THE BECKMAN CENTER FOR THE HISTORY OF CHEMISTRY

HUBERT N. ALYEA

Transcript of Interviews
Conducted by

Jeffrey L. Sturchio and Ron Doel

at

Princeton, New Jersey

on

22 and 30 May 1986

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THE BECKMAN CENTER FOR THE HISTORY OF CHEMISTRY

Oral History Program

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(Signature) Hubert N. Alyea

Hubert N. Alyea

(Date) 5/29/92

(Revised 20 February 1989)

HUBERT N. ALYEA

1903 Born in Clifton New Jersey on 10 October

Education

Princeton University
1925 A.B., chemistry
1926 A.M., chemistry
1928 Ph.D., physical chemistry

Professional Experience

1926-1927 General Electric Coffin Fellowship
American-Scandinavian Fellow, Nobel Institute, Stockholm

1927-1928 Proctor Fellow, Princeton University
1928-1929 National Research Fellow, University of Minnesota
1929-1930 International Research Fellow, Kaiser Wilhelm Institute, Berlin-Dahlem

Princeton University
1930-1934 Instructor in Chemistry
1934-1940 Assistant Professor
1940-1954 Associate Professor
1954-1972 Professor
1972- Professor Emeritus

Honors

1949-1950 Visiting Professor, University of Hawaii
1958 Lecturer, International Exposition, Brussels
1962 Lecturer, International Exposition, Seattle
1967 Lecturer, International Exposition, Montreal
1954 New Jersey Science Teachers Award
1957 New Jersey Education Citation
1964 Chemical Manufacturers Association Award
1970 Award in Chemical Education, American Chemical Society
Honorary D.Sc., Beaver College
James Flack Norris Award, Northeast Section, American Chemical Society
1984 Priestley Award, Dickinson College
1991 Robert H. Carleton Award, National Science Teachers Association

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INTERVIEWERS: Jeffrey L. Sturchio and Ron Doel

LOCATION: Princeton, New Jersey

DATE: 22 May 1986

STURCHIO: We'd like to ask you about what got you interested in science first, and then go on from that to when you came to Princeton.

CHILDHOOD (1903-1915)

ALYEA: First let me tell you about my childhood.

Born during a Rain Storm. (October 10, 1903)

Both Venus, Goddess of Love, and Hubert, were born under unusual circumstances. Venus, so we are told, rose from the Sea fully grown. Hubert was born in Clifton, NJ, on the rainiest day in the 20th Century. My mother told me that Dr. van Riper, to assist in my birth, splashed through two miles of rainwater, and waded knee-deep through a brook that had overflowed its banks. And the Clifton newspaper, a few months ago, reported suffering a terrific rainstorm, "exceeded only by the worst rain Clifton had ever experienced this century, on October 10, 1903" (my birthday).

Mastoiditis, Pneumonia. (1904)

But whereas Venus was born in good shape (if we are to believe what we see in the Art Galleries) [laughter], Hubert was born in

such poor shape that three months after being born he ended up in the hospital with double mastoiditis and pneumonia. To save Hubert's life, Dr. McKernon in the Brooklyn Eye-and-Ear-Infirmary (Mother was a Brooklynite) had to remove Hubert's right eardrum, and the muscles on the right side of his face. Having only one ear was an advantage; if my wife began to scold me, I simply rolled over on my good ear. [laughter] Mother took good care of me. She took me to the doctor who had operated two days before on John Jacob Astor, so my surgeon had had good practice, and was in good humor, having been paid by a millionaire. Also, Mother Nature took good care of me too: when I had polio 19 years later, they discovered that muscles on the left side of my face had grown 6 times normal to push my face around ("God tempers the wind to the shorn lamb"). This qualifies me for the Guinness Book of Records!

Sixty-four years later I gave the Commencement address in that same Brooklyn Eye-and-Ear-Infirmary to 200 graduating Nurses. A telephone was run from my mike to Dr. McKernon, who still lived in Brooklyn, but was now 88 and in a wheelchair. "Dr. McKernon," I began, "you will have to listen to me because you saved my life when I was only a 3-month-old lump of protoplasm with a loud speaker at one end, and no responsibility at the other." [laughter] The Nurses loved me: here was a Princeton Professor who spoke their language!

I CHOOSE MY BRIDE. (1909)

STURCHIO: Was it after you were at Minnesota that you got married? It was in 1929.

ALYEA: I fell in love with my wife when she was seven years old. Evelyn moved across the street from me in 1909. We four boys were bending over ready to run our usual course around the house, criss-cross across our tennis court, around Auntie's house and back to the starting line, pretzel-fashion. Evelyn, seven years old, was across the street in her velocipede, trolling for boys. We called her over to start us. Instead of saying the conventional "1-2-3-GO," she said:

"One for a nickel;
Two for a show;
Three to get ready;
And four to...GO!"

As I ran around my house, past the lilac bush, I remember saying to myself, "Gee! That's a cute little girl; I'm going to marry her someday." And I did!

Evelyn was older than I by 1 1/2 years, but I skipped a grade and caught up to her in the 6th Grade. Thereafter I always maneuvered it (or maybe "we" maneuvered it!) on the opening day of school to sit, for the remainder of the term directly behind her. I

would threaten to dip her pig-tails into my open inkwell. The teacher would call on Evelyn to stand up, repeatedly, but when she finally struggled to her feet, she was good-sport enough not to exclaim, "I couldn't; Hubert was holding onto my pig-tails!" (If she had, I wouldn't have married her!) We graduated from High School together. Evelyn was at the head of the class, and I wasn't even mentioned. [laughter] I always knew I was going to marry her. In those days it was good advice to wait before getting married. Hugh Taylor advised me, "Hubert, put your emotions on ice; you'll get further ahead." Some of today's graduate students start housekeeping too early.

Incidentally, one of the four lads running that race was my playmate, Don Collister, later Judge Collister, who had to rule on pulling the plug on Karin Quinlan. He had a wonderful, friendly disposition.

HUBERT BECOMES A CHEMIST (1915)

DOEL: When did you first become interested in Chemistry?

Ethan, my older brother, supplies a Role-Model.

ALYEA: My older brother, Ethan, was the family genius. He passed all his College Board Exams when he was 13. He received a letter from the Princeton Registrar asking, "Why didn't you appear; you were admitted?" So he wrote: "I will come next year; my folks don't think I am mature enough. I will take a 5th year of High School: Latin, Greek, and typewriting." When Ethan graduated from Princeton in 1916, he was Latin Salutatorian of his class. He received more prizes than anyone had since 1883. There in Alexander Hall, at Commencement, I sat, up in the gallery, looking down at my brother talking in Latin for half an hour without any notes. I couldn't believe it! My big brother! [laughter] And then they began to read the prizes, in Philosophy, in History, in Mathematics; the recipient was always Ethan D. Alyea. He had six friends, and one after the other he had them go up and accept his prizes.

Now to relate when I decided to become a chemist.

It was in his Junior year that my brother, Ethan, came home from Princeton for a week-end, and brought four of his classmates with him. One of these classmates was Charles P. Smyth. Ethan pointed him out to me, saying, "This man is going to be a Chemist." Now I had already, for a couple of years, played around with Chem-

Craft sets, with much curiosity. But, suddenly, here in my own home was a real live Chemist. I looked upon Charlie Smyth in rapture, and at that moment decided, "Oh, I want to be like him!" [laughter] Isn't that amazing? Little did I realize that I would become one of his colleagues for many years.

Edwin, the younger of my two brothers supplies a Lab Manual.

ALYEA: When I was about twelve years old I wrote to my brother, Edwin, then a Sophomore in Princeton. (He became a doctor at Johns Hopkins, later (1929-1970) at Duke University, whose Urology Clinic bears his name.) I still have the card on which I wrote, "Dear Ed: please bring home some sodium nitrate, carbon, and sulfur." Those are the ingredients in gunpowder. He never brought them, thus depriving me of the opportunity of being originator of the Big Bang Theory, half a century before the Astro-physicists concocted their Theory. [laughter]

Instead, he brought home Baskerville and Curtman's Qualitative Analysis (301) that the Sophomores were using in Princeton. In those days students spent an entire year on Qualitative Analysis.

We lived in an old Dutch house with beams two feet square. You couldn't possibly burn it down. I made a chem lab down in the cellar there, with an asbestos (!) mat, and gas. And, at twelve years of age, I carried out all the qualitative analysis experiments there in Clifton, New Jersey, in this old Dutch house. I did what the Sophomores were turning out at Princeton. I balanced all the chemical equations, and thought I was having the most fantastic time

in the world! From then on, there was no question: I was going to be a Chemist. Obviously, I had no problem in getting an "A" grade in Princeton in Qualitative Analysis seven years later!

My Father supplies the Chemicals.

STURCHIO: Was your father in the chemical industry?

ALYEA: No, my father was in business. My father was originally a banker. They wanted to send him out to Chicago to take over their Chicago branch, but he didn't want to leave the East, where his family was. So he left them and worked for the Mutual Life Insurance Company. I wouldn't say it was a menial job; he was in charge of three hundred people. (My grandfather had an even more responsible job. He had 600 people under him. He cut grass in a cemetery.) [laughter]

My father was in charge of the Foreign Department of the Mutual Life Insurance Company. It was quite a responsible job, apparently, but his life was his Sunday School. He was superintendent of Sunday School of the Clifton, NJ, Reformed Church. He would come home from work at five o'clock. That was very early in those days, because he left New York at four o'clock. Usually people worked until half past five or six. I can still see him coming in, taking off his coat, and going into his study to get ready for the Sunday School. He worked until midnight on Sunday School business. Every Sunday 1000 children attended; every kid in town. You see, there was no

other large congregations, Catholic or Episcopalian, in Clifton at that time. The day's attendance was posted prominently in the assembly room. I still recall rainy days, when my father was disappointed if the posted number fell below 1000. So many came, that it was necessary to have both morning and afternoon sessions. It had 125 Teachers. Mother was superintendent of the Junior, Auntie of the Primary, and Grandmother of the Beginners Departments. For Father it was a major operation; and he did this for twenty years, gratuitously. I cannot resist relating a comical story about my Grandmother, Mrs. Dinsmore, Superintendent of the Beginners Department. Each Sunday, when the little tots put their pennies in the collection plate, they sang

"Hear the pennies dropping; listen while they fall;
Every one for Jesus, He will get them all.
Dropping, dropping, dropping, dropping
Hear the pennies fall; Every one for Jesus;
He will get them all."
(Repeat.....)

One little girl reported to her Mother who told it to Mrs. Dinsmore. Her little girl knew better than that; she saw Mrs. Dinsmore put the pennies in her black bag, and take them home! [laughter]

Father went to New York each work-day. At one time he had about a thousand chickens (by the time I came along he kept about 300). Each work-day he would take a huge basket of eggs to the New York Fulton Market. The eggs were stamped ETHWINBURT after his

three sons Ethan, Edwin, and Hubert. The income from them put us through college. As a lad I would walk about 2 miles to the Quarantine to get prize eggs shipped in from Denmark to be hatched in Clifton. We enjoyed a full, happy, family life.

My father, who worked in New York, was sufficiently cooperative to bring home all of the chemicals Hubert needed (including 100 grams of potassium cyanide for the analytical separation of antimony from copper; those were innocent days).

UNDERGRADUATE COLLEGE YEARS (1920-1925)

Playing the 'Cello.

We were a musical family. The Alyea home resounded with the strains of our music, all my childhood.

Mother studied with the finest Church Organist in New York City, intending to make it her profession; instead she devoted her life to her family (including pre-school teaching her children). Father was a jolly banjo player. Ethan, my older brother, studied with the New York Philharmonic's first cellist. Edwin, my youngest brother, played violin; but in College discovered he had a better voice, and was leader of the Princeton Glee Club.

My Mother taught me to play the piano at an early age. I began 'cello lessons when I was about eight. I continued taking lessons throughout High School, travelling by trolley two hours each Thursday from my home in Clifton, NJ, to my teacher (a Mr. Klauder) in East Orange, NJ.

The Triangle Club.

One of Princeton University's greatest extra-curricular activities was an amateur theatrical group called The Princeton Triangle Club. Seniors, upon leaving Princeton, yearly voted winning a "Triangle Key" (awarded for three years' service in the Club) as desirable as a Varsity P in athletics. I played my 'cello in the Triangle four years.

Each Christmas-time the Triangle would take a fabulous three-weeks' trip, playing one-night stands. We travelled in two sleeping cars which were attached, each night, to some express train. In 1921-2 we played in Plainfield (NJ), Pittsburgh, Cincinnati, Louisville, St. Louis, Milwaukee, Detroit, Toledo, Buffalo, and New York. In 1922-3 we played in Wilmington, Baltimore, Pittsburgh, Cincinnati, Nashville, Memphis, New Orleans, Birmingham, Atlanta, Jacksonville, Savannah, and Montclair (NJ).

In 1923 the Triangle Club rented the NY Metropolitan Opera House and played there to 2000 Princeton Alumni and their families. That year (Frank) Chapman sang while I accompanied him with a 'cello obligato. (Chapman was later a singer in the Metropolitan Opera, and husband of Gladys Swarthout.)

Playing the 'Cello for Hollywood's Great. (1932)

Another interesting Triangle Club event occurred in 1932. When I came back as an instructor, the students thought that it would be fun to have me along, since I had taken three Triangle trips. I said, "Okay. I won't take the trip because I would cheat someone young out of it. But I'll come out and practice with you, and I'll play in New York, Philadelphia, and at the McCarter Theater" (it had just been built).

So I sat in the pit in McCarter Theater its opening night in February, 1932, while three undergraduate architects danced on the stage above me: José Ferrer, Josh Logan, and Jimmy Stewart! Three Princetonians who later made good in Hollywood. There was no

department other than Art and Archaeology open to artists in Princeton in 1932.

The Banjo Club.

I'm the only Princetonian who ever played the 'cello in the Banjo Club. This is how I got a free trip down to White Sulfur Springs and The Homestead, in Virginia, for ten days in 1922. All our Banjo Club had to do was to play for the guests an hour each evening. Forty-two years later, when I received the Chemical Manufacturers Association Award in 1964, it was presented at a banquet in White Sulfur Springs. I remarked to the fellow sitting across from me at the dinner-table: "I haven't been here since 1922, when I played my 'cello here with the Princeton Banjo Club." He said, "Are you Professor Alyea?" I said: "Are you Carter, one of our best banjo players?" The two of us had not been to White Sulfur Springs for forty-two years.

As I recall our performances, there were three rows of seven chairs each. In the front row sat seven of the most wonderful Banjo players on the College circuit. And they played, while the guests listened and watched. In the second row were six football players plus a Banjo player. And in the third row six baseball players and a Banjo player. (Basketball wasn't important enough in those days to warrant a fourth row!) I, with my 'cello, was in the back.

The twelve athletes each had four dots on their finger-boards, showing where to hold their fingers. Every time the Banjo-player on their row nodded, they plunked! So Row 2 played one chord, and Row

3 played another. Seven front-row Banjoes and two chords in the rows behind them. With Alyea in back of them all, playing a melody or obligato; heard but not seen! [laughter] That is how I got a nice free trip!

A Triangle Song: "Marriage by Radio."

STURCHIO: I'm curious about "Marriage by Radio" in the Triangle Club Show.

ALYEA: I sang that song last Fall. You see, in 1921-1922 we included, amongst other cities, Cleveland, Birmingham, and Jacksonville. I lectured last Fall in Birmingham to six hundred people, and sang them this song. I lectured to two thousand people in Cleveland at a science convention, and sang this song. I lectured to three hundred chemists in Jacksonville, Florida, at an Anheuser-Busch brewery, where on the wall hung the picture of their President, son of Augie Pabst (my classmate). So I sang this song those three times last Fall. I had not sung it since 1921. Just a month before I left, one of the girls in the chem lab was getting married. When I got over there they said I could not leave until I told them a joke. "Professor Alyea, you've got to tell us a marriage joke, because Elaine is going to get married on Saturday." "The only marriage joke I can think of I can't tell you girls." [laughter] "But I'll tell you what I'll do. I'll try to remember a song that I played my 'cello to, back in 1921." In the various cities I have mentioned above I would say: "I played my cello in

your vaudeville theater (I'd found out which theater in each place), back in 1921, sixty-four years ago. And this is the song."

In 1921 they didn't have television. The radios didn't have speakers. All they had were earphones. They advertised in the New York Times, "Tune in on WOR at five o'clock on Saturday, and you'll hear the first marriage by radio. The groom is in New York, and the bride is in Chicago. You'll hear the first radio-marriage." Well, that Fall the Triangle Club wrote this song. Wally Smith, who wrote "Ships that Pass in the Night," and many others, and who was President of the Triangle Club later, sang it. He was up on the stage, in the old building that was later burned dow while Students, singing "Keep the home-fires burning" kept firemen at bay. He sang while I played my 'cello. I think it was staged with Wally singing, with violin and 'cello accompaniment. This is how it went:

"Tarka, did you hear about the wedding that was held by radio?
Here was he, there was she, miles in between.
He said 'yes', she said 'yes'; no one was seen.
Now when the wedding ceremony ended,
The poor groom curled up and died!
What do you suppose was the matter?
He could hear them all kissing the bride." [laughter]

MY BOUT WITH POLIO (1923)

STURCHIO: Did you get polio in your Junior year?

ALYEA: No, in the Fall of 1923, my Senior year. I had come back early, and my roommate and I had taken a room. He hadn't come back yet, and I was all alone. I went down to the Infirmary because I had this awful headache, but I had no fever. In fact, they fired the doctor who hadn't spotted it, because they had two cases of polio in Princeton at the time. The Infirmary wouldn't take me. "There's nothing wrong with you; go on back." All night, I had this horrible headache again. The next morning, down to the Infirmary. Again, turned away. From there I went to the Chem Lab to set up a van't Hoff boiling-point apparatus. But I couldn't raise my right arm. I suspected something wrong, and set off for the Infirmary again. On the way there, my knee gave way and I fell. That is when the Infirmary suspected polio. Dr. [William] Draper came down from New York, made a lumbar puncture, and confirmed polio.

Where did I catch polio? I had been a councillor at a boy's camp in Connecticut that summer, where no one had it; so I couldn't have caught it there. But the week before this I had attended the Chemical Show in New York City, and undoubtedly must have caught it there. I had a heavy coat on, and it was a hot day. The doctors guessed that I must have encountered somebody. Chemistry gave me my polio. [laughter] Today, I only have one muscle in this leg,

instead of four. It's putting pressure on my knees, and my knees are getting very weak. In my Christmas card this year, I said, "Mother Nature's catching up with me. My knees are getting weak, but my morals are still strong. I wish it were the other way around, it would be much more fun." [laughter]

STURCHIO: Did you have to take a year off?

ALYEA: Yes, but it was not a wasted year.

I am grateful for that polio; if I had to choose my life over again, I would include polio. That year in bed changed me from an adolescent into a mature adult. It formulated two codes by which I would live for the next seventy years:

1- "This, above all else, to thine own self be true; then thou cans't not be false to any other man." (An abbreviation from Hamlet.)

2- The concluding remarks by President Horace Mann at Antioch College's first graduation exercises. Deemed so sage that they were chiseled into a stone slab that stands in the center of the Antioch College campus, for students to read, as they pass it, to and from their classes:

"Young Gentlemen, I beseech you to give heed to these my parting words: Be ashamed to die until you have won some Victory for Humanity."

And I learned other things that year. I learned how to type 140 words a minute (but sometimes misspelled!).

I learned to be patient.

I learned some Physical Chemistry; Professor [Hugh] Taylor sent me Physical Chemistry Textbooks and worksheets from Princeton (Great Teachers do things like that).

I remained in the Princeton Infirmary for about two weeks. Then I was taken, by ambulance, to my home in Montclair, NJ. There I remained in bed for nearly a year. After that I was on crutches for about two years. Since then I have run like a deer until last year, when Post-Polio Syndrome caught up with me.

You see, polio does not destroy the muscles; it dissolves the nerves; and the muscles subsequently atrophy from lack of exercise. Nerves from my 3rd and 4th lumbar region had been destroyed. Rehabilitation consisted in protracted 2-hour daily gentle exercises to train adjacent nerves to take over the function of those destoyed by the polio.

Once a month I was taken by ambulance to the Grand Central Station, then by night train to Back Bay, Boston, then by ambulance to 234 Marlboro Street, where Dr. [Robert] Lovett's staff evaluated the strengths of all my muscles and instructed my Mother in exercises for me to do the following month.

