instrumentation Magnetic Tape Recorder

***Walt Selsted leaves HP***

Our fine leader and friend, Walt Selsted, actually moved to Mountain View with us but he left HP soon after this move. His new boss Gordon Eding was no John Young and Walt didn't want to be part of Eding's staff. So, Walt left and was replaced by Walt's long-time friend and X-Ampex guy, John Leslie. John was a pleasant guy but nothing like Walt. I can state that no one could replace Walt Selsted.

Shortly after our move to Mountain View Division my enthusiasm for magnetic recording was starting to wane. I was disenchanted mainly because Walt left HP and our group, they re-assigned my dear friend Erma to someone else and the air horns continued to blast unexpectedly. I stuck it out for a couple years at Mountain View because I was in the

middle of an important project and wanted to complete it. I would not feel right about leaving any project unfinished. I remained until after production prototypes were finished and all documentation was complete and up to date.

***Portable recorder the HP3960A-D***

This final project (3960A, B, C & D) was a very sophisticated portable instrumentation tape recorder. The project leader was Petter Brevik. A fine electrical engineer from Norway. Aki Awata, developed the casting for the tape transport, motor mounting, tape path and head mounting. I was the product designer for electronics support, front panel, instrument case, all the interconnecting wiring and plug-in circuit boards. I had the pleasure of working with a fine Industrial Designer, Kail Peterson, on the panel and case design. The design of this instrument was clean and fresh. It had four channels of record and reproduce and either direct or FM. It utilized 1/4" wide tape. It had a voice channel also. It was all transistor and tightly packaged. It could operate from 120/240Volts line voltage or 12 VDC.

This was a real packaging challenge. We had a lot of circuits to fit into a small package. When the instrument was removed from the case, it was designed to open like a book for trouble shooting and servicing the printed circuit "Pancake" motors, internal wiring and components behind the front panel. It was built into a custom designed instrument case. Clement's cabinet system would not work for this one. It was 16" Wide X 14" High X 7 3/4" Thick. It weighed about 50 pounds.

I had lots of fun working with Kail on the case. Since I had a table saw at home, I spent a lot of time cutting sheets of plastic and 1/8" plywood to make several different case mockups. We tried different colors and designs. The venting and cooling needed to be there but discreet. We just didn't want to punch holes at random but created a front and rear grill for airflow. We included a fold-away handle on the back and feet on the bottom. We had a flip up cover with a window to cover and protect the tape reels. The final case design was made up of sheet metal and assembled extrusions even though we considered a molded fiberglass design.

***Time to leave Magnetic Recording***

There is no question about it, I really learned a lot working in the tape group. It was a very rewarding experience in more ways than one. From this point on I feel very comfortable and knowledgeable working with and designing sheet metal parts, machined parts, castings, plastic moldings and extrusions. I really appreciate all the help I got from tooling engineers and various folks in the trades that helped broaden my experience and knowledge. I discovered that every day was a learning experience working in the lab at HP. Working with Walt Selsted and in his group was the right choice for me. The Magnetic Recording folks gave me five raises during these past four and one-half years. Completing this 3960A tape project and turning it over to someone else was good. While I enjoyed working with the folks at Mountain View and missed some of them greatly, it was really good to get back to the Microwave Division.

Toward the end of the 3960A project, I got a call from Rod Carlson, Lab Manager at the Microwave Division. I had very high respect for and had worked with Rod Carlson in the Scope Lab. When I met Rod in Scopes, he was project leader on the 185A Sampling Scope. He told me that he heard I was looking for a change and would I be interested in coming to Microwave? I said yes, and we arranged to meet for introductions and interviews with a couple of the Microwave mechanical engineers. Those interviews went well and I was hired and assigned to Brian Unter's Spectrum Analyzer section. I left Magnetic Recording on 1/31/69 and on the next day, I was really fortunate to be permitted to join Rod Carlson's Microwave Group.

***My last day at Mountain View Division 1/31/69***

On that last Friday at Mountain View Division It was a little sad for me to leave the Magnetic Recording group. There were some very fine folks there. The main person I would really miss was my dear friend and helper, Erma Rhinehart. We had worked together for several years. Before I left, she handed me a lovely card and small box with a gold desk thermometer inside. I couldn't speak, I had tears in my eyes and I just had to leave with a whispered "thank you." I still have the thermometer to this day, 42 years later, and a special soft spot in my heart for Erma.

Her card read:

**A Parting Gift for You…**

It's been so nice to know you that there isn't any doubt
You're someone who'll be missed a lot and often thought about
And this gift for you brings wishes (They're much warmer than you'd guess!)
For a future filled with best of luck and lasting happiness!…Erma

***Moving to the Microwave Division***
I was really lucky regarding the move from Magnetic Recording to Microwave Division. As the company grows, it seems that logistics and moves become more complicated. Each division looks at the bottom line and work hard to control all costs. I was afraid that I would have to leave my desk, lab bench, file cabinets and drawing board for my replacement and just move their contents. But after several discussions with management, I was able to move those furniture items along with myself. That saved me a lot of work and worry and saved HP a lot of wasted time and money. I turned all the project items, drawings and prototypes, over to the fellow that replaced me and moved everything I used on a daily basis.

One problem item that I moved was an adding machine that I selected and purchased from Sears (using HP money). I used it every day so I moved it along with all the other items. The folks at Mountain View Division wanted the adding machine back. Somehow they felt I should not have taken it. It was my machine, I thought. I even made a special bracket for it to mount to my drawing board for ease of use! I was the only one that ever used it. It was like they wanted my drafting pencil and erasers back. It only cost $67.00. I was really surprised but gave it to them a few days after my move. Actually my replacement came to Microwave to pick it up from me. That was actually OK because the Microwave Division folks let me purchase a better adding machine. I guess I'll never understand management?

## MICROWAVE LAB 1969-73

***My experiences in the "Microwave Lab" 1969-73.***
I joined the HP Microwave lab on February 3, 1969. The time I spent in Microwave continued on for 21 years. Then on about 3/27/90 I retired and left the Microwave Division (at that time called Stanford Park Division) and came back the next day as a contract employee and consultant doing the same thing I did before retirement. Why? We'll discuss that in a later segment of these chapters. Since my involvement in Microwave covered so many years I'm going to break this up into four or five segments.

***Entering the Microwave Division 2/3/69***
On 2/3/69, I was assigned to Brian Unter's Spectrum Analyzer section. Brian and his team just completed the development and introduction into production of the 8552A IF (Intermediate Frequency) section and the 8553L RF (Radio Frequency) section of a spectrum analyzer that plugs into a 140S Oscilloscope mainframe. The whole system was part of a family of spectrum analyzers that were smaller, more convenient to use, broader range and more accurate than our previous model and the competition. The 140S mainframe was a modified 140A, developed in the oscilloscope lab a few months earlier. Its panel was re-designed by Jack Magri, a fine and competent Industrial Designer. His design was to compliment this new family of spectrum analyzers and plug-ins.

My first assignment by Brian was to improve on the range of the intensity control of the 140S. It was just too coarse. A few degrees of rotation of the control would go from nearly off to full brightness. Because of my earlier experience in the scope lab this was an easy assignment. I changed the control from a linear taper to a logarithmic taper and solved the problem. It was easily done in one afternoon. That worked well…problem solved…what's next? Brian was impressed that the solution was so fast and simple.

These next couple of paragraphs make one wonder if we know what we are doing. It wasn't at all typical of this microwave group. As a new guy on the block, I wasn't involved in any decision making…I just did what Brian told me to do. I've often wondered why the RF plug-in was initially called an 8553L, then we changed it to 8553A, then we changed it to a 8553B. I'm sure Brian told me but I've forgotten. Maybe it'll make sense as I review it below.

In another section of our microwave lab a group of engineers were working on a new instrument called a Tracking generator. This instrument (8443A) worked along with a spectrum analyzer to enable the user to plot response curves of filters, crystals, RF components and other electronic devices. It was about ready to be released to production when I joined the microwave lab.

My next assignment in Microwave was to enable the 8553L that was plugged into a 140S (I assume the "S" means spectrum) mainframe to connect to a 8443A Tracking Generator. This required some additional connectors, cables, mounting hardware to be designed, documented and added to the 140S mainframe and 8553L plug-in. (I think these changes caused the plug-in change from 8553L to 8553A.) And the 140S changed to 140T ("T" for tracking). Since these instruments were in production it also meant writing production changes and, in addition since these instruments were in the field it meant creating a modification kit and writing a modification procedure for the customer and/or service center. Irv Hawley was

the production engineer for these instruments and he and I worked together on the changes and documentation. Irv was a smart, focused, no-nonsense and hard working electrical engineer. (I learned the term "What's his face" when Irv couldn't remember someone's name.) "What's his face" was really no help in identifying the person but seemed to work for Irv. Irv, "what's his face" Hawley was related to the Hawley folks in Spokane that sold trailers.

A little later, I was involved in some more changes on the 8553A. These changes caused us to change names again. Now it's an 8553B. The changes that I remember were to make the 8553A frequency window read either 0 to 110MHz or 0 to 11MHz. Those numbers were in 10MHz steps or 1MHz steps. The mechanical solution to that problem was to have a switch that actuated a sliding silk-screened Lucite sheet that would allow the extra zero appear or disappear. It worked well. We also changed a couple front panel variable resistors from single turn to ten-turn for a more precise control and resolution. I'm sure there were some internal electronic changes also.

While working on the 8553A & B, Brian asked me to design a package for a 500MHz high frequency probe that would connect to the input of the 8553B and get its power from a front panel connector. I did and it looked nice and worked well.

Since the 8553B worked together with the 8552A IF Section, we made several changes in that product also. Included was the addition of an annealed mu-metal shielded housing and a couple PC boards which caused us to change that model number to 8552B.

***Project offer at Fairchild computer***

About January '70 I got a call from an old Scope Division friend, Kay Magelby, to leave HP and work with him and Horst J. Korpanic at Fairchild Semiconductor in Mountain View. They had this computer project started and needed a product designer. I was quite flattered that he wanted me to be the key guy designing this new product for Fairchild. He actually wanted me to leave HP and become a Fairchild employee. Gee, that's big stuff. Kay completed his doctor's thesis at Stanford on computers and designed HP's first computer so I know he knew what he was doing. Kay was a fun guy, smart and good friend and would be fun to work with him again. But, leave HP? That's a big decision. Well, I thought about it for a day or two and told Kay thanks but not at this time. Much to my surprise, Kay was back working at HP a year later. I don't know why he left Fairchild and I'm not even sure they completed this new Fairchild computer. What if I had joined Kay, left HP then Kay leaves Fairchild. I'm so glad I didn't make that move. One of life's lessons.

***Rit Keiter and the 8555A Spectrum Analyzer 5/69-7/70***

At this point in our microwave division history there was a lot of focus on this family of spectrum analyzers and a high customer demand for them. We had several other analyzers in the planning stages. We were learning customer needs and making instruments that would satisfy their needs. We were doing important stuff. So, hang onto your hat…you haven't heard the last of my spectrum analyzer story. It was good these 8552 and 8553 design changes were pretty well completed by May of '69. Because there was a serious need in Rit Keiter's section for a product designer. I was assigned to Rit to help do the product design of the 8555A, another spectrum analyzer.

The HP 8555A Microwave Spectrum Analyzer Plug-in

Rit had a fairly large group of engineers (about 6 or 7) that had been doing circuit design for the 8555 for over a year. He had one product designer that had been working on the front panel layout and calibrated dial assembly along with Jack Magri, the industrial designer

This band switch had about six different positions and a different scale for each position. The 8555A was another spectrum analyzer plug-in that covered beyond 20 GHz (Gigahertz). The front assembly was perfect and well engineered. But Rit was totally frustrated in that the assigned product designer had not done any internal design layout or planning. He had not determined how this instrument was going to go together nor was he able to provide PC board blank sizes so that boards could be laid out allowing circuits

to be tested and evaluated. Rit desperately needed product design help. His schedule was starting to slip so I was assigned to help.

It didn't take me long to interview each of the circuit designers and get a feel for their space needs board areas and any special components that take up space. I observed and took dimensions of their special components and studied the block diagram for my layout. I made a full-scale mockup of the plug-in including special housings for oscillators, filters, routing of semi-rigid coax cable and circuit board requirements. I got everyone to agree that the layout would work. Then I created board blank drawings so they could get boards started. I was Rit's hero. He was so happy that things were moving forward on his project. The other product designer was finishing up his panel design and documentation and I just focused on everything but the front assembly. We agreed on where we would interface our designs and our plan and working relationship worked out well.

Top inside View of the HP 8555A Microwave Spectrum Analyzer Plug-in

While waiting for parts from the model shop, Rit asked me to work on a 1.5 GHz notch filter design and a new center post for the second local oscillator cavity in the 8555. This was more of an electrical design but its performance was dependent on physical parameters. It was logical to have a mechanical person contribute to the design. It was fun and interesting. Rit showed me how to calculate the size of the mechanical components to get the desired frequency right on. He showed me how to measure the performance of the filter and oscillator. I really enjoyed working for Rit. I have a lot of respect for him. He is brilliant regarding electronic stuff, he loved flying his airplane, he loved riding his motor cycles. He was a young engineer but more like a fun and smart kid with a good sense of humor.

***HP's first six-layer PC board***

As you recall, several years ago there was no way that we would be allowed to design an instrument using PC boards. We had so many warranty problems with them that Packard outlawed them until we could make them much more reliable. The PC fabrication technology continued to improve and soon we had two-sided boards with plated-through holes. Then we had four-layer boards with plated through holes. I'm pleased to say the 8555A is the first instrument developed at HP that used a six-layer board with plated through holes. It was a small mother board (about 5X6 inches) designed to accommodate five very dense plug-in boards. It had about 90 connections to the board edges. The 8555A was a very dense packaging challenge. It worked well and was released to production about July '70. Both Rit and our Division Management were happy that it passed all the tests was released to production on schedule.

***Some additional small projects June '70 - Sept '70***

Back at the lab, John Page took Rod Carlson's place as lab manager when Rod moved up to be Microwave Division manager. John was a splendid, bright, helpful engineer and manager. John gave me my performance evaluation about March 1970. John assigned me to work on a preliminary design of another spectrum analyzer plug-in, 8556A and do some consulting on another product, the 8729A. I can't remember any details about the 8729A and what it was supposed to do.

Thin-film hybrid microcircuits were just becoming popular about 1970, especially in high frequency RF circuits. Our lab came out with a family of Wide Band Amplifiers. This family was the 8447 "A" through "F." They had various gains, bandwidths and connector configurations. These were a fairly simple product design job requiring a small Clement system housing, a power supply, panel, cables and connectors.

