

1. U.S. 2,118,091, 24 May 1938.

2. U.S. 2,274,272, 24 Feb. 1942.

Cover the high-efficiency, controllable-color zinc-beryllium-silicate:manganese phosphors, of which thousands of tons were used in commercial white-emitting fluorescent lamps during the first two decades of world-wide lamp production. Smaller amounts were used in the JEDEC-coded P3, P6, and P18 luminescent screens for oscilloscopes and television kinescopes.

3. U.S. 2,402,759, 25 June 1946.

Covers inclusion of three fluxes in synthesizing sulphide phosphors with superior efficiency for television (color and black & white) and radar kinescopes; used in making hundreds of tons of phosphors since 1942.

4. U.S. 2,452,522, 26 Oct. 1948.

5. U.S. 2,452,523, 26 Oct. 1948.

Cover the long-persistent cascade luminescent screens, P7 and P14, which were used in thousands of PPI radar indicators during and after World War II.

6. U.S. 2,527,365, 24 Oct. 1950.

Covers the most efficient infrared-stimulable phosphor, strontium-sulfoselenide:europium:samarium, used in metasopes for nocturnal viewing, starting in World War II.

7. U.S. 2,402,757, 25 Jan. 1946.

Covers the dual-activated long-phosphorescing sulphide phosphor used as the P2 luminescent screen for radar kinescopes.

8. U.S. 2,108,683, 15 Feb. 1938.

Covers inclusion of electrolytes in aqueous suspensions of phosphor particles; used in making uniform luminescent screens in early commercial kinescopes for black & white television.

9. U.S. 2,233,276, 25 Feb. 1941 (co-inventor with V.K. Zworykin and J.E. Ruedy).

Covers the surface-oxidized silver-magnesium dynode, used as a secondary-electron emitter in several commercial electron multipliers.

10. U.S. 2,066,044, 29 Dec. 1936.

11. U.S. 2,470,173, 17 May 1949.

Covers the efficient, long-lived manganese activated zinc and magnesium orthogermanates, used in dial markers that emit light under alpha-particle bombardment from radium.

12. U.S. 2,579,267, 18 Dec. 1951 (co-inventor with I.J. Hegyi).

Covers superior magnetic ferrites containing beryllium. Concern about beryllium toxicity has deterred commercial use.

13. U.S. 2,742,631, 17 Apr. 1956 (co-inventor with J.A. Rajchman).

Covers the use of stimuable phosphors for temporary storage of information (e.g., as required in computer memories). Workable, but not yet competitive with magnetic materials.

14. U.S. 2,757,304, 31 July 1956.

Covers efficient three-phosphor kinescope screen for color television, using red-emitting zinc-selenide:copper that was inherently superior, prior to the europium-activated materials, but incompatibility with the photo-resist materials used in manufacturing was not overcome before the europium-activated materials appeared.

Autobiographical Account

Humboldt W. Leverenz

Family:

Father: Paul Christian Frederick Leverenz, born in Chicago, Ill., 7 September 1885; one of nine children of Carl Friederich Gustav Leverenz (born in Jacobsdorf, Pomerania, Germany, 16 April 1851, died in Chicago, Ill., June 1934) and Amalie Auguste Erfurth Leverenz (born in Oshatz, Saxony, Germany, 5 July 1853, died in Chicago, Ill., 1936) who were married in Hobart, Indiana, 6 September 1874.

Mother: Lydia Ophelia Emma Humboldt Leverenz, born in Watertown, Wis., 5 December 1888; one of eight children of Ernest Humboldt (born in Stettin, Pomerania, Germany, 1842, died in Watertown, Wis., 1907) and Bertha Miller Humboldt (born in Stettin, Pomerania, Germany, 1843, died in Milwaukee, Wis., 1919), who were married in Germany.

Brother: Paul Carl Leverenz, born in Chicago, Ill., 17 May 1913; married Lucille Lua; 3 children; now living in Chico, Calif.