Dr. Lovett was the world authority in this treatment. At the time of the 1917 polio epidemic, the New York doctors brought Dr. Lovett down from Boston to direct them. While Dr. Lovett was treating me, he was also treating Franklin D. Roosevelt. I move only in the best of medical circles. [laughter]

To appreciate the fundamental goodness of human nature, have someone push you through Grand Central Station in a wheelchair. Hundreds of people will look upon you with pitying eyes.

After my polio my Mother restored my life. She supervised and participated in the daily 2-hour exercises for a year. When I returned to Princeton, on crutches, I had to swim in the Gym Pool two hours a day. I had been naturally athletic; a boy with two older brothers has to be in order to survive! I was 2nd from the top in handball in Princeton. But those daily swims! Ugh! I hope I never have to swim again. If, after death, I am condemned to Hell it will be to swim til Eternity in Hell Pond. [laughter]

Because of my polio, I had two remarks that entertained my Students. First, I was in the class of '24 but didn't graduate until 1925. They thought it amusing that their Professor took 5 years to get through Princeton. Second, I would advise them: "Fellows, when you turn 20, a valuable experience is to spend a year in bed, alone. [laughter]

MY MOTHER (1923)

STURCHIO: Tell me more about your mother.

ALYEA: My Mother was unbelievable! Don't get me boasting about her! She was one of the most intellectually active persons that I have ever known. My father had been very sick with Parkinson's Disease for fifteen years, and when he died my mother came down here to Princeton and lived in Palmer Square for a decade. She was very independent. In her eighties she attended three summer schools at the theological seminary, and took thick notes that would put the ministers to shame. In fact, about this time the voluminous Interpreter's Bible came out. She went to order three sets each, for her sons, at the book store on Palmer Square. But the salesman said, "We never heard of it." "Oh, you must have; they told us about it at the Seminary Summer School." "No, Mrs. Alyea. You're the first one to ask about it." The next week he said: "Well, Mrs. Alyea, you beat all the Ministers. They have been coming in here, in droves, all week."

Here is an example of her fantastic memory. When she was 82 years old, Mr. [Francis Theodore] Tilton, Clerk of our home town, Clifton, NJ, came down to Princeton to see her. He said, "Mrs. Alyea, I'm writing a history of Clifton. Unfortunately, the records were burned up. We have here fifty names. Can you tell us anything about these fifty people?" And Mother gave him the dates of birth and death of forty-two of them. (I can't even tell you when my own Father and Mother died.)

Well, the question was, was she right? Six months later, he sent my Mother a letter. He wrote: "We found a duplicate set of records in the Paterson Court House. Here's what you said, and here's what's in the records." She was exactly right on thirty-eight of them but was wrong on one count each on four of them. Instead of being proud, Mother was furious. She exclaimed: "The idea! (Mamie) Aspel the 25th of April! She always celebrated her birthday on the 15th. Old Dr. van Riper was so slow recording it that he put down the 25th!" [laughter] We never looked up phone numbers. She could tell us instantly.

When Ethan went into law, and Edwin went into medicine, and I went into chemistry, she immediately became an authority in these three fields, and conversed professionally with us. I recall returning from my year in Hawaii, and my Mother enquiring, "Did you see Queen Kapiolani's famous throne?" "What?" said I. "Why Hubert," said Mother, "didn't you learn anything about the history of Hawaii!"

Mother traced the Alyea family history back to 1664, when Jan D'Allie settled in New Jersey. Then she communicated with Mayor D'Allie of Amsterdam, and traced us back to 964 A.D., to the French estate of Allie-sur-Haute-Cloche, near Amiens, France. And Cardinal D'Allie, President of the University of Paris, and guardian of the royal jewels in Saint Chapelle. When my brother was entertaining a Dutch lawyer visiting him in Montclair he was asked: "The Mayor of Amsterdam is corresponding with an interesting old lady in Princeton, NJ, Sarah Alyea. Do you know her?" "Yes,"

responded my brother, beaming, "she is my Mother."

All three of Mother's sons made it into Who's Who, but in the wrong sequence. Ethan, the genius of the family, was the last to get in. Edwin, the dumb one of the Alyea boys, got in first. Only Hubert was entered properly. (But Ed was not that dumb; he graduated third from the top of his class in the Johns Hopkins Medical School.)

THE PRINCETON CHEMICAL FACULTY (1920-1928) (1930-1950)

STURCHIO: Who were some of the Professors who taught you in Princeton?

ALYEA: Here is a list of them, and some personal remarks.

My Princeton Professors. (1920-1928)

General and Inorganic: [William] Foster, [Alan] Menzies, [Charles P.] Smyth.
Analytical: [D. P.] Smith, [LeRoy] McCay, [N. Howell] Furman.
Organic: [Lauder] Jones, [Frederick] Neff, [Gregg] Dougherty.
Physical: [George] Hulett, [Hugh S.] Taylor, [Abraham L.] Marshall, [T. Jefferson] Webb.

Later Princeton Professors (1930-1950)

After I joined the Faculty in 1930, the following Professors became my colleagues at various periods during the next two decades.

General and Inorganic: [William] Foster, [Alan] Menzies, [Charles] Smyth, [T. William] Richards, [John] Turkevich, [Richard] Powell, [Wendell] Taylor.

Analytical: [D. P.] Smith, [N. Howell] Furman, [Earl] Caley, [Clark] Bricker.

Organic: [Gregg] Dougherty, [Eugene] Pacsu, [Everett] Wallis, [John] Lane, [Edward C.] Taylor, [Kurt] Mislow, [Maitland] Jones, Jr., [Martin F.] Semmelhack.

Physical: [Hugh] Taylor, [Robert N.] Pease, [Henry] Eyring, [Donald S.] McClure, [Robert A.] Naumann, [Leland C.] Allen, [Arthur] Tobalsky, [Thomas] Spiro, [John T.] Groves, [Steven L.] Bernasek, [Zoltan] Soos.

Chemistry Department 1984-1985

Professors:	Associate Professors:	Director of Undergraduate Laboratories:
Leland C. Allen	Steven L. Bernasek	Miles Pickering
Maitland Jones, Jr.		
Donald S. McClure	Assistant Professors:	
Kurt M. Mislow	Andrew B. Bocarsly	
Robert A. Naumann	G. Charles Dismukes	Lecturer:
Herschel Rabitz	Andrew D. Hamilton	Joseph E. LaPrade
Jeffrey Schwartz	Andreas Mayr	
Martin F. Semmelhack	Jeffrey K. McVey	Emeriti:
Zoltan G. Soos	Robert A. Pascal, Jr.	Hubert N. Alyea
Thomas G. Spiro	Warren S. Warren	Walter Kauzmann
Edward C. Taylor		Charles P. Smyth
		John Turkevich

PERSONAL NOTES

MY ELEMENTARY AND INORGANIC CHEMISTRY TEACHERS

[WILLIAM] FOSTER was a thorough gentleman of the Old School. An interesting, but not inspiring lecturer, and concerned in the progress of each of his 200 students. Aside from his Doctor’s Thesis on thio-arsenates he did little research.

Allan] Poe, McCay was a confirmed bachelor, but at tea-parties was always surrounded by a lively group of ladies. McCay was a pupil of [Robert] Bunsen at Heidelburg, and of [Clemens A.] Winkler at the Freiburg School of Mines.

In lecturing, McCay became an actor. I took his course in the History of Chemistry in which only I and another student were enrolled.

But McCay, to the two of us, would dramatize a reincarnation of some event in chemical history, as though he were entertaining an audience of 500.

Dr. McCay's field of research was arsenic, arsenic, arsenic. He is undoubtedly now reclining on a throne of pure arsenic in Heaven. [laughter] McCay prepared and characterized various sulf-arsenicals. After any Chemical lecture, the first question would come from McCay: "By the bye, what is the effect of arsenic on that reaction?"

McCay in his lab late one night, forgot to lay away, in his ice-box, a plate containing crackers smeared with butter or margarine. The next morning, being an observant scientist, he noticed that the mice had nibbled only the butter. McCay's mice-nibbling test became an official test in World War II for distinguishing butter from margarine.

McCay had a plethora of stories. An example: [Robert] Bunsen, in Heidelburg, whose hands were calloused from glass-blowing, would be blowing glass the day a new student entered the lab. Bunsen

would hand the hot glass rod to the neophyte, who would obviously drop it. "Young man," Bunsen would thunder, "before you leave my tutelage, you will be able to handle glass that hot."

Another McCay story. Analytical chemistry, and mineralogy, were important from 1860 til 1925. Winkler at the Freiberg School of Mines, with whom McCay was studying, had a salt of glucinium, today called beryllium. Now one analytical procedure in those days was to precipitate a salt, collect the precipitate on a filter paper, ignite the paper, and finally carefully weigh the ash and precipitate. The weight of a filter-paper ash was known, so the weight of the ash could be calculated.

Now one day as Winkler was carrying on this operation, a fly entered his laboratory and alighted on the precious precipitate. You see, glucinium salts are sweet, like glucose; that is how glucinium got its name. To Winkler's horror, the fly plunged its proboscis into the precipitate, and sucked up some of the precious stuff, rare as can be. Winkler caught the fly before it flew away. He ignited the fly and the precipitate. Now the only trouble was that he didn't know the weight of fly-ash. So he summoned his students. He had twenty students, and each student had to catch him two flies. He took forty flies and ignited them. Then he divided by forty, and got the weight of the ash of one fly. He subtracted that, and got marvelous results. [laughter]

Another McCay story. In the same lab was a glass tube

containing gallium (m.p. 29.75°C.) predicted by [Dimitri] Medeleff in 1871, and discovered four years later by [Lecoq] de Boisbaudraan. There was, of course, no air-conditioning in those days, and the lab rule was that if the gallium became liquid, it was too hot for lab-work. So, when the day was moderately warm, and the Geheimrat was seen entering the lab, the students could win a holiday by warming the tube of gallium in their hands. [laughter]

[N. HOWELL] FURMAN, one of the Chemistry Department's finest teachers. His lectures were soporific (even he almost went to sleep!). But in the lab, how different! Furman stood beside you, demonstrating some analytical operation, then watching you perform it, then questioning what you did, and why. He was wonderfully empathic. Furman was co-author, with [H. H.] Willard of Michigan, of a popular Analytical Chemistry text ( ). Furman was President of the American Chemical Society.

MY ORGANIC CHEMISTRY TEACHERS (1920-1928)

[GREGG] DOUGHERTY I don't recall, who lectured to me in beginning Organic Chemistry; probably a composite of all the Organic Professors. Gregg Dougherty ran the lab; six hours a week. He was young, affable, and accessible.

A year later he gave his first graduate course. He lectured on Alkaloids and Natural Products. [Harold] Beatty and I were the only ones taking the course. Gleaning his information from huge tomes, Gregg wrote, and wrote, countless complex formulas on the blackboard, while Hal and I copied pages and pages. At the end of the course, Hal said to me: "Hubert, I don't know what I'm going to do about that final exam." (There weren't any other exams, just the final.) "I'll make a pact with you. You're going to get an A, and I will get a B. If you agree to write only ten pages, I'll agree to write only five pages." Well, I didn't think that was against the honor system. I wasn't getting any help from him. I was delighted because I wondered how I was going to write all I knew. Then I said, "Okay, Hal, it's a deal." It was a three-hour exam. I condensed into ten sheets more knowledge than any human being in the world had ever condensed, all on alkaloids and natural products. [laughter] In half an hour, I was finished, and Hal was finished. His was five pages, mine ten pages. I think we sat around and smoked until just fifteen minutes before the exam was to end. Gregg came in, and asked, "Are you fellows finished?" "Oh, yeah, we finished long ago." "Fine, I'll take your papers." Sure enough, I

got an A and Hal got a B. The years passed. In fact, fifty years passed, and Gregg retired. The day he retired I told him I had something to confess. He said, "Hubert, you have cleared up a mystery that has been with me all my life. I took your papers and thought, 'Let's see how much I can teach these young fellows.' I picked up Harold's paper. Five pages; is that all he knows! Well, let's see what Alyea has. Only 10 pages? Well, I guess that's all they could learn. The next year I got fifty and sixty pages. I thought, 'Gee, am I getting better.'" [laughter]

DOEL: That's a good story.

ALYEA: Dougherty's research was in the field of organic sulfur compounds.

Two of Gregg Dougherty's Ph.D. students became famous. One was [Otto] Haas, President of Röhm and Haas Company. The other was [John] Wallace. Jack received his Ph.D. during the depth of the Depression in the 1930s. When he could not find a suitable job, he did the next best thing; he married an heiress, [Betty] Lambert, daughter of Colonel Lambert, President of the Lambert Industries (Colgate, Palmolive, Peet).

In 1937, during the second Depression Jack invented and, with financial help from his father-in-law, marketed the anti-perspirant, ARRID, whose sales quickly outstripped its competitor, MUM. Jack told me that his intentionally misspelling "arid" paid millions in dividends. A lady, having heard about it at a bridge party, would

later see a jar of ARRID in the drug store. The misspelling hooked her! Jack and his wife personally bottled 3000 jars of ARRID its first year; shortly, sales soared to millions of jars annually.

Subsequently Jack Wallace was one of the first to market an antibiotic. He named it MILLTOWN after the New Jersey town in which it was manufactured. But he removed it from the market because too many people were allergic to it.

[WILLIAM LAUDER] JONES was our top Organic Chemist when I was a graduate student here. His one-term lecture series on Organic Nitrogen Chemistry (he had worked with [John U.] Nef in Chicago) was phenomenal: clear, concise, exciting.

Lauder Jones (Chairman of the Department before Hugh Taylor) would have enormously enhanced Princeton's reputation in the late 1920s, but for a terrible tragedy that befell his charming young daughter. I knew her when we were both about twenty years old; she played her violin, and I my 'cello, in Haydn's Toy Symphony in Miss Fine's School in Princeton. In the summer of 1927 (?) she and her father went on a trip to the Grand Canyon. Lauder Jones's daughter got too close to the edge of a cliff, and slipped over it; but arrested her fall by clutching a bush. Her father called, "I'll help you," and knelt down to rescue her. But unable to hang on any longer, she fell to her death. Her father had been that close to saving her.

Well, Lauder Jones cracked up completely. He left Princeton

and began to travel abroad for the Rockefeller Foundation. In fact, when I was studying in Berlin in 1929, he came through with his sister, and I spent the day with them. But he did no further research; nothing. That was the end of his career.

Lauder Jones's Role in the Origin of the Frick Chemical Laboratory (1916, 1929)

[William Lauder] Jones was responsible for the Frick Laboratory being built. It's an interesting story. [Henry Clay] Frick, the great steel magnate, had promised Princeton a million dollars (or more?) for a chemistry laboratory. It was an enormous amount of money in those days. Then he died, and the war came. About 1920 Lauder Jones came to Princeton. He went to President [John Grier] Hibben, and said, "The chemistry department's been promised a million-dollar laboratory." Hibben replied, "We don't have the money, so we can't give it to you." "But, President Hibben, we've been promised it." (What had happened was that Frick left his money to Princeton, but didn't ear-mark the million dollars for the Chem Lab.) "I'm sorry but it was a verbal promise, and we have no way of taking that money and spending it for a Chem Lab." "But we were promised." "Well, Lauder Jones, if you can tell me how to raise a million dollars you will have your Chem Lab." Jones said, "I will tell you how to do it. Raise tuitions." And Hibben said to him, "You shall have your Chem Lab." And so it was built on raised tuition. Isn't that an interesting story? Hugh Taylor told me this, so I'm sure it is true.

Two of Jones's graduate students were [Everett] Wallis, who

became a Professor here (stereochemistry), and [Randolph] Major, later Director of Research at Merck and Co.

[Lauder] Jones also brought in [Eugene] Pacsu from Budapest, an eminent sugar chemist, colleague of Princeton's [Claude] Hudson. I later, during the war years, had the opportunity of auditing some of Pacsu's graduate lectures. He was a delightfully lucid teacher, always establishing a simple background before launching into complex subject-matter.

FREDERICK NEHR, near retiring age, offered a one-term Graduate Course covering special topics in Organic Chemistry. His lectures would have been boring, but for the fact that he was a superb raconteur, and we students would purposely divert him from his formal lecture notes to hear tales about famous scientists he had known. He did little research of note.

MY PHYSICAL CHEMISTRY TEACHERS (1920-1928)

[GEORGE] HULETT, a prominent electrochemist, was Princeton's chief physical chemist during the first quarter of this century. But by the time I was ready to attend his lectures, Hulett had had a stroke and become considerably incapacitated, and Hugh Taylor had replaced him. However, I had contact with Hulett another way. As a Senior on crutches (which I needed just enough to get my car on campus) [laughter], he had me measure his Standard Voltage Cells. Hulett had made them back in 1905, and here they were 20 years later. I think they produced a standard 1.183 volts. The cells contained mercury compounds, but they react with water and deteriorate. He had about 300 of these cells. I was to measure carefully, and find out the ones that weren't any good, and why they weren't any good. In those days standard voltage was an important thing. Standard cells were what Hulett was famous for. That whole year I must have put in at least two hundred hours of work, measuring these old cells that he had, that were now twenty years old, to see whether they had deteriorated or not. And then he got a stroke, and became incapacitated. He could still lecture a little bit, but not too much. That's when Dr. Taylor soared into prominence, in 1925, just when I was graduating. Dr. Taylor took over and really made a name for himself in the field of catalysis.

[THOMAS JEFFERSON] WEBB taught undergraduate Physical Chemistry. In 1927 I took his graduate course in Quantum Mechanics. He did not teach; he simply threw the material at you, by writing it on

the blackboard. I first met Jeff, an affable Southern gentleman, in the Fall of 1926 in Sweden when, upon returning to the States after a year with [Peter] Debye in Zurich, he stopped off and I took him over to introduce him to Svante Arrhenius (Jeff remarked it was like calling on God). His course, and one I took later, from [Eugene] Wigner, paid me dividends, when I presented a course in Quantum Mechanics at the University of Hawaii, where I was a Visiting Professor in 1949-1950. Webb later joined Merck and Co.

[ABRAHAM LINCOLN] MARSHALL ran the Physical Chemistry Lab. He was friendly, apparently billiant in research, but not a teacher at heart. It was exciting to see him skillfully glassblow and assemble complex apparatus. He left shortly to join the General Electric Company in Schenectady.

SIR [HUGH STOTT] TAYLOR was God's gift to Princeton. Little did [George] Hulett know when, in 1915, he invited the young Englishman, fresh from [Svante] Arrhenius in Sweden, and [Max] Bodenstein in Berlin, he was importing a Physical Chemist who would set the Chemistry pace in Princeton for the next half century.

Until the 1920s Analytical Chemistry was most important, with [LeRoy] McCay in the driver's seat. Chemistry was clearly divided into Analytical, Organic, Physical, and Inorganic. Today these boundaries have become less important. By the mid-twenties, aging Dr. McCay had yielded to Organic Chemistry, with [Lauder] Jones in charge. Then came the tragedy described above. [Hugh] Taylor, the

Physical Chemist, took over the reins. Within a decade Taylor had established a world-wide reputation with Princeton as a center of catalysis research.

I have known, of course, hundreds of famous chemists, and worked with four Nobel Prizemen: [Svante] Arrhenius, [Fritz] Haber, [Cyril] Hinshelwood, and [Linus] Pauling. I think that Taylor, as a research chemist, ranks with them. In fact I always felt that Taylor and Hinshelwood should have jointly shared a Nobel Prize, and [Nikolai J.] Semenoff, who was better than either of them, been awarded a single Nobel Prize instead of sharing one with Hinshelwood (305). Taylor's research acumen was phenomenal. At the conclusion of any seminar he would raise the most poignant question of the afternoon. The many publications of his graduate students reflect his extraordinary inventiveness. Within a decade Taylor had elevated Princeton to leadership in catalysis research. When [Henry] Eyring came to Princeton in 1931, a remarkable symbiosis between Eyring and Taylor occurred: young new ideas restrained by mature judgement.

[Hugh Stott] Taylor was not only a brilliant Chemist, but a wonderful human being. Underneath his apparent bluster, was a shy person; it made him appear aloof. He was deeply religious, attending Mass almost daily, and was a member of the Vatican Scientific Advisory Committee. Unfortunately his defiant posture as an Englishman living in America invited animosity in some chemists in the American Chemical Society. Retribution came when he was elected President of the prestigious Faraday Society, which carried with it a Knighthood, so that he became Sir Hugh.

