# The Hewlett-Packard Years

**Optoelectronics Division**
**September 1973 through January 1999**
**by**
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**Optoelectronics Applications Engineer**

## Foreword

## Optoelectronics Applications Engineer—Dave Evans

There are already two informative HP Memoirs on this website, written by Bob Steward and John Uebbing. Both memoirs have great technology and personal stories about how HPA started from a materials science group in HP Labs in the mid-1960s. This venture came from a vision which saw great promise in exploiting the remarkable ability to get visible light out of Gallium-Arsenide-based semiconductors, at very low (portable) voltages. Bill Hewlett and others in HP Labs backed up this venture with generous funding, especially in 1970 when 15-digit miniature displays were needed for Bill's pet project, the HP-35 electronic slide rule.

By the time Dave Evans was hired at HPA LED group in 1973, I had already spent almost three years (1969 – 1972) in the earliest years trying to manage the introduction of LED displays, culminating in the wildly popular HP-35 electronic slide rule. I moved on in late 1972. But that period starting in about 1969 was technologically exciting, as LED digits and alpha-numeric displays were finding applications all the way from auto tail and brake lights to traffic stop lights. But we really didn't know what was coming.

The clear advantages of semiconductor light, used to generate small digits for revolutionary pocket calculators or in portable HP instrumentation and quickly in desktop engineering calculators were obvious. It was also obvious to HPA's marketing teams like Milt Liebhaber and Rick Kniss, that the super reliability of LED bulbs were going to be natural for applications like the tail and stop lights of autos. The reason being that having lifetime performance installed in cars meant that an expensive $100 shop mechanic task to change a 50-cent incandescent bulb weren't going to aggravate a customer. Or, if installed in street stop light applications, cities would not need expensive periodic deployment of one of their cherry-picker trucks to go around replacing those bulbs. Of course, in the early 1970s, only the color red was available, since we weren't yet able to generate those wonderful yellow and green and blue colors. But the promise was there.

That's about the time that Dave arrived on the LED scene. Hewlett-Packard marketing was structured for sales of instruments to engineers, and not much customization was needed. HP's instruments went directly to the design bench or production test rack or out into field maintenance facilities. At the HPA Division, they had been established to design and manufacture components, such as microwave diodes and infra-red emitters. So, it took some convincing to get an instrument field salesman to spend time with a customer design engineer who might need a lot of hand-holding to figure whether a tiny HP diode component would perform properly in the new circuit design.

Hewlett-Packard enhanced our test instruments with a huge archive of application notes. These were tutorial publications, handed out freely, and promoted by advertising and PR media, and the massive annual HP catalog. Most significant new instruments would have an associated application note and perhaps a related product note, which expanded on the product's instruction manual. The same information techniques were used for the tiny rf diode and later the LED diodes, covering all of the necessary performance and environmental data, suggested circuit configurations and such. But often that was not enough. When state of the art components are available, it was sometimes necessary to refer the customer engineer directly to the factory for one-on-one consulting. Enter the Components Application Engineer.

Dave's recall is amazing, and this story presents so many fascinating episodes in customer's plants, assisting the local field engineer in boosting the customer design engineer to make him look good using HPA LEDs in his new creation. Other times, a trip was necessary to investigate product failures, often caused by their

production processes which compromised the performance of the digits and alpha-numeric components. HPA components were the essence of the visual interactive displays of the customer's product, aesthetically and functionally. Application engineers were also relied on to travel across the US to augment the field sales engineer in their daily sales job, especially when a "big deal" contract was on the line.

Dave's creativity was working continuously in the factory, he cheered technical projects to expand the performance parameters of components, to match customer needs in difficult environments, from nuclear submarines to desert heat. He created publications for application information to design engineers, which mirrored the kind of comprehensive technical data featured by the semiconductor industry giants. And he "enjoyed" the expense account life of a seminar presenter, running through airports, driving hours to be at the next town for a morning lecture. One story involved a dangerous overnight drive through a serious snow storm.

The theme I particularly liked about Dave's story was his career-long commitment to the Trade Association, Aerospace Lighting Institute (ALI). Industrial volunteering was a corporate value of Dave Packard and Bill Hewlett. Packard was Chair of the Palo Alto School District and Stanford Board of Trustees, for example, not to mention his tour as US Deputy Secretary of Defense. Although it was a personal decision, large numbers of HP execs did outside volunteering in their favorite causes. The downside was that there was always a small doubt that outside work would work against faster promotions in the company, where managers who committed full-time to HP would have an advantage.

I applaud volunteers like Evans. I, myself, committed 28 years to an International Trade Association for Metrology, which had considerable influence on the measurement industry calibration standards. I felt that association work was important to HP's future in all customer's measurement quality, and my management agreed. In Dave's work in ALI, he helped write industry standards that reflected HPA's display technology knowledge, combined with real customer needs, and thereby improved the final applications of this brand new lighting revolution. As you will see, Dave enjoyed those professional interactions as well as contributing to that industry progress. There are many more customer trade groups he served, from NCUTCD to NCHRP, in one case helping to write industry specifications for the well-known blinking amber crosswalk lights we have all observed. His work on committees which wrote standards on military night vision goggles greatly helped our national defense technology. These were not trivial accomplishments, and getting HP to have a hand in writing performance specifications gave us a step ahead of other competition. Good work, Dave.

But this is a personal life story, with a LOT of HP mixed in. It is a stimulating read. One abiding impression. I imagined myself as Dave Evans, going about his retired life now, seeing LED building EXIT signs, highway information signs, airport runway lights, and the massive use of LED home illumination, and I would smile and realize that it was my committee tutoring and standards-writing that helped accomplish all those benefits for society.

---John Minck

Click HERE for the HP Memoir of Steward and **HERE** for the HP Memoir of Uebbing.

Dedication

This HP Memoir is dedicated to all those in the Hewlett-Packard Optoelectronics Division who helped me be a success as an Applications Engineer; including but not limited to: Stan Gage; Bob Steward; Hans Sorensen; Mark Hodapp; Bob Zettler; Milt Liebhaber; Norm Tarowsky; Janice Leatherwood; to George Godfrey and the Aerospace Lighting Institute for allowing me to have an influence in the aerospace lighting industry; and to my wife Judy Evans who loved and supported me during those 25½ years.

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Before I begin the Hewlett-Packard Years, I want to let you know there are not that many Hewlett-Packard pictures to show you. You need to understand that companies and organizations were not in the business of taking pictures for historical reasons; and neither was I. However, what pictures I do have of the Hewlett-Packard years I will show you.

**I am hired by Hewlett-Packard**

The end of August, 1973 was difficult for me. I had been teaching statistics at The University of Notre Dame, Belmont, California, which was out of session for the summer. I was scheduled to teach another statistics class in the fall quarter of 1973 along with a Saturday graduate statistics class. I had decided to not accept the University of Notre Dame's offer of an instructor teaching position. My decision disappointed the evening school director. I still had not found an engineering position nor did I have any prospects of an engineering job. My only hope at this point of finding an engineering position was to contact the head hunter that a Raychem friend of mine had suggested to me. The head hunter had his office in Mountain View in the heart of what was to become known as the Silicon Valley.

After a short interview and an examination of my resume, the head hunter told me that Hewlett-Packard was looking to hire an applications engineer in the field of light emitting diodes. I had some idea of what a light emitting diode (LED) was. I had come across a Monsanto single digit dot matrix LED display device while teaching basic electronics at the College of San Mateo. I had not wired up a drive circuit to make the device actively light up and display numbers, so I had no idea of how it worked. I had seen red LED displays in some of the electronic equipment at the College of San Mateo, but beyond that my knowledge of LEDs was nil. The Hewlett-Packard facility was the HPA Division on Page Mill Road in Palo Alto, one block west of El Camino Real. HPA was the acronym for Hewlett-Packard Associates, the division making LEDs at the time. My interview at the HPA Division was on Friday afternoon, August 24, 1973.

I arrived at the main lobby of the HPA Division promptly at 8:00 am. I introduced myself to the receptionist, who I had previously known at AMPEX. She had left AMPEX a year after I had and had found this job at the HPA Division. She called to announce that I was in the lobby, awaiting escort to my

interview. Shortly after she made the phone call, I saw walking down the hallway towards me a man who resembled a photograph of a man I had seen portrayed in a Boeing advertisement. His name was Bob Steward. Bob Steward was 27 years old, very handsome, was a Stanford graduate, walked and talked with the authority and confidence of a highly educated, experienced electronic engineer. Bob Steward was the Manager of the Applications Group for the HPA Division of Hewlett-Packard. I was very impressed and honored to meet him. Bob was very kind to me throughout the interview session, which lasted most of the day.

The first thing Bob did, was to take me to a coffee and donut stand nearby that was provided free to employees by the company. I did not know how to react. I did not drink coffee and I was not sure about helping myself to a donut. But with Bob's encouragement, I took and ate a glazed donut. I was not scared, nor particularly nervous, but I was not sure what to expect either, for I had never interviewed for an engineering job before, and this was my first time. Bob introduced me to the other two engineers in the Applications Group, Stan Gage and Hans Sorensen, both Stanford graduates. Both were brilliant electronic engineers.

Stan was about Bob Steward's age and Hans Sorensen was five years older than I. Bob had been working for Hewlett-Packard (HP) for two years, Stan for one year, and Hans for five years. Bob had two technicians working for him, Al Petrucello and George Liu. Al Petrucello was the optical measurement technician and George Liu was the electronics technician, both experts in their respective fields. In the course of the interview I met other HPA employees, including Bob Zettler, the Manufacturing Manager. Bob Zettler's concern was would I at 39 years of age be willing to work for a man 27 years of age. My answer was assuredly yes, explaining to Bob Zettler that I had worked for managers younger that I at the University of Washington wind tunnel and at the College of Notre Dame and at the College of San Mateo.

During the interview process I had difficulty answering many of the questions asked of me. One was a question by Hans Sorensen concerning the Miller Effect. I had no idea what the Miller effect was. Hans explained to me that it was a feedback effect of a simple vacuum tube amplifier circuit. When questions concerning LEDs were asked of me, I pleaded ignorance on the subject. And when interviewers asked me questions concerning manufacturing, quality assurance, and marketing I again had to plead ignorance for I knew nothing about these subjects. I did, however, turn the tables on my interviewers by asking them to explain their jobs to me. I asked each interviewer his background and how he fit into the HPA organization. By doing this, I began to learn about the HPA Division and its place within HP. At noontime, Bob, Stan and Hans took me out to lunch. Now I was nervous, for I was not sure what to expect. The head hunter had warned me about lunch, and to order an inexpensive item on the menu. So I did.

The others didn't. It was 3:00 pm and Bob took me downstairs to a conference room for a private wrap up session. He asked my thoughts on the interview. I gave him some positive comments. Then, Bob asked me a question on a subject I had no idea what he was talking about. Bob asked me if I could explain to him the advantage of CMOS? What the heck was CMOS? I had no answer to give him! Bob wrapped up the interview and I left, knowing I had no possible chance for this job.

I was in tears when I got back to the head hunter's office and told him what had happened at the interview. I told him I had no clue what was meant by CMOS. The head hunter turned around in his chair and reached for a couple of electrical engineering magazines. "Here," he said, "Read these. Both have articles on CMOS. Maybe the answer is in one of these magazines." I took the magazines and left for home. Over the weekend I plowed through both magazines. I learned that CMOS stood for Complementary Metal Oxide Semiconductor, whatever that was. Then, in the middle of one article was a paragraph that said, "**The advantage of CMOS is that it does not use any power in the quiescent**

**state**." In other words, a **CMOS transistor only draws electrical power while in a switching state but does not draw electrical power when it is in an idle (off) state**. Thus, CMOS circuits draw very little power and as a result offers extended battery life in battery operated circuitry. That was the answer Bob Steward was looking for.

Sunday night, I wrote Bob Steward a nice thank you letter for the interview, and said, "By the way, here is the answer to your question concerning CMOS." I then gave him the above explanation in the letter. On Monday morning, August 27th, I went back to the receptionist at the HPA Lobby and asked to see Bob Steward. The receptionist told me that Bob was leaving on a business trip that morning. I pleaded with her to please give my letter to Bob before he left on his trip. I explained to her why it was so important that Bob Steward get my letter before he left the plant. She told me she would do her best to see that Bob got the letter before he left the building.

I went home with my heart in the dumps. If Bob did not get my letter, I could forget any chance of working for HP. That evening I went for a long walk. I left home and walked up into the Belmont Hills just a mile from our house. I burst into tears. This was my only chance for an engineering position, and it may very well have slipped away from me. After all, I really did poorly on most of the interview questions, and I knew nothing about LEDs or electronic circuits. And as far as I could judge, I was not the professional caliber of the people I had met during my interview at HPA.

I was gone four hours and it was late when I walked in the front door. "Where have you been?" Judy demanded. "You've been gone four hours and there is a Bob Steward from Hewlett-Packard who has been trying to get hold of you. He is in Texas and wants you to call him right away! Here is the phone number of the hotel where is staying." Bob had gone to visit the CORVUS Corporation in Dallas, Texas a manufacturer of small hand held calculators that used HPA LED numeric displays. I called Bob at his hotel. Bob told me that he was very impressed with my letter, and that I was the first and only candidate who had taken the time to research an answer to a technical question. Bob also told me that many of the interviewers were impressed with my interest in them and their positions at HPA.

Bob Steward then said to me, "I am pleased to offer you the position of Applications Engineer for LED Technology at the HPA Division, at a starting salary of $14,500 per year. Will you accept the offer?" I could hardly believe my ears! I was flabbergasted! I had never heard of a salary of that large an amount. "Yes! I am pleased to accept your offer. When do I start?" Bob explained that he would be back to work the day after Labor Day and could I start then. Yes, I would start work on Tuesday, September 4, 1973. Thus was the start of my career with the Hewlett-Packard Company that would last for 25 years and 5 months.

What I did not realize in this moment of jubilation, until years later, was that all of the experiences I had gone through in my life were preparing me to be successful as an Application Engineer at HP. On Tuesday, when I reported for work, I was greeted with enthusiasm by Bob Steward, Stan Gage and Hans Sorensen as well as others with whom I had spoken with during my interview. Bob Zettler came out of his office to greet me personally. Now, at the outset I want to tell you this: Almost to the individual, all of the people I worked with at HP were the very best. Some better than others, naturally, but all professional people who for the most part showed great respect for me as an individual and as a professional Applications Engineer. Oh I would have my ups and downs, arguments with people over issues of one kind or another, but my experience was that people the caliber of Bob Steward, Stan Gage and Hans Sorensen made it possible for me to have a successful career at HP. That is the kind of company HP was. Those working at HP did things "The HP Way".

HP was founded by Bill Hewlett and David Packard, both graduates of Stanford University. Their first endeavor was in the garage in back of David Packard's house, in 1938. I highly recommend that you

read David Packard's book, *The HP Way, How Bill Hewlett and I Built Our Company*, published by the Harper Business Division of Harper Collins Publishers, New York, NY, 1995. This book gives you an excellent inside look at HP and "The HP Way" as chronicled by David Packard. From my vantage point, The HP Way is hard to define, let alone live by. It is basically the Golden Rule: "Do unto others as you would have them do unto you." For me, living The HP Way means honesty, respectfulness and sincerity of all actions in personal and business relationships. Employees are HP's most valuable asset. Customers are the life blood of HP's business. HP products are the links that tie the two together. Profits provide the resources for HP to prosper and grow. That' s how I see it, and what an exciting environment to work in.

**The Applications Group**

The Applications Group had their desks and work area on the upper floor of Building 11 on Page Mill Road in Palo Alto. My desk was next to one of the large windows looking out to Page Mill Road. There was this black thing on my desk that I had apprehensions about, a telephone. Oh, please don't ring! I don't know any answers yet. Bob assured me that I would have at least two weeks to get up to speed before I would be required to take customer phone calls. It was not long before the phone rang. I answered and a customer had an application's question. Now what do I do? Well, what was the question? The customer wanted the "pin out" configuration of an LED display. I knew about HP's Optoelectronics Catalog; So I looked up the data sheet in the catalog for the LED display. There in front of me was the pin out information. I read the pin out information to the customer on the phone. He was happy with the answer to his question, thanked me and hung up. That was my very first applications phone call.

The first week at HPA was indoctrination week. The course welcomed all new employees and gave basic training in LED technology; who were who at HPA; what was HPA's business and associated information on products, departments, and procedures. I found the course interesting and helpful. I learned the combination of a semiconductor light source, the light emitting diode (LED), "Opto" for optical, and the associated drive electronics, "electronics," is called "Optoelectronics." I learned that the Monsanto Corporation and Hewlett-Packard had joined together to develop and promote the LED in the engineering field. The joint venture was called Hewlett-Packard Associates.

When the two companies divided up their patents on LED technology and went their separate ways in competition with each other, the Hewlett-Packard part of the joint venture chose the initials HPA as the name for the division. It was not long after I had joined HPA, that the name was officially changed to the Optoelectronics Division (OED) of Hewlett-Packard. At the end of the indoctrination course we were required to write a paper on what we had learned. I asked if this was to be in the form of a college term paper. I was told yes it was. Yuk. I wasn't going to write any term paper, I had done enough term papers in my time and I was not about to do another one. So, I never wrote it. I did, however, write many application notes and seminars during my HP career.

HPA shared two buildings with a microwave group, Buildings 11 and 10. Building 11 was a new modern building that housed the marketing, engineering, and semiconductor fabrication departments. Building 10 was an old building that housed the main manufacturing and product assembly functions. The microwave business had been funding the LED business until 1973 when it became evident that the LED business was expanding at a rapid pace. Optoelectronics had taken hold in the marketplace and HPA found itself growing so fast that it needed to hire people to keep up with business demands.

I was hired at the beginning of what I would call the glory years of Hewlett-Packard's Optoelectronics business. The Optoelectronics business growth rate was exceeding 25% per year. During the first two months I was at HPA I went to fourteen lunches and dinners welcoming new employees to HPA. I gained twenty pounds that I still carry around with me today. I asked Bob Steward if this was normal

with HP. He assured me this many lunches and dinners was not normal. I had been used to studying for most of my life, as you have read, so I applied my efforts to study and learn all I could about LED technology and the Optoelectronics business. I would have to keep up this study effort all the years that I worked for HP. The attitude at HPA was amazing. HPA was our division. Hewlett-Packard was our company. And, Optoelectronics was our business. This was an exciting environment to work in! Everything was new to me and I had so much to learn and so many opportunities to explore.

There were no boundaries. I could poke my nose into any part of the business I wanted to learn about. Everyone encouraged me and took their time to help me learn. Here at HPA I was being uplifted by constant encouragement and support. At every chance they had, Bob, Stan, Hans, Al and George taught me LED technology. I quickly learned they were at my disposal to answer any question I had, and to teach me what they knew.

There were now four engineers in the Applications Group, Bob, Stan, Hans and me. Bob, Stan and Hans were developing the Optoelectronics Seminar for 1974. The previous year, Stan and Hans had presented a similar seminar in Europe. It was while they were in Europe that Hans Sorensen discovered that he had diabetes. Diabetes would plague him all the rest of his life. Much of the 1974 seminar material had been written, and that gave me a golden opportunity to learn more about LED technology. Bob told me that I would be part of the presenter team for the seminars, doing seminars in the United States.

The first seminar I did was in Los Angeles. With all my experience at teaching B-36 aircraft systems in the Air Force Mobile Training Command and at the University of Notre Dame and the College of San Mateo, being up in front of a group of people to give a talk was easy for me. Except, this time the audience were experienced electrical engineers and that made me feel uneasy and nervous, especially since I was a novice in the field of Optoelectronics. Stan Gage was my partner on this seminar trip. I expressed my concern to Stan and his reply was encouraging, “David, you are in front giving the seminar on LEDs because you know more about LEDs than they do, that’s why they are in the audience. If they knew more about LEDs than you do, you would be sitting in the audience. I understand that many in the audience know more about electronics than you do, but again, you are the LED expert, not them.” With Stan’s encouraging words, I never had trouble giving an LED seminar again.

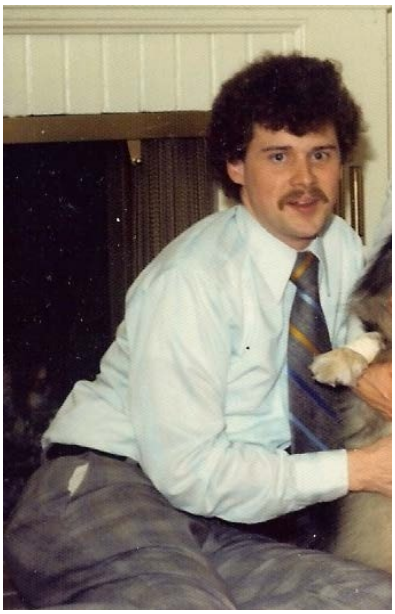
Al Petrucello and George Liu, our two technicians made the Applications Group function with ease. Al Petrucello was almost exclusively supporting Hans Sorensen. Hans Sorensen and Al Petrucello did much of the early characterization work on LEDs. Hans wanted to know the actual real world performance characteristics of LEDs. Hans devised experiments and measurements for Al to perform on LED devices and over a period of time developed much of the technical information that Applications used. Al had a library of data stored in files under his work bench that were extremely valuable and helpful. Many times

I would go to Al Petrucello for help or guidance on measurements. Al did a lot of LED characterization work for me. I had been told that the radiated wavelength spectrum of LEDs did not change with operating current, but I could not find any data to prove the claim. So, Al devised a test. He die-attached an LED die to a large block of copper to act as an infinite heat sink to keep the temperature of the LED constant. He then drove the LED at 1 milliamp and at 100 milliamps. Al measured the wavelength spectrum of the LED at both currents and showed the spectrum did not change. We now had the data necessary to prove the claim correct.

George Liu did all of our breadboard circuits and prototype work. George and his lovely wife, Cathy who also worked for HP in another division, came from China. George tells his story of his family leaving Shanghai as the communist army was moving into the city. George said he and his family took only a few clothes with them and did not even bother to close the door to their home as the left to catch the last boat leaving Shanghai. George and Cathy were fabulous cooks. They had the applications group and

wives over to their house for Chinese dinner. We all ate while Cathy cooked and George served unbelievably good real Chinese food. Only after we all had enough did George and Cathy join us to eat their dinner. George and Cathy were the perfect hosts! Whenever a new semiconductor device came on the market, George would call the local sales office of the manufacturer and asked for a sample. I would see George almost daily on the telephone ask, "May I have a sample?" Or just, "Please send sample." By doing this, George had a collection of semiconductor devices sufficient to build almost any kind of circuit one of us application engineers might need.

Bob Steward hired a college graduate to join our Applications Engineering Group. His name was Mark Hodapp. Mark was a graduate of Purdue University and had his MSEE with an "A" grade point average. Mark was tall, had a nice kindly smile and a head of hair so thick he could not run a comb through it. Mark Hodapp was a sharp electrical engineer, good at mathematics, good at circuit design, and a faster learner than I was. But I had one thing of unimportance in my favor. The University of Washington Husky football team had played the Purdue Boilermakers football team in the UW football stadium. The Huskies beat the Boilermakers with a score of 7 to nothing! So, now there were five of us engineers in the HPA Applications Engineering Group, supported by two superb technicians. It could not get any better than this for me!

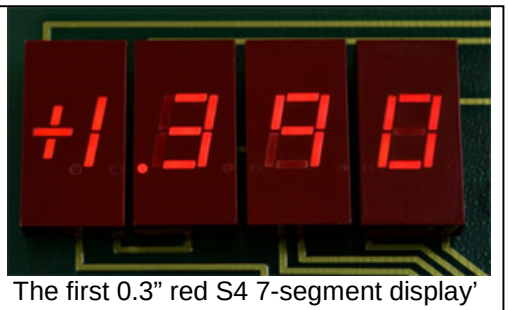

Mark Hodapp, HP OED Applications Engineer; 1974

Shortly after being hired, Mark announced he was getting married to a girl in Dallas, Texas, named Sheryl. Well, we in Applications could not let Mark get married without a bachelor's luncheon. We invited others in HPA to join us in this important event. During the course of the luncheon, to be sociable, Mark agreed to one drink after another. Mark got drunk, real drunk. When the luncheon was over, all went back to work, except Mark and me. Mark had an afternoon airplane to catch to Dallas. I took Mark back to his apartment, helped him get his clothes and things together and took him to the airport. I poured Mark onto the airplane and he got to Sheryl in Dallas on time as he had promised.

**HPA's fiscal year 1973**

HP's fiscal year was from November 1st through October 31st, and fiscal year 1973 was a banner year for HPA. HPA had grown considerably in personnel, sales were up and business had grown by 25%. Pete Manno was a marketing manager and his description of HPA's performance was "truly outstanding!" I liked Pete Manno. He had the go get'em attitude that I liked, but he also had a very expressive personality that conflicted with the driver and analytic personalities of other HPA managers.

It was just before the end of fiscal year, 1973, that I was involved in my first customer issue. The customer was Transaction Technologies, Inc. (TTI). TTI made transaction terminals for bank tellers and was using HPA's 7-segment LED displays. The 7-segment LED displays had a square package containing 8 individual LED lighted segments capable of displaying all numbers from "0" through "9." The device's rectangular package, called a scrambler, was colored black to hide it from view, letting only the lighted segments show to display a desired number. The official name for these LED displays was "single (digit), stretched, seven, segment" LED display." The four "s" in the name



The first 0.3" red S4 7-segment display'

formed an acronym for these displays, “S4.” HP used the acronym S4 so often it became an industry standard for these LED displays in the same fashion that “Kleenex” has become standard to identify soft paper tissues.

The LED displays were being soldered to a printed circuit board and cleaned by a Freon cleaning bath after the soldering process. Their cleaning process was washing the black coloring off the scramblers. I was part of the team sent to TTI to examine and hopefully solve the problem. The team consisted of John Naderny, from Marketing, Norm Tarowsky from Manufacturing, a quality assurance engineer, myself, and Paul Taylor, the HP FSE (Field Sales Engineer) servicing the TTI account. This was my first experience in dealing with a customer at his own manufacturing facility. The morning meeting between HP personnel and TTI personnel got nowhere. TTI explained that there was a problem and the HP team was trying its best to either stall for time or to determine a cause on TTI’s account. I felt embarrassed at the way the HPA team was treating the TTI people. I knew what the problem was, but said nothing due to my inexperience. I was hoping to learn from HPA colleges on how to properly deal with a customer who had a problem with one of our products. But that was not happening in this morning meeting. Lunch time came, and we all went out to lunch.

The President of TTI sat next to me at lunch. He leaned over and quietly asked me what was going on with the HPA team? I quietly told him the HPA team were afraid of what TTI might do if TTI knew what the problem was; they did not want to lose TTI’s business and were trying everything they could think of to avoid the loss of TTI’s business. He then asked me, what was the problem? So, I told him. The 7-segment display scrambler was made of LEXAN, a polycarbonate plastic made by the Plastics Division of the General Electric Company. The LEXAN had titanium dioxide in it to make the scrambler white to reflect out as much of the LED red light as possible. To hide the white scrambler from view, it was being painted with black recorder’s ink. Recorder’s ink is newspaper ink with an added hardener. The FREON cleaning bath was dissolving the recorder’s ink and washing it off the scramblers. That was the problem. At issue was what should be a solution to the problem, and at the present HPA did not have a solution to the problem.

When the meeting reconvened after lunch, the President of TTI got in front of the group and told the HPA team what I had told him. I watched as John Naderny’s face turned pale. He then told the HPA team that TTI was willing to work with HPA to find a solution to the problem, and then stated that HPA had not lost TTI’s business since he had confidence HPA would find a solution to the problem. This made Paul Taylor happy. We left TTI with a promise to work diligently to solve the scrambler black ink problem. On the way back I sat in the airplane next to Norm Tarowsky. He asked me if I had told the President of TTI what the problem was at lunch. I told Norm that I had. I also told Norm that what was happening during the morning meeting was not The HP Way of doing business. Norm agreed with me, and that started a long term friendship between Norm Tarowsky and me.

When I got back to HPA, I contacted a manufacturing engineer by the name of Heinz Merg. Heinz was a German, had been in the German army during WW II, was a very large man in stature, was in his late fifties, and perhaps drank and smoked a bit too much. But he was a good manufacturing engineer. He and I put our heads together and came up with a proposal to spray the complete inventory of S4 displays with clear polyurethane, the same finish that is used on hardwood floors but without the satin additive. The polyurethane would not attack the recorder’s ink and would protect the ink from being dissolved by FREON. The polyurethane being clear, there would be minimal loss of LED red light from the S4 displays. Paul Sedlewicz, the Manufacturing Manager, and Al Wilson, the Quality Assurance Manager, bought the idea and Manufacturing sprayed the complete 7-segment display inventory with clear polyurethane. TTI was pleased with our solution because there was no impact on their manufacturing process or final product and HPA maintained TTI’s business.

The next issue was what to use to replace the recorder’s ink. Here, Heinz Merg, who had a chemistry background, came up with the answer. The Markem Company made a black marking epoxy that easily replaced the recorder’s ink and was impervious to FREON. HPA’s scrambler painting process required

only small changes to accept the Markem epoxy. From then on all S4 display products were made with an epoxy coating screened on the scramblers. Problem solved. Both Heinz Merg and I were congratulated for providing the solution the problem. This incident established me once and for all time as a qualified, experienced and professional Applications Engineer in the LED technology field.

After the incident with TTI, Bob Steward mentioned to me that he was attending a meeting with Bob Zettler and other managers to decide whether or not to keep the S4 product on the market or to sunset it by the end of six months. This was a surprise to me that management would even consider such a thing. I asked Bob how long had the S4s been on the market and he told me 18 months. I then explained to Bob that it took about 18 to 24 months for a new product to be accepted and designed in by customers and that within the next six months sales of S4 displays would significantly increase. I waited with bated breath for Bob to return from the meeting. When Bob returned he told me he had told those at the meeting what I had told him and the outcome was that a decision on the S4 products would be delayed for another six months.

### Bob Steward leaves the Applications Group

I do not know the details of why Bob Steward decided to leave applications, but Bob announced that he was transferring to Manufacturing as a Manufacturing Engineering Manager. Bob's announcement took all of us by surprise, except for Stan Gage. But, sure enough, Bob moved over to manufacturing reporting to a super manager in manufacturing, Paul Sedlewicz. For a couple of months Applications was without a manager.

Not having a manager bothered Hans Sorensen and he went to Bob Zettler to recommend that Stan Gage take over as Applications Manager. Now, I do not know if Hans and his request had anything to do with this or not, I suspect not, but Stan Gage was named Applications Engineering Manager to replace Bob Steward. This was very good for Applications because Stan Gage had the personality, vision, judgment, and perseverance to make Applications a formable, positive contributing department within HPA. Bob had been in manufacturing for only a few weeks when orders for S4 LED displays skyrocketed. So large was customer demand for S4s that HPA could not keep up with the orders and quickly built a backlog of orders. I made a point to go see Bob Steward and essentially said to him; "See, I told you the S4s would take off."

### I changed LED derating to 70°C

Hans Sorensen was a world of knowledge on LED technology. Many times I used Hans to provide to me the information that I needed to answer a technical question for a customer. One such instance was a crusade I launched to change LED data sheets. The data contained on LED data sheets came from product development characterization data and from manufacturing production test data. This data sheet information was supposed to guide an end-user on the limits of operation for an LED device. The problem with this information was that it many times it did not accurately depict what the actual performance limits were in a real world product design. The information I wanted to change were the maximum ambient operating temperature limits.

When I first started work at HPA, I noticed that all LED products were derated in their maximum operation from an ambient temperature of 25°C (77°F). I knew this was definitely not real world, as many pieces of electronic equipment operated in ambient temperatures much greater than 25°C. I teamed up with a quality assurance engineer, Ron Pitman, to collect sufficient data to prove LEDs were capable of operating at much higher ambient temperatures. We ran into opposition to our endeavor from Product Development and Manufacturing but I had the full support of Stan Gage, and that is all I needed. I also had full support from Marketing people who also wanted data sheets to reflect a broader range of

performance. Ron Pitman ran test at 35°C and showed no ill effects at that temperature. I wasn't satisfied, so Ron ran further tests at 50°C, and still no ill effects.

Ron and I were able to get the derating temperature moved to 50° in the new edition of the Optoelectronics Catalog. But, Ron had data that showed some devices worked without any difficulties at temperature above 50°C, specifically 70°C (164°F) the temperature at which he performed his tests. Interestingly enough, most silicon semiconductor devices, like simple silicon transistors, were derated from 70°C. It took me 1½ years to win my battle and get the maximum operating ambient temperature allowed without derating moved from 25°C to 70°C for most all LED devices. This was a major achievement and won for me and Ron Pitman a considerable amount of respect. It proved to Stan Gage, Bob Steward, Hans Sorensen, Bob Zettler and others that I knew what I was doing and that I made very good judgments. It also showed people that I was gaining a substantial understanding of the useful limits to which LED devices could be subjected. I carried this theme successfully throughout my whole career at OED.

**LED technology**

The original LEDs were made from a gallium arsenide (GaAs) crystal. The elements that made up the semiconductor LED crystals were called III-V materials (three-five materials) because they came from the III and V sections of the chemical activity periodic table. The narrow wavelength spectrum of the light emitted by GaAs LEDs was in the deep red color region at the light wavelength of 600 nm (nanometers). The light emitting efficiency was not very good. By the time I started work at HPA, phosphor had been added to the LED crystal structure, forming the GaAsP (gallium arsenide phosphide) crystal structure which moved the wavelength spectrum into the normal red color region at the light wavelength of 570 nm with an acceptable light emitting efficiency. So, all LED products of the 1970s were GaAsP red.

One of the earliest LED display products that HPA designed was a 4 digit device for NASA. It was a ceramic substrate, glass window device with four 7-segment LED die to form the four numeric characters. The display was used the Lunar Excursion Module of Project Apollo. It was a very expensive device to make and was not placed on the open market. Designing and building this display for NASA gave HPA designers good experience at designing other LED displays.

Al Petrucello told stories of the early days of LEDs. Making simple LED lamps proved to be a challenge. LED wafer yields were poor. Perhaps one out of ten wafers would yield useable LED chips, called LED die. The lamps were small, about the size of a pencil eraser and were handmade. The lead frames were purchased for an outside vendor. The LED dice were hand die-attached to the top of the lead frames by hand, using tweezers under a microscope. A conductive epoxy, developed for silicon transistors, was used as the die attach adhesive that had to be cured in a hot oven. Then the lead frames with the LED die attached were hand placed into small molds containing a red tinted epoxy and then a base metal ring was had placed at the top of the mold to hold the mold together. The metal ring became part of the finished lamp. The yields were terrible, perhaps a half dozen LED lamps per day if they were lucky. The early LED die, being GaAs, were not very efficient, so the light output of a finished lamp was not very good. But all that hand experimentation laid the ground work for developing a high volume LED production process that would yield millions of LED lamps per month.

## The HP Components Group

The optoelectronic business was now on a self-sustaining growth path and no longer needed to be supported by the microwave semiconductor business. So, in 1975, two new divisions were created out of HPA, forming what was called the Components Group; the Optoelectronics Division (OED) and the microwave division called the Optical Communications Division (OCD). Dave Weindorf had been the HPA Division Manager and was made Components Group Manager. Dave Weindorf was a nice guy and I liked him. He was about my height, with dark hair; I guessed in his early forties, soft spoken and ran the Components Group with a soft touch, leaving a free hand to the division managers to run things. Bob Zettler became the OED Division Manager. It was under the wise direction and leadership of Bob Zettler that OED grew and prospered; and as the years passed by' OED became the dominant supplier of LED products throughout the world, a performance that Pete Manno called, “Truly Outstanding!”

Bob Zettler; OED Division Manager and later Components Group Marketing Manager, after he retired and shortly before he died; 2002.

HPA/OED, and then Components Group, had its own Field Sales Force. Hewlett-Packard Field Sales was divided into separated Field Sales Organizations for each Group. There were nine groups in HP and therefore nine separate field sales organizations. Milt Liebhaber was made the Components Group Field Sales Manager. Each sales district, in the US and in other countries, had a district manager who reported to Milt Liebhaber. Throughout my HP career I worked closely with the US and Canadian field sales districts. I never did work with any of the overseas sales districts to any extent worth mentioning. The US and Canada were my territory. If it had to be taken care of within the US and Canada, I was one of the applications engineers that were sent out. If it was Europe or Asia, other application engineers went, never me. I some ways I liked that arrangement, but in other ways I felt pushed aside. The big advantage for me was that I became well known and respected throughout the US and Canada; better known than other OED applications engineers. The only other applications engineer that well known was Hans Sorensen, but mainly for his work with optocouplers, not for his work in optics and LED characterization.

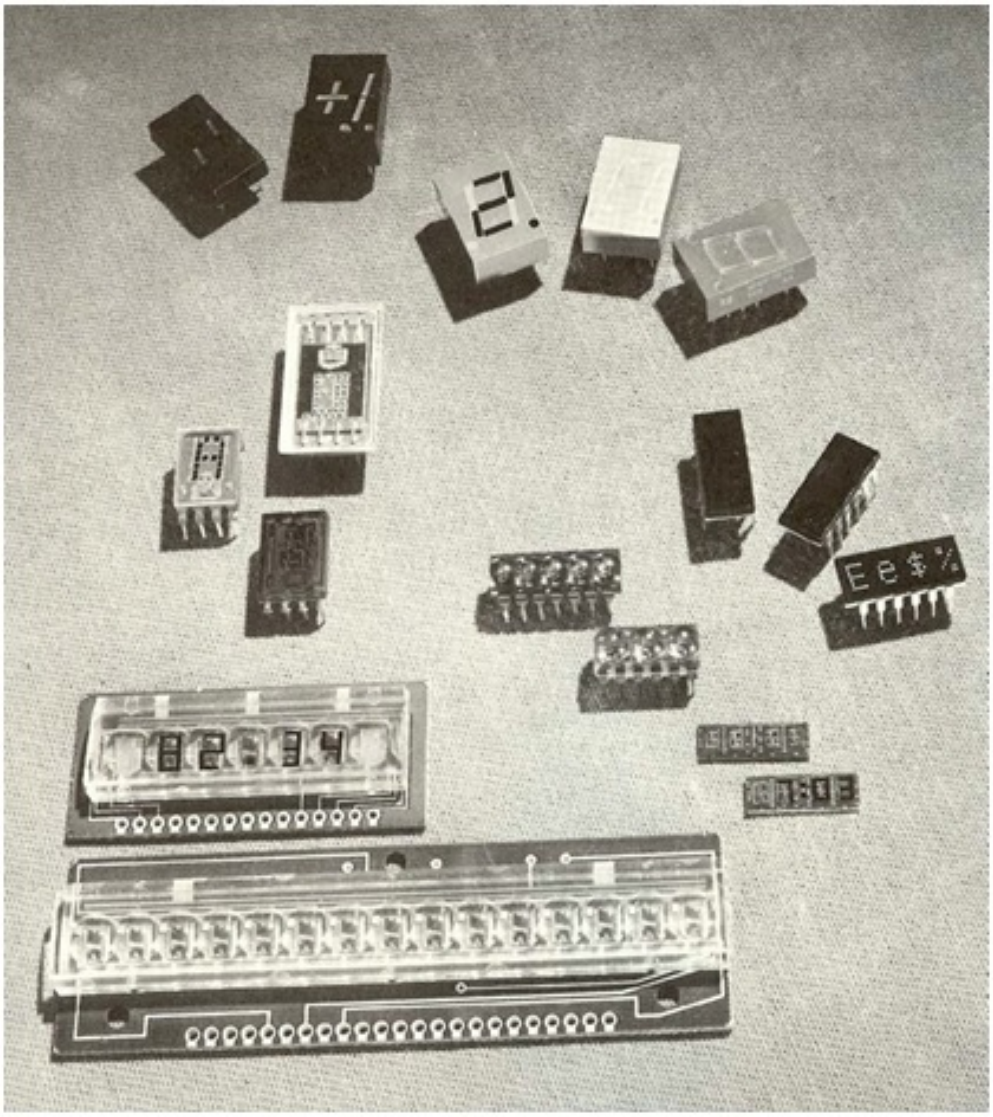
## SAN displays

Roland Haitz was the Product Development Manager. Roland Haitz was Swiss, wore a cut short beard, and had what I considered to be a belligerent driver style personality. Roland had his PhD in physics from Rice University in Houston, Texas. Roland pranced around like he was number one; he and I never got along. His claim to fame was his design and development of S4 LED displays. Roland had very talented designers working for him who came up with good LED products, some with management approval and some without management approval. One particular LED display product that was designed under the table, so to speak, was a small 4-character alphanumeric dot matrix display.

The Desktop Calculator Division of HP wanted a new small alphanumeric display for a new desk top calculator that was being designed. OED management was not keen on the idea because the HP Calculator Division was the only identified customer. With only one customer, management did not want to spend resources necessary to develop the product, thus the clandestine design effort. The display had four 5 x 7 dot matrix LED characters that were 0.100 inches high (that is 140 red LED die per display). An electronic data shift register circuit and LED drivers on two silicon chip integrated circuits were die attached between the outer two LED characters. The prototype design utilized a plastic package.

The Calculator Division liked the prototype but the product proved to be unreliable. Dick Kern was the Product Line Manager for dot matrix displays and his manufacturing engineers were enlisted to design a new package for the display. Dick Kern's group designed a glass widow, ceramic substrate package that was extremely reliable, although more expensive. The product was released as the HDSP-2000, a Small Alphanumeric (SAN) red LED dot matrix display. The acronym "SAN" came into being from the product name and became an industry standard name for this type of product.

The marketing person for the SAN displays was Steve Cohen. I don't think Steve Cohen realized the potential of the SAN display product. Even though a bit pricy, the SAN device was widely accepted by industry and designed into many products around the world. Al Martini was the manufacturing engineer for SAN displays, reporting to Dick Kern. He and I worked closely together as more SAN products were brought to market. Larry Luiz, who also reported to Dick Kern, had the job of scheduling the production of the various SAN products to meet the market demands.