Sister: Dorothy Elisabeth Leverenz Gray, born in Paso Robles, Calif., 22 August 1918; married Robert Wayne Gray; 2 children; now living in Seattle, Wash.

Self: Humboldt Henry Walter Leverenz, born in Chicago, Ill., 11 July 1909; married Edith Ruggles Langmuir (born in Los Angeles, Calif., 20 July 1917) in New York City, 30 November 1940; 4 children: Langmuir David Leverenz (born in Orange, N.J., 2 July 1942), Edith Humboldt Leverenz (born in Princeton, N.J., 14 January 1944), Julia Bulkeley Leverenz (born in Princeton, N.J., 3 November 1947), and Ellen Langmuir Leverenz (born in Princeton, N.J., 14 February 1949); now living at 35 Westcott Road, Princeton, N.J.

Handwritten note on the left margin:
The above information is from the family records of the Humboldt family.

According to my grandfather, Carl, the Leverenz (or Lewerenz, in German) family had a thriving business making rope by hand until the advent of rope-making machines. Then, two of the young Leverenz's, August and Carl, migrated to Chicago, Ill., to seek their fortunes in another land and in other fields. In 1960, a visiting scientist from Sweden told me that the name Leverenz is now prevalent in Sweden, and so I assume that they diffused across the Baltic as well as across the Atlantic;

There is a bit of mystery about Ernest Humboldt. He and his brother Albert were born in Stettin; Albert on 3 October 1831, and Ernest in 1842. In 1860, Albert left his job as gardener on a large estate and migrated, with his wife and infant daughter, to Watertown, Wis. Ernest and his wife also migrated to Watertown in the next year or two. Ernest's children believed that he was descended from Baron Friederich Heinrich Alexander von Humboldt (1769 - 1859) who was about 73 when Ernest was born. Ernest's seventh child, born 24 December 1882, was named Alexander --- he ran away from home when he was about 16, and disappeared from the family's ken. Ernest's sixth child, born February 1878, was named Heinrich (later called Henry --- died in March 1963, in Morro, Calif.). According to my Uncle Henry, Ernest as a lad was once told that a great estate in Germany could be his, "if the truth could be told." (In 1855, Alexander von Humboldt deeded all of his property to a man named Seifert who, according to Encyclopaedia Britannica, was an old and faithful servant with a powerful influence on Humboldt).

If I had bothered to look up Alexander von Humboldt's biography, I would have spared myself an embarrassing moment

that I experienced in 1931. At that time I was a first-year graduate student at the Universität zu Münster in Westfalen, Germany, under a fellowship from the International Institute of Education. In the hope that I could continue my graduate work, I applied for, and was awarded, an Alexander von Humboldt fellowship which provided free tuition at any university in Germany. At the end of the academic year, I went to Berlin to visit Herr Oberpostsekretär Otto (?) Lewerenz, a distant relative, and stopped in at the headquarters of the Alexander von Humboldt Stiftung. After introducing myself to the beautiful young receptionist, I said that I was especially glad to get the fellowship because I understood that I was descended from Alexander von Humboldt. She looked at me rather queerly and said, "Aber er hat nie verheiratet" ("But he never married").

In this country, both of my grandfathers were iron-workers. Carl Leverenz worked on construction jobs in Chicago, and Ernest Humboldt had a blacksmith shop in Watertown, Wis.

My father worked as an electrician for the Commonwealth Edison Company in Chicago up to October, 1915. He attended night classes at the Lewis Institute, and remembers Robert A. Millikan giving a lecture there on the falling-drop method for determination of the charge carried by an electron (Near the end of the lecture, Millikan stood back from the well-filled blackboard and said, "Isn't that beautiful!"). He remembers, also, when Charles P. Steinmetz was brought to Chicago to advise on an out-of-phase problem caused by trying to link alternating-current generating stations in Chicago and Milwaukee. Steinmetz asked for certain data, closeted himself in his hotel room for

several days, and then came out with specifications for a converter station to be located at a particular point between the two cities; a station that eliminated the phase difficulty when it was built and installed.