Taylor, when discussing research, was inspiring; in fact [Bright] Wilson told me that at Princeton he had enrolled to be a chemical engineer, and was assigned [Hugh] Taylor as a preceptor in Freshman Chemistry. Wilson said: "I didn't learn much General Chemistry from him, but when he began telling us about his catalytic researches, he became so excited, and inspired me so much, that I switched from Engineering to Chemistry. I reasoned, that if a person could get that excited about his work, it must be a challenging field." Wilson went on to become one of Harvard's brilliant Physical Chemists. His son recently, at Cornell, was awarded a Nobel Prize.

In 1931 [Harold] Urey announced heavy water. When Eyring came and worked with Taylor a great deal, in the early 1930s, they began to make heavy water. Princeton made more heavy water, probably, than anywhere else in the world.

Taylor became President of the British Faraday Society and delivered the Presidential address on the occasion of its 160th-year Anniversary. Cavendish, who had discovered hydrogen in 1781 belonged to this Society and attended dinner there, every Thursday, for years. Cavendish was an eccentric. He was uncommunicative. He never allowed women servants to come into his presence; and if they did, he would discharge them. His biographer characterized him as "The Richest of the Wise, and the Wisest of the Rich."

Hugh Taylor sat around with all these famous British

Scientists; then arose and held aloft a test tube full of heavy water. "Gentlemen," he announced, "just exactly a hundred and fifty years ago, Sir Henry Cavendish rose from this same table to announce the discovery of Hydrogen. Today I announce that here, in this test tube, is more heavy water than in any other place in the world." Taylor had just brought it from Princeton, and intended to continue research with it.

Later, upon returning to the United States, Taylor brought the tube of heavy water with him. When he got to the New York Customs, they asked him, "What's in there?" "Water." "What?" "Water." This went on and on. Finally, Customs telephoned Princeton University. "Do you have a Dean there who brings in a test tube of water?" "Oh, yes, that's Dean Taylor with his heavy water." That's how he got the heavy water through New York Customs. [laughter]

Although inspiring in the research field, [Hugh] Taylor put little effort into teaching his course in beginning Physical Chemistry. The year that I took his course, his lectures consisted of reading from that week's manuscript of the Physical Chemistry Textbook he was writing. It was dull. But later lectures on Catalysis were reputedly stimulating.

I sincerely admired [Hugh] Taylor, to whom I am deeply indebted for having made possible most of my professional career. However, although it is like biting the hand that feeds you, I must in the interest of historical accuracy report two instances, involving Taylor, where I was plagiarized.

The first instance involved my Ph.D. Thesis. Background for

the thesis was accumulated at the Nobel Institute during daily contact with Hans Bäckström, my mentor there. Upon my return to Princeton, actual research procedures were conceived solely by me. I recall, vividly, coming to breakfast in my home in Montclair, NJ, and proclaiming to my Mother: "Well, I know how I am going to solve my Thesis." (Taylor had nothing to do with my planned research.) But when he gave the Nichols Medal address much of his speech consisted in discussion of, and including tables from, my yet-to-be-published Thesis. He presented my data, remarking: "These data were obtained by Mr. Alyea in my laboratory," giving the impression that I had carried out Taylor's ideas.

The second instance was "activated adsorption," which I conceived in 1929, when working at the Kaiser Wilhelm Institute in Berlin-Dahlem with [Fritz] Haber. I became convinced that explosion chains of H2 + O2 were initiated by H-atoms adsorbed on the container walls. I named this "activated" adsorption because the term "activated state" was being applied to glowing sodium vapor by [Mark] Polanyi and [Henry] Eyring who were working in the same Institute as I. In February 1930 I wrote about this "activated adsorption" to Taylor. When Haber and I jointly published a paper that Spring, I wanted to include "activated adsorption," but Haber objected. "Dr. Alyea," he said, "that is too revolutionary. Our paper may be the last one I shall ever publish." (I think it was his next-to-last.) "I don't want scientists to say that Fritz Haber's last paper was incorrect. When you return to Princeton, you

can publish it and become famous; if it is wrong, you will have five years to correct your mistake."

I returned to Princeton, and for the next year argued vigorously with [Hugh] Taylor and [Robert] Pease in support of my theory. Finally I made measurements, and published the first paper that showed hydrogen was absorbed on quartz around 150°C., de-sorbed at about 250°C. and, especially, re-adsorbed again above 500°C.: "activated adsorption" (7).

When, three years later, [Henry] Eyring (who knew nothing about my previous theory) came to Princeton, he and Taylor tackled the problem, and re-named it: Chemi-sorption.

A few months before Taylor died, at a tea when we were alone together in a corner, Taylor gently remarked to me, "Hubert, didn't we have fun inventing high-temperature adsorption?" I refrained from reminding a frail old friend of many years, I had battled to convince him of it. I write this because in the literature it has been claimed that Taylor discovered activated adsorption ( ).

HUBERT CHOOSES TEACHING AS A CAREER (1925)

By the Fall of 1925 I had completely recovered from polio. I am forever indebted to Hugh Taylor for recommending my Ph.D. program. It was to

1- Apply for a American-Scandinavian Foundation Fellowship to study with [Svante] Arrhenius, director of the Nobel Institute in Sweden.
2- Continue my Ph.D. thesis work with [Theodore W.] Richards in Harvard. Richards was the No. 1 Chemist in the United States, the only chemical Nobel Prizeman here from 1903 until 1926. (Not only for the "Harvard purity" of substances made to measure atomic weights, for a fantastically sensitive balance for determining these weights, but especially for discovering the two lead isotopes: 207.22 in lead ores, and 206.00 in lead from the radioactive decay of Uranium-238.)

In the Fall of 1925 I went to Harvard to see Richards. In his office I found a kindly old gentleman, who enquired, "Do you want to be a Teacher or go into Industry?" I replied, "I think I want to be a Teacher." "Well," he remarked, "this is a very important decision in your life, isn't it? I see you are anxious to get to the football game." (I was.) "Suppose you come down to my house after the game." He was so kindly, and gentle; I immediately respected him.

After the game I went to his home. Like all undergraduates I stayed longer than I should have. Richards talked kindly to me like a father advising his son. "If you win the Fellowship to the Nobel

Institute, by all means go; then come back here and I will be glad to have you work with me." Accepted into Harvard Graduate School instantly like...that. (Of course I had a letter from Hugh Taylor saying I was one of five best students in Chemistry in the ten years he had been teaching in Princeton.) But today if you asked the Chairman of the Chemistry Department at Yale, Princeton, or Harvard, he would respond: "Well, go down the hall to Assistant Professor Smith; he handles our applications, and we will notify you next Spring."

I left Richards's home with only one resolve: To be a Teacher all my life, as much like Theodore W. Richards as possible. Little did Richards know that five years later, in Princeton, I would share an office for ten years with his only son, W. T. Richards.

Bill Richards knew how much I worshipped his Father, and upon leaving Princeton gave me a lovely 3 x 2 ft. framed photograph of him sitting in his laboratory. That picture hung over my desk in the Frick Chem Lab for 40 years. I had other pictures I could have hung up, too, but I stashed them away in my desk: the last photograph ever taken of Svante Arrhenius (by me) and autographed; a steel engraving (3 x 1 1/2 ft.) of Fritz Haber on which he had inscribed (in German), "To Hubert Alyea, in memory of the jolly days of Hydrogen-Oxygen ignition, F. Haber." A year after I retired, I took Richard's photograph (showing him seated at his lab-desk) and gave it to his daughter Dorothy Richards, Mrs. [James Bryant] Conant, wife of the President of Harvard. She thanked me for

returning it to her family, and said, "I will give it to Haverford, where Father studied, and they can hang it in the Richard Memorial Carrel in their library."

I won an American-Scandinavian Fellowship and went to Sweden. But upon returning they told me at Princeton: "Your work in Sweden is almost good enough for a Ph.D." (I had already taken and passed the Princeton Ph.D. prelims.) So I stayed on in Princeton and received my Ph.D. in June, 1928. What a lucky break it was in my life! If I had gone to Harvard I would not have finished my Ph.D., and a couple of years of post-doc work, until 1932. That would have been during the depth of the Depression, and Universities were not hiring Chemistry Instructors then. I would have ended up in Industry.

[J. N.] BRONSTED (1925)
Copenhagen

In the Fall of 1925 I went to the Nobel Institute on a American-Scandinavian Fellowship to work with Svante Arrhenius. En route I stopped off in Copenhagen, where two interesting events occurred.

The first was in the Tivoli Gardens, that make Disney World, New York's Central Park, and the San Diego Zoo seem third class. After visiting it, another young ship-mate and I went into its restaurant. But we hastily exited (prices were too exhorbitant for young Americans) and crossed the street to a huge Cafeteria. Prices there were amenable, but there was no printed menu; only a 80 x 30 ft. wall chart. But it was in Danish! Instead of asking the waitress (who probably spoke English more correctly than we), we attempted to translate. Good! There was “Ros Boef Soppa” (which we translated to be Roast Beef Supper, for only 75 cents, a price within our means).
We two hungry boys ordered it and sat, perched on our high stools, awaiting our sumptuous feast. At last it arrived: Rose-bud Soup! (not Roast Beef Supper). Rose-buds floating in sugar-water, a great Danish delicacy! (laughter). That night two young Americans went to bed hungry, but wiser: if you don't know, don't be hesitant in asking.

My second experience in Copenhagen was more delightful; I called on J. Christensen, whose pioneer paper (329) on chemical chain-breaking was to be the cornerstone of my Doctor's thesis, and

he took me in to meet [J. N.] Bronsted, author of an important Acid-Base theory. Bronsted took a liking to me (and I to him; he was a charming, polished gentleman), and when he learned I was going to work with Arrhenius, he invited me to his home for dinner that night. At the dinner was another American, working with him, Robert Livingston. Mother Nature plays such tricks on us humans! Little did I anticipate that four years later I would spend a year with Bob as a colleague at the University of Minnesota and, twenty years later, in a Government research laboratory, three war years in Washington, D.C.

[SVANTE] ARRHENIUS (1925-1926)

Nobel Institute, Stockholm

When I got to Sweden I was the last student [Svante] Arrhenius ever had. The Nobel Institute wasn't very big. There were about a dozen researchers there. I worked very hard, often past midnight. Arrhenius was 65, but in those days that was considered old. I was working with [Hans] Bäckström, who later came here when I was getting my Ph.D., and supervised the final getting of my degree. Arrhenius lived right next door, and he would come in twice a day, in the morning, and in the afternoon, "Well, Mr. Alyea, what have you done today? Oh, that's nice. Oh, that's nice!! Have you thought of doing so and so?" Well, I wasn't an idiot. Of course I hadn't thought of doing it, but it was much better than what I had thought of. "Yes, I think I'll do that this afternoon." "Oh, good, oh good!" I can still see him, shuffling away. That one time I cheated. I could see him as he walked away saying, "Gee, that's a bright young fellow, he thinks of things before I do." [laughter] Just once that happened; the rest of the time he would come in and we would discuss what I was doing.

He had a cat, who came in with him each day. She loved to wind in and out of all the delicate apparatus, and look up triumphantly when she got to the end without knocking anything over.

This is an amusing story that Arrhenius told me. When he was eighteen he was working at a chemical factory one summer and the

director of research, just for fun, gave him a little cork-stoppered vial with mercaptan in it. Now you know what hydrogen sulfide smells like: rotten eggs. Mercaptan smells like ten thousand rotten eggs. Awful! Just for fun, his boss said to Arrhenius, "Get rid of this, will you?" So Arrhenius was riding his bicycle into Stockholm, and threw the vial into the Malaren, the waterway in Stockholm. Unfortunately, the cork came unstoppered and the mercaptan spread like a cloud all over the southeast portion of Stockholm. For two days they had the most awful odor you could possibly imagine. They set up a learned chemical committee to investigate it. After two weeks, the Committee issued a sophisticated report: "Something meteorologically very unusual had happened. On one side of the city there was a pulp mill that generated SO2 and other gases, and on the other side of the lake there was a petroleum refinery releasing various gases. The winds had blown the two emissions together and they combined to make mercaptan." (They recognized the mercaptan.) "It was a very unusual meteorological condition, which they didn't think would happen again." Arrhenius said, "I knew it wouldn't happen again." [laughter]

With Arrhenius, you couldn't be with him for a minute but realize what a sharp, bright mind he had. He was alert to everything that was occurring. He drank excessively, but he was never intoxicated. Because I was an American-Scandinavian Fellow, I sat right up in the front row at the Nobel Prize dinner, December 1926, at the foot of a long table at which sat fifteen Nobel Prizemen. Arrhenius had the center seat, and he acted as host. He

would jump up and drink German Schnapps with [James] Franck, French wine with [Jean] Perrin, tea with an Englishman, and Swedish Punch with [The] Svedberg. Arrhenius elicited gales of laughter amongst his guests by toasting, with great fanfare, an American with a glass of water (our USA had Prohibition then). At the conclusion of the dinner, everyone at the head table was tipsy excepting Svante Arrhenius; he remained cold sober.

At times Arrhenius's scientific enthusiasm outweighed his responsibility as a host. I recall a formal dinner at his home one night (and the Swedes can be very formal) with all the gentlemen in Tuxedos. Just before the guests were summoned to dine, there was a magnificent display of Northern Lights. In Sweden it is a fantastic, unique, spectacle. Not the colored spectrum of lights that one views to the North in the States. No, the entire sky directly overhead is completely filled, like a canopy, with throbing broad shafts of white light. Arrhenius insisted on taking all of the guests (the ladies were bored stiff) out on to the lawn where he proposed his theory of ionization as the cause of this magnificent display. Dinner grew cold. Arrhenius was always excited about what the people in his Institute were doing. His example taught me to have, later in life, the excitement of a sixteen-year-old kid. I have the same excitement now that Arrhenius had when I studied with him. You can be just as excited, no matter what your age is, if you're really excited about chemistry.

Arrhenius showed special interest in exotic sciences, and

entertained visitors from foreign lands interested in Astrology, Parapsychology, and Pan-Spermia. He believed that spores might transport life through frigid space and generate life in other celestial bodies.

MY PH.D. THESIS (1928)
Chain Reactions and the Theory of INHIBITION
Illustrated by THE DOMINO EFFECT

STURCHIO: Tell us about your Ph.D. Thesis.

ALYEA: It confirmed thermal reaction chains and how they were broken by inhibitors.

THE PHENOMENON. You buy a bottle of Hydrogen Peroxide. It would decompose into water within 24 hours, but for the fact that it contains a pinhead of acetanalid (marked on the label).

QUESTIONS

1- How does it work?
2- What is a chain reaction? And an Inhibitor?
3- What happens to an inhibitor when it breaks a chain?
4- Why does so little of the inhibitor suffice?
5- Why does the inhibitor last so long?
6- How about other inhibitors?
7- How about concentration of inhibitor?

In 1928-1929 I lectured to nearly a dozen American Chemical Society Sections answering these questions in a lecture entitled "The Chain Reaction Theory of Inhibition." I illustrated it with the first lecture-demonstration I ever invented: A Domino Board. (One of my original domino boards is in the Beckman Museum.)

ANSWERS-

1. The decomposition of Hydrogen Peroxide is a Chain Reaction, and an inhibitor works by breaking the chain.

2. What is a Chain Reaction? See page 70 where the photochemical chain reaction H2 + Cl2 2 HCl is discussed. This chain sequence is illustrated by a long row of standing dominoes. Knock No. 1 over and it knocks No. 2 over, and so on, until the whole chain is toppled. Insert a pencil (the Inhibitor) in front of a domino and it breaks the chain. These chains may consist of thousands of molecules; or, as in the case of the photochemical H2 + Cl2 2 HCl, a million HCl molecules form before the chain is broken. One pencil prevents thousands of dominoes from falling.

3. How does the inhibitor work? The figure below shows three inhibitor molecules breaking three chains. My thesis studied the oxidation of aqueous sodium sulfite by gaseous oxygen, inhibited by various organic substances. Whenever an inhibitor molecule broke a sulfite oxidation chain, the inhibitor molecule was oxidized.

4. Why does so little of the inhibitor suffice? If the inhibitor is 10 times more efficient than the reactant is in continuing the chain, then a concentration of inhibitor 1/1000th that of the reactant would limit the chain-length to 100 molecules.

5. Why does the inhibitor last so long? In place of thousands of molecules reacting, only one inhibitor molecule is destroyed when it breaks a chain. Therefore the inhibitor lasts thousands of times longer than the reactant.

6. How about other inhibitors? In the figure above three rows of dominoes are being broken. Therefore three of any inhibitor molecules will be oxidized (or destroyed). Or, the amount of inhibitor destroyed is the same for all inhibitors.

7. How about concentration of inhibitor? If the concentration of inhibitor is increased, the chains will be broken sooner. But, in our figure, there are still only three chains to be broken, so three inhibitors will be destroyed. This results in a law that differs from Guldberg and Waage's Mass Law. New Law: when the inhibitor concentration is so large as to break all of the chains, the amount of inhibitor destroyed is independent of the concentration of the inhibitor. ALYEA'S Mass Law. [laughter]

About thirty-five years after I had proposed The Domino Theory of Inhibition in Chemistry, President Eisenhower applied it to our political action in Southeast Asia.

My Ph.D. publication on Inhibition was met with acclaim by Rubber chemists, since it revealed how their rubber anti-oxidants

worked. I was completely ignorant of Rubber chemistry, but I was elected by The India Rubber World as one of the 1000 rubber authorities of the World! I was reluctant to accept the honor, but Dr. Lind, with whom I was working, encouraged me to accept. So I journeyed from Minneapolis to Akron, where several hundred Rubber chemists welcomed me as a fellow rubber-chemist! Firestone guided me through their research lab to show me the 5000 chemicals they had tested Edisonian-like in hopes of discovering a better anti-oxidant. Then General Tire chemists conducted me on a similar tour, four blocks away from Firestone, where they had tested the identical 5000 chemicals. Of course, neither company told the other company what they had tested! I was glad to be headed for a University career, where one's scientific discoveries would not be covetously witheld from public knowledge. Partly as a result of this new knowledge of how anti-oxidants worked, the life of automobile tires has been extended from 3000 miles to 40,000 miles.

I WIN MY FATHER-IN-LAW'S APPROVAL (1928)

My Father-in-Law was a wonderful person, but a hard-headed business man, a Professional Printer. He couldn't understand that the brilliant lad his daughter was in love with could be so stupid as to go into teaching, when he could earn thrice as much as an Industrial Chemist.

In the Fall of 1928 I journeyed to Schenectady to lecture on my Inhibition research to General Electric. (I first met [Irving] Langmuir there when he was in the library perched atop a 12-ft. ladder. He, incidentally, asked the most searching question about my research of all my many thousands of auditors that year: whether the chain was a thermal or free-radical chain.)

As remuneration for my lecture, General Electric gave me a check for $75. This was a staggering sum, equal to two-week's (later) Princeton salary for a chemistry instructor. I returned home, and took the check over to my future bride, and enthusiastically presented it to Evelyn. Her eyes popped, and she proudly passed it on to her father. "Look, Papa, what Hubert got." Future Father Shields eyed the check in amazement. "Wonderful, Hubert. What did you do there?" "I spoke for an hour." "Only an hour? How much did your hotel and meals cost?" "Oh, GE also paid for that." "You mean you got $75 for an hour's lecture?" Hubert (proudly): "Yes." Evelyn and I in after-years had such fun recalling her Father's reaction: "$75 an hour, 8 hours a day, 5 days a week, 52 weeks in a year: COME INTO THE

FAMILY!" [laughter]

INDUSTRIAL VERSUS ACADEMIC CAREERS (1928-1935)

STURCHIO: You just commented about how your future in-laws wondered why you were going into teaching when a lot of people were going into industry. I noticed that many of your fellow Ph.D.'s from 1928 had industrial careers or government careers. Could you tell us about some of those people, like Stanley Morgan, and Wendell Niederhauser, and some of the others who got their Ph.D.'s at that time?

ALYEA: Princeton fathered many chemistry teachers. [Nicholas] Milas, a post-doc organic chemist, became a Professor at M.I.T. Two of Professor Menzies's Ph.D.'s taught at Gettysburg College, and Western Maryland College. [Ralph] Beebe, one of Taylor's students, became a Professor at Amherst. [John] Turkevich and I stayed on at Princeton. So did [John] Bates and [Wendell] Taylor, although Bates subsequently transferred to the Sun Oil Co. and W. Taylor to teach in Lawrenceville. Princeton Ph.D. graduates flooded the faculty at Northwestern University: [Charles] Hurd, [Arthur] Frost, and [Pearce] Selwood. [Clark] Bricker began at Princeton, then ended up in the University of Kansas. These are a few of our Ph.D.'s who became teachers.