About August '70 I got assigned to Tom Grissell's section to help design the 8444A Tracking Generator. This new generator would cover a higher frequency range than the 8443A released earlier. I worked with Tom and his group a couple months on the project and due to medical problems, Tom decided he didn't want to be a project leader and that project was canceled. I was disappointed because I thought the project was going along well and it would be a contribution to our product line. There may have been other extenuating circumstances that I don't know about.

About this same time I was asked to review the cooling of the counter in the 8443A. HP was having field failures due to temperatures climbing too high in the counter section. The design was such that there was no heat-sinking nor convection cooling of temperature sensitive components. My solution was to add a very small Hall-effect DC fan motor just outside the counter box and force air in the box and across the sensitive components. The solution worked well and we had no additional temperature failures that I'm aware of.

***Finnigan Instrument consulting activities 4/69 - 2/71***

About April '69 I got a call from Hank Taylor who worked at HP, about helping out at a nearby company called Finnigan Instruments. The founder of Finnigan Instruments was Dr. T.Z. Chu. They made Mass Spectrometers. That was before HP got into the Mass Spectrometer business. Their lab was located right down Page Mill Road on Hanover. I often passed it on my way home. It was no trouble to stop in at Finnigan after work, meet with their engineers and discuss their project and problems, take the information home, work on solutions and the next day stop by and discuss a workable approach. I consulted with Finnigan for about two years to February '71.

I started with Finnigan at $10.00 per hour. I thought that was pretty good pay since I started with HP at $1.80 per hour. While waiting in the cafeteria lunch line one day with Rit Keiter he asked if I was doing any consulting. He asked what I was being paid which I thought that was a little forward and none of his business (but I'm glad he asked.) He said, "Ten dollars and hour, that's ridiculous, you are worth much more than that!" So when I completed one project at Finnigan and they wanted me start on another, I agreed to help them but the pay had to be increased from $10.00 to $25.00 per hour and it had to be retroactive to three months earlier. They went along with that plan and thanks to Rit, I made more funds than expected. That was one thing I liked about Rit…he came right out with it on any subject.

While at Finnigan we accomplished some clever designs mainly on a new controller for their Mass Spectrometer. I learned a lot working with those folks on a part time basis. I was careful not to allow outside consulting interfere with my HP schedules and design activities. In any case, during my free time away from work, I would be spending time building electronic stuff and experimenting in my workshop at home. I thought if I could be paid for this additional electronic fun and work…what could be better than that?

***New wheels and other activities throughout '71***

We were all outgrowing our bicycles and because someone stole the kid's bicycles from behind our fence and next to the garage, we purchase several new bikes. Each of us went to the bike shop of our choice and picked out the make, model and color that was just right for each of us. Needless to say, I built a lockable bike shed for storage of the four new bikes.

About mid '71 someone parked their new car, a Porsche 914 on the street next to our home. I'll never forget it…a bright yellow one and so handsome in design. Its engine was behind the front seat and the solid roof panel could be removed and stored in the rear trunk. It was small and very stylish. I called Donna to come out to see it. We both fell in love with that car. We had to have one. We went to Anderson-Behel Porsch-Audi, talked to the folks there and made the purchase. We got a white one. Right away we put the roof in the trunk space and drove up to Sun Valley Idaho and into southern Washington for a test drive and mini-vacation.

Coincidentally, we entered Sun Valley Idaho at the same time a Porsche Convention was breaking up. We couldn't understand why we were passing so many Porsches on our way to Sun Valley. They'd flash their headlights and wave. We thought they were congratulating us on our new handsome car purchase? We finally figured it all out.

Here is a short story about the Porsche battery problems. Several years later we needed a new battery for the Porsche and it was time for a lube. We took it to a local Porsche service shop in Palo Alto. We arranged for a new battery to be installed and we walked home. I went back to pick up the car a few hours later and the mechanic was embarrassed to show me the car. He lubed the car and replaced the battery but he also dented the front hood and smashed the left yellow directional signal light. It turns out that after replacing the battery he wanted to start the car to ensure that it was installed correctly. He reached through the front window, turned on the key, the car jumped forward (because it was in gear) and it smashed into a VW that was up off the ground resting on supports. It knocked the VW off the supports and we all are lucky no one got killed or injured. Our car got banged up and they later repaired it, but it was difficult to show Donna her damaged car that afternoon.

***Our 8640 Signal Generator 9/70 to 9/72***

Things are really getting serious now. John Page assigned me to Ray Shannon's section to assist on the product design of the 8640 Signal Generator. Bill Bull, a mechanical engineer was doing the mechanical design of the Cavity Oscillator and mechanical Tuning Dial for this product. That was a full-time job for Bill. I was assigned to do the remaining product design. Bill and I agreed how and where our designs would meet and that worked well. Bill was a fine engineer and I was sad when he left HP after this project and went to work for Apple Computer.

Ray Shannon was an interesting and very bright project leader. When I started on this project, Ray and I got along very well. There were a lot of strange and wonderful packaging challenges required to accomplish this design. About eight months after working with Ray on April '71, he was to give me my annual performance evaluation. I'll never forget it. Most evaluators have typed, legible and readable copies of the evaluation to discuss during the evaluation process. Ray handed me his evaluation copy and I looked at it but couldn't read it. His writing was small and bunched up and the copy was a very poor Xerox copy.

I was so embarrassed when I handed it back to him and said, "I'm sorry Ray but I just can't read the words." I didn't want to embarrass him nor did I want to get poor marks in cooperation. But I just couldn't make out the words. He obligingly read it to me and we discussed each item as was the tradition. I still have that evaluation in my notebook and still can't read it without the aid of a magnifying glass and steady hand. I was looking at this old review and it says, "Bob is the most competent, creative, productive product designer that has been my pleasure to work with in my twelve years experience and the success of our project will in no small way be a result of his design efforts." I was quite pleased and flattered with those kind words even though I never liked being evaluated nor the evaluation process in general. I could write several pages just about evaluations, the positive benefits and inherent problems.

***Design details of the 8640 Signal Generator***

The 8640 was designed to take replace the HP-608 which HP had been successfully selling for over 20 years. The 608 was a signal generator designed using vacuum tubes. It was large, heavy and expensive but very good at what it did. The 8640 was all solid state and was designed to be smaller and with more features and capability than the 608 but keep the same spectral purity of the output signal as the original 608.

Before I got on the project, Ray Shannon spent some time communicating with Dan Derby, one of the Microwave Industrial Designers. Between them, they came up with a general front panel layout. At first glance it looked good. All the major controls were represented and logically placed. My philosophy as a product designer was to try and work within the aesthetic restraints proposed by the Industrial Designer. If the stuff behind the panel just wouldn't work or fit, then the industrial designer and I would meet and we'd come up with an alternate mutually acceptable panel layout that would accommodate the human factors as well as be practical layout for the required hardware. Working with Dan was always good and his original 8640 panel plan (with minor adjustments) worked fine from a product design standpoint.

The 8640 was packaged in a System 1 (Clement) cabinet that measured approximately 16" wide X 16" deep X 5.25" high. We had several assemblies to fit into that volume. Most of them had to relate to Dan's front panel.


The HP 8640B Signal Generator

The 8640B was the most densely packed instrument because it had a counter assembly with six push-button switches and frequency readout including a time base vernier. There was also a meter assembly

with a meter, three annunciators and three switches. Also an output attenuator, coarse and fine tuning assembly, frequency range switch, FM deviation switch, modulation frequency switch, audio output switch and PC slide switches to select AM, FM modulation and RF on/off. There were also front panel connectors AM, FM and Pulse input/output, counter input and RF output. In addition at the rear of the instrument was the modulation amplifier assembly, power supply, and a fan driven by a DC Hall-effect motor. All of these assemblies were designed to be a size and shape that would fit within the box, interface to the front panel and provide enough internal volume to accomplish what is required in each assembly. As I write about it, it doesn't seem possible. But we did it.

This was a big project. There were 13 engineers involved for more than a couple years. That's over 26 man-years to complete this product.

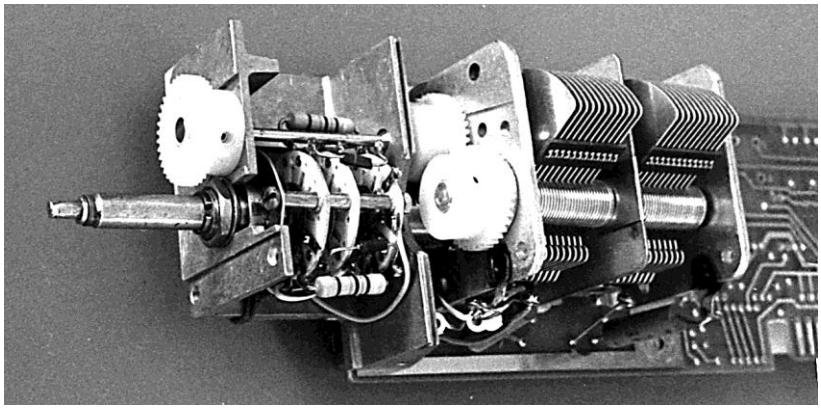
From a mechanical standpoint the 8640A/B was the most fun and challenging project that I worked on at HP. I could spend several pages describing the cams, levers, gears, housings, castings, extrusions, and moldings that we designed and tooled to make this fine signal generator. Since this was a totally new signal generator, designed into a smaller package, it was difficult to borrow parts from existing products. As a result most of the fabricated parts were unique to the 8640A/B. Just for fun, I'll list the quantity of unique and complex parts below:

| | | |
|---|---|---|
| 1 | Custom die castings | 10 |
| 2 | Plastic molded parts | 12 |
| 3 | Printed circuit boards | 28 |
| 4 | Special plastic gears | 18 |

The instrument was split down the horizontal center with a mother board and had smaller boards plug into that from both top and bottom. In order to minimize wiring, many of the interconnections were accomplished by using PC boards. The lower power supply motherboard was connected to the center motherboard with the aid of a riser board. The riser board approach was used in both the counter and divider/filter assembly to interconnect their main boards.

The general circuit approach was to start with a Cavity Tuned Oscillator operating in the 230-550MHz range. Then to get lower frequencies these frequencies were divided down in steps of 2 (divide by 2.) Then the signal was Amplitude Modulated, if required. The divided signal went through several RF Filters to smooth the signal. This divider/filter assembly consisted of one section of dividers and another section of filters. The filters had to be shielded from the dividers and switched in and out depending on the desired frequency coverage determined by the range switch. Well, needless to say, this got very complicated from a packaging standpoint.

We had a Frequency Range switch on the front panel that the operator would rotate to select his desired frequency band. When rotating the switch, several things had to be accomplished. It had to: 1) rotate the mechanical tuning dial in the 8640A to display a different range, 2) select and switch in the desired frequency divider and filter and 3) deselect the unwanted frequency divider and filter. In switching in and out these very high frequencies it was important that they be shielded and physically separated from each other. If not, we would have serious circuit interaction and cross talk.



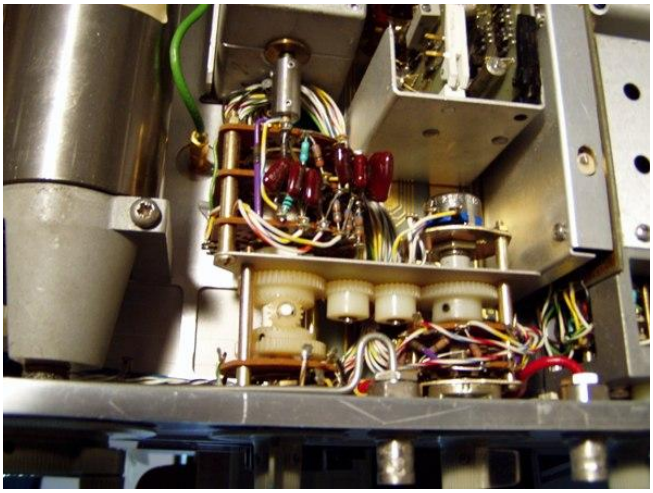
This range switch had multiple complex switching functions

The solution to the above problem was to design the filter board so that it was mounted on a flat surface, had wide traces where switching would occur and the traces were gold plated. Then we designed a long

molded Lexan bar that precisely retained eight gold-plated springy contacts that would touch down on the switching traces when the Lexan bar is set in place. By shifting the position of this bar lengthwise, the proper switching would occur. We had six of these switch-bars in the filter section that had to be positioned precisely each time the band switch was rotated. This switching required that all 48 contacts would dependably make and break at the proper time. That was 48 contacts total and any one, not making contact, would cause signal dropout problems.

In order to control the position of the bars I designed some rocker arms that inserted into a snug fitting recess in the bars. I designed six different cams that controlled the left, center, and right position of the rocker arms as the switch was rotated. Now, when rotating the range switch, the cams were rotated which actuated the rocker arms and that in turn moved the slider bars to the left, center or right and did the appropriate switching depending on the frequency range selected. This design worked surprisingly well and was a fun design experience.

Both the Audio Oscillator and Attenuator design was similar in front panel indication. If one rotated the center shaft of either switch it would cause a recessed dial behind each switch knob to rotate indicating audio frequency or output attenuation. To accomplish this we had a gear attached to the rear end of the center shaft. That gear mated with a gear on an idler shaft, and rotated the idler shaft which then (by a pair of mating gears on the other end of the idler) rotated the appropriate dial. The center shafts also rotated the variable resistors to control audio frequency or output level as desired. The output level was calibrated in volts, millivolts and microvolts. The audio oscillator dial was calibrated from 20 to 200 (with switch positions of X1, X10, X100, X1000 and X3000. That provided an audio oscillator range from 20Hz to 600KHz.



HP 8640 Gear Box Detail

We wanted the RF range of the 8640A/B output attenuator to cover from +20 to -140 dbm in 10 dB steps. At the time our standard 355B attenuator covered the range of 0 to -120 decibels in 10 dB steps. So it was necessary to add several more switch positions and another attenuation section to the 355B attenuator. The number of positions went from 13 to 15 plus the addition of a vernier potentiometer and switch wafers on the rear of the switch. This modification required that all the cams and detent in the 355B attenuator had to be redesigned. A fairly major modification but it all worked out OK.