The Move to California

By 1915, my father became impatient about waiting for his supervisors to retire or die before he could advance beyond foreman in the utility company. In that mood, he agreed to join in a partnership venture with his younger brother, Walter, a professional baseball pitcher who had visited California. In that venture, ideally, one would be one's own boss and make a good livelihood by raising almonds on a forty-acre hilly tract of land near El Paso de Robles, California. Nearby tracts were owned by baseball player Johnny Levan (later an M.D.) and baseball manager Del Howard.

In October, 1915, my father boarded a train with his young wife, two small sons, and his adventurous father, Carl, bound for San Francisco. After a few days at the Pacific Exhibition, the final leg of the rail journey was completed to the dirt-street town of Paso Robles (population about 1,000) midway on the El Camino Real between San Francisco and Los Angeles. Our belongings, including an upright piano, were then put on a wagon that was pulled over the roadless hills by a ten-horse jerk-line team. The horses were hitched two abreast, to pass between trees, and were guided by coded jerks on a single light line to the halter of one lead horse.

El Pomar (the orchard)

For the first two years we lived in a large tent atop a steep hill, with our kitchen ~~XXXXX~~ simply a stove outdoors under an oak tree. We were 13 miles southeast of Paso Robles on 40 (later 50) acres of chalkrock hills that we called our ranch. My small brother ambled off unobserved through the grass that was higher than he was. Our nearest neighbor was a young, single, German immigrant, Frank Runitz, who had an almond orchard about a mile away from ~~XXXXX~~ our uncleared land.

We cleared the land of trees and brush, tilled it, and planted almond tree seedlings. We scraped out a road that spiraled ~~XXXXX~~ up the steep hill, and had a well drilled at the foot of the hill. *for water* Meat could be had by shooting rabbits, quail, wild doves, and deer. We raised chickens, turkeys, ducks, geese, pigs, and vegetables. There was a family cow, and four to six horses to work the property. ^{it} A drastic change from city life.

At the end of two years, my father designed and built a house with a central fireplace; also a barn. And, very important to all of us --- especially my mother --- he built a tankhouse atop the hill, ~~XXXXXX~~ and laid a waterpipe up from the pump he installed at the well. Then, he put water pipes through the firebox of the wood-burning kitchen stove, to provide hot water, and installed a modern bathroom and a cesspool. At last we were emancipated from the discomfort and indignity of the outhouse.

The initial dream of this venture began to fade as we waited four years until the young almond trees became large enough to bear crops. During that unproductive period, we planted pumpkins one year, and beans another, between the rows of trees, in an effort to get salable produce. The crops were

good, but the market was bad. To earn subsistence, my father worked for neighbors. He was resourceful with the large chest of tools he had brought from Chicago, and became that region's general inventor-mechanic. For example, he invented and constructed a system with new automated mechanical apparatus to eliminate much of the inefficient manual labor that was then used to harvest and hull almonds. At the age of nine, I started working for neighbors at twenty five cents an hour, and was gainfully employed every summer thereafter, moving up to fifty cents an hour for performing men's work.

As an aside, I recall an incident with my first employer, Frank Runitz: Near the end of one very hot day that he and I worked side by side, hoeing weeds around the trunks of almond trees, we stopped to drink from the canteen and lean a moment on our hoes. I was feeling proud because I knew (and I knew he knew) that I had worked harder and done a better job that entire day than he had. He leaned there a few minutes, looking at distant hills, and then turned blandly to me and said, "You know, Humboldt, if I didn't have you, I'd have somebody else." (That incident came to mind later when I heard someone say, "Individuals die, but corporations don't.")