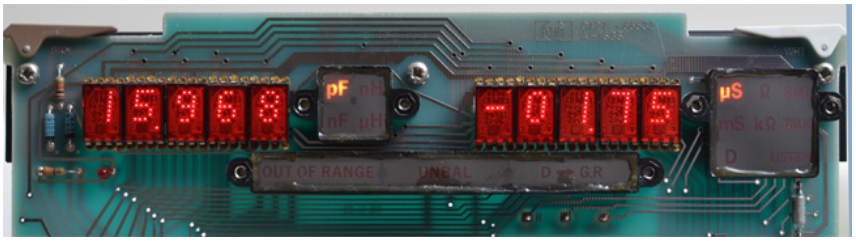


OED visible LED optoelectronic products:
Top: 0.03 inch and 0.43 inch character S4 Displays
Left center: HDSP-7300 and -7010 Dot matrix OBIC Displays
Center: Monolithic calculator displays
Center right: HDSP-2000 SAN displays
Lower left: PC board displays.

Hewlett-Packard used an 8 digit numbering systems with the first four digits representing the division that manufactured the product. The last four digits were the part number of the product. HPA's first four digits were 5082. When OED was created, the numbering system was changed to use alpha characters as the first four digits to reflect the kind of LED product, with the letter "H" as the first digit to identify Hewlett-Packard:

HDSP = for LED displays HLMP = for LED lamps HCPL = for LED optocouplers

I don't know how much Stan Gage had to do with the design of the 2000 SAN display, but it was one of his favorite LED products. Stan Gage developed most of the application support information for the device which I then used, including various drive circuit designs. I provided the applications support for all of the Dick Kern's dot matrix LED display products. Dan Rausch was the marketing engineer for the single digit numeric dot matrix LED display products. One product was a single digit modified 5 x 7 dot matrix LED display with an on board data storage latch/LED driver integrated circuit (IC) die-attached to a substrate and encapsulated a red tinted epoxy, the 5082-7300. This was an LED display that was designed for Northern Telecom in Canada; I think in 1971 and placed into production in 1972. The character height was .03 inches, just perfect for viewing at arm's length. It was a neat device. All one had to do was connect four data lines, a 5 V dc power line and a ground line and you had a single digit display. Place them side by side and you had a numeric display of a many digits as you needed. The 7300 display was designed into many pieces of electronic equipment such as power supplies, voltmeters, frequency measuring devices, and medical equipment. The 7300 LED display was a favorite device of industry through the 1980s.



A typical application for the dot-matrix HDSP-7300, shown on a PC driver board for an HP 4071A impedance meter.

In the early 1990s, Marketing wanted to discontinue the 7300 LED display because sales had been flat for about two years. I vigorously opposed this move, because as I explained, the 7300 was the key that unlocked the doors to sales of other LED products. Technicians used the 7300 displays for bread boarding circuits. Customer in-house test equipment were still being designed with 7300 displays. There was no other product like the 7300 on the market, since the Monsanto equivalent had long been removed from the market. And besides, the 7300 was an industry standard LED display just like Ivory Soap, which was an industry standard soap and must not be discontinued for the convenience of OED. Bad analogy, but Marketing listened to my arguments and did not discontinue the 7300 LED display.

Another single digit numeric dot matrix LED display, first produced by HPA was the 5082 7010. The 7010 was a military grade display with a dot matrix pattern of LED die that formed the 7 segments and an LED driver circuit IC die attached to a ceramic substrate, mounted inside a metal can package and hermetically sealed with a glass window. I was involved in the characterization of the 7010 to qualify it as a military device, typically called a "Hi-Rel" device, meaning a high reliability device. A Hi-Rel device went through a prescribed environmental screening program as defined by military specifications. The Hi-Rel screening was done by OED's Hi-Rel Department, Jim Chrysler, manager. OED sold the 7010 into many military applications. However, as time passed by, the 7010 fell out of favor by the military, being replaced by other LED displays, and production of the 7010 was discontinued.

A few years later OED received an order for one hundred 5082-7010 LED displays, screened to full military specifications. The order had a Department of Defense (DoD) DX priority attached to it. Since the 7010 had not been in production for a few years OED refused to acknowledge the order. We soon learned that a DX order meant the DoD had to have the device and OED was required by law to make it. These one hundred 7010 displays were replacement parts for use in US Navy nuclear powered submarines. Larry Luiz poked around and found a sufficient quantity of substrates and metal can packages to make 100 pieces. A partial wafer of ICs was located that could be used. The problem was the light emitting efficiency of red LED die had been improved and over the years and current LEDs were too bright and could not meet the dimmer military specification for light output. In order to fill the order, OED would have to make a detuned production run to get a wafer of dim red LED die. OED

reluctantly accepted the DX order and charged $300 for each 7010 display. The original price had been $70. OED produced the one hundred 7010 LED displays and the DoD paid the $300 piece price without question. OED lost money on the order.

It seemed like every two years management just had to reorganize everything and everybody. Move everybody around to gain better efficiency, right? I guess all large companies do this. Downstairs in the basement of Building 11 was an underground vault. Stan had been anxious to set up an optics lab and the vault was just the place. So, in 1975 during the biannual everybody move, Applications moved to the basement of Building 11, adjacent to the vault. A highly sophisticated optics lab was set up in the vault and Al Petrucello was its chief technician. From 1975 through 1985, the optics lab proved extremely valuable for making all kinds of optical measurements on LED devices. Calibration samples were measured in the Application's Optics Lab and provided to manufacturing on a regular basis. I had a considerable amount of optical characterization and light output measurements done in the Optics Lab.

**LED demo units**

HPA had handheld LED sales demos made from the cases of HP35 calculators, appropriately called HP35 handheld LED demos. These were favorites of the field sales force. These demos used the same monolithic LED display as the HP35 calculator, but where the key pad would have been were two sizes of S4s, a 0.3 inch and a 0.43 inch, a 7300 and various LED lamps. The field sales force asked for one HP35 LED handheld demo per field salesman. Since OED Marketing was going to fund new demos, only one HP35 LED handheld demo per field sales office was approved. I was placed in charge of getting these new HP 35 LED handheld demos built. It was a challenge to obtain the number of HP35 cases with LED displays from the HP Calculator Division. OED paid dearly for the HP35 cases, even though it was an HP internal product transfer. I had to make some changes in the pc board, and that exercise taught me about PC board layout and manufacture. I had to deal with the HP PC board shop in the main HP complex at 1501 Page Mill Road. George Liu helped me get the necessary parts and I requisitioned the necessary LED devices. It took almost three months before all the HP35 handheld LED demos were built and shipped to the field sales offices.

The HP 35 handheld LED demos were fine for a one-on-one demonstration of LED devices, but were not effective when showing off LEDs in front of a seminar audience. Stan Gage decided we needed some real good table top LED demo units. One table top demo box unit had been built to demonstrate OED's family of LED lamps and was reasonable successful. Mark Hodapp had become interested in a new family of devices coming on the market called microprocessors.

Hewlett-Packard, as well as other companies, was investigating these new microprocessor devices. One favorite was the Z80 microprocessor. Stan commissioned Mark Hodapp and George Liu to design and build new table top demo units that were programmable and microprocessor controlled. I was asked to help in the mechanical design. I give both Mark and George credit for designing two very good table top demo units. The demo units were about 11 inches tall and about 17 inches wide. One unit was a programmable demo of all of OEDs LED display products. Preprogrammed messages could be displayed across a string of a given type of LED display to simulate a real world application. The LED lamp demo had a row of lamps for each of OED's lamp devices and could be programmed to show only one row or a grouping of rows. The two units would fit into aluminum carrying cases made by the ZERO Company. We made four sets and they were extremely effective at demonstrating OED's products. We kept one set of demo units at OED for use in seminars. The other three were constantly being shipped between the various field offices.

## Optocouplers

During the first few years that Hans Sorensen spent working with LED technology he had spent his time with visible LED devices, primarily LED lamps, doing light output and real world performance characterizations with the help of Al Petrucello. Now, a new LED product was being introduced, optocouplers, sometimes referred to as optoisolators. Hans assumed the applications support responsibility for optocouplers.

An optocoupler was a non-light emitting device designed to couple together two circuits operating at different voltage levels. On the input side of an optocoupler was an LED. The light from the LED was detected by a photodetector on the output side of the optocoupler. The photodetector produced a small photocurrent in direct proportion to the light from the LED. The optocoupler contained a small photocurrent amplifier that would drive a receiving circuit. As an example, an input circuit operating at 5 V dc could be coupled to a circuit operating at $\pm$500 V dc with no electrical interconnection. The two circuits were optically coupled and totally electrically isolated from each other.

Over the years a family of single channel, dual channel, and four channel optocouplers was developed. Hans developed circuits and techniques to use optocouplers in many different electronic applications. Hans was very good at providing electrical applications support but admitted that he did not have the necessary expertise on providing mechanical applications support. So, I picked up that responsibility. Not only did I assume the mechanical application support responsibility for optocouplers, but did so for all of OED's LED products. As time went by I learned a considerable amount concerning the soldering and assembly processes used in the manufacture of electronic assemblies. Although I never worked in an electronic assembly plant, I did gain a wealth of knowledge by dealing with customers, helping to solve their manufacturing problems and by attending seminars on printed circuit board manufacturing.

## Soldering LEDs

LED lead frame devices were very susceptible to damage during PC board assembly and wave soldering processing. I assumed the responsibility of learning all the possible failure modes of LED devices and how to avoid destructive damage of LED devices during PC board and wave soldering assembly. The rule was simply this: The maximum safe duration of any LED or IC lead frame device in a solder wave was 1 to 1½ seconds, and no longer. Anytime longer than 1½ seconds in a solder wave will most likely damage an LED or IC lead frame device. I will say, that I was considered OED's expert on the subject of soldering and assembling LED devices onto PC boards and into electronic assemblies in general. I carried this distinction all through my career at OED.

One of my very first customer visits was to a customer in Columbus, Ohio. The field engineer was desperately trying to close a $200,000 order and was not having any luck. Stan suggested that I fly out to Columbus and visit the customer to see what I could do. I flew to Columbus, Ohio and the FSE met me at the airport. We drove directly to the customer's facility. At the meeting with the customer it became obvious to me that we had nothing that would solve his problem and RCA Semiconductors did. I gave the customer the RCA part number and the telephone number of RCA Semiconductors. The customer was glad to get the information from me, but the FSE was disappointed and was not pleased with what I had done because he had just lost a $200,000 order.

I told the FSE that his job was twofold; first to solve customer's problems and second to sell OED's products, in that order. I also told the field engineer that the next time the customer had a problem the customer would call him for a solution. The FSE was so angry with me he didn't even say goodbye to me when he dropped me off at the Columbus Airport on my way home. Two months went by and I received a phone call from the same FSE. He was as happy as a kid with a new bicycle; for the customer

had called him to help solve another problem. The customer had told the FSE he called back because he knew HP would help solve his problem even though it might not lead to a sale. This time, however, OED did have a product that solved the customer's problem and the sales order was for $400,000. "See. I told you," I reminded the FSE on the phone.

### Growth of OED Applications Group

During the years 1975 through 1978, Stan increased the size of Applications to 20 people. Some of those Stan hired were: Carolyn Jones, from Monsanto; Dick Jamison, who was involved in application support for optocouplers; Wally Scott, who was a very good electronics technician; Bob Krause, who dabbled in all of OED's product line; Denise Dow as secretary. In 1977, Stan decided to divide the applications group in to two sub-departments to make the Applications Group easier to manage. It also relieved him of writing so many performance reviews. More on that subject later.

From my perspective, this was a bad decision, for I thought Stan was doing a good job the way things were. This decision put an unnecessary level between me and Stan so we cooperated less with each other than before his decision. I did not like that one bit! Stan chose Mark Hodapp as one manager and Bob Krause as the other manager. I was placed under Mark Hodapp who had responsibility for visual LED products; Bob Krause assumed the responsibility for non-visual LED products. Stan chose Mark Hodapp for his expertise in electronic circuit design and Bob Krause because Bob had been a 2nd Lieutenant in the military.

Neither of these two had any experience in managing people, and as far as I was concerned did a lousy job of it. Both tended to boss their subordinates rather than guide and coach. Where Stan managed by setting goals to be accomplished and letting his subordinates figure out the details required to accomplish an assigned goal, Mark tended to micromanage me and I rebelled against that. I took a while before Mark realized his approach to managing was not working, especially with me, and I finally got a freer hand at doing my job. Mark knew I was not good at electronic circuits, but never really accepted the fact that I was good at other things.

### LCDs

Liquid crystal materials are molecules that are neither liquid nor solid, but are what is termed nematic, a mesomorphic state where molecules respond linearly to electric fields. When placed in an electric field, nematic molecules change their orientation by 90°. Liquid crystal molecules in a liquid crystal display (LCD) can then be use to control light either by reflection or by transmission by application of an electric field. Wrist watches, for instance, use reflective LCD technology. Illuminated LCDs use a transmissive liquid crystal technology. It was 1975, and LCD watch displays had just come on the market. These were small reflective LCDs that were hard to see in dim light conditions, not visible at night, and had long reliability problems.

Dr. Sun Lu was an expert in liquid crystals and was trying to get OED to fund the development of LCD technology. He had made some sample LCD devices and had shown improvements over what was then available, especially in optical contrast and long term reliability. I was the applications engineer assigned to the LCD project. I found the technology fascinating and spent a considerable amount of time learning all I could about liquid crystals and their characteristics.

Sun Lu proposed an LCD development plan to OED that would cost $3 million over 10 years. By then, he projected OED would have solved all the problems currently identified with LCDs and would have a line of LCDs on the market. Paul Sedlewicz called a meeting to discuss Sun Lu's proposal. At that time, OED's sales had just topped $25 million and $3 million seemed like a lot of money for OED to spend,

especially since OED was putting all of its available resources into the development of advance LED technologies. The outcome of the meeting was to terminate the LCD program. I was one of those who voted for termination. That may have been a good decision in the short term, but it was a bad decision in the long term. Today, 30 years later, LCD displays are everywhere; reflective LCDs being used in watches, clocks, telephones, and all kinds of small battery operated devices. Back illuminated color LCDs are used in hand held computing devices, lap top computers, cell phones with video capability, gasoline station pumps, aircraft cockpit multifunction displays, digital cameras. Today one can buy a color LCD high definition TV set. None of these applications of LCD technology was envisioned by anyone in 1975.

**ALI**

It was early November of 1996 when Stan Gage called me to his desk. He asked me if I knew a George Godfrey and did I know what ALI was? No I didn't; who was George Godfrey and what was this ALI thing? Stan asked me to call him back and find out what he wanted. I did. George Godfrey was the Chairman of the Aerospace Lighting Institute (ALI). George Godfrey wanted someone from Hewlett-Packard to give a talk on LEDs at the upcoming ALI Advanced Seminar, the first week of February. I told Stan about George Godfrey's request and he said why not go do it. So I did. I took our new demos with me including a new auto demo that George Liu had made. One of OED's goals was to get LED technology designed into the automotive market. A significant requirement was sunlight visibility. Any LEDs designed into cars had to be visible in bright sunlight (more on this later). George Liu had built two simulated automotive instrument clusters out of OED LED displays and lamps. We had bought a 1,000 watt stage size sun lamp to shine on the auto demos to show LED readability in bright sunlight. I took both an LED auto demo and the sun lamp with me.

The ALI Advanced Seminar was held at the Commodore Hotel LAX, adjacent to the Los Angeles Airport, later to be bought by Sheraton Hotels. George Godfrey and his lovely wife, Jeanette, met me at the Loa Angeles Airport in a small size rental car. They both wondered; who was this fellow from HP with all that equipment in aluminum suitcases. The equipment barely fit into the back seat and trunk of the rental car. I was impressed by the size of the crowd, all lighting engineers from the aerospace industry. Companies like Boeing, Lockheed, Vertol, Convair, Grimes, Douglas, US Navy, US Air Force, US Army, Canadian Forces, and many small aerospace lighting firms were represented. Over 120 people in all were attending this conference. The presenters were experts in their field. The presentations were highly technical and well done.

I watched as one presenter gave a talk on electroluminescent lighting (EL) for military aircraft cockpits; the conference roomed darkened so we all could see the bluish white light from the flat strip of EL. George Kalen was one of Godfrey's close associates. He owned a small company called Kalite. During his presentation, George mentioned that I would be presenting after him and that LEDs would never be used in aircraft because they were not bright enough to be seen in sunlight. George Kalen's comment set the stage for my presentation.

Before the conference started, I had set up both table top LED demos and the auto LED demo on a table in the front of the room with the sunlamp standing close by. All my demos were turned off. When my turn came, George Godfrey did a nice and polite introduction, informing me I had 45 minutes in which to make my presentation, as time was running short for other presenters. I walked to the front of the room, turned on the two table top demos and began my presentation on LED technology. About 20 minutes into my talk, I brought up George Kalen's comment about LEDs and sunlight readability. I then turned on the auto LED demo and the sun lamp. The LEDs in the auto demo were clearly readable to all. The audience literally stood on their feet, stunned with amazement to get a better look. I kept on talking, for a total time of 2 hours and 15 minutes, before George Godfrey interrupted me to announce to everyone in

the conference room that it was lunchtime.

In the back of the audience was a man from Litton Industries, Clint Pierce. Clint Pierce was a senior manager in Litton Avionics that was designing a new inertial navigation system for the Boeing 747 aircraft. During the lunch break, Clint came to me to get my name, phone number and to schedule a visit to OED the following week. I called Stan and told him what had happened and to get a visit time scheduled. The Los Angeles field salesman was, Harry Newhoff. Stan called Harry Newhoff and the visit was arranged with Litton the following week. Harry Newhoff and I became friends and worked closely together for many years. When the ALI conference reconvened after lunch, the next presenter said, "David, you are a hard act to follow!" George Godfrey was impressed with my presentation and told me how much he had enjoyed it. George told me so well done was my presentation and so intense was the audience interest in my topic were the reasons he let me talk so long. This was the beginning of my involvement with ALI that would last through January, 2003, four years beyond my retirement from HP.

### LEDs in aerospace

Clint Pierce and his team from Litton came to OED to discuss their need for a display to go into their new inertial navigation system. Red was not a color option. What was needed was another color. At the ALI meeting was a human factors engineer from Wright Patterson AFB, Dayton, Ohio. He gave an excellent talk on the ability of the human eye to resolve lines per inch under different lighting conditions. In his talk he stated that the human eye had a double imaging effect under red light, and under blue light it was impossible for the human eye to focus with any precision.

Although the human eye had its peak response in the yellow-green region, where the leaves of most plants leaves and grasses are located, the human eye had the sharpest focus at 585 nanometers in the yellowish-orange, or amber, color region. It was Clint Pierce's concept that what Litton needed was an amber LED display for their new inertial navigation system. During the meeting, the concept of an amber LED color 0.200 inch high SAN display was proposed. Clint Pierce and his team liked the idea and wanted to know when Litton could expect the first samples. Marketing was kind of cold on the idea of a new product because they did not have a vision of where else such a product could be used. However, Stan Gage, Dick Kern, and Roland Haitz were for the idea and so marketing went along. It took only two months for OED to design and place into production the first advanced SAN display product, the HDSP-2301, built to meet Litton's specific requirements. The HDSP-2301 used AlInGaP amber LEDs, used a larger version of the existing SAN substrate and modified ICs to accommodate the AlInGaP LEDs. The display was sunlight viewable behind a neutral gray contrast enhancement filter (more on contrast enhancement later on).

Litton designed the HDSP-2301 into their inertial navigation system. The navigation system display sat on the pedestal between the pilot and copilot in the Boeing 747 cockpit. It was an immediate hit with pilots. I wanted to get a demonstration ride in a 747 to see the HDSP-2301 displays in action, but disappointingly was never offered the chance. News travels fast in the aerospace industry and soon other aerospace companies were coming to OED to see this new LED display for themselves. OED had an arrangement to only deliver this new amber SAN display to Litton for about nine months before offering it to other customers. Nevertheless, other aerospace companies began to design their new products around the new amber SAN display and LEDS were now firmly established in the aerospace market.

### LEDs in sunlight

I want to backtrack a bit to 1976 and contrast enhancement and the invention of AlInGaP LEDs. After completing the HPA indoctrination course in October of 1975 and refusing to write a college style dissertation on what I had learned, Bob Steward asked me to write an application note on contrast

enhancement techniques for LED displays. This was my first application, extremely well received!

**Application notes** were technical documents written to explain some aspect of LED technology. They were published as Hewlett-Packard documents, and by policy did not include the name of the author.

**Contrast enhancement** was a method of improving the readability of LEDs in sunlight conditions by placing in front of an LED device an optical filter that reduced the effect of sunlight and still permitted the LED light to pass through to an observer. The contrast between the dull and dim filter area surrounding the LED device and the brighter light emitted through the filter from the LED provided the required readability.

In 1973, Bob Steward had designed an impressive active domo unit for S4 displays and had used a dark red filter to enhance the readability of the red LED S4s. A woman engineer by the name of Peggy Christiansen had tackled the subject of contrast enhancement for red LEDs, based on Bob Steward's experience, and had published a short application note on the subject. Bob wanted me to take what she had done and enlarge on it. I did a rather thorough investigation of contrast enhancement options, verifying some of Peggy Christiansen's findings and negating others. I determined that for amber LEDs the best contrast enhancement filter was a neutral gray with 25% optical transmission. I wrote a rather extensive application note on the subject that was subsequently published in the technical magazine, Electronic Design. It was this kind of filter technique that Litton incorporated in their inertial navigation system display module.

What made all of this possible was the invention in 1976 of AlInGaP (aluminum-indium- gallium-phosphide) LED technology. The early GaAsP red LEDs had two problems: First, to paraphrase Henry Ford, you could have any color LED you wanted as long as it was red, and second the light output was not sufficient to be seen outdoors in sunlight. A new high efficiency red LED technology, AlGaAs (aluminum-gallium-arsenide) was developed. AlGaAs had 10 times the light output efficiency of the older GaAsP red LEDs and was touted to be the very latest in LED technology. So advanced was the AlGaAs LED technology that OED put forth a major advertising campaign. Stan Gage was so enthusiastic about this new development that he put much time and effort into promoting AlGaAs, including a worldwide teleconference to promote the new technology. Even I too, got heavily involved in promoting AlGaAs LEDs to customers.

However, AlGaAs had two major problems. First, its color was red. The older GaAsP were called Standard Red LEDs and the new AlGaAs were called High Efficiency Red LEDs. Second, was the fact that AlGaAs LEDs had a layer of active aluminum in the crystal structure that would easily corrode leading to a high rate of degradation in light output. Even without aluminum corrosion, AlGaAs LEDs degraded far more rapidly than did GaAsP LEDs.

But in 1976, a new LED technology was introduced, AlInGaP (aluminum-indium-gallium-phosphide). AlInGaP LED technology could produce colors from reddish-orange at 635 nm to pure green at 565 nm. The LED colors selected were, reddish-orange at 635 nm, amber (yellowish-orange) at 585 nm, yellow-green at 569 nm and pure green at 565 nm. It was the 585 nm amber LEDs that Litton chose for the navigational display module. Note: The name amber was taken for the color yellowish-orange from automotive specifications because OED wanted to penetrate the automotive market (more on that a bit later). The light output efficiency dropped off dramatically as the AlInGaP technology was pushed into the pure green color range. Also, for reasons never fully understood, the light output degradation of pure green AlInGaP was unacceptably high, so the market for pure green LEDs never really developed to any great extent. But, so successful were amber LEDs that OED soon found itself in an embarrassing situation. Marketing had not understood the market well enough to predict the huge demand that arose suddenly for amber LEDs. So huge was customer demand for amber LEDs that orders flooded order

processing and quickly OED found itself in an 18 months backlog situation. So severe was this backlog problem that OED went into an allocation mode, allocating only enough amber LEDs to any one customer to keep that customer's production line from shutting down. As an Applications Engineer I found myself acting more as a referee between customers and OED than as a technical advisor. Marketing had another worry. OED's LED production was geared to producing Standard Red LEDs, not AlInGaP LEDs.

The sale of High Efficiency Red LEDs was eating into the Standard Red LED business at an alarming rate. For a time, Marketing tried to offset the sale of High Efficiency Red LEDs in favor of Standard Red LEDS in an effort to balance OED's capacity. It didn't work. OED had to scramble and spend millions of dollars to ramp up production capacity of AlInGaP LEDs. That was fine for me, because amber LEDs were becoming my specialty. Most of the customer support I was providing had to do with the use of amber AlInGaP LEDs in all kinds of applications, not the least of which was the aerospace market. I even worked closely with NASA to get amber LEDs designed into the long term Space Station project.

I had two run-ins with Roland Haitz. The first was in 1976 over the viewability of LEDs in bright sunlight. At a meeting I was attending, Roland Haitz claimed that LEDs were not bright enough to be seen in sunlight and a new "big blaster" LED had to be made to achieve viewability in sunlight. I challenged Roland on his statement saying that readability of LEDs could be achieved in bright sunlight by incorporating the proper contrast enhancement. Roland strongly disagreed telling me it just was not possible to achieve viewability in sunlight without first having a "big blaster" LED that produced much more light output than did existing LEDs. Both Bob Steward and Stan Gage agreed with me.

Well, as it turned out, I proved Roland Haitz wrong. The LED automotive instrument clusters, that George Liu made, were the first LED demos built that prove Roland Haitz was wrong. Then, the use of amber SAN displays in aircraft using glass neutral density gray contrast enhancement filters also proved Roland Haitz wrong. Next, I and others in OED began to push S4 displays for use in sunlight readability applications using plastic neutral gray contrast enhancement filters. The second run-in was in 1977 over the OBIC S4 (on board IC) display project. The project was to develop a 7-segment equivalent of the 7300 dot matrix displays. Each individual OBIC S4 would have it own IC to store data and to drive the 7 LED segments in a similar manner as was done in the dot matrix 7300 displays, but at a lower cost to the customer.

It was a great idea and I was 100% for the project. Barry Rose, a product development engineer who had a PhD in mechanical engineering, was assigned to design the OBIC S4 package and Dave Colliccio, an IC designer in Product Development, was assigned to design the IC. Barry Rose did a beautiful design of the OBIC S4 package. Barry and I were friends and Barry asked my advice on how best to design the lead fame and scrambler package so the OBIC S4 would easily go through a customer's wave soldering process. The problem was the IC design.

The IC stopped functioning when the temperature reached 70°C; the design requirement was for 100°C as a minimum. I attended a meeting held to discuss this problem. Barry Rose, Dave Colliccio, Roland Haitz, and Mike Cowley were among the attendees. At the meeting it was revealed that Product Development had spent $500,000 in development of the IC that did not meet the required temperature specification. Also, it was revealed that the IC required too much electrical power to be useable in a customer's circuit. All that was needed was another $160,000 to fix these two problems. I raised strong objections to continuing the project and sternly recommended the OBIC S4 project be scrapped, because it was obvious to me that Product Development could not design the IC that was needed.

Roland Haitz and I got into an argument over this and I had to leave the meeting. During lunch time I ran into Mike Cowley, who at that time was the silicon IC production manager. Mike asked me my reasoning behind my objection to completing the OBIC S4 project. I answered Mike, "If Product Development could not design the IC with the $500,000 they have already spent, what makes you think they can design the IC that we need with another $160,000? My guess is they can't. So, why throw good money ($160,000) after bad money ($500,000)?" Mike Cowley agreed with me, and the OBIC S4 project was cancelled. Roland Haitz never forgot these two incidents, where I had won out over him, and I was on his persona non-gratis list as long as I worked at OED. A short time after the OBIC S4 incident, Dave Colliccio left Hewlett-Packard.

### Performance reviews

So active did I become in pushing amber LEDs that I got in trouble with others within the walls of OED and I suffered for that in my performance reviews. It did not matter that the Field Sales Force was praising my efforts to the hilt; it was how I was being perceived by others at OED. Unlike AMPEX, which had a purely objective performance review system, HP had a subjective performance review system. Your performance review was solely based on the opinion of one's supervisor, others with whom you worked, and intradivision politics. No matter what I accomplished, no matter what influence I had outside the four walls of OED adding to OED's sales, no matter how many positive inputs came from the Field on my behalf, what counted was how well I played the political game inside OED. And, I did not play the political game.

I was not interested in playing games with people, just to please higher egos, I was interested in getting done what I thought was important to get done. I guess all large corporations have their internal politics, their idiosyncrasies, and other personality traits and HP OED was no exception. Internal politics seemed to always play a role in my performance review. If you were to read my performance reviews, you would never hire me. I was always criticized for pushing for my own way, of not listening to other points of view, of not being cooperative, of not being a team player. If that all were true, then why was I continuously selected as the applications engineer of choice for so many projects and programs? More on this performance review system and how it affected me personally later.

As I said, OED wanted to penetrate the automotive market and get LEDs designed into cars and trucks. Mark Hodapp asked me to assume the role of applications support for the automotive market. I was deeply involved in servicing the aerospace market and saw the automotive market as a long term effort before OED would realize any benefits in sales, so I politely refused to take the assignment. Mark took on the responsibility for applications support to the automotive industry. This refusal on my part would have a haunting effect for years in my performance reviews.

### Automotive LEDs

I did get involved in automotive applications, in those areas where Mark was not interested. One was a special 4-digit amber LED display module for General Motors (GM). This was OED's only venture into air gap S4 technology. The display was sunlight viewable behind a 25% transmission neutral gray filter as described in my application note on contrast enhancement. GM asked that OED provide them with a business plan to ensure adequate delivery of LED display module for the Cadillac car line. It was in the dead of winter that Paul Sedlewicz, OED Manufacturing Manager, Ron Lang, OED marketing, and yours truly flew out to Flint, Michigan to present OED's business plant to officials at the Delco Division of GM.

Delco was the electronics arm of GM that made car radios, among other things. I had been working closely with Delco engineers to get the amber LED display module designed into the Cadillac car line, and knew many of the issues Delco had with the use of the display; and that's why I was part of the team

visiting Delco. We arrived in the snow and cold at Delco at 8:00 am. The local field salesman accompanied us to meeting. We were ushered into a conference room. On the way in I got a good look at the Delco production line installing out LED display into radios. I must say I was not all that impressed with the line. The temperature outside was well below freezing, and inside the conference room it was 85°F. I thought I would melt.

We sat down and the Delco people started the meeting by welcoming us and then spent the next 1½ hours telling us what they expected from HP. When the Delco people were finally finished, Paul looked at Ron, then looked at me, packed up his briefcase and reached for his coat. Ron and I did the same, and all three of us and the field salesman headed for the door to leave. This took the Delco people by complete surprise. "Where are you going?" They asked. "Home, back to HP," Paul replied. "Wait a minute," was the Delco manager's response to Paul. "Why? Asked Paul. "You have no interest in what we have to present; you are only interested in what you are demanding from us. If that's your attitude and the way you do business with your suppliers, then go find yourself another LED supplier. HP has no intentions of doing business with GM Delco under these conditions."

Paul's retort stunned the Delco personnel. They did not know quite how to react. No one had ever talked to them this way before. Finally, the Delco engineer with whom I had worked so closely calmed everyone down and asked Paul to please present HP's business strategy. I told Paul that I knew the Delco engineer quite well and that perhaps we should make our presentation. Ron agreed with me and we sat down while Paul made our half hour long presentation. The Delco people applauded HP's business plan and accepted it without changes, stating it was the best business plan any of their suppliers had ever presented to them. Thanks to Paul Sedlewicz, this incident established once and for all the relationship OED would have with Delco for many years; HP was on top and Delco accepted without question what OED said!

**The Optoelectronics Manual**

Hans Sorensen, Mark Hodapp, David Evans, Stan Gage,
and the Optoelectronics Applications Manual; OED, HP Building 11 Lower; 1977
Photo from the Hewlett-Packard employee magazine Measure, August, 1977

In April of 1976 Stan Gage came up with what I considered to be a brilliant idea. Applications should write a book on LED optoelectronics. Stan had hired a secretary named Denise Dow. Denise was a beautiful girl and had a brain that worked brilliantly. To write the text in a format ready for publishing, Stan rented a composer, a word processing machine that was dedicated to publishing complicated documents. Denise quickly mastered the composer and typed the complete manuscript for the book on the composer. The authors of the book were Stan Gage, Hans Sorensen, Mark Hodapp and David Evans. The book, the *Optoelectronics Applications Manual*, published in 1977 had nine chapters. I wrote part of Chapter 1; LED Theory; part of Chapter 2, LED Lamps; part of Chapter 5, Displays, all of Chapter 6, Contrast Enhancement, part of Chapter 8, Reliability of Optoelectronic Devices; and all of Chapter 9, Mechanical Handling Considerations for LED Devices.

Stan Gage commandeered a conference room for us to use as our writing room. We took no phone calls, attended no meetings. It took us three weeks to write the book, working from 8:00 am until early evening doing nothing but writing, making descriptive drawings, graphs and drawing electronic circuits. Stan hired a professional artist to do our drawing for us.

The book was published by the McGraw Hill Book Company. If you're interested, the ISBN is 0-07-028605-1. Upon publication, Mr. Tyler Hicks, the Vice President of McGraw Hill for technical publications came to Palo Alto to give a congratulatory luncheon for us authors. Bill Hewlett and David Packard were invited and attended the luncheon. Bill Hewlett sat directly across from me and David Packard sat directly across from Hans Sorensen. During the course of the luncheon, Mr. Hicks from McGraw Hill made a few congratulatory remarks and then presented each of us authors with our own personalized leather bound specially printed copy of our book. Mr. Hicks then invited Bill Hewlett to say a few words. Oops! Bill Hewlett stood up to speak. Bill Hewlett was a short stocky man and stood slightly leaning forward as he spoke. Bill stated that he disapproved of HP engineers wasting their time writing books. They should instead be spending their time designing new products.

That angered me and Hans Sorensen. We both tied into Bill Hewlett like two cats after the same mouse, admonishing him for his criticism of us and our book. I did not care that Bill Hewlett was one of the founders of HP, he had no right to criticize our effort on writing what we thought was a valuable technical book and marketing tool for LEDs. Next it was David Packard's turn to speak. David Packard was a tall man and towered over the lunch table like a giant statue of authority. David Packard praised our book, said it was a wonderful thing we had written, and stated that more of HP's talented engineers should write books on HP's products. Talk about being different; Bill Hewlett and David Packard were like Mutt and Jeff with two distinctly different personalities and views. No, I did not get reprimanded for challenging Bill Hewlett and his criticism and neither did Hans Sorensen. This was the kind of company HP was. An employee with a just criticism of a supervisor could express it without fear of retribution, as long as the criticism was not done with malice.

Hans Sorensen, David Packard, David Evans (me), Bill Hewlett, Stan Gage, and Mark Hodapp at congratulatory luncheon sponsored by Mr. Tyler Hicks, Vice President of McGraw Hill, 1977
Photo from the Hewlett-Packard Components Group news *The Solid Stater*. Volume III, No. 8, September, 1977.

We published a second edition of the Optoelectronics Applications Manual in 1981, titled the "Optoelectronics, Fiber-Optics Applications Manual, 2nd Edition." The 2nd Edition, published by McGraw Hill, had a total of fifteen chapters. Two other newly hired Applications Engineers added to the text of the Manual, Dick Jamison and Bob Krause. My complaint with McGraw Hill was that we had made corrections and changes to the 1st Edition that McGraw Hill refused to incorporate in the publishing of the 2nd Edition.

**ALI Basic School**

George Godfrey called me and asked if I would become a Faculty Member of ALI and teach LED technology at the ALI Basic Lighting School. I agreed without first getting permission from either Mark or Stan. Stan backed me with his approval and Mark agreed. My first class was in August of 1977 at the Commodore Hotel where the Advanced Seminar was held. I had to generate a complete new seminar for my all day class on LED technology. Mark had hired a new administrative assistant, Marjory Mok. Marjory was a valuable aid to me in preparing my lesson plan material and slides for my ALI class. She was able to proof much of my material which helped me do my preparation in time to make the August deadline. My first Basic School class had 75 attendees. I did my best to carefully explain each slide and concept.

The attendees in the class were very much interested in learning all they could about LEDs. I had numerous questions on light output, reliability and the use of LEDs in NVG (Night Vision Goggles) applications. The class made me feel comfortable, and gave me confidence as the day went along. The more I talked, the more the class wanted me to tell them. It seemed to me that LEDs was the topic of the day and I was eager to tell them as much as I could in the time I had. When the session was over, many of the attendees came up to tell me how much they enjoyed my presentation and could they contact me for help. I told them to call me anytime they had an LED question and I would be glad to help them. I will tell you more about the Basic School later on.

**OED seminar trips**

The application seminars started in October 1972. HP Optoelectronics had been invited to present a paper on the technology at an electronics conference in Switzerland. Topics included optoelectronic device applications, support circuits of HP's infra-red (IR) emitters and detectors, opto-isolators, and LED lamps and displays. So Hans Sorensen and Bob Steward prepared the seminar material; Hans for the IR devices and couplers, and Bob for LED lamps and displays. The slides were published in a bound book given to each seminar participant. Nothing fancy; no text, just copies of the slides bound together. To take advantage of the trip, Hans and Bob gave these customer application seminars over a 6 week period throughout Europe. The seminar covered half a day (a full day if translators were used) and was given in a variety of locations in England, The Netherlands, Sweden, Denmark, France, Germany, Italy, and Switzerland. This was followed a few months later by a series of 6 seminar trips by Hans Sorensen and Bob Steward to every region of the US.

The first time I was out on a seminar trip with Hans Sorensen, I listened intently to his presentation to learn all I could. About half way through, Hans suddenly stopped short in his talk and exclaimed, "Oh, before I forget I've got to tell you this!" Hans then proceeded to deviate from his theme and explain a very important aspect of optocouplers. I was amazed that Hans could do this on the spur of the moment. The next day, at the exact same place in his presentation, Hans suddenly stopped short in his talk and exclaimed, "Oh, before I forget I've got to tell you this!" Hans then proceeded to explain the same important aspect of optocouplers.

Again I was amazed. But on the third day, when Hans did the very same thing, I knew it was all part of Hans' act to keep up the interest of his audience. It was then I learned that part of giving technical seminars was the ability to entertain the audience. People remember things that entertain them, and Hans had developed techniques for entertaining his audience while at the same time explaining complicated technical subjects. I learned to do the same thing by studying Hans' presentations and adopting many of his techniques; and soon I had my audiences in the palm of my hand, even though my session was after lunch when people normally get sleepy on their full stomachs. In my description of OED seminar trips, I want to combine incidents from various seminar trips to give you a picture of what a seminar trip was like.

Milt Liebhaber decided to charge a fee to attend the 1977 OED application seminars to help offset the travel costs. It was a bad idea and a total failure. I had only one come to attend the seminar in Salt Lake City, so the seminar was cancelled and OED had to absorb the travel costs anyway. We had a poor showing in Portland Oregon, and Lane Lee, the Northwest District Manager and other district managers objected. Milt had to give in and drop charging a fee for the Midwest and east coast seminars. Most all of my seminar trips were with Hans Sorensen and we made a good team together. The seminars were given in two sessions. The morning session was always optocouplers and the afternoon session was always the visible LED products, lamps and displays. Some seminar trips were two weeks long and some were three weeks long.

Doing a seminar trip was exhausting work. Seminar trips could last one to three weeks. A schedule usually went like this. Up at 6:00 am, grab a quick breakfast, hope the hotel has a buffet; open up the conference room by 8:00 am. Greet the attendees with small talk; do the morning presentation on optocouplers. Share a catered lunch with the attendees in an adjoining conference room. Do the afternoon presentation on LED lamps, LED displays, photometry and reliability. Spend some time saying goodbye and thank you for coming to the attendees as they leave. Pack up all the equipment; make sure nothing gets left behind. Rush to the airport to catch an early evening flight to the next stop. Check the bags and equipment. Check in with the tickets and board the airplane.

Fly the hour to three hours to the next stop. Be greeted by the Field Engineer at the next stop. Wait for the baggage and equipment to come off the airplane. Go to dinner with the Field Engineer, usually at some fancy restaurant he had picked out for the evening. Get to the hotel. Find the conference room; set up all the equipment and make ready for the morrow's show-n-tell. Say good night, I'll see you in the morning to the field engineer, find my hotel room and crash. Time, typically 11:30 pm to 12:30 am. Up at 6:00 am the next morning and repeat the process all over again, five times each week. So, the rule was, plan the seminar trip so that I would be in a nice vacation like location during the weekends. That way, I could use the weekends to go sightseeing and relax on the company's money.

**Seminar trip experiences**

Our Midwest stops included Minneapolis/Saint Paul, Minnesota and Milwaukee, Wisconsin. Naresh Gandhi was a District Manager in the Midwest and he and I became good friends. On one occasion a customer a few miles down the Mississippi River was having troubles utilizing our LED lamps. I was asked to go visit the customer. I told Naresh Gandhi that I should not go because I had the afternoon presentation to make. The field salesman assured me that we would be back in plenty of time for me to do my half of the seminar. So, we left St. Paul and drove down the Mississippi River. It was a pleasant drive, especially along the palisades that lined the shore of the river.

When we arrived at the customer's facility, they were happy to see me. The customer's problem was a poorly operated wave soldering process. Now, you remember, I had never run a wave soldering process myself, but watching their process in operation I could easily spot areas where things were going wrong; too high a solder temperature; too long a time through the solder wave; improper fluxing. I made suggestions on how to improve their soldering process and left to get back to St. Paul. We arrived back just in time for me to begin my afternoon session. No lunch that day, but a thank you for the help; HP solved our problem from the customer and made the day.

We arrived in Milwaukee late in the evening. The field salesman invited us out for dinner. I said no thanks. I was going to hit the sack; I had a big day tomorrow. Hans and the field salesman stayed out drinking all night long. The next morning Hans was tipsy but managed to do his presentation. One poor attendee asked Hans a question, using incorrect terminology to describe what he was asking. Hans stepped to the edge of the stage and said in a clear loud teaching voice, "As Mr. Voltaire has said, If we

are to converse we must employ proper terminology." Hans then proceeded to correct the questioner and explain the answer to his question. That afternoon, I was about ¼th the way through my presentation when I heard a loud rumbling noise emanating from the back of the room. I stretched to look back, as did others in the audience, to see Hans slumped in a chair in blissful sleep snoring his head off.

This is jumping ahead a bit but at this point I want to include this little story about the character of Hans Sorensen. Hans was sort of a mad scientist type, always doing some goofy experiment. On this occasion, we were doing a special seminar at the Holiday Inn in Palo Alto, California, a short distance from OED on Page Mill Road. I had agreed to do part of the optocoupler session and was well into my presentation, and a bit nervous about explaining the information correctly, when I looked to the back of the room and saw Hans Sorensen holding his hand up high, as if to ask a question or to make a comment.