One item that was poorly selected was the many required gears to accomplish our needs. Because of their low cost and ready availability we decided to use nylon gears. These gears were just molded nylon. We had our model shop drill and tap the gears for set screws to secure them to switch and idler shafts. The gears worked fine for a while but later, after environmental tests, the nylon dries out and splits at the tapped hole causing it to slip on the shaft. The solution to that problem was to have the gears molded over a brass knurled brass bushing. Then we could drill and tap the gear and bushing and it would hold quite well. The added bushings increased the cost of each gear about five times. Only in our most critical applications we specified the brass bushing.

A very special design was the Delta Frequency and Band switch. I shouldn't even attempt to describe it but will. For electrical reasons two switches were ganged so that rotating either one of them caused additional

switching to be accomplished on a third set of switch wafers. This complete assembly consisted of a front panel knob rotating a rotary switch with one wafer of switching and on the end of that shaft we had a coupler to another shaft that rotated the cams which rocked the rockers that positioned the sliders. There was another knob rotating a second rotary switch and two wafers of switching. That switch had an inner shaft that rotated a vernier potentiometer mounted at the rear of this switch. The two switch shafts were coupled together using seven gears. One gear on each switch shaft, two idlers and one planetary gear set of four gears rotating a third shaft of three wafers of switching. I'm sure that description was as clear as mud. This switch was fun to design and worked as intended. When this switch was assembled it was important to align all the switches and cam shaft at position #1 before tightening the gear and coupler set screws.

I loved designing rotary switches. I got lots of experience doing that in the Oscilloscope lab and more experience working in Magnetic Recording lab. Oak, Centralab and Grigsby were the rotary switch supplier of the day. We bought most of our complicated rotary switches from Oak. We even had a prototype switch assembly area in our lab to make weird and wonderful new prototype switches.

It seems that an engineer's best guess doesn't always pan out. It doesn't really matter if the engineer is a lab manager, section manager, project leader, circuit designer, or product designer. No matter how careful and thoughtful ones plans might be, due to unforeseen inputs, reduced requirements or other circumstances the plans change. What am I talking about? In product design, I like to design the product to utilize the internal instrument space uniformly and efficiently.

We did a pretty good job in the 8640A/B except in the modulator assembly. Early on it appeared we required more PC Board space then we eventually used. The modulator housing has space for five boards and we completed design with only two boards in place. Toward the end of this project, I checked with Shannon and Page to see if I could redesign the housing to simplify that part, make it lower cost and made better use of the wasted volume. They both agreed that they didn't want to upset the schedule by doing a small redesign. I tended to agree (mainly because they were my bosses) but I'm sure I could have made the changes without messing up the schedule. Oh well…that's the way it goes sometimes.

The counter assembly in the 8640B was a fairly simple product design. Since it had a frequency readout in the front, it had to be positioned toward the front panel right behind the front window. It was designed to fit in a clamshell cast housing. To get power from the motherboard we utilized a rectangular connector with about 24 gold-plated contacts. This connector was sandwiched between two PC boards. When the counter was screwed in place contacts touched down against gold-plated traces on top of the motherboard and against gold-plated traces on the underside of the counter board. Cooling and shielding the counter was an issue. Both ends of the counter were designed to be open but inserted into recesses in the ends was an aluminum honeycomb material that allowed maximum airflow and good shielding from the high frequency signals inside the counter. Heat-sinking the display LEDs was accomplished by designing a cast aluminum heat-sink bar that spanned the width of the window and between the LEDs and their sockets and attached to the counter housing. This provided good heat flow from the display to the housing.

***Stanford, ME103 and the 8640 Signal Generator***

Our industrial designer, Dan Derby, was teaching a couple of classes at Stanford University. After the 8640A/B was designed and in production, In late '77 Dan was discussing the design and manufacture of the 8640 with a couple professors in the mechanical engineering department, Ernie Chilton and Phil Barkan. They decided it would be interesting for the ME-103 class to learn about the design of the 8640. I brought an 8640 over to Stanford and spent an hour telling the class why anyone would want one, what it's for, why we designed it the way we did including many of the mechanical design details of the project.

It was a fun experience for me to lecture at this prestigious university. The presentation was well received by the students. Professor Barkan decided to make a class project of the 8640 if HP would allow it. He asked for samples of some of the more complicated parts and copies of their drawings for study. The class spent several months studying the 8640. The class studied the drawings in detail and later they were taken on a tour of HP casting and plastic molding shops. At the end of the course, each student wrote a report about the tour of our shops and many manufacturing details. One of the students found an error in one of my drawings. I thanked the student and corrected the drawing. Professor Barkan sent me some copies of the student's reports and also wrote a couple thank-you letters to me and Bob Guisto of HP. Bob presented a discussion of the tooling design and build for some of the molds and dies for the 8640.

***Designs: 11687, 11690 and Power Line Module***

In parallel with the 8640A/B product design, I was asked to design a 11687A 50Ω to 75Ω Adapter and a

11690 Frequency Doubler to be used with the 8640.

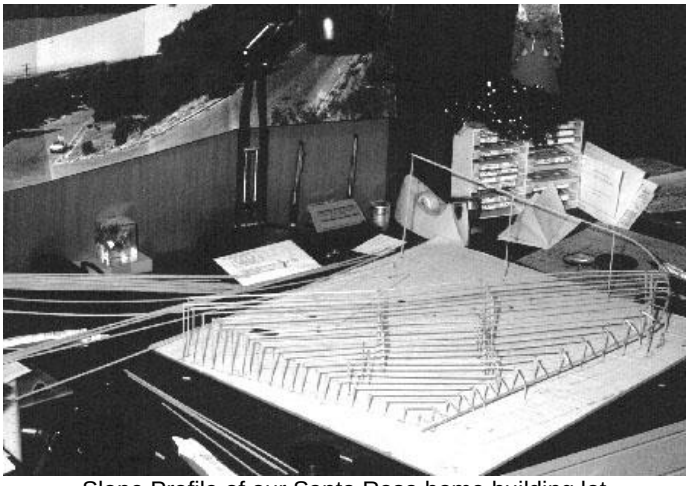
This switchable power line module with proper line transformer could adapt to 100, 120, 220 and 240VAC

In parallel with the above designs, Jack Magri (our industrial designer) and I put our heads together to come up with a Four-Voltage Power Line Module. This module would be used on most all HP instruments that plug into the wall for power. It was designed to mount on the rear panel of the product. It contained a fuse, fuse mount, fuse extractor, a fuse access door, an interlock to be sure to remove the power cord before accessing the fuse, a four-way switch to select the available line voltage and a connector for the power cord. This module along with an appropriate power transformer would allow the user to operate the instrument at four voltages. They are: 100V, 120V, 220V, and 240V. This was a fun project and took several months to get it all together, tested, evaluated, plastic molds made and released to production. Two Power Line Module designs were needed. One included RF line filter components and the other was a non-filtered version. This module became a corporate wide component to facilitate the same product to be used across the globe. Some countries have 100 Volt AC line and some others have 220 VAC line. It was very popular and was not only used by HP but used by many other electronic manufactures on their products.

***Doug Rytting, Hugo Vifian and the 8505A***

After the 8640A/B project was completed and released to production, I was assigned to Doug Rytting's section about February '73 and did some preliminary design on plug-ins for the 8672A Synthesized Signal Generator. I worked on the the 8671A/B control unit and later transferred the project to Santa Rosa about 5/1/73 then I worked on the 86710B RF unit for a few months then transferred that project to Wally Rasmussen's section. In development of new products the model numbers change more often than I'd like so I may have the above model numbers mixed up.

While in Rytting's section I was assigned to Hugo Vifian and his team. Before I knew it, I was asked to help design a new Network Analyzer. Meeting and working with Hugo and his guys and on such an interesting product was the answer to a prayer. This project was the 8505A that was comprised of several assemblies. They were the 85050 Source Receiver (Dan Harkins), 85055 Display Control (Hugo Vifian) and the 85052 Mainframe (can't recall his name?).


Slope Profile of our Santa Rosa home building lot

***Microwave Division split to Santa Rosa, CA***

About this same time that I started working with Hugo, the microwave division split and the move to Santa Rosa was hot and heavy. Many of our Microwave Division engineers were moving to Santa Rosa. It came as quite a surprise to me when I learned that Hugo's project, most of Hugo's team and Hugo were moving to Santa Rosa. I discussed this situation with Donna and we decided to spend a week up in Santa Rosa to see if we wanted to make it our home. We packed our two kiddies in the car along with our four bicycles

and headed to our motel in Santa Rosa. We biked and drove all over the place. We looked at homes and lots. We talked with realtors and builders. The kids were not enthused about the move. It meant a change in schools and making new friends. Donna was just slightly enthused especially when we were looking at lots and discussing plans to build a dream home on a Santa Rosa hilltop.

After serious discussion we decided we liked it enough to move there so we found and purchased a half-acre lot on the corner of Alta Vista and Happy Valley roads. We had quite a view toward the west from this lot. We had the lot surveyed and talked to a couple builders. I was enthused about our new lot. I went to the Geological Survey in Menlo Park and purchased an aerial view of that area of Santa Rosa including the lot. Using the surveyor's drawings I built a model of the lot using balsa wood. The model was intended to show a scaled down size, shape and slope so we could consider how our new home was to be designed and built. I was more and more enthused about moving so I could continue working with Hugo and his project.

A few days later our property tax bills came for both the Palo Alto and Santa Rosa property. It was clear to me that the property taxes were much higher in Santa Rosa. We surmised that was because Santa Rosa was still a growing community and schools were being built, roads were being put in and various utilities needed to be added.

Several thoughts caused us to reconsider this move:

- We are well settled in a nice home in lovely Palo Alto.
- We'd have to take the kids out of school and put them in a different one.
- The kids would have to make new friends.
- There was no financial incentive to accomplish this move.
- My work would be the same either in Santa Rosa or Palo Alto,
- My commute to work and grocery stores would be longer in Santa Rosa.
- Various other factors caused us to reconsider the move.

It didn't take us long to decide that we were better off to stay where we are, so we put our Santa Rosa lot up for sale with the same realtor that sold it to us initially. Within a few days he found a buyer and we made a couple thousand dollars on the completed transactions. With those funds from the lot sale, I paid off our remaining home loan for 1300 Cowper St.

***Another "Y" in our road of life***

I've often wondered how our lives would have changed if we made the Santa Rosa move. Many things we accomplished and folks we met were a result of staying here in Palo Alto. I'm sure we would have made other new friends and have different experiences if we moved. That Santa Rosa decision was another "Y" in life's road. We'll never know what might have been. Our (actually, my) greatest incentive to move was to be a part of the group that were developing this new Network Analyzer and be able to work with and for this good guy, "Hugo Vifian." Actually, I was on his project only a few months but we've been friends and have kept in touch these many years. Forty years later after we both retired from HP, we actually worked together again. The company? Anritsu of Morgan Hill and the products we worked on were network and spectrum analyzers. That's a story for another day though.

About 5/8/73 I was assigned to work with Rolly Hassun on the 8661A and later renamed to the 8662A. This was a pretty sophisticated Frequency Synthesizer. I'll describe it and other activities, in some detail, in the next section.

## MICROWAVE LAB 1973-79

***My experiences in the "Microwave Lab" 1973-79***

On May 2nd 1973 Donna and I celebrated our 20th anniversary in Carmel for two days. We each had new wedding rings that we purchased from Shreve's Jewelers at Stanford Shopping Center. I married Donna at her young age of 19 and apparently she was still growing because her original engagement and wedding rings were hopeless to remove over her now larger knuckles. Fortunately I brought along a pair of wire cutters and had to snip the rings off to remove them. While putting on our new rings, hugging and kissing each other, we celebrated with a bottle of Sparkling Burgundy wine. It was a lovely and memorable occasion. (We hadn't become heavy drinkers yet.)

JoDee graduated from Palo Alto High School this summer. She got a job working in the warehouse for Hewlett Packard. She worked there until the spring of '74 when she registered at Foothill College. Her

registration cost only $2.50 back then. She started out pursuing a computer science major. In 1973 computers were pretty young and I thought I had her convinced that computers were the coming thing. This would help her get in on the ground floor of computer technology. Much to my surprise she changed majors after experiencing a couple semesters of physics at Foothill.

It was about August '73 when the new programmable HP-65 calculator was introduced. I just had to have one of those. It was awesome. Having that calculator helped broaden my math skills and, in addition, helped me better understand computer programming. What a fine instrument! I wrote several programs that helped me do a better job as a product designer. In general the programs were quite simple and recorded on little magnetic cards. As you recall the magnetic cards contained the program steps and to use the calculator one just inserted the card into the side of the HP-65, the card was read, and the program was ready to run. It was so slick.

HP-65 Programmable Calculator

***Transfer to Brian Unter's section, late '73***

Because most of the network group was moving to Santa Rosa I transferred to Brian Unter's section. With a tear in my eyes and mixed emotions I finished up my Network Analyzer preliminary designs and documentation and turned those papers and prototypes over to my replacement, Oleg Volhontsef. I said goodbye to Hugo and the good guys in Hugo's section then focused on many important, different and new microwave projects while working with Brian. As you recall Brian was my original boss when I joined microwave in 1969. During this period, Brian was promoted from a Project Leader to Section Manager.

***Education Promotion: Ranking, Income, and Pay***

Brian was a good guy, a good boss, a good friend and in many ways and I enjoyed working in his section. I knew I was a low man on the lab totem pole because all my co-workers were graduate engineers with at least a BS in EE or ME. Some had an MS or even PHD. Until that time, I never gave lab ranking, income, and pay curves much thought. One day Brian told me, "In a wage review the section managers agreed that I was underpaid for the work that I've been doing." So to enable some financial adjustments, they decided to rank me as having a BS degree in mechanical engineering based on the date when I joined HP. That opened the door for a higher position on the pay curve since the pay curve was referenced to years since first degree. As you know, I don't have a degree (but often wish that I did) nor have I ever attended any college. All the electronic theory I know is what I learned at the Spokane Trade School, in the Air Force, in my own shop, on the job, watching others or reading about technical things of interest. As a result of this ranking change, my pay continued to climb in bigger steps, more frequently and at a much steeper slope than when I worked in test, scopes or the early years in microwave. So I thank Brian and the other managers for making that income adjustment for me.