Looking back on those days at the ranch, I believe that my desire to be creative with physical things was stimulated ~~was stimulated~~ by seeing my father accomplish so many admirable things with his problem-solving ideas and ingenious use of tools. I wanted to escape from farming and, as an avid reader, I read some of the volumes of technical books (International Correspondence Schools) he had brought to California, as well as a variety of books from the Carnegie Free Library in Paso Robles.

There was no electricity of telephone on the ranch during the ten years we lived there. When I was in grammar school, I bought a galena-crystal/catwhisker radio to listen to nearby stations, and during high school I bought a two-section battery-powered Westinghouse tube radio (WD-11's). We thrilled at hearing Los Angeles, San Francisco, Salt Lake City, and sometimes Pittsburgh and even Havana, Cuba. Radio brought urban music, and other reminders of urban living, into our lives.

Music was one of our major delights. My mother played piano, and my parents and I sang in church choirs and community singfests. We started attending the little Lutheran church in Geneseo; a community about five miles away that consisted of one church and one school. A few attendees came in straw hats, some barefooted, to hear services held first in German and then in English. When we got our first auto, a second-hand 1913 Ford touring car, (the 'brindle flivver') we were able to transfer to the new Lutheran church in Paso Robles where I was confirmed. (In 1925, I bought an E-flat saxophone and a B-flat clarinet; played in the high-school band and orchestra, and transposed some Christmas music to be played by a violin/trumpet/clarinet/saxophone/trombone/piano ensemble in the Lutheran church. In 1926, the director of the Stanford band spied my rather large hands and said, "You're going to be our new bassoon player." I was given an old French Buffet bassoon, took one lesson from a piccolo player (literally), and played it --- after a fashion --- for the next four years. At the inauguration of Herbert Hoover, the Stanford band serenaded him over a nationwide radio hookup, and I found myself and my 'snoring bedpost' sitting dangerously close to a microphone as we played in front of the Stanford chapel.)

During our ranch days, the community had two notable musical visitors. One was Jan Ignace Paderewski, pianist-composer, and later Premier of Poland, who sporadically came to stay in the Paso Robles Hot Springs Hotel. He believed that the sulfur-water mud baths improved the index finger he had injured during his first concert tour of the U.S. On the other side of the Salinas River he established a little Polish community in two adjoining properties: The Rancho San Ignacio, for himself, and the Rancho Santa Helena, for his wife. Once, he gave a little speech to townfolk assembled in one of the main streets of Paso Robles. The other musical visitor was Oscar Rasbach, musician-composer, of Los Angeles. He came to our ranch to court my cousin, Alma Rudolph (Los Angeles), as a guest along with other Rudolphs. It was on our ranch, during almond blossom time, that Rasbach composed the music to accompany Joyce Kilmer's poem, 'Trees,' on our old upright piano. He later gave the original manuscript to my mother. (No, Alma didn't marry him; she married Otto Mehrbach who worked for the Southern California Edison Co.).

Parents' moves

In 1925, we moved to Paso Robles, where my father first ran a fruit-shipping operation, and then managed the new California Almond Grower's processing plant and shipping center. My mother worked as bookkeeper, and I was warehouse foreman, with my brother as a helper. Regular paychecks were welcome after the precarious days on the ranch --- even after the almond trees became full-bearing there were years when there was so little rainfall that there was no crop to harvest.

In early 1929, my parents moved to San Jose, Calif., where my father became a roving engineer-salesman for the Pacific Gas and Electric Co. He continued in that role when he was transferred to Chico, Calif., in April, 1943. In 1950, he^{was} retired from the company and devoted himself to designing and installing the electrical and lighting features of a Lutheran church in Chico. In 1952, he went to work again; this time as a designer of mechanical and electrical apparatus for submarines and destroyers, at the Mare Island Navy Yard, San Francisco Bay. There, he later took an in-house course in nuclear engineering that was offered in anticipation of servicing nuclear-powered submarines in the Pacific, and he did so well that he asked for and was granted a transfer to the U.S. Naval Air Station, Moffett Field, near Sunnyvale, Calif. At Moffett Field he served as Supervisory Electrical Engineer until his voluntary retirement, in 1959, at the age of 74. My parents are now living in San Jose, Calif.