But at the time of the 1929 Depression Universities were hiring few teachers. Those it did, received starvation wages. My first annual salary from Princeton was $1800; but I was the envy of the other Instructors because I received a $400 bonus for research.

Teachers are a strange breed. I don't believe that [Stanley] Morgan was a teacher by nature. [Wendell] Niederhauser wasn't. I got him his job in Röhm and Haas (where I consulted), and he was happy there. Later his brother became a chief officer in the Company. Our most distinguished Ph.D. graduate was Charlie Smyth's protege [William] Baker, who became Director of Research at the Bell Labs.

LATER PRINCETON CHEMISTRY PROFESSORS (1930-1950)

In addition to the Professors described above, the following were active in the teaching staff during 1930-1950.

Elementary Chemistry teachers: [William T.] Richards (who left for the NY labs of the Rockefeller Institute; he was T. W. Richards's son, [John] Turkevich, [Wendell] Taylor who went to Lawrenceville, and [Richard] Powell who went to Berkeley.

In Analytical Chemistry: [Earle] Caley (who went to Ohio State), and [Clark] Bricker (who went to the University of Kansas).

In Organic Chemistry: [Eugene] Pacsu, [Everett] Wallis, [Theodore] Taylor, [Kurt] Mislow, [Maitland] Jones.

In Physical Chemistry: [Robert] Pease, [Arthur] Tobolsky, [Donald] McClure, [Thomas] Spiro, [Lee] Allen, and [Henry] Eyring (who became Dean of the University of Utah Graduate School).

From 1960 on, I concentrated my research towards improving devices for Freshman Chemistry: Tested Demonstrations, Projection of experiments, and Armchair chemistry. I had a staff of five or more assistants. I organized and subsidized a Summer Institute with 50 High School teachers. And I taught 13 hours a week, and lectured away from Princeton three times a week.

STURCHIO: Well, you were going at a furious pace.

UNIVERSITY OF MINNESOTA (1928-1929)
as a National Research Fellow with [Samuel C.] Lind

STURCHIO: I wonder if we could talk about your work in Minnesota.

ALYEA: I went to Minnesota to work with Lind, to substantiate my Domino Theory of Chain Reactions. By 1928, chemists were about to accept the revolutionary concept that molecular fragments (like H, Cl, and OH) could participate in thermal chain reactions analagous to the accepted H and Cl fragments in the photochemical hydrogen + chlorine combination postulated by Nernst/Bodenstein in 1914.

Now [Samuel C.] Lind, editor of the Journal of Physical Chemistry, was a world authority on radioactivity. If you introduce radon gas into a mixture of oxygen + hydrogen, ions form and water is produced. Lind theorized that there were "Ion clusters." Oxygen had these ions clustered around it, and then the cluster suddenly generated the water. I didn't believe that, because I was steeped in the falling dominoes concept. I said, "Just as you hit one molecule by a particle of light to start a lot of reaction, I bet you could start a chain reaction with one ion starting one reaction chain and a whole lot of molecules would react." To Dr. Lind, I said, "I'm going to prove this."

I had forty thousand dollars worth of radium, and every two weeks I'd pipe off the radon gas. I was over-exposed to the radon that we're so afraid about today. They didn't have Geiger counters.

They had a gold-leaf electroscope, and I put my radium here, and I put my radon there. It was a hundred times what you're supposed to be exposed to, even with heavy shields, but just the same I must have built up some immunity along the way. [laughter]

Then I'd take that gas and put it in a tiny little glass bulb that was so thin that you needed to make two hundred of them before you get one thin enough for it to work. The alpha particle given off by the radon would go right through the little bulb into hydrogen and chlorine in a surrounding glass reaction vessel. My theory was that, just as one photon of light caused a million molecules of hydrogen and chlorine to combine, one ion created by an alpha particle would cause a million reactant molecules to combine. All that year I studied the phosgene reaction, the reaction of carbon monoxide and chlorine forming phosgene, $COCl_2$. I showed that the kinetics, the chemistry of the reaction, was identical whether you started with photons or with ions (3). So I disproved Lind's cluster theory, and established that you had chain reactions. Then I did it for five different chlorination reactions, and showed it was the same, no matter how you started it (5). Later I studied other reactions, for example hydrogen peroxide decomposition and polymerisation of vinyl acetate (8.10). I essentially assured people that these were chain reactions. It wasn't really fundamental work. The only fundamental ones that were mine were the inhibitors (1,9), and activated absorption (6,7). The others were interesting, but there are dozens, hundreds, thousands of phenomena

that were of interest equal to what I did. Then I was to go to Germany to study with Haber.

STURCHIO: Before we go there, I wanted to ask you a couple more questions. Who else was with you in Minnesota, when you were working there?

ALYEA: The University of Minnesota had an able staff the year I worked there. [Samuel C.] Lind, Dean of the School of Engineering, Chairman of the Chemistry Department, a Physical Chemist; [Henry] MacDougel in Thermodynamics; [Lee Irving] Smith in Organic Chemistry; and [Izaak M.] Kolthoff from Leyden, author of nearly 2000 analytical papers.

Here are stories about Kolthoff. He preferred to be called "Piet." He was one of the best analytical chemists in the country, third winner of the Fisher Award. Six of us faculty lived in the University Faculty Club, so we got to know one another well. We played pool every evening. Kolthoff was a nice, jolly fellow. I had my 'cello, and we used to play quartets every Sunday for four hours. Then whenever a professional quartet (like the Flonzally) visited Minneapolis, we always studied their program a few weeks beforehand. Then we listened to them, came back to the Faculty Club and criticised them. We got back maybe at eleven o'clock at night. Piet Kolthoff used to go to bed very early. He'd come out in his pajamas, "What the hell you guys making all this noise for!" [laughter].

At the end of the year we had a going-away dinner, and composed comical poems about each other. The one about Piet was so typical of him and so delightful that when he lectured in Princeton some years later I introduced him by reciting this poem:

"There was a Dutch chemist named Piet,

Much versed in the slang of the street.

Though he swears like a trooper

When roused from his stupor,

We rank him amongst our elite." [laughter]

You see, when Kolthoff arrived here from Leyden he wanted to become Americanized quickly. So, for fun, we'd tell him all kinds of American slang; and he used slang all the time with his classes. On one occasion we told him to say this, and he did. To his large co-ed class, at the end of his lecture, instead of saying “Let’s quit”, he followed our suggestion and said: "Now, boys and girls, let's all hit the hay." [laughter] He was puzzled the students all laughed. (This expression is a No-No in farm country!)

He was a wonderful person. A genuine scholar. I visited him in Minnesota just about two years ago when he was eighty-three.

DOEL: Did you have any contact with the physicists who were out at Minnesota?

ALYEA: Yes, I took a lot of advanced mathematics, and when I went to Hawaii, I actually taught quantum mechanics, because I had gotten it from Wigner and Eyring. I had contact with some of the physicists there. Much of my work was quite high-powered physical chemistry. More physical chemistry than straight chemistry.

THE AMERICAN CHEMICAL SOCIETY
MINNEAPOLIS MEETING (September 1929)

During the summer of 1929 I concluded my honeymoon in Minneapolis, completing my work with Dr. Lind, and carrying on research for Röhm and Haas Company. When the American Chemical Society held its Fall meeting there I had two interesting experiences.

Bonhoeffer demonstrates ortho-para Hydrogen

[Karl F.] Bonhoeffer came over from the Kaiser Wilhelm Institute in Berlin-Dahlem to demonstrate the ortho-para hydrogen catalytic conversion that he and [Paul] Harteck had just discovered. Since I was to work in the same Institute later that month, I was looking forward to meeting him. He was to demonstrate that hydrogen formed two H2 molecules, where the two nuclei of H-H could rotate either in the same, or in opposite directions. I believe they would have won a Nobel Prize for this, but two years later [Harold] Urey discovered heavy hydrogen and he got the spotlight. Bonhoeffer and Harteck discovered ortho-para hydrogen primarily predicted by mathematics, and then they went into the laboratory and confirmed it. [Irving] Langmuir said that this was the first example where one hundred percent prediction by mathematics had led to a discovery that probably would not have been discovered in the laboratory for a hundred years.

Bonhoeffer came over to Minneapolis to demonstrate this. He needed a very elaborate glass apparatus which he was going to use for displaying it. Lind said to me, "Why don't you blow it for him, Hubert? You're a pretty good glassblower." So I blew the whole thing. Bonhoeffer was going to have the hydrogen at room temperature, with an ortho-para ratio of three to one, and pass it through activated charcoal at liquid air, at which temperature it would shift to a 1:1 ortho-para hydrogen ratio.

Bonhoeffer explained this, and announced : "Dr. Alyea will turn a stopcock to direct the hydrogen mixture through activated carbon at liquid air temperature. A change in the thermal conductivity of the gas mixture will be revealed by the projected mark on the screen moving." I turned the stopcock; Mother Nature responded splendidly, and line moved several feet on the screen. The audience applauded and cheered.

That Fall I worked for several months in the same room as Bonhoeffer and Harteck in the Kaiser Wilhelm Institute in Berlin-Dahlem, before Bonhoeffer left Berlin for Koln.

I lectured to Harteck half a century later, when he was a Professor at Rensselaer Polytechnic in Troy, NY. During the War he was stationed in Hamburg; it was he who alerted Hitler to the threat of U.S. Atomic Warfare

Bodenstein proposes a new Unit: the EINSTEIN

At this same Minneapolis Meeting I first met the famous photochemist [Max] Bodenstein from the University of Berlin. He gave a short paper in which he proposed a new Photochemical Unit.

He said, "When you have an Avogadro's number of particles, that's called a mole. If you have an Avogadro's number of electrons, that's called one Faraday. I propose that, if you have an Avogadro's number of photons, we call them an Einstein." It never did take, as a matter of fact, but mine was the very next paper, and I was discussing yield per photon. So I quickly shifted gears. For the next fifteen minutes I talked about yield per Einstein; and Bodenstein was laughing. He was a jolly fellow, somewhat like Debye and Henry Eyring. In fact, all three of them were poured from the same mold. Arrhenius, holding aloft a Swedish Punch, Eyring holding aloft the Book of Mormon, and Debye holding aloft a calculator. When I finished my talk, Bodenstein jumped up, grinned out over the audience and said, "I never realized, or believed, that my suggestion of fifteen minutes ago would lead to such immediate international acceptance." [laughter]

THE UNIVERSITY OF BERLIN (September 1929)

In Berlin, where I was to spend a year at the Kaiser Wilhelm Institute I paid my respects to two famous Professors at the University of Berlin. Let me first describe their photo-chemical research, for which they are noted.

In 1905 Einstein published papers applying the Planck constant (h) to five different fields. One was in Photochemistry. It claimed that light came in particles, called photons; and that when one photon was absorbed by a chemical mixture, one molecule would react. This was the Einstein Photochemical Equivalence Law.

During the next decade dozens of Chemists tested the law and found it to be true, excepting for the reaction

$$1 \text{ photon} + H_2 + Cl_2 \rightarrow\rightarrow 2\ HCl$$

For this reaction, as many as 1,000,000 molecules of HCl formed per photon absorbed.

In 1914 [Walter] Nernst and [Max] Bodenstein at the University of Berlin, proposed the following reaction mechanism to account for this apparent aberration. The initial photochemical reaction obeyed Einstein's law,

$$\text{a photon} + Cl_2 \rightarrow\rightarrow\rightarrow\rightarrow\rightarrow Cl + Cl,$$

but it was followed by a "chain mechanism":

$$Cl + H_2 \rightarrow\rightarrow\rightarrow\rightarrow HCl + H \rightarrow\rightarrow\rightarrow\rightarrow H + Cl_2 \rightarrow\rightarrow\rightarrow\rightarrow\rightarrow HCl + Cl$$

and that these two consecutive reactions continued thousands of times until the chain was broken by reaction with an impurity

(say O2):

Breaking stage: H + O2 →→→ HO2

(Subsequent reaction steps changed HO2 into H2O.) The revolutionary aspect of the Nernst-Bodenstein mechanism was that it postulated the presence of free radicals (like Cl, H, and OH) as well as conventional Cl2 and H2 molecules.

[Max] Bodenstein. I had a pleasant session in Berlin with Bodenstein whom I had just met in Minneapolis earlier that month. We discussed the work I intended to do with Haber. Bodenstein was a fine gentleman.

[Walther] Nernst. Author of the Third Law of Thermodynamics. How different from Bodenstein! I gave Nerst a letter of introduction from Hugh Taylor, who had worked with him in 1914. Nernst's first question to me was "With whom are you working?" I was wise enough to remark I had just paid my respects to Bodenstein. "Ach, Bodenstein," said Nernst approvingly; "Ist gut." If I had mentioned Haber, Nernst would have said "Heraus mit" me. [laughter] My visit with Nernst was brief. Nernst was a typical German Geheimrat with his young assistants hovering over him, like vultures, waiting for him to die so that they could sit in his over-stuffed chair. Nernst and Haber hated one another because Haber became fabulously wealthy with the ammonia process, based on Nernst's third law. Nernst, though he got a Nobel Prize, was still a poor college professor; but Haber was a multi-millionaire. They hated each other so much. I might be planning to go out to a scientific dinner-meeting with

Haber, for example the Bunsen Gesellschaft. He would call up and make sure that Nernst was not going to the meeting, because if he were, Haber wouldn't go. There was just terrible rivalry.

It originated from when Haber made a miscalculation using Nernst's law. I think it was at Karlsruhe, but I'm not quite sure. At that meeting in 1907, Haber was a young man. He got up and apologized because he had made a miscalculation. Three hours later, Nernst got up and lambasted this stupid young fellow who misused his equation, and had made these mistakes, even though Haber had already publicly apologized for it. From then on, they hated one another.

It is reported that Nernst always began his Thermodynamics course with the remark: "Many scientists know the First Law of Thermodynamics. Only a few understand the Second Law of Thermodynamics. Only I understand the Third Law of Thermodynamics, because I invented it."

I assessed Nernst as an aged, self-opinionated, Geheimrat.

NOBEL PRIZEMEN (1925-6, 1929-30, 1950)
with whom I have worked

STURCHIO: Tell us about the Nobel Prize winners you worked with.

ALYEA: I worked with [Svante] Arrhenius in Stockholm, [Fritz] Haber in Berlin, and [Linus] Pauling in Pasadena. Let me characterize them by saying that they were as different as chalk, cheese, and cauliflower. Arrhenius, at sixty-five, had all the enthusiasm of an eighteen-year-old lad. Haber was an austere but friendly Prussian Geheimrat. Pauling was wonderfully human.

I also spent one summer in Sir [Cyril] Hinshelwood's laboratory at Baliol College in Oxford. He was keenly intelligent, sphinx-like. Hinshelwood read Greek and Latin for relaxation. The same year that he was President of the Faraday Society, he was also President of the Society for Ancient Languages. At the end of my summer in Oxford I told his colleague, [Harold] Thompson (whom I knew as a young man, when he was getting his Ph.D. with Fritz Haber; later Sir Harold, for his infrared research) "Harold, I have worked with Hinshelwood all summer and I don't understand him." Harold replied: "Hubert, I have been his colleague for eight years and I still don't understand him!" Harold and his wife, Penelope, were in our Princeton home the day that Hitler invaded Poland; they were terrified that when Britain declared war, Hitler would retaliate by immediately bombing Cambridge and Oxford (where their children were).

THE KAISER WILHELM INSTITUTE (1929-1930)
Berlin-Dahlem

Scientists there

STURCHIO: In addition to Fritz Haber, who else was at the Kaiser Wilhelm Institute the year you were there?

ALYEA: The Kaiser Wilhelm Institute (renamed the Max Planck Institute) consisted of half a dozen moderately large buildings in a garden setting in Dahlem, a suburb of Berlin. Fritz Haber was Director; and worked with the Physical Chemists. Those of his Physical Chemistry colleagues who had visiting Fellows from abroad include the following: With [Michael] Polanyi: Henry Eyring from Wisconsin. With [Herbert] Freundlick: [Nelson] Taylor from Minnesota, and [Samuel S.] Kistler from California. With Haber: [Hubert N.] Alyea, from Princeton, a remarkable fellow [laughter], [Harold] Thompson from Oxford, and [Ronald] Mooney from Scotland.

The remaining resident staff included [Paul] Harteck (later at Hamburg where he warned Hitler about the Atom Bomb; he subsequently came to Rensselaer Polytechnic), [Eugene] Wigner and [Kurt] Ladenburg (who joined the Princeton faculty), and the two Farkas brothers [Adalbert] who came to an oil company in Philadelphia, and [Lasoslas] who went to Israel. [Karl] Bonhoeffer left Dahlem in the Fall for Cologne. There were half a dozen others whom I cannot recall.

A few yards away was the Physics building, [Otto] Hahn

director. Here, two decades later, with his colleagues [Gustav] Strassman and [Lise] Meitner, Hahn was to achieve the first man-made nuclear fusion. [John] Wheeler related to me how, in December 1939, [Niels] Bohr, trembling with excitement, related this event upon his arrival in New York to work with Wheeler in Princeton.

The chemists and physicists met only infrequently. At such joint Seminars Haber would preside. When the speaker had concluded, Haber would rise, congratulate him, then jovially remark, "But I didn't understand a word of it." Following the laughter, Haber would pose an erudite question, showing he understood very well.

THE KAISER WILHELM INSTITUTE, Berlin-Dahlem (1929-30)
as an International Research Fellow with Fritz Haber

ALYEA: I worked with Fritz Haber from September, 1929 until June, 1930. The Kaiser Wilhelm Institute was in Dahlem, a suburb of Berlin. It was like the Institute for Advanced Study in Princeton. Haber was the Director (just like [J. Robert] Oppenheimer). I worked as Haber's chief assistant and published papers with him, one that led to the concept of "activated adsorption."

Haber was completely different from Arrhenius. Haber would come into my lab and question me: "What have you done today, Dr. Alyea? Have you done so and so?" And then, no matter what I related, he would nod his head and say, gravely, "Aber! Aber! Aber!" (Translated "But! But! But!") I could write an essay on "Haber aber, Haber aber, Haber aber." [laughter]

Fritz Haber is famous for having invented the high pressure catalysis of ammonia (NH_3) from N_2 in the air + H_2 from water. NH_3 could be made into nitric acid by the Ostwald Process, and finally into the fertilizer/explosive, ammonium nitrate. This replaced gunpowder, previously made from Chile Saltpeter ($NaNO_3$), lying in a strip along the coast of Chile, 220 miles long, 20 miles wide, and 5 feet thick, deposited by millions of seagulls leaving more than Footprints on the Sands of Time. [laughter]

World War I did not begin in 1914 because the Arch-Duke was murdered in Sarajevo, as the historians would have you believe. No, it began because the industrial process for manufacturing ammonium

nitrate explosive was perfected in late 1913 by Haber/Bosch. This gave Austria/Germany an incentive for a quick-strike against a French/English/Russian alliance.

The tonnage of Amitol explosive (a mixture of 80% NH_4NO_3 + 20% nitro-toluene), used in wars, is staggering: 300,000 tons in WW-I, 900,000 tons in WW-II, undoubtedly well over 10,000,000 tons in Vietnam and probably 10,000,000 tons in the 1991 Persian Gulf War. Today, in peacetime over a million tons of ammonium nitrate fertilizer is manufactured annually. Haber told me that they almost lost WW-I in the first few months. Something went wrong with their factory, and suddenly after the War had begun they couldn't make ammonium nitrate. But they discovered a shack in Belgium that had ten thousand tons of ammonium nitrate in it. They captured it; and they fought with that Belgian ammonium nitrate until their Haber-Bosch plant began to produce again.

Use of ammonium nitrate after WW-II. If you think the Korean War started in 1951, you are wrong. I was in Intelligence in Washington, D.C., and I came home at the conclusion of WW-II and said to my wife: "I hope to Heaven that our military planes are landing in North Korea." But our stupid Military didn't do what our Intelligence recommended. They allowed the Russians to take over North Korea, which was an industrial leader in Asia. Every little North Korean town had its own hydro-electric plant. And most of the aluminum in the Japanese airplanes was produced in these hydro-electric plants.

We, stupidly, took over South Korea, harboring a bunch of farmers without any fertilizer. I know these statistics are correct, because one of my best friends was a military man partly responsible for this project. From 1945 until 1951 we shipped in a hundred thousand tons of ammonium nitrate every year to the South Korean farmers. After 1951, with the outbreak of the Korean War, we dropped hundreds of thousand of tons of ammonium nitrate explosive on North Korea.