So I called back to him from the front of the conference room, "Hans, do you have a question?" He gave me no answer. So I asked him again. Still no answer, but he still had his hand held up high. This time I shouted at him, "Hans Sorensen, do you have a question?" He looked up with a start, looked around then sheepishly said, Oh, no. I'm trying to determine the focal length of my glasses. You see there is a ceiling light directly overhead and I was trying to focus it onto a sheet of paper so I could measure the focal length. I'm sorry if I have interrupted you. Please continue."

One of our seminar trips took us to Toronto. We had the weekend off before giving the seminar on Monday. Hans and I went down to Niagara Falls on Saturday.

That same seminar trip took Hans and me to Florida. Hans wanted to go visit friends in one direction, and I wanted to go directly to Tampa where the seminar was to be held. So, I rented a car and Hans rented a car. Normally only one car, not two cars, is budgeted for a weekend between seminars, but that did not bother us. I toured the Tampa area.

Ben Howell, the District Manager from the Orlando HP office, Sandy Vehonsky, an FSE from Orlando, and Mike Hutcheson from the Tampa HP office hosted the seminar. The Florida seminar was one of our best. Sandy Vehonsky and I were to become friends, and we still keep in touch via e-mail during our retirements.

When I got back to OED and submitted my expense report for the trip, Stan Gage refused to approve it. At issue was me renting a car when Hans had rented a car. I explained to Stan that we each went in opposite directions over the weekend, thus the need for two cars. Stan was not going to buy my argument. The day I got back I heard the buzz around OED of the extravagant outing that Dave Weindorf had treated the European Sales Force to. Dave Weindorf had taken the whole European Sales Force to the French Riviera for a sales conference and had dropped $6,000 on a bar bill the same weekend Hans and I were in Tampa, Florida. I brought this to Stan's attention, stating that if Dave Weindorf, the Group Manager, could spend $6,000 of OED's money on booze for the Europeans, then OED could surely afford to spend $110 on a rental car for me. Stan signed my expense report.

On another one of our seminar trips, Hans Sorensen and I flew from sunny San Francisco to snowy Rochester, New York to start our seminar trip. As we landed there was a light snow falling in Rochester. By morning there was between two and three feet of snow on the ground. We did get a good turnout of attendees to the seminar, however, mostly from Xerox and Kodak, the two major companies in Rochester. By late afternoon the snow level was over four feet. Our next stop was at the IBM facility in Poughkeepsie, New York.

There was no possible way we could fly to Poughkeepsie in the bad snowy weather, so the only alternative was to drive; in the snow! Ron Atwater was the district manager at the time. Ron

requisitioned a station wagon from the HP Rochester motor pool and we loaded our seminar equipment in the back seat and in the luggage area behind the back seat. Ron did the driving. Hans sat in the front passenger seat, and I huddled in the back seat on the right side alongside our equipment. Ron got me a blanket to use to help keep me warm because the car heater was not effective in the back seat area with all the equipment taking up space.

We started out from Rochester about 5:30 pm; it was snowing and the roads were barely passable from having been recently plowed. I could hear road noise below me. I looked down to discover that the right rear wheel well was rusted out and I was looking straight down at the snow covered road. I thought to myself, what am I doing this for? I work for a multimillion dollar company and here I am riding is a rusted out station wagon traveling on snow covered roads with only a blanket, my coat, hat, and rubber boots that I had brought along on the trip to keep me warm. This was crazy at best. As the night wore on, Ron Atwater kept on driving. I was hungry, but there was no place to stop. Hans spotted a roadside store that was still open. We stopped to get a sandwich and some wine. I did not drink wine but Hans and Ron sipped the bottle to keep warm, so they said.

We soon came to the town of Utica, NY and Ron pulled into town to look for a restaurant. We got out of the car and walked the streets of downtown Utica at 10:30 pm and found no restaurant open and our feet never touched the pavement. Back in the car, Ron kept on driving. I got a few winks of sleep as the car plowed through fresh fallen snow on the highway. The night wore on, Ron kept on driving and the snow stopped falling. Daybreak found us near the bridge across the Hudson River that led to Poughkeepsie. Ron stopped at a car wash and got the car washed. We drove across the bridge into Poughkeepsie and to the IBM facility, a huge complex of buildings. Ron found the main IBM building, a large brick structure where the conference room was located. We unloaded our equipment and set up the seminar, no breakfast.

Some thirty IBM employees attended the seminar. What a bunch of dead pans they were; a very drab audience to talk too. IBM did provide the lunch; food at last. During my afternoon session I got perturbed at the audience and scolded them for not responding to what I was trying to teach them. They were all IBM employees, there was no other company represented in the audience, so why don't they just loosen up and be part of the show? Little by little I got the audience to come alive, and by the end of the day, I was answering questions from the audience, something Hans Sorensen did not get a chance to do.

Mark Hodapp, who became Applications Manager after Stan Gage had left Applications, hired a young female engineer named Lori Louie. She was small in size and a second generation Chinese, and was a sharp engineer. Mark asked me and Lori to do a seminar trip together. I was not sure this was a good idea having me and Lori travel together. But Mark could not foresee any difficulties and encouraged me to go on the trip with Lori. So, I agreed to go.

Lori and I had fun on that trip. For example, we would go into a restaurant and have dinner. The waiter would look askance at us, a middle aged Caucasian man with a small Chinese girl in her twenties having dinner together. The fun part was when Lori would pick up the check and pay the bill.

Monday morning was the seminar. Since optocouplers were now being supported by OCD, they were no longer part of our opto-seminar, so our seminar being strictly on visible LEDs was to be four hours long, from 8:00 am until noon. I would do this particular seminar which would be mostly made up of XEROX and Kodak attendees. When I got to the conference room, the HP field engineer told me that Mark Hodapp had called stating that there was an urgent need for me to immediately visit a customer in Binghamton, NY who was having problems auto-inserting our LED lamps. I had to leave then and there for Binghamton. Lori told me that she could do the seminar just fine and for me to go.

Our next seminar was in Binghamton on Wednesday and Lori told me she would meet me there an Tuesday night. I could not fly from Rochester to Binghamton, but had to make a connecting flight out of Syracuse, NY. It took all day just to fly to Binghamton; I could have rented a car and gotten there faster. The next day, Tuesday, I visited the customer. The customer's facility was modern and had all the latest equipment for manufacturing PC board assemblies. His problem was simple, too much insertion pressure which was breaking the LED lamps. I asked the customer to reduce the insertion pressure by half, which still was sufficient to insert all the components on a PC board but light enough so as not to break LED lamps. All that took a half hour. The customer then gave me full access to his facility and I spent the rest of the day touring his facility looking at all his processes to learn as much as I could. I met Lori and the HP field engineer that night at the hotel.

Lori had quite a day on Monday. As XEROX and Kodak engineers came into the conference room, looking for me, they were disappointed that I was not there, but instead there was this little Chinese girl. Lori said as she started the seminar none of the attendees expected much, in fact a few left expecting nothing of importance to be gained by staying. When she had concluded the seminar she was surrounded by XEROX and Kodak engineers begging her to come to their offices to help solve LED problems they were having. She stayed well into midafternoon, answering questions as best she could, apologizing that she had to move on and could not go to their individual offices. In short, Lori was a rousing success!

**The McIntosh visit**

McIntosh is located in Binghamton, NY. Two years earlier, McIntosh had visited OED to discuss using LED displays in their audio designs. I wanted to be part of the discussions with the McIntosh people, but Stan Gage said no, he wanted that all for himself. That made me mad, but I could not do anything to convince Stan otherwise. McIntosh did not use any OED LED devices, but instead bought their LEDs from OED's competitor, Monsanto. McIntosh used Monsanto S4 LED displays in only a couple of its products, one of which was the MR80 FM tuner, which I have as part of my stereo hi-fi system. McIntosh dropped the use of LED displays in favor of Japanese vacuum fluorescent displays because they provided better flexibility in displaying various kinds of information than did LEDs at a lower cost.

The manufacturing manager for McIntosh who had been on a visit to OED earlier greeted us and took us on an extensive tour. The McIntosh building was not much to brag about; but the McIntosh operation was first class. I was impressed with the cleanliness and layout of the McIntosh assembly areas. The people who worked for McIntosh showed extreme care in what they were doing. The McIntosh products were hand assembled with loving care that was for sure. Each component was tested before being assembled into a piece of McIntosh equipment. We toured the McIntosh speaker facility and the acoustical lab where speaker systems are tested.

The acoustical lab is a silent room. The interior had "padded" walls and ceiling made of sound deadening foam in the shape of cones that absorb sound. The floor was made of cork to deaden any possible sound reflections. It was so quiet, standing inside this acoustical lab room, that I could easily hear my heart beat and my blood being pumped through my skull. My ears heard a hissing sound; air molecules hitting my ear drums. When our host played a McIntosh speaker system inside the acoustical lab it sounded muted, dull, no reflected sound to liven it up. By placing a speaker system into the acoustical lab for test, the exact frequency response could be measured without any interference from reflected sound waves. We spent 2½ hours touring the McIntosh facility. I now had an appreciation of why I insisted on owning McIntosh audio electronic equipment exclusively in my own stereo hi-fi system.

**ALI and NVG**

The 1978 ALI Advanced Seminar had far reaching positive consequences for me. It was a joint meeting of ALI and the SAE A20 Aerospace Lighting Committee. The conference topic was Night Vision and Night Vision Goggles (NVG). Night vision goggles (NVG) had been used by the military for some time. NVG were designed to be used by pilots flying at low altitudes with respect to the ground in nighttime conditions. NVG use an infrared optical amplification system to utilize nighttime ambient infrared light to see by. The NVG resemble binoculars and produce a green image of the nighttime terrain on the eye pieces for a pilot to see. The image is very detailed, although the angle of view is limited to 40°. The NVG are mounted onto a pilot's flight helmet with the eyepieces directly in front of his eyes, space about 1½ inch away from his face so he can still view dimly lighted cockpit instruments. A new GEN III version that was now in use required compatible lighting in aircraft cockpits. The level of acceptable lighting was based the luminance of moon illuminated tree bark.

The Naval Air Development Center (NADC), Warminster, PA, was in the process of writing a military specification for NVG compatible cockpit lighting. Ferd Reetz of NADC was leading the team writing this new specification. Ferd Reetz gave a presentation, in which he stated that the level of NVG compatible lighting had to match the brightness of tree bark as viewed through night vision goggles. With this statement, Ferd generated considerable skepticism amongst the joint attendees. Many of us felt this was a ridiculous this concept, and let Ferd know it. How wrong we all were and how correct he was. Ferd introduced a new measure of performance called NVIS Radiance (NR), suggesting the limit be $1.7x10^{-10}$ NR. The term NIVIS was an acronym for night vision imaging system, what the rest of us called NVG.

In his presentation, he described a new military specification for NVG used in aircraft cockpits, MIL–L-85762. This new specification had been written by the Navy to serve all the armed services. The first draft was now ready for review and anyone at the ALI conference who wanted a copy could have one to review. I got a copy of the specification. As with many military specifications, it was complicated and confusing to read and understand. It took me a few times through reading the document before I got an understanding of what the specification was trying to do. It was complicated, defining every possible aspect of NVG that could be envisioned; the response characteristics for NVG, the colors and luminance levels of cockpit lighting that could be used with NVG; the testing required to qualify NVG for use; the testing requirements necessary to qualify cockpit lighting for use with NVG. NVG compatible cockpit lighting had to be in specific color ranges of red-orange, amber and green. Luminance levels for NVG compatible cockpit lighting had to be at 7-orders of magnitude below normal cockpit lighting levels.

I saw an opportunity for LED technology to play an important role in NVG compatible lighting. For the next 12 years, I made it my priority to get LED devices designed into military aircraft cockpits and other military applications that included NVG. I got the backing of Stan Gage and Marketing in this effort. LEDs had a two big advantages; First LEDs produced little infrared in their light emitted spectrum. And secondly, LEDs could be easily dimmed to the extremely low luminance levels required by MIL–L-85762A. I sent in to the Navy my inputs on what changes I thought should be made to make the specification easier to use and understand. Others from ALI did the same. None of my recommendations were accepted. After about a year the specification was finalized and released as MIL-L-85762A. From that point on, the business of NVG and NVG compatible lighting in military aircraft and other military applications became big business.

I the spring of 1977, I received a call from the ITT, Fort Wayne, Indiana, asking about the possible use of SAN LED displays in something called the SYNGARS radio. Every so often I would get a phone call from the ITT on the subject, never really understanding what SYNGARS was or how the SAN displays were to be used. In 1978, the topic changed to using NVG compatible SAN displays in the SYNGARS

radio. More on this later; and it is interesting, because it ties in with NVG and how other people would treat me to gain their own advantage.

Throughout 1978 I worked through ALI to get across the concept that LEDs were an ideal light source for NVG compatible lighting. I was successful, both with ALI members and with OED Marketing. So convincing were my efforts and the efforts of field engineers who had NVG lighting customers that OED introduced SAN and S4 displays for use in NVG lighting applications. OED had a military grade, metal can package, standard red LED lamp that had been designed during the early years of HPA. By incorporating AlInGaP red, amber and yellow-green LED die into the product, OED quickly had a military grade LED lamp product that could be used NVG compatible lighting applications.

This product made considerable money for OED. Unisys wanted a panel mount LED lamp that was NVG compatible. OXLEY of England had a panel mount LED lamp that incorporated an infrared filter to make the device compatible for use in NVG lighting. OED decided to challenge OXLEY. Meantime, at ALI, I got the chance to look through a pair of ANVIS NVG. The acronym ANVIS stood for Aviation Night Vision Imaging System. It was awesome to stand in a dark conference room and look around through the NVG and see everything in the room as if all the light were on. I knew then that OED should buy an NVG monocular to be able to visually demonstrate to customers and the military the NVG compatibility of LEDs. It took me a while, but I finally got the purchase order approved to purchase a Litton NVG monocular; it cost $10,000. Upper management was not sure about this expenditure. Unisys was in the process of deciding between OXLEY's LED panel mount lamp, and a new NVG panel mount lamp that OED had made.

Before I can continue with the Unisys story, I need to deviate to the topic of NVG filters. An NVG filter filters out infrared light emitted by a light source so the infrared light cannot interfere with the operation of the NVG utilizing ambient infrared light. The most successful company in the field of NVG filters was WAMCO of Fountain Valley, a section of Los Angeles. Mike Matthews was President of WAMCO and had his first business encounter with HP by providing the leather carrying cases for the HP 35 and HP 45 hand held calculators. WAMCO personnel were members of ALI. At each ALI meeting, on Tuesday evening, WAMCO would throw a party for all attendees, with WAMCO picking up the tab. The WAMCO party would typically start immediately after the day's session was over and ended whenever it ended.

WAMCO decided to go into the NVG filter business. The first product was a blue glass filter with infrared suppression better than 7 orders of magnitude, called the NV-2C. For HP, WAMCO made a similar filter out of green glass. Placed over a yellow-green LED, the color exactly matched the color requirements as well as the luminance requirements of MIL-L-85762A. Placing the green LED version of OED's metal can military lamp inside an aluminum panel mount cylinder that also held WAMCO's green NVG filter made a better NVG compatible panel mount device than OXLEY's device. But, Unisys wanted to be shown the HP product was better.

I was flown out to New Jersey to demonstrate to Unisys OED's green NVG compatible panel mount lamp. The district manager and two FSEs went with me. One of the FSEs was a woman. All three wanted to look through the NVG monocular, but where to do the demonstration. What better place than in an inside bathroom of a motel room? So we stopped at a motel and rented a motel room for an hour. Can you imagine what the motel proprietor must have thought seeing two men and a woman renting a motel room for only one hour? We all four went into the inside bathroom. So crowded were we that the district manager and the woman sales engineer stood in the bathtub. The monocular had an infrared LED that could be used to provide infrared light for demonstration purposes.

I turned out the light and it was dark in that bathroom. The I turned on the NVG and its infrared LED. To the unaided eye, the bathroom was totally dark. But when they looked through the NVG monocular each one could clearly see the others in the bathroom. They were flabbergasted at seeing through the NGV monocular. All three now understood what I was talking about when I would talk about NVG. At the Unisys meeting, we had a similar experience. Unisys engineers had never seen through an NVG device before. They only knew of NVG by reading and working to the requirements of MIL-L-85762A.

Unisys engineers and purchasing personnel and we from HP all gathered in an inside conference room. The door was closed. I had a small hand held LED demo box with the OED green NVG compatible panel mount in it. I turned out the lights. The only light entering the conference room was from underneath the door, otherwise the room was totally dark. I turned on the NVG monocular, but not the infrared LED. I then turned on the OED NVG panel mount lamp and passed both to the Unisys people. The demonstration was a success. OED got the order over OXLEY. The order was for $800,000 worth of OED's NVG panel mount lamp at $70 each. I had no more trouble from anybody at OED concerning me spending $10,000 for the NVG monocular.

Now that you have some understanding of NVG, let me finish the ITT story, even though it is out of sequence. The acronym SYNGARS stood for Synchronized Ground Army Radio System, a ground base portable radio that used a carrier frequency that changed at 30,000 times a second. When two SYNGARS radios linked up in sync with each other, it was impossible for an enemy to intercept their radio messages. What was needed was an 8 digit small size character display. LEDs could fit the requirement. OED had undertaken, for a different customer, the development of an 8 character SAN style LED display. But this new display would have an intelligent IC. The IC would store the alphanumeric data for all 8 digits and strobe the data through the LEDs to display an alphanumeric message.

This new display was far more sophisticated than the original SAN displays and was much easier for customers to use than the original SAN displays because of the data storage and LED drive capability of the onboard IC. The problem was the politics involved in the development of the product. Roland Haitz and Marketing had their idea of what this new display should be, and I had another. Their idea was to develop a purely commercial plastic package device. My idea was to develop a military device using a ceramic substrate and a glass window that would form a hermetic seal to meet military specifications. The product design engineer found himself caught between these two fields of thought. He listened to me instead of listening to Roland Haitz and Marketing and designed a military grade 8 character LED display. So enraged were Roland Haitz and Marketing that he got fired. His design had serious flaws.

When the product was transferred to Dick Kern's manufacturing group, one of Dick Kern's manufacturing engineers, Mark Kriss, did a complete redesign, bringing to production both a commercial plastic and a glass/ceramic military version of the display, the HDSP-2350 series. It was the military version that ITT wanted to design into the SYNGARS radio.

I was sent to ITT at Fort Wayne as part of a team to close the sale with ITT that included a new young person from OED Marketing, a person from OED Hi-Rel, and the local FSE and the district manager. At the meeting, I learned that ITT had to meet the requirements of MIL-L-85762A and had no concept of NVG or NVG compatible lighting. ITT had done nothing towards meeting the requirements of MIL-L-85762A and wanted to design in the red LED HDSP-2350 display. Using a red LED display was an absolute no-no if ITT was to meet the NVG specification. There was no possible way ITT could meet NVG specifications with a red display. I spent most of the meeting describing to the ITT people the basics of NVG, trying to convince them to use the amber LED HDSP-2351 version of the display which would give both sunlight readability and compliance to the NVG specification. The meeting was contentious. I seemed to upset everybody, especially the person from OED Marketing. Back at the plant I

received numerous calls from ITT engineers asking for guidance from me in just how to design in the amber LED version of the military 8 character display to meet the requirements of MIL-L-85762A.

After a few months, in mid-1979, the order for the HDSP-2351 came into OED. The HDSP-2351 amber LED version of the military grade 8 character display had been designed in using a WAMCO amber glass NVG filter, had been shown to the Army and had been approved and accepted by the Army's NVG experts. Full credit for the sale went to the new young Marketing person. He was publicly congratulated by OED's upper management for his efforts. I got nothing, no recognition at all for my efforts dealing with ITT that had spanned over two years. I felt deeply hurt and ignored. However, I kept quiet, licked my wounds and went on with my job. The postscript to this story was that the young Marketing person quit OED a year later.

We applications engineers were doing a lot of bench characterization work on OED's LED devices, I did a lot of optical and voltage susceptibility testing on various LED displays and optocouplers. Stan Gage decided the department could use an automatic tester. Stan located a used Fairchild automatic semiconductor IC tester and convinced Paul Sedlewicz and Bob Zettler to let him buy it for the Applications Department. It was a big electro-mechanical machine, about the size of an upright piano. The tester was more or less in pieces when it was delivered to Applications in the basement of Building 11. Stan asked me to piece the machine back together and get it ready for use. Stan also asked me to be the engineer in charge of the tester and learn how to program it to test various OED LED devices. Well, I did not want to do this and gently told Stan my feelings about the tester. Stan countered by saying that the tester was mostly a mechanical machine and that I was the only mechanical engineer he had. So, I was my job to get this contraption, as I saw it, working.

Hewlett-Packard had the SEED (Student in Engineering Education Development) Program which hired engineering college students for summer jobs. The objectives of the SEED Program were 1) to give young engineering college students engineering type employment during the summer and 2) to get look at these summer job students as a selection process for hiring some of them when they graduated. Stan hired Diane Bustamonte, an engineering student from Stanford. Dianne was a straight "A" student and would be a senior when she returned to Stanford. Dianne Bustamonte was a little bit of a girl; if she turned sideways you would never notice her.

However, she had an amazing brain. She was brilliant! I have never known anyone with the brain power of Dianne Bustamonte. Stan assigned Dianne to work with me to get the Fairchild tester up and running. I will admit, I had no clue as to where to start and did not understand how this monstrosity of a machine was supposed to work. But it did not take Dianne long to figure things out and get started. Dianne worked in Applications for two a half months and during the summer of 1978 and single handedly got the Fairchild tester up and running and taught me how to program it. Dianne wrote a short operator's manual for the machine so all the applications engineers could use the tester.

Dianne went back to Stanford and graduated Tau Beta Pi, with straight "A" grades. A vice president of General Electric called me to ask for my opinion of Dianne and whether I thought she would make a good GE employee. I gave him the highest recommendation on Dianne's behalf I could, explaining to him how brilliant Dianne was. The last I heard of Dianne Bustamonte was that she had her PhD in medical electronics and was working on the development of MIR (magnetic image resonance) machines; I would presume at General Electric. The Fairchild tester was not used by the applications engineers to the level that Stan had envisioned. He offered it to manufacturing that did use the machine some. But after a while, the tester sat idle and was sold by OED on the used equipment market.

**Hi-Rel**

Being so deeply involved with the military side of OED's business, I was working closely with OED Hi-Rel. The Hi-Rel Department provided the high reliability screening and testing of OED's military devices to meet military specifications. The profits from Hi-Rel screening were pure gravy. There were no piece parts to buy, no manufacturing cost to sustain, and the Hi-Rel test equipment was flexible enough to screen and test a variety of OED's military LED products. Hi-Rel was originally set up to screen and test the military grade hermetic LED lamps, but was expanded to include military optocouplers and LED displays, and then finally OED's military grade NVG panel mount lamps. At the peak of Hi-Rel's business in 1979 & 1980, military screening was 3% of OED's sales and 30% of OED's pretax profits, so it was a lucrative business.

Jim Chrysler was the Hi-Rel Department Manager and he and I were working closely together. In 1978 Jim mentioned to me he needed an engineering manager. I thought it might be a good thing for me to make a change from applications engineering to Hi-Rel as the engineering manager. I had two reasons: First, I would get experience in the Hi-Rel field, gaining a familiarity dealing with military contracts and personnel as well as gain an understanding of military specifications. Second, this would be a good way to break into the management ranks at OED. Also, since Hi-Rel was located only a short walk down the hall from Applications, I could keep in close touch with the applications engineers and get their direct support whenever I needed it.

Jim's support staff included George Strickland as the Hi-Rel Production Manager, Sharon Hamilton as the Testing Supervisor and Cindy Hunt as the Specifications Supervisor. I knew all three and thought I would fit in with these people just fine. I approached Jim Chrysler about the position and Jim agreed to have me join his team. Stan Gage was adamantly opposed to me making the move. His basic reasons were he felt that Hi-Rel was actually a dead end road for me and second Stan knew about Chrysler's style of management that I did not know, but would have to confront later on. I went ahead and made the change and Joined Hi-Rel in the fall of 1978. At first everything was wonderful.

The whole Hi-Rel staff welcomed me with open arms. I quickly settled in learning my new job and responsibilities. Something very new to me was the necessity of writing performance reviews for those reporting to me. I would find this not an easy task to accomplish. I had two level 1 technicians reporting to me, Al Ramos and Shellie Tillman, whose job it was to keep the Hi-Rel burn-in and test equipment running. That wasn't enough staff. I quickly learned that Hi-Rel's test equipment had a huge percentage of down time that in some weeks approached 60%. I was not skilled in the technical support for the Hi-Rel test equipment and needed to quickly find someone who could do the job. A senior level 4 technician, whose first name was Patrick (I cannot recall his last name), knew that I was looking for someone and approached me about the job. I hired him and Jim did not oppose my choice.

Patrick had attended the University of Rochester, and was completing his requirements for a BSEE by correspondence; if I remember correctly only two elective courses that he needed to complete before getting his degree. Patrick's specialty was computer engineering. It did not take him long to determine that most of the difficulties were software problems, and immediately set out about solving them. Within three weeks, the up time for all Hi-Rel's test equipment was at 95%. I worked alongside him as best I could to learn what he was doing. Al and Shellie were doing their level best to keep the test equipment maintained and were doing a very good job of it.

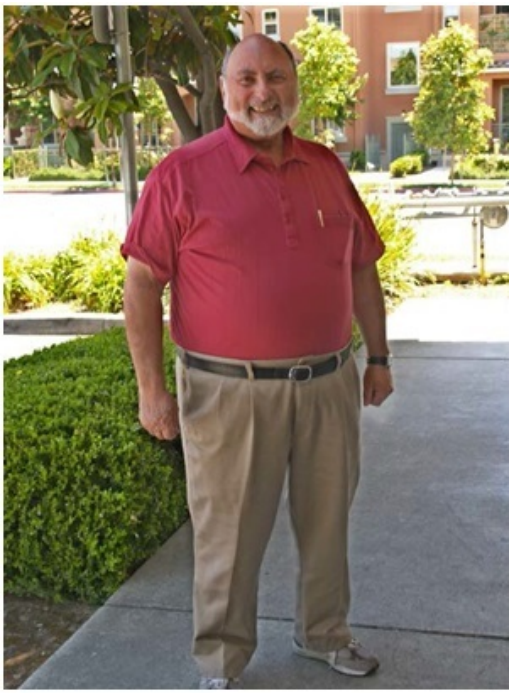
I now ran into the problem with Jim Chrysler that Stan Gage was worried about. I put in the necessary paperwork to raise Al and Shelly from Technician 1 to Technician 2, which would mean an increase in their wages. Jim Chrysler opposed my move. Jim said the two technicians were not doing level 2 work. I later figured out Jim's real reason was he did not want to add more expense to his departmental budget

by giving out promotions. It took me two weeks of diplomatic arguing on their behalf, along with support from George Strickland, to get Jim Chrysler to change his mind and finally approve the promotions.

I told both Al and Shelly, now level 2 technicians, that I knew they were hourly paid employees. But, it was their job to keep the Hi-Rel test equipment and burn-in ovens working at better than a 95% up time, hopefully approaching 100% up time. Therefore, I did not expect them to be present every minute of every day. If they had some personal business to attend to, then go ahead and take care of it and don't worry about the clock time while being away from the plant. However, if I they were needed at 2:00 am on a weekend morning to come rushing down to Hi-Rel to fix a burn-in oven or some other piece of equipment, I expected them to immediately respond, in other words I expected them to be on call 24 hours, 7 days a week. I also told them to charge overtime whenever such an off-hours situation demanded their immediate attention. Jim liked the idea of the techs being on 24 hour call, but disapproved of me allowing them to take company paid time for personal business. I rebuffed Jim by saying that we professionals could do so and the company did not care.

The problem here was the laws of the State of California. Professional employees were on what was called exempt pay status, meaning professional employees were paid on a monthly salary basis and could be asked to work over time without overtime pay. Technicians, on the other hand, were non-exempt employers, paid on an hourly basis and would be paid overtime pay (time and a half) for any time worked over 40 hours per week. I understood that, but California law did not mention nor cover hourly employees who were expected to be on a 24 hour, 7 days per week emergency call. So, to offset the 24 hour, 7 day per week emergency call status, I wanted to extend to my technicians the same privileges as were afforded HP's professional employees. Although Jim protested my decision to do this, it paid off numerous times when I had my technicians come down to Hi-Rel on weekends because a burn-in oven or other piece of equipment had gone down. They were loyal to me and I stood up for them.

The first big fight that I had with Jim Chrysler was over my level 4 technician. Patrick had completed his requirements and received his BSEE in Computer Sciences from the University of Rochester. As soon as Patrick had proved to me that he had graduated, and had his BSEE degree, I set out to change his employment status from Technician 4 to Engineer. Jim immediately opposed me. Jim again felt that Patrick as a Tech 4 with a BSEE was not qualified to be paid as an engineer. I discussed this with George Strickland and he recommended I fight for the upgrade. Again I guessed the Jim was trying to save expenditures on his departmental budget. Norm Tarowsky had been sent to the OED manufacturing facility in Pinang, Malaysia. Norm spent three years as Manufacturing Manager at the Pinang facility and was given the position of manufacturing manager for OED upon his return to OED. Jim Chrysler reported directly to Norm. I took my problem to Norm for his advice and support. After a short, but careful review, Norm Tarowsky backed me on promoting Patrick from Technician 4 to Engineer.



Norm Tarowsky; OED senior level manager after retirement. Photo September, 2005.

Now, in those days at HP, managers rarely gave orders to their subordinate supervisors, and Norm told Jim he approved of the promotion and would support it, but did not order Jim to approve the promotion. I had one other person to turn to for help. Gary Ruppel was the OED Personnel Manager. I figured that if I could enlist the help of Gary

Ruppel, Jim would have to approve the promotion. Gary and I had known each other from the first day I was hired at HPA. Gary Ruppel was and still is one of the nicest, fairest, and honest people I have ever had the pleasure of meeting. Gary is a bit of a wheeler dealer in the field of corporate politics, and usually got his way simply because he was usually right on personnel issues. Gary backed me on the promotion, which forced Jim Chrysler to approve the promotion. So Patrick was promoted and became an Engineer in the Hi-Rel Department reporting to me.

I did not yet realize just how serious was Stan Gage's concern about me working for Jim Chrysler, but would soon learn that I had rubbed Jim the wrong way twice and would do so a third time with dire consequences. Jim Chrysler decided to do a reorganization of the Hi-Rel Department. Evidently, Cindy Hunt and Sharon Hamilton had some sort of compliant about reporting to George Strickland. I never did find out what the trouble was, except that the girls were unhappy having George as their manager; so Jim Chrysler put George Strickland under me and kept Cindy and Sharon reporting to him.

I thought this reorganization was dumb and unnecessary. George Strickland took the change in stride, however, stating that he no longer had to write performance reviews. Even though George was now reporting to me, I treated him as an equal as we had been when I first came to Hi-Rel. I did two performance reviews for my people. Oh, were they difficult to write, trying to be as objective as I could be and still stay within the framework of HP's subjective performance review policy. Jim Chrysler fought me on both review cycles, claiming I was too complementary about my subordinates and not critical enough of their performances. It was on the second performance review that Jim Chrysler and I clashed with serious results. I took the time to review my employees pay status in relationship to those who had equivalents positions within OED.

To my sad surprise, my people were being underpaid by about 5% when compared to others in OED doing equivalent work. So, with their performance reviews, I put in for 5% raises for my people. Jim disapproved the raises and severely criticized the positive performance reviews I had written to back up my request for raises. This started a fight. Again I turned to Norm Tarowsky and Gary Ruppel, who both backed my on the pay raises and the tone of the performance reviews. This was my first real indoctrination into OED politics. In order to for me to get a win, I had to back down on my raise requests to 4.5% which was the Division's average raise for that pay period. Jim Chrysler never forgot that three times I had beaten him at his game, and he developed a grudge against me. I first learned of this grudge from both Sharon Hamilton and Cindy Hunt. Cindy Hunt was very clever in how she dealt with Jim Chrysler, and would get information out of him that others could not. Cindy kept us informed of Jim Chrysler's moods and decisions.

Now before I continue, I must give you some sympathetic background on Jim Chrysler. The human eye has in the retina, cones for daytime viewing that respond to both brightness and color. For nighttime viewing, the retina has rods which only respond to low level light at night and have no color capability. Jim Chrysler is one of the less than ½% of the population that are born without cones in their retinas. As a result, Jim was totally color blind and had difficulty seeing. He wore special glasses, and to read anything, had to put his face down very close to the page or paper he was trying to read. Out in daylight, Jim had to squint to protect his eyes.

As a child growing up, Jim had trouble in school and was treated as a slow learner, or even as a retarded child which of course he was not. Jim had difficulties dealing with all kinds of situations all of his life because of his eyes having no cones, only rods to see by. Jim was not able to get a California driver's license until the age of 32, and then only was permitted to drive during daylight hours. So, Jim had a physical handicap to deal with all of his life. In some ways, Jim internally felt inferior to other people because of his handicap and took his handicap out on others, what is commonly called an inferiority complex.

So angry was Jim with me for beating him three times, as he saw it, that he fired me. Jim cut termination papers on me and sent them to Personnel. When the termination papers reached Gary Ruppel's desk, Gary called Stan Gage. Jim told me I was fired and had 30 days to find another job; at least this was not a two weeks' notice so my termination would be without prejudice. That same day, Stan Gage called me and offered to me my old applications engineering position on two conditions. First, Mark Hodapp would be my supervisor and second I would stay in Applications and not seek another position outside Applications. I agreed to both conditions and went back to OED Applications in early 1980. Jim Chrysler made life so unpleasant for Patrick as an engineer that he found a higher paying engineering position outside of HP and left Hi-Rel not long after I went back to Applications. Soon after all of this happened Jim Chrysler was relieved as Manager of Hi-Rel. Pat Goodman was appointed Hi-Rel Manager and told me later that he discovered a "pay drought," as he put it, for Hi-Rel personnel and immediately had their pay levels increased to meet OED Division standards.

A little side bit about Shellie. Shellie Tillman was a young, tall good looking girl with a quiet reserved personality. Shellie was very good and dependable at her job as a technician and had finesse with the test operators that made everybody's job in Hi-Rel easier. She was, however, very self-conscious about her nose, which had a high ridge. I told her she looked fine and not to worry about her nose. But Shellie confided in me that she wanted to have her nose reshaped. One week Shellie asked to take Thursday and Friday off. I checked with Al to be sure he could cover for her, he said yes, and I let Shellie have the two days off. On Monday morning Shellie came in with the high ridge on her nose gone and a little bit blue in color. Her nose was now straight and she felt so proud of it. I will admit her straight nose added to her already attractive looks. Shellie told me she felt so much better about herself now that she had had her nose altered. I watched as Shellie slowly began to be more outgoing and much less reserved in her personality and dealings with people.

Some comments about Al. Al Ramos was of Filipino descent. He was shorter in height than I was and was a handsome looking guy with his olive skin, dark hair, and dark eyes that twinkled like stars in the night sky. He insisted on calling me Mr. Evans. Al had an upbeat look at life, always with a smile on his face to brighten my day and working with Al made my stint in Hi-Rel bearable. No matter what went wrong, Al would always point out to me the bright side of things, and in many cases offered solutions that I had not thought of. Al was very good at his job in Hi-Rel and was so dependable that many times he would tell me he had fixed something before I even knew there was a problem. Shortly after I left Hi-Rel, Al Ramos also left Hi-Rel, finding a position in another HP Division with a promotion to Technician 3.

I did have interesting experiences while I was in Hi-Rel. Just after I joined Hi-Rel, OED management made a major decision that affected Hi-Rel. Buildings 11 and 10 were getting overcrowded with people. In 1976, OED celebrated passing $25 million in sales. At that time, OED had annual division performance reviews for all employees to attend on the Saturday morning after the end of the fiscal year. It was a gala affair, with manager's presentations on the departmental performances and a complete review of OED's overall business performance. As Pete Manno said, "OED's 1975 performance was Truly Outstanding!"

Let me digress for this bit of sad news. Pete Manno got into a political struggle with others in OED's upper management and lost, leaving OED in 1976. I hated to see Pete Manno go, because he understood the LED market and had done so much as Marketing Manager to boost OED's business. Rick Kniss took over as Marketing Manager. By 1978, OED's business had more than doubled in sales and personnel, and as a result more space was needed. Management moved a number of departments from buildings 11 and 10 to the Harbor Site, east of Bayshore Freeway, off East Embarcadero Road. The Harbor Industrial Complex was a group of one and two story wood frame buildings adjacent to the Palo Alto Airport and about ¼ mile from San Francisco Bay. Hi-Rel was moved to the Harbor Site. Applications stayed in the

basement of Building 11. Hi-Rel and I were now three miles away from OED Applications, which by distance severely limited my contact with the other applications engineers. Out of sight; out of mind.

The move to the Harbor Site was a good news, bad news story. The good news was that Hi-Rel now had sufficient space to expand. We bought new burn-in ovens and more test equipment, but did not do any hiring of hourly employees. There was an alcove to an outside door at the back of the area that was a perfect location to install a new large temperature cycling chamber. Hi-Rel desperately needed this piece of equipment and I had the experience of selecting it. It was made by the Blue M Company and having two chambers could cycle between +150°C and -65°C; the upper chamber being the hot dry nitrogen chamber and the lower chamber being cooled by liquid nitrogen.

I had two experiences with this new chamber. One of our female operators was sitting in the alcove in front of the chamber, observing its cycling operation. She was counting the cycling operations to make sure the chamber was programmed correctly. As I looked at her, she seemed to be in a trance, as if to be sleeping with her eyes open. I mentioned her to one of my technicians and he agreed, something was wrong with her. We both rushed to her side, picked her up, opened the door next to the chamber and took her outside. Shortly she came to, asking what had happened. We just said she had fallen asleep and wanted to waken her. We instructed her to go back to her work bench and we would take care of the chamber. Looking a bit puzzled, she went back to her work bench. It is what had happened that scared the hell out of us! She had been caught in a nitrogen rich atmosphere and was starving for oxygen. Had we not noticed her condition for another few minutes, she would have died from the lack of oxygen. The problem was the installers had vented the dry nitrogen into the alcove instead of venting the nitrogen to the outside. I immediately called in OED's building maintenance.

Henry Dingly was the building maintained supervisor for the Harbor Site. I pointed out the bad, incorrect installation and asked that the chamber be immediately vented to the outside. Henry wanted a work order. I said no work order; you did the installation incorrectly, now it is your responsibility to correct it! Henry and I hassled over this a bit before he agreed to vent both halves of the chamber to the outside of the building without a work order. I told Jim Chrysler of the venting fiasco, but I did not dare tell anyone about almost losing the life of a Hi-Rel employee because that would have caused all kinds of investigations.

The other incident was an explosion in the upper chamber. We had a lot of optocouplers under test when the upper chamber experienced the explosion. What was puzzling to us was ice had formed in the lower cold chamber. What happened was the Air Products Company had used a load of oxygen to fill out dry nitrogen tank. No one was hurt by the explosion and the chamber did not sustain any damage, but we lost the lot of optocouplers. Air Products did pay for a complete purge of our nitrogen tank, piping and chamber and the cost of the lost optocouplers. Oh yes, Air Products made sure from then on that the tank was only filled with dry nitrogen.

Dealing with military customers and military specifications was an educational experience. I had to deal with customer source inspectors on many occasions, and found them to be reasonable people. On one occasion, we had a lot of SAN displays that was having difficulty passing screening. We needed a waiver on one specification. The source inspector agreed with me and did get from his company the specification waiver we needed to ship the SAN devices. The other situation was very serious and demonstrated the integrity of OED in standing behind its military products. Hi-Rel had screened and shipped a lot of 150 4-channel military grade optocouplers to NATO countries. These 4-channel optocouplers were very expensive devices and were being used in sensitive NATO defense equipment. A problem arose with one coupler as the operating temperature approached 100°C. The couplers were tested to be useable above 100°C without failure. But, one had failed due to high leakage current at 100°C. Hi-Rel obtained samples of the 4-channel optocouplers from the same production lot and tested

them for high temperature performance. The samples showed no leakage current problem until the temperature exceeded 95°C, then exhibited a high leakage current phenomenon above 95°C. Hi-Rel had Marketing recall all 150 optocouplers from NATO. All 150 were returned to OED. A new lot if coupler ICs was run and another 200 4-cahnnel optocouplers were made. Out of the 200, Hi-Rel yielded 200 good optocouplers with insignificant leakage currents measured at temperatures above 100°C. From this lot, OED replaced all 150 4-channel couplers at no cost to NATO. To me, that showed the high standards of business conduct and integrity that the Hewlett-Packard Company was known for.

The Defense Electronics Supply Center (DESC) located in Dayton, Ohio, was in charge of military specifications and procurement of military electronic components. DESC was writing a specification for OED's military grade, hermetically sealed single digit HDSP-2300 series displays. OED received a copy of the preliminary specification for review. The specification had so many errors in it that OED decided to send a team to DESC to negotiate changes in the spec. Dick Fellows from Marketing, who was the marketing engineer for military components, and George Strickland and myself from Hi-Rel made up the team that visited DESC. Dealing with DESC was like dealing with General Motors, only worse. The three of us found the meeting contentious because the DESC personnel had in their minds what they wanted and that was that.

Well sort of. I soon figured out that the DESC people knew nothing about LED technology, and considered LEDs to be like silicon semiconductor devices. Not true, we told them. Over the period of three meetings we were able to get the DESC people to change the specifications to match OED's data sheet almost exactly. That was the easy part. The issue of contention was the country of origin. All LED devices had to be made in the USA. No offshore manufacturing was to be permitted. My mind flashed back to Paul Sedlewicz and our meeting with Delco, when Paul packed up his briefcase and headed for the door when it became obvious that GM had a preconceived outcome of the meeting. I decided to take a similar attitude with DESC concerning the issue of country of origin.

All of OED's manufacturing was done in Pinang, Malaysia except for the manufacture of the LED wafers. All of OED's LED wafers were made in Palo Alto, Building 11 and shipped to Pinang to be used in the final product manufacturing process. OED did buy some II-V crystals from other suppliers to meet LED wafer production demands. I forcefully explained all of this to the DESC personnel with a take it or leave it option. If DESC wanted to have LED devices available for use in military hardware, DESC better get used to buying from companies that used offshore manufacturing. Companies could no longer afford the cost of manufacturing military components in the US because the volumes of military components were too small to offset manufacturing costs in the US. The DESC people backed down on their demand and agreed to accept offshore country of origin as long as the semiconductor LED material was made in the US. We all three from OED agreed and DESC completed and released the specification. We had done good at DESC, as the saying goes, and OED did receive a considerable amount of profitable business from the release of the specification.