Schooling

Elementary: My grandmothers had me speaking german before I talked much english. On attending kindergarten and first grade in Chicago, however, english completely supplanted german, and I later had great difficulty in re-learning german in college. On arrival in California, I went to second grade in a one-room lone schoolhouse in Linné, four miles from the ranch, usually walking. The next year, a schoolbus service was instituted from Templeton (population 200) seven miles away, and I went through the rest of elementary school and the first three years of secondary school in Templeton. The walk to the bus stop was only one mile. On entering third grade in Templeton, I was "jumped"

to fourth grade, chiefly because I could read eighth grade books without difficulty. Thereafter, I was near the bottom of the class until seventh grade, because I'd not mastered multiplication tables, and found it difficult to catch up in arithmetic and some other subjects. In seventh and eighth grades, a severe, uncompromising elderly Miss Bertha Hampton prodded me into doing better, but not outstanding, work. During those early years, my mother worked long and hard with me to help me improve (To this day, if she were to silently point a finger at me, I'd say, "forty nine," in remembrance of the block I once had about 7×7 ; a block that she helped me overcome. In retrospect, it seems odd that I should have had so much trouble memorizing simple numbers while I readily memorized lengthy poetry and prose for performances in school and church.)

Secondary: My first three years were good, but not distinguished, in Templeton ^{Union} High School (total enrollment of 56). A Miss Duhoulain made algebra and geometry interesting, but I was bored by english and history and had the mediocre marks to prove it. I detested the course in chemistry that was taught for the first time in that school by a retired architect. Mechanical drawing was fun, and I dreamed of being an architect. We had some excellent athletes in that school, and I strove unsuccessfully to scintillate among them in football, basketball, track, and baseball. Only in baseball, where I'd learned a few tricks of the trade from my Uncle Walter, did I become a secure player on the school team. Long hours of practice pitching to my rugged brother also helped. In those days, the Pittsburgh Pirates, champions of the National League, came to Paso Robles

for spring training and inspired every boy to want to emulate the graceful, powerful heroes he saw in action in the Paso Robles Ball Park. In college, I won my freshman and varsity letters pitching on the baseball team, but I recognized that I had neither the physique nor the native ability to make a career out of baseball. I threw a variety of curves for many years, including a bit of semiprofessional ball, before I figured out the physics of making a baseball curve by spinning it on delivery.

For my senior year I transferred to nearby Paso Robles Union High School (over 300 students). There, I was astonished and elated to find that I was easily getting the highest academic record in the entire school. I was not valedictorian, however, because the marks during my first three years lowered my average for the four years. Flushed with success, I applied only to Stanford University. At the appointed time, Stanford sent me a polite but firm refusal. Later, I learned that two graduates of Paso Robles had previously gone to Stanford and both flunked out in the first quarter. Also, the valedictorian of my class entered Stanford a year later and he flunked out in the first quarter. The refusal by Stanford could have made a tremendous change in my later life if my father had not known a Mr. George Langley, chemist-assayist and dabbler in mining of diatomaceous earth near San Miguel and Lompoc. Mr. Langley had occasionally sent fossil specimens to Dr. David Starr Jordan, Chancellor Emeritus of Stanford, and offered to write to Dr. Jordan in my behalf. Shortly after Mr. Langley's letter was posted, Stanford informed me that I was accepted.