Explosions of Ammonium Nitrate manufactured for explosive but <u>being shipped as fertilizer.</u>

I was attending an Officer's meeting of the American Chemical Society in Atlantic City in 1946 when a messenger came in and handed [Charles] Thomas, President of Monsanto, a telegram. He turned pale, and excused himself. A vessel in Texas City, loaded with ammonium nitrate being shipped as fertilizer by the Monsanto Company to France had caught fire in Texas City. When the temperature of the ammonium nitrate reached about 140°C it exploded, killing several hundred people.

Similarly, right after World War I, in Oppau, Germany, the same thing occurred. [Hugh] Taylor said that after the War, he was sent by British Intelligence there, and walked past one mile of dunes of ammonium nitrate, a hundred feet high, at the German Storage yard in Oppau. The ammonium nitrate had caked from the rain, and somebody stupidly detonated it to loosen it up, to use it for fertilizer. The whole thing went off, and made a two-block hole, two hundred

feet deep, and killed five hundred people. But even worse, up in Halifax, two ships loaded with ammonium nitrate, to use as fertilizer, collided; two thousand people were killed.

Those are ammonium nitrate stories in War and Peace.

Haber was a millionaire. [Walther] Nernst, the Third-Law man who made it possible for Haber to invent the ammonia process, was just a poor professor. Haber got one pfennig for every pound of ammonium nitrate ever made and that made him a millionaire. I was very close to Haber. I was his top assistant. I used to have lunch with him at least twice a week. His home was right by the Institute. He'd say, "Dr. Alyea, I like to have you over here because when I talk to you, you always tell me what you think. With my German workers, the minute I ask a question, they say to themselves, 'What does the Geheimrat want me to say?' and then they will answer in a way to please me. You, instead, answer what you think is the truth. So I trust you."

Oh, there were so many interesting comments that Haber made during my luncheons with him. When the New York Stock Market crashed on October 29, 1929, he predicted: "Dr. Alyea, that ends Democracy in Germany. Your system has failed. Our financiers will no longer give us sufficient money for research, and German Chemical Industry will fail. But your country will spend money lavishly."

One day he received a letter from one of his past students who

was working in Florida on the first electric furnace, to produce phosphorus from the mineral, Apatite. An account of this trial-run was written up in the American journals in 1930. But the furnace had burned out. The letter from his colleague read: "We got the phosphorus burning, but one hour later the electric furnace froze, and went completely useless. But, Dr. Haber, we're starting to build another one today. Maybe in six months we will have the answer." And Haber remarked: "That's the way with you Americans. You make ten attempts, and if one of them succeeds, you are delighted. In Germany, if one of them fails we give up the project, and everyone from the President down to the Janitor goes around, glum, for weeks."

On another occasion, in 1929, Haber predicted the Holocaust. He spoke mournfully: "The future of Jews in Germany is something terrible to anticipate." This was three years before the advent of Hitler. If it hadn't been Hitler, it would have been someone else. In Germany, the non-Jews complained (possibly wrongly) that the Jews dishonestly outsmarted them during the depression of 1922. That they went to Holland to work, send Guilders back (illegally through the mail), exchanged them for nearly valueless Deutsch Marks, and bought up valuable German Property for a song.

DOEL: Did you hear any criticisms of Haber after the War by the Allies?

ALYEA: Haber loaned me his 1915 lecture notes to his gas officers;

about a hundred and fifty pages. Now in those notes are two things that are interesting, but not in the history books. He began by accusing the Belgians of being the first ones to use gas warfare. He said, "For one whole year, they used bromine lachrymators, a tear gas. The Belgians used tear gas before the Germans used chlorine." Now the second thing was about the chlorine attack on April 22, 1915, when fifteen thousand Canadians and English were killed at Ypres. Haber said, "It wasn't a major operation. Our major battle was on the Eastern Front, and this was just to be sort of a diversion. In fact, we hadn't dreamed it was going to be so efficient. With the chlorine, we could have blasted through to the Atlantic Ocean if we'd known it was going to be that efficient; if that little bit of chlorine was going to kill fifteen thousand troops. We had forty-four pound tanks of chlorine in the trenches, and they were there for six weeks, because the wind wasn't blowing right. Finally the military told us, 'If you don't launch it tomorrow, we're going to take the chlorine tanks out, because they're interfering with our movement in the trenches.' Early the next morning, you could see [James] Franck, later a Nobel Prize winner, standing and holding a handkerchief aloft in the wind; and the handkerchief was blowing towards the Canadians. We launched the attack, and it killed all these people." Then he said, "Ten weeks later, I think it was, we launched an attack when we used twenty times more chlorine. And practically nobody was killed. Why? Because they had instructed the soldiers to urinate on their handkerchiefs and hold them to their noses. The ammonia in the

urine would absorb the chlorine, and save their lives."

There is another interesting story that isn't in the history books. He said, "You know, Dr. Alyea, the first [gas] attack the Germans launched wasn't April, 1915, in Ypres. We launched an attack in Russia several months earlier. But we stupid chemists didn't realize how cold it was in Russia, and all the snow that was there. As the chlorine gas blew across towards the Russian trenches, it united with the snow and formed a solid hydrate and never reached the Russian trenches. When Spring came, and it grew warm enough for it to evaporate, the lines were now fifty miles away; the chlorine evaporated and nobody realized it. The first chlorine attack was earlier, in Russia."

Here was Arrhenius, a happy fellow, excited. Here was Haber, coldly analytical. "But (aber!) haven't you done the following?" Then he'd go out, and come back in the afternoon. "Have you done it?" "Yes, yes, professor." "Sehr gut." And out he went. Whereas Arrhenius was, "Oh, wonderful, wonderful", Haber was coldly impersonal. But to his colleagues, compassionate and loyal. He was Jewish, but Hitler hesitated to oppose him openly since he was lionized by the German people because of his war record. So, instead, in 1933 Hitler sent Haber a list of the Jews to be expelled from the Institute. Thereafter, Haber quietly went about the business of placing his colleagues in institutions outside of Germany. He placed the two Farkas brothers, [Adalbert] in a Philadelphia oil company, and [Lasoslas] in Israel. The latter showed how to soak paper with diphenyl for wrapping up oranges. The

result was when oranges were shipped to England from Israel, ninety percent of them went through. In the old days, less than 30% went through unspoiled. [Michael] Polanyi went to Manchester, England. [Eugene] Wigner came here to Princeton, although Wigner knew already that he was coming to Princeton. In fact, Wigner came to me there at the Kaiser Wilhelm and said, "Dr. Alyea, I've been invited to come to Princeton. Will I have to teach Freshmen?" I said, "No, Eugene, you'll give lectures in the Graduate School." He said, "I think I'll go." [laughter]

When all of these associates were located outside of Germany, Haber died. It is reported that he had a heart attack on a train passing through Basel. Perhaps. But once, in 1930, Haber opened his wallet to show me that it contained two cyanide pills. He confided in me: "Dr. Alyea, if you hear that I have died of a heart attack, I may have taken these pills. Götterdammerung?"

[ALBERT] EINSTEIN (1929-1955)
in Germany and Princeton

ALYEA: Shall I tell you about Einstein?

STURCHIO: Sure.

ALYEA: When I was at the Kaiser Wilhelm Institute with Haber, [Albert] Einstein was one of the Associate Directors of the

Institute. He came to visit Haber one day. Haber brought him in to see my crossed-stream apparatus. It included a very complex instrument, an interferometer, a tube twenty feet long; at one end of it were two lenses. They would be illuminated, and you twisted them [the quarter-wave plates] until the light through the lenses was of equal intensity. Then you could read the percentage of oxygen in this long tube. So Haber came in with Einstein, and Einstein immediately went to the wrong end of the tube; not where the lenses were, but twenty feet away, where there were just pipes. He bent over, and he looked and looked at the pipes. As I say to teachers, "What would most of us have done? We would have been afraid to show our ignorance. We'd have said, 'Very interesting, very interesting,' and walked away." But not Einstein. He wasn't afraid to show his ignorance. He said, "I can't see anything." Haber said, "Herr Professor, on this side." I guided Einstein to the lens-end. He bent over, peered through the lenses, turned the lens collar, and looked up and exclaimed with excitement: "Wunderbar!" I've told teachers, "That's something that I learned that day from Einstein, something that every teacher should tell his students: 'Never be ashamed to show your ignorance once, rather than remain ignorant all your life.'"

Three years later Einstein came to Princeton, where he lived over 20 years, until his death. A few weeks after his arrival, he attended one of my lectures, and afterwards came up to thank me. I recalled our first meeting in Berlin; he remembered me. But I was polite enough not to recall the wrong-end episode!

Einstein attended half a dozen of my lectures, including my Atomic Energy: Weapon for Peace lecture. He was attentive. Whenever he came to my lectures, he always sat about two-thirds of the way back, over on my right side. He always had this big shock of white hair, standing out amongst the crowd. When you get to know your audience, feedback from your audience is very important. I'd say something, but that white shock of hair would just stay still. He hadn't understood. So I'd say it a different way, and it remained still. I'd say it a third way. Still motionless. Then a fourth way, and the hair would bob up-and-down. At that, I'd go on to something else. I figured that if Einstein understood it, everybody did. [laughter]

Now I'll tell you a story about Freddy, my little son, when he was about two and a half years old. I bought a huge number of Fortune magazines which sold for a dollar a copy. That was a lot in those days, but I got them for a nickel apiece, second-hand in New York. They had beautiful colored pictures that you couldn't easily buy in those days. I cut out these pictures, art pictures and things like that. I thought that if Freddy saw these when he was little, it would make him interested in art. Today he's a chemical engineer, and artistic; but I don't know if that had anything to do with it. When he was two and a half, I had made this very thick scrapbook, with all these pictures from Fortune magazine. One was an entire page of a picture of Einstein, who was teaching out at Caltech that year, about 1937 [see following page] (19). The picture filled the page. Einstein's hair was all on end. Freddy

used to think it was a woman. He used to call it "Mrs. Einstein." He was hypnotized by this picture of "Mrs. Einstein." We had a regular routine. Every night, when Freddy was in his pajamas and ready for bed, we'd start looking at these pictures. He'd look at one, and then another one; and just before we got to Einstein, to tease him I'd say, "Now we're going to go to bed." He'd look up and grin and say, "No, I want to see 'Mrs. Einstein.'" I'd open it up, and he'd see it, and then he'd toddle off to bed.

A few months later, Einstein moved to Princeton. In those days, the Institute [for Advanced Study] wasn't built, and he worked at the mathematics building, Fine Hall, and he would walk past where we lived, on his way home for lunch. One day Freddy was playing outside. He stopped playing and gazed down the street. Along came Einstein, his hair blowing in the wind, until he got no further away than five feet, about as far away as you are now. And in his little baby voice Freddy cried out: "Daddy, is that Mrs. Einstein with the big hair?" Einstein bowed and said, "Yes, that's Mrs. Einstein, young man." [laughter]

He liked children. Evelyn often took Freddy down to the golf course where there was a little brook, one of the hazards. Freddy would push little boats out into it, and then would run and pick them up further down. The path on the other side led from Einstein's home. One day Einstein was walking past and stopped to watch Freddy playing with his boat. Freddy pushed the boat, and it got onto Einstein's side of the brook, caught in the weeds. Einstein got down on one knee and pushed the boat back to Freddy.

Well, Freddy knew "Mrs. Einstein," so he pushed the boat back to him. And Einstein pushed it back to Freddy, and Freddy pushed it back to him. I think he was studying Freddy's reaction. And back and forth they pushed it, four or five times. Afterwards I said, "Just think Freddy, when you get to be an old man, and they ask, 'Grampy, did you ever know Einstein?' say, 'Oh, sure. I used to play boats with him.'" [laughter]

[Barbara L.] Rahm, a professional violinist who was later the first violinist in the San Francisco Orchestra lived in Princeton. Because Einstein played the violin, she organized a quartet when Einstein came here. Since Barbara was a professional, she played first violin. She used to say, "I never thought I would live to see the day when Einstein played second fiddle to me." [laughter]

A newspaper man told me that when two newsmen, flanking Einstein, were walking down Nassau Street, they came in front of the drug store. Einstein said, "Excuse me a minute," went in, leaned over the counter, and whispered to the druggist. The druggist disappeared and came back with something wrapped in paper, and gave it to Einstein. Einstein came out and bent over the paper-wrapped article, and began to lick it: it was an ice-cream cone! If he had walked down the street licking it in the normal fashion, someone might have photographed him. In Berlin, he used to sail a great deal on the lake, Wannsee. One day, followed by a motor boat of photographers, he capsized. The next day the front page was filled with a picture of Einstein, and the caption "Einstein capsizes on Wannsee." [laughter]

One day a man called the Princeton telephone operator and requested Dr. Albert Einstein's telephone number. She replied: "I'm sorry, it's an unlisted number." "Oh," said the voice, "but I need to have it." "Sorry, we aren't allowed to give out unlisted numbers." "Well, can you please tell me where Professor Einstein lives?" "No, sir, I'm sorry, we cannot do that." "But I must know." "Why must you know?" "I'm Professor Einstein." He had moved there a couple of weeks before, and forgotten where he lived. [laughter] Understandingly, the phone operator gave him Dean [Luther P.] Eisenhart's phone number, and Eisenhart's twelve-year-old son came, fetched Einstein, and took him home. [laughter]

STURCHIO: That's a great story. I hadn't heard that one before.

CONSULTING FOR ROHM AND HAAS (1929-1972)

I consulted for Röhm and Haas for forty years. In fact, my summer house has, perhaps, the first Plexiglas window ever installed. I was lecturing down in Philadelphia, at one of the service clubs. There were about three hundred people for the dinner. When I returned home, Evelyn asked me, "Did they pay you anything?" I replied, "They don't pay anything. It's a Service Club. I've lectured a thousand times; I had to pay my own way down and back." But something opportune did occur. The Vice-President of Röhm and Haas sat next to me. He enquired, "How's your house at the beach coming along?" I said, "Well. But I have to put a thermopane window in it." (In those days the window would have cost $300; today probably $1000.) Suddenly I had a wonderful idea. "You know," I said to him, "you ought to give me one of your Plexiglas bomber sheets." (Röhm and Haas were casting Plexiglas sheets onto plate-glass, then putting the Plexiglas sheet over a large hole and sucking the Plexiglas bubble.) "Give me one of those, and I will write you a wonderful report of how it stands up under blowing sand and intense sunlight. My house is right on the beach." "What size is the window?" "It's six feet seven by eleven feet eight." Later I got a message, "They have just called up from Bristol. They cut your window. When should they deliver it?" "My gosh, they're going to give me that window!" That was in 1951. I was going to go to Oklahoma to a summer institute that day. I decided to pick the window up before they changed their mind. I dashed down to the beach. Of course, it fit exactly, but I didn't know how to put it

in. I had made studies for them, on crazing and cracking under pressure. I knew I couldn't just bore holes and put it in. I hastily thought, and then took a one-by-two and some staples, and a rubber gasket like you have on a refrigerator door. I put the Plexiglas sheet in place and toed the nails in so, as the nails went in, the wood strip squeezed the rubber. It stayed there from 1951 until 1981, and it never leaked, or crazed from the intense beach sunlight. But one Halloween some bad boys shot holes in it with a BB-gun. Later it was discovered that the sand that blows above about 4 feet is so fine that it does not scratch Plexiglas; but that the coarser sand, blowing lower than that, does.

HENRY EYRING COMES TO PRINCETON (1931)

STURCHIO: How about [Henry] Eyring?

ALYEA: I know a lot about him. I was responsible for Henry Eyring coming to Princeton. This is the way it happened. He was working with Polanyi, and I was working with Haber, at the Kaiser Wilhelm Institute in Berlin. We got to know each other, and our wives too, very, very, well that year (1929-1930). We often had dinner together. In Harnek House at the Kaiser Wilhelm Institute, four American families (the Henry Eyrings, Nelson Taylors, Samuel Kistlers, and Alyeas) celebrated a regal Thanksgiving Dinner, which included a huge bowl of gigantic German Pickles!

Now, about Henry's coming to Princeton. It began in Indiana in 1931, where the American Chemical Society was meeting. I was there. Henry had returned to Berkeley from Germany. He told me, "I'm looking for a job. There's no job in Berkeley, and I don't know where I can go." I immediately went to Hugh Taylor. I said, "Henry Eyring is a wonderful guy, and we ought to nab him. He's going to give a talk in a few minutes." He said, "Oh, I'll go hear him." He came back and said, "Have him come and give the same talk at Princeton." So I went to him and said, "Henry, we're going to pay your way to Princeton, and back here again, and we'll give you an honorarium." He said, "That's fine." So he came, and never left Princeton. He telephoned Mildred and said, "Come to Princeton. They've offered me a job as an instructor." That was 1931. He

stayed on until after the War. I forget when he left, but he was in Princeton a good fifteen years. Then he became Dean of the University of Utah Graduate School. Late in life he co-authorized an important treatise in Molecular Biology (302).

Henry was just a wonderful person. Everything was always "going to work." Quantum mechanics solved anything you wanted, until you got down to the nitty gritty, and then there were some hard bumps, and you were "not quite ready to handle something like that." He was a wonderful person to work with. Hugh Taylor had a fantastic imagination, and Henry had a sound mathematical training in quantum mechanics. Together they made an extremely fine pair, and published very interesting material. Both of them contributed equally. It wasn't entirely Henry. Hugh Taylor was a catalyst for Henry. The two of them worked wonderfully together. Everything Henry did was perfect. To know him was to know a University.

Henry Eyring was an absent-minded Professor. He was giving a talk up at Brooklyn Polytechnic. Now, the year before he had talked there, and he hadn't gotten home until midnight. He said, "I'll come and talk, but you've got to get me to the train on time, so I can get home at eleven o'clock. I don't want to get home at midnight." They drove him from Brooklyn all the way over to the station, and got him there ten minutes before the train left. So Henry rushed down and jumped on the train. The conductor didn't come through, to punch tickets, until they were past Newark. He said, "This train doesn't stop at Princeton Junction. The first stop is Trenton." He'd gotten on the express that left five minutes

earlier instead of the one that stopped at Princeton. When he got to Trenton he asked when the next train was leaving for Princeton. "Well, it's going back in an hour and a quarter." So he sat there in Trenton an hour and a quarter, and he got on the train. And the new conductor told him, "This train doesn't stop at Princeton Junction. The first stop is Newark." [laughter] It was five o'clock in the morning, or something like that, when he finally got home.

STURCHIO: You and Eyring and the others must have had a chance to talk kinetics. What were his scientific views like? What was he like as a chemist?

ALYEA: Everything that he had he would reduce to mathematical formulas and equations. He would handle them beautifully, so you could understand what he was explaining. He gave lectures on quantum mechanics that were so intelligent. And Wigner did, too. When I went to Hawaii, I gave a course in quantum mechanics, based on what had been taught me. But I never really used it in my research.

COOPERATION OF THE SCIENCES IN PRINCETON (after 1932)

DOEL: In looking through the records at Princeton, I noticed that some of the science departments such as astronomy, biology, and physics, were attempting to begin cooperative research within the different science departments.

ALYEA: In the 1920s there was little of mutual interest in the various Sciences; that is why the Princeton Section of the Society of the Sigma Xi was not formed until 1932 particularly because of the efforts of the biologist Professor Harrison Shull and an enthusiastic graduate student. Frank Johnson, later a Princeton Professor pre-eminent in the field of Bioluminescence (302). Then it enjoyed rapid growth. The cyclotron interested both chemists and physicists. Organic chemists and biologists became mutually interested in Natural Products. Quantum Mechanics became an important tool in all three Sciences. Professors [Eugene] Wigner in physics, [Henry] Eyring in chemistry, and [Frank] Johnson in biology exemplify three of numerous Scientists who collaborated. See the joint Eyring/Johnson publication (302).

QUANTUM MECHANICS FOR THE RUSSIAN PEASANT (1932)

DOEL: [Edward] Condon was there in Minnesota when you were there.

ALYEA: Let me relate an interesting story about Ed Condon and his colleagues in the Princeton Physics Department. In 1924-1926 the Heisenberg/Schrödinger Quantum Mechanics appeared as a brilliant new mathematical tool. A few years later two monographs appeared from the Princeton Physics Laboratory (303). [R. W.] Gurney came from Cambridge University to work with Condon and [Phillip] Morse. Gurney told me that 300 copies of his Quantum Mechanics text were sold in Britain and the United States.