### I return to Applications

Mark Hodapp was apprehensive about my returning to Applications and reporting to him. He had a one-on-one meeting with me to express his concerns, all of which I thought were childish. But I promised him I would be a good boy. During the time I was in Hi-Rel, Peggy Christiansen had been attending ALI meetings. She had gone to work for Stan Gage as an Applications Engineer for LED displays to replace me. George Godfrey admitted he was apprehensive about this little blond girl replacing me at ALI. However, Peggy quickly proved her worth and made superb presentations at the ALI Advanced Seminars and did a very god job teaching LED technology at the ALI Basic School. George Godfrey had the highest praise for Peggy Christiansen, but also was happy to see me return to ALI. I immediately found myself deeply involved in NVG through ALI, even more so than when I left Applications to join Hi-Rel

two years earlier.

George Godfrey asked me to teach the Basics of Light and Color section of the Basic School. This section was the first session taught on Monday and laid the groundwork for the rest of the School. George Kalen had put together the topics for the Basics of Light and Color, but George thought it needed revising. I agreed to teach the session, if George Godfrey would give me George Kalen's material. He did and I began to revise and expand what George Kalen had put together. It took me most of the year to make all the revisions and additions to the session.

The attendees at my first time teaching the Basics of Light and Color seemed to absorb what I was explaining to them, all except one. This particular attendee had a PhD in Optical Physics and disputed everything I was saying about light. Soon he became a real nuisance with his constant rebuttals and the attendees began to become confused. I asked him politely to withhold his comments and see me after the afternoon session was over and we could discuss his views then. He kept on correcting me. Then George Godfrey told him to either keep quiet or leave the Basic School. He shut up. His problem was he was looking at light strictly from a particle theory point of view and I was using wave theory to explain the attributes of light. When the day was over, he came up to me and apologized for his constant interruptions, realizing later in the afternoon that we both were correct, just a difference in theories. He then offered to help me load my equipment into my car, and proceeded to load the trunk and the back seat for me.

The first seminar trip I did after returning to Applications was with Bob Krause. Bob Krause was scheduled to do the morning session on optocouplers and I was to do the afternoon session on LED displays. We flew on American Airlines to Chicago and had the salmon filet for dinner on the airplane. By the time I reached the hotel in Chicago, I felt sick; Bob was also complaining about feeling ill. I guessed we both had contracted food poisoning from the American Airlines salmon dinner. During the night I was on the pot many times with the runs. Bob had the room adjoining mine and I could hear him heaving all night long through the thin wall. The next morning I was on the mend; Bob was not, so we switched and I did LED displays during the morning session. By afternoon, Bob felt well enough to do the optocoupler presentation, but cut the session short after only an hour and a half.

Bob Krause planned the trip to spend the weekend in Dayton, Ohio so he could visit his parents. That was fine with me, because I mistakenly assumed I would at least be invited to meet them. Also, the district manager for the Dayton area, who had his office in Chicago, told me he wanted to take me for an airplane ride in his private plane. Well neither event happened and I spent the weekend on my own.

The better of the two days, weather wise, was Sunday. I spent Sunday at the Air Force Museum at Wright Patterson AFB in Dayton. If you have never been to the Air Force Museum you should go. There is the history of Air Force aviation at the museum, from the first Wright Brothers type airplanes, to the Independence, the DC-6 that President Truman used, to the huge supersonic B-1 bomber. One Air Force airplane was of special interest, an F106 delta wing jet fighter. It was winter when the Air Force pilot had troubles with the F106 and bailed out, thinking the airplane was going down. The pilot parachuted safely to the ground and was rescued. The Air Force search team could not locate the crash site of the F106. No one in the area reported a plane crash. After widening the search, the Air Force found the F106 in a corn field many miles away. The engine of the F106 had flamed out, but because the airplane was so well trimmed, it glided to a soft landing in the deep snow covering the corn field. The plane was not damaged in any way. Once the engine was fixed, the airplane was in perfect flying condition. Because of its unique story the Air Force decided to place the airplane in the Museum rather than place the F106 back into service.

We had a seminar scheduled for Friday in Boston, the week after Memorial Day. I had spent the Memorial Day weekend sightseeing Toronto, Canada. It was Thursday evening and the Northeast District Manager had big dinner for us and the components sales team at a Boston fish restaurant. There were about 25 HP people at the dinner, including a young salesman just hired. This young salesman was asked to select the wine for dinner, which he did. He selected a $125 bottle of French wine that the restaurant wine steward recommended. When the wine steward served the taste sample, the young HP salesman said the wine was vinegar. That started an argument between him and the wine steward that almost got out of hand. The District Manager tried to mediate the argument. Soon the owner of the restaurant came over and tasted the wine. He confirmed, the wine had turned to vinegar, turned in disgust to the wine steward and fired the poor guy on the spot.

The next day, Friday, the seminar was a bust, almost no one that HP had invited showed up. This was the first real indication that HP's optoelectronic seminars were falling out of favor with customers. By 2:30 pm it was obvious that there was nothing for me to do but take off for the weekend. So, I headed for Cape Cod. My weekend on Cape Cod was nearly as romantic as Patty Page makes it sound when she sings the song *Old Cape Cod*.

The District Manager Ben Howell and saleslady Sandy Vehonsky met me at the Orlando Airport. The seminar in Orlando was not that well attended which gave further evidence that perhaps the days of optoelectronic seminars was about over. Mike Hutchison, the field salesman in Tampa, was working with a customer, Hi-Tech Electronic Sign Company, a father and son operation run by Penasis Sr. and Penasis Jr. I had visited earlier on a trip to extend help in solving a design problem involving OED's LED lamps.

The Penasis were now in a financial bind trying to save the company. They had a New York venture capital company's representative down for a look see visit to determine if Hi-Tech Electronic Sign Company would be a good investment. Mike Hutchison had agreed to have me give this venture capitalist fellow HP's positive opinion on the viability of Hi-Tech because Mike wanted to grow their business. The two Penasis had been negotiating with big customers for electronic LED signs, one of whom was the Disney Company. Their problem was insufficient capital to execute any contracts they would be able to get in house. If the New York venture capital company would finance them with $5 million then Hi-Tech Signs could accept some big profitable contracts and Mike Hutchison would get the order for all the LED lamps, a nice piece of business with a substantial commission.

I was reluctant to place Hewlett-Packard in the position of recommending one of their customers for anything of this nature. The more I resisted the more Mike and Ben pushed me. Finally I agreed to meet with the New Yorker on neutral ground; which turned out to be a fancy restaurant in Tampa, Florida. Ben Howell and Sandy Vehonsky drove me over to Tampa.

I had a seminar in Tampa the next day, so I called George and Janette Godfrey and asked if I could spend the night with them They agree to have me stay with them. Penasis Sr., Penasis Jr, the Marketing, Finance, and Engineering Managers from Hi-Tech, Ben Howell, Sandy Vehonsky, Mike Hutchison, me and the man from New York all sat down for a business luncheon paid for by Hi-Tech Signs. I sat next to the man from New York, with Mike Hutchison on the other side of me. During the course of the lunch, the topic was raised and the man from New York asked for my honest opinion. Now what do I tell him? Do I tell him what my opinion really is or do I paint a bright picture for him to visualize. I had to be very careful to not imply this was an endorsement by HP, and I said so at the outset. I chose to do the later, my reservation being I did not like the way the Penasises were running their company. Hi-Tech Electronic Sign Company was capable of making good LED signs, but their chief electronic designer had left the company. Both Penasises were honest people and not prone to cheat any customer of theirs. So I painted in the mind of the New York venture capitalist a picture of what Hi-Tech could become with

careful management and an improvement in their engineering staff. Evidently I was convincing and Hi-Tech received the $5 million in venture capital funds.

Hi-Tech's business boomed over the next few years and OED realized some profitable business in LED lamps of all colors as a result of Hi-Tech's success. I had a very nice visit with George and Janette Godfrey. Like Orlando, the Tampa seminar was not worth the time, money, and effort. I stayed a second night with George and Janette and then flew back home.

I made a number of business trips to Florida, and on one occasion had the weekend in Orlando to myself. What better thing to do than visit Disney World just outside of Orlando. What a fun place that was. Disney World was an upgraded copy of Disneyland in Anaheim, California. The entrance to Disney World was by boat across a large man made tropical lake. The paddle wheeler boat actually traveled on rails across the lake between the entrance station and the Disney World theme park and Disney World Hotel. I spent the whole day at Disney World, having a ball, taking in the rides and attractions way into the late evening. When darkness fell, I enjoyed the Disney World Parade of Lights that marched up Main Street. At 10:00 pm, Disney World put on a laser light and fireworks display that was impressive to watch. The day seemed to fly by; I had so much fun just being a kid once again. My mind flashed back to when Uncle Art had surprised me with a visit to Disneyland when I was in the Air Force. I kind of wished he was there at Disney World with me. It was after midnight when I finally got back to my hotel room.

I think it was 1975 when Stan bought 5 acres of land in Los Altos Hills and built a beautiful home. Stan planted a vineyard to grow grapes for his own personal wine making. He had a tractor that he used around his property. One day it tipped over on him, pinning his arm underneath it. He managed to free his arm but suffered a long time from the resulting sprain. Hewlett-Packard had a policy of managers throwing a dinner party for their employees once a year, all expenses paid by the Company. Stan Gage and his lovely wife threw two dinner parties for the Application Group and their wives and girlfriends that were just fabulous. Stan and his wife were perfect hosts, making everyone one feel special in their home. Stan would cook a large ham and his wife would prepare more delectable side dishes than anyone could consume. Judy and I went to both dinner parties.

Then in 1979 something happened to Stan Gage that changed him dramatically. I am not sure what it was, although I do know Stan and his wife nearly lost their young son to lactose poisoning. Stan was not the congenial understanding and supportive manager that I had known for five years. In later years, after our retirements, Stan and I became very good friends.

In 1980, I had my own troubles brewing. Judy and I were having some marriage difficulties and one day she informed me she had enough and was finding herself a divorce lawyer. I was panicky. In fact I seriously thought our marriage was over. It was just a matter of time before I would be facing losing Judy. What I did not realize was that Judy was just blowing off steam, verbally releasing her frustrations and had no intentions of carrying out her threat. Stan and I were in some kind of disagreement on something, which I do not remember, and I was at his desk. He was essentially chewing me out, quite unusual for Stan to do to one of his engineers, when I burst into tears, "Stan, I don't want to lose her. I don't want Judy to divorce me!" Stan stopped what he was saying, and looking surprised, turned to a compassionate tone and told me not to worry about the issue, and if I needed to just go home for the rest of the day. I stayed at work. Over the next two week I waited for Judy to act; nothing happened and Judy forgot the whole incident.

## Changes in command

Every large company has its internal politics and Hewlett-Packard was no exception. Starting in 1979, there were many changes to occur within OED and the Components Group. As time passed, Stan's problems seemed to grow and in late 1980 or early 1981 the announcement came that Stan was moving to Product Development as Engineering Manager, a position that before had not existed. Mark Hodapp was to assume the position as Manager of Applications and Applications was being transferred from Manufacturing under Paul Sedlewicz to Marketing under Rick Kniss. I did not know what his change would mean for Applications because we were losing the forceful management that Stan Gage had been providing.

Mark Hodapp was a very good engineer, but had not proved to me, at least, as having good management skills. Dave Weindorf suddenly left as Components Group Manager and transferred to a "parking position" at HP Corporate. A parking position was usually created for upper level managers to hold on a temporary basis until they could find another management position within HP or outside of HP. I lost track of Dave Weindorf at that point. John Blocker, a man in his late 50s, was a friend of Bill Hewlett and needed a position until he reached the age of 60, HP's mandatory retirement age for senior level managers.

John Blocker was appointed Manager of the Components Group. Mr. Blocker knew absolutely nothing about the components business, let alone LEDs, and had spent his entire HP career in HP's "electronic box" businesses. For Mr. Blocker, it was a good deal. For OED it was disastrous, he almost drove OED and the Components Group into the ground. John Blocker pushed OED into developing some "box level" LED products that never should have placed in OED's product line. This took valuable resources away from new LED products that OED was developing and produced only marginal business growth improvement. Mr. Blocker never came around to meet the people in OED, to find out something about OED's LED business, or to just shake hands. I saw Mr. Blocker only once, but never met him. Thankfully, John Blocker's tenure only lasted about three years, when he finally reached retirement age and retired from HP.

Bill Craven, who at one time was the HP Corporate Personnel Officer, was appointed Components Group Manager. Once again, the HP corporate Fathers had selected a person who knew nothing about the components business to head up the Components Group. But, Bill Craven was a significant improvement over John Blocker. Next it was Bob Zettler's turn to make a change. The announcement came out of the blue, at least to me it did, that Bob Zettler would be assuming the position of Components Group manufacturing Manager, again a position that had not existed before.

Was Bill Craven building a Components Group Management empire of his own? Mike Cowley, who was the LED and IC production Manager, was named Manager of the OED Division. OCD was also going through some major changes. Just before OED moved some of its operations to the Harbor Site, the Manager of OCD was essentially fired and Paul Sedlewicz was named Manager of OCD. This change was a win-win for both Paul and OCD. Just before he left, I went to Paul and offered my congratulations, or my condolences, whichever was most appropriate. He told me he would let me know which one was correct.

## OED moves to San Jose

The Components Group had outgrown both Buildings 11 and 10 and the Harbor Site and needed a needed new home. Hewlett-Packard had purchased 130 acres of prime farm land off Trimble Road in San Jose, adjacent to the Guadalupe Canal a couple of blocks east of Bayshore Freeway. The land was the floodplain of the Guadalupe River, which was now contained by high dikes making the river into a

canal. The Components Group received HP Corporate's permission to build on the site. The first building built, designated Building 90, was a modern two story steel reinforced concrete structure with windows all the way around. The building had a full basement for storage and an interstitial floor to house all the necessary ventilation and other facility supporting equipment. In order to support the building, steel pilings had to be driven 90 feet down into the soft surface to anchor the building to bedrock. OCD moved into the building as the second building, designated Building 91, was under construction.

Dick Klinke was the HP liaison between the architect, building contractor and Hewlett-Packard. Dick Klinke was an interesting guy; I called him "Billy Goat Gruff" because of his abrupt and somewhat condescending opinionated attitude. Dick Klinke was a close friend of Mike Cowley and they palled around together.

HP Optoelectronics Division (OED) Building 91 (left) and Cafeteria (middle); Optical Communications Division (OCD) Bldg. 90 (right), San Jose, CA; 1985-1999. **Red dot** locates OED Applications and David Evans desk on 2nd floor in Bldg. 91.

About this time there was another change in the structure of the Components Group. The microwave product activity was an original part of HPA's business. When the Optoelectronics Division was formed under Bob Zettler, the microwave semiconductor components business was placed into the Microwave Semiconductor Division (MSD) with Paul Sedlewicz as Division Manager. Later, the Optical Communications Division (OCD) was formed with Rick Kniss as Division Manager, whose main product were optocoupler devices. Although these changes did not affect me, they did show that HP's component business was still growing.

Me, unpacking Applications at the San Jose Site, Bldg. 91; 1985

The energy crisis of the late 1970's caused rethinking in the design of buildings and Building 91 was built with half the window area of Building 91. It too was a modern two story steel reinforced concrete structure, essentially a sister building to Building 90 with a full basement built for occupancy and an interstitial floor to house all the necessary ventilation and other facility supporting equipment. It also was supported by steel pilings driven 90 feet down into the soft surface to anchor the building to bedrock. The two building were connected by a large hall way and a large modern cafeteria that doubled as an assembly hall. OED moved into Building 91 in 1985.

Mark Hodapp was the Applications Manager when OED moved from Bldg. 11 in Palo Alto to Bldg. 91 in San Jose in 1985. Steve Hall was the Applications Engineer for the optics lab. It was his responsibility to run and maintain the optics lab, but not to perform optical measurements. Those wanting to make optical measurements would schedule time in the lab through Steve and then either make the measurements themselves or have their technicians make the measurements. Wally Scott took George Liu's place as an Applications Technician when George went to OCD. Wally worked closely with Mark Hodapp on automotive applications. Al Petrucello stayed with OED when Hans Sorensen moved to OCD. Al Petrucello retired not long after this picture was taken.

Lori Louie; Steve Hall; Al Petrucello; Mark Hodapp; Wally Scott; Renee, Administrative Assistant; OED Applications; Bldg. 91; 1985.

Jim Talbot was a reliability engineer and a friend of mine. He and Lori Louie began dating. After a while, Lori came to me to discuss her feeling towards Jim Talbot, expressing that as far as she was concerned things were getting serious, and she wanted to marry him. At the same time, Jim got into a political squabble over some reliability testing issue. I was on Jim's side, because I thought he was correct. Jim lost the squabble and was more or less forced out of OED. Lori and Jim got married, and Lori left OED to go to work for Raychem along with Jim. The last I heard, both Jim and Lori were doing very well at Raychem and Lori had received the Employee of the Year Award from Raychem.

The move from Palo Alto to the San Jose site on Trimble Road in 1985 was the beginning of many changes that would eventually lead to the demise of OED. When Rick Kniss took over OCD, Jerry Kolansky was brought in from the East coast sales region to be Marketing Manager for OED. Jerry Kolansky had been a super FSE bagging some impressive deals, one of which was over $2 million. Jerry tells an interesting story. For a period of time one of Jerry's best sellers was a microwave diode, bought by the Raytheon Corporation. But, as time went by Raytheon stopped buying the diode. MSD was at the point of discontinuing the production of the microwave diode when out of the blue Raytheon placed a big order for the diode. The story was; the microwave diode was a critical component in the Patriot Missile Program. For a while production on Patriot Missiles had come to an end, but with the outbreak of the first Gulf War in 1991, the need for more Patriot Missiles created an urgent need for more of MSD's microwave diodes.

**The Ford incident**

It was in January of 1987 that I was sent to the Ford Motor plant in Toronto, Canada to solve a problem Ford was having with OED's auto-insertable LED lamps. OED had got into the business of providing auto-insertable LED lamps, packaged in large rolls and I was the applications engineer supporting auto-insertable LED products. The Canadian Ford plant was using an auto-insertable T-1 LED lamp in an instrument cluster item for Ford cars. These T-1 lamps were only $1/8^{th}$ of an inch in diameter and were never intended to withstand the impact of the auto-insertion process onto PC boards.

The Canadian field engineer and district manager met me at the Toronto airport and we drove directly to the Ford plant. I had been to the Ford plant with Hans Sorensen once before, presenting an optoelectronic seminar. It was at that seminar when we introduced the concept of using auto-insertable LED lamps to Ford. That was an interesting visit. We had to pass through one of the Ford assembly plants to get to the conference room building. Because of union rules, we were not allowed to carry our own seminar equipment through the assembly plant. Ford had to get union workers to carry our equipment through the

plant from one door to the other. The union men would not carry our equipment the 20 feet from the assembly plant building to the conference room building, because that was outside the union contract. So we had to carry our equipment those 20 feet.

This visit, however, was different. It was at this visit that I first encountered what is called the "bate-and-switch" technique of negotiating. As the meeting with Ford started, one of the Ford people, supposedly a manager type, tied into me like a lion after raw meat. He chewed me up one side and down the other for OED providing Ford an inferior product, causing Ford to unnecessarily lose production and money. All I could do was to sit there and take his barrage of complaints. This guy even set the Canadian field engineers back in their chairs. It was obvious to me that I could not work with this Ford person to solve the problem Ford was experiencing with OED's auto-insertable lamps.

After about 45 minutes or so the meeting was adjourned for a short break and the Ford man who had been delivering the tirade was ushered out of the room. When the meeting was reconvened, another Ford manager introduced as a higher level manager, apologized to me for the other Ford person's behavior and offered his assistance. This was what is called the "bad guy-good guy bait and switch" technique. It all had been planned by Ford to put me, representing OED, at a disadvantage.

I asked to visit the auto-insertion area of the plant so I could see for myself what the problem was. I actually already had a good idea of what was wrong, but wanted to see for myself. At the auto-insertion station, my theory was correct; the force of the auto-insertion machine placing the T-1 LED lamps onto the PC board was fracturing the tiny plastic domes of the lamps. I proposed a solution to Ford which was that OED could look at enlarging the base of the lamps domes to $3/16^{th}$ of an inch in diameter which then would make the lamps strong enough to withstand the force of the auto-insertion process. I gave to Ford no guarantees that OED management would accept my solution because my solution required OED to make all new tooling to build the modified lamp design, and that HP may request that Ford pay for such tooling. I faxed to OED my proposal for a redesign of the T-1 LED lamp.

What I did not know, was that Ford informed OED management by way of the Canadian Field Office in Mississauga (the HP office for the Toronto region) that I had committed OED to the design change at no cost to Ford. When I got back to OED, all hell broke loose and I was accused of committing OED to something that had not been agreed to by OED management. It was the Monday after my Canadian trip to Ford that found myself facing an inquisition by both by boss, Mark Hodapp, and the Marketing Manager, Jerry Kolansky. They claimed I had no authority to commit OED to such a design change and that using a different epoxy to make the T-1 lamps would solve the problem without OED having to retool. My job at OED was on the line and possibly I was to be fired by the end of the day.

I had been reading an interesting book on how to negotiate. In the book was a chapter on how to turn a personal attack situation around in a person's favor by reflecting back the arguments of the accusers. I was desperate to try anything, so I tried this technique. As I faced both Mark Hodapp and Jerry Kolansky, I began to see just how childish their actions and accusations were. Neither of them was listening to my side of the story and I did not have time to call the Canadian Field office in Mississauga to get their view of what had happened and what I actually had promised and had not promised Ford. As the day wore on, I began to build some confidence, that I could win this thing if I could just turn their accusations around back onto them. The technique began to work, just like the book said it would. By 5:30 pm, Mark Hodapp had enough and went home, taking no action against me of in favor of me, leaving the final decision up to Jerry Kolansky.

Now Jerry Kolansky and I had worked closely together on solidifying sales when he was an FSE, so I figured I had some leverage there. The more he and I talked, the more the situation turned to my advantage. For 1½ hours in his office, Jerry Kolansky and I debated and I slowly began to win and Jerry

began to back down. By 7:30 pm, Jerry Kolansky had lost the debate and I had won the debate saving my job.

Looking back on this incident, the whole episode was idiotic. First, a different epoxy did not solve the problem and other customers besides Ford complained to OED about the inability of T-1 LED lamps to withstand an auto-insertion process. Second, OED stopped supplying T-1 lamps in the auto-insertion format. And third, two weeks before I retired from OED, Marketing proudly announced a new T-1 LED lamp for auto-insertion, the very design changed I had proposed at Ford. This whole fiasco was a symptom of the decline of OED, the inability of OED management to accept and implement new ideas.

With Mike Cowley as OED Division Manager, Jerry Kolansky as OED Marketing Manager, and Mark Hodapp as Applications Manager the influence of Applications was on the decline. The move of Applications from Manufacturing to Marketing on the surface made sense. It was the change in management of Applications that caused the decline. Unlike Stan Gage, who had been a forceful manager and Paul Sedlewicz and Bob Zettler who both had been advocates of a strong and influential Application Group, this management team was considerably less supportive of Applications as a vital tool of OED.

Mark Hodapp was wrapped up in trying to get LEDs designed into the automotive market. Mark's family lived in Cincinnati, Ohio and he would plan business trips to automotive customers that just happened to have a stop in Cincinnati. Mike Cowley was not a real manager type of person, but was silicon semiconductor person and found managing a $350 million business more than he could handle. Jerry Kolansky's expressive personality clashed with Mike Cowley's analytic personality and the two found it difficult to get along. The result was Applications was made part of Marketing, but on its own, with little attention being paid to it.

I can remember marketing meetings where Jerry Kolansky would complain about the inept management style of Mike Cowley, stating that what OED needed was a new aggressive division manager. I countered in one meeting saying that OED did not need any more managers; OED had enough managers and needed instead leaders in the field of semiconductors who knew the LED business and markets and could move OED forward. Jerry Kolansky found himself in a difficult political situation and left Hewlett-Packard, only to return a couple of years later to work for a different Division of HP.

Mike Cowley also found himself in a politically difficult situation as OED sales began to decline. Mike made a number of booboo decisions, one in particular that I remember. OED had been working closely with Motorola to develop an intelligent LED display for a high end cell phone that Motorola was designing. This new display was a major design effort for OED because for the first time OED was experimenting with surface mounting LEDs and IC on the same substrate. This was a whole new technology for OED. Negotiations with Motorola had resulted in an agreement for Motorola to fund this new technology to the tune of $200,000 in the form of non-recurring engineering charges. The design of the new surface mount, intelligent LED display was a success and resulted in a considerable amount of profitable business from Motorola for OED. The Motorola business was so important to OED that a Motorola team was set up in OED, headed by Aneta Davis of OED Marketing.

When it came to the contract signing between OED and Motorola, Mike Cowley said he wanted to attend the meeting which was held at the Motorola in Phoenix, Arizona. Now there was an unwritten rule among marketing and sales people that said, "Never let a senior level manager interface with a customer unsupervised!" Evidently, those HP people at the meeting were not aware of this unwritten rule. At the meeting with Motorola, the subject of developing surface mounted LED technology came up, and Mike Cowley without hesitation said in a loud voice, "Oh we can do that for about $100,000."

Instantaneously Mike Cowley had thrown away $100,000 of development money Motorola had agreed to pay OED and had jeopardized future business negotiations with Motorola. Mike Cowley was relieved of his position as OED Division Manager and was moved to a parking position at HP Corporate and subsequently left HP. Bob Steward was involved in the surface mount development program and I tried to convince him to move the technology into a standard line of surface mounted LED displays products for the open market. No go. He said it was too much for OED to do.

During this period of time, problems in Product Development mounted. Stan, along with others, brought to OED the concept that process was what counted most, not necessarily the product under development. The theory was that if one had the process correct then the results desired would automatically follow. In OED's case, if OED had the proper product development processes in place, new products would automatically be the result. Stan and others were mandating that OED follow a strict product development process to ensure the development of new products in a timely fashion. I thought this was absolute nonsense. I agreed that OED needed processes to operate as an effective business entity. But having to follow a strict product development process did not make any sense to me; because many of OED's most successful products had not been developed using any particular process and some had even been developed clandestinely to keep from being killed by management before they were brought to fruition.

I was required, along with many others in OED, to attend what I called process indoctrination courses taught by OED product development managers in HP Building 100. Building 100 was a few miles away from the OED location and had conference rooms set aside for divisions of HP to use, keeping the class attendees away from telephones and contact with other employees that could cause distractions from the class subjects being taught. The resistance by employees against having to follow strict product development process rules soon took on the name "Process Paralysis," the phrased originally coined I believe by Gary LaBelle. In fact, that is exactly what the new product development process did; it paralyzed the progress of many product development programs.

People in OED began losing the confidence and respect of the product development managers in the division including Stan. Eventually, Stan Gage left HP OED and took a position in HP Corporate Quality Insurance. I was sad to see Stan leave HP OED; for I could recall the good days of Applications when Stan Gage was the Applications Manager and was at time a very good manager indeed. In fact, Stan Gage was one of the two best managers I ever worked for; the other one being Norm Tarowsky.

### Interviewing Job Applicants

As my tenure at OED became longer I was asked to interview job applicants. I became one of those selected by managers to interview job applicants for a variety of positions within OED. I had one criterion. I was not much interested in what each candidate knew, or how good his college grades were, what I wanted to know was could the applicant think? I could teach any person hired what they needed to know about LEDs and the LED business, but only if that person could think. I was interested in learning in a 20 minute period could this person I am interviewing solve a simple LED problem which he had never seen before. I would describe what needed to be known, give the person a few bits of information and asked him what he thought. Many candidates just fell apart, and I voted no on hiring them.

Others, however, would ask me questions concerning the problem. I would answer each question and offer more information towards solving the problem. The person didn't have to actually solve the little problem, just show me they were on the right track to a solution. Most of the time, I was correct in my evaluations of candidates. I was wrong twice, very wrong in fact. The two candidates where I totally misjudged their thinking and problem solving abilities were Reggie Short and Bill Antle,

both manufacturing engineers. Reggie Short solved a major problem with OED's subminiature LED lamp called the polyled. Polyleds were so small their little epoxy packages would easily break apart under mechanical and thermal stress. This problem went on for years. I counseled customers to not use polyleds in their designs. Then Reggie Short designed a cross link lead frame with solved the problem. The reliability of polyleds with Reggie's cross link lead frame was so good, that I encouraged customers to design them into their products. Retooling the polyled lead frame cost OED $350,000 which upset upper management. But after the change, polyled sales took off like a rocket, and the $350,000 cost of retooling was forgotten.

Bill Antle solved a number of serious manufacturing problems that plagued OED over the years. Bill Antle's involvement with the development of new LED products save OED much money and pain by making sure that new products were in fact manufacturable.

I remember a few candidates I interviewed that OED did not hire. One candidate was from MIT. Why he was interviewing for a position in Hi-Rel puzzled me. When Jim Chrysler, George Strickland and I took him out to lunch, he told us he was not going to complete the interview with HP. HP and the Bay Area had nothing to offer him, and he was going to accept an offer from the GM Automotive Proving Grounds. Another candidate was one that Mark Hodapp was considering. He claimed to be a computer programming expert, receiving his Master's Degree in computer programming. I asked him if he knew the difference between a "jump" instruction and a "fetch" instruction. He didn't know. I told him a "jump" instruction moved the computer's program line pointer to another location in the computer's program. A "fetch" instruction retrieved a piece of data from memory. We did not hire him.

Mark Hodapp would ask college graduates to give a simple 10 minute talk on any subject with which they were very familiar; any subject at all was fine. This one candidate who was to graduate with a Master's Degree in logic circuit design started to describe a logic circuit he had designed in college as his Master's Thesis. The candidate called every item in his explanation a "puppy." This puppy here and that puppy there; he never called any component in his design by its proper name. After a few minutes, I told Mark to dump this puppy. Mark sent him back home before the morning's interviews started.

However, there was one impressive candidate that we interviewed for Applications, Doug Silkwood. Doug brought in his robot, his version of the Star Wars robot R2. The robot could move about the room floor without bumping into things. Doug had full control of his robot by way of a hand held microwave control unit. I asked Doug where did he get the parts for his robot. He said out of Radio Shack stores and Fry's Electronics store and hardware stores, nothing particularly esoteric or complicated. OED hired Doug before he had completed the morning rounds of interviews with OED people. More on Doug Silkwood later on.

### SAE A-20A Committee

George Godfrey was not only founder and Chairman of ALI; he was also Chairman of the SAE A-20A Aircraft Cockpit Lighting Committee. I had joined SAE when I was dealing with Delco helping Delco design in the 4 digit LED display module for the Cadillac car. George Godfrey asked me to join the SAE A-20A Committee because he thought I could contribute to the committee's efforts in writing an Aviation Recommended Practices (ARP) document on NVG. I had been to SAE automotive meetings and found them to be difficult to work with and get things accomplished. The cooperation among committee members was not good. The reason for this was that when Ford, General Motors, and Chrysler engineers were in the same room, they were afraid to talk to each other lest they reveal some secrets to their competitors.

I described to George these automotive meetings as needing to wear a parka to keep warm, the atmosphere in the meeting room was so cold. George assured me that working with the members of the A-20A Committee was nothing like working with automotive committees. I agreed to join the A-20A Committee. Bob Owens was the Chairman of the A-20 Committee of which the A-20A was a subcommittee. The A-20B Subcommittee wrote SAE documents on aircraft exterior lighting and the A-20C Subcommittee wrote SAE documents on airport lighting. George Godfrey was a member of the A-20B and C subcommittees. George Godfrey was correct; the A-20 subcommittees were totally different than were the SAE automotive committees and the cooperation among members of the A-20 committees was very good.

Members of the SAE A-20 Aircraft Lighting Committee; May, 1987
Standing from the left: George Godfrey (Chairman SAE A-20A and ALI), David Evans (me), Jim Duke, Dick Smith, George Kempf, Dr. Gerry Gross. Ernie Yost, Paul Greenlee. Seated: Bob Owens (Chairman SAE A20), Don Hobbs

I gave presentations at the general meetings of the A-20 Committee. At one A-20 meeting in Nashville, Tennessee, there was a very large crowd and I gave an off-the-cuff talk on the use of LEDs in NVG applications. I talked about the military's requirement to always buy from the lowest bidder and how limiting this procedural requirement was necessary, especially when the military was buying NVG equipment. My argument was that the lowest bidder most likely had no idea of what NVG was and most likely could not meet NVG specifications. I firmly stated that when purchasing NVG equipment, it was best for the military to look at the highest bidder because 1) NVG equipment was expensive and 2) the highest bidder had a high probability of understanding and meeting the requirements of MIL-L-85762A. In the audience was a Navy Lieutenant from Naval Procurement. He chastised me for making my statements. I shot back by telling the Navy Lieutenant that the military should never buy solid fuel rockets from the lowest bidder; in reference to the NASA Challenger Shuttle disaster where a solid fuel rocket, purchased from the lowest bidder, burned through igniting the main fuel tank during launch, and the Shuttle exploded killing all the astronauts on board. The Navy Lieutenant had no come-back.

I wrote SAE ARP 4168 and ARP 4169 on NVG Compatible Light Sources that discussed incandescent, electroluminescent, and LED light sources for use in NVG applications. I had written the two texts and had submitted the texts to the full A-20 Committee for review. Ernie Yost was the chief engineer for Kopp Glass, Pittsburg, PA and was knowledgeable on many different light sources. Ernie Yost was the only A-20A member to get back to me with comments and called to tell me he had some concerns about my texts and needed to discuss these concerns with me as soon as possible. Oh Oh! I thought I was in trouble with what I had written.

I knew that I did not know as much about aircraft lighting as the other A-20 members did because they had been in aircraft lighting all their working careers. I worked myself into a frenzy over what Ernie

Yost might say to me. At the next ALI Advanced Seminar meeting in Los Angeles Ernie and I sat down together to discuss the texts of my two SAE ARPs. Ernie was very complimentary on what I had written. He then worked through my texts suggesting very valuable changes based on his experience. I agreed with all of his changes and incorporated them into my two texts. I resubmitted the two texts to the full A-20 Committee for review and got back a few minor changes, which I incorporated into the texts. At the next SAE A-20A meeting the two texts were approved and the A-20 Committee sent the documents to SAE Headquarters which adopted ARP 4168 and ARP 4169 in 1987.

At the October, 1987 meeting of the A-20A Cockpit Lighting Committee meeting in Long Beach, California, George Godfrey gave a rewards luncheon for me and Dave Elliott. Dave Elliott had completed the writing of an ARP on measuring the characteristics of aircraft cockpit color flat panel displays. The whole SAE A20 committee attended the luncheon. We both received official SAE Recognition Awards at the luncheon for the ARP documents we had written. George thought it was appropriate that both Dave Elliott and I be honored, and roasted, for the successful completion and publication of our SAE ARP documents. George had engraved brass Recognition Award plaques on walnut bases made up for Dave Elliott and me. George presented the plaques to us with much praise for what the two of had accomplished.

Me, receiving an SAE Appreciation Award from Bob Owens, A-20 Committee Chairman, for writing ARP 4168 and 4169 on NVG Compatible Light Sources; May, 1987.

Me and David Elliott receiving our SAE Recognition Awards; dated April, 1987; presented to us by Don Hobbs; October, 1987.

Me, George Godfrey, David Elliott with our brass plaque Recognition Awards; presented to us by George Godfrey, Chairman SAE A-20A; October 7, 1987.

*Recognition Award*

BE IT KNOWN THIS DAY, OCTOBER 7, 1987, THAT
**DAVID L. EVANS**
WAS PRESENTED THIS SPECIAL AWARD OF APPRECIATION
FROM HIS ASSOCIATES IN THE AEROSPACE VEHICLE LIGHTING
COMMUNITY FOR HIS WORK AS TASK LEADER
IN SUCCESSFULLY DEVELOPING
S.A.E.'S "NVG Compatible Light Sources" A.R.P.

*Geo W Godfrey*
Geo W. Godfrey, Chairman, A-20A

**Text of the SAE Recognition Award.**

*SAE A-20 Committee meeting luncheon as I saw it from the honorees end of table; Long Beach, California; October, 1987.*

Other Side of Same table.

Of the members of the A-20A Committee, I became good friends with Dr. Gerry Gross and Ernie Yost. After the ARP was published, Ernie Yost considered me to be one of his friends. He invited me to give a presentation on LEDs to Kopp Glass employees. I went to Kopp Glass to give the presentation, but found the company did not have a projector or setup to give the presentation and had only a few employees who would be interested in LEDs. My visit to Kopp Glass ended up being a plant tour, which I thoroughly enjoyed. I was able to convince Dr. Gerry Gross to attend ALI meetings. Dr. Gross made some very good presentations at ALI and considered me one of his closest business associates in the aircraft lighting field. Dr. Gross would call me for my advice on NVG lighting projects he was involved with.

**Milt Liebhaber**

Evidently Bill Craven felt the same way I did, that OED needed someone who knew the LED business and could move OED forward. Milt Liebhaber had been influential in building the LED business since the days of HPA. It was Milt Liebhaber who built the European sales force. I had only brief encounters with Milt but knew who he was and his reputation. Milt had the reputation of playing hard ball with people, accepting nothing less than positive results. Field District Managers were virtually afraid of Milt Liebhaber because they were expected to perform and bring in sales; and when that did not happen they got into trouble with Milt. Milt always tied to project a happy face when dealing with people outside his

direct influence, and at times could be irritating in his manner. However, Milt knew the LED business and Bill Craven selected Milt to become OED Division Manager. This was the position that Milt had longed for.

Over recent years, Milt had expressed a desire to head up OED before he retired. With the departure of Mike Cowley, Milt was now the Division Manager of OED. The first day on the job, I invited Milt to lunch to give him my impressions of where OED was and what he needed to do to move OED forward. Milt accepted and we went out to lunch together. I had been reading Victor Kiam's book *Going for It* on his purchase of the Remington Company, and since he had bought the company, he was going to make it succeed. I politely told Milt that in effect he had bought OED and now it was up to him to run OED and make it succeed. Milt agreed with my assessment of where OED was and the responsibility he had to make OED prosper.

During our lunch I found a Milt Liebhaber totally different than his reputation. In fact, I found Milt to be a pussy cat, not a ferocious tiger, when someone talked to him on his level. He paid for the lunch. Where others in the division had a fear of Milt Liebhaber, I did not. During his tenure as Division Manager, the relationship between Milt and I was very good. Many times Milt would come to my desk to discuss something on his mind or to ask my opinion on a particular issue. Whenever I asked for something, Milt always approved it without me having to give an explanation or a reason to back up my request. Few in the division had that luxury.

Milt hired Mark Chandler to replace Jerry Kolansky as OED Marketing Manager. Mark had been in Group management and I had little contact with him. However, as soon as he became Marketing Manager, Mark Chandler and I became friends, almost like close associates. With Mark Chandler as well as with Milt Liebhaber I had a blank check to do whatever I wanted, regardless of what others thought or wanted. This would prove to be a vital asset for both me and OED in very short notice. I am not sure if this privilege bothered Mark of not, because I could always bypass him whenever I needed something and many times I did, especially when Mark was hesitant to approve what I was requesting.

Milt came to my desk one day with a serious problem. The morale of the OED employees was at an all-time low and was declining. People were grumbling about almost everything and Milt was looking for a way to turn around this serious negative trend in attitudes. My mind flashed back to my first encounter with Bob Steward when he took me to the coffee and donut bar when I did my interview with him. In those days, HP had food everywhere for the employees to enjoy. Even the field offices had food. When Bill and Dave formed the Hewlett-Packard Company, Dave Packard's wife would bring down coffee and donuts to the early employees as a continental breakfast, thus the tradition of coffee and donuts at HP was started.

During the business down turn of the late 1980s employees offered to give up donuts every morning to save HP $3,000 a day. The donut tradition at HP died with that gesture. I reminded Milt of this history; saying to him that one way a woman finds the way to a man's heart was through his stomach. Milt took my suggestion to heart and reinstated food as a means of building employee morale. Every Friday, at least in OED Marketing, we had a short departmental meeting with fresh fruit and goodies. At each meeting we would discuss the latest business activities, new opportunities, and praised those who had accomplished something unique that week, all while enjoying the good food. Milt went even further than that with the whole division.

During Milt's tenure as the OED marketing Manager, OED's sales topped $500 million and were increasing. To show his appreciation and to boost employee morale, Milt instituted quarterly beer busts, something HP and other companies had used in the past to thank employees for a job well done. Although well attended, beer busts did not have the desired effect of improving employee morale. Milt began to throw lavish fiscal year end parties for OED employees which included a catered dinner. The most famous of these was the Casino Night party held at the end of fiscal year 1994. The cafeteria was well decorated and the tables were covered with white linen table cloths; with elegant white china and tableware at each place setting.


David Evans and Milt Liebhaber, OED Division Manager, at the OED Casino Night Party.

Milt hired a professional song group to sing oldies from the '50s through the '70s. Milt also hired a company to replicate and operate a real live casino for all the employees to enjoy. The catered dinner was elegant. The music group sang songs made famous by the Mills Brothers to songs sung by Tony Bennett. Gambling at the casino was a huge hit with the employees. Play money was used for gambling. At the end of the evening, we all could use the play money we had won to bid for prizes that included stuffed toys and goofy prizes like an HP catalog. The fiscal year end parties had the desired effect. These parties told OED employees the division's business is growing; you are the reason the business is growing; you are special, the very best in HP; thank you for all your efforts. The morale of OED employees improved significantly and the OED working environment also improved dramatically.

I thought Mark Chandler was a good marketing manager. He and I had a good working relationship, as I shall describe later. Mark, taking Milt's lead, had thrown an afternoon party for the Marketing Department which boosted morale. But, evidently Milt thought otherwise. One day, Milt sat down at my desk to discuss his concerns about Mark Chandler. In confidence, Milt expressed his reservations about Mark's performance as marketing manager. I did not see things about Mark the way that Milt did, but sympathized with him. It was shortly thereafter that Mark Chandler announced he was moving to HP Corporate. I lost track of him after that.

**Tie-pulling incident**

Before I tell you about the tie pulling incident, I must give you some background information which will take a little reading. LED sales and OED's business had grown so much that Marketing and upper management were only interested in big corporate deals of $1 million or more. Management would not allow OED would not accept any direct business unless the business was at the $1 million level or higher, expecting all less dollar volume business to be handled by distribution. Ever since the days of HPA, Jan Black had worked diligently to build up the Components Group business relationships with electronic component distributors in the US, Europe and Asia.