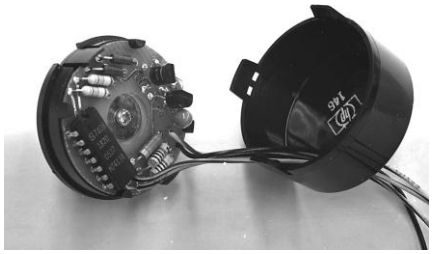
***8640/54 Attenuator Tester***

One of the first projects assigned to me by Brian was a means of testing attenuators. Many products at HP require Electronic Tools (ET) to aid in the production of a given electronic assembly or sub-assembly. The output attenuators in the 8640 and 8654 had a lot of components, cams and switches. They all had to be constructed correctly and the switches had to work in the proper sequence or the attenuator would be rejected. Because it's easier to test and repair the attenuator outside of the instrument, I designed and built a couple of test fixtures to test the performance of these devices. It was a short and fun project that actually worked better than I expected. It would quickly identify any problems within the device and defective parts could easily be replaced or proper adjustments made. All 8640A and 8654A attenuators were to be tested by this fixture before being installed in our new instruments.

***RPG Cost Reduction & Re-design***

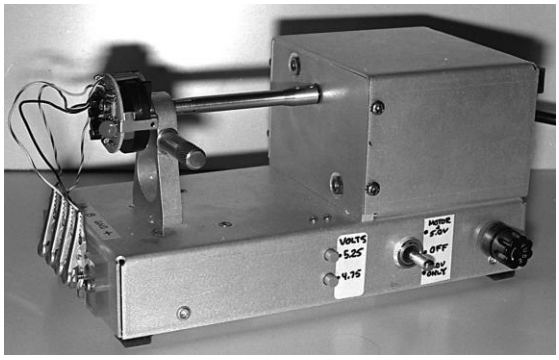
In many of our new products we were using a unique HP assembly called a Rotary Pulse Generator (RPG). This component allowed the user to use a rotary knob to increase or decrease modulation, attenuation or frequency changes in our digitally controlled signal generators. Many users were accustomed to controlling signal generator parameters with a rotating knob rather than keying in a particular frequency, modulation or attenuation using pushbuttons. The problem is similar to telling time by reading a digital readout rather than viewing the hands on a clock. It takes time to mentally adjust to the new way of doing things. Actually, the digital readout and inputs are more precise but to this day, some folks still like to turn a knob to reduce the volume of a radio or rotate a knob to tune in the stations.

Our present RPG was quite costly to manufacture so Brian asked me to see what I could do to reduce cost. I worked with Russ Riley and Bill West on this project. Russ came up with a low-cost circuit design and I completed the product design. Bill helped with several production details. The RPG is a panel-mounted device that had a shaft with a knob on the front. As the knob was rotated, the RPG electrical circuit would cause an output of two square waves that were 90º apart. This phase shift in output would allow following circuits in the instrument to know if the knob is rotated clockwise or counter clockwise. When used on the front panels of our signal generators, If the knob was rotated clockwise the circuits would increase frequency, modulation or output level and CCW would cause a decrease in frequency, modulation or output level.



New rotary pulse generator

Inside the RPG we had a thin chemically milled fixed shutter and rotating shutter. The rotating shutter had slots appropriately placed around the outer perimeter of a thin flat disk. We had a fixed shutter with similar slots. We had a bulb projecting light on one side of the rotating shutter and two photo transistors mounted on the PC board on the other side of the fixed shutter. We had two set-screw adjustments to control the light reaching the photo transistors. As the knob was rotated the light reaching the photo transistors would be turned on and off at the proper time and sequence causing the circuit to produce the required pulses.




Motor driven RPG tester

To assure that the new RPG was working as intended it was necessary to design and build a couple more electronic tools. This one was designed to provide power to the new RPG, to attach a motor to its shaft and rotate the shaft at a constant 100RPM speed. The outputs of the RPG were connected to the two vertical channels of an oscilloscope resulting in an easy to read display of output pulses amplitude, width, and timing.

Our final RPG design would snap together and was smaller, lower cost, adjustable, and was ultimately used in many of our microwave products and other HP instruments.

***Another good year was1974***

During the past year I've noticed an old dust covered 8640B prototype under Tom Grisell's workbench. It is serial number 1222A00056. It is one of our first lab prototypes. This 8640B was not in the best of shape because it went through Class-B environmental test. But it's been under his bench for over a year and it's not doing any good there so I asked Tom if it was surplus. It was! I asked Ray Shannon if I could have it since no one seemed to want it. Ray said OK so John Page signed a property pass and gave it to me. I cleaned it up, checked and calibrated it for proper operation of all circuits and have used it these many years. It still works like new.

Since I joined HP, I've actually never ventured out and solicited extra work for extra income. I don't know why, but frequently someone would ask me if I would be interested in doing some consulting for one company or another. Early '74 I got involved in helping to design a control panel for SHM Nuclear. I worked about 500 hours on their project. Our goal was to create a very large and sophisticated control panel and housing for a nuclear radiation device to treat cancerous tissue in humans. I spent a lot of spare time in my

den and at SHM Nuclear understanding the need, checking component specs and making drawings. My shop and tools was invaluable for constructing a full scale control housing mockup of wood and plastic. The project went well, looked very professional and the additional income helped too.

Our daughter, JoDee, spent the summer of '74 working at HP testing diodes. This summer work is very helpful both from a financial standpoint and in setting a career direction for her. She is convinced she hates warehouse work and piece work. Testing diodes is driving her nuts. She can hardly wait for summer to pass so she can start Cal Poly in September.

Oh boy, HP came out with a new calculator. This time it's the HP-45. I've got to have one of those. I don't know how many more calculators HP will invent or how many more I'll be able to afford but it's got to stop soon. In the meantime, I'm having more fun with all these calculators. Some of my co-workers are teasing me about my calculator collection.

***Digital FM receiver and amplifier***

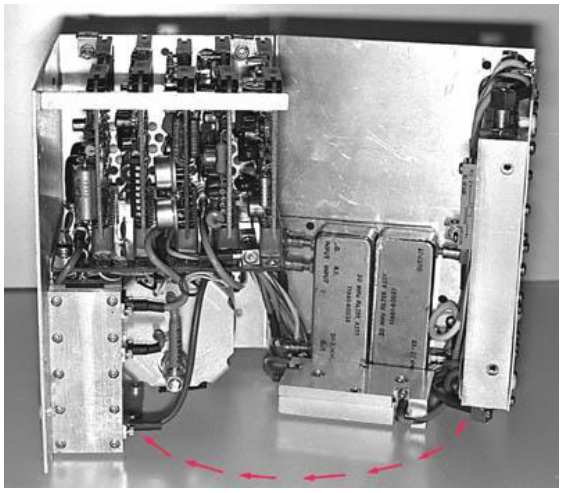
Then another consulting activity came along. He was years ahead of his time but later in the year I got involved with a company called "Resounding." Hal Baraclough, who once worked in HP Labs, was the boss, owner and inventor of a digital controlled FM Radio Receiver and Power Amplifier. His idea and the technology seemed impossible back in 1974 but most hi-fi of today is digitally controlled. There was nothing like it back then. His design called for a hand-held remote control to select the stations, adjust volume, balance, tone, etc. The main housing contained a very handsome tuner/amplifier with a panel bezel made of sculptured Walnut including a LED readout and a few enunciators. His project went well for a while and we were making good progress. He was anticipating sales in the hundreds and was investing lots of his own money selecting and buying parts to satisfy his future prototype and manufacturing needs.

Hal was a lovable guy and brilliant too. The product would have been a winner if only the funds held out. He had full scale models of the tuner and remote control but no actual working circuits that I'm aware of. I tried to get him to get the tuner and amplifier circuits laid out for PC boards and tested. I think he believed the first layout would work perfectly. In most new products, the circuit is designed, constructed and tested in parallel with the product design. The goal is to accommodate a working practical circuit.

I, along with several others, worked for him for a couple years. To accomplish his design he hired industrial designers, circuit designers, product designers and machinists part time. About then his wife got upset with him because he was spending all his free time and resources on this tuner/amplifier and remote control dream. She filed for divorce and he was forced to drop the project. I think they had one small child. I was involved in a legal battle between them regarding their assets and some deferred pay still owed to me. I was summoned to participate in a hearing with a judge and their lawyers. I have no idea how much money Hal spent total on the project. I've lost track of Hal and his project but often wonder about him and what is he doing now?

***8660B Fan and Heatsink Changes early '74***

We had been making and selling the 8660B signal generator for several years. It had a couple of plug-ins that enabled appropriate modulation and output level selection. Because of some design changes and additional power requirements it was necessary to improve the cooling and heat-sinking of some of the power components so I was called upon to accomplish that task. To accomplish these modifications or production changes the Production Engineer normally would have taken care of them but due to his work overload, I was asked to pitch in and help.



HP 11661, Part of the HP 8660B chassis assembly unfolds for servicing

***11661 Re-design for easier servicing access***

In addition there was an assembly in the 8660B that was a servicing nightmare. I was asked to make the necessary changes to this sub-assembly to make it more accessible and easier to service. This wasn't too difficult. The problem was simply solved by redesigning the supporting structure and including a piano-hinge along one edge of a rectangular sheet metal housing allowing the assembly to open like a

book. When opened, all components, cables and connectors were easily accessible.

***The 8672A&B family of signal generators***

The 8672A&B family of synthesized signal generators included the 86720A Design, and the preliminary designs on the 86701B, 86710B, 86720B, 86721B. I'm having trouble remembering how all these products relate. These projects were not as memorable for me like so many others that I worked on. That may be because I was involved only part time on this product and never saw it to completion. I think some of the final product design was handed over to Charles Cook to complete. Some of the plug-in designs were done in Palo Alto and the mainframe design was done is Santa Rosa. These Frequency Synthesizers covered frequencies from 2.0-18.0 GHz. They were an amazingly successful product for HP.

I recall one small contribution that I made for the plug-in front panels. In addition to the RPGs, RF connectors, PC Slide switches, meter and frequency readout we needed a few push-button switches. In lab stock there was quite a choice of micro-switches. There was a little one about 0.30 wide, 0.45 long and 0.40 high. A single switch could mount on the front panel PC board. I designed a plastic molded key-cap just large enough to fit over the switch, that included ears to keep the key-cap from falling out of the rectangular panel hole. This resulted in a front panel mount, low-cost and dependable momentary push-button switch. We used that idea on several different plug-in front panels.

HP 8662A top view shows modular packaging

***8662A Synthesized Generator Design early 1973-78***

While completing some of my earlier project responsibilities, I remember talking with Ham Chisholm about a new frequency synthesizer project that he was working on with Rolly Hassun. Rolly was the project leader on this project. He suggested that I get my foot in the door to become the product designer on this new 8661/2A. Ham was to design the digital control, frequency counter and readout circuitry. Ham told me that it would be a very sophisticated and interesting project and that Rolly was a fine project leader. I discussed it with both Brian and Rolly and they agreed that I should do the design. I had no idea what I was getting into but I couldn't have been happier.

Usually lab projects take one to two years to production. One sure thing I learned at the end of this project…it was a big one. We had twenty engineers working for five years on the 8662A. That's 100 man-years of top-quality engineering effort. It is a frequency controlled generator with an exceptionally low side band phase noise. The final product, the 8662A, contained 6393 total parts and assemblies. In the beginning I had no idea of the complexity, capability and reliability of this fine product. Helping on this project was another learning experience for me. I'll be the first to admit that every day, working in the lab at HP, I learned new things from everyone and anyone. What a great place to work and be paid for working there!

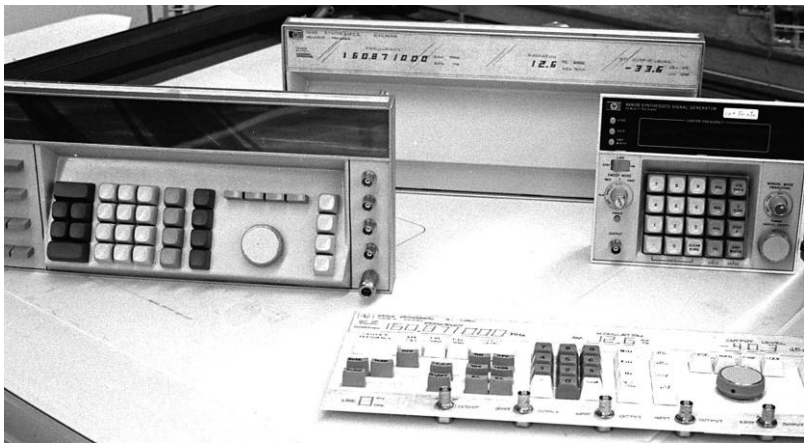
In the beginning there were just a few of us on the project and it wasn't clear to me what this unit did, how it did it, and who'd want to purchase it. About this time at HP there was a lot of focus on getting the product designer and production folks into new projects very early in its design cycle. I truly did get involved early in the 8662A design cycle.

When getting started on a new project I could list about a hundred different things a product designer

needs to know. By now I had quite a lot of experience as a product designer. I realized in product design there are a lot of common elements from one design to another. It doesn't matter what the product is intended to be, there are just some fundamental things that I need to know. These questions are the same from project to project. Some examples are: project work order number, EEs and MEs on the project, what are their names, what are their responsibilities, what is the product, is there a block diagram available, what size cabinet do you want this to fit into, is there a schedule, are we on schedule, etc.

Well, to save some time I bring out this list of questions and give them to the project leader to answer. The all are important and make it easier to get involved in this new product. When I got started on the 8662A I gave the list to Rolly looking for answers. He answered about five of them, skipped over most of them and when he reached the questions, "Is there a schedule? He answered, "No." "Are we on schedule?" He answered, "Yes." It was our working relationship and his subtle humor that made working with and for Rolly just wonderful.

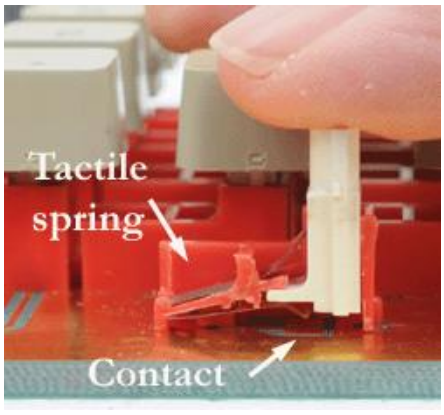
The final instrument size, shape, keyboard numeric entry system and readouts hadn't been determined but we were exploring all possible ideas. It didn't take too long to determine that in order to fit all the circuits in the box and all the buttons on the front panel we'd better settle on a System II frame size of 8.75" high X 16" deep. Five years later it was clear this was a good choice. The final product was dependably sound and densely packed yet ran cool. Its final weight was 65 pounds.