The Russians wrote to Gurney asking if they could translate and publish his book. (I know this is a true story, because it was related to me by Gurney.) He granted permission, but never heard further from them.

In 1936, Gurney went to a Physical Society meeting in Leningrad, and thought, "I wonder if they ever published my book?" (In fact, when I was there for a couple of months, I actually went over to the courtyard to re-enact in my mind what happened.) So Gurney went to the publisher's office, and handed them his card. The Editor-in-Chief came out and said, "Welcome to the USSR, Professor Gurney." He said, "You know me?" "Why, of course, we know you. We published your quantum mechanics book." "Well, I didn't know it." "Well, we weren't allowed to tell you. We sold so many, and there was such a big royalty in the USSR, that we thought

you would come here just to get the royalty. Now that you're here we can give it to you."

"How many did you sell?" "Oh, we sold ten thousand copies." Gurney couldn't believe his ears. Ten thousand copies! Remember they had sold only 300 copies in Great Britain and the USA.

"Professor Gurney, this is why we sold 10,000 copies. Yours is a new frontier of science in the Western World, and every one of our 2000 Colleges must have a copy of your book. The other eight thousand are rather comical. The Russian peasants are becoming very active, and want to show that they are learning to read. In the old days, they had an icon hanging on the wall. But now, to show off to their neighbors, they have a little table with a pile of books. Your book is so little that it is inexpensive, and so full of hieroglyphics, that even if they can't read, they put your book on top. And when a visitor appears, and the host goes out to get a vodka for him, the visitor takes a sneak-look at the books. 'Golly,' he exclaims (in Russian!). 'I can't read that well.' Eight thousand of your books, Dr. Gurney, are scattered all over Russia, in the peasant homes." The publishers gave Gurney such a big bag of rubles, as royalty, that he and his British friends, in the next two weeks, were living like Czars trying to spend the stuff, because they could not take it out of Russia with them! [laughter]

MR. ORTHO-DICHLORO BENZENE (1933)

In the Fall of 1933 Evelyn and I attended the American Chemical Society meeting in Cleveland, Ohio. On Tuesday night they entertained 2500 Chemists in their Civic Auditorium. I lectured in the same Hall to a couple of thousand High School pupils about twenty years later, and related this story to them.

They entertained us Chemists with a high-class show: a Double Octet from The Student Prince from Broadway, an opera singer (a woman) from Chicago, also, a marvelous magician. Finally, they hired a local yokel (an accordion player in Cleveland's night-clubs) to conclude the show. He began by asking the audience for headlines from the Cleveland Paper. "A tree blew down on Euclid Avenue." "An explosion in the Wilmington, Du Pont Laboratory." "Ortho-dichloro Benzene." At this the 22-year young man staggered back with his accordion. "Oh, yes," he exclaimed, "I forgot you are all Chemists. What did you say? Ortho-dichloro Benzene? Give me something I understand." "A balloon drifted from Japan to Oregon." "A fire in a forest in Oregon." "Ortho-dichloro Benzene" (in stentorian tones). "Mr., what's your name?" Strident answer: "Mr. Ortho-dichloro Benzene. “Well, Mr. Ortho-dichloro Benzene, we can do without you, here.” This byplay continued several minutes, along with newspaper headlines and a dozen ortho-dicholoro-benzenes.”

For a couple of minutes the entertainer played a popular tune, while he was thinking. Then followed the most fantastic intellectual performance I have ever witnessed. The young man began

to play and sing, composing a story containing all of the newspaper headlines that had been given him, versed in couplets that rhymed. It was unbelievable! Anyway, I thought, and so did the other 2500 Chemists, we've got him licked on including Ortho-dichloro Benzene in his song. But when the performer ended his skit, he danced off the stage singing:

"As I walked down the street what do you think I seen?
A girl dressed in Ortho-dichloro Benzene."

The remainder of the evening that is all we Chemists talked about; this amazing performer.

Twenty years passed. My wife and I were in the attic cleaning out a trunk. I hauled out a program of the Cleveland meeting. "Oh, Evelyn, here is the program of the American Chemical Society meeting in Cleveland years ago." "Oh, Hubert, do you remember that brilliant accordion player who composed the song that rhymed?" "Yes, and here is his name: BOB HOPE!" It was the first big professional job Hope had ever had; he was accustomed to singing in Cleveland night clubs. But he had delivered the goods that night! I still recollect that night whenever I see Bob Hope performing.

SPUTNIK (1935)

Here is a story that the Russians deny. But it was related to me by [W. G] Gurney, so I am sure it is true.

Gurney and [Pyotr] Kapitza attended a Physics Conference in Leningrad in 1936. Now Kapitza had been born in Russia, but at the age of 18 had gone to England to study. Three weeks before the Leningrad meeting he had been made Director of the Mond Low Temperature Laboratory at Cambridge University. (This information is leading up to the Sputnik story.)

When they got on the plane to take them back to England the Russian police came aboard, to take Kapitza off the plane. Kapitza protested. "You can't take me, I'm an English citizen." The KGB replied: "You were born in Russia, you can't renounce your birthright." "But I must return to England: I'm the Director of the Low Temperature Research Laboratory in Cambridge." The KGB replied: "What do you think we're taking you off for? You're going to build an identical low temperature research lab right here in Leningrad." And they took him off the plane (304).

They took Kapitza off; and they not only built a laboratory, but actually bought some of the Mond Laboratory equipment from Cambridge and shipped it over to Leningrad. He lived well. He had a chauffeur, and his own car. He had a summer home on the Black Sea. He had everything he could want. But in Russia. I do not think he was enamoured of his Mother Country.

Everything I've told you is true, but now I'm going to theorize; and I think my theory is right. This was in 1936. Now if you had been in Russia, at that time, you would have said, "How will we defend ourselves against America? America has ringed us with short range missles. Russia must make intercontinental ballistic missiles. We must have tremendous boost." Now, the Soviets had leading Scientists; and they were not Germans. They had Kapitza and they had [Nikolai N.] Semenov. Semenov shared a Nobel Prize for his pioneer research on the kinetics of chain reactions (305). That is the same field that I worked in. He received a Nobel Prize. He deserved it. I didn't. [laughter] He was top man in his field. Here were leading Scientists in Russia on chain explosions and low-temperature research, in 1936. I believe at that moment the Russians began to do research on boosters. In addition to Kapitza and Semenov there were other top-notch Physicists who collaborated.

In 1957, they got Sputnik aloft. They had a thrust of eighty thousand pounds. We, who had done no research of any kind, had a thrust of forty thousand. We couldn't possibly put a man into orbit; we didn't have enough booster thrust. What we did was a scientific desecration. I was lecturing to my students the moment we "launched" Alan Shepard. Sadly, the American press boasted: "See, we can put people in orbit, too." I said, "Gentlemen, this is a travesty of science, taking a human being, and putting him into orbit astride a giant missile. What has been learned? Nothing at all, except to show we could put a man up in the air riding on a

bullet, and endangering his life." Later the Russians had two men in orbit. And we said, "Hey, they're a bunch of idiots." What Americans should have done, and NASA knew it: told the public, "Yes, but now the Russians have a two hundred thousand pound thrust. We can't, in America, put one into orbit because we have only a hundred thousand pound thrust. They can do it and we can't."

My colleague, [John] Turkevich went to Russia to lecture in 1964. They asked me to go. I said, "Maybe you'd better take John, because he can speak Russian." I was in Washington those days about once every ten days. In February I cautioned John: "I may land an interesting job for you this summer; don't sign up for any other job." But it wasn't until June he was invited; then he and his wife and three children all got jobs at the Moscow Fair. They did a splendid job. Khrushchev talked with John in 1964. Khrushchev said, "Yes, Dr. Turkevich, you Americans will get to the moon before we do. Why? Although we have tremendous thrust our instruments are like big alarm clocks. But you, in America, have only little thrust; even the vehicle you travel in has to be as thin as possible, because you can't have a heavy space ship. It must be just thick enough to protect your men through the Van Allen belt. But because it has so little thrust, your American instruments are like little Swiss watches. To get to the moon, we need seven million pounds of thrust. And at that time you will have those 'little Swiss watches' and we Russians won't."

Instead of trying to out-boast the Russians about our space flights, we should have informed the American public about other space accomplishments. For example, the Landsat Project. Two Landsat satellites are up there, three hundred miles up. Every second taking a picture. Every two weeks (of course, it's spying) we photograph every square yard of our Earth. A lady camouflaged in a grass-green dress in a field of green grass is invisible to the naked eye. But not to the Landsat camera! Her dress lacks chlorophyll spectra: only the grass would give the chlorophyll spectra. Inform the public of such wonders, rather than waste time belittling the Russian accomplishments.

FIRESIDE PRECEPTS (1935-1972)

As an Undergraduate at Princeton I took as much English as I did Chemistry. My Preceptor both in Shakespeare and Modern Poetry was a very popular English Professor, J. Duncan Spaeth. (The boys called him J. Drunken Spaeth because he lurched when he walked, not because he was drunk.)

(J. Duncan Spaeth was the brother of Sigmund Spaeth, the Radio tone-detective who would trace the origin of current popular musical phrases to Haydn, Bach, Beethoven, or other Masters.)

J. Duncan Spaeth coached rowing for 40 years, and was as popular with the boys as Pete Carrel is in basketball today. Spaeth lived in the Barracks, a house occupied by the Hessian soldiers during the Revolution, guarding the ammunition the English had stored in Nassau Hall (Buzz Cuyler's home). Spaeth would have a roaring fire there, and we students would come there for our English Precept. Mrs. Spaeth used to bring us polished bright, apples and cider. And there we would discuss Shakespeare. I thought, "If I ever grow up to be a teacher like him, I'm going to have Home Precepts."

So for many years I held Wednesday-night Precepts in my Chemistry-for-Non-Scientists course in my home, which was a block from campus. The boys dubbed it "Housemaid's Chemistry." In my living room I had a blackboard, and 20 folding chairs for the students.

Each group numbered about 20 students. Group 1 came from 7 til 8:30 p.m.; Group 2 from 8:30 til 10:00; and supposedly Group 3 from 10:00 til 11:30, but we usually drove them out of the house at midnight! Oh, yes! I mustn't forget, in Winter, there was always a roaring fire in the hearth.

We started the Class with a 7-minute exam. Then we graded it, reviewing as we did so, the week's assignment. Following which, since we had the Honor System (thank God), they reported their grades to me. After that there was a 30-minute review of an outside reading assignment (like Madame Curie, or The Cry and the Covenant).

Finally they would all adjourn to the dining room where Evelyn (bless her) had made cup-cakes for them all. (When the group swelled to 60, we bought doughnuts; each student had two or three.) We had apple cider; fortunately beer was not a problem because in those days the students didn't guzzle beer.

My home Precepts were very popular. My students were adolescents, but wanted to pretend they were men. They loved that touch of our home. Later, at June reunions they would bring their wives and children, and introduce them, saying, "Darling, this is Professor Alyea." "Oh," would come the reply, "my husband told me how he used to come over to your house, by the fireplace, for his Chemistry Precepts."

I had always hoped that some wealthy Alumnus would establish a snack-fund, available to young faculty members who wished to conduct

fire-side precepts, as I did. It cost the Alyeas a couple of hundred dollars a year, and that was an awful lot of money when you were making only about four thousand dollars a year. We had cider. Today it's a problem, because of the beer, but they couldn't drink beer in those days. I used to get fifteen dozen doughnuts. Everyone had about two or three doughnuts. It was just wonderful. Those last thirty minutes is when I really learned about my teaching with the students, because they let their hair down. "Why did you teach us that? We had that in High School." Or: "That was tough stuff you gave us yesterday." (In that case I'd repeat it the next week.) Then they used to argue about girls, and about sex, and about God. I'll never forget this huge burly football player, bending over a tiny little fellow on the couch, shaking his head and saying, "I tell you, there is a God!" [laughter] The little kid was scared. But that was when I really got to know the students, and they got to know me. That is the way for a teacher to get to know the kids. They weren't afraid to pull punches, and say, "Oh, we had that in High School," or "We didn't understand that very well."

SOIREES AT H. P. ROBERTSON'S HOME (1937-1938)

H. P. Robertson was one of our top Mathematics Professors; I was only an Assistant Professor. We played chess twice a week. We were expert, but not professional. I beat him more often than he beat me. Our wives, Evelyn and Evangeline were good friends. Like Grauman's theater, we put our finger-prints in the cement in their Pasadena home when, later, they moved there.

One day, in 1937, when we were in their apartment, Bob said to me: "Hubert come over tonight, we're going to have some Nobel Prizewinners in for tea." "Delighted," I replied. Now why did he invite me? Because we played chess. There was no scientific bond between us. We knew this. But we enjoyed one another's company.

The next week Robertson said to me, "Come back again tonight, Hubert; we are going to meet every Tuesday." I replied, "You don't want me, Bob." Then he said something that people who know Hubert Alyea know I must be lying to claim. But he did say, "Sure we want you. You keep your mouth shut." [laughter] I never heard anyone else say that about Hubert Alyea. "You sit in the corner over there. As long as you don't say anything, we don't know what you are thinking, private thoughts or not. Come on back."

So, six times in 1937, and six times in 1938, I went back and sat in the corner and listened to them. The only conversation I remember was once with [John] von Neumann the brightest of all of

them. I was on TV a couple of times, and I exploded a milk-can. Von Neuman came to me and said, "I saw you on TV last week. I saw you explode that milk-can. What are you going to do next week?" He was an authority on probability. I said to him, "John, you're the world authority on probability. If you can't calculate what I am likely to do, you're losing your grip." He grinned. "Good show, old man."

Up until about three years ago, I used to think that the only reason they tolerated me was that I was Bob Robertson's friend. Then I read a statement that people who excel in one field have reverence for people in other fields. Most of Bob's guests saw me on that television show. "We all saw you on television. Alyea's going to be on television." I think they saw that there I was interpreting to the public in a way that they were not able to. "Despite all our learning, we can't communicate to the public the way this guy can." They tolerated me, also, because I kept my mouth shut.

Tuesday was Robertson's night. About a dozen would arrive, about half of them Nobel Prizemen. There were different notables at each session, depending upon who was passing through Princeton that week. Princeton residents included [John] von Neumann, [Niels] Bohr with John Wheeler, [Eugene] Wigner and, or course, [Howard P.] Robertson. Scientists who happened to be visiting the Institute for Advanced Study: [John] Van Vleck and [Fred] Hoyle from Harvard; [Hans] Bethe from Cornell; [I. I.] Rabi from Columbia, [Erwin] Schrödinger, [Werner] Heisenberg, and [Max] von Laue from Germany; [Paul] Dirac and [Michael] Polanyi from England (Manchester).

Einstein never appeared: those fellows dabbled in Quantum Theory, not Classical Mechanics!

There was a fixed ritual each evening. Guests arrived about 8 p.m. A couple would converse, then groups of four, and finally, after about fifteen minutes, a single topic would be chosen for all to discuss for the remainder of the evening. At 10:30 p.m. Evelyn (my wife) and Angeline (Bob's wife) would appear with drinks and cakes; and at 10:45 the guests would depart. How I regret that I did not tape the conversations!

CONCEPTION OF THE COMPUTER (1937)

The modern computer is a product of the 20th Century. It was antedated by hundreds of years of simpler machines. Our first modern computer was probably the one made in Iowa State in December, 1939 ( ). Previous to that, many centers of learning speculated on how to construct one.

Let me report on a meeting I attended in the Spring of 1937 at the home of Mathematics Professor [Howard P.] Robertson at 120 Prospect Street, Princeton, NJ. This meeting persuaded [John] von Neumann, expert in the Theory of Games, to develop computers; especially to having them function as brains, not super adding-machines. Thirteen years later he had devised the Univac.

One night this group of a dozen Mathematicians and Physicists, about half of them Nobel Prizemen, were discussing the urgent need for a mechanical brain. They concluded that by the time you had completed 4 years of High School, 4 years of College, 3 or 4 years of getting your Ph.D., followed by a couple of years of Post-doc, that you would be 35 years old before you could tackle the current complex calculations worthy of a Nobel Prize. They went around the group, and each one recalled how old he was when the idea that gave him the Nobel came to him. And everyone had been twenty-two, or younger! I think one guest said thirty-one, but that was when he received the Nobel; the idea came to him when he was twenty-two.

Johnny von Neumann was especially excited. But the others

said, "You can't really make a mechanical brain. You will have to have 20,000 diodes; and a diode lasts only 2 months." (Today a single chip can do the work of 20,000 diodes.) Before any calculation is completed, they said, some diodes will have burned out, and your answer will be incorrect. (In fact later, when the Univac was first operated at Forrestal, they always ran the known, then the unknown, and then the original known, to make sure the first and the later knowns were the same; that nothing had burned out.) Here was a calculation that would take me a month to come up with a wrong answer. But these great minds began to think, and in about five minutes, both Wigner and von Neumann came up with answers: 7 seconds and 6 ½ seconds; a bulb would burn out every seven seconds. Everybody commented, "That's a long while. You could get a lot of answers in seven seconds." And the rest of the night, that's all they talked about. How would this machine be made? Would it be multiple choice, binary numbers? What kind of a mathematical system would you have? Would you be able to air-condition the diodes?

At 10:30, Evelyn and Angeline used to come in and pass drinks around. There was a strict ritual. Fifteen minutes for drinks, and then they would leave. At quarter to eleven they all left, all except von Neumann. I was sitting over in the corner with him. I always stayed on afterwards, and talked with Bob for ten minutes while he briefed me on what they'd said. Von Neumann was still very excited; when he reached the door he turned to thank his host for the evening. As he shook hands with Robertson, Johnny exclaimed, "By God! I'm going to work on that." It was a moment of conception

in the Modern Computer Age.

Later the Historian at the Institute for Advanced Study filled me in with subsequent details. When the War came, von Neumann insisted on computerizing the Manhattan Project. He went out to Los Alamos, and they set up a mechanical card sorter. They called it the MANIAC. He supervised the building of the MANIAC. Then, pretty soon they got the tubes working a bit better, and then they took it down to the University of Pennsylvania, and built the ENIAC [Electronic Numerical Integrator and Calculator]. The ENIAC in Pennsylvania, and up at MIT. They didn't really use the ENIAC much for the War. It wasn't until the end of the War that it was really operating. It didn't have much of a chance during the War, but it was then on sound ground.

Von Neumann did not perfect the UNIVAC until 1960, at the Forrestal Center in Princeton University.

STURCHIO: These must have been very intriguing gatherings.

ANY TOP SCIENTIST? (1938)

One night Robertson's august group spent some time discussing whether the 20th Century had produced any great scientists the equal of Newton, Lavoisier, or Faraday. This was in 1938, when [Niels] Bohr and [John] Wheeler were present. "Niels," they said, "you're fifth class. The rest of us Nobel Prizemen we'll rate as sixth class." (Alyea was 28th class and knew it.) [laughter]

But there wasn't anybody fourth class, there wasn't anybody third class, there wasn't anybody second class. "Einstein is only one-and-a-half class. There is somebody greater than Einstein. Einstein doesn't quite make it, unless his Unified Field Theory is proven within his lifetime." (In fact, it's being proved now.) Now remember, Einstein never came to Robertson's soirees. Einstein was in classical mechanics, and they were in quantum mechanics. They didn't speak the same language. He must have been very unhappy in that situation, to be surrounded by so many brilliant quantum mechanics people.

Someone greater than Einstein? In an audience of 500 common citizens, perhaps not more than a dozen have ever heard of the man these Nobel Prizemen selected: [Max] Planck. Why did they rate Planck above Einstein? Because Planck's Constant, h, is the basis of much of modern Physics. When Planck published this in 1901, he didn't quite know what to do with it. Four years later, Einstein published five papers based on the Planck Constant, any one of which

could have earned Einstein a Nobel Prize; one of them did.

There was E=mc2. There was the laser. There was the photochemical equivalence law. There was the prediction (for which Einstein received the Nobel Prize): that one electron can be ejected when one photon is absorbed; the Photoelectric Effect. The fifth one was in the field of Colloid Chemistry. Jokingly, we might remark that Einstein succeeded because he had a Planck to stand on. [laughter]

When I was an Undergraduate in Princeton I attended a ceremony in Alexander Hall (1923?) when [Marie S.] Curie and [Albert] Einstein were awarded honorary degrees. Madame Curie exhibited a confident, charming simplicity. Einstein, on the other hand, was so confused that he had to be guided to the podium to receive his hood. I saw [Hugh] Taylor, who had worked in 1914 in Berlin confirming Einstein's Photochemical Equivalence Law, go up and ask Einstein a question, only to be answered by a shrug. Later I asked Taylor what had transpired. He told me, "I asked Einstein, 'What's new about your Photochemical Equivalence Law," and he shrugged and responded, 'Ach! Ich habe das ganz vergist.'" Little did Einstein realize that within another decade he would return to Princeton for the remainder of his life.