Let me inject something here: Jan Black was the only Group Manager who ever spent time walking around the Components Group, stopping at people's desks to ask how things were going and answer any questions they might have, a process called Managing by Walking Around. For this, I had great respect for Jan Black. I continue. The idea was to have electronic component distributors like Hamilton Avnet

and Hallmark service small LED customers, thereby providing the small customer with better service and availability. The distributors would agree to buy products from the Components Group and resell the products to small customers at a reasonable markup on a real time basis. I had visited both distributors and other distributors at various locations and had determined that the percentage of LED sales was small in comparison to their overall sales. Although distributors offered application support to small LED customers they could not provide the same level of technical support that OED Applications could provide.

In many cases, it took the same amount of applications support to win a small piece of business as it took to win a $1 million piece of business. As far as I could tell, OED was consciously chasing the big guys and ignoring the little guys to its detriment. I remember an FSE telling OED managers that he would rather have ten $10,000 customers than one $1 million customer, because if he lost a $10,000 customer he would still have $90,000 worth of business remaining. If the $1 million customer went away he would have nothing. My observation was that OED had lost sight of that piece of wisdom. What OED managers were looking at were big customers, like IBM and Motorola, GM and Ford, and were not looking at Markets. Markets made up of small customers were in many cases significantly larger than the big guys by themselves. Such was the case of the traffic management market for LED lamps, made up of small business customers which I shall describe in detail later.

Now, to the tie pulling incident. The City of New Orleans is below sea level. Should any emergency happen, such as a hurricane, there are only three possible escape routes out of New Orleans, west and east on Interstate 10 or northeast across the Lake Pontchartrain Causeway Bridge. The Bridge Authority wanted to place a quantity of 25 electronic signs along the bridge to inform motorists of conditions on the bridge during normal hours and in cases of an emergency.

The Bridge Authority was in the process of determining what electronic sign technology was most appropriate. A two man consulting firm in New Orleans was trying to convince the Bridge Authority to use LED signs. Their competition was a large sign company in Spokane, Washington that was pushing flip disc technology signs. OED was asked by the two consultants to come to New Orleans and make a presentation on LED signs to the Bridge Authority. Joe Torres from OED marketing and I went down to New Orleans.

One of the members of the Bridge Authority was a county sheriff. He gave me his card which had a gold badge imprinted on it. This sheriff was part of Louisiana's "good old boy" political network. He told me, "Now don't you worry. Should anything happen, remember it's all taken care of." He meant it. If we had gotten into an accident of some kind while we were in the New Orleans area, no matter what, he would have made sure we would have gotten off Scott-free. Not all the Bridge authority members showed up for our presentation. Those who did not show were a minority but had already made up their minds to go with the Spokane company and use flip disc signs. As negotiations from the sign contract were nearing a close, we were asked to once again come down to New Orleans and meet with the full Bridge Authority in a final attempt to convince all the members to use all LED signs, and not flip disc signs, on the bridge.

When I approached Mark Chandler he told me it was not worth OED's time to go to New Orleans a second time because the two consultants were too small a customer to bother with. That was the wrong thing to say to me. The signs were to be full dot matrix signs with 50,000 LED lamps per sign at 20¢ per lamp, $250,000 worth of business. To me that was good business and I said so. Mark then told me that I did not understand. At that point I got mad, grabbed hold of his tie, pulled his face up close to mine and told him, "No. You don't understand!" Oops! That was violence in the workplace that I had just committed; and violence in the workplace was, and still is, an absolute no-no and was reason for instantaneous dismissal. Those standing close by witnessing this happen, thought I had committed the

unforgivable sin and would be fired before the day was out. Because of our good working relationship, Mark agreed to have it out with me the next day over lunch.

When we met the next day over lunch in one of the conference rooms, I had two hours to spend with him. During those two hours, Mark Chandler heard something different that he expected me to say. I never mentioned anybody's name, never blamed nor praised anyone, which was what he expected me to do. Instead, I tried to paint in Mark Chandler's mind my vision of where OED was currently in its LED business; paint in his mind steps OED needed to do to be successful in the traffic management market; and describe to him what I thought OED need to accomplish in order to enter illumination markets. I explained to Mark, that OED's future was not in maintaining positions in indication markets, but the future for OED was to penetrate illumination markets with new super bright LED lamps of new designs, displacing the incandescent lamp within twenty years.

I explained to him my concerns over OED's attitude towards customers; that OED's long term business future was not with the big fellows, but with big markets made up of little guys. It would be the little companies in big markets, like the traffic management market, that would grow OED's long term business, not the big guys who could walk away at a moment's notice due to changes in their business strategies. OED had to change its current policy and start doing direct business with little companies in big market segments if it expected to survive.

Relying solely on distribution to serve little companies in big markets was a recipe for disaster. I did most of the talking during the two hours. What I had told Mark was what others in OED had been saying for months, especially the PhDs in LED Research and Development. I concluded my dissertation by explaining to Mark that the Lake Pontchartrain Causeway Bridge sign project was for 25 signs, at 50,000 amber LED lamps per sign, for a total of 1,250,000 amber LED lamps at 20¢ a lamp, and that was $250,000 worth of business just for one highway sign project that OED could not afford to throw away, just because it didn't meet the one million dollar criteria. I also told Mark, that if OED got the Bridge Authority's sign business and LED signs were installed on the Lake Pontchartrain Bridge; it would be the best advertisement to the US traffic management market that OED could ever hope for. When I was through with my two hour dissertation, I said to Mark, "Now, you understand!"

Mark Chandler sat back in his chair with a serious look on his face. He said to me, "Boy, David. You have thought this out thoroughly, haven't you?" "Yes, I have" was my response to him. He then told me he had not known the details of nor consequences involved with the Lake Pontchartrain Bridge LED sign project. He also said that I had told him things he had never thought of; strategies and market approaches that had not occurred to him. We left the conference room friends, and the tie pulling incident was never mentioned again.

Mark Chandler left OED two weeks later, so none of our discussion was acted upon by him. OED lost the business. The Bridge Authority bought the flip disc signs from the Spokane company with one caveat. The flip disc signs had to have a small cluster of amber LED lamps in the center of each flip disc as a backup in case of flip disc failure. To rub salt into a sore wound, OED had to share that much smaller piece of LED business from the Spokane company with our competitor, Toshiba.

Milt had a crusade, trying to follow the IBM model of moving people around the increase the competence and experience level of key top people. With this in mind, Milt brought over from the European Components Marketing Organization (CMO), Germany, Martin Schoeppler to be the new OED Marketing Manager. Interestingly enough, Martin and Mark were of similar personalities, had similar management styles, and had about the same vision of where OED's business ought to be going. Although not as freehanded with me as Mark was, I still got pretty much what I wanted from Martin, and that was good.

Then, Milt's health began to decline. Milt Liebhaber was 6 months younger than I was but looked to be in his late '80s. Milt's ability to manage and make decisions began to decline. Milt would fall asleep in meetings. When invited to a customer conference, Milt would ramble off into never-never land with his conversation, embarrassing me each time this happened. It came to the point of me asking that Milt not be invited when a customer came to visit OED. Milt finally "retired" from HP and the job of Division Manager was passed to Karen Owyeung.

**LED traffic signals**

Milt Liebhaber had decided that OED should go all out to get LEDs designed into the automotive market. A special OED automotive team was established to accomplish this goal. Mark Hodapp was selected as the applications engineer to work closely with automotive customers. Tom Flynn had been an FSE in Florida. I knew Tom Flynn well by telephone. He would call me frequently to discuss customer issues and to get technical information on specific OED products he was selling. Tom Flynn was moved from the Field into OED Marketing and was assigned to be Applications Engineering Manager, replacing Mark Hodapp. About the time Tom Flynn came to OED Marketing, OED came across a video tape on LED traffic signals, produced by the Pacific Gas and Electric Company (PG & E). The producer of the video tape was a man who worked for PG & E, Stuart Spoto. Stuart Spoto was the star of the video tape and in the tape made a convincing argument for using LEDs in traffic signals.

Stuart Spoto's thesis was the power savings that could be achieved by using LEDs in traffic signals was so significant over incandescent lamps that by installing LED traffic signals public entities could save large amounts of money on electric bills. Stuart also pointed out the high reliability of LEDs over incandescent lamps that would add to traffic safety at signalized intersections. Tom Flynn contacted Stuart Spoto at PG & E and he visited OED. Stuart Spoto was so impressed with HP and OED, that he quit PG & E and Tom Flynn hired him to come to work for HP OED in 1994. Stuart Spoto sat at the desk directly across from me. Although Stuart Spoto was officially part of Applications, reporting to Tom Flynn, Stuart's job was to provide OED marketing support for the traffic management market in the US.

The interesting thing here is that the use of LEDs in traffic signals had not been thought of by anyone in OED Marketing. The marketing 5-year business plan projection for 1993 through 1998 said nothing about LEDs in the traffic management market. In short, LED traffic signals caught the OED organization by surprise.

In late 1993, I received a phone call at OED requesting that I attend a meeting of the Santa Clara County Supervisors to discuss traffic signals. I do not recall the name of the man who called me and wanted me to join him at the meeting. He told me the topic at the supervisor's meeting would be LED traffic signals. The term LED traffic signals didn't register with me. I discussed the request with Mark Chandler and he suggested that I decline the invitation because HP usually did not get involved in local politics. I called back and respectively declined to go to the meeting.

That was the wrong decision to have made. I did not realize what was happening; OED's involvement in LED traffic management markets, worldwide. The next phone call came from Ray Deese who was President of Electro-Techs, located in Los Angeles. Electro-Techs had installed LED traffic signals for Santa Clara County and the City of Fresno, California. Ray Deese suggested that I should become involved with the Institute of Transportation Engineers (ITE) to help move LEDs forward into the traffic management market in the US. This started my six-year involvement with the US traffic management market that would last until I retired from HP OED.

Brian Thorbrogger was the OED marketing engineer assigned to the traffic management market. Brian Thorbrogger knew someone from the American Traffic Safety Services Association (ATSSA). In August of 1993, ATTSA had its convention and product show in San Jose, California and Tom Flynn suggested that Brian and I attend the conference. This was the start of my six year involvement with ATSSA. ATSSA was an organization of companies that provided the traffic safety equipment used in roadway construction zones, barricades, warning signs, electronic message signs, marker cones, flasher signals, personnel safety clothing, and a whole list of valuable equipment used in roadway work zones.

There was only one company at the1993 ATSSA show that was using LEDs in their roadway sign products. All other manufacturers were using incandescent lamps in their products. In August of 1994, Brain and I attended the ATTSA convention and product show in San Antonio, Texas. At that ATTSA show, there was only one manufacturer still using incandescent lamps in his sign products. All other manufacturers at the ATTSA convention of 1994 were using LEDs in all of their products. Effectively, in one year's time, the roadway safety equipment manufacturers had converted from the use of incandescent lamps to LEDs in all of their products, save one manufacturer.

The LED lamp of choice among all the ATSSA manufacturers was the 15° amber LED lamp. 15° amber LED lamps were designed into all of the electronic message signs, flasher units, and other traffic safety equipment. The issue of amber LEDs for use in the traffic management market became an issue in within OED in 1994. The light output radiation patterns of amber LEDs were 6°, 15°, and 30°. The 6° lamps had high on-axis intensity due to the narrow beam of LED light. The 30° lamps had much lower on-axis intensity because the light from the LED lamps was spread over the wide viewing angle. Neither of these two lamp designs was usable in the LED traffic management market. Brian and I were arguing for the 15° LED lamps to be the standard amber LED for the traffic management market.

Both of us found ourselves fighting for our position against managers within OED who knew better than we did. They did not want to produce 15° lamps because there was not much of a developed market for them as there was for the other two lamps. Meantime, in the European traffic management market, 15° amber LED lamps had been designed into large over highway message signs. One big LED sign was over a freeway in Paris, France. Scotland had 15° amber LED traffic message signs on many of its highways to inform motorist of fog and other adverse weather conditions.

OED marketing knew nothing about the European traffic management market, and management knew little of these 15° amber LED signs, except there were troubles with them which included light output and color variations. So, Brian and I found ourselves caught in a real political struggle. Over two days of intense meetings arguing this issue, Brian Thorbrogger and I finally won out, but not without help. Orders for 15° amber LED lamps were increasing at an alarming rate. It was only when OED Marketing revealed where these orders were coming from companies who built electronic traffic message signs that Brian and I won the argument.

That was my first big battle I would have to experience in my six year involvement with the traffic management market. Brian Thorbrogger found himself the loser in issues involving what OED should do to properly service the traffic management market, and as a result left OED and HP. Stuart Spoto assumed the role that Brian Thorbrogger had played in OED. So now the OED team to service the traffic management market in the US went from being Brian Thorbrogger and me to being Stuart Spoto and me.

The City of Fresno had installed AlGaAs red LED traffic signals throughout the city on an experimental basis. Brian Thorbrogger and I drove down to Fresno to take a look at these red LED traffic signals in the summer of 1993. I was impressed by the visibility of the red LED traffic signals over the standard red incandescent traffic signals. The incandescent red signals looked dim in comparison to the red LED signals. The AlGaAs red LED lamps used were 15° lamps, further adding to our later argument that 15°

LED lamps should be the standard LED lamp for the traffic management market.

Now please realize that the light output of LEDs decreases as the temperature increases. In high temperature conditions, LEDs can lose a significant percent of the light output that is measured at room temperatures. In the summer the City of Fresno can easily experience daytime temperatures between 100°F and 110°F. The day that Brian and I were in Fresno, the temperature was 104°F, and the red LED traffic signals, with their reduced light output due to the high temperature, visually outperformed the incandescent red signals. People back at OED, and others within the traffic signal market, were saying that LEDs could never be used in places where daytime temperatures would reach 100°F or higher. But, the City of Fresno LED traffic signals were living proof the argument had no merit. I would fight this battle until the day I retired.

**Conversion to 15°AlInGap red LEDs in traffic signals**

There loomed a serious problem with AlGaAs red LEDs. Long term light output degradation test data collected by OED reliability showed that AlGaAs red LEDs had a very high rate of light output degradation over time. This was something totally unexpected, but easily explained. What made the AlGaAs red LED so efficient in light output was a layer of active aluminum in the crystal structure. This active aluminum layer would corrode over time, reducing light output. OED marketing had decided to push the use of AlGaAs red LEDs in traffic signals.

When I learned of this light output degradation characteristic of AlGaAs red LEDs, I knew immediately that the AlGaAs red LED traffic signals in Fresno were in trouble. The light output from these AlGaAs red LED signals could degrade within a year to such an extent as to make them unsafe for use. I immediately raised a red flag to OED management of the potential problem. To my surprise, I received strong backing for my concern from OED R & D and OED Reliability departments. Frank Steranka, who was a senior LED scientist in R & D, immediately backed me and my concern. I recommended that OED immediately contact Electro-Techs and the City of Fresno and supply without cost new AlInGaP red LEDs to replace the AlGaAs red LEDs. The AlInGaP LEDs had a low rate of light output degradation. The aluminum that contributed to the high light output in AlInGaP LEDs was locked up in the crystal structure and could in no way corrode to reduce light output. The decision was made to accept my proposal to prevent OED from becoming liable should the AlGaAs red LED traffic signals in fact become so dim as to cause a traffic accident. It took some time to retrofit the City of Fresno with AlInGaP red LED traffic signals.

**ITE**

One of the issues was LED red color. The AlGaAs LED red color was red. The AlInGaP LED color was actually red-orange and there was concern that red-orange would not meet the red color requirements for red traffic signals This issue was to propel me in becoming involved with the Institute of Transportation Engineers (ITE). ITE had color standards for traffic signals. I obtained a copy of the ITE specification for traffic signals and it showed that both red and red-orange were acceptable colors for LED traffic signals. I also learned that incandescent red signals were almost red-orange in color, not red in color. So, not only was the change to AlInGaP red LEDs preferable from a reliability standpoint, but also from a color standpoint as well, because the AlInGaP red-orange nearly equaled the incandescent red color.

The need for an ITE specification for LED traffic signals soon became a necessity if LED traffic signals were to be used throughout the US. I joined ITE as an industry Associate Member and for five years I was a member of the ITE committee charged with writing the specification. I guess belonging to ITE and being one of the authors of the LED traffic signal specification was my most significant contribution in getting LEDs accepted into the traffic management market. Rather than go through all the ITE meetings

that took place to write the ITE specification for LED traffic signal, I am going to combine incidents from all the meetings into one single description.

There was a core of people who made up the ITE specification committee: Darcy Sullivan, Chairman of the Committee who had retired as the Traffic Engineer for the State of Tennessee; Henry Arcand of Ecolux, Canada an LED traffic signal manufacturer; Gary Durgin of Dialight, and LED traffic signal manufacturer; Peter Lemme of Marktech, representing Toshiba LEDs; Hank Mohle, a traffic consultant; Peter Hochstein of Relume; Curtis Gobeli of Minnesota DoT; Nathan Behura Traffic, Engineer for Anaheim, CA; John Davis, Department of Transportation, Ft. Meyers, FL; George Schongar of NY DoT; and me, David Evans of HP OED. Louisa Ward was the ITE liaison to the committee and was a valuable asset to the committee in helping the committee to get its work done and the specification approved and published. Others would come and go as the committee progressed. It took five years to write the specification for LED traffic signals.

The first issue the committee had was to learn what was an LED? What were the limitations of LEDs as the light source in a traffic signal? What could be done to offset these limitations? What should the specification include, not include? At first, the specification was thought of as being a totally new document, only for LED traffic signals. That idea was quickly tabled in favor of making the LED speciation part of the existing ITE speciation for traffic signals. This meant two things, 1) existing traffic signal requirements did not have to be reiterated in an LED specification, and 2) LED traffic signals would have to meet most of the incandescent signal requirements. The early LED traffic signals were simple modules that would be a direct replacement for the incandescent lamps inside traffic signal housings. This concept proved valid with the LED traffic signal installations at Fresno, Santa Clara, and in Montreal, Canada. The existing incandescent lamp fixture inside a signal housing would be removed and the LED signal module would use the existing wires and fit inside the signal housing with no modification to the housing required. This became a mandatory requirement early on.

The issues that became of paramount importance were: LED light output at high temperatures, LED light output degradation over time, LED color, power consumption and electrical power factor, LED compatibility with existing traffic signal electrical controllers, and long term reliability. Everyone on the committee had his opinion on what the specification should contain and what the requirements should be. Initially the specification was rather simple, but then as people began to understand LEDs the requirements grew in number.

Peter Hochstein was European and claimed to be a scientist. Peter had a dominating personality and always talked with authority. He claimed that as a scientist he had made measurements on all the issues and had collected data to back up his vision of what the requirements for LED traffic signals should be. Many a time when others in the committee wanted the specification to be written one way, Peter had data to prove that was wrong and the committee should write the specification his way. Sometimes Peter Hochstein was correct and many times he was wrong.

The committee rarely asked Peter to produce his data. When challenged, Peter would wiggle his way out of presenting any data, saying that he had done the testing, or he had made the measurements, or he had done the research and would produce his data at the next meeting. He never did. Once, Peter Hochstein claimed he had made a study of the traffic signals in St. Paul, Minnesota and they all met ITE specifications. Not true. Many of the traffic signals in St. Paul were old style incandescent signals that did not meet current ITE specifications.

The committee argued over what constituted a valid operating traffic signal. Was a signal with a burned lens still a valid operating signal? Was a traffic signal with a low wattage incandescent lamp a valid operating traffic signal? No one knew the answers to these and other similar questions. Once again the committee heard from Peter claiming that all traffic signals had to meet ITE specifications regardless of their actual condition. A valid point, but many operating incandescent signals in the US did not for a variety of reasons.

There was one ITE member that raised hell with the committee and me personally. I won't mention his name out of courtesy. The individual was dead set against LED traffic signals. At one meeting, this individual threatened to sue ITE and members of the committee if ITE proceeded to authorize LED traffic signals in the US. His argument was simply that LED traffic signals would not work and were a hazard to traffic safety. So real was his threat in my eyes, that I became concerned that he might carry out his threat. Thomas W. Brahms was the Executive Director of ITE and I discussed the threat with him. Thomas Brahms told me that this individual had a history of threatening ITE with law suits but had not yet done so; however, this time he just might carry out his threat.

At one meeting I decided to try some diplomacy with this individual. When I was in grammar school at Richmond Beach School, I read a book on the adventures Tom Moran. In the book, Tom Moran was in occupied France on a spying mission during WW II and was looking for a place to be safe from the NAZI army. In the book a Frenchman tells Tom, "Go to the heart of danger, for there you will find safety." I thought of this little bit of advice and decided to take the individual in question to lunch in an effort to get him to change his mind. We spent almost an hour together as I presented my arguments for him to wait on his threat and see what developed before moving ahead with his law suit. I thought he had agreed to wait and I told Thomas Brahms about our luncheon meeting and what I thought was the outcome. Thomas Brahms told me that the individual did not agree to anything and had gotten the best of me.

When I returned to the meeting, members of the committee asked me where I had been during lunch. I told them of my meeting with the individual and they all looked askance at me as if I had betrayed the committee. The next week, back at OED, the individual called me to let me know he had filed a personal lawsuit against me. I immediately told Tom Flynn and called HP Corporate Legal. I met with an HP corporate lawyer who assured me that if the individual had in fact filed a law suit, HP would eat him alive in court. That reassured me. Nothing happened. Evidently the individual was bluffing, hoping that I would be scared off and back out of the committee. The committee heard very little from the individual after that. My guess is that HP lawyers may have given the individual a friendly call. I seem to recall that ITE lawyers may have also stepped in to give the individual a warning as well.

As meetings progressed, the text of the specification became unruly and way out of proportion to anything reasonable. But out of all this it became obvious that LED traffic signal modules would have to contain electronic control circuitry to ensure the LEDs operated effectively in all temperature environments, in the summer heat of the desert southwest as well as in the frigid cold of winter in Alaska and Canada. Little by little the specification was boiled down to two main issues, LED light output to meet radiation pattern requirements and reliability. The issues of signal dimming for nighttime operation, LED signal module compatibility with signal load switches and conflict monitors, and the impact of temperature and environmental conditions were not included as part of the specification but were added as Technical Notes at the back of the document. Peter Hochstein did win one argument. Peter had come up with a design for a box with which to test LED traffic signal modules in various temperature conditions. It was a simple design of some practical value and the design was included as a technical note.

The document was finally released as the ITE Interim LED Purchase Specification, as part of the Vehicle Control Signal Heads Specification, Part 2: Light Emitting Diode (LED) Vehicle Traffic Signal Modules; published by ITE in July, 1998. Even before the specification was released, Ecolux and Dialight were the two major LED traffic signal module manufacturers in the US and Canada; both offering electronic LED traffic signal modules. It is interesting here to realize the cost relationships with LED traffic signals vs. incandescent traffic signals. In 1998, it would cost about $72 US to buy and complete three color traffic signal housing, incandescent lamps not included. One red LED signal module cost about $300 US. So, the initial purchase cost of a complete LED signalized intersection was significantly greater than the cost of an incandescent signalized intersection. But the operational cost saving paid for the LED signals.

The electrical power cost of an LED signalized intersection was 15% of the cost of an incandescent signalized intersection, an operational cost savings of 85%. Not only that, the LED signal modules did not have to be replaced once a year as was the case with incandescent lamps, a necessity for red traffic signals. So, taking into account the 85% plus cost savings, over a period of ten years the LED traffic signals were essentially free to the operating authority. So enthusiastic were electrical power companies for the use of LED traffic signals by traffic authorities, due to the electrical power savings, that power companies like PG & E in California were offering to purchase LED traffic signals and provide the signals free of charge to traffic authorities. By 1988, red LED traffic signals were installed in most of the signalized intersections in the US and Canada.

Two issues with LED traffic signals arose in 1988. The first was a signal out condition. If an incandescent lamp burns out in a red traffic signal, that is a red signal out condition and a situation for a traffic accident to occur. That was the reason why the incandescent lamps in red traffic signals were typically replaced once a year; the average life of an incandescent lamp being 8,000 hours. What about LED traffic signals? There was a simple answer. An LED traffic signal module has many individual LEDs in a circular pattern that make up the illuminated area of the signal. If one LED goes out, all the other LEDs in the circular pattern are still operating, producing light. So, where the failure of an incandescent lamp meant a signal out condition, the loss of one or more individual LEDs did not mean a signal out condition, but rather a valid operating signal condition. In fact if one or more LEDs did fail, it may not be necessary to replace the LED signal module because it would still meet ITE light output requirements for a valid signal.

The other issue was interesting and unexpected. The issue had to do with automatic dimming for nighttime operation. The Cities of Santa Clara and Sunnyvale in California had all their red incandescent traffic signals replaced with red LED traffic signals. Immediately motorists began to complain about being photographed by the cities while driving through intersections with red LED traffic signals. The motorists knew they were being photographed because they saw a flash of “white” light as the signals turned red. Neither city was photographing motorists nor was there a flashing white light at any intersection. Yet, complains from motorists got so bad I was asked to get involved to find out what was going on.

The answer was interesting and had to do with the dimming sequence of the red LED signal modules and the response of the human eye to red light. The LED signal manufacturer had his signals come on at full brightness and then step down the LED drive current to reduce the light output to match the ambient lighting condition, which could be overcast daylight or nighttime. At night, the red LED signal would come on at full brightness, presenting a large contrast of bright red light to a black background to the human eyes of motorists. The human eye would immediately become saturated with the bright red light, which was then interpreted by the brain as a flash of “white” light. Within two seconds, the signal modules would reduce the drive current to the red LEDs to reduce the light output to be compatible with the ambient nighttime condition.

To solve this problem, the manufacturer reversed the dimming sequence of his red LED signal modules. With the change in dimming sequence, an LED signal module would first come on at full dim and then increase the LED drive current to increase the light output to meet the ambient light condition, which as the limit would be bright sunlight. Complaints from motorists about flashes of white light and being photographed stopped when the LED signals were modified to have the bright-to-dim light output sequence replaced with the dim-to-bright light output sequence. More on LED traffic signals later.

### George Godfrey's visit to OED

George Godfrey owned his own company, Godfrey Engineering, located in Clearwater, Florida. Godfrey Engineering supplied airport lighting equipment, worldwide. One product line was obstruction warning lights for towers, buildings, and bridges. Obstruction warning lights were red glass envelope devices illuminated by an internal 500 watt incandescent lamp. A significant problem was the incandescent lamps would burn out after about 8,000 hours of operation; a similar situation to incandescent traffic signals. If an incandescent lamp burned out, there would be no red obstruction light to warn aircraft at night the obstruction was there; thus causing a safety hazard for nighttime aviation.

The cost of replacing a burned out incandescent lamp could be expensive, especially if the obstruction warning light were on a tall radio tower. To climb a radio tower to replace a burned out lamp cost a minimum of $500. George Godfrey thought by replacing the incandescent lamps with red LEDs he could 1) reduce the burn-out lamp condition and the resulting flight safety hazard at night, and 2) reduce overall costs by not having to replace burned out lamps. Another cost savings would be that he could use untinted glass which was cheaper than red tinted glass. What was needed was an LED module that would directly replace the incandescent lamps.

George asked me if HP OED would be interested in making such an LED replacement device. I did not know, but invited George to make a presentation to OED management to see what their response would be. So in 1987 George Godfrey came to OED and made a presentation to OED management. I had briefed OED managers on what George would be talking about; suggesting this was a perfect application for AlGaAs 30° red LEDs. I met George at the San Jose Airport and took him directly to OED. Present at the meeting were Mike Cowley, OED Division Manager; Jerry Kolansky; OED Marketing Manager; Wayne Snyder; Section Manager in OED Product Development; Mark Hodapp, Manager of Applications; and others of interest from OED.

George Godfrey made a very good presentation, describing in detail the issue, the potential market, which was $90,000 of immediate business, and assurance of FAA approval. OED listened but did nothing; $90,000 worth of immediate business was not sufficient to warrant OED spending resources to make an LED replacement for the incandescent lamps. After the meeting was over, I took George out to lunch and then gave him the cook's tour of OED. In late afternoon I drove George to our house where he stayed overnight with us. Judy and I had a very good and interesting visit with George, as he told us how he met his wife Jeanette and how he started Godfrey Engineering. The next morning I dropped George off at San Francisco Airport to catch his flight back to Tampa, Florida. There were attempts by some small companies to develop red LED modules to replace the incandescent lamps in aviation obstruction lights; but as far as I know none were successful. Today, I understand aviation obstruction light still use incandescent lamps. Sadly, an opportunity lost.

### Visit to NCHRP

As I began my involvement in the traffic management market I quickly learned that I had to become known in the market and know the players in the market, both commercial and governmental. On my first visit to Washington, DC in 1993, I was advised to meet with representatives of NCHRP (National

Cooperative Highway Research Board) whose offices were on Wisconsin Avenue in the Foggy Bottom district of Washington, DC. The name "Foggy Bottom" came from the early 1800s when Washington DC was selected to be the nation's capital by President George Washington. Within the limits of the Washington area was a grass, swamp like depression in the landscape that would fog over each morning as the sun rose. The foggy depression in the landscape was called "Foggy Bottom," and the name has stuck over the years.

I met with Ray Derr, Rich Conard, and Ken Opilla for about an hour. All three were sympathetic to the concept of LED traffic signals but advised me to warn OED management that it would take 10 years to get LED traffic signals accepted in the US. They explained o me that the NCHRP was the governmental agency charged with selecting, approving and administering highway research project in the country in cooperation with the states. Each year, NCHRP selects which research projects it will administer and establishes a budget to cover the costs of the research projects. All 50 states then proportionally contribute to funding the budget. Also, I was told that NCHRP held annual meetings at different locations throughout the country and recommended that I attend the next one to be held in Houston that summer

Brian Thorbrogger and I flew to Houston and attended the meeting. It was the first traffic meeting and traffic engineering product show that I had attended and it was an education. The NCHRP meeting was attended by traffic officials from the US and around the world. The meeting was divided into two sessions, a closed session and an open session that we could attend. I was able to meet traffic engineers from various states and even briefly shook hands with the Secretary of Transportation. This particular meeting was an award meeting to honor certain traffic officials that had made contributions to the fields of traffic engineering and management. I also learned what research programs were underway and where I could possibly get involved to move LED technology forward into the traffic field.

Brain and I both found the traffic product show of little interest, since none of the products being shown had any possible utilization of LED devices. The meeting was 2½ days long. We decided to take one afternoon off since the meeting was discussing agenda items we had no interest in. In one of the outlying districts of Houston was a 901 feet tall skyscraper. We went out to look at it. Wow was it tall; requiring two separate elevator systems in series because of its height. We took the elevator systems to the top floor. Naturally, a law firm had its offices on the top floor, but allowed visitors to look out the expanse of floor to ceiling double pane tempered glass windows at the scenery below. I could look out for 30 miles across the flat Texas prairie landscape. I had not realized just how flat Texas was around the Houston area. Over the six years I was involved with the traffic engineering and management market I would regularly attend NCHRP meetings and became well known by many state traffic engineers.

**AASHTO**

The American Association of State Highway and Transportation Officials (AASHTO) was another organization whose meetings I attended. Members of AASHTO were state traffic engineers and traffic engineers from major cities like New York and Los Angeles. Here also I met and became known by many state and local traffic engineers. The meetings were divided into two sessions, a private session during the morning of the first day and then public sessions for the rest of the two day meeting. As a private citizen, representing HP OED, I could sit in the back of the room with other quests and listen to what was being discussed. If I wished to make a comment, I could stand and be recognized by the Chair and have my say, as long as my comments were in good taste and on the subject being discussed. There typically was no traffic product show associated with AASHTO meetings, but not always. The first AASHTO meeting I attended was in Biloxi, Mississippi in the summer of 1993. My wife Judy went to Biloxi with me.

It was interesting what I would learn from attending AASHTO meetings. At this meeting I learned that the State of Mississippi had a traffic accident problem in the some 500 small towns throughout the state. Each little town had a single traffic signal, and most of the accidents were caused by red light runners. To reduce the traffic accidents, the State Traffic Engineer of Mississippi had all the traffic signals in these small towns removed and replaced by four way stop signs. The accident rate dropped to near zero overnight. The traffic signals had been installed at the request of the residents of the small towns, but these same residents now did not want the signals to be reinstalled.

David Evans at the AASHTO meeting. Looks boring doesn't it?

AASHTO meeting, Biloxi Mississippi, summer of 1993:
(L) David and Judy with a member of AASHTO sightseeing Biloxi.
(R) Judy joking with one of the AASHTO member's wives.

**NCUTCD and the MUTCD**

The Manual of Uniform Traffic Control Devices (MUTCD) is the manual that specifies how various traffic control devices shall be used in the US. The text of the manual is written by the National Committee on Uniform Traffic Control Devices (NCUTCD) made up of 50% people from government and 50% people from industry. It was important for me to get involved with the NCUTCD as a means of having some influence on the writing of specifications for the use of LED signals.

The NCUTCD held two meetings a year, one in Washington, DC and the other at some selected location around the US. The first meeting I attended was in January of 1993 at the Washington, DC meeting. For years the NCUTCD used the Sheraton Hotel in Arlington; a short distance from the Pentagon; a medium grade, inexpensive hotel that had many conference rooms. The rooms were fair and the food was edible, but beyond that it wasn't much. I arrived the evening before the first meeting. I did not know anyone and Ken Kobetsky, the Chairman, had arranged for a pre-meeting evening dinner at the hotel.

Although, uninvited, I decided to join in. Surprisingly I was allowed to join the group for dinner; that pleased me because I began to meet various committee members at the dinner. Cost me $10; money well spent. The NCUTCD is actually made up of the main permanent committee of 50 members, half from government and half from industry and traffic organizations such as AASHTO, ITE and ATSSA, and a number of subcommittees that are assigned to write the drafts of the various specifications that comprise

the MUTCD. The memberships of the subcommittees are also supposed to be split 50-50. The meetings lasted three days, always starting on a Wednesday.

The morning of the first day is the closed session of the main NCUTCD committee. The beginning in the afternoon of the first day, the subcommittees meet, usually well into the night, all the next day and into the night of the second day. Then on the third day, Friday, is when the main NCUTCD committee reviews and comments on the work done by the subcommittees.

Changes recommended by the main NCUTCD committee are referred back to the subcommittees for further action at the next meeting. This process repeats over and over until the main NCUTCD is satisfied with the text of a proposed specification. When approved, the NCUTCD passes the text of the specification on to the Federal Highways Administration (FHWA) for their review, comment, and approval. Once FHWA is satisfied with the text of the specification, the specification is incorporated into the MUTCD at the next release. As you may well imagine, this process can take years to complete a specification, and usually did. I was interested in the traffic signals subcommittee.

At the first meeting of the subcommittee Scott Wainwright, the subcommittee Chairman, let me sit at the table and contribute to the discussions. The meeting lasted until 8:00 pm the first day; until 8:30 pm on the second day. The discussions mainly concerned wording of sentences and paragraphs, rather than the actual content of the specification. Each specification had in order of importance a “Shall” paragraph, a “Should” paragraph, and a “Recommended” paragraph. Much of the discussions were in which paragraph should a sentence be placed. The issue of LED traffic signals was high on the agenda. There were some on the committee anxious to get LED traffic signals written into the MUTCD and others opposed to the use of LED traffic signals. I had to discern who my friends were and who were in opposition. I quickly learned my strongest ally was the subcommittee’s Secretary, Bruce Friedman of Kimley-Horn, Florida, a traffic engineering and consulting firm. We quickly became close associates within the subcommittee. Others strongly in favor of LED traffic signals included Peter Lind, Jim Pline, George Butzer, and Ray Pussey, the Transportation Engineer for the State of Delaware. Ray Pussey and I became close associates within the subcommittee.

I attended all the NCUTCD meetings from January, 1993 through the summer of 1998. Most of the meetings were absolutely boring. At the first meeting a subcommittee member complained about my being allowed to sit at the table and participate like a member, when I was not a member of the subcommittee. I applied to join the subcommittee but was denied membership. The reason was longevity. Members of the NCUTCD and subcommittees were members for years on end; the membership rarely changing from year to year, so there was no opening for me to fill on the subcommittee. Therefore, at each subcommittee meeting I had to sit on the sidelines as an observer of the proceedings with little chance given to participate in the discussions.

**FHWA**

I made some valuable contacts at the Office of Highway Safety at the Federal Highway Administration (FHWA), Rudy Umbs, Chief of the Office of Highway Safety; Raj Ghaman, and Ernest Huckaby, Highway Safety Engineers. These three gentlemen were instrumental in getting LED traffic signals accepted by FHWA. I worked closely as I could with each to help move along the acceptance of LED traffic signals. Their efforts made the difference between non-acceptance and acceptance.

During one winter NCUTCD meeting the weather across the country was bad, with a cold front pushing snow eastward. Heavy snow was predicted to hit Washington, DC on Friday morning. I was so bored with the meeting that I decided to leave Washington, DC early on Friday morning. It snowed that night. The roads in Washington, DC were barely passable. I got a taxi to the airport and caught a 10:30 am

flight to Chicago. It had snowed heavily in Chicago that night, but the airport was open. I caught late afternoon flight on United Airlines to San Francisco. In those days, United had passenger listening access to radio communications on Channel 9. I tuned in to listen to the pilot's communications with ATC. The aircraft was a Douglas DC-10, not my favorite airliner to fly in.

As we departed Chicago and before we were handed off the Minneapolis Center, I heard a Lear Jet depart Chicago. The takeoff from Chicago was through snow clouds to 35,000 feet above the weather. The Lear Jet climbed to 40,000 feet. When our pilot was handed off to Salt Lake Center and called in, the ATC controller acknowledged the check-in and came back with something like this: "Hey Sam, is that you?" "Yes, Joe it's me, how are you doing?" Evidently the ATC controller and the DC-10 pilot knew each other and had been communicating on this flight for some time. They carried on a friendly conversation for some minutes. The ATC controller then asked our pilot if he had heard any communication from an American Airlines flight that had failed to check in with Salt lake Center on schedule. Our pilot had not heard any communication from the American Airlines flight.

When we were handed off to Oakland Center, the Lear Jet passed our DC-10. The Lear Jet landed at SFO about 10 minutes before we did. It was later that I learned the snow storm had hit Washington, DC a half hour after I had flown out to Chicago. The snow storm was so fierce that the members of the NCUTCD were stranded in the Sheraton Hotel for three days. The hotel ran out of food and the hotel heating system could not keep the hotel warm in the cold weather. The committee members had a miserable time in the hotel until they could leave on Monday afternoon. No, they did not do any more committee work while stranded in the hotel.

The NCUTCD meeting in Milwaukee, Wisconsin was especially nonproductive for me. As far as I was concerned, nothing got done at that meeting that interested me. The afternoon of the first day, I went to my hotel room and took a 1½ hour nap. When I returned to the subcommittee meeting, the members were still discussing the wording of the same sentence as when I had left for my nap. On the second day, it was obvious time that I should just leave and go for a sightseeing drive. I drove around Milwaukee looking at the sights and then committed myself to return for a full day's visit sometime in the future. I left for home early on Friday morning.

**Yellow LED traffic signals, amber LED message signs and sunglasses**

In 1998 the Maryland Department of Transportation (DoT) had purchased new trailer mounted LED message signs for use in roadway work zones. One of the new signs was on test across the street from the Baltimore Traffic Engineering Office. It was Monday morning when one of the traffic engineers pulled into the parking lot, parked his car and looked at the LED message sign across the street. He could not see the amber LEDs. He took off his sunglasses and found to his surprise he could easily read the sign. He put his sunglasses back on; couldn't read the sign. Unknowingly he had discovered a problem reading amber LED traffic signs wearing sunglasses. It wasn't long after I got a telephone from both the Maryland DoT and the sign manufacturer telling me of the problem. This was news to me. I asked what brand of sunglasses the man was wearing. The sunglasses were of a new brand called REVO. I had never heard of REVO sunglasses. I used Serengeti sunglasses for both driving and flying and had no problem seeing and reading amber LED signs. REVO sunglasses were expensive; $120 a pair.

I convinced Tom Flynn to let me buy two pair of sunglasses; one REVO pair and an expensive pair of another well-known brand; total cost to OED $220. The information tag on the REVO sunglasses stated they provided superior protection from sunlight and enhanced the recognition of red and green traffic signals for added driver safety. Stuart Spoto and I got into my car and went driving around looking at LED traffic signs with the three pairs of sunglasses. I could easily see and read amber LED signs, see amber incandescent traffic signals, and see and recognize automobile amber turn signals wearing my

Serengeti sunglasses and the other brand of sunglasses. However, I found I could not see nor read amber LED traffic signs, nor could I easily distinguish amber incandescent traffic signals, nor could I see and recognize amber turn signals on cars wearing the REVO sunglasses. Something was definitely wrong with the REVO sunglasses.

I had spectral transmission measurements made of all three pairs of sunglasses by our Applications optics lab. Both my Serengeti and the other well-known brand had long pass transmission spectrums on the order of 25%. The REVO sunglasses had an 8% spectra transmission characteristic with a notch at the 590 to 592 nm wavelengths where the transmission was less than 0.5%. Naturally it stood to reason; if the brain was denied wavelengths of light in the amber region from the eyes it would automatically tend to enhance wavelengths in the red and green regions. Thus, red and green traffic signals would stand out to an observer at the expense of not being able to recognize amber traffic signals.

Meantime, the Maryland DoT had sent a pair of REVO sunglasses to FHWA. FHWA measurements verified my measurements exactly. REVO had also been notified that their sunglasses had a problem by extinguishing the viewing of amber LEDs. Then, I got a call from Mr. Jim Pritts, President of the Sunglasses Association, asking me to come to an urgent meeting of the Association in Washington, DC. I went to the meeting and presented my transmission measurement data on the three pairs of sunglasses. Tom Loomis, of Corning Glass, was the Technical Chairman for the Sunglasses Association. Through discussions with Tom Loomis I learned that Corning Glass made the glass used in the REVO sunglasses. The Corning glass was a special optical glass formulated specifically for use as safety glass for those involved in the testing of sodium vapor lamps used in street lighting. Sodium vapor lamps produce light at only two wavelengths in the amber region, 590 and 592 nm. Corning was adding a rare earth, neodymium, to the glass melt to act as a notch filter in the 590 to 592 nm amber wavelengths.