My first 'physics course' was taken in that fourth year

at Paso Robles. Physics was not scheduled to be taught that year, but another boy and I prevailed on the principal, Mr. Reitt, to teach us the course. He met with us just twice, gave us free run of the experimental equipment, and suggested that we build a neodyne radio receiver for him. We had lots of fun with electrostatic generators, geissler tubes, and other paraphernalia, but learned practically nothing about physics. We ~~did~~ did build the radio, thanks mostly to the other boy, Ralph Marion Bell, who later entered Stanford as a junior, and is now an M.D. in California.

During that summer, after graduation, I thought intensively about the ~~major~~ subject that I should elect at Stanford. As I stated in response to the question, "Why do you want to go to college?", my desire was "to be anything but a farmer." For reasons that I no longer remember, I resolved to major in electrical engineering. Two weeks before I was to go to Stanford my father learned of my decision and proceeded to dissuade me. He had talked with two recent Stanford graduates who said that the coming field was chemistry (neither of them majored in chemistry). Mindful of my father's unhappy start in electrical engineering, and influenced by his and the two Stanford graduates' belief that electrical engineering was not a growth field, I reluctantly changed my intended major to chemistry --- a subject distasteful to me since the fumbling high school course ^{that was} keynoted by alcohol burners for heating test tubes.

College: The first quarter in Stanford was my poorest, academically, with a D in European History, a C- in German, and B's in Elementary Chemistry and Citizenship. I got a passing grade in "bonehead"

Elementary English --- a course I was required to take because I flunked the entrance test in English. I took Physics all three quarters of my Sophomore year, getting a B in Mechanics and Heat, an A in Electricity, and an A in Modern Physics. That was all the undergraduate physics I had, but I remember some booming stirring lectures by David Locke ~~Wilson~~^{Webster}, soft and thoughtful lectures by Pearson Asley Ross, and rapid-fire lectures by young George ~~HANK~~ Russell Harrison (who came from Arroyo Grande, Calif., against whose high school I had competed in football and baseball). Quantum phenomena and relativity were relatively new and exciting concepts that still required considerable hand-waving to win adherents. Physics was obviously a fascinating growth field. The physics laboratory exercises, on the other hand, were mostly dull, with uninspired guidance for execution and interpretation of the experiments.

The last quarter in Stanford was my best, academically, with A's in Physical Chemistry Measurements, Differential Equations, Engineering Economics (now called Operations Research), Second-Year German Reading, and Physical Education (Baseball), and an A- in Quantum Mechanics. In the first two quarters of that year, I took Physical Chemistry from George Sutton Parks, who did a creditable job of making abstruse concepts (entropy, free energy, ...) interesting and understandable. In ^{that} ~~my~~ class, ~~was~~^{followed without} William ~~Hanson~~^{Webster} ~~who~~ once interrupted Prof. Parks to give a simpler derivation of an equation, using some basic principles and techniques of physics.

During that senior year I also had two quarters of Chemistry Research under Maurice Loyal Huggins. His specialty was X-ray analysis of molecular structure. We had some European-built demountable X-ray equipment in the Chemistry Department basement,

plus nominal access to experimental X-ray gear in the basement of the Physics Department. Under Huggins, also, I was an instructor in General Inorganic Chemistry. Years later, Frederick Seitz told me that he was in my section for two weeks before he ^{was} shifted to another one, because my section was over-populated. (Fred said that I "once gave him hell for putting two s's in gases.")

Toward the end of that year, in spring of 1930, I was interviewed on campus by a four-man team from AFST. The last man I talked to was R.J. Heffner from Bell Telephone Laboratories. At one point, he suddenly asked me, "What would you do if I gave you a million dollars?" I said I'd build a little laboratory in the foothills near Stanford and assemble a small staff to tackle the problem of performing quantitative analysis nondestructively, with X-rays. He then offered me a job at BTL, at \$30/week. That evening, he telephoned to say that he'd called the home office and been empowered to raise the offer to \$35/week. As we concluded our chat in the afternoon, however, he said, "Don't expect the world to revolve around chemistry at Bell Telephone Laboratories."