In 1930, when I was in Berlin, every Saturday afternoon Einstein appeared at Planck's house with his violin under one arm and his wife under another. And he and Planck played music from three in the afternoon until ten at night, with an hour out for

dinner. Those great men didn't find that the music intruded on their science. It made them dream. Therefore, when I'm talking to young people, I tell them, "You can be a great technician if you undertake science, but you can never be a great scientist unless you dream." These men found that that music didn't intrude on their Science; it helped them dream. Here were the two greatest scientists of our century, spending all those hours playing music.

Planck, in fact, intended originally to be a professional pianist. His father wanted him to do one thing, he wanted to do another. When he graduated from the University in Berlin, his father paid the fifty dollars matriculation fee, which was a lot of money then, both to the Conservatory of Music and to the Physics Institute. Planck attended lectures for six weeks in both subjects, and finally chose to be a Physicist; Number One physicist of our century!

It is interesting to speculate on how much influence Planck's playing the piano had on his sub-conscious mind. His was a concept of discreteness. Atoms are discrete particles of matter. Electrons are discrete particles of electricity. Photons are discrete particles of light. Planck's h links them together. If Planck had played the violin (emitting continuous sound waves) and Einstein the piano (emitting discrete sound waves), would h have been conceived by Einstein?

I INVENT AN AUTOMATIC SLIDE-CHANGER (1937)

During the 1930s, household gadgets flooded the market, since increasing wages made housemaids a luxury. Being inventive, I made my bride a kitchen mixer several years before the Waring Blender appeared on the market. My gadget stirred puddings, mixed salads, and even peeled fruit and potatoes; but its motor and flexible shaft baffled Evelyn.

My next invention was more successful. In Frick, my assistant was horribly inefficient in handling my much-used projector. My brother, Ethan, had bought a novelty: an automatic record-changer. (Complex: in those days, the played record had to be removed from the spindle, turned over, then returned to the spindle.) Bingo! Why not an automatic slide-changer? I invented one, hitching the slide-projector to a Minneapolis Honeywell coal-stove monitor, and activating it by the signal button in the front of Frick Auditorium. In the Spring of 1937 I demonstrated this at the American Chemical Society meeting in Chapel Hill, NC, in a paper entitled "An Automatic Slide-Changer." (216).

I now had a year in which to patent it. Hugh Taylor gave me bad advice: that I could not defend my invention against a battery of Kodak lawyers on permanent tenure. (Today, the Research Corporation would handle it, and I would get 12 1/2% royalty). So I didn't patent it.

But the next week, business men invaded Frick from Kodak,

Ansco, Agfa, Minnesota Mining and Bessler. One lawyer and two stenographers came to Princeton and had me sign a statement that I was not going to patent it. I'm sure I could have sold my rights to one of them.

At least I have the satisfaction, whenever I attend a lecture using an automatic slide-changer, of gloating: "There's another of my illegitimate children." [laughter]

WENDELL WILLKIE (1940)

STURCHIO: Why not tell us about Wendell Willkie?

ALYEA: Wendell Willkie's son was in the class of 1940. They said that he made a Politician out of me and I made a Chemist out of him. He wasn't really a chemist. I was fond of him and he was fond of me. He wasn't good at science at all, but somehow I made science understandable for him. He came down to the beach, and spent a whole week helping me put up a ceiling. I spent the night at his home several times. In fact, I was up at the hospital the night his father died. The weeks after he was nominated, Philip said that his father got a hundred and fifty invitations a week, and accepted only two. One time he agreed to lecture in Princeton. Now he was to speak to a group of forty students in, I guess, a politics course. He specified he would come only on condition that no one would know he was coming (including the members of that class). Philip and I could also come. Nobody else. He sat there, in a little room, perched on the desk, talking earnestly to these forty students about the TVA battle he was fighting. Willkie was fighting exactly what was happening, the Government taking over Private Industry. He said, "This is not a battle for building dams down in Tennessee, it's a battle for Government versus Private Industry ownership." I remembered, as we walked back past Nassau Hall late that night, his saying to me: "It's a damn lie, to say that they can give people cheap electricity with that water power. They can never compete with coal, never! All 48 States will pay for that electricity."

Well, I talked down at Muscle Shoals, Alabama about twenty years later. I found out where the seven States that are furnished by the TVA get their electricity from. Five percent of it comes from water power. Twenty-five percent of it comes from coal. All the rest of it comes from nuclear reactors. Isn't that amazing! Willkie was right.

Here he sat, talking to these students. These forty students were more important than those in the room on the other side of the wall, where Robert Moses was lecturing to 550 people. But Willkie was quietly telling students that this was an invasion of the private industry which had made America strong. The government would furnish inefficient management, and this would weaken our country. This is what he told these young people, before they went out into the world. In the next room, Robert Moses was getting cheers and applause from 550 people. I went home and thought about it. "Think of the difference. They'll go home, those people, and think, 'Robert Moses was a good talker. Wasn't he interesting?'" But they'll do absolutely nothing about it. But in these forty young men he's planted seeds that will grow to giant oaks, as they struggle in defense of private industry, and the rights of private industry versus government take-over." It taught me a great deal. I'm sure that had an influence on my decision that I would remain on, teaching here, rather than accept a lucrative TV offer that later came my way.

STURCHIO: What year was that?

ALYEA: That was 1940. There were only five of us present in the room when Willkie learned that he was defeated. I don't know why all these things happened to me. Dean [Robert G.] Albion, a naval historian who later went up to Harvard, Philip and I were very close together. That night Philip said, "Let's go up and pay our respects to Dad." So we drove up from Princeton that night to the Hotel Commodore, I think. On the ground floor there were two thousand Willkieites, cheering. A few floors up there were about two hundred important people. Further up, there were only twenty-five people, including Governor [Thomas] Dewey and two or three of his people. I remember that Claire Booth Luce was there. And there were some other people. On the next floor there was a little room, not much bigger than this (12 x 14 ft.), with a couch on which Mr. and Mrs. Willkie were sitting. There was a television over in the corner. Philip's brother had just arrived from Louisville. Philip said, "They're all going up to see Dad. Let's us go up, too, and pay our respects." So the five of us went up. Philip told me that the minute that the Cleveland Plain-Dealer claimed victory or acknowledged defeat, his father would going along with it. As we walked in, they turned on the TV and the Cleveland Plain-Dealer had just acknowledged defeat. Willkie buried his face in his hands, and his wife was patting him on the back comforting him. "Why can't the people understand?" Half an hour later, he came down to the group of twenty-five, and half an hour after that he came down to the

group of two hundred. And an hour later, he came down, looking radiantly grateful, and thanking his 2000 supporters.

CIVILIAN DEFENSE IN NEW JERSEY (1941-1945)

STURCHIO: One thing that you started to tell us about last week was the work that you did for the State of New Jersey with gas defense in World War II.

ALYEA: This section will be brief since I have placed on file in the Archives of the Princeton University Firestone Library a 500-page report of it. I didn't know whether to give it to you or to the Princeton Archives.

STURCHIO: Probably to the Princeton Archives. That's exactly the sort of material I was talking about before. This is an important part of the record of your service to Princeton and in this case to the State. Princeton should be interested.

ALYEA: I was in charge, as Senior Gas Officer for the State of New Jersey, of organizing the State's defense against Chemical, Radiological, and Bacteriological Warfare. No foreign invasion was anticipated, but there was a real threat of sabotage, since New Jersey produced about one-sixth of the USA wartime chemicals.

I organized the following four projects.

PROJECT 1. GAS OFFICERS. This included:

A Control Group of about 50 active people, roughly one from each County in NJ. I met with them every few months.

Chemists, about 500 from industries, many of them Ph.D.s. I continued teaching students (Army ASTP), but I also had an office in Trenton, with secretaries to attend to enquiries. The Chemists were furnished Gas Masks, and other defense equipment.

Gas Wardens, about 1500, people who volunteered to notify the populace in event of an attack. They were given instructions, including First Aid. My most illustrious Gas Warden was Professor Einstein, himself, who volunteered his services and attended the briefings.

PROJECT 2. GAS SCHOOLS.

New Jersey was, I believe, the only State where Gas Schools were paid for by the U.S. Military. When I first proposed this in Trenton, they scoffed, and said Industry would not send anyone. Instead, we ended up giving two 2-week schools held in Amherst College for 60 enrollees each. Several of the larger Chemical Companies were left begging me to admit more of their own Chemists.

The lecturers, supplied by the Military, instructed at an advanced level, so that my Gas Officers left well-informed about sabotage. Perhaps that is why New Jersey was free of sabotage.

PROJECT 3. PUBLIC SHOWS.

Mid-way in the war we staged four-hour shows, put on by the Military for our Gas Officers and their families; at Englewood for northern NJ, at Princeton for central NJ, near Camden for the Philadelphia area, and at Atlantic City for southern NJ. Thousands attended. The Director of NJ Civil Defense, [Leonard] Dreyfus, accompanied me at each Show.

For example, 20,000 attended the show in Palmer Stadium, Princeton. We had a tent-full of chlorine gas, and most of my 2000 Gas Officers put on gas masks and stayed in the tent for five minutes. I had nurses put a drop of mustard gas on the right and left arms of 2000 of my Officers. Then they washed the spot on the right arm with yellow laundry soap, and the spot on the left arm with mild Ivory Soap. Result: the mustard gas on the right arm was neutralized by alkaline soap; but on the left arm there remained a quarter-inch scar, for life, of 2000 Gas Officers. [Alyea displays his mustard-gas scar]

PROJECT 4. PREPARING GAS TEST-KITS.

Several Saturdays, during the Spring of 1945, about fifty Chemists, mostly Ph.D.s, came to the Frick Lab in Princeton to make 200 Poison-gas Test Kits. We were to be flown over to France, if the Germans opened a poison-gas offensive during their final retreat across France. Luckily, this never came to pass. Why, is interesting. At the Nürnberg trials [Alan] Dulles, of OSS, was privileged to ask [Hermann] Göring one question. Dulles' question:

"Why didn't you Germans use poison gas when you retreated across France?" Göring's answer: "Horses." Dulles understood. Do you? You see the Germans were so devastated, by that time, that they couldn't use trains or lorries to bring their military material up to the front lines; they had to use horses. Now, you can put gas masks on human beings, and they will still be 80% efficient. But not on horses. The Germans knew that if they started Gas Warfare, we would retaliate.

Concluding Remarks

I can't conclude this section without revealing my chicanery that won admiration of my Gas Officers for my supposed sagacity. The rule was that they could telephone me, in Trenton, any weekday, noon-time, between 11:45 and 1:15. I would leave my Princeton lecture at 11:30, dash down to Trenton eight miles away; then return to my lab class by 1:30. In Trenton two secretaries sat poised for action, behind card files, one card for each of my 500 Gas Officers. The Trenton authorities were horrified that I destroyed letters; but I could boil each letter down to a single line on the correspondent's card.

For example, I might note on one card:

"Joe Blokes wants five gas masks. His kid has a broken elbow." Months later, he'd call back. "Oh, you want to get some more gas masks to add to the five you got." "Do you remember that?" "Sure, I remember. And how's your boy's elbow?" "You remember that!"

They didn't know, when they called, I'd whisper to the secretary who it was and she would quickly get the card from the file. [laughter]

FINALE for 1940-1945

As I review my war record, I marvel at the pace I lived at: (1) Senior Gas Officer for the State of NJ, with an office in Trenton, and 2000 Gas Officers and Wardens; (2) Director, organizing 80 Graduate Courses in Newark, Elizabeth and Bound Brook for 3000 enrollees for Engineering, Science Management War Training (ESMWT); (3) Teaching (1941-1943), 18 hours a week, Princeton students in the Army Science Training Program (ASTP); and (4) Research (1943-1945) for OSS in Washington, DC and on the West Coast.

(See pages 121-3, 126-8.)

ESMWT (WAR TRAINING COURSES) (1942-1945)

DOEL: I understand that during World War II you organized courses for Chemists in Industry?

ALYEA: My reply to this will be brief because I have deposited a complete record of this in the archives of the Firestone Library of Princeton University.

From 1942 to 1945 the U.S. Government subsidized instruction by Professors in Engineering Schools. The title of the program is given above. The purpose of these courses was to upgrade workers in Industry.

Professor [Frank] Heacock of our School of Engineering was its Director. He asked our chairman [Hugh] Taylor if Chemistry wished to participate. Dr. Taylor agreed, and asked me to act as Associate Director in charge of the Chemistry Courses. In the end the tail wagged the dog: Engineering gave about 20 courses, and Chemistry over 80, the majority of them at the Graduate level. Courses 4 nights every week. Six courses each week; each course 2 nights a week for 6 weeks.

Princeton's Chemistry Professors would go to Newark, Elizabeth or Bound Brook to lecture twice a week, leaving Princeton about 5 p.m., and returning to Princeton about midnight. It was a strenuous routine. Each course ran for six weeks and covered the identical material being taught in Princeton. Class size ranged from 30 to 60. The same final exam was given as was offered in Princeton,

graded with equal severity. Any candidate who flunked (about one-fifth) was allowed to repeat the course. Those who passed were given a Princeton diploma. I enlisted almost the entire Chemistry Faculty in the Program. Lecturers included:
--- in organic chemistry, Professors [Everett] Wallis, [Eugene] Pacsu, and [John] Lane.
--- in physical chemistry, Professors [Hugh] Taylor, [Robert] Pease, [Henry] Eyring, and [Richard] Powell.
--- in general chemistry, Professor [John] Turkevich, and myself.

Enlisting enough students to qualify for a course was often hard work. You had to have at least twenty enrollees in order to get money from Washington to approve the course. If only seventeen had enrolled, I had to locate three more. I would sit in the phone booth in the Pennsylvania Station in Newark for eight hours, calling industrial research directors. I had a long list of them! I sat there in the phone booth dropping coins in, one after the other. "Sure, Doc, I'm so glad you called; we missed your announcement. I'll send you three next Wednesday." And on Wednesday, registration day, forty applicants would show up!

I don't know how I lasted, physically. I would go up to Newark four nights a week. I would teach in Princeton all day, then catch the 5:17 train from Princeton. [Everett] Wallis, who lived next door to me, would start out an hour early for our train, and I'd

leave home five minutes before the train left. [laughter] We'd sit together on the same train going up, and return home about midnight. Four nights a week! It shows what one can do under pressure!

One night John Turkevich and I were sitting on the side-seat of a trolley taking us from the train station to Newark Academy. On our laps we delicately balanced huge molecular models which the public, crowded around us, eyed with suspicion. I became fearful that they might press against and damage the models. Suddenly I had a diabolical idea. I began to stroke the models fondly, murmering, "Da! Da! Da!" Frantically, the passengers fled to the rear of the trolley, leaving our models intact!

After the War, as Director, I received a number of letters from Graduate Schools (Columbia, Rutgers, NYU, University of Pennsylvania) re these industrial chemists who were going on for a Ph.D., and wanted course credit for the War Training courses Princeton had given them. In reply I would send a copy of the final exam and state that the student had taken that exam, that our Faculty had graded the student's paper with the same severity as for our Graduate Students, and had passed it. In all instances course credit was granted.

ATOMIC ENERGY LECTURE (1945-1958)

LIFE Magazine and Karsh

Between 1945 and 1960 I gave a 1½-hour demonstration lecture, entitled "Atomic Energy: Weapon for Peace," 2640 times in over 80-countries for the Atomic Energy Commission, the Department of State, and to the general public. In it I explained conventional and Nuclear explosives, and why the latter could annihilate Mankind. I also described the fantastic peace-time uses of isotopes. Re Nuclear Reactors, I deplored the misguided environmentalists (generally commendable) who stymied progress with Nuclear Reactors by championing laws that set permissible levels of radioactivity in a Nuclear Reactor plant below that of the radioactivity in the NY Grand Central Station (it has radioactive granite).

I estimate I have lectured face-to-face to over 3 million people. In Pearl Harbor, on December 7, 1949, I gave a 4-hour Memorial lecture to 6000 military personnel. And, with Burgess Meredith in 1954, I gave a TV show to an estimated audience of 64 million people (more than ever listened to Sarah Bernhardt. [laughter]

At that time, the celebrated photographer [Yousuf] Karsh came down to Princeton to make a series for LIFE Magazine (13) [see accompanying two pages].

It is an amusing story how Karsh achieved his famous photograph of Churchill, sitting in an armchair, with a contemptuous grimace (supposedly inspired by Hitler). Karsh sat chatting pleasantly,

with Churchill contentedly smoking one of his famous cigars. At a pre-arranged moment one of Karsh's assistants dashed in and snatched the cigar out of Churchill's mouth. At that instance Karsh snapped the famous picture! [laughter]

Karsh took 600 pictures of me, and published about a dozen of them in LIFE Magazine. After the photographic session, we were chatting in the Nassau Inn Yankee Doodle Tap Room. Karsh said: "Doc, you are moving in high society. Just last week I did a series on Marlene Dietrich." (She with the beautiful gams; and I with my polio-stricken legs.) So we toasted to Marlene Dietrich's brain and Hubert Alyea's legs. [laughter]

(See pages 130a and 130b)

HAWAII: from SERFDOM to CAPITALISM (1949)

I gave my lecture "Atomic Energy: Weapon for Peace" 54 times in all of the Hawaiian Islands in the Spring of 1949, at a time when Hawaii was undergoing a major industrial revolution. Wages on the sugar and pineapple plantations were 25 cents an hour in the Fall of 1949, and $ 1.25 an hour (but without company benefits) in the Spring of 1950.

Why this fantastic change? You see, during the War years, thousands of men were brought from the Southern States to serve as stevedores for the heavy military shipping from the Pacific Coast. With the war over, demand for them shifted to Hawaii. But hourly wages in California were over a dollar an hour, and in Hawaii only 25 cents. Gus Hall, the labor leader called a strike. President Truman declared it was a local, not a national issue. For six months no ships crossed to Hawaii. (My car was jacked up in San Francisco for nine months.)

My lectures put me in touch with three groups. Here are their comments.

The Plantation Owners. At the Maui Country Club where I lectured to a dozen owners and managers, one owner said to me: "Dr. Alyea, my Company is spending two million dollars digging up rocks in that cane field. We cannot cut cane by hand profitably and pay the workers $1.25 an hour. We are preparing to substitute machines, and cut the work force, which once numbered 1500, down to 500. Fortunately it will not be a hardship on our workers: during the War a thousand young people left our employ to work for the military

over in Honolulu. They won't come back. But unfortunately, with our smaller hospital demands, we shall no longer be able to attract young interns from the Mainland to spend a year in Hawaii, or to benefit from new Hospital equipment. We will have to ship the sick to hospitals in Honolulu."

The Plantation Workers. This group, friendly Orientals, would meet me at the airport, and entertain me in their homes over the week-end. We would eat Oriental style on low tables. Their wives would eat, separately, in the kitchen. "Doc," they would say, "we don't know whether we will be better off with the new, higher, wages. Until now the Company supplied all our needs. If my kid broke an arm, or my wife had a baby the Company would cover the cost. But now??? Also, each Wednesday and Saturday we stopped work at noon. The entire family was bused ten miles into town. In the afternoon, our kids would watch a free movie, while my wife and I window-shopped. The family had dinner, anywhere, with company chits. Then a family movie, and back home by ten o'clock. We doubt whether we will get into town more than once a month now.

Educators. (of course I agreed with them) "Yes, Doc, but they will be free human beings, not serfs. Their lives will take on a new meaning."

I have returned to Hawaii a dozen times and witnessed a remarkable progress. Walking, then bicycling, then VWs, then better cars; people having a freer choice as to how to spend their earnings.

A PAULING FAMILY REUNION (1950, 1954)

Following my year at the University of Hawaii I spent the summer of 1950 at Cal Tech while Evelyn and Freddy remained in Hawaii, where Fred took swimming lessons from an Olympic Champion. I roomed at the Faculty Club on recommendation of Professor [H. P.] Robertson, my Princeton friend. I worked hard, for three months with Linus Pauling. But my labors were unfruitful. My task was to make an unstable compound, iodine tetroxide, for X-ray studies. I made the tetroxide all right, but the X-ray machine broke, and the Ph.D. student, who was to take the photographs, died. However, during the whole summer I was in daily contact with Pauling. What a wonderful human being he is! He would come into my lab in the morning, greeting me cheerily, "What are you doing today, Hubert?" Then off would go his jacket and he would work alongside of me for a while.