Personnel involved in testing sodium vapor lamps wore this special glass to protect their eyes from damage from long term exposure to sodium vapor lamps. The glass was never intended to be used in sunglasses. Meantime, the word had spread that amber LEDs could not be seen wearing sunglasses; sunglasses of any type! Of course this was not true. The next meeting of the Sunglasses Association was held in Seattle, Washington. I attended the meeting. At that meeting it was decided that the ANSI-280.3 specification for sunglasses in the US had to be changed to prevent the use of neodymium glass or any other glass that had a notch filter characteristic. The way to do this was to rewrite ANSI-280.3 to include a minimum allowable transmission from 500 nm to 750 nm.

I agreed to write a white paper describing exactly what the problem was and how the problem was to be fixed. The question was; just how many REVO sunglasses were out there being used by drivers, and how best to do damage control. It was determined that there were some 1.5 million pairs of REVO sunglasses, and at an estimated discard rate of 800,000 pairs per year all the REVO sunglasses then in existence would be gone in less than 1½ years. I wrote the white paper which became the basis for changing the ANSI-280.3 specification. FHWA reprinted my white paper in their newsletter. The European Sunglass Association agreed to change the European sunglasses specification to be in concert with ANSI-280.3. Within a month or two the furry over amber LEDs and sunglasses died down and was forgotten by year's end.

**ATSSA, Minneapolis**

If my memory serves me right, it was Tom Flynn, who at the time was in charge of Applications that decided OED should participate in the ITE traffic engineering show in Minneapolis, MN in 1997. Tom contacted a company that specialized in assisting companies participating in product shows to help with logistics. OED bought a 10 foot wide portable exhibit booth. Banners, signs, and photographs depicting the benefits of LEDs in traffic signals and highway signs were created to decorate the booth. As displays

we used actual red, amber and green LED traffic signal modules. We also had a demo simulating an LED highway sign. I was on the team that went to Minneapolis.

Tom wanted to buy Hewlett-Packard monogrammed shirts for us to wear at the show, but I and others objected. The show was two days long. We had mostly traffic engineering people visit our exhibit booth during the first day, but by early afternoon of the second day we had more vendors visiting vendors than we had traffic people visit the exhibit booth. We had a large glass fish bowl for visitors to our booth to toss in their business cards for a drawing to win an HP scientific calculator. We got a nice pile of business cards that were recorded into a data base; but I don't remember if we ever gave away the calculator.

Marktech, the sales organization in the US for Toshiba LEDs who was in direct competition with OED, also had an exhibit booth at the show. During the show we visited each other's exhibit booths to see what our competition was exhibiting. Marktech kept their exhibit small, concentrating on Toshiba's 15° LED lamps. I met my Marktech counterpart at the show, Pete Lemme. I had met and known Pete Lemme earlier as a member of the ITE committee writing the LED traffic signal specification, and we had liked each other right from our first handshake.

During the show Pete and I got to talking and agreed that the two companies should work together as a completive team to move LEDs into traffic management and other markets. We stayed at the Minneapolis Hilton Hotel. The night of the second day, we all went down to the Hilton Hotel lounge to relax and have a drink before dinner. Sitting across from us in the lounge were the Marktech folks. I suggested that we go over and say hello to them. Tom Flynn objected, stating it was not wise for us to get involved with competitors. I countered Tom's objection by reminding him that we had already spoken to them at their exhibit booth in the show. After some coaching, Tom agreed and we all went over to where the Marktech folks were sitting. They greeted us warmly and we sat down to visit. It was an hour and a half later when we all decided it was time to go to dinner. The two competitors had much to gab about and Tom later told me he had enjoyed visiting with the Marktech people and had gotten a greater appreciation of just who they were.

It was about a year later that Pete Lemme called me at work to let me know he would be in the Bay Area and I invited him to come to our house for dinner. Pete came to our house and Judy, bless her heart, fixed a nice dinner. Pete and I sat in the family/stereo room listening to music and talking about all sorts of things, his family, the economy, world affairs, and personal histories for over four hours that evening; not once mentioning LEDs. Pete Lemme stayed with Markech for about another six months or so; then called me to tell me he was leaving Marktech to go to another company in a totally different business. I asked him to please keep in touch; but as things go in the modern world I lost track of him. OED did participate in one more traffic engineering show with the exhibit booth, an ATSSA show, before giving up the idea as being too costly for not much return. What amazed me about these shows was how fast things happen after a show closed. It would take us about a half day to get our exhibit booth all set up ready for show. But when a show closed, convention center teams of men would have everybody's exhibits packed and moved out of the building for shipping in about one hour; readying the building for the next event.

### Jim Capiccioli as Applications Manager

When Karen Owyeung became OED Marketing Manager; she brought with her, her own cronies, two who were Dave Zabrowsky and Jim Capiccioli. Dave Zabrowsky was in his late twenties and looked much like a tall version of the late Clark Gable of movie fame, complete with facial features and mannerisms. Dave Zabrowsky had been successful as a field sales engineer and OED management had taken notice of this.

Dave was brought in from the field to work in OED Marketing and Karen put him in charge of managing OED's high brightness LED product, code named the Piranha. This was a square, four pin device that could be driven at high currents to produce a large amount of LED light. I had worked with the product design engineers on the Piranha project and knew much about the product and its capabilities. I was actively encouraging customers to design in Piranha LED devices; the only problem was most of the Piranha business I was dealing with was way under the $1 million mark required by OED to take a direct order. Distribution had not been set up to handle Piranha LED sales so all such business had to be taken direct.

Dave Zabrowsky knew how to play OED politics and stick to the party line as it were and would not accept an order under the $1 million dollar mark. He and I got into an argument over this; neither one of us neither backing down nor winning the argument. I suspect Dave's attitude hurt Piranha sales considerably. Dave Zabrowsky's tenure in OED Marketing lasted for only a few months before he left OED for another position.

Karen appointed Jim Capiccioli Applications Manager to replace Tom Flynn. Jim Capiccioli was 31 years old at the time and had no managerial or application experience. He was a bit taller than I was and had a partially bald front, a bit premature for his age. Jim moved around in what seemed to me to be in a bit of a huff and projected the impression that he was always right on issues. All one had to do to get along with Jim Capiccioli was to agree with him.

Ever since I left Hi-Rel, I had not been getting raises in the percentages others were getting who were younger and less experienced than I was in OED Marketing. Like other divisions of HP, OED had adopted a ranking system to establish pay and pay raises. This ranking system was purely subjective, much like a popularity contest held by managers behind closed doors. There was no freedom of information when it came to the ranking procedure and what had gone on in ranking sessions. With my longevity in Applications I had been ranked as a level 62 engineer.

HP had a ranking system that went like this: Level 58 was equivalent to an associate engineer's position at Ampex; level 60 was equivalent to an engineer's position at Ampex; level 62 was equivalent to a senior engineer's position at Ampex; and levels 63 and 64 were reserved for senior research and design engineers. When my pay was compared with other engineers in OED under the old pay scale system, my pay was commensurate with others of my longevity and experience. The first ranking session that Jim Capiccioli attended I was demoted from level 62 to level 60. Jim told this to me with caveat that the demotion would not affect my existing pay.

Again, one never knows who their friends are and neither did I when it came to Karen Owyeung. Karen objected to the demotion and had the decision reversed back to level 62 with a hefty 4½% pay raise. Jim Capiccioli and I never really got along. I think me being so much older than he constituted a generation gap that may have contributed to my difficulties with Jim Capiccioli. Things got so bad between us that I feared for my job because I knew if I got into a sticky situation Jim Capiccioli would not be there to defend me, but would step back and let the wolves have their feast.

George Willis, a tall black man with a wonderful, kind, and gentle personality, was a long time OED employee. When George was first hired, Stan Gage said George was one of OED's best hires. Over the years, George Willis proved his worth as an engineer many times, and as a friend of mine. George saw what was happening to me and came to my rescue as a shoulder to cry on. George Willis lived in San Mateo, and for a while he and I commuted together while he listened to me tell him my tales of woe.

One day Jim Capiccioli came to my desk, leaned over and said to me, "You know what your trouble is Evans? You know too much and are right 98% of the time." With that he walked off in his usual huff.

Jim Capiccioli and I had a number of confrontations while he was Applications Manager; however he never got in my way as I continued my active involvement in the traffic management, EXIT sign, and illumination markets. I think Karen had a lot to do behind the scenes protecting me from Capiccioli. I credit my friend George Willis for helping me to get through this ordeal.
When Milt Liebhaber retired he announced the Karen Owyeung had been appointed General Manager of OED. Karen was a beautiful red head, about mid-thirties and was married to a super American-born Chinese named Willard Owyeung. When first hired, Karen was a Product Marketing Engineer in OED Marketing. When HPA was formed, Marketing had two major positions, Product Marketing Engineer (PME) responsible for marketing HPA LED products and Regional Sales Engineers (RSE) in support of regional field sales offices.

When Rick Kniss took over as Marketing Manager from Pete Manno, he did away with the RSE position and combined both responsibilities into the PME position. So Karen as a new inexperienced PME had a tough job to handle. Karen not only did very well as a PME but distinguished herself a being able "smell money" and land some very lucrative business for OED. Karen Owyeung was appointed to the position of Department Manager within OED Marketing and once again proved herself a stellar performer as a manager. So it was natural for upper management to select Karen Owyeung to be the next OED General Manger when Milt Liebhaber retired. Karen Owyeung's ascension to the position of OED General Manager for me was a mixed blessing. When Martin Schoeppler took over as OED Marketing Manager from Mark Chandler and Karen Owyeung became OED General Manager, Jim Capiccioli abruptly left Applications to join another division within HP. I do not know the exact whys and wherefores concerning this abrupt change except that I do know I was not the only one in OED having difficulties with Jim Capiccioli.

Karen Owyeung wanted to move Doug Silkwood into the management ranks at OED; what better place to start than Applications. I realized my worth at OED when Martin Schoeppler came to me to ask if it would be OK with me if Doug Silkwood assumed the position as Application Manager. He gave the reasons wanting to get Doug started in management and that it would be easier for him to start as Applications Manager since he had once worked as an Applications Engineer for a period of four years. Martin told me he wanted to be sure this would be alright with me before he moved Doug into the position as Applications Manager. If not, and I objected for whatever reason, he would then find some other managerial position for Doug to fill.

It was the summer of 1998. I was 64 years old and saw no chance of me ever being promoted, and besides I would be working for only one more year to age 65 and retirement. So I agreed to have Doug Silkwood assume the position as Applications Manager. Once again I had a manager who was much younger than I was, but Doug had the necessary applications and marketing experience to fully understand what was going on in the world of OED. Doug Silkwood and I got along fairly well, but I had the problem of looking at him as the younger, me the older and me trying to help the younger. I think Doug sensed this as I tried to coach him as assumed his responsibilities.

**Change of Command at OED**

Karen Owyeung as OED General Manager in my opinion had a difficult time. I think she tried hard enough to do the very best for the division as she could, but she had other responsibilities that distracted her; her two young daughters. By this time, Willard Owyeung had been made District Manager for the southern San Francisco Peninsula Region. Their combined salaries must have topped ½ million dollars, enough for Karen to hire help to care for her two children. Even so, I think there was a struggle between caring for her children and running a division with almost a billion dollars in sales. Karen tried to place her own stamp of management style onto OED, but as far as I could tell without the success she had

hoped. The morale of the personnel at OED had fallen to an all-time low. Although sales were high and growing, OED was having profit problems. Milt Liebhaber had tried to get OED people to buy into the need to increase profitability of the division without much success. Cost cutting in the manufacturing of OED products had become the guide word for improving OED's profitability.
Karen continued this approach with emphasis. At a division wide meeting, I saw Karen reading poetry in an effort to stimulate employees. This did not sit well with me. Karen decided the division needed to take time to have a conference on innovation as a means of simulating employees to come up with new and better ways of doing things. The conference was held at a hotel on Cannery Row in Monterey, California. The whole division went to the two day conference. Because of the number of OED people verses the number of hotel rooms, everyone had to share a room. I shared a room with one of the newer male employees, with whom I had little contact at work. I found this arrangement uncomfortable for me, and I think he felt the same way, so we sort of made the best of it.

The Optoelectronics Division at the conference on innovation in Monterey, CA; November 6, 1997. All are wearing "OED innovation" pullover shirts.

Karen Owyeung, with red hair, is 4th from the left in the front row. I am the 2nd person, white hair, directly behind Karen. Stuart Spoto is to the right from me, dark glasses with his head turned. Tom Flynn is second directly behind me. Mark Hodapp is at far right with dark sweater. Bob Steward is 4th up from Mark Hodapp on right side. Jim Leising is third to the left from Bob Steward. Doug Silkwood is two up from Bob Steward.

The conference was more of a creative workshop than a straight conference. Teams were formed to work on innovative idea projects and then each team reported to the group what they had accomplished. To make it fun, the teams competed against each other for the best ideas. I did not see the conference as others may have seen it; I thought the conference did not address the problem of "it is there company not my company" attitude that prevailed within OED. I could remember when I first started at HPA. "HP is my company" was the prevailing attitude, but no more. Most of the attendees at Karen's conference on innovation were to "young" to have any connection with the early days of HPA.

In the second day, we all were asked to give our opinions of the conference. I gave mine. I gave a two minute lecture on how we all should consider OED as our company and act accordingly. My short lecture was not well received; most thought it out of context. It was the end of the conference that drove the nail home. Scott Adams who drew the comic strip Dilbert was the guest speaker. Scott Adams was very perceptive in his closing remarks. He topped off the conference with the following description of

one of his comic strips: Dilbert is talking to his manager. The manager is discussing what are the most important priorities in the company? Dilbert asked where did people in the company stand in the list of priorities. The manager replied 9th. Dilbert then asked what was 8th on the list of priorities. Scott Adams said it took him three weeks to think up the answer. Then Scott said with a firm voice, the answer the manager would give to Dilbert was: "carbon paper!" Scott then said to the audience, "Nobody uses carbon paper anymore." All of the OED people attending the conference fell silent. The silence was defining until someone started to laugh and the silent spell was broken as everybody laughed, and knew exactly what Scott Adams had intended on doing with his story. Scott Adams had driven the nail home. It was the people of OED that was most important, not innovation by itself. It would not be long before OED would be no longer in existence. Shortly after the conference, Karen Owyeung announced she was pregnant with her third child and would be leaving OED as General Manager.

**LED Barricade flasher lights**

Barricade flasher lights have always been trouble for work zones, mainly due to battery life. Fresh batteries may only last for 18 hours of operation and should be replaced on a regular basis; most of the time they are not. Thus, many times barricade lights would go out before morning, increasing the possibility of an accident. The lighting technology used in barricade lights was an incandescent lamp with a flasher circuit that had a high current drain on batteries. The answer was to convert from incandescent lamps to amber LED lamps. In 1998 an ATSSA committee was formed to write a specification for LED barricade lights, similar the ITE specification for LED traffic signals. I was selected to be one of the committee members. The ATSSA committee was far easier to work with than the ITE committee, much less politics and concerns about meeting old requirements. The committee met in Washington, DC before a draft of a specification was ready for review. It only took one pass through the ATSSA mill to get comments. Final approval for the LED barricade flashers specification was completed just before I retired.

**LED EXIT signs**

EXIT signs are extremely important in public building for they show a way out should an emergency occur. EXIT signs are a pain. First, architects do not like them because they disrupt the look of the inside of a building. Second, building maintenance don't like EXIT signs because the batteries must be replaced on a regular basis. Thirdly, nobody pays any attention to EXIT signs anyway, right? Yet, EXIT signs are required by fire marshals to be functional and clearly visible at all times. The problem was incandescent lighted EXIT signs were not reliable and had a high failure rate of the incandescent lamp. The solution to this problem was to convert incandescent EXIT signs to red LED lighted signs. Manufacturers came up with all kinds of red LED retrofit devices, claiming easy conversion and 100,000 hour life. Well, not really. Most of the red LED retrofit kits did not work, or at best did not meet luminance requirements for the word "EXIT".

I got involved with a number of retrofit manufacturers, trying to coach them on how to make better designs. I visited a number of these red LED retrofit companies including Prescolite in San Leandro, California and Astralite in Annandale, New Jersey. Prescolite was a big lighting company and had an impressive facility. The company had a wide range of lighting products including EXIT signs. Prescolite's approach was to build a red LED EXIT sign from a fresh design, not a retrofit design. My visit with the company went well, but they spent more time trying to convince me they were a top rated company than listening to my suggestions on how to do a good LED design.

Astralite made red LED retrofit kits that were somewhat successful in the EXIT sign market. They were having product troubles and I was asked to visit them to give assistance with their problems. I made the visit with the local New Jersey FSE and made a number of suggestions that I thought would improve

their retrofit products and offered ideas on how to design an LED EXIT sign from scratch. They were so pleased with my suggestions they offered to give me an ac-dc computer power supply made by their parent company Computer Power, Inc. The retail price of the power unit was $269. I could not accept such a gift; it was against HP's policy for employees to accept gifts from customers so I turned down their offer. No, they wanted me to have it, and said I could buy it at for $69 which was their manufacturing cost. Again I had to respectfully refuse the gift. As we left, they seemed a bit perturbed that I would not accept their gift as a way of saying thank you.

EXIT sign manufacturers belonged to NEMA (National Electronic Manufacturer's Association), Kyle Pitsor, Director. Kyle Pitsor asked me if I would give an LED seminar at a NEMA meeting at the Prudential Insurance Building in New York City. He told me he was going to ask Pete Lemme of Marktech to also give presentation on Toshiba LEDs. I called Pete and suggested that we make sure we both said essentially the same things about LED technology so as not to confuse the EXIT sign manufacturers in attendance at the meeting. Pete agreed and we both agreed to keep our presentation strictly technical in nature. The Prudential building is a tall building in Manhattan. The conference room was on the top floor, with windows all the way around so one could look out over the city of New York.

Just up the way was the Chrysler Building with its gold crowned top. Other skyscrapers were easily visible, but blocked a view of the Empire State Building. The area around the Prudential building was semi-residential New York, with outdoor cafes, a small fenced in park, and narrow streets where one could walk in relative safety. I had dinner at an Italian sidewalk café. The waiter was not very friendly to me because I was alone; he wanted more at the table for a bigger tip. The food was good, spaghetti and meatballs with an Italian salad, not bad for $8:00. The hotel wasn't much, however, just a small room to get some sleep.

The meeting was crowded, I would say over 50 people attended the meeting. My presentation was more elaborate than Pete's. I had put together a seminar describing what LEDs were, discussed long term reliability issues including long term light output degradation data, and presented design concepts for modern LED EXIT signs that included white LEDs. Pete Lemme's presentation was not as elaborate as mine, but essentially mirrored my presentation on LED technology and LED reliability and long term degradation data. The two presentations, although different, worked very well together. We both were praised for our presentations. I felt the two of us had made a significant impact on the way the EXIT sign manufacturers would approach their designs for future LED EXIT signs.

Being involved with EXIT signs meant I would get involved with Underwriters Laboratories (UL) in Santa Clara, California. Every EXIT sign product must be approved by UL. UL puts products through a variety of safety tests, including fire resistance, electrical safety, mechanical integrity, etc. Most all of the tests were designed by UL before LEDs came into being. As a result, many of UL's testing was not appropriate for products containing visible LED devices. OCD and MSD had dealt with UL on qualifying their non-visible LED products to UL standards.

Since these LED products need not be made of optical grade materials, qualifying to UL standards was somewhat easy to attain. However, with visible LED products, the epoxy and plastic materials were of optical grade and could not withstand the UL fire resistance tests. This immediately became a problem when qualifying LED EXIT signs to UL standards. UL would not certify LED EXIT signs, even though the EXIT sign industry was making a 100% conversion from incandescent lamps top LED lamps. I got involved with UL in an attempt to change UL standards to accept visible LED devices. Have you ever tried to move a battleship with a rowboat? Convincing UL to make changes in their standards to account for visible LED devices was like trying to change US tax laws to benefit the tax payer; nigh on to impossible. I got in trouble with OED management over my efforts with UL, because OCD feared I was damaging their relationship with UL. The battle with UL went on for several months without making

any progress. Meantime, LED EXIT signs were being installed in buildings throughout the country without UL approval. Things got to a point, I quit. UL was never going to change and as far as I was concerned, it was a battle the EXIT sign folks should fight, not me.

## IES

My trip to New York City was coupled with a visit to the Lighting Research Center, Rensselaer Polytechnic Institute, Troy NY. LED technology had moved forward with a 10x improvement in light output performance ever few years. LED efficiency had risen from about 0.5 lumens per electrical watt to 50 lumens per electrical watt in laboratory produced wafers. It was now possible for OED to predict that within five years LEDs could move from the world of indication to the world of illumination; and within 20 years could replace the incandescent lamp.

The organization that dealt with illumination was the Illuminating Engineering Society (IES) of North America. The Lighting Research Center at Rensselaer Polytechnic Institute was a testing lab that serviced IES. The Research Center did long term performance testing on illumination devices from incandescent lamps, to fluorescent lamps, to Xenon, to Halogen, and Argon illumination devices. The Research Center director was Mark Newman who was also the editor of the IES Handbook. Rita Harold was the Director of Education & Technical Development at the Center. Mark Newman had invited me to visit the Center and Rita Harold met me in New York after the NEMA EXIT Signs meeting.

Talk about knowing how to get around in New York City, she was a pro. I just followed as she hailed a taxi and got us within walking distanced to Grand Central Station. We took the evening commuter train to Troy, NY. The train ride was quite peasant; traveled up the east side of the Hudson River at a good clip. Stops, though frequent, were short. Light food was available for purchase on the train. The trip didn't take long and in a couple of hours we were in Troy. I stayed at a hotel near Rensselaer.

The next morning, Rita picked me up and took me to the Research Center. It was quite a place, well equipped to do a considerable amount of testing as well as research design into new lighting techniques, not including solid state lighting, however. I spent only a half hour with Mark Newman; he and I seemed to have two different agendas for our meeting. I was not quite sur where he was coming from or exactly what he wanted. I got the impression that he thought I was the one who had asked for the meeting, not him. In the short time I spent with him I tried to enlist his and the Center's cooperation in moving LED technology from indication to illumination. He didn't seem much interested in the idea. I spent the next hour looking around the Center; noticing the quantity of fluorescent lamps on test, more than any other lighting source. I came away with the feeling the Center really serviced the fluorescent manufacturers.

This story has an interesting ending. In mid-1998 I received a call from Mark Newman. The IES Handbook was in the process of being revised, as it was every four years, and Mark Newman wanted me to write an updated version of the LED section in the handbook. I told him I would obtain a copy of the latest handbook and take a look; the LED section was two pages, one sheet of paper, written about 1974. I called Mark Newman and explained to him that much had changed since 1974 and I would be pleased to write a revised section but it would be longer than 2 pages. He told me he could afford me 4 pages. When I finished the text of my LED section it was 10 pages long; include as much information in a condensed fashion as I could, keeping in mind the reader was a lighting engineer not a scientist. I mailed the draft to Mark Newman. He called back and told me it was way too long and would have to be cut back to 4 pages. I said no. This was the information I thought should be in the IES handbook to make it useful for a lighting engineer to effectively understand and use LEDs in a lighting application and I was not going to reduce it in size or content. He could accept what I had written and publish it in the 1998 edition of the Handbook or not as he pleased. It was his choice. I do not know if what I wrote was published in the 1998 Edition of the IES Handbook or not.

I went to two IES conferences; one at the Hilton Hotel in Las Vegas in 1997 and one at the Moscone Center in San Francisco in 1998. IES puts on one terrific show and conference. The technical papers presented at each IES meeting were of high quality; full of considerable amount of useful information that lighting engineers could use. I learned a lot about lighting and lighting techniques from listening to many technical presentations. The IES product shows are impressive and very well done. The lighting vendors spared no expense in displaying their products and lighting devices. I learned considerable by just wandering around the displays and talking to manufacturers about their products and lighting designs.

When IES announced their November 1998 conference would be in San Francisco, I decided to attend. This time maybe I could encourage some of OED management types to attend as well. Jim Leising, an upper level manager agreed to go with me to the product fair. Like Las Vegas, the San Francisco show was tremendous. It was decided that OED should present a paper on LED technology at the IES conference; naturally the task fell to me.

Jim Leising and I went to the San Francisco IES conference together. I had known Jim Leising for many years, ever since he joined OED as an LED process engineer in the front end. Jim had a tad of Jerry Colona, Bob Hope's side kick, in him. Jim had a tendency to strut around when he walked and gave the impression that he felt above most people. Nothing could be further from the truth. I found Jim Leising very likable and easy to get along with, yet a bit intimidating because of his rapid rise in management at OED. Jim talked with authority and would express his opinions with forcefulness, which to many people meant that he had word on a subject. We toured the IES product show and Jim was highly impressed with what he saw. Jim got from the IES a better appreciation of the challenge LED technology was facing in getting into illumination markets. LED technology had a long way to go to develop the kinds of solid state illuminating devices that would fit into established illumination markets.

After the IES meeting Jim and I had dinner with the management team of Ecolux from Canada. Across the street from the restaurant there was a new building under construction. While having before dinner drinks we all found it interesting to watch how the construction workmen would hoist large steel beams by crane and precisely bolt them in place ready for welding. The steel beams, all precut and predrilled went together with ease and precision; the workmen handling the large beams like dancing in a ballet. This was a business dinner to discuss some sticky issues that had arisen between OED and Ecolux. I had been dealing with Ecolux for about 5 years and knew some of their senior people quite well, and Jim knew this. During the discussions, I chose to keep my comments to myself and let Jim do all the talking and negotiating.

The dinner and discussions went well. At the end of the dinner, all were in good spirits and I was praised by the Ecolux people for my efforts in working with them on their behalf and for helping to move LEDs into the traffic signal market. One never quite knows who his friends are until the last minute. On the way home, Jim and I discussed the dinner meeting with Ecolux and Jim told me he appreciated me letting him take the lead in the discussions. As we talked I began to realize that Jim Leising was one of my most fervent supporters in OED. Over the years Jim Leising had been watching me move LEDs into the traffic management market with considerable interest and approval. As we drove back to OED, Jim let me know how much he appreciate my efforts and successes and told me he thought I was one of OED's most valuable employees. To my amazement, over the years, Jim Leising had been a silent friend, and because of his support, I had been able to do the things I had been doing without any opposition.

**Three new young hires into OED Marketing**

People come and go in large companies and OED was no exception. People changed jobs and new people were hired to take their place; such was the case in Applications. Applications had hired a young brunette girl engineer named Inez Amaro. Ines Amaro was pretty, sharp, and very technically competent. Marketing had hired a young blond girl named Amy Arden. Amy Arden was also sharp and very competent. Andy Lipman had been hired in Marketing sometime earlier and was assuming the role of marketing support for traffic management and illumination. Andy Lipman was young, energetic, ambitious, and tended to go his own way without asking the advice of others more experienced than he was. Andy would get an idea and just charge off with it regardless of what anyone else thought.

Andy had attended ITE meetings with me. He and I saw things from different perspectives, as if we each had attended different meetings. Maybe it was an age difference, Andy being some 40 years younger than I was. We did do a customer round robin together with Amy Arden. During the trip I felt like a third wheel; Andy and Amy acting like a team with me on the side getting in their way. When I told Andy I was going to the final ITE Committee meeting on the LED traffic signal specification, he told me "to not piss anyone off because we needed to get the specification released." I immediately took affront to his comment. I was not sure if he was joking or was serious, but noting the tone in his voice I took him seriously. This was the first time anyone my junior in both age and experience had insulted me like this. It turned me against Andy Lipman and from then on I found it difficult for me to work with him.

Amy Arden and I got along rather well and I could see her going far in Marketing if only she would show more initiative than she did. I think the job she had was a little intimidating for her. Amy was assigned to provide marketing support for the entry of LED technology into illumination markets.

Inez Amaro was a terrific girl, a super person dealing with customers. Since I was retiring in two months, Inez Amaro was to take over my application responsibilities. Inez learned extremely fast, and remembered what she learned accurately. Ines came up to speed very fast and was performing as if she had years of application experience. I saw no reason for me to do a presentation at the San Francisco IES conference if these two girls were to assume my responsibilities between them. Therefore, I told management I would not do the presentation, and the responsibility of doing the presentation ant he IES conference should fall to Inez Amaro and Amy Arden. I felt these two girls should write their own show and do their own presentation, with me being available for any help they might need. Ines and Amy put together a very good presentation. At the IES conference, they did an excellent job of presenting what they had prepared, I was proud of them.

**SMT and auto-insertion**

I first heard the term SMT (surface mount technology) in the early 1980s. OED was not into surface mount technology or auto-insertable devices at the time. By the late 1980s OED was shipping LED lamps packaged tape and reel. LED lamps were attached to a paper tape by their leads and wound onto a large cardboard reel. The reels were mounted onto an auto-insertion machine by the customer for automatic insertion of the device leads into holes in a printed circuit board. I knew nothing of this process, however, being the mechanical applications engineer it fell to me to learn all I could about the auto-insertion process. This was a long term learning process that would last well into the mid-1990s. The only way to learn was to go visit customers who were using auto-insertion and learn from them.

I made a number of customer visits just to learn about auto-insertion. I have described one trip to Ford Canada to you already. There was another trip that is of interest, and that trip was to the Texas Instrument (TI) plant in Johnson City, Tennessee just south of Knoxville. This was a very large modern electronic manufacturing plant that was using OED tape and reel mounted LED lamps. I learned many

valuable things from this visit: how to properly set up an auto-insertion machine; how to set the auto-insertion pressure for different kinds of devices; how to correctly target an auto-insertion machine so as to insert leads of devises into the proper holes in a PC board; the different kinds of auto-insertion machines and the different kinds of tape and reel configurations.

### NEPCON

The National Electronics Packaging Conference (NEPCON) was held every year in Anaheim, California; adjacent to Disneyland. NEPCON was a giant of a show and conference for manufacturers of electronic equipment lasting 4½ days. NEPCON is a manufacturing show, with exhibits displaying all kind of equipment and processes available for the manufacture of electronic products. The conference is more of a large short course school, than a conference; with workshops, seminars, and lectures on every subject imaginable that is connected with electronic manufacturing. The NEPCO show filled three large display buildings adjacent to the Anaheim Hilton and Marriott Hotels. Even to the two hotels were full of hospitality suites, exhibits, and gatherings for the conference.

I went to NEPCON five times, twice for two days and three times for four days. I took in as many of the workshops, seminars, and lectures as I could squeeze in and still have time to wander throughout the exhibits. Some of the exhibits were small in size; an 10 x 8 foot booth, and some were so large they could fill a hotel conference room thrice over. I learned a lot going to NEPCON. OED managers did not understand nor appreciate the value of NEPCON, so except for a few times, I was the only one from OED who attended the conference. I tried to tell OED managers that OED product development and manufacturing engineers should go to NEPCON to learn what I was learning; thus be better equipped to design and make LED products that were compatible with the latest manufacturing equipment and processes. I couldn't convince them; they just did not want to spend the time and money to go to a manufacturing conference and equipment show; after all OED was in the component business, not in the electronic products business. How short sighted. NEPCON was the school for me.

I gained most of my manufacturing and wave soldering knowledge from attending NEPCON. I learned how multi-layer printed circuit boards are made; what chemicals were used in manufacturing processes; what the various pieces of equipment are used in the manufacture of electronic products; and the latest SMT techniques. I learned about problems others had solved; learned techniques that I would use to solve OED customer problems; learned about pitfalls of circuit designs; and the list of what I learned went on and on.

### LightGuard Systems

I had just returned to work after a business trip in early summer of 1996. As I walked into Marketing, one of the secretaries told me I had best call the Santa Rosa Police Department right away. What? What for? I had not been in Santa Rosa for over five years. What could they possibly want with me? You had better call them; the Chief of Police is looking for you! OK, I'll call them. I called. His name was Sal Rosano, Chief of Police of Santa Rosa, and sounded delighted that I had returned his call. He needed my help immediately, and could I come to Santa Rose as soon as possible. Well, I could, why? The story went like this:

Mike Harrison was a corporate pilot, flying a large twin turboprop aircraft for a developer in Santa Rosa. Mike had a close friend. One night, the friend of Mike Harrison hit and killed an elderly lady in a crosswalk in Santa Rosa. The crosswalk, not lighted, was between a park with tennis courts, and a small shopping center. Mike's friend was not cited for the accident, but the incident devastated Mike's friend and upset Mike as well. Mike thought there had to be a way to prevent such accidents. What might work was based on airport runway lighting.

Runways have imbedded in them a lighted centerline that is easily seen by pilots at night, both from the air and on the ground. What if, crosswalks were marked with lights imbedded in the pavement adjacent to the crosswalks? What if these lights flashed at motorists only when a crosswalk was occupied by a pedestrian? Mike Harrison presented his idea to the City of Santa Rosa but the Department of Public Works did not like the idea and would have nothing to do with it. Sal Rosano liked the idea and offered to have the Santa Rosa Police Department fund a study to see if the idea would actually work. In order for this to happen, sample flashing light modules had to be designed and made for testing. Mike Harrison needed funding, so Sal Rosano and a few prominent people around Santa Rosa put up the money to form a small company to design and make the flashing light fixtures for testing. This was the start of the company, LightGuard Systems, Inc. The flashing light fixtures were made to sit on the surface of a roadway just for testing. The idea did not work. The flashing lights could not be seen in daylight conditions. Mike Harrison tried various incandescent lamps and strobe lights but nothing would penetrate the Santa Rosa sunshine. At night fine, the flashing lights were easily seen, but not in the daytime.

While all this was going on, Mike Harrison and Sal Rosano had contacted the California Traffic Control Devices Committee (CTCDC) to get on their agenda for approval of testing at crosswalks in California. The CTCDC was a committee sanctioned by the State of California to approve all testing of highway signaling devices within the state. If testing of flashing light at crosswalks was to take place in Santa Rosa, the CTCDC had to first approve the testing. Efforts to convince the CTCDC to allow testing had failed because the flashing light idea had failed in daylight conditions. Somehow, Sal Rosano got hold of my telephone number and had called me for help.

I agreed to go to Santa Rosa because I knew that amber LEDs, mounted in the correct housing, were easily seen in bright sunlight; they were easily seen in amber highway signs in broad daylight so they would be seen on the surface of a roadway in broad daylight. Judy had the summer off, so she went with me to Santa Rosa. We met Sal Rosano at the Police Station and he took us to lunch to tell me his story. After lunch, we went to the Santa Rosa utilities yard to meet Mike Harrison. I had brought with me a small battery powered demo box with amber LEDs mounted in it. Mike Harrison told me of the trials he had made to get his idea to work. My response was, of course the idea wouldn't work because Mike used white light from strobes that gets washed out by bright sunlight. What Mike needed to use were amber LEDs.

I told Mike and Sal to stand where they were and walked about 30 feet away from them and turned on the demo box. They could easily see the amber LEDs in the bright sunlight. I slowly walked backwards, turning the demo box on and off to simulate flashing of the amber LEDs. At about 100 feet away I stopped and stood there flashing the amber LEDs at the two of them. They were dumfounded to say the least. They could hardly believe their eyes; there at about 100 feet away they could easily see the flashing amber light from the small LED lamps. It was obvious to both Mike Harrison and Sal Rosano that use of amber LEDs in their test modules was the answer. How could they get some amber LEDs right away? I would give them some free samples to use in their initial test modules.

I had been invited by the ITE Central Valley Chapter to go to Modesto and give a short talk on LEDs. The ITE meeting in Modesto was that evening and Judy had agreed to go with me to Modesto. We left Mike Harrison and Sal Rosano with my promises to get the sample LEDs to them before the end of the week. It was hot in the central Valley, 108°F when we arrived in Modesto. We got a room at the motel where the ITE meeting was to take place. The ITE meeting started at 7:30 pm and I had one half hour to talk from 8:00 pm to 8:30 pm.

By the time I had given my talk and was well into answering questions, one after the other concerning LED traffic signals, LED highway signs, and work zone LED safety devices it was 11:30 pm and the meeting chairman called the meeting to a close for the night. I had a similar experience about two weeks

later. The Santa Clara County Chapter of ITE asked me to give a similar talk at their meeting; having heard about my talk from the Modesto chapter. This time I only talked for two hours, because I made it a question and answer session without a presentation. I started the meeting by asking the attendees to give me twenty questions they wanted me to answer. After writing down the questions on a flip chart, I spent the evening answering their questions with elaboration. The meeting went very well.

I sent the sample 15° amber LED lamps to Mike Harrison by FedEx the next day. Sal Called and thanked me for the sample LEDs and asked if I would give a talk to the CTCDC which was to meet in Santa Rosa the following week. The CTCDC members wanted me to give a short talk on why the CTCDC should approve testing using LEDs instead of using other light sources. I agreed to give the talk. At the CTCDC meeting, I waited for almost two hours before the chairman recognized me. It was nearing lunch time and the committee wanted to wrap up the morning session in time for lunch. I had 10 minutes to give my talk. I took twenty minutes describing why white strobe lights could not work and why amber LEDs would work. It was just about noon and the chairman said, “Mr. Evans, I have no idea of what you just said, but it sounds good.”

He put approval for testing with amber LEDs to a vote of the committee members, who voted unanimously for approval of testing of in-roadway flashing lights at crosswalks using amber LEDs as the light source. It was done. Testing of Mike Harrison’s idea began within two months at school crosswalks in Santa Rosa. The testing was successful. Mike Harrison’s idea proved itself in initial testing. Now, OED’s 15° amber LED lamps were not only being used in traffic signals, highway signs, and work zone safety devices; they were destined to be used in the surface of roadways as flashing safety warning lights at crosswalks.

**MUTCD, NCUTCD and LEDs at crosswalks**

For the next 4 years, LightGuard systems would be fighting government bureaucracy to get testing accomplished and approval for the use of in-roadway flashing amber safety lights at crosswalks. One vitally important step was to get specifications for in-roadway flashing lights at crosswalks written into the MUTCD. This meant dealing with the NCUTCD to write the specifications. That could take years. Mike Harrison, Sal Rosano, a lady from LightGuard Marketing and I attended the January, 1999 meeting of the NCUTCD in Washington, DC. Our purpose was to introduce to the Signals Committee the concept and test data for in-roadway flashing safety lights at crosswalks.

This was a contentious assignment, but we managed to do it. We found LightGuard had competition; a member of the NCUTCD was in cahoots with a competitor from Sacramento, California. His agenda was different from Mike Harrison’s and Mike found himself in brawled in discussions with Committee members to get them to accept LightGuard’s proven position based on actual data from CTCDC approved testing, rather than accept this other fellow's hearsay ideas. This was Mike Harrison’s first experience with the politics that lurked within the NCUTCD membership. However, we made progress and initial text for in-roadway crosswalk lights was written.

The next NCUTCD meeting was in Florida in June of 1999. I retired from HP OED at the end of January, 1999, yet agreed to go to the NCUTCD meeting with Mike Harrison if he would pay my travel expenses. He agreed and I went to the Orlando, Florida meeting with Mike. Once again Mike found himself embroiled in heated conversations with members of the Signals Subcommittee. I stayed out of these discussions and played the role of coach to Mike to keep him for getting into a situation he could not win. We had two influential friends on the Signals Subcommittee; Ray Pusey of the Delaware DoT and Bruce Friedman of Kimly-Horn. They were influential in getting revised specifications text out of the Signals Subcommittee and submitted to the National committee for their review.

After a few minor changes, the National committee approved to the specifications text for presentation to FHWA. FHWA then put the text out for public review for a period of two months. I wrote my comments and sent them to FHWA; all were ignored. Mike Harrison called me to inform me that FHWA had approved the specifications text for in-roadway crosswalk safety lighting for publication in the 2000 Edition of the MUTCD. We had done it! Unheard of! LightGuard had in less than a year had got new specifications for a new traffic safety lighting device written into the MUTCD! It was now legal for any traffic organization to install in-roadway flashing amber safety warning lights at mid-block crosswalks. That was part of the rub; only approved for mid-block crosswalks only! Not what we wanted, but at least the idea was now a reality written in the MUTCD. Also, we did not get a light source specified in the MUTCD, so anyone could use any light source they wanted. Meantime LightGuard had applied for a US Patent on the whole in-roadway crosswalk lighting concept. The Patent was approved and issued by the US Patent Office.

I called Sandy and Frank Vehonsky and told them I was in Orlando at the NCUTCD meeting and would like to visit them. Sandy and Frank had moved into a very nice mobile home park in Zephyrhills, Florida just north of Lakeland. They dove over to Orlando and picked me up. They had their house built as half mobile home and half permanent structure. Alongside was a large concrete parking pad where they parked their motor home. I had a very enjoyable overnight visit with them. Frank was a good host and barbequed the best chicken I have ever eaten. Sandy and I spent our time reminiscing about our past HP days as we leisurely walked around the park.

To back up a bit, in mid-1998, Mike Harrison gave me an in-roadway demo module for OED to keep and use as a demonstration device to show to other LED customers. The LightGuard demo module was shown to HP's Corporate President, Lew Platt, who expressed his personal approval for the idea. With Lew Platt's personal approval, OED management also approved of me fully supporting LightGuard in its dealings with the CTCDC and the NCUTCD. The next time you approach a mid-block crosswalk; look for two white bollards on either side of the crosswalk and in-roadway modules that flash amber LED warning lights to oncoming motorists as you step between the bollards into the crosswalk telling motorists that you are in the crosswalk crossing the street.

**Green and blue LEDs**

Red, amber, and yellow-green LEDs were common in the early 1990s. AlInGaP green LEDs, called emerald green, were available but had two problems, low light output and high long term light output degradation. Alternate semiconductor crystal structures were being investigated to produce a high quality green LED with high light output and low long term degradation. One such possibility was silicon carbide, SiC, the abrasive used in grinding wheels. When made into the form of an LED, SiC produced a definitive blue light at efficiencies about that of AlInGaP LEDs. Light output was reasonable for non-outdoor applications.

Cree was a company formed to develop SiC LED technology and bring blue SiC LEDs to the market placed. Still, a true green LED was illusive. About 1995, Nichia of Japan announced InGaN blue LEDs. InGaN had been tried earlier without success. Ammonia, $NH_3$ had been used as the gaseous environment in which to anneal InGaN wafers. Nichia discovered that by using pure nitrogen, $N_2$, as the atmosphere in which to anneal InGaN wafers, InGaN LEDs worked, producing a stable blue light at about 460 nm with high light output with very low degradation.