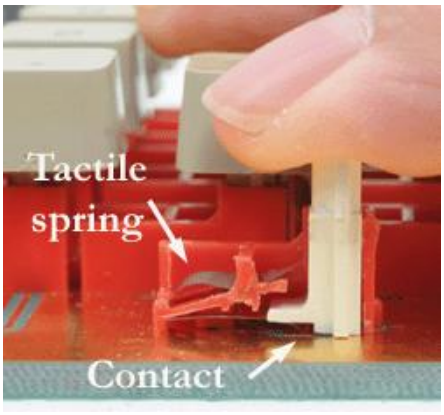
HP 8662A Front Panel Mockups showing alternatives to project engineers

***Designing the "West" switch***

To this point I've mentioned the Clement "System I" cabinet design. The System I is based on the inch dimensioning system. The 8662 was designed into our new "System II" cabinet system. It is designed about the metric dimensioning system. About this time HP was converting from inches to millimeters and flat-head screws were 90º in metric rather than 82º in inch. So side frame tooling had to be changed for System II. And all hardware was mm rather than inch.




West switch mounts on PC board (off)




Tactile spring "fall away" push action (on)

I spent many early project days working on the front panel plan and how we might want to enter data and obtain readout information. I mocked up thumb-wheel switches with numeric readout, slide switches with numeric readout, rectangular key caps over micro-switches, etc. Many of our approaches had some merit but not right for this product.

We had the production experience of the older 8660B and its method of data entry including fairly large and expensive keycaps and switches. Even before the 8660B these same switches were designed into a desktop computer that HP made earlier. It was a temptation to use that keyboard design on the 8662A. In fact, we made an early mockup using those large keys and switches along with the rectangular key caps and micro-switches. It wasn't long until it was clear those keys and switches were too large, bulky and expensive for us to be able to fit in the total number of keys we needed in this product. So Ham and I worked with Bill West, a fine mechanical engineer, who developed the "West Switch."

This was a small simple dependable push-button switch that took about 1/4$^{th}$ the room and cost much less. It was a simple, and clever design consisting of four parts. They were a housing, plunger, gold plated contact strip and tactile feedback stainless steel return spring. Included later was a key cap with the proper markings for the function desired. All the individual switch parts snapped together. A completed switch would be heat-staked to the front panel PC board for mounting.

I helped in the development by making a life-test device that would enable the environmental folks run a life test on several dozen switches for several million operations. We would then examine the switches for failures if there were any. This "West Switch" became very popular at HP and was used in many other products as well.

The "West Switch" cured the data entry problem. We decided on a mostly flat front panel with the data entry area tilted for ease of use. For the readout, we used numeric LEDs with a dot matrix pattern for readout flexibility and clarity.

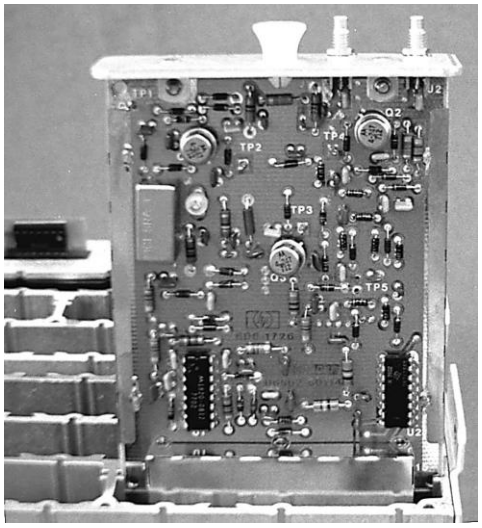
But the true test of the West switch was when customers sat there inputting data into any instrument with that keyboard. Those nice large buttons clicked in with such a QUALITY feel, it was kind of like a ker-thuck, but they didn’t make a noticeable click. Their spacing was just right to prevent key interference, one factor that all HP product designers thought about, because stories had come back about Packard, in a product review, a big man, also had big fingers, and was known to complain about key spacing.


HP 8662A became a world standard for low single sideband phase noise

***The 8662A Modular Packaging System using Extrusions***

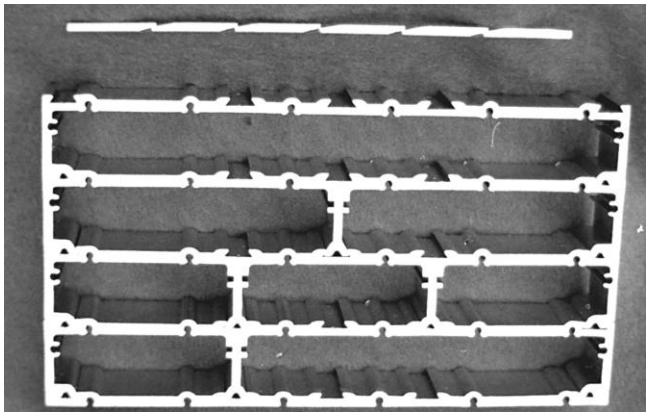
Early on, we decided we wanted a modular packaging system. It was clear there were a lot of independent interconnected blocks in our block diagram. In order to provide independent circuit design for each of the circuit designers it was prudent to come up with a flexible, well shielded but modular packaging scheme that would work for all. As you know, some circuits take more space than others. The packaging method has to accommodate small circuits as well as large ones but all had to be well shielded from one another and yet had to be within close proximity of each other.

I wanted this instrument to be extremely serviceable from either top or bottom and utilizing a tilt-down front panel approach, components behind the panel could be easily accessed. I didn't want to have to remove modules to access buried additional modules. That just makes servicing a nightmare.


Extrusion compartments provide signal isolation between adjacent PC boards

During the early stages of this project, I spent several months examining the shielding integrity of extrusions and identifying any potential RF sources of leakage between extrusions and covers and between extrusions and motherboards. In a sophisticated signal generator like the 8662A, we wanted no external signals from the instrument except the one that was intended to come out the front panel output connector.

It didn't take too long to focus on a family of interlocking extrusions rather than custom made housings or castings. We selected the extrusion family because they are quite low in cost and would allow us the flexibility to adjust the size of the shielded housing to accommodate any variation in circuit requirements as seen in the photo. The family of extrusions were full-width, 1/2 width, 1/3$^{rd}$ + 2/3$^{rd}$ width 3-1/3$^{rd}$ widths and end plate. We used element called a "shearing wedge" at each extrusion interface. Each pocket was well shielded from the other. There were locations for 14 screws on both top and bottom to secure the extrusion to the mother board and secure the covers to the extrusions. In addition to these screws we used copper waffled gaskets to seal any gaps between covers to extrusion and extrusion to motherboard.


Interlocking extrusions offer great design flexibility

The shearing wedge was a DeVries idea. It was a strip of aluminum that was to be inserted at the extrusion to extrusion sliding interface. After the extrusions were assembled and the wedges inserted, each wedge was pressed on both top and bottom. This caused the wedge to shear apart at the thin sections and wedge against the opposing extrusion surfaces. This insured a good electrical connection between extrusions resulting in good shielding between extrusion sections. Any slots or gaps between extrusions and/or other metal surfaces acted like a slot antenna and would radiate internal signals to the outside world.

***Medical consulting using low-level RF treatment***

The following story is a very unusual experience in my life but did expose me to an area of disease analysis and healing outside of the medical establishment.


Oscilloclast, circa 1934

In mid-October 1975, I answered my ringing telephone. It was Dave Baker, a friend that I had known for many years and who worked as a Materials Engineer for Hewlett Packard Co. He asked me if I would be interested in fixing an electronic device for Bev Ritchie, the manager at Eber Hi Fi in Menlo Park, California. Because I was very interested in Hi Fi, I said I would meet with Mr. Ritchie and learn more about this device to see if I could be of help. (I apologize if this gets a little technical. This could be a long story.)

The next day I stopped in and Bev showed me this old (vintage 1934) electronic box called an Oscilloclast. This box had a knob and eight buttons on the front, and inside a couple transformers, capacitors, resistors, and two #27 vacuum tubes. The owner of this box was

interested to know if this device was still working and wanted it fixed if it was inoperative. She suspected it to be inoperative but had no way of confirming it.

After I assured Bev that I was somewhat competent in electronic matters, he let me take the box (Oscilloclast) home to investigate it. I can't remember if I was given a schematic at that time but I spent some time tracing the circuit and checking what it was supposed to do. I learned that it had two oscillators. A Hartley oscillator working in the range of 43-44 MHz. And a low frequency oscillator in the region of 100 Hz/minute. I also learned that this RF oscillator was turned on and off at a 60 Hertz rate and that 60 Hz rate was turned on and off at a 100 Hz/min. rate.

I corrected the problems; poor solder joint, weak tube, and calibration. Since there was no convenient way to show Bev at his Hi-Fi store that it worked, I invited Bev to come over to my house to confirm that it worked correctly before I gave it back to him. To confirm that it worked used a HP 8640A signal generator connected to the "LO" (local oscillator) port of a mixer. The Oscilloclast output was connected to the "RF" (radio frequency) port and the "IF" (intermediate frequency) output was connected to an HP 130C oscilloscope. It was easy to see the zero beat of the oscillator and the frequency change with pulsing. He was pleased and impressed that it worked. I told him how much he owed me for the service and he took the Oscilloclast back to his shop and delivered it to his mysterious customer.

At this time Mrs. Packard (of 88 Faxon Road, Atherton CA) was keeping a low profile. Bev didn't tell me who his customer was until later. Bev and Mrs. Packard were members of the same church. Mrs. Packard is no relation to David Packard of the Hewlett-Packard Company.

A few days later I got a call from Bev asking if I had a few minutes to meet his customer to discuss the Oscilloclast repair. I said it would be convenient that afternoon after work. I met Bev at Eber's about 4:00 P.M. and he drove me to Mrs. Packard's home that was beautiful home at the end of Faxon road in Atherton. I liked her the instant I met her. She was very gracious woman, very pretty, hospitable, pleasant, and religious.

She was a widow of about 10 years when I met her. Her late husband, Gordon Packard, was a marketing manager at IBM She seemed well-to-do, living in a well kept, very nice home with beautiful surroundings and furnishings and a Japanese maid and gardener.

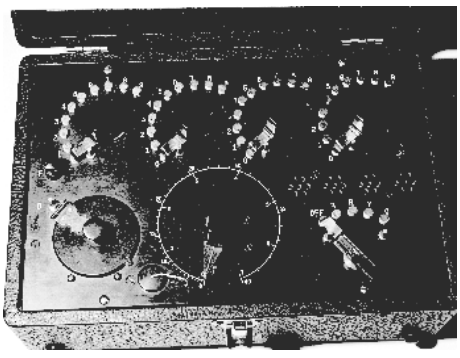
Mrs. Packard discussed the Oscilloclast that I repaired and gave me a little history regarding this device. She had some printed matter that gave me even more insight into the subject. That first meeting we spent a couple hours together and her question was: "Could I design and build a smaller, portable and modern day equivalent of her old Oscilloclast." The Oscilloclast was about a foot cube and weighed about 20 pounds. Mrs. Packard had about 6 or 8 different versions of the Oscilloclast that were built about 1938. Some were new and in the original carton. The original Oscilloclast or "Tic-Toc" was one of several inventions of Dr. Albert Abrams (Dec,1863-Jan,1924). The purpose of the Oscilloclast was to treat a patient to stimulate healing. Dr. Abrams had many physicians that leased his Oscilloclasts and hundreds of patients were treated by that device.

Another Abrams invention was the Radioscope which was used for diagnosis. This diagnosis and treatment, to date, has come about in several progressive steps.

First, Abrams found that when a cancer patient faced west, percussion revealed a dullness on the patient's abdomen.

Second, when a piece of cancer tissue was held close to the forehead of a healthy person, whom Abrams called the "reagent", percussion revealed the same dullness on the reagent's abdomen.

Third, the energy radiated from the cancerous tissue could be conducted over a wire to the reagent and produce the same dullness as when the tissue was held to the forehead of the reagent.



Radioscope

Fourth, by the same procedure not only cancer, but other diseases, could be detected by the energy radiated from the patient, or from a sample of the patient's blood.

It would seem obvious from Abrams' discoveries that disease could be identified by simply tuning in on the frequency that moved along the wire from the sample to the reagent's forehead. Strange as it may now seem, Abrams thought he was dealing with resistance. His first diagnosis device was made with rheostats which when set at 30 and 50 ohms, Abrams said he found the "vibration rates" of carcinoma because the dullness then occurred on the abdomen of the reagent. But identification of "vibrations" in terms of ohms of

resistance on its face makes no electronic sense at all. And so it is not surprising that medical science at once branded Abrams as a fake without any investigation to see if perchance, the rheostats might have been inductively wound so that the settings of 30 and 50 could have fortuitously turned in on the frequency radiated by cancer. By that time electronic science had not developed enough to accept any such explanation of the Abrams' phenomenon.

A Canadian doctor, T. Proctor Hall, was curious enough to attend an Abrams seminar demonstration. Hall was so thoroughly convinced by what he saw that he read a paper before the British Columbia Academy of Science on April 27th 1923 in which he reported that Abrams' diagnosis and treatment really did work, although, "it seems ridiculously simple".

Mrs. Packard's interest and involvement in the diagnosis and treatment procedures came about by a series of progressive events.

Mrs. Packard's mother had malignant lumps removed from both her breasts. Then the malignancy spread and both breasts had to be removed. Her health failed to improve, and new symptoms appeared, so she went to the Abrams clinic. A blood test with Abrams' diagnosis device revealed a further malignant lesion, which had not been detected by other doctors during prior examinations. Abrams diagnosed it as terminal cancer but refused to accept her as a patient because her demise, which seemed imminent, would only add to the attack on Abrams by the American Medical Association. However, a chiropractor using Abrams' procedures accepted her as a patient and she was cured by the frequency treatment. Forty-six years later, when she died of a staph infection, autopsy revealed no cancer.

Next, When Mrs. Packard was quite young the family's doctors determined that she had tuberculosis, but they did not know how to treat her. However, a chiropractor in San Jose, California applied the Abrams frequency treatment and Mrs. Packard was healed.

A couple years before Dr. Abrams passed away in 1924 he founded the Electronic Medical Foundation in San Francisco. Dr. Thomas Colson was the one at the Foundation who developed and made practicable many of Abrams' procedures.

I later learned that Mrs. Packard's father, Fred Hart, had several patents on the Oscilloclast. Fred Hart was an entrepreneur in many activities. He had the first lettuce farm in Salines growing iceberg lettuce. He had the first radio station in this area in San Jose. His Call letters were KQW then later became KCBS.

In 1938, after selling his radio station, Fred Hart retired and offered his time and administrative talent to the Electronic Medical Foundation and the College of Electronic Medicine in San Francisco and became president of that foundation. Fred Hart added some new features to the Oscilloclast and got several additional patents on other devices. I have no idea how many Oscilloclasts Fred Hart made, sold or leased.