Also, a number of times the Paulings had me to their home for dinner: Linus was dictating his new Freshman Chemistry Textbook onto Edison Records, and I would listen to them. He knew everything about chemistry, and I knew a little about undergraduate immaturity in comprehending it.

Four years passed. In 1954 Linus Pauling came to deliver four afternoon lectures in Princeton. I had a desk placed for him in my office in Frick, for him to use; and so I could take him around to visit the Chemistry Faculty. The first of his lectures were on Sickle Cell Anemia. He had three more to give. That night he learned he had been awarded a Nobel Prize.

Evelyn, who was a good entertainer, suggested that I invite Linus and his wife, for supper in our home, with just the four of us re-living our times in California, when she and Freddy came over from Hawaii my last couple of weeks.

When I congratulated Pauling the next morning, and issued my invitation, he was delighted. "Hubert," he enthused: "That's the nicest invitation I have had since I won the Nobel Prize. We'd love to come. Everyone in Princeton wants to throw a big celebration for me; we'd much rather spend the evening quietly in your home." That evening Linus and his wife were jubilant. She noticed that we observed their joy. "Do you know why we're so happy, Hubert?" "I'd be happy too, if my husband won a Nobel Prize." "No, it is for an entirely different reason. Just this morning we sent four cablegrams off to our children. Linda is in Norway, Peter in England, Crelin in Oregon at Reed College, and Carl in Hawaii. We cabled: 'come to Stockholm on December 10th; Dad has just won a Nobel Prize.' You see, we had what we thought was to be the last Pauling Family Reunion this Summer when we camped for two weeks on the Mohave Desert. Oh! How we cried when we broke up. We thought it would be our last family reunion, just the six of us together. But now we can have another Pauling Family Reunion in Stockholm."

And I tell Teachers: when explaining the Nature of the Chemical Bond (for which Pauling received his first Nobel Prize), get out the December 10, 1954 Chemical & Engineering News, and there on the cover they will see the six Paulings, all smiling happily, not because their Father has won a Nobel Prize, not because they are saying "Cheese" in Swedish, but because they are having a Pauling Family Reunion.

TESTED DEMONSTRATIONS (1951)

STURCHIO: Hubert, one of your most valuable contributions in the field of Chemical Education was your Series, Tested Demonstrations, being published monthly in the Journal of Chemical Education. What prompted you to begin it?

ALYEA: Its conception began in 1925. Its birth took place in 1951. And since then, it has been published for forty years, and is still a monthly feature in the Journal.

Let me outline its progress. In 1925 [Hugh] Taylor invited George Kistiakowsky to come to Princeton as a Research Fellow. Taylor had worked with [Max] Bodenstein in 1914 in Berlin, and Bodenstein had recommended Kistiakowsky, a White Russian emigré, to Taylor.

Taylor met Kistiakowsky at the Kennedy airport when he arrived in the States. The following conversation ensued as Taylor was driving Kistiakowsky back to Princeton that day: Kistiakowsky: "Do we get to Princeton tomorrow afternoon?" Taylor: "No, this afternoon. It takes only two hours." Kistiakowsky: "Two hours? I looked up in a map of the United States and thought the University was in Princeton, Indiana!"

Kistiakowsky was a remarkable glass-blower. He could work with quartz, which begins to melt and becomes liquid within only a 60-degree working range. You have to be a fantastic glass-blower to be

able to build quartz spirals, or other quartz apparatus. Professional glass-blowers can't always do it, but George could.

He got married shortly after he arrived here, and they had a tiny daughter, Vera. Only this Spring I was having lunch with the woman who is President of Cal State in Fullerton, [Jewel Plummer] Cobb, and I happened to say something about Kistiakowsky. She said, "Oh, I know his daughter Vera very well. Vera is a Professor at MIT." So I said to President Cobb: "The next time you talk with Vera, you tell her that you had lunch with a man who held her in his arms for a whole hour--when she was two weeks old." [laughter] I used to baby-sit for them every once in a while; in return George's wife, who was Swedish, taught me Swedish because I was going to the Nobel Institute.

George was writing a Photochemical book (310). His chemistry was perfect, his English left something to be desired. I helped him. In the book he thanked me, and that was the first time my name ever appeared in print.

I'll never forget the time he came down from Harvard on the day that Germany invaded Russia. He stood with his back against the wall, in Frick lab, and there were just the two of us standing in the hallway, conversing. And his saying, "Now we're going to live in an armed camp all the rest of our lives." He was very prophetic about it.

All my Tested Demonstrations is because of [George] Kistiakowsky. At least, he did the seeding that led to Tested Demonstrations. I knew Kistiakowsky well, since he was in Princeton

three years before going to Harvard. There is an excellent tribute to him in the Minutes of the Royal Society (309).

The Harvard faculty voted Kistiakowsky one of the twelve most learned people on the entire faculty. He was Eisenhower's chief Science Advisor and really a top physical chemist. When, in 1948, he was chairman of the Harvard Chemistry Department he wrote me. "Hubert, you won't believe what I'm going to teach next term. I'm going to teach a terminal course in chemistry to two hundred and fifty Radcliffe Freshmen. I've looked at the chemistry texts, and they're full of nonsense. I haven't had Freshman Chemistry for forty years. I couldn't possibly give an exciting course, using textbooks. But I remember those exciting demonstration lectures you gave at Princeton. Will you hire a secretary? I'll pay for her services (scientific only) [laughter] to record the experiments that you do."

I discovered that when I first began teaching in Princeton that they had instructions for about two hundred experiments. I had written another five hundred, so by 1948 we had seven hundred of them. I wrote each experiment on a little card that would say something like, "Exothermic reaction. Gives off heat." It also said what the assistant should put out for the lecture. "A dropper-bottle of mercury. A little solid iodine. A small mortar and pestle." Then in capital letters what the lecturer did. (Since he couldn't see very well, it had to be capitalized.) "TAKE ONE DROP OF MERCURY, ONE TINY FLAKE OF IODINE IN THE MORTAR. KEEPING YOUR

FACE AT A DISTANCE, GRIND CAREFULLY. This forms mercuric iodide, is exothermic; and the heat will be enough to vaporize iodine, so you get a little puff of violet iodine vapor."

George said, "I never did the experiments before class. I was giving Mother Nature a sporting chance. The assistant would put out five cards, and five sets of chemicals for doing five experiments. I'd come in each day and say, 'Let's see what Alyea has for us today!' We'd take card Number 1, and we'd do the experiment. If it worked exactly as it should, then we'd bless you. If it didn't work, then we'd curse you, and spend the rest of the hour trying to make it work." And, with George carrying on the investigation, learning a lot of chemistry.

He said, "I'll never forget that exothermic reaction. The card said mercury plus iodine, I didn't bother to look at the rest of it." Obviously mercuric chloride has a strong bond; mercuric bromide a weaker bond; and mercuric iodide such a weak bond, and its formation so exothermic that it breaks the bond and releases a cloud of violet iodine vapor. "So," he said, "I took the mercury (not one drop but I poured it all into the mortar). I took the iodine, and dumped the iodine in. 'Girls, you're going to see an exothermic reaction.' BOOM! It exploded! I was covered from head to foot with iodine. A violet mushroom cloud of iodine arose to the ceiling, like an atomic bomb; 250 girls jumped to their feet in alarm. 'Girls,' I exclaimed, 'you have just seen an exothermic reaction. The class is dismissed.'" He said, "It was the shortest

and the most dramatic lecture I ever gave."

Well, he didn't know it, but that changed my life completely. At that time I was doing very exciting work on surface potentials, with two people who got their Ph.D. with me, Judd Ihrig and Brian Mead. I had intended to push my surface potential research for the rest of my life. The whole of surface chemistry could grow out of what I was doing, depending on what I discovered. But I went to Hawaii right after that, in 1949. They were very excited about my lecture demonstrations, and they asked me to set up the chemicals and equipment for doing them. So I set up all the chemicals, and I rewrote those cards, and in 1950, I came back to Princeton.

Now, I was one of the Associate Editors of the Journal of Chemical Education. I thought, "Well, I should pull my weight in the boat, so let's publish these for the College and High School Teachers." So I started the series, and published them. The series was called "Tested Demonstrations." To the original 700 I added many demonstrations a month until by 1970, I had published about six thousand demonstrations.

STURCHIO: George Gilbert took it [that section of the Journal of Chemical Education] over.

ALYEA: No, [Fred] Dutton of Michigan State took it over for about a decade, and [George] Gilbert of Denison College has been Editor of the series since. Tested Demonstrations by Hubert Alyea and

Frederick Dutton was later published in book form by the Journal of Chemical Education.

PREDICTING THE H-BOMB FROM ITS LITHIUM FLAME (1951)

ALYEA: The following was related to me by [R. W.] Wood, a famous spectroscopist at Johns Hopkins University. When he was a student in Germany he complained to his housekeeper that the chicken soup that she gave him for lunch was made from the bones of the chicken that he had the night before. (I always tell this story when I'm talking about flame tests, with sodium giving the yellow flame, barium giving green; red for strontium, and the deep red for lithium.) She said, "No. It is very fresh chicken." "No," Wood said, "you took the bones, boiled them, and they're in the soup for lunch here, today." She replied, "Nein, nein." So he took out a little alcohol burner and lit it, took out a little platinum wire on a glass rod, dipped the wire into the soup, held it in the hot flame; and a beautiful dark-red lithium flame resulted. "Yesterday, before you took those bones out into the kitchen, I sprinkled some lithium chloride on them. And here, they're in the soup today." (The housekeeper was in hot water!)

When the Eniwetok explosion in 1952 took place, we were talking about flame-tests in class at that time. I marched out in front of the students, held up that day's New York Times, and proclaimed, "Gentlemen, a hydrogen bomb has just been exploded at Eniwetok today." That it was a hydrogen bomb wasn't released to the public for three weeks. The boys thought I was a wonderful Professor who had "broken the code." What was on the front page?

A sailor was reported as saying, "I've seen three atom bomb explosions. But this was the first one where there was a dull red glow in the sky for fifteen minutes after the bomb went off." I told my class, "That can be only one thing. That's lithium hydride (actually lithium deuteride). A hydrogen bomb was exploded." Then I demonstrated the red lithium flame to them, and related the above R. W. Wood story. The students were very much impressed with their Professor that day!

THE OLD NASSAU REACTION (1957)

Being a Princetonian, I was delighted to have discovered a clock-reaction which turned Princeton's colors: from Colorless to Orange, to Black.

This is how it was discovered. Two of my Non-Science Students had proposed, as their original research, to find some inhibitors to the Iodine-clock, a reaction which turns suddenly from colorless to black. (277).

One day, in lab, they came over and reported to me: "Doc, we put in some mercuric chloride, and it turns orange, not black." I immediately realized that orange mercuric iodide had formed, but jocularly told them: "What do you expect in Princeton: it's a fifty-fifty chance: Orange or Black!" I suggested: "Repeat it, but cut down considerably on your mercuric chloride." (I figured that after the mercuric salt was all precipitated, the black starch-iodine would follow.) It worked! I immediately reported our discovery to the entire class, 140 students, who spent the remainder of the lab period confirming the orange-and-black sequence.

The reagents, and the sequential reactions for these reactions, are described in Reference 277.

I christened this reaction THE OLD NASSAU REACTION for the following four reasons:

1. Nassau Hall is a Mecca for Princeton students. They sing:

"Going back, going back, going back to Nassau Hall;
Going back, going back, to the best old place of all.
Going back, going back, from all this earthly ball;
We'll clear the track as we go back;
Going back to Nassau Hall."

2. Nassau Hall was the British depository for their ammunition, guarded by the Hessians in the Barracks, still standing on Edgehill Street. On January 3, 1777, Washington crossed the Delaware to seize the ammunition that was stored in Nassau Hall. (His first crossing was December 24th to capture 807 British soldiers in Trenton.)

Washington, advancing to Princeton, encountered the Hessians and was victorious. The Battle of Princeton was one of four Washington won. Historically it was a critical battle, since Washington's victory persuaded the wealthy German and Dutch inhabitants of the Philadelphia area to join him, and to give his troops food, clothing, and money.

3. The first telegraph message was sent through Nassau Hall in 1830, three years before [Samuel F. B.] Morse patented the telegraph. Morse admitted that he got the idea of the telegraph from Joseph Henry's Princeton contraption. Morse's great-great grandson lived next to us in Montclair, NJ, and I used to tease him by telling him that he got rich by his old, old man stealing ideas from a Princeton Professor. [laughter] When [Joseph] Henry came down to Princeton College from Albany College to be Professor of

Physics, and later Dean, he brought with him a huge 2000-coil electro-magnet (still on exhibit in our Physics Lab).

He placed it in the kitchen of his home (now called "the Henry House") just east of Nassau Hall. Henry ran two wires from his electromagnet through Nassau Hall to the Dean's Office located in a small building located near where Stanhope Hall now stands. Each afternoon Dean Henry would repeatedly tap together the two wires in his office; the electromagnet in his kitchen 150 feet away would click, signalling, "Put the water on to boil, the Master's coming home for tea." Not as lofty a message as the historic "What hath God wrought," but what more could you expect of a Physicist. [laughter] Incidentally, [Joseph] Henry retired to become the first Director of the Smithsonian Institution. He had also been invited to become President of Princeton.

4. The fourth, and most important reason for calling it the Old Nassau Reaction, was that Nassau Hall is, I believe, the oldest College Undergraduate Laboratory in the World!

There was no question that it was the oldest in the colonies. I think that it was in 1797 that John Maclean was supposed to have issued a list of chemical equipment that students should bring with them to Princeton for laboratory experiments. He came in 1795. There were only two Professors of Chemistry in the New World, [John] Maclean at Princeton, and [Benjamin] Rush at the Philadelphia College of Pharmacy, which later joined the University of Pennsylvania. All of the others were Professors of Natural

Philosophy. Harvard and William and Mary didn't have Professors of Chemistry. John Maclean only held that chair for one year, and then he was promoted to Professor of Natural Philosophy.

In 1803, Benjamin Silliman introduced laboratory work in the Freshman course up at Yale, and said that he got the idea from John Maclean in Princeton. There was no question that Princeton antedated Yale. Harvard and William and Mary were later, between 1808 and 1810. I don't think there is any question that Princeton had the first undergraduate laboratory in the colonies. Now, why in the World? In Europe they didn't conduct undergraduate courses in Chemistry. Instead, they had apprenticeships. Sir Humphry Davy said his greatest discovery was his apprentice Michael Faraday, who had come to wash chemical equipment. I've asked about this whenever I've gone abroad. The oldest I can find is the University of Edinburgh, and that was 1818.

Nobody that I've known in Germany or France has ever claimed that they had a college laboratory course in chemistry earlier than 1797.

Here is an interesting item I discovered about John Maclean in the Princeton Library Archives. He was fined $75 for irreligiously transporting glass chemical equipment from Philadelphia to Princeton College on a Sabbath. He willingly paid the fine. Said he: "The highway from Philadelphia to Princeton is so crowded with wagons

during week-days, that I would have broken over $75 worth of glass apparatus in transporting it week-days."

STURCHIO: I can't think of any undergraduate chemistry laboratory, but there were plenty of Professors of Chemistry.

ALYEA: But they were called Professors of Natural Philosophy. Incidentally, it is interesting to note that Chemistry was a required course in Princeton for all students during the nineteenth Century.

STURCHIO: Chemistry required? Why was that?

ALYEA: Because Biology was an unmentionable Science. In the late '90s "Bones Schenk," the Chemistry Professor, had a human skeleton in the front of his class, and used to digress occasionally from Chemistry to Biological subjects. That's when his students all stayed awake. [laughter] The skeleton was covered with paper. Rumor has it that one day, when it had been snowing, one of the more jocular students slipped a snowball inside of the paper-covered skeleton, and in the midst of the Chemistry lecture raised his hand and commented, "Excuse me, Professor Jones, I think your skeleton needs to leave the room...Oops...too late!" [laughter]

THE ABSENT-MINDED PROFESSOR (1958-1960)

ALYEA: Shall I tell you about the Absent Minded Professor?

STURCHIO: Please do.

ALYEA: I was lecturing at the Belgian Fair (Expo-58) and [Walt] Disney came over to see his Cyclorama. The King and potentates wanted to entertain him. Instead, Disney said, "Treat me like a tourist." So they took him to the International Pavilion. The American Exhibit there consisted of two parts: a mock-up of a Nuclear Reactor, and my 1-hour Demonstration Lecture: "Atomic Energy, Weapon for Peace," which I gave six times a day, five days a week, for six months. I gave it in (compound fractured) French, and my assistant would repeat whatever I said, but in Dutch for the Flemish audience.

Disney stayed listening to me for three repeats, and for the last one I announced, "We are privileged to have with us, today, the World's Greatest Educator, Mr. Walt Disney." He stood up and waved to everyone. He came up to me after the talk. "Where do you teach, Professor?" "Princeton." "Well, you will hear from me." When I returned to Princeton I received a telegram from Hollywood, from Disney, "When can I telephone you next Monday or Tuesday; I am thinking of a movie, with Fred MacMurray playing your role." So I gave Disney a break and suggested he call me after six p.m., at evening rates. [laughter] On Monday we talked for half an hour. Disney explained that they had just finished "The Shaggy Dog Story,"

and they wanted to follow it up with another. As he watched me do my chemical experiments he remembered a script, The Absent Minded Professor, and the idea came to him to have Fred MacMurray act like me.

I always fly tourist, but Disney put me on a first-class plane to Los Angeles, full of Miss Rheingold contestants. Of course, they were all girls. [laughter] They had all come from Hollywood, and they were all professional models. You know, Rheingold Beer picked out the six prettiest in the contest and published their pictures for several months. If you drank a Rheingold beer you could vote for one of the six girls. The girl who got the most votes became Miss Rheingold for that year. There they were, a hundred girls, all very pretty. The girl who sat next to me was nobody's fool. She had a master's degree in psychology. She told me, "We're all professional models, but we don't say we come from Hollywood. I was born in Pasadena. But if I'm asked where I was born I say Des Moines." I was no fool either. Before we landed, I got her picture to show the boys when I got home. The first thing I did when I returned to Princeton the next week, was to display her picture to my class, and announce: "You see, gentlemen, your Professor believes in 'making hay while the sun shines.'" [laughter]

On the phone Disney had enquired: "Now, Doc, where do you usually stay when you're in Hollywood?" I was going to say "Joe's Bar." [laughter] Then I reasoned that my son, Freddy, was up at Stanford, and he could fly down to Los Angeles. My nephew and his wife were at Cal Tech. So we could have a family reunion over the

weekend. "Mr. Disney, may I suggest that I come out on Saturday. I prefer to stay in Pasadena. I know the chemists at Cal Tech (I worked there for four months). I'll get the chemicals and lecture equipment there, and then I won't have to ask your men to provide them."

I was met at the airport by a guy in a Rolls Royce and a cap. He had a hand-written two-page letter from Walt Disney, apologizing that he couldn't meet me personally because he was scheduled for a special appearance in Disneyland that day. But that a chauffeur would take care of me. I didn't want this chauffeur. I said, "Look, I can drive the car. Wouldn't you like to have a free weekend?" "Thank you sir, thank you." He was off like a shot. Probably he was going to spend the weekend with his mistress, and tell his wife he was spending it with Professor Alyea. [laughter]

In Pasadena they put me up in the Bridal Suite at the Huntington Hotel. When I registered the clerk said: "I have a message for you, Professor." It was from my niece, Jane Alyea, who had been at the Huntington several weeks, writing an article for Fortune Magazine, but unfortunately had to return to New York the day before I arrived. Small World!

When son, Fred, arrived from Stanford I had propped up on my dresser the photo of the Hollywood girl. Oh, yes, the girl on the plane. She said I could take any picture I wanted, so I took the one with the least clothes on. [laughter] She wrote on it, "Professor Alyea from Anne Newman." She was one of the six

finalists. Freddy came walking in (his mother was back in Princeton) and here was his Dad in Hollywood with the photo of a model on his dresser. Fred exclaimed: "Gee, Dad, you're a fast worker." [laughter] So I called his mother and said, "It's all right. I'm being chaperoned by Freddy."

Monday morning I drove over to the studio. Right in the center of the Disney Property was a small building for about 30 executives. It was surrounded