The InGaN crystal structure was multi-layer and very complicated compared to the simple crystal structure of AlInGaP. OED investigated Nichia's patents and immediately started development on its own InGaN LED structure. It soon was shown that InGaN wafers could be made to produce a vivid blue-green to true green color with high light output and very low long term light output degradation. The

money making color was the blue-green that matched the blue-green color of green traffic signals. True green InGaN found an immediate home in full color matrix LED signs. It is interesting to now that with red-orange and amber AlInGaP LEDs with blue and true green InGaN LEDs; a full color matrix LED sign produced more colors to an observer than did a standard cathode ray tube TV.

But, it was with green traffic signals that blue-green InGaN LEDs found a home. In 1996 I started a one man campaign to get the front end to concentrate on developing only three InGaN colors, a 490 nm blue for full color matrix signs, a 508 nm blue-green for traffic signals, and a 525 nm true green for full color matrix signs. The PhD types wanted to know was I absolutely sure those were the colors they should concentrate on developing. Yes, I sad those were the three colors. As it turned out I had little opposition from OED marketing or OED management on my crusade; evidently they thought I was the most knowledgeable about what colors both markets needed.

**Green LED traffic signals**

Portsmouth, NH was the first to use green LED traffic signals in the US. I had long conversations with a traffic signal maintenance engineer for the State of New Hampshire, Perley Cherrette and later the State Traffic Engineer for New Hampshire, Butch Knowlton. Both were convinced that green LED traffic signals were best for the State of New Hampshire. I convinced Perley Cherrette to make a presentation at an ITE conference on the reasoning behind the State of New Hampshire's decision to go forward with blue-green LED traffic signals. Perley Cherrette was not used to talking in front of large audiences, and the ITE conference was just after he had retired from the State of New Hampshire. But, I thought he gave a very fine presentation.

Nichia blue-green LEDs were used in the first green LED traffic signals installed in Plymouth; but later signals would also use OED blue-green LEDs. I spent a considerable amount of my time talking up the benefits of converting from incandescent green traffic signals to blue-green LED traffic signals. I figured that the cost savings derived from the use of blue-green LED signals would more than pay for the conversion. The average use time breakdown for traffic signal on-time in the US was: red signals ON 55% of the time; yellow signals ON 5% of the time; green signals ON 40% of the time. Note: In California, red signals are on 60% of the time because of all the protected left turns and green signals are on only 35% of the time. So for green signals being on 35% to 40 % of the time using blue-green LED signals was a big savings in electrical costs over incandescent green signals.

The only problem I could see holding back full adoption of blue-green LED traffic signals was the high price for InGaN LEDs at 3x the price of AlInGaP red-orange and amber LEDs. I made a prediction that price of InGaN blue-green LED would drop in less than a year to a level that made blue-green LED traffic signals attractive to buy. I got myself in trouble with OED Marketing people for making a price reduction prediction that was not officially sanctioned by OED Marketing. OK, I was wrong in predicting blue-green LED traffic signals would be common place by year 2000. I missed in my prediction by one year. It was year 2001 when blue-green LED traffic signals would be commonly used throughout the US.

**Mytel in Ottawa, Canada**

One business trip in January to Canada included a stop at Mytel; a Canadian telephone manufacturing firm. The name Mytel comes from the founders, Mike and Terry who started in the lawn mower business; Mike and Terry's Lawn Mowers. Their business flopped after a couple of years so they decided to go into the telephone manufacturing business; the "M" for Mike; the "y" for Terry" and the "tel" for telephones. I gave a short talk at Mytel about the advantages of using LEDs in their telephone designs.

However, this particular customer visit did not result in much business for OED.

### The Chrysler visit

I think it was 1982. Ben Howell was the FSE for the southern US. Ben Howell had worked for Monsanto and HP had pulled him away from Monsanto to be the FSE for the southern region. Ben was tall, and if he wore a beard would look much like Abe Lincoln. When I first met Ben Howell, at a sales meeting at OED, I nicknamed him "Mr. Lincoln." Ben did not object to me calling him Mr. Lincoln and rather took to the nick name. Ben wanted me to visit the Chrysler automotive plant in Huntsville, Alabama. On Monday morning, Ben Howell picked me up and we headed for Huntsville, Alabama. The Chrysler plant in Huntsville built instrument clusters and dash assemblies for Chrysler cars. Ben had been trying for months to get information from the plant to better serve Chrysler's need with LEDs. So far, he had not been very successful at penetrating the account. When we arrived, Ben called a Chrysler engineer he knew to let him know we were in the lobby. After a few minutes the engineer came out to greet us. Ben introduced me, emphasizing that I was an Applications Engineer from OED.

Immediately the engineer's eyes lit up. He had lots of questions about LEDs he had not been able to get answered. Now, here in front of him was me, the guy from OED who knew all the answers. The Chrysler engineer ushered us through locked doors into the engineering department conference room. This was the first time Ben Howell had ever been allowed to enter the Chrysler plant.

I started the conversation by asking him some pertinent questions about Chrysler's designs that I knew Ben wanted answered. In only a few minutes time, the Chrysler engineer told me all the information that Ben Howell had been trying to obtain for over two years. He would talk to me because I was an engineer, not some salesman trying to sell him something. I then answered his LED questions. The Chrysler engineer took us on a tour of the Chrysler plant; Ben taking copious notes along the way. Our visit lasted 1½ hours. During our visit Ben Howell obtained enough information about the Chrysler account that over the next two years he was able to close LED sales with Chrysler that he would not have otherwise been able to close without having the information.

### McCain Traffic

One of OED's customers was McCain Traffic in San Diego who was attempting to get into the LED traffic signal business. McCain was a manufacturer and a distributor of traffic control products throughout the western states. McCain had a large manufacturing facility and a large warehouse and shipping facility to serve the western half of the US. Peter Kohl was in charge of marketing for McCain and was a member of ITE. Pat Mullin was the engineering manager. I had first met Peter Kohl at an ITE meeting in Lodi, California where he was the chairman of the Northern Central Valley Chapter.

I attended four of the Chapter meetings in Lodi, two by myself and two with Stuart Spoto. On one occasion, the southern Central Valley chapter of ITE asked me to do a presentation on LED traffic signals at their meeting. Peter Kohl had suggested the southern chapter to have me do a presentation on LED traffic signals so I went down to Bakersfield and gave a one hour talk. The meeting was well attended with traffic engineers from both the Southern Central Valley and the Northern section of the Los Angeles area.

Although the presentation was well received, I did not detect the interest in LED traffic signals that was prevalent in the Northern Central Valley ITE chapter. Stuart knew some of those at the ITE meeting from his days at PG&E and was able to renew his contacts. At this particular meeting I was able to expand my contacts with traffic engineers and others from the Sacramento region, northward. I also met Frank Giradot who owned Synchronex, a traffic equipment representative company located in San Jose. Frank

Giradot and I would do a lot of business together as he picked up the distributorship in northern California for Ecolux LED traffic signals.
Tom Flynn and others in OED marketing thought that McCain Traffic would become a major player in the LED traffic signal market and wanted me to work closely with McCain. I looked at McCain differently. McCain Traffic was a family owned business and I did not see the expertise or the commitment necessary from McCain people to successfully become a major supplier of LED traffic signals. Attending the ITE Central Valley meetings allowed me to get to know Peter Kohl. Peter was European and spoke with a European accent. I found Peter a little difficult to deal with because he had a basic European style and attitude that I found difficult adapt to.

McCain had designed their LED traffic signal module with AlGaAs red LEDs. McCain was having trouble with their design and manufacturing of their LED traffic signal module, so I was called down to offer my help. On my first visit I did not meet the upper management of McCain; instead I saw Peter Kohl, Pat Mullin and the two designers that had designed the LED signal module. In my opinion there were some needed design changes necessary to meet the ITE LED Traffic Signal Specification that was being written. There was reluctance on part of the McCain people to make any changes in their design. Also, I found areas in their manufacturing process that could be improved and some of my recommendations there were accepted. I made two trips to McCain. On the second trip, I ran into a complete reorganization of McCain's management. Of the people I had met with during my first visit, only Peter Kohl remained.

The City of Anaheim, California had made a decision to convert their red traffic signals to red LED signals. Nathaniel Behura was the city traffic engineer and was a member of the ITE LED Traffic Signal Committee. Nathan Behura and I knew each other quite well. I worked closely with Nathan as the City of Anaheim proceeded to place an order with McCain Traffic for their LED traffic signals; all made with AlGaAs LEDs. I encouraged both Nathan and Peter Kohl to change their contract agreement to using AlInGaP red LEDs to avoid the light output degradation issue with AlGaAs LEDs. Although I think Nathan understood that AlInGaP LEDs were better, the City of Anaheim did not change their order and AlGaAs LEDs were used. The installation of the AlGaAs KED traffic signals was completed while I was attending NEPCON.

I found myself in hot water with Tom Flynn and OED management and was severely criticized for my reluctance to continue to support McCain Traffic in the LED traffic signal business. However, as I predicted, the only big LED traffic signal McCain had was the Anaheim project and eventually McCain Traffic dropped out to the LED traffic signal business.

**PEEK Traffic**

It was in 1996 that I was asked to go to Palm Springs to give a seminar on LED traffic signals to the southern California sales force of PEEK Traffic. PEEK Traffic was a major worldwide supplier of traffic management equipment. PEEK Traffic, being only a sales organization, needed some education on LED traffic signals to be effective in their distribution efforts. OED management thought it was important to have contacts with PEEK Traffic to further sales of LED traffic signals.

The seminar at PEEK Traffic was interesting. The manager in charge had not made arrangements for me to give a presentation at the PEEK Traffic Palm Springs sales meeting, and was surprised when I showed up. One of his sales people informed the manager that the PEEK Traffic's Central Office had arranged for me to give the seminar. I suggested that I give my presentation during their lunch time and the PEEK manager agreed to that compromise. I talked for 1½ hours with PEEK Traffic sales people asking question after question. When I was done with the seminar, the PEEK manager apologized for the mix up and profusely thanked me for the seminar and for me taking my time to come to Palm Springs. PEEK

Traffic never became a major distributor of LED traffic signals in the US.

**The David Franklin incident**

Jim Capiccioli was the manager of Applications at the time. I remember David Franklin had been hired by Mark Hodapp. As far as I could tell, David Franklin was well liked and seemed to fit into OED Marketing just fine. David was a reasonably good engineer, not exceptionally strong in electronics, but better at it than I was. David and I got along very well together and found ourselves working as a team. As far as I could tell, David was good with customers when talking on the phone. David came up many good ideas which I borrowed and used frequently. I seem to remember David writing one or two short Application Notes. David seemed to have a good knowledge of LED technology and had some understanding of the traffic management market I was involved with. David did not do any business traveling and acted as my backup while I was traveling.

David met a very nice girl named Dale. The two of them made an ideal couple and they got engaged. Not long after, they got married in a church in Palo Alto. Judy and I and most of the people in OED Marketing attended their wedding and reception. David and Dale bought a house in the east Bay, Fremont I think. All seemed well with David Franklin. David had his faults, however. One fault; he was a terrible speaker. David Franklin could not get up in front of a group of people and give a talk on a subject he was thoroughly familiar with. David also found it difficult to formulate a seminar topic. In short, David Franklin lacked public speaking skills and made no attempt to gain those skills. Public speaking was a necessity for an OED Applications Engineer to succeed. David was also very opinionated and a little flippant at times, evidently irritating a female section manager in OED Marketing. I am not sure that David Franklin got along with Jim Capiccioli. He and Capiccioli were having their difficulties. David also was having some problems with the female section manager.

I was having my own troubles with Jim Capiccioli. He and I did not see eye to eye on many issues. I would confide in David whenever I had some difficult problem to solve or found myself at odds with Capiccioli. I don't recall exactly what happened that Friday afternoon. Jim and I had a serious quarrel about something that afternoon that upset me terribly. David Franklin left for home early without saying his usual cheerful goodbye. I decided to drive over to David Franklin's house on Saturday for a chat about our problems with Capiccioli. David greeted me at the door, giving me no indication anything was wrong. David was a hi-fi buff, like me, so we spent some time talking about his hi-fi system before I brought up our difficulties with Capiccioli. I did most of the talking with David adding very little to the conversation. After about an hour; I left for home with not much gained from my visit.

On Monday morning, David Franklin did not show up for work. I asked if anyone had seen or heard from David. I was told David Franklin had been fired without advanced notice on Friday afternoon. What? Fired! Why? The reason given to me was the female section manager had him fired for reasons I could not determine. Knowing my situation with Capiccioli I decided to not ask any more questions and just keep quiet. Jim Capiccioli did not come to me to tell me David Franklin had been fired; he just let me find it out on my own. I did not ask Jim for any details and Jim did not offer to give me

Mike Clarkin sitting, on telephone; David Evans showing something to David Franklin; OED Applications Department and OED Marketing, 2nd floor, Bldg. 91; 1993.

any information concerning David Franklin's sudden departure. This was the only time anyone had been summarily dismissed from Applications and it shook me up. The firing of David Franklin bothered me for some time, and I looked at the incident as one more indication of the decline of OED. With David Franklin gone, there was no one in Applications to back me up while I was traveling. If any questions came in for me from customers, they had to wait for me to get back from my travels to get an answer.

To continue this story, and I am not sure if there was any connection, but Jim Capiccioli abruptly left OED for another HP Division shortly after the firing of David Franklin. David Franklin found a good position in failure analysis with Seagate, a manufacturer of computer hard drives located in Scotts Valley west of San Jose. I called David a few times to find out how he was doing and he gave me every indication he was doing better at Seagate than he did at HP OED. The last time I saw David Franklin, he and Dale had a boy and David was doing very nicely at Seagate.

**HP Christmas traditions**

When I first joined HP HPA Division in 1973 I was introduced to HP's Christmas traditions. The first tradition was the annual departmental holiday luncheons held at offsite restaurants; paid for by HP. These luncheons were informal affairs, full of fun and good cheer for all. The first lunches I went to were for Applications even though Applications was part of Manufacturing. We Apps Engineers were a subdued group; but we enjoyed each other's company making the best of a joyous occasion. It was when Applications became part of Marketing that for me the holiday luncheons became big events.

**Scenes from two OED Marketing Christmas lunches.**

From left: Janice Leatherwood; Karen Owyeung; Aneta Davis.

From right: Mike Dunn; Mark Hodapp; David Evans

Mark Chandler on far left; 3 girls: Carol Miller; Debra McGee; Michelle Mullins.

From left: Chris Togami; Kamel Shaloub; Dave O'Brien; Jovani Torrez.

From left: Michelle Mullins; me; Mark Hodapp; Mike Dunn..

From right: Marjorie Mok; Doug Silkwood; Jason; Stephanie.

From left: Sean Curry from HP UK; Brian Thorbrogger; Aneta Davis.

From left: Katie Montalvo; Janice Leatherwood.

Photos are courtesy of Janice Leatherwood.

Christmas Eve for HP was a half day at work, although tradition had it nobody worked. Christmas Eve day started off with a 6:00 am formal dress breakfast at one of the local restaurants. For HPA and when OED was in Palo Alto, the restaurant was Stickney's in the Towne and Country Shopping Center on El Camino Real, across from Stanford University. The gals would be all dressed up in their formal gowns and dresses and the men dressed up in the best suits. This was a Dutch treat affair with everybody chipping in to pay a single bill. I so much enjoyed those breakfasts and felt proud to be included in such warm and joyful gatherings.

By 8:30 am everyone was at work, or so we said we were at work just to follow the ½ day work rule. Employees decorated up the building with Christmas trees and decorations. Each individual department had their own separate little Christmas party; with all kinds of food and goodies brought from home. Everyone in the department brought a Christmas wrapped gift for the gift exchange and placed it under the department Christmas tree. The gifts ranged from expensive wines to goofy items brought to just have fun. The gift exchange usually started a 9:00 am and lasted until all the gifts had been distributed; usually at about 11:30 am. The gift exchange rules were 1) each person dew a number and selected their gift in order of the number they drew, 2) any gift could be stolen from anyone, and 3) a gift could be stolen only three times and the person who did the 3rd steal got to keep the gift. Talk about fun; prized gifts were stolen at least three times, and laughter over goofy gifts gave everyone the best time at the gift exchanges. A few times I ended up with a gift that someone else really wanted. So, after the gift

exchange was over I would give the gift to that person to say Merry Christmas.

Christmas Eve afternoon was when HP held the official all company Christmas party for employees at a local hotel. The hotel room was decorated, a dance band provided the music, and finger food was provided; all paid for by the company. The HP Party lasted from noon until 4:30 pm. I went to a few of the HP Christmas parties, but found them too crowded and too noisy for my taste. Those were the good ole days, the happy days of HPA and early OED. When OED was split between Buildings 10, 11 and the harbor site the traditions fell apart and only the holiday luncheons met anything to me. But when OED moved from the harbor site to Building 91 in San Jose, two holiday traditions once again became important. The Christmas Eve breakfast and the HP Christmas party did not survive, but the holiday luncheons and the gift exchange traditions did return better than ever. I have combined a few pictures from two marketing holiday luncheons that were held when Mark Chandler and Karen Owyeung were each Marketing Managers.

**Trade magazine articles**

Publishing magazine articles was not considered a high priority by OED management. Even so, when someone did publish an article in a recognized journal they were rewarded with praise and a $500 check from HP. I published a total of 7 magazine articles as an OED Applications Engineer. The first article was a reprint of my application note on contrast enhancement by *Electronic Design* in the No. 17 issue, August 16, 1976; titled Enhance LED Visibility. I got a $500 gratuity from HP OED for this article. The next 6 articles were concerning LEDs in traffic management applications; published in *Traffic Technology International* by UK & International Press, Surry, United Kingdom. All these articles were coordinated through the European CMO office so I only got one $500 check from HP for these six articles. These articles did, however, bring me to the forefront of recognition throughout the traffic management world. In order of publication the articles were:

- Long Term Light Output Performance of AlInGaP LED Technology; April/May, 1996.
- Precision Optical Benefits (of LEDs); October/November, 1996.
- Moving up the Ratings; Assessing why LEDs perform for ITS; Annual Review, 1997.
- LEDs Blow Hot and Cold; Annual Review, 1998.
- Which LED? ITE's interim LED signal specification; October/November, 1998.
- The Light of Your Life, In-pavement LEDs stop cars and save lives; Annual Review, 1999.

**Tribute from NCHRP**

Rich Canard of NCHRP announced a one day conference on LED traffic signals to be held in Irvine in the Los Angeles area. Rich telephoned and asked me and anyone else who would like to give a paper on LED technology. During our telephone conversation I mentioned that I was retiring from OED in January of 1999 after being with HP for 25 years. OED decided to send a PhD from Front End R&D down with me to also give a paper on LED technology. I don't remember the name of the young PhD that went with me, except to say that he had one idea of what a paper should cover and I had another idea. I knew the audience would be mostly traffic engineers, he did not. I asked that he and I coordinate our two presentations and make the trip together. Although he agreed, our two presentations were totally different and uncoordinated.

My presentation, all done with picture colored slides, gave concepts of how LEDs could be used in a variety of traffic management applications. He disapproved of my presentation complaining it was too elementary. His presentation, done with text and equation slides, was on the physics of LEDs which I would wager none of the audience understood. We did make the trip together. Rich Canard asked that the two of us sit in the front row of the auditorium, which was much like a movie theater with the rows of

seats on a steeped floor so all could have a full, unobstructed view of the stage. We were the last two papers presented. The PhD from OED made his presentation before I did, mine being the last presentation of the conference.

When I finished my presentation and started to sit back down, Rich Canard asked me to remain standing. Rich then proceeded to announce that I was retiring at the end of January and praise my efforts in getting LED traffic signals accepted by the traffic management world. Rich gave a quick thumbnail sketch of my accomplishments over the past 6 years and asked the audience to give me applause of appreciation. As I turned around and faced the audience, I watched with humility as 120 traffic engineers stood on their feet, clapping their hands in tribute to me. Tears of joy streamed down my cheeks as I realized, these guys meant it. They were thanking me and giving me tribute for what I had tried so hard to do since early 1993.

I knew them all; men and women I had worked with from many companies and governmental agencies all standing there clapping their hands, some waving to me to wish me well in retirement. I tried to wave back to the crowd, but found I was too overcome by emotion. As the clapping subsided I sat down; as Rich Canard said something like, "David. To you a tribute well deserved. We all wish you the very best of happiness in your retirement." It was one unbelievable honor I had just received. I never knew just how much impact I had made in the field of traffic management until then. Back at OED I had a chance to mention this tribute to Jim Leising. Jim looked at me and said, "David, you deserved it." I think Jim Leising was the only manager in OED who knew I had received this tribute. Oh, the PhD that I traveled with was unimpressed.

**My retirement from OED**

Mike Cowley was OED Division Manager when he called everyone into the cafeteria for an important announcement; HP's first early out program. The announcement was that HP had determined it was necessary to reduce the number of employees to remain completive. At that time the number of HP employees worldwide was in excess of 130,000 people. Instead of just laying people off, HP was offering early retirement to those employees who met the 85 rule; where age and years of service with HP added up to 85 with the following minimum requirements: at least 55 years old and a minimum of 15 years' service. I met both requirements but no had intention of taking early retirement. There were not many takers from OED.

During the next few years, HP offered three more early retirement programs. The features of each early retirement program varied from one program to another, none with benefits I would even consider accepting. I remember being told I had to attend a meeting where the latest early retirement program was being explained to qualified employees. I went to the meeting and listened as the person from personnel encouraged us "to participate in the program." Not me, thank you. Once on a Saturday, the doorbell rang. It was a postman with a special delivery packet from HP. All I had to do was sign the enclosed forms and I would be "participating in the program." I threw the papers in the garbage. One would think with all this pressure, HP was trying to get rid of me. After the fourth early retirement program was offered, there was an announcement that HP would not offer another early retirement program. The cost of the early retirement programs had become too expensive for HP; topping $150 million. I was safe. I had outlasted the HP early out retirement programs.

It was October, 1998 when to my surprise, and everyone else's surprise, HP announced a fifth early retirement program. Rumors had been flowing around HP of a major change in the corporate structure. Lew Platt was HP's CEO. He and the senior management team of HP along with the board of directors were looking at options on how to restructure HP to be more competitive in the various markets HP was participating in. The reason being given was that managing a $49 billion company in about 25 market

areas was too difficult to be effective. One rumor had HP being split into four distinct entities, as yet to be defined. Other rumors had a major reorganization of business groups.

What was happening behind the scenes was a planned split of HP into two separate companies. And in October of 1998, this rumor became widely spread throughout HP. Frank Steranka had moved from Front End R&D to Marketing as Marketing Manager when Karen Owyeung was OED General Manager. It fell to Frank Steranka to make the announcement. As I listened to Frank's explanation of this 5th early retirement program, I detected an ominous tone to his remarks. Evidently, the rumor of HP slitting into two separate companies was not a rumor, but a fact. Frank and I had known each other for a long time. Although, not close associates, we had worked well together over the years.

I had great respect for Frank Steranka as a PhD research scientist and I think he had respect for me as an applications engineer well. I did have the feeling that Frank was out of his realm in the position of Marketing Manager because Frank had absolutely no marketing or sales experience. Frank had been a department manager in Front End R&D for some time, so he could draw on that experience. However, I doubt that gave him the experience he would need to manage a $500 million plus optoelectronics business. I asked Frank how serious was for it me to take this early retirement. Gently shaking his head Frank told me I had better take it.

I had known Freda Bittner for many years. She had worked in OED personnel during her whole time in OED. Freda Bittner was Scottish, born and raised in Scotland and had moved to the US shortly before joining HP. She talked with a distinct British accent, and talked with a Scottish accent. Freda and I had a run-in in 1991 or 1992, don't remember which year. Marketing had hired a young female Administrative Assistant (AA). She was attractive with long black hair and a sweet smile. She seemed pleasant and would fit into the marketing environment just fine. I tried to be friends with her, stopping by to say hello when she was out in her car for a rest during lunch time. Mark Hodapp was Applications Manager at the time. Mark and Freda called me into a conference room to confront me with an accusation of me of harassing this young female AA. I was shocked!!

Freda laid out this girl's charges against me while Mark sat by in silence. I animatedly denied the charges and gave Freda a challenge in return to watch this young girl closely for other signs of this type. Freda gave me the one time warning as required by HP. I went out of the conference room raving mad at Freda and Mark for even thinking of making such accusations. Well I was correct; others soon found themselves facing similar complaints from this young girl. Being an AA, this young girl had to interface with all kinds of people and as it turned out she just could not do that. Her performance as an AA was less than what was expected and within two months she was let go. Freda came to me with an apology for falsely accusing me of harassing the girl. Freda told me that if she had known what she now knew about the girl she would have never had that confidential meeting with me and assured me there was nothing in my HP personnel file relating to the incident. So, the outcome of that incident was I had a trusted friend in personnel to whom I could go to and discuss this 5th early out program.

I went to see Freda at her desk. "David'" she said, "Take it. It's going to be a blood bath in February!" Freda knew what was about to happen to HP, but would not tell me. So, I signed up to take the 5th early retirement program. I was the first person to do so. There were three end of fiscal quarter retirement dates given; end of October, 1998, end of January, 1999, and the end of April, 1999 for those working on critical OED projects. For me, early retirement would take effect at the end of January, 1999. The early retirement benefits this time around were better than any of the other four earlier early retirement programs: full medical benefits and one year's additional salary were the two most important for me.

Within a few days more people had signed up for this early retirement than OED and the Components Group wanted to let go. In OED alone, the years of experience invested in those wanting to "participate in the program" totaled 1600 years. Unlike the other early retirement programs, OED held a three day retirement conference on company time. I went to the conference which discussed everything from medical issues, insurance, Social Security, financial planning, to adjusting to a retirement life style. It was a very good conference with speakers from outside HP who were experts in their fields. The conference room was packed solid with people who had opted for this early out program. One nicety, I could spit the additional year's salary; take ¼ of it in 1999 and the other ¾ of it in 2000 which reduced my income tax burden.

Once I announced I was accepting the early retirement I thought my work load would diminish, not so. Doug Silkwood was Applications Manager and I was concerned how he would treat me now that I was retiring. I was sort of acting like an uninvited mentor when Doug assumed the position as Manager of Applications because I wanted him to succeed. I also think that since I was much his senior, Doug may have found it difficult to manage me and I think those two issues that may have irritated him somewhat. I got the feeling Doug was glad to see me leave OED; but he had no idea of what was in store for him after I had left OED. The month of December included the usual OED Christmas party at an offsite restaurant and the usual ½ day off on Christmas Eve. The month of January, 1999 for me was extremely busy. I had a scheduled trip back to Washington, DC during the last week of January to attend an NCHRP conference and a meeting of the ITE LED Traffic Signal Committee. I elected to not attend the NCUTCD meeting held the first week of January.

The second week of January, 1999 I flew to Washington, DC. It had snowed in DC and the weather was cold, the streets covered with snow, and the sky dark with overcast. I could not get a room at the hotel where the NCHRP Conference was being held and had to stay in a second class hotel about two miles away. Luckily the light rail traveled between the two hotels. The NCHRP conference was crowded with attendees. I did make the rounds of all the exhibits; one exhibit in particular; hi-tech police cars with NVG and FLIR. Military NVG and FLIR (Forward Looking Infrared) technologies had finally made it into law enforcement. The cars on display were as hi- tech as any military vehicle, modified to meet law enforcement requirements.

Videos showed how effective these new technology were in apprehension of suspects in various nighttime situations. In short, suspects could run; but a night they could never hide. The ITE committee meeting was short, lasting only about an hour. I could have skipped it as it turned out. The trip really had not been worth the effort or expense; and I was glad to get home to warm California away from the cold snowy weather of Washington, DC. I got home, Thursday night. On Friday morning, nobody asked how my trip went or what I had accomplished. On Friday morning, Martin Schoeppler came by my desk and gave me a Hewlett-Packard Service Recognition Plaque for my 25 years' service at HP. He told me there had been a service recognition lunch on Wednesday while I was in Washington, DC so I missed getting the plaque. At least that was something, better than nothing for my 25 years and 5 months at OED.

Carol Miller had also decided to take the early out. Carol Miller was a beautiful blond in her early thirties, I would guess, and was pregnant with her first child. We were good friends and had worked together for some time. She had an interesting career at OED. Carol was in charge of Hi-Rel when we first started working together. George Strickland and I were involved in the development of OED's panel mount NVG compatible LED lamp when Carol assumed the role of Hi-Rel manager. She would oversee the dismantling of Hi-Rel as a separated department due to the sharp reduction in military business. This was hard for her to go through.

One afternoon, just after eating lunch in the cafeteria, Carol expressed to me her reservations on her abilities as a manager and her doubts about herself as a valued HP employee. As we stood in the hall outside the cafeteria, I told carol what I saw looking at her: a beautiful, highly intelligent woman who was extremely capable of making very good decisions; a person who had weathered a difficult storm on the dismantling of Hi-Rel; a manger who had those working under her direction at heart; a young woman that was the ideal HP employee. I think my little pep talk was all that Carol Miller needed; for from then on she acted with extreme confidence in herself. Milt Liebhaber gave Carol a very difficult assignment.

**ISO 9000**

The European countries had established the International Standards Organization (ISO) whose charter was to establish ethical business standards throughout Europe. One of the standards was ISO 9000, a standard that basically required companies to adhere to their own internal business practice standards and procedures. In order to sell successfully in Europe, companies had to become ISO standards certified and the one that HP OED chose was ISO 9000. Carol Miller was given the task and the authority to bring OED up to ISO 9000 standards, a very difficult and politically charged assignment. She did a fabulous job of handling this very difficult assignment, which affected everyone in the division. I rebelled against the idea of being ISO 9000 certified. OED would pay $50,000 for two men from Brittan who were ISO examiners to come to OED; research OED's standard operating procedures and then go around asking people questions about those procedures to make sure each understood those procedures and were executing their individual jobs in accordance with those procedures. Luckily, I did not have to answer any of their questions because Applications did not have any written procedures. Once satisfied, the two Englishmen would issue to OED an ISO certificate of compliance. At that point OED could claim it was ISO 9000 certified. This was to be done once every year.

To me this sounded like a protection racket, similar to those of the gangsters in the 1920s. In the 1920s gangsters would demand protection money from small business owners. If a small business owner paid the protection money, the gangsters would leave the business owner alone. If, on the other hand, a small business owner refused to pay protection money, the gangsters would destroy his business. In Europe, if a company paid for ISO 900X certification, then the business was certified by the ISO to do business in Europe. If a business chose to not be ISO 900X certified, then that business was sort of blackballed as not being certified to ISO standards for doing business in Europe. Note the similarity. The phrase that was supposed to be OED's business motto was, "Customer Piece of Mind". I thought this to be ridiculous; I thought "piece of the customer's mind" would be more appropriate. My reasoning was that in most cases, the last thing to be considered by customers in product designs was the customer-to-user interface and what indications should be used to achieve that interface.

It was at this point in a customer's design cycle that LEDs and HP OED would come to mind. Carol had gone through three of these ISO certification cycles when the 5$^{th}$ early out was announced. I expressed my concerns over the ISO 9000 certification to Milt Liebhaber. He told me that HP had determined it was necessary if OED was going to continue doing business in Europe. It is interesting to note, that as far as I could observe, the ISO 9000 certification craze died out after about 5 years as companies realized they were spending money for something that did not improve their sales in Europe or elsewhere.

When Carol Miller announced she was pregnant and was accepting the early out, people in OED decided to have a retirement party for Carol, to be held the last week of January just before she would leave OED. No such retirement party had been suggested for me, and I knew this. I knew my popularity within OED had fallen to a very low level, especially among some of the managers in the division. Many in OED considered LEDs to be commodity items rather than high technology products. Many people

were questioning whether it was necessary to maintain an applications group; assuming most customers understood LEDs well enough to do their designs without the need for OED applications support. With me gone from OED, the last remaining of the original applications engineers, that would be sufficient to disband applications altogether.

Kimberly Wallace was the administrative assistant for Applications. She was a sweetheart of a girl. Kimberly's big asset was she knew how to play the system within OED. If something needed to get done, Kimberly knew just who to contact to get it done. Kimberly, bless her loving heart, took me under her wing. She made it her business to take care of me whenever she could. Whenever I needed something done, Kimberly took care of it; many times she would take care of something even before I realized I needed it done. Kimberly Wallace made my life as an applications engineer in OED easy for me. I don't know how many times she greased the skids for me with others within OED. Such was the case with my retirement luncheon. Kimberly told me that a retirement luncheon had been planned for Carol Miller and she was able to get me "tacked on" to the luncheon as well so the two of us would be honored together. Please notice; if it were not for Kimberly Wallace, I would have not had a retirement luncheon. To this day, I owe Kimberly Wallace a huge debt of gratitude.

**Carol Miller's and David Evans HP OED retirement luncheon**

Mary Jo Piramoon, me, David Evans, Bernard McIntosh, Dawn Martin, Doug Shamblin

Doug Silkwood and Jim Leising Bernard

Bill Magruder, Amy Arden, Dave O'Brien, Lou Dadok

Andy Lipman, Doug Shamblin, George Strickland

Doug; Inez Amaro who took my position; Radich; Frank Steranka (with beard)

Dave Mackle; Dawn Martin; Bill Antle; Bill Majkut


Bill Beecher, Aneta Davis; Comptoise; Marjorie Mok

(?) Mark Hodapp; Katie Montalvo; Rosemary Bill Beecher

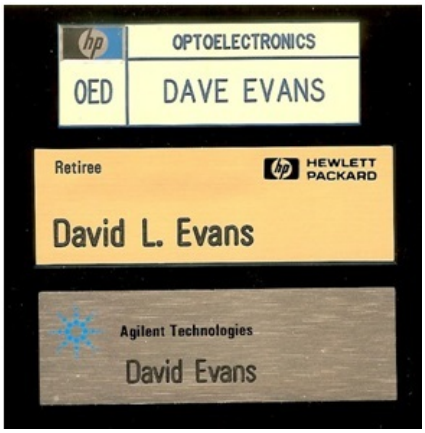
Kimberly Wallace, Marjorie Mok, Janice Leatherwood, George Willis.

Carol Miller and Bob Steward who hired me into HPA on September 4, 1973

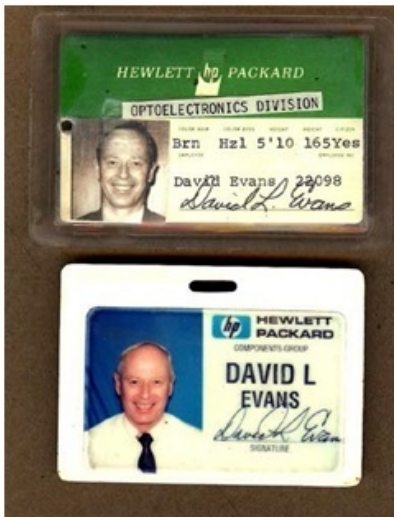
I enjoyed my retirement party. It was held at a Mexican restaurant where we had a section all to ourselves which made it fun. Most of those who attended were all working friends of mine who I thought were special. I was asked to give a short speech, which I did telling everyone that all OED had to do was reach out and grab markets ready to accept LEDs. All who were there personally wished me the best of luck as I entered into my retirement.

It was Friday, January 29, 1999 my last day at HP OED. Doug Silkwood made sure I had everything wrapped up. I made backup discs of everything on my computer hard drive and gave them to Doug so he would have the information and the presentations to load on his computer. By noon, my computer had been disconnected from the server. My telephone was also disconnected. Doug told me I had to see a 20 minute video on protecting HP secrets before I left. He and I watched the video; not much except to say do not give HP secrets to anyone once I had left the company and stating that if I did I could be liable for prosecution.


My HP business card as a Technical Engineer; 1996 to 1999.




My HP OED name badge and my two Marketing retirement badges from HP and Agilent.




My two ID cards: Note on the top card “Optoelectronics Division” used to cover “HPA Division”; 1975. Note: Employee number on top card not used on new card due to privacy concerns by employees; 1991.


Hewlett-Packard Service Recognition Plaque.

I spent much of the day saying goodbye to those I had worked with for so many years; each one shaking my hand and wishing me well. It was tough to say goodbye; hard for me to realize I was actually saying goodbye for real. At 3:00 pm I walked out the door for the last time, after giving Doug Silkwood my keys and one of my ID cards, I kept the other two ID cards. At age 64½ I was at last retired. I had made it all the way to the end. I was an HP retiree with all the privileges of an HP retiree. The drive home seemed normal, with the usual traffic tie-ups, as if I would be returning on Monday morning. So, now as of January 29, 1999, I was retired and starting a whole new way of life. It was what happened on Monday morning that changed everything.

**People of OED Applications**

Bob Steward and Stan Gage,
Application Managers

George Liu and Al Petrucello,
Application Technicians

During my years as an Applications engineer I saw many people come and go in Applications. I will mention a few here who I feel made a contribution while in Applications:

**Bob Steward;** the first manager of Applications who got the group started; for hiring me in 1973; for designing the S4 demon unit, the first electronic LED demo unit; for encouraging me to write my first application note on contrast enhancement.
**Hans Sorensen;** researched the essential characteristics of LEDs and laid the groundwork for the basic LED applications technology for both visible and non-visible LED devices; for publishing many Application Notes on Optocouplers; for his participation in worldwide optoelectronic application seminars; for his support, teaching and mentoring of me.
**Al Petrucello;** who made so many crucial measurements of LED devices in support of Hans Sorensen, me and other Applications Engineers.
**George Liu;** for his superb electronic technician support in the building of demo units and other valuable application tools.
**Stan Gage;** the second manager of Applications who established Applications as a valuable asset for OED; implemented the writing and publishing of the Optoelectronics Applications Manual; for his participation in worldwide optoelectronic application seminars; for his superb support of SAN LED display devices; for allowing me to be involved with ALI.
**Denise Dow:** for her outstanding effort in composing the text for the Optoelectronics Applications Manual.
**Mark Hodapp;** for designing the LED demo boxes that were so valuable for the Field Sales Force, for his participation in worldwide optoelectronic application seminars; for providing technical marketing support to the automotive market.
**Carolyn Jones;** who worked with the CIE committee on standards favoring LEDs.
**Bob Krause;** for his participation in worldwide optoelectronic application seminars and his contributions to the text of the 2nd edition to the Optoelectronics Applications manual.
**Dick Jamison;** for his contributions to the text of the 2nd edition to the Optoelectronics Applications manual.
**Steve Hall;** for establishing the Applications optical measurement lab.
**Lori Louie;** for her superb presentations of Optoelectronic Application seminars.
**Wally Scott;** for his valuable technician support.
**Dave Yeaple;** for his superb efforts in customer support as an Applications Engineer and for his productive efforts as an FSE.
**Mike Clarkin;** for moving Application into technical marketing rather than just technical support.

**David Franklin;** for his back up support of me while I was involved in traffic management.
**Marjorie Mok**; for her superb secretarial and seminar preparation support.
**Kimberly Wallace;** for her valuable secretarial support and for being instrumental in seeing to it that I would enjoy a retirement luncheon.
**Doug Silkwood;** who proved himself both as an Applications Engineer and as a Product Marketing Engineer; who was the last manager of Applications.

Members of the former HP OED Team:
Mark Hodapp's retirement from Philips with 50 years in optoelectronics; July 2014. Carolyn Jones, Stan Gage, Bill Beecher, Bob Steward, Mark Hodapp, David Evans, George Liu, Bob Krause.

**Agilent**

It was Monday, February 1, 1999 when the announcement came that Hewlett-Packard had been split into two separate companies; Hewlett-Packard and Agilent. Hewlett-Packard was composed of the printer and computer businesses, at $40 billion in sales, and Agilent, at $9 billion in sales, was composed of everything else. Ned Barnholt was the CEO of Agilent and Bill Sullivan retained his position as the Components Group Manager. The Components Group and OED were now part of Agilent. Not only that, all retirees from day one who had retired from the business groups that now composed Agilent were made Agilent retirees, totally divorced from Hewlett-Packard.

I had lost my status as an HP retiree along with thousands of others going back to the early days of HP. Talk about some angry people, many complained, even those who were in top management positions in earlier days; but to no avail. The new HP did not want the financial responsibility associated with us now ex-HP retirees. That was the bad news. The good news was that I retired with 25 years and 5 months service. As an HP retiree, I would have had to be with the company for 30 years to get all the retiree benefits. But being an Agilent retiree, I needed only 25 years' service to get all the retiree benefits. So, in that respect I lucked out.

Within a very short time Agilent dissolved OED, sending everything that had made up OED to the custody of Lumileds. Agilent did retain the business of selling LED lamps under the Agilent name, purchasing them for resale from Lumileds. The predictions of OED's demise had sadly come true. It was at last all over. Some of those left in OED found other positions within Agilent; some were hired by

Lumileds, and others found the pavement outside very cold and hard. Freda Bittner's prediction of a blood bath was very close to reality.

**ALI February, 1999**

I had agreed to give a talk at the ALI Advanced Seminar in February of 1999. I had told George Godfrey that I would be retired from Hewlett-Packard and this would be my last ALI presentation. I also had told George that I would no longer be teaching at the ALI Basic School and he had to find someone else to teach The Basics of Light and Color. At the ALI Seminar I gave a paper which was a brief history of my years at ALI. It was well received by the audience. Many at ALI wished me well as I entered into my retirement.

Me, David Evans, as presenter at the February 1999 ALI meeting.
Display of aerospace panels with LEDs in background.

This is the paper that I presented at ALI, permanently recorded in the annals of ALI. This particular paper was the most widely distributed paper that I ever presented. By the end of year 1999, the paper found its way through much of the military night vision compatible lighting industry.

## My Twenty Three Years with the Aerospace Lighting Institute (ALI)

**A Look Back**

**By David L. Evans**

**Advanced Seminar, February 2, 1999**

A marvelous time, a valuable education, and wonderful people summarize my twenty three years with ALI. No other technical organization has enhanced my professional world as much as ALI. I look back with fond memories of happy times, on learning the basic fundamentals of light and human vision, and association with the greatest people in the world. Combined with 25 years and five months association with the Optoelectronics Division (OED) of Hewlett-Packard, this has been one fantastic experience. Some of the more significant events that I remember may be of interest to you.

### What's ALI? and the Litton Inertial Nav System for the Boeing 747

It all started one day in late 1976. I was an Applications Engineer with OED involved in all aspects of the world of light emitting diodes (LEDs). I had been hired by Hewlett-Packard in September of 1973, and still considered myself a novice in the world of LEDs. The Applications team in OED had just finished the 1976 world wide Optoelectronics seminar tour. My responsibility had been to present Optoelectronic seminars throughout the United States and Canada. The series of 1976 seminars had been a huge success.