In 1953 The Foundation published a booklet entitled MOLECULAR RADIATIONS by Thomas Colson, B.S.,L.L.B.,D.O. and Editor, Journal of Electronic Medicine, 1928-1946. Fred Hart assisted in preparation of the booklet for publication. In the booklet Colson explained why the Abrams' procedure permits functions and diseases of the body to be discovered in the molecules (which are present in the blood) before the cells of the body are effected.

In the booklet Colson also reported on the development of the "Radioscope" which has a circuit designed after a radio receiver but which has no detector of its own but instead uses the reflexes on the abdomen of the reagent.

The Radioscope has a receptacle for a blood sample and its dial settings tunes in frequencies of the energy radiated from the blood sample. Each such disease frequency as it is tuned in is separately transmitted to the forehead of the reagent. And when the dullness occurs on the reagent's abdomen, it indicates the presence, in the blood sample, of the disease entity to which that particular frequency belongs.

The treatment for a disease is by application of a particular frequency in the 43 MHz range, which would cancel the dullness on the abdomen, which had identified its presence in the blood sample of that particular disease.

Over the years a large number of chiropractors and osteopaths made use of the diagnosis and treatment services of the Foundation until in 1953 the Food and Drug Administration (FDA) challenged the validity of the Abrams procedures and demanded an end to its activities.

Fred Hart said, "the whole treatment issue was that in the opinion of the Food and Drug Administration advisors, no radiation except radiation strong enough to produce heat, as in diathermy, has any value in the treatment of living tissue." In the course of the controversy, which lasted about ten years, Hart was

sued; a consent decree was entered; and finally Hart was indicted for alleged violation of the decree. To avoid a costly legal battle, Hart entered a plea of nolo contendere and the Foundation was dissolved. Fred Hart had given to Mrs. Packard several Radioscopes and treatment equipment that included several Oscilloclasts.

The interesting thing is, Mrs. Packard believed that the Oscilloclast really did help to stimulate healing. She had been involved with it since she was quite young. She knew others that had used the Oscilloclast that cured problems that doctors had lost hope in curing. She had used the Oscilloclast often enough that she could tell if it was working or not. That's why she suspected that the one Bev gave me to repair was inoperative. I later learned that just by a treatment, Mrs. Packard can tell if the oscillator is on frequency and if the cables from the treatment oscillator are in good repair.

I considered her request (of building a transistorized equivalent) a couple days of thought and told her yes, I would design and build a smaller transistorized version of the Oscilloclast. I explained to her that I am a product designer, not a circuit designer.

In the begining I studied some literature that Mrs. Packard had given me on the Oscilloclast and experimented with a couple of her Oscilloclasts to learn more about the output waveform shape, frequency, modulation and level. I got circuit ideas for the transistor equivalent from books, studying schematics, and from transistor and Integrated Circuit catalogs. By December I had a breadboard of a working Transistorized Oscilloclast. We called it a "Pulsed Oscillator".

I continued building, testing, experimenting and communicating with Mrs. Packard for more than 25 years until she passed away. Summarizing these activities could take a hundred pages or more and is quite interesting but I won't include any more information about the Pulsed Oscillator project in these papers.

***Another Calculator***

In late October '76 HP came out with the new HP-97, programmable calculator. I was quite excited about that one. I just had to purchase one. It was like the HP-67 but with a paper tape for recording your calculations and calculator programs. It also had a card reader for the little magnetic program recordings. I'm happy that I got it and used it a lot for the next few years. Finally the card reader failed due to a rubber pinch-roller that turned into a sticky goo that coated the magnetic tapes and made the impossible to use. The recorder wouldn't read the tapes anymore due to the deteriorating pinch roller.


HP-97 Desktop Calculator

***Presentations and Demonstrations***

Because the HP 8662A was such a big and important project Rolly thought it would be good to give a presentation to all the folks that helped design, fabricate and assemble the parts for the "soon to be released" 8662A. Rolly asked me to put something together and present it to a couple hundred people in the HP conference room. I put together a slide show and demonstration that lasted a couple hours. There were two sessions, one on 11/14/77 and the other on 6/16/78. We displayed an assembled 8662A as well as all the individual fabricated parts set out on tables for examination. The attendees could see the many parts and how they fit together. Since many of the attendees were assembly folks and had little knowledge about electronics, I had 34 slides and presented a short lecture on DC, generators, AC, oscilloscopes, voltmeters, frequency, various types of modulation, output power, and frequency spectrums. I had three radio receivers around the room and would transmit from the signal generator to individual receivers set to a given frequency. The presentations went well and were quite fun.


Vibration isolation for sensitive crystal filter

***The 8662A Crystal Shock Mount***

There was always packaging challenges in the product design of the 8662A. One day Dieter Scherer came over and told me that in his circuits he had to include a couple crystal filters to eliminate some side-bands on the signal. These crystals are like very sharply tuned resonant circuits. The will allow only the passing of the frequency that is at the frequency of the crystal and all other frequencies are rejected. They are just perfect for this

required task but they are very sensitive to vibration. You've probably heard of crystal microphones and crystal phonograph pickups. In those cases sound waves are converted to electrical voltages by the crystal. In our case the crystal filter would be disturbed by our fan vibrations and lab bench vibrations. Our fan was already mechanically balanced and mounted on rubber shock mounts to minimize conducted vibration. But we still needed to isolate our crystal filter. Dieter and I performed about twenty experiments using different techniques to isolate and shock mount the crystal. It was a memorable experience.

We mounted a small circuit (mother) board on the cone of a loudspeaker to use as a small shake table. I made up several daughter boards with various crystal mounting schemes. I mounted the daughter board on the small motherboard that was mounted on the loudspeaker cone. I placed an accelerometer on the daughter board to measure the amount of acceleration as the speaker was varied in frequency. We observed the output of the accelerometer on an audio spectrum analyzer. If the output observed on the spectrum analyzer was at a minimum or low, the isolation scheme was working well. The larger the signal the poorer the isolation scheme. Well after many measurements on many test boards we settled on using small "O" rings and posts to mount the crystal along with some mass to lower its resonant frequency. We connected it to the motherboard with some very highly flexible wire. This assembly gave excellent isolation in all of the three directions and we used it in a couple critical locations in our product.

***Computer Aided Design (CAD)***

We still didn't have computer aided design at the Microwave division at the beginning of this 8662A project. But, hang onto your hats…it won't be long now. Thanks to Jim Burnham for introducing me to a computer drawing system called "Draw." (Not to be confused with HP-Draw which came along later.) It was part of a computer circuit analysis program called "Spice." One day toward the middle of the 8662 project, Jim came over and told me about "Draw" and how it would allow the user to draw rectangles, circles, arcs, etc. using the computer. He showed me how to use it and I've been hooked on CAD systems ever since. I was the first one in the lab using it and was quite creative making various mechanical design drawings. Because of my interest in CAD, I was later asked to be the Microwave Division's CAD rep at various CAD meetings with other divisions.

Computer Aided Design made Product Design so much more efficient

A few months later Bruce Borrows came over from our HP division in Scotland and introduced us to a CAD system named "MINT". Folks at that division wrote the software for Mint. It worked on the computer System 1000 that we already had installed at Stanford Park. It was just what we needed. I immediately saw the benefits of Mint over the "Draw" system I was using. It didn't take long for me to use Mint for all my drawings.

In many microwave designs where transmission lines, strip lines or microstrips are required, before CAD we would make an image five or ten times size on mylar sheet and fill in the required area with red tape, photo reduce and etch the appropriate layers of a PC board. With MINT we would designate the shape and push the "Fill" button and the required area was filled with black. It cut down the design of the required image to about 1/20 the time of the old method. I used Mint extensively doing the design of Dieter's Oscillator described below.

HP 7580A "Big Bertha"

large format plotter

Over a period of several months I trained all our product designers how to use Mint to make drawings. I spent several

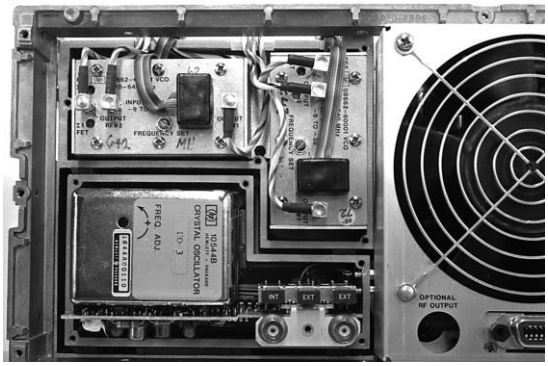
days in our Spokane Division training the designers in the use and advantages of Mint. For each of our designers we ordered and got computer terminals placed at their desks. From the computer all our drawings were then plotted on the HP 7585 "Big Bertha" Plotter. Our personal drawing boards were becoming just a place to set our computer-generated drawings. We could put away our electric erasers and pencil sharpeners. No more circle templates required. It was a new and wonderful era. I'm really glad that I could play an active part in our early CAD activities.

The subject of CAD could fill several pages but, about this time in HP history, several different CAD systems were available and being evaluated by various divisions. I'm sure I personally evaluated 6-9 different systems for our formal CAD system for our Microwave Division, and later, Stanford Park Division.

***Dieter's Reference Oscillators.***

We always referred to them as Dieter's Oscillators. These were unique oscillators used in two places in the 8662A. They were constructed using copper clad thin Mylar sheets designed to be shorted transmission lines. The transmission lines were laid out on thin Mylar sheets using MINT our CAD system. These sheets were chemically milled then mounted surrounding a couple of Rexolite blocks. That assembly was clamped in an aluminum housing made of sheet metal and extrusions. The finished oscillators were mounted in a die casting, adjacent to the fan, and accessible from the rear in the 8662 along with the 10.0 MHz oven controlled reference oscillator. Because the crystal oven is intended to be warm we placed it away from the fan because the fan is used to cool components. By doing that we saved a considerable amount of precious power in this instrument.

It would take several pages and a smarter guy than I am to describe how Dieter's oscillators worked and how they were utilized in the operation of the 8662A. That really is beyond the intent of this chapter. I do know the oscillators were designed to operate in the range of 320 MHz to 640 MHz. I know that these oscillators along with the 10 MHz reference oscillator, 1/n loops, phase lock loops and some mixers and frequency doublers, we came up with a pretty fine frequency synthesizer that covered a range of 10.0 kHz to 1280 MHz with a resolution of 0.1 Hz.



All three ultra-low SSB phase noise oscillators

It was my good fortune to work with more fine engineers i.e. Don Borowski, Bill Chan, Bill (Skip) Crilly, Fred Ives, Al Kovalick, Don Mathiesen, Dave Platt and John Richardson. These talented engineers, along with others working together over this five-year period came up with a major contribution in synthesizer design.

When I wrote the name, "Skip Crilly" above I was reminded of the dogged determination of the various engineers to make this the best product available. Skip did his part. I'm so impressed with him finding the solution to a difficult problem I want to tell you about it. The problem was intermittent spurs or side bands on the output signal. They shouldn’t be there but were and could come from anywhere. Skip was determined to solve this intermittent problem. I couldn't tell you how much time he spent looking but by the process of elimination and careful analysis he found that the spurs were due to intermittent grounding of one of the shields of our triple-shielded coax interconnecting cables.

What is triple shielded cable? One could use just a wire and ground to connect the signal from one place to another. At these frequencies a single wire would radiate signals like an antenna. A layer of grounded braid around the signal wire would help. But that is not good enough. A layer of foil around the braid would help more. But that is not good enough. OK then another layer of braid around the foil would be even better. That works very well but our problem is that the foil was secured to a thin plastic film which was an insulator. The insulating surface was against the inner braid and would intermittently allow the outer foil to touch the inner braid. The solution to the problem was to wrap the signal conductor with the foil first with the insulating side against the center conductor. Then the two layers of braid were wrapped around the foil.

In the 8662A we probably use 30 of these special triple-shielded cables. In a critical location and under the right circumstances if the shield isn't solid and consistent it could insert slight changes on the signal. Because of Skip's fine detective work and thorough analysis we redesigned the triple-shielded cable so that the grounding is solid and consistent. Problem Solved…thanks to Skip. I loved working with guys like

Skipper!

One last, but important detail of this new product was the power supply. This design was completed by Gerry Ainsworth with the help of Al Kovalick and Marilyn Lawrence. His design was special in many ways. He developed a high frequency and efficient switching power supply design rather than a large 60 Hz power transformer, filters and regulators for the 650 Watts of power required for this instrument. His output voltages had very low ripple. The supplies were protected from over voltage, over current, shorting together, shorting to ground, and had a high temperature shutdown. All the various synthesizer circuits were protected as well as the supply.

HP 8662A switching power supply

It was my job to design this power supply circuit into the space available and assure everyone that it would dependably interconnect to the other circuit modules, conduct the voltages and currents as required and not radiate any unwanted frequencies from the switching circuits. It was mounted in a direct cool air path from the fan for maximum cooling. It was an efficient compact design. It was quite serviceable and primary power circuits were clearly marked for safety for the service technicians. It had some heavy components but they were mounted securely to survive our shock and shake tests. The 8662 is a very successful HP/Agilent product and is still in the HP catalog today (30 years later) selling for nearly $50,000.00 each.

***8663A Synthesized Generator Preliminary Design***

After the 8662A was introduced and released to production I was asked to help develop the 8663A. As I recall, many of the components and specs were the same but because more circuitry was added we increased the length of the instrument three inches. This product was designed to have an extended frequency range, more output power and greater modulation capability. I worked on the 8663A for several months then it was transferred to the Spokane Division when several of my co-workers moved to the Spokane Division. The 8663A is a very successful HP/Agilent product and is still in the HP catalog today (29 years later) selling for as much as $70,000.00 each.

***8903A Audio Analyzer Design '79***

The last project of this section was the 8903A Audio Analyzer. I'm having trouble remembering the details of the project. I know that Jim Foote was the project leader and it seems to me that Derrek Kakuchi worked on the HPIB interface. I can't remember the others on the project. This project took only a few months of my involvement. A couple things I remember is that we wanted it to operate without the aid of a fan. By mounting the hot components on or near the outside of the rear panel we were able to run cool enough. The Front panel had a clean layout with logical locations for the "West Switch" pushbuttons. The most unusual detail is that the front panel BNC connectors were for differential input with a grounding switch for one of the inputs. We designed a single GR to BNC adapter so the user could use the GR (General Radio) connectors. We had those connectors on 3/4" centers to accommodate the GR connectors. The product was a clean simple design. It worked well, looked nice and we sold many.

HP 8903A Audio Analyzer

## MICROWAVE LAB 1980-90

***Computer Control of HP instruments***

I don't intend to tell you about all remaining 58 Microwave projects but will hit some of the high spots.

I know we weren't, but, speaking of computers, I've been totally sold on computers since they were first

introduced. In the beginning, I had no idea what they did or how they did it but they were just mysteriously wonderful. I tried to follow various computer languages and the various models available on the market. I tried to understand the logic and various advantages of each computer language. Computer technology has always been a fast-moving and deep subject. Several of my lab co-workers were taking courses in computer science and programming languages at Stanford. I'd overhear their conversations of what they were studying and learning. I tried to understand the benefits of one computer language over another and a different language would pop up without warning. I always liked Basic and did a little programming in that language. I did understand how it worked. Before long someone came up with HP-Basic that was a little different but just as easy to understand. Then there was machine language and compilers and other mysterious technologies to understand. And it all continues on to this day.

Many of our new test instruments became programmable and could be remotely controlled to test and measure various parameters on a product. Back in the '80s the control signals and results were connected between the various instruments and computer by the HPIB (Hewlett-Packard Interface Bus). The computer controlled the various test instruments. The test results could then be printed out, displayed on the computer screen or stored in computer memory for further analysis. This was a boon to test instrumentation technology and has continued to become more and more sophisticated as time goes on. Many of the test instrumentation of today have built-in computers and microprocessors resulting in much simpler, real-time, more precise signal analysis and control.

***11715 AM/FM Test Source***

Radio communication has always been important to HP. It seems that during this time there is more focus and/or more importance placed on transmitters, hand-held telephones, and later, cell phones and the fidelity and/or distortion of these devices. Cell phones were just in their blossoming stages and cell networks were just being planned, constructed and tested. My next few product activities were aimed at this blossoming new market.

HP 11715A

In early 1980 I helped develop the 11715 AM/FM test source. This was a simple product from a design standpoint so the design went quite quickly. This test source provides a very flat, wide-bandwidth and low distortion amplitude or frequency modulated RF signals for testing receivers or test instruments. It's still in the Agilent catalog selling for $4,500.00 each.

In early 1980 test systems with the HPIB (Hewlett Packard Interface Bus) and computer control became very popular. More and more of the instruments designed after 1980 had the required HPIB circuits inside and the HPIB connector on the back panel. This made it simple to create automated test systems. As you recall my recent years were devoted to the 8662/3A synthesized signal generator and the 8903A audio analyzer design. Both of these products had that HPIB hardware and capability included.

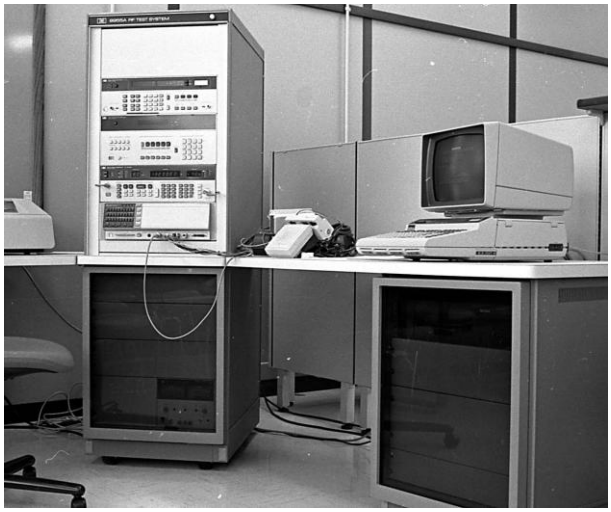
***8901B Modulation Analyzer and 11722 Remote Sensor.***

I provided some preliminary design on the 8901B modulation analyzer. It also included the HPIB hardware for computer control. After some preliminary layout and mockups Bob Waldron, a fellow product designer, completed the design and documentation. That all worked out well and Bob did a fine job.

HP 8901B and 11722 Sensor

While Waldron was working on the final design of the 8901B, I was assigned to design a remote sensor (11722A) to be used with the 8901B. This required an unusual package design. Our industrial designer, Peter Lee, came over to my house and we actually designed the outside shape using a redwood 4X4 and the table saw to cut and trim the redwood to be a comfortable fit for the hand. Our design made it aesthetically handsome and just large enough to accommodate the various parts this sensor must contain. It was a fun and efficient way to

quickly come up with a final module design that would work. To make drawings and have parts made in the model shop would have taken weeks. Doing the design at my table saw took about three hours. Twenty-seven years later Agilent is still selling the 11722A for $4,000.00 each. From that 3D redwood model, I made the appropriate drawings to get a mold made to make final housing parts. It wasn't long till we released that instrument to production.



HP 8955A (Big Foot I)

***8955A Transceiver Test System (Big Foot I)***

A little later, one of my contributions was to help design a transceiver test system the 8955A. It was called "Big Foot I". It is taking full advantage of the HPIB remote control of our instrumentsand the control of our instruments by a programmable computer. It would automatically step through all the tests required in the manufacture of transceivers such as cell phones, which technology was just getting started. It was a large system designed to support the required equipment and designed to provide an adequate work surface for the programmer and test technician. We wanted it to look nice, house all the equipment and be a comfortable place for the workers.

HP 8956A User Interface

The 8956B is a user interface and important part of the 8955A (Big Foot) test system. This instrument includes a lot of microwave switches and connectors behind the flip-down panel on the right and pushbutton selection to control the various tests required when testing transceivers. This was a fun project and went together well. The Big Foot systems were later sent to Spokane Division to be made there.

***11721 Frequency Doubler***

Some products are quite simple to design. This next one is a Frequency Doubler. You put 500MHz in the input and get 1000MHz in the output. It consisted of a simple extrusion, a PC board, a couple covers and a couple type "N" connectors. I was asked to design and document this new Doubler HP-11721A. It didn't take long before it was introduced into production.

***8770A Arbitrary Waveform Synthesizer (AWS)***

I could spend several pages discussing the 8770A. It turns out this began as an under the counter design. Rolly Hassun was the project leader of two new products called “Data Source” and “Arbitrary Carrier Synthesizer.” Somehow Rolly knew that by combining the proper modules we could create and build an Arbitrary Waveform Synthesizer. As I understand it, this synthesizer could make about any waveform one could imagine. It was computer controlled and had a fine display to show the waveform. He told me that we

could get this to market faster than the other two products we were working on. It was an easy design for me. Most of the hardware was invented and existing. There were some minor changes, software had to be written for the computer. Quite a bit of work went into the DAC design. Management accepted this new product. Julie McDonald saw it through environmental tests and it was quite successful.

***Lab Thermal Profile and Test System***

After becoming familiar with the rack mount hardware used in the "Big Foot II" project, it followed that I could help the lab by bringing together the proper instruments, rack mounted, in a short rack with a flat work surface and make a self-contained thermal data acquisition system. Part of our responsibilities, as product designers, was to run a thermal profile of any new instrument designed. Completing a well engineered thermal profile on a new instrument was a big job and quite time consuming if done correctly.

The thermal profile is an important development step in the design of new instruments. If some areas get too hot, it could force serious changes in the placement of major assemblies and cause a redesign. To complete a thermal profile required placing as many as 30 thermocouples throughout the new product, turn the power on, and monitor the temperature at each thermocouple. We would do that at high line (128 Volts) and low line (102 Volts). We would do that with fans running and fans disabled. Sometimes we would run test with covers on and covers off. After a couple weeks of testing, we would know where the "hot spots" are in the instrument and how hot it would get.

In order to make it easier to run these tests, I worked with John Page, our lab manager, and proposed the idea of a thermal test system. It would include a programmable computer controlling the switches to select the appropriate thermocouple, a programmable voltmeter to read the temperature at that thermocouple and the computer would be used to step through the various tests and store the data for later analysis. It would also include a Variac for setting the AC voltage into the unit under test. It included an AC ammeter to measure line current and outlets to power the instrument under test.

Thermal Data Acquisition System

John gave me the OK to go ahead. I put together the system. it worked well, was on casters for easy movement from one end of the lab to the other, short enough to fit under the lab bench when not in use, easy to set up and was used to run thermal profiles on many instruments. We used a programmed set of instructions in the HP 9825 to control the tests through the HPIB cable to the other instruments. The thermal profile test system was designed and constructed along with and in addition to my other projects and responsibilities.

A company by the name of Wahl made an infrared hand-held thermal sensor for spot checking temperature. It was shaped like a large pistol and one would point it at the hot spot to get a reading. Hard to use though, when the instrument covers are on, but one still wants to know the temperature of a device. Other thermal test devices were available that would focus on the components of a PC board and take a thermal photo. They were helpful sometimes but quite expensive. For good thermal information, I used the thermal test system most of the time.

***Dad Turns 90 Years Old***

Speaking of Spokane Washington, my home town and a fine place to live. In early 1981 my Dad was celebrating his 90$^{th}$ birthday. Donna and I attended this celebration. Lots of pictures taken and lots of family and friends visited Dad at his office to wish him well. Even the Mayor of Spokane came to his office and participated in the festivities. William DeVries Company was the name of his business and even at age 90 he would go to his office every day. It was a service station supply business. He would greet customers,

make sales, keep the place clean and enjoy every day at his office. He had inside storage parking and a parking lot to the left of the building. He had three gas pumps to service customers. He was boss and the only employee throughout most of his years there. He lived in his apartment above the business. An easy commute up or down about 30 steps.

Not long after we returned home from Spokane, I spent some time in the darkroom developing and printing many photos taken at Dad's 90th. I put the photos in chronological order and mounted them in an album and shipped it off to Dad. He was delighted to have this photo record of his 90th. He would show it to friends and customers as they came and went from his office. He really enjoyed it viewing it and sharing it with others. Even though I've been a little critical of my Dad, he was a good fellow! He passed away at age 92.

***Bicycling in Northern Holland***

About April of 1981 our division manager, Rod Carlson, knew that Donna and I liked to bicycle. Rod stopped by my desk one day with an advertisement of a Dutch individual that started a company that conducts bicycle tours of Northern Holland. It was called International Bicycle Tours. DeVries is a good Dutch name. We read about it and sent for more information. We got quite excited about the idea and signed up for three weeks of bicycling in Northern Holland. We left for Holland in early September '81. We biked over 400 miles on the two week tour then spent the last week In the "Hotel Smitz" in Utrecht. We visited various Dutch cities by train and just walking the streets of Utrecht, Amsterdam, Rotterdam, Gouda and other fine Dutch cities. Several folks asked me directions to various places because I looked like a typical Dutchman. I had no idea what they were asking because that language is foreign to me. It was a memorable trip and needless to say, I took several hundred pictures. Both black & white and color slides. Later after organizing the slides, during one lunch hour I presented a long-winded slide show about our Holland trip to my friends and co-workers in the HP 5M1 conference room.


HP-85 "Personal Computer"

***My New HP-85 and HP-150***

For a Christmas present on December 1981 Donna bought me a Hewlett Packard computer. It was just what I wanted. The HP-85. What a fantastic tool and toy. It came with lots of software, a small screen, a standard "qwerty" keyboard, an integrated printer and a tape recorder/player for programs. I really loved it and used it daily. It took me a while to learn to use it to the fullest. It was programmable so I did a little programming in Basic. The HP text editing program was awful but, fortunately, a little later Tom Ligon wrote a program called "Text 85" that was just wonderful. Not long after that I got an Ink Jet Printer that worked fine with the HP-85. This was my first real computer and I was sure computers couldn't get any better than this. I was so happy!

Then later, I purchased the HP 150 computer along with an "A" size HP plotter. It had a touch screen, a fine large keyboard, a larger sharp display, an internal thermal printer…it had everything a person would want. I used a HP 150 at home and another at work. I could bring work home just by having it on the floppy. In those days it had lots of memory, single then double sided disk storage. There is no way personal computers could get better than the HP 150. Boy, was I wrong about that. I can't tell you how many computers I've had since.

***Converting to Metric System***

Because we were a world class company and selling our products into countries that used the metric system as their measurement system, HP decided to convert everything to millimeters rather than inches. This was a big and expensive change for HP. It involved almost everyone in the company. I was asked to be our labs metric coordinator in addition to my regular product design activities. There were large meetings involving all the lab folks as well as smaller meetings involving model shop machine operators and tool makers. All our lab hardware was converted to mm. All our measuring tools were calibrated in mm. That included micrometers and vernier calipers. The model shop and production shops changed all their tooling for the metric system. In the lab, initially we used dual dimensioning, both inch and millimeter. Later all drawings were in millimeters. Any tapped holes in castings or plastic moldings were mm. A lot of time and money was spent converting from one system or another.

As lab metric coordinator I was to hold classes for the other engineers in our lab discussing and demonstrating the use of metric measuring tools. I'm sure they all knew how to use a metric scale and how to read the little marks on the scale, but it doesn't hurt to review. One day, before class I asked our prettiest and shapely secretaries in the lab if she would help me with a metric measurement demonstration. I explained what I'd like to do and she agreed to help me.

Toward the end of the class I told the 30 male engineers attending that I had a practical measurement demonstration. I had a flip chart with a drawing of a pretty lady on it. I had arrows pointing to the hips, waste and breast. The drawing showed the lady with arms outstretched. About that time, our pretty secretary came in the room and stood by me with arms outstretched. I was getting some offers from my lab coworkers wanting to help me. "No, I don't need help…just pay attention as I make these measurements." So, I proceeded to get her hip measurement in centimeters and wrote it on the chart. Then I did the waste measurement in centimeters and wrote it on the chart. Now I was offered even more help. Several guys even stood up and started to come forward. I told them to go back, sit down and pay attention as I made this last measurement. So with my metric tape in hand, I brought one end of the tape toward her breast, and since her arms were outstretched, I measured the length of her arm to the finger tips. Several guys were so disappointed that they tossed their coffee cups at me, called me names and I got a lot of hissing and booing. It was a memorable experience and one I'll never forget. I thanked and think of the dear lady that helped me with this demo. See…Metric conversion can be fun!

***Searching for new Product Designers***

Throughout later years before my retirement, I got involved in phone screening and inviting various potential mechanical graduate students out to Palo Alto to have an in-plant interview and tour. This was to learn if we thought this candidate would become an interested contributing smart product designer. HP had a system where various engineers would visit some of the best schools and interview graduate students looking for work. Various professors would confide in our interviewers the names of the better students and their GPA. Our HP guy would interview and if he or she passed this initial interview then their name and recommendation would be sent to personnel.

Then personnel would contact one of us in the lab to do a phone screen. If the candidate had potential, we would invite them out. Usually the one doing the phone screen would be the candidate's host for the day. I know I did more than fifty phone screens over a six-month period and invited out several different candidates. The host and five or six engineers spent the day interviewing the invited candidate. This procedure took most of the day. By the end of the day, we'd vote…should we make him an offer? In some cases, it was clear. This person was HP material and would make a fine designer. In other cases some voted yes and some voted no. Generally, the section manager had the final say.

One day I called Pete Zivkov on a phone screen. He sounded good to me so we invited him out. Later I checked with our Personnel Department asking when would he be coming out? The nice lady in Personnel said, "Pete Who?" I told her that we wanted to meet with Pete and so we invited him out for the in-plant interview. Oh, she said, "I just tossed his paper work in the trash because I hadn't heard anything about Pete." She searched her trash, found his paperwork invited Pete out, we interviewed him, all of us liked him so we made a job offer and he accepted. We all celebrated that evening at a fine Palo Alto restaurant.

Pete turned out to be a fine HP employee. He contributed to our excellent product designs in many ways. He was a real asset regarding CAD systems too. I'm so happy we didn't let him slip through the cracks.

***Mentoring and Product Design Central***
We hired several new product designers in a short time. The tradition at HP was to have one or two product designers sitting among six to ten circuit designers. The goal was to get good feedback from the circuit designers as instruments evolved. Because I was chosen to mentor four new product designers and because we were all using CAD and we had one plotter to share and to send drawing to be plotted, we created a friendly arrangement of desks, work benches and plotter. We called this arrangement “Product Design Central.” We were positioned near our respective circuit designers but we were within arm’s reach of each other so we could discuss problems and solutions.

Our group consisted of Doug Halbert, Jim Bertsch, Theresa Loney, Julie McDonald and Pete Zivkov. Ray Shannon was our lab manager. I always liked the open door policy he had for mentors. Any of these new folks could do dumb stuff or ask silly questions but those details never got back to management to go into their evaluations or personnel records. When evaluation time came, I was frequently asked by the project leaders, “How is Theresa doing or how is Pete doing?” I would tell them, “you must find out for yourself, I can’t tell you.” This approach was fair and reasonable. It gave the new employee total freedom to seek information and It forced the project leader to get to know the new kid on the block much better. I’m proud of all the new engineers that I’ve worked with. They have been successful in many ways. I won’t take all the credit but maybe I helped? Being a mentor was a good experience for me. I’m sure I learned more from the new employee than they did from me.

***Manufacturing and Mechanical Engineering Manual***
As a product designer this manual was most helpful. It contained several sections describing preferred engineering parameters for sheet metal, castings, plastic moldings etc. In the sheet metal section it listed preferred hold sizes, fold radius, holes near folds, holes near edges, etc. All these little aids helped all MEs from making fewer design errors, fewer prototypes required in the development cycle and shorter period to instrument release to production.

Many of our new microwave instruments required higher frequencies to function properly. This required semi-rigid coax rather than flex coax to interconnect modules. There was no section in our engineering manual for semi-rigid coax fabrication. Yet making semi-rigid cables is just as complex as sheet metal design and fabrication. So, to make a long story short, and with the aid of John Borgsteadt we added two new sections to the manual. Semi-rigid Coax design and fabrication and the other section was devoted to Extrusion design guidelines.

***Learning About Myself***
It's amazing to me how much I've learned about myself as I put this information together. While looking through old evaluations I was surprised to recall that I was quite stubborn, didn't really like too much constructive criticism, was more of a product designer loner than a "team" guy and I wanted to work efficiently and effectively. These characteristics were noted and commented on by several different project leaders over many years.

I listed below various projects and products that I worked on. In many of these activities I was involved from start to finish and some of them I was providing some consulting or preliminary design help to various co-workers.

As I became more experienced as a product designer and really was familiar with the design routine, I could get lots done. I loved to multi-task. As I plotted drawings from the CAD system, I could be writing a note or memo or checking on parts. As parts were being made in the model shop for one project, I'd be working on drawings or design for a different project. I could run temperature tests during project meetings and have the results after the meeting was over. Doing two or three things at a time worked well for me and resulted in lots of completed projects in a short period of time. From a list of completed projects in this ten year period, I count 58 projects completed. That's 5.8 projects per year.

***Substitutes for my memory***
I'm sure the reader is wondering how Bob does it. How can he recall all those details? Well, I never throw anything away so I have old evaluations and raise slips from HP. I have a computer file I call "What/when" that is a listing of significant happenings over the past 100 years. I have an Agilent catalog for reference, three notebooks of black & white and color negatives, some are of HP projects that I helped design and there are other references too. In putting these memories together, I look in one book then another to get most of the dates and details correct.

Two things make me quite proud during my thirty-four year HP career as a product designer.

1) I was always on time or ahead of the schedules and never in the critical path on any of my assignments. That included over 130 different projects.
2) I missed only one day of work in those thirty-four years due to the 24 hr flu.

As I look back over these many pages, it seems that I'm focusing on myself too much That isn't my intent to be tooting my own horn all the time. My objective was to communicate, to the reader, the many products that I focused on during my 34 years at HP. I also wanted to include some folks that really made a difference in our lives. This was also a summary of some of the paths we took and "Y's" in the road of life. I sometimes wonder what would be the outcome if we took the other path at the "Y" junction? We'll never know. I certainly have no complaints and consider myself very lucky to have met and married Donna, learned about and was hired by HP, worked in their fine lab doing what I love to do, and working with so many wonderful and knowledgeable people. What could be better than that?

Bob DeVries
Palo Alto, CA
July 2011

## *Bob DeVries Biography*

*Bob DeVries was the youngest of six children born and raised in Spokane Washington . His 10 years older brother, Adrian, was interested in early electronics and listening to the shortwave bands. Adrian had several friends who were ham radio operators. Bob watched and learned from Adrian as he put electronic things together. Bob's interest in radio and building things began about age six. Bob made crystal sets, Super-Regenerative, TRF to Super Hetrodyne receivers. Popular Mechanics always had a few pages devoted to electricity and electronics that he carried around and studied.*

*Through grade school and high school, Bob was always interested in math, mechanical drawing and electronics. He attended High School for traditional courses and took courses at the Spokane Trade School for electronics. Here he got a lot of basic electronic theory. He fixed many different home and car radios. Along with war surplus items at low cost, Bob was able to disassemble surplus electronic devices, and clean up the removed capacitors, resistors, tubes, sockets for new projects. While in high school, Bob built a working 5 inch and 9 inch oscilloscope.*

*In 1948 Bob joined the Air Force, worked in the radio shop for a couple months then the radar shop for 3.5 years. Most of Bob's training was "on the job." Later, for three years, Bob was a traveling salesman for the William DeVries Co., An automobile parts and accessory house owned and operated by his dad.*

*Early 1956 Bob learned about HP and that it was a fine place to work. He applied, was hired to work in the test department and, early on, became the Scope Test line leader. Three years later he made a temporary move into the lab to finish a project started while in the test dept. Our lab management had so many products and projects to complete that Bob was never sent back to test and after a few years was considered a Mechanical Engineer with a BS degree and be ranked and evaluated with the other engineers. He retired from HP in 1990 but went back for a couple years as a consultant.*

# APPENDIX

## Oscilloscope Designs from 1959 to 1964

*Product and project responsibility*

***120A Oscilloscope Cabinet and Rack Mount Version Redesign to 120B***
***120A Oscilloscope Cabinet and Rack Mount Version Redesign to 120BX & 120BRX***
***120H Oscilloscope, 3" Version for Hughes (a redesigned 120BRX)***
***120N Oscilloscope, 14" Deep for the Navy (a redesigned 120BRX)***
***120 X/Y Oscilloscope (Special…another redesigned 120BRX)***
***166A Dummy Plug-in for the 160 Oscilloscope***
***166B Time Mark Plug-in for the 160 Oscilloscope***
***166C Display Scanner Plug-in for the 160 Oscilloscope***
***166D Sweep Delay Plug-in for the 160 Oscilloscope***
***170A High Frequency Scope Engineering Support***
***185A Sampling Scope Engineering Support***
***130C Oscilloscope, Single Beam, Low Frequency and Sensitive Oscilloscope***
***132A Oscilloscope, Dual Beam, Low Frequency and Sensitive Oscilloscope***

## Tape Group Designs from 1964 to 1968

*Product and project responsibility*

***3513A 7 Channel, 1.5MHz Record Mainframe Design***
***3514A 7 Channel, 1.5MHz Reproduce Mainframe Design***
***3534A Direct Record Plug-in Design***
***3535A FM Record Plug-in Design***
***3535A Opt 01 Plug-in Design***
***3537A Plug-in Design***
***3538A FM Plug-in Design***
***3538A Opt 01 FM Plug-in Design (Flutter Compensation)***
***3540A Plug-in Design***
***3541A FM Record Plug-in Design***
***3543A Plug-in Design***
***3544A FM Reproduce Plug-in Design***
***3950A 14 Channel Preamp Housing***
***11539 Reproduce Track Selector***
***11560 Dummy Plug In***
***Amplifier Extractor and Extender***
***3535A FM Record Oscillator Drift Investigation***
***2 MHz System Labeling Plan***
***7 Meter Reproduce Mainframe (Special)***
***Tape Speed Tachometer (Special)***
***Low Speed Equalizer (Special)***
***3604A Voice-Channel for tape systems***
***3605A Frequency Source for Calibration***
***3960A Portable Instrumentation Recorder***
***32 Channel Preamp Housing investigation***
***Transistor & Diode Curve Tracer (Special ET)***
***Power Line Monitor (Special ET)***
***Isolation Power Supply (Special ET)***

## Stanford Park Designs from 1969 to 1973

*Product and project responsibility*

***140A Modification Kit to Accommodate Tracking Generator***
***8553L Modification Kit to Convert to 8553A***
***8553A Obsolete and Redesign to 8553B***
***1120B High Frequency Probe***
***8552A Production Change Support***
***8552B Design Modifications***
***8555A Design Instrument (Except Front Panel Assy)***
***8556A Preliminary Design***
***8729A Design Consulting***
***8447B Preamp Design***
***8447C, D, E, & F Preliminary Design***
***8444A Preliminary Design***

## Stanford Park Designs from 1973 to 1980

*Product and project responsibility*

***8640A & B Design Instrument (Except Dial and Oscillator)***
***11687A 50 to 75 Ohm Adapter***
***11690A Frequency Doubler***
***Four Voltage Power Module***
***86701A Preliminary Design***
***86710A Preliminary Design***
***85050A Network Analyzer Preliminary Design***
***85052A Network Analyzer Preliminary Design***
***85055A Network Analyzer Preliminary Design***
***8640A/54A Attenuator Tester (Electronic Tool)***
***Rotary Pulse Generator(RPG) Redesign for Cost Reduction***
***8660A Fan and Heat Sink Changes***
***11661 Redesign Module for Easier Access***
***86720A Design***
***86720B Preliminary Design***
***86721B Preliminary Design***
***86710B Preliminary Design***
***86701B Preliminary Design***
***8662A Synthesized Generator Design***
***8663A Synthesized Generator Preliminary Design***
***8903A Audio Analyzer Design***

## Stanford Park Designs from 1980 to 1990

*Product and project responsibility*

***11715A FM/AM Frequency Source Design***
***8955A System Design (Big Foot I)***
***8956A Preliminary Design (Big Foot II)***
***8901A Design Modifications***
***8901B Preliminary Design***
***1722A Remote Sensor for 8901B Preliminary Design***
***Temperature Data Acquisition System Design***
***11721A Frequency Doubler Design***
***Metric Coordinator for the SPD lab***
***Geometric Dimensioning & Tolerancing (GD&T) Coordinator***
***Interview for new product designers,***
***Mentor Pete, Theresa, Julie, Jim Bertsch and seed students***
***Vector Demodulator Design (ET)***
***Variable Delay Line (ET)***
***Evaluation of multi-conductor flat cable and connectors***
***Evaluation of multi-layer PC Boards***
***8970B Noise Figure Meter (Assumed responsibility and released to prod)***
***CAD Activities: Mint, Draw, Draft, Titus, Piglet, Anvil-4000, EasyDraft II ME-10***
***E-mail Activity: EIES & Confer***
***Investigation of Mint to replace HP Draft Cad System***
***Investigation of HPs ME-10 to replace Mint Cad System***
***The conversion of Mint drawings to ME-10,***
***Investigation of Mint to replace Draw Cad System***
***Parsyn Breadboard Design***
***Parsyn DAC preliminary design support***
***8770A AWS Preliminary Design***
***86970A DATA SOURCE Preliminary Design***
***86971A ACS Preliminary Design***
***86972A IF Agile Preliminary Design***
***8971B Noise Test Set(ET)***
***8353/4A Mid '86 Preliminary Design Considerations…scrapped to focus on Si'***
***347B mm Wave Noise Source Design Assistance***
***8970A Production Modification support***
***437A Power Meter Preliminary Design***
***8675A Late '86, Preliminary Design Considerations for Al Barber on the "Si'" synthesizer***
***MMS Modified Tracking Generator Design Considerations***
***MMS Repackage 8673 Output Design Considerations***
***Peltier Cooler (ET) Preliminary Design for Ron Larson***
***Hi Speed Modulator using Peltier cooler to maintain modulator temperature***
***8487A Design Assistance to Pete Szente***
***ET-25022 Programmable Power Supply Design Assistance***
***08770-KOI Frequency Divider and Signal Source design assistance***

***A Section 614 additions of the Corporate Design and Manufacturing Manual on Semi-Rigid coax cable design and a section on extrusion design.***
***8370 Family of Synthesizers including Si' and Simore***
***MMS equivalent of 8370 family of Synthesizers***
***VXI equivalent of 8370 family of Synthesizers***
***83710A & 11A (Si')Product Design***
***83711A (Si'more) Product Design***
***83712A Product Design***
***83713A Product Design***
***83730A & 31A (SiMore)Product Design***
***83732A Product Design*** MMS Equivalent Mockup/Drawing of 83711A Prelim Design
***VXI (D-Size) Equivalent Mockup/Drawing of 83711A Prelim Design***
***MMS 70100A Power Meter EMI and Grounding problem solved***
***Semi-Rigid Coax section of Mechanical Engineering & Manufacturing Manual***
***Extrusion section of Mechanical Engineering & Manufacturing Manual***
***MCG Platform Task Force***
***MCG Sbeetmetal and Standard Instrument Task Force etc.***