In 1976, OED had developed the first sunlight viewable LEDs, based on the then new nitrogen doped, transparent substrate gallium phosphide (GaP) technology. For the worldwide seminar, we built a number of demo units to show off Hewlett-Packard's line of GaP LED devices. One was a special sunlight viewable auto dash demo unit that we called the automotive instrument dash board of the future. This futuristic auto dash demo used OED's new GaP red, yellow, and green sunlight viewable LED displays.

So it was late 1976, when a phone call, from a Mr. George Godfrey, came into the desk of the Applications Manager, Stan Gage. Mr. Godfrey wanted someone to speak on LED technology at an ALI seminar in February of 1977. Stan asked me if I knew anything about an organization called ALI. No I did not. Stan and I agreed, however, that it might be worthwhile to have me present a shortened version of the 1976 Optoelectronic seminar at the ALI meeting.

I packed up the numerous demos, the sunlight viewable auto dash demo including a 1000 watt stage size sunlamp, the 35 mm slide trays, and over 100 handout follow along booklets and headed for the Sheraton Hotel LAX (later to become the Viscount Hotel LAX). George Godfrey met me at the airport and helped me carry all this stuff to the hotel. George had rented a small car, not realizing the volume of stuff I had brought with me. We barely got it all into the car, and made it safely to the hotel. I think George was wondering what was all this stuff in aluminum suit cases? That evening I set up all my LED demos, including the sunlight viewable LED auto dash demo.

The next morning others ahead of me made their presentations. One presentation was of a new blue-green electroluminescent (EL) lamp to be tested on military aircraft. The lights in the conference room were dimmed way down so everyone could see the glow of this new EL lamp. George Kaelin, one of George Godfrey's closest friends, had made an earlier statement to the effect that LEDs were interesting, but not bright enough for use in aircraft cockpits. Now it was my turn to present.

George Godfrey informed me that I had forty five minutes to make my presentation. I turned on all of the LED demos, except the sunlight viewable LED auto dash demo. I began giving my seminar presentation and flavored it to the audience who were interested in how LED could be used in aircraft cockpits. The audience was attentive, showing considerable interest in the subject of LEDs and what I had to say. After about forty minutes into my talk, I brought up the topic of sunlight viewable LEDs, walked over to the demo table and turned on the sunlamp viewable LED auto dash demo. I then turned on the 1000 watt stage sunlamp and placed it off center about three feet from the auto dash demo. The light from the sunlamp flooded the face of the auto dash demo. The LEDs in the auto dash demo were clearly visible. Everybody in the room stood up to get a better look at this marvel. I continued my talk.

Two hours and fifteen minutes had past and I was still talking about LEDs. George Godfrey walked to the front of the room and informed me I would have to stop, it was lunch time. At the beginning of the afternoon session, George Kaelin began his talk by saying, "Dave Evans, you are a hard act to follow!"

In the back of the room was a gentleman from Litton Aero Products, named Clint Pierce. Clint Pierce was a senior engineering manager for Litton on their new inertial navigation system for the Boeing 747 airplane.

When the day was over, Clint asked me for my business card. He spent considerable time examining the auto dash demo, and was especially interested in the small alphanumeric LED display that we used as the odometer readout.

Within a couple of weeks after the ALI seminar, Clint Pierce and others from Litton Aero Products visited the Optoelectronics Division of Hewlett-Packard in Palo Alto, California. Litton asked OED to build a special small, glass ceramic packaged, sunlight viewable, yellow LED alphanumeric display for use in their new inertial nav system. OED agreed, and in less than one year, Litton Aero Products showed off their new inertial nav system with the LED display readout at the 1978 Pairs Air Show. It was an instantaneous hit. Within weeks, all of the major airframe and avionics equipment manufacturers had visited OED to see this marvelous new LED display that could be seen in the bright ambient of a commercial aircraft flight deck.

The LED display was the HDSP-2301. Pan Am pilots were the first to fly 747's with the new yellow LED alphanumeric display in the flight deck. Their feedback was overwhelmingly positive, and LEDs were now on their way to becoming a major light source in modern day avionics. It was because of ALI, a whole new market for LEDs in aerospace had opened up to Hewlett-Packard.

### I Become a Part of the Aerospace Lighting World – The Basic School.

The 1977 presentation, and subsequent ALI presentations, soon established me as the expert resource the aerospace lighting industry could call upon for help in designing LED devices into their products. Hewlett-Packard's aerospace LED business began to grow rapidly. Much of this new business came in the form of military, Hi-Rel LED business, and was extremely profitable. As a result, OED's management decided to support my involvement in ALI on a long term basis.

One activity that ALI had become noted for was the Basic School. The basic school had been established by George Godfrey, with the help of George Kaelin, in the early days of ALI. Originally, ALI was an outgrowth from the Society of Automotive Engineers (SAE). SAE had asked George Godfrey to set up a training course in aerospace lighting utilizing various college professors as instructors. George Godfrey disagreed with this approach, and instead used experienced lighting engineers involved in aerospace lighting. SAE refused to endorse this approach, so George Godfrey established the ALI Basic School. George Godfrey and George Kaelin were the first instructors. George Kaelin taught The Basics of Light and Color section of the Basic School.

George Godfrey asked me to teach a section on LED technology in the ALI Basic School. This was a great opportunity for me, but I had to squeeze the information into a four hour session. Each August, I was able to teach the basics of LEDs and introduce new LED products to lighting the engineers and equipment designers in the aerospace. Hewlett-Packard's business continued to grow, and I became better and better known throughout the industry. Soon, my phone was ringing off-the-hook with engineers calling for help in designing LEDs into avionic equipment.

George Kaelin died in 1989. This was a sad and tragic event for ALI. ALI had lost one of the key pioneers in the aerospace lighting industry, a very good friend, and a mentor to me. George Godfrey asked me to step in and teach George Kaelin's The Basics of Light and Color section of the Basic School. This is a full day of basics. I had some knowledge of the fundamentals of vision, light, and color at the time. But now I had to learn it all. Much of what George Kaelin had taught now became my text book. And, over the years since I have built on what George Kaelin taught, and so now have a relatively good fundamental understanding that I am able to pass on to students who attend the ALI Basic School.

### More About the Basic School

The Basic school was 4½ days long. Attendees came from the aerospace lighting industry, the military, and countries from Canada, to Sweden, to Israel. Companies sent new hires to the Basic School as a means of quickly bringing them up to speed in the world of aerospace lighting.

Subjects included exterior aircraft lighting, taught by George Godfrey, the fundamentals of vision, light, and color, taught by George Kaelin (later replaced by myself), LEDs, taught by me, incandescent lamps, taught by Tom Knopp, the fundamentals of NVIS compatible lighting, taught by Don Guthrie (and later expanded by the addition of Harry Reichardt), and aircrew station lighting, taught by Wayne Hanks. Wayne Hanks provided the finale with his real world tales of converting aircraft cockpits into fully NVIS compatible illuminated cockpits.

I started out by teaching, and preaching, LEDs to attendees at the Basic School. This was easy for me, as I knew the subject of LEDs extremely well and had

lots of seminar experience to draw from. While doing LED technical seminars, I had lot of coaching from my fellow Hewlett- Packard colleagues, and learned how to involve the audience as the seminar progressed. But teaching the basic physics of vision, light, and color was to be for me an ultimate challenge.

Teaching The Basics of Light and Color section at the ALI Basic School has been one of the most beneficial things I have ever done. First off, attendees to the school had little understanding of the fundamental physics of vision, light, and color and that was why they were at the School. Secondly, I had to develop the skill of explaining rather difficult concepts in laymen's terms, without talking down to the intelligence of the most sophisticated in attendance. I started the course out by first explaining how the human eye works, then gave the fundamentals of light and color, followed by a short explanation of simple optics. Usually this took from 8:30 AM until 5:00 PM, with 1½ hours off for lunch, and all through the day I was able to keep the attention of the attendees with antidotal stories.

As time progressed, my skill at explaining the basic fundamentals of vision, light, and color grew. At Hewlett-Packard, I was able to coach others in these basic fundamentals, even some PhD's in semiconductor physics who were struggling to understand light. It was teaching the Basic School that raised my stature in the eyes of my ALI colleagues. Not only was I looked at as the expert in LEDs, but also as an authority in the fundamentals of vision, light and color. Little did I realize, that by teaching this section of the ALI Basic School, I was actually preparing myself with the skills necessary to move LED technology into the world of traffic management, i.e. LED traffic signals and LED roadway work zone safety devices, during the mid and late 1990's. I soon found myself acting as a consultant to others in the field of lighting outside the aerospace lighting industry. Truly, teaching the ALI Basic School has been a greater reward than I could have ever dreamed.

Only once was I ever challenged by an attendee at an ALI Basic School session. This one attendee claimed to have a PhD in physics and he constantly challenged my simplified explanations of the fundamentals of light and color. It got to a point that George Godfrey almost threw him out of class. After the day was over, this fellow eagerly helped me package up my equipment and load it into my car for the trip home. He apologized for his behavior and thanked me for giving him new perspectives on the basic theories of light and color. He also asked me if I would mind if he called me for assistance on occasion. I told him, that would be fine with me, and I would be glad to help whenever I could. I never heard from him again.

### The Blue and Gold ALI Jacket

So successful had the ALI Basic School become, that George Godfrey decided to give the Basic School instructors special ALI jackets. The jackets are nylon, medium blue in color with a bright yellow-gold ALI emblem embroidered on the back. Each jacket has the name of the instructor on it. I cherish mine, and have worn it to many ALI Advanced Seminars and always wear it at each Basic School.

### WAMCO's Parties – and the Viscount Hotel Fire

WAMCO is a marketing company that sells incandescent lamps and displays to both the aerospace and automotive industries. Then people that make up the WAMCO team are the best ever. Their leader, Mike Matthews, is always ready to indulge in a party at the slightest suggestion, and for as many years as I have been with ALI, has sponsored the ever famous WAMCO/ALI parties. These parties occur at the conclusion of the first day of the Advanced Seminar, in February, and at the conclusion of the second day of the Basic School. All you can eat and drink, starting at 5:00 PM and lasting until ----? The mood was always friendly, loud, and full of sincere camaraderie. It was at these parties that I became one of the crowd, one of the family of friends that makes up the aerospace lighting industry.

Another beneficial activity was sitting in the hotel bar and lounge and listen to the talk and gossip after each days' worth of formal presentations. I don't drink alcoholic beverages. It is amazing the amount of information one can learn, sitting in the lounge drinking orange juice and ginger ale. So famous did I become drinking these two beverages, that at WAMCO parties, WAMCO would bring a gallon of orange juice and plenty of ginger ale just for me to drink.
Sheraton had sold the hotel and it was now known as the Viscount Hotel. Not much changed, as the new management failed to renovate the hotel as advertised shortly after the ownership changed hands. One night, after about 10:30 PM, while sitting in the lounge, we all noticed a man dressed as a fireman walking down the hall. "Must be a costume party in the hotel," we assumed. As time went on, another dressed as a fireman walked by. Then came another, this time dragging a fire hose. "You don't suppose the hotel is on fire, do you?"

Just then one of our ALI buddies came into the lounge to announce there were fire engines just outside in the parking lot. We all went out for a look. Sure enough,

one wing of the Viscount Hotel was on fire, and smoke was billowing out of the windows on one of the upper floors. No fire alarm had been sounded in the hotel. No hotel personnel had come to alert guests that the hotel was on fire. In fact, this seemed like a blasé event to many of the hotel personnel.

The upshot was that an electrical panel on the fifth floor had developed a short circuit which then turned into a rather substantial fire. Many of the ALI guests were relocated to the more expensive an luxurious Marriott Hotel across the street. I was moved to another room in the Viscount Hotel, and was charged for only one night.

### NVG, a Whole New World of Lighting for ALI and the WAMCO NV-2C Filter

Night vision goggles (NVG) had been used by the military for some time. A new GEN III version now in use that required compatible lighting in aircraft cockpits. The level of lighting hinged around the luminance of moon illuminated tree bark. This all started at the February 1982 joint meeting of ALI and the SAE A20 Aerospace Lighting Committee.

The Naval Air Development Center (NADC), Warminster, PA, was in the process of writing a military specification for NVG compatible cockpit lighting. Ferd Reetz of NADC was leading the team writing this new specification. Ferd Reetz gave a presentation, in which he stated that the level of NVG compatible lighting had to match the brightness of tree bark as viewed through night vision goggles. With this statement, Ferd generated considerable skepticism amongst the joint attendees. Many of us felt this was a ridiculous concept, and let Ferd know it. How wrong we all were and how correct he was. Ferd introduced a new measure of performance called NVIS Radiance (NR), suggesting the limit be $1.7x10^{-10}$ NR. The term NIVIS was an acronym for night vision imaging system, what the rest of us called NVG.
At the same meeting, Mike Matthews of WAMCO demonstrated a new blue glass filter which he claimed suppressed the infrared emissions from incandescent lamps sufficiently to meet the $1.7x10^{-10}$ NR requirement proposed by Ferd Reetz. Again, skepticism was order of the day.

However, as time went on, the aerospace lighting industry began to understand what Ferd Reetz was telling us, and WAMCO began developing more sophisticated NVG filters. The Military specification was released as MIL-L-85762 and the new blue glass filter was WAMCO's first night vision goggle filter product, the NV-2C. Some revisions to the specification were necessary, and shortly the night vision imaging compatibility specification was re-released as MIL-L-85762A. NVG and NVIS compatible lighting now became ALI's number one topic of interest for years to come.

### Visit to NADC, Harry Reichardt and Application Note 1030

Hewlett-Packard had no data as the amount of infrared emissions LEDs produced. HP did not know what amount of filtering of IR emissions was necessary to meet the $1.7x10^{-10}$ NR requirement of MIL-L-85762A. To get some credible measurements, I made a visit to NADC. Harry Reichardt was on the MIL-L-85762A team and managed the NADC optics laboratory. Harry spent a full day with me making very careful and accurate IR emissions measurements on the sample of GaP LEDs I had brought with me. This started a long term friendship that Harry Reichardt and I enjoy today.

The data obtained from the NADC measurements were the basis for writing the Hewlett-Packard Application Note 1030, LED Displays and Indicators and Night Vision Imaging System Lighting, first published in 1995. I wrote three preliminary versions, A, B, and C, before Application Note 1030 was actually published. A few months prior to publication, I made a business trip around the United States, visiting Hewlett-Packard's night vision lighting customers, many of whom were members of ALI. Along the way I passed out a few copies of AN 1030, version C. Soon after, I was informed, by the Hewlett-Packard Field Sales people servicing these customers that a large number of copies of version C were showing up all across the aerospace lighting industry. After publication, AN 1030 became the industry standard application resource document to those involved in designing NVIS compatible lighting systems.

### ALI Becomes the Organization to Learn About NVG; Semi-Log Plots and Toilet Paper Tubes

After the 1982 meeting, ALI presentations concentrated on NVG lighting technology. The technology developed fast. Designers found they could meet the requirements of MIL-L-85762A, but the cost of doing so was far greater than early estimates predicted. NVG filters cost upwards of $50.00 per square inch. Test equipment could cost many tens of thousands of dollars. Presenter after presenter described their individual solutions for meeting the MIL spec requirements. Thus, a virtual library of valuable knowledge on NVG and NVIS lighting technology emerged that was not available anywhere else in the world, except at ALI.
Don Guthrie, of Aerospace Optics, and me gave

presentations explaining that the transmission characteristics of NVG filters, used to suppress infrared emissions produce by light sources, had to be presented by semi-log plot graphs, with the energy transmission characteristics of NVG filters being presented on a logarithmic scale and the wavelengths presented in nanometers on a linear scale. This was the only way one could see graphically the suppression characteristics of an NVG filter, 7 orders of magnitude down in the infrared region. WAMCO was the first to realize this and all of their NVG filter product data was plotted on semi-log plots. People understood clearly the performance characteristics of WAMCO filters in the IR region, and as a result, WAMCO became the primary supplier of glass NVG filters. Other would be NVG filter vendors who did not realize this and who used linear-liner plots to describe their NVG filter product characteristics soon found themselves out of business.

At one ALI meeting on NVG, George Godfrey found himself without a couple of key presenters. They had canceled at the last minute. George asked me if I could fill in for these two during the second day's schedule. With a lump in my throat, I agreed. What was I going to say that would occupy two hours of time without losing audience interest? I stayed up most of the night, talking out loud to the wall in my room, rehearsing everything I knew about NVG lighting.

The next day, I gave my rehearsed talk on NVG lighting. The talk went surprisingly well, as I told NVG war stories (learned from previous presenters at other ALI meetings) and verbally painted pictures of NVG in the minds of the attendees. In that talk, I suggested a method of simulating viewing through night vision goggles. The ideal was to take two toilet paper tubes, cover one end of each tube with green cellophane, hold the open end of the tubes to the eyes and walk around outside in sunlight. The images seen on the green cellophane would represent the images pilots see with night vision goggles. The length of the toilet paper tubes would give a viewing angle close to that of night vision goggles. Sometime later, the San Jose Mercury News newspaper had an article on NVG and compatible lighting. In the article, the Mercury News used my toilet paper tube simulation for night vision goggles, described almost verbatim as I had described it earlier at the ALI meeting.

### The C-17 and NVG Compatible LED Displays

I first heard about the C-17 aircraft on a business trip to an aerospace company in New England. At that time, the C-17 was not that well defined by the Air Force, but it was to have all of the latest NVG technology. The aircraft was supposed to be capable of operating off short unimproved fields in combat zones. I tried my best to convince this company to use LED displays in the C-17 flight deck. I also encouraged them to attend ALI meetings to learn more about NVG lighting. All to no avail.

A year or two later, I received a telephone call from an Air Force officer at Wright Patterson AFB. The subject was NVG compatible LED displays on the C-17 flight deck. He had gotten my name from ALI. We spent over an hour in the phone discussing LED displays, how best to design them into an overhead display panel and methods to make them NVG compatible, all on the government's dime. I often wonder if the officer ever got called on the carpet for such a long phone call. Later that year, I received a similar call from McDonnell Douglas, St. Louis, and once again preached the features and benefits of NVG compatible LED displays in the C-17 flight deck. The application was the overhead information display panel on the C-17 flight deck. This panel was to be composed of both yellow and green LED displays to provide a number of information functions to the pilots.

Later, at an ALI meeting, a presentation was made on the C-17 aircraft. In that presentation, the person stated the C-17 was going to use red LED displays at the parachute jump station. Using red LEDs in an otherwise NVG compatible aircraft to me seemed ludicrous. So, I stood up and made a statement to the effect, "That if red LEDs were used in the C-17 aircraft over a live war zone area, the red light emissions would make the C-17 an attractive target, and the C-17 would take a ground-to-air missile right up its back!" This upset the presenter no end. Shortly thereafter, McDonnell Douglas arranged for me to visit facility for a high level meeting with the Air Force to discuss NVG compatible LED displays in the C-17. The meeting never took place.

In 1997, my wife agreed to accompany me to the Experimental Aircraft Association Air Show and Convention at Oshkosh, Wisconsin. Bless her heart, my wife spent nine hours wandering around with me looking at aircraft and related exhibits. On display was a C-17. It was a huge, four jet engine, high wing aircraft with a fuselage as wide as a C-5A. I got to tour the flight deck. There, overhead the pilot/copilot stations was a beautiful all NVG compatible LED display panel, designed basically as I had described in my telephone conversations years earlier. The jump station did use red LED displays, but they were properly filtered to suppress the IR emissions. Yes, I

was thrilled to see all those Hewlett-Packard NVG compatible LED displays used throughout that C-17 aircraft.

### Col. Barnes and the Piper Cheyenne

In the early 1990's, Colonel Joe Barnes, USAF, became a prize presenter at ALI. Col. Barnes operated a wing of F-16's out of Tucson, Arizona. These F-16's were used by the Air Force to develop techniques flying with night vision goggles. They were also used in drug interdiction activities across the US/Mexican border. As a grand finale to an ALI meeting, Col. Barnes would show real in-flight NVG videos of aircraft interceptions, and air to ground support activities, all flown with night vision goggles. Oh what a thrill those videos were; I remember one in particular.

One video was of a night interception of a Piper Cheyenne. This large, twin-turbo prop aircraft was being used to smuggle drugs into the US across our southern border. Col. Barnes and his wing man, flying with night vision goggles, intercepted the Cheyenne at night and followed him all the way to his landing site. The NVG video was so clear, that the N-number on the Cheyenne was clearly visible. Both F-16's slowed down to match the airspeed of the Cheyenne, flying in close formation with the Cheyenne, hanging back just aft of the wings.
What a surprise it must have been when the pilot of the Cheyenne landed, only to find US Treasury Drug Enforcement agents waiting for him. The Cheyenne pilot probably never knew that he had been night intercepted by two F-16 pilots using NVGs.

### Wayne Hanks and the Night Vision Jacket

Wayne Hanks, of Control Products, Grand Prairie, Texas, is one of my favorite people in ALI. My wife and I had a chance to visit Wayne and his wife in Texas, and they treated us graciously to a wonderful day sightseeing Fort Worth.

Control Products primary business is converting the lighting in aircraft cockpits and flight decks into fully compatible NVIS lighting per MIL-L- 85762A. Wayne has many stories to tell, like the time a US Admiral called him personally to convert aircraft into NVG compatible lighting for use in the Persian Gulf. Wayne also tells a tale of when he executed a contract to convert Egyptian aircraft for use with NVGs. In this case, the obstacles he had to overcome in dealing with the Egyptians makes one wonder about crazy middle east values, i.e. couldn't bring tools into Egypt and couldn't take tools out of Egypt, etc.
Wayne designed a special black nylon jacket with the Control Products night-vision-seeing cat emblem on the back as a promotional item. These jackets soon became a prized item. At each ALI Advanced Seminar Wayne holds a business card raffle and gives one of these prize jackets away. Wayne makes a big deal out of drawing the winning business card, by first throwing out cards from his competitors, cards of those he could care less about, and so on, all in good fun, until he actually selects the winning card. Then with little pomp and circumstance, Wayne presents the winner with a jacket.

I wanted one of those jackets. After a few times of not being a winner, I asked Wayne if I could buy one for myself. His answer was no. I was deeply disappointed. But, a week later, a package was delivered to may house, and there to my surprise was one of the Control Products prize jackets, and in my size. I have cherished the jacket for many years and still wear it when I teach the ALI Basic School.

### Footlamberts and other Myth-Conceptions – Papers I Have Presented at ALI

Over the years I have presented many technical papers at ALI. I presented one paper at the 1998 ALI seminar that had a major impact. When I first became involved with ALI, I heard people talked in terms of "so many footlamberts of light" in their conversations. The unit of light measurement, the footlambert, fL, was first introduced as a means of quantifying the illumination of a motion picture screen when that was illuminated with white light for a movie projector. It is a cumbersome unit for quantifying light. Many misused the unit of footlamberts and did not realize that the mathematical definition of footlamberts contains the factor $\pi$ (3.1416) and is highly dependent upon the definition of area in square feet.

As time progressed it became apparent to me that many in the aerospace lighting industry were using the term footlamberts without really understanding its meaning. The term footlamberts, as applied to light emitting diodes and NVG LED displays, was definitely being misused by those presenting papers at ALI. I soon became irritated at this, and began to openly state the question, "What's a footlambert? A foot is the length of the foot of King Charles the First and Lambert was an Englishman who studied light. Beyond this I don't know what a footlambert is until I know what the light intensity and lighted area are?"

So, at the 1988 ALI advance Seminar I presented a paper titled Footlamberts and Other Myth–Conceptions of LED light Measurement. This was the

first paper I am aware of that that explain correct definitions and terminology used internationally to describe light, light output, and illumination. After I resented this paper, I began to see a change in people as they began to use correctly the various technical terms for quantifying light in their presentations. I subsequently incorporated much of this paper into my teaching of The Basics of Light and Color at the ALI Basic School.

After Hewlett-Packard published the Application Note 1030, on LEDs and NVG, I presented it as a paper at the 1990 ALI Advanced Seminar. This presentation established me as an expert in night vision light, although I have never actually done a NVIS lighting conversation. As a follow along to AN 1030, I presented a second paper A Spreadsheet Method for Calculating the Parameters for NVG Filtered LED Light. In this paper, I presented, in detail, how to use either Lotus 123 or Microsoft EXCEL to calculate all of the values required by MIL-L-85762A.

Another paper of importance was an outgrowth of my efforts to get LEDs designed into the flight decks of Boeing commercial airliners. I began to lobby for this design-in at the 1986 SAE A20 Aerospace Lighting Committee meeting in Las Vegas, Nevada. This would become a long term effort, having to overcome the long standing tradition that incandescent lamps were the only acceptable light source for illuminating integrally lighted panels, at least as far as the Boeing Commercial Aircraft Company was concerned. It took me six years of constant effort to finally convince Boeing to design-in LEDs into the overhead illuminated panels in the 777 flight deck.

One problem arose. Boeing decided to drive the LEDs off the 400 cycle, 14 volt peak-to-peak aircraft ac power bus. LEDs are typically driven off dc power, or strobed using rectangular current pulses. Driving LEDs off a sinusoidal ac current waveform is not the usual thing to do.

The question was, what kind of long term light output performance could Boeing expect out of LEDs driven of an ac power buss. There was no simple way to calculate the answer. Hewlett-Packard had sufficient dc current reliability data to convince Boeing using LEDs was a beneficial idea, but calculating the expected light output was not easy to do.
Simultaneously, and independently, Boeing engineers and myself came up with a method of calculating the light output of LEDs when driven off an ac power buss. I presented this method at the 1993 ALI Advanced Seminar in a paper titled Calculating Green LED Performance when Driven by 7 Volt Peak, 400 Cycle Ac Power.
Little did I realize, that this would later serve me well as I transitioned from aerospace lighting into the world of LED traffic signals, all of which are driven off 120 volt ac power grids.

The last paper of significance I gave at the 1998 ALI Advanced Seminar. Until recently, the only LED colors available have been yellow-green through red. High brightness LEDs in these colors are now produced using the high luminance AlInGaP LED technology. In 1993, InGaN LEDs ere introduced that produce colors blue, blue-green, and green. In 1998, InGaN/phosphor white LEDs were introduced. Now, all possible colors, including white, are available with LED technology. This has brought forth new applications for LEDs including full color video, tri-color traffic signals, and solid state illumination in a time frame less than three years.

This new LED technology sparked such considerable interest in the aerospace lighting world that I presented a paper titled Blue LEDs at the 1998 ALI Advanced Seminar. Once again, I had about 45 minutes to make my presentation. Interest on the subject of blue and white LEDs by the audience was extremely high, with many questions being asked as I presented my talk.
Finally, after talking for over one and a half hours, George Godfrey came to the front of the room and inform me that time had run out and I needed to wrap my talk up as quick as possible. I did so by taking another five to ten minutes. It was Deja vu, 1977, all over again.

### The ALI Award and Roasted by Sheila Sherman

Over the years I have received praise and wards for this and that contribution. Hewlett-Packard is a great company to work for, as the company rewards employees for years of service in a big way. I once received an award from SAE for writing tow ARP documents on NVG lighting. The Institute of Transportation Engineers awarded me full membership in 1998 for my successful efforts in moving LED technology in the field of traffic management, even though I am not a registered, professional traffic engineer. However, above them all in the coveted ALI Appreciation Award.
George Godfrey, being the Chairman of ALI, began in 1988 to present ALI Appreciation Awards to those individuals who had made significant contributions to ALI and the aerospace lighting industry.
The first to receive the Award was Victor Korski of

General Dynamics, 1988. Victor was the lead cockpit lighting engineer for General Dynamics, and had made significant contributions to the technology over a long period of time. Second to receive the Award was George Kaelin of Kaelite, 1989, a longtime friend of George Godfrey who helped to get the ALI Basic School under way. Both died of cancer shortly after receiving their awards. The third recipient was Don Guthrie of Aerospace Optics, 1990. Don made significant contributions to the art of NVIS compatible lighting technology. I was the fourth to receive the Award, 1991.

When I first heard that I was to receive the award, I called George Godfrey and told him others in ALI deserved the Award more than I did. George would hear none of it, and told me that I was going to get the Award. My wife Judy, felt this event to be important enough for her to take a day off from teaching and accompany me to the February 6, 1991 ALI Advance Seminar meeting to see me receive the Award. Now the tradition is to roast the recipient of the Award at the festivities. Sheila Sherman of WAMCO agreed to roast me.

And what a roast, more like being hit by a flame thrower. Wow! Where did she dig up all that stuff about me? Some of it true, some of it not so true. I thoroughly enjoyed every minute of Sheila roast, and have never laughed so hard in my life. I thought it was all great fun. Not so Judy. Judy, not understanding the close relationships I had developed over the years with Sheila and others within ALI, took offense at this roasting of her husband. She did not like it. Sheila sensed Judy's displeasure and began to feel uneasy about the whole thing. Time has passed, and Judy now recognizes the incident for what it really was, a tribute to me from ALI in a manner reminiscent of the famous Dean Martin TV roasts given to famous entertainment personalities. Judy has absolutely no ill feelings towards Sheila, but in fact, has great admiration for her. But, to this day, I think Sheila still feels uneasy about it.

The Appreciation Award plaque now hangs on the wall across form the computer in my office at home. On it the inscription reads:

THIS APPRECIATION AWARD IS
GREATFULLY PRESENTED TO

*David L. Evans*

FOR HIS PROFESSIONAL CONTRIBUTIONSTO
THEUNTED STATES AEROSPACECREW STATION
LIGHTING TECHNOLOGY
BY HIS FRIENDS AND COLLEAGUES

AEROSPACE LIGHTING INSTITUTE
TAMPA, FLORIDA

FEBRUARY 6, 1991

The list of Appreciation Award recipients has grown over the years, their names are listed below:
Victor Korski 1988 Wayne Hanks 1995
George Kaelin 1989 Col. Joe Barnes 1996 Don Guthrie 1990 Dr. Len Nelson 1997 David Evans 1991 Claude Gaudette 1998
Tom Knopp 1992 Harry Reichardt 1998 Ernie Yost 1993 Dr. Ted Cohn 1999
Archie Sherbert 1994

There are those who have worked very hard to make ALI a success. These people have been recognized by ALI with a Special Award. They are:
Sheila Sherman 1992 George Godfrey 1995
Pam Levers 1993 Mike Matthews 1996
Jeanette Godfrey 1993 Tim Godfrey 1998

### Hewlett-Packard Benefits by Supporting ALI, But Pulls Out After the Berlin Wall Comes Down

My association with ALI brought a significant amount of very profitable business to the Optoelectronics Division of Hewlett-Packard. As my contacts through ALI grew, so did HP's business supplying LED products to the aerospace lighting industry. LEDs got designed into many important programs, some of which are listed below:

- The Litton Aero Products inertial navigation system for the Boeing 747.
- The US Army's SINCARS Radio program.
- The US Army's M-110 tank fire control system.
- US Marine Corp's ground fire control systems.
- The US Army's FLR vision system on the Apache helicopter.
- The US Navy's F-14 Tom Cat and Marine

Corps Harrier fighter aircraft.
- Israeli F-16 aircraft.
- Flight deck pedestal displays on the McDonnell Douglas DC-8 and MD-11 aircraft.
- The C-17 flight deck overhead display panel.
- The display readouts for II Morrow's, Trimble's, and Northstar's panel mount GPS systems.
- The overhead communication control panels for later model Boeing 737 aircraft.
- The overhead integrally lighted panels on the Boeing 777 aircraft.

As the LED aerospace and military Hi-Rel business grew, HP OED's management became more and more willing to support anything that I asked for that was associated with ALI. Up through late 1989, the LED aerospace business was an important part of HP OED's business portfolio. Then, the Berlin wall came tumbling down. So did HP's Hi-Rel LED business.

By early 1992, HP OED's LED business in the aerospace-military market had shrunk to a pitiful level and HP decided to no longer participate actively in the remaining aerospace lighting business, and pulled its support for ALI. I was deeply hurt, but understood the reasons why. I did not teach the ALI Basic School in 1993. Dr. Leonard Nelson of Korry Electronics sat in for me that year. I was not happy. In 1994, I proposed an arrangement with HP's management, if HP would not dock me for a day off, I would pay my own way to teach the ALI Basic School. They agreed, and in 1994, I resumed teaching the basic School. That year, George Godfrey agreed to move the Basic School from August to September to make this agreement with HP possible.

### A Short Term Turn About by Hewlett-Packard

In 1996, the European CENELEC agency decided to adopt eye safety rules proposed in the IEC-825-1 standard. These European standards were originally written for eye safety with products incorporating lasers. The Europeans consider LEDs to be lasers. Hewlett-Packard and other companies objected to these new standards as they really did not fit with LED technology.

LEDs are not the same as lasers. Today, the discussion on adopting these standards is ongoing. However, in 1996, Hewlett-Packard thought it best that I present a paper on LEDs and eye safety per the CENELEC standards to ALI. And did so at the 1996 ALI Advanced Seminar. The paper was called Light Sources and Eye Safety. This opened the door to the opportunity for me to present another paper to ALI on behalf of Hewlett-Packard, and I present the paper Blue LEDs at the 1998 ALI Advanced Seminar.

### Special People, That's ALI

Over these 23 odd years, the people within ALI have become very special to me. They have been a part of my life. There are so many wonderful people to remember. And, if I do not mention your name here, please do not take offense, as I no way mean to slight you. Some of those who I have been associated with over the years include:

- George and Jeanette Godfrey – ALI
- George Kaelin (deceased) – Kaelite
- Victor Korski (deceased) – General Dynamics
- Mike Matthews, Sheila Sherman, Harry Reichardt, Claude Gaudette - WAMCO
- Don Guthrie - Aerospace Optics
- Wayne Hanks - Control Products
- Ernie Yost - Kopp Glass
- Archie Sherbet – Boeing Vertol
- Colonel Joe Barnes – USAF
- Tom Knopp – Micro Lamps
- Gerald Gross (deceased) – H. Koch & Sons
- Lars Forsberg – Sweden
- Paul Greenlee (deceased) – Grimes Aerospace
- Ian Lewin – Lighting Sciences
- Tim Godfrey – ALI
- Dr. Ted Cohn – University of California
- Mary Stratton – Kaelite
- Chet Pieroway – Control Products
- Ron Jensen – Control Products
- Jerry Terrell – US Naval Warfare Center
- Mary Lou Woolsey – Photo Research
- Nancy Towe - Lamptronics
- Roger Wong - Boeing
- Peter Wycoff – Boeing Commercial
- Richard Austin – Gamma Scientific

- James Blackmore – Honeywell
- Don Bailey – Hoya Optics
- Arnie Bazensky – Schott Glass
- William Lang – Interface Products
- Bud Johnson –Bud Johnson Assoc.
- Jose Perez – K-Light
- Dr. Leonard Nelson – Korry
- Bob Ruff – Opto-Cal
- Lee DeFord – Photo Etch
- Jim Amis – Spectra Lux
- Woody Hertzog – Spectra Lux
- James Dupree – Western Photometric
-

**And Now, Retirement**

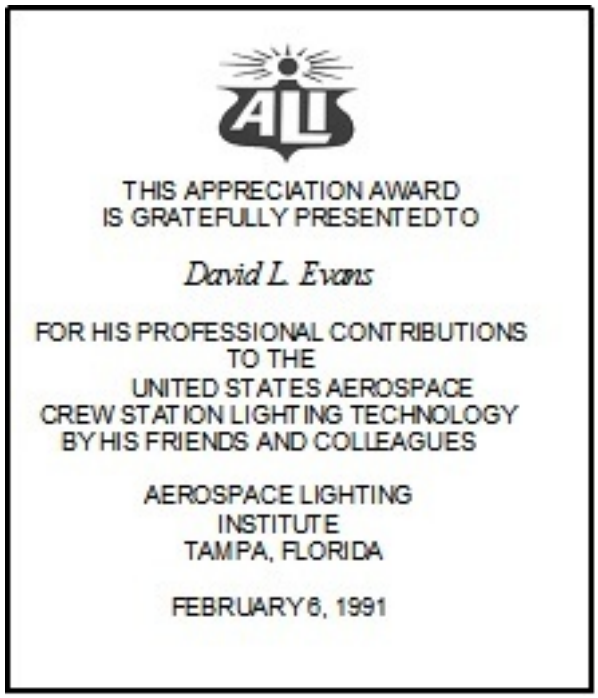
After 25 years and 5 months of working for the Optoelectronics Division of Hewlett-Packard it is time for me to retire. It is now time for me to sleep in, smell the flowers, and fly the sky in my Cessna 172 (weather permitting of course). I still plan to keep involved with ALI and teach the Basic School for a few more years.

To you who read this, I hope you have found a bit of nostalgia in looking back with me over twenty three years with ALI.

To all, I wish you Many Happy Landings.

*David L. Evan*

ALI Appreciation Award; February 6, 1991.
I was the 4th recipient of this prestigious award.




Size of plaque with walnut frame is 18 inches tall x 15 inches wide. The engraving is 7½ inches x 5½ inches.

**George Godfrey, ALI Director, presenting to me the ALI Appreciation Award; February 6, 1991.**

I received two emblem jackets for my contributions to the Aerospace Lighting Industry in teaching night vision lighting with HP OED 15° green LED technology designed into night vision goggle (NVG) military applications. One jacket was from the Aerospace Lighting Institute and the other from the Control Products Corporation.


The blue and gold ALI emblem jacket given to ALI Basic School Instructors awarded by George Godfrey.

The Control Products black Cat's Eye emblem NVG jacket awarded to ALI attendees by Wayne Hanks.

**HP OED Alumni lunches**

The story of how the OED Alumni lunches got started goes something like this. Bill Majkut, Bill Franks, Bill Beecher and Bill Antle, all ex-HP OED employees, decided to get together for lunch. All but Bill Majkut were retired from HP OED and thought it would be nice to get together on a quasi-regular basis for lunch to keep in touch with each other. Bill Majkut was still working for Agilent and scheduled the lunches. Bob Picha heard about the lunches and asked to join in. Bill Majkut decided the group should be called "The "5-B's" (4 Bills and a Bob). Then Norm Tarowsky heard about the lunches and joined in. So did Dick Kern and Larry Luis, all ex-HP OED.

I heard about the lunches from Bob Picha and asked to join the group in 2002. Soon more and more people from HP OED asked to come to the lunches. Bill Majkut began to schedule the lunches at about 6 week intervals and announced them to everyone by e-mail. I called Bill Majkut "Chairman of the Board," a title he willingly accepted. The lunch group began to increase in size as more retired people from HP OED wanted to join in. Most of the time we would have about 20 people at a 5-B's luncheon. Not always the same people would come, however. Eventually, the 5B's lunches would grow to over 25 people from HP OED.

The OED Alumni Luncheon group; November 10, 2006:
Standing left to right: George Willis, Dick Fellows, Bob Steward, Gary Ruppel, Dick Kern, Bob Krause, Bill Franks, Roland Haitz, Akhtar Khan, Reggie Short, Stan Gage, Mike Cowley,Norm Tarowsky, Walt Heinzer.
Sitting left to right: Debra McGee, Gencer Birincioglu, Bob Capriles, Robert Go, Richard Lira, Ed Aoki, Bill Bilobran, Bob Picha, Bert Matsukawa, me-David Evans, Mark Hodapp, Bill Majkut, Michelle Mullin sitting on Kevin Weitsman's lap, Mark Kriss.

When Bill Majkut moved to a home near Austin, Texas, I, David Evans, was unanimously appointed as lunch coordinator. I changed the name of the lunch group to the HP OED Alumni luncheon. For fourteen years we held an HP OED Alumni luncheon once every six weeks. But then as number of luncheon attendees began to decline and it became obvious that having a luncheon once every six weeks was too frequent. It was in 2015 that the decision was made to hold an HP OED Alumni luncheon once a calendar quarter.

The Christmas Holiday HP OED alumni lunches were always well attended. There were 50 HP OED Alumni who attended the 2013 Christmas luncheon, the largest attendance of any of the HP OED Alumni lunches. I held the position of lunch coordinator for sixteen years. In December of 2015, Bob Steward assumed the position of HP OED lunch coordinator.

**Honor Roll**

The following are the names of those I worked with at HP OED who have passed on since I retired, January 29, 1999. Their names are listed in order of their passing.

Al Martini (manufacturing engineer) 1998
Harry Vossen (manufacturing engineer) 1999
Kathy Harris (computer equipment maintenance) 2000
Norm Zinker (manufacturing manager) 2000
Dick Klinke (design engineer) 2001
Paul Sedlewitcz (functional manager manufacturing) 2001
Milt Liebhaber ( OED division manager) 2003
Cindy Turley (manufacturing) 2004
Dick Fellows (quality assurance) 2006
Bob Zettler (OED division manager & Group marketing manager) 2006
Bill Craven (group manager) 2007
Hans Sorensen (applications engineer) 2008
Al Hockley (sales)
Mike Teitelbaum (field sales Connecticut)
Marv Cherry (field sales, San Diego)
Ben Howell (field sales, Orlando)
Frank Magnifico (field sales, Rolling Meadows)
Ron Leonardo (field sales, North Hollywood)
Rosemary Comptois (manufacturing) 2015
Dick Kern (product line manager) 2015
Jerry Kolansky (marketing and sales) 2015
Roland Haitz (research and development) 2015
Ray Morris (shipping and receiving) 2015
Michelle Mullin (marketing) 2015
Bob Teichner (age 103; research and development) 2016

**Looking Back**

To use the phrase of the radio news commentator Paul Harvey: "Now you know the rest of the story." I have told you my life's story in considerable detail of the 25½ years I spent as an Applications Engineer in HP OED. I have left some things out on purpose for various reasons that I need not go into. Looking back I can honestly say that my life with HP OED was quite a ride. The experiences I had lived and the people I had met during those 25½ years made my life an adventure; with ups and downs and yet full of great rewarding successes.

OED Applications (from left to right): Bob Lombared, Mark Hodapp, Stan Gage, George Liu, David Evans, Bob Steward; at OED Alumni luncheon on May 22, 2015.

Luckily, the number of great rewarding successes have outweighed the number of downs leaving me with fond memories of The Hewlett-Packard Years that I spent at OED in Optoelectronics. In fact, I won each and every issue that I was conscientiously involved with.

With my sincere Regards,

*David L. Evans*

BS ME University of Washington, 1962
BS EE University of Washington, 1966
MS Engineering Santa Clara University, 1971
Applications Engineer Optoelectronics
Hewlett-Packard Optoelectronic Division
September 1973 to January 1999

David Evans and wife Judy Evans together on their 25th wedding anniversary; June, 1987. Married 49 years; 1962 to 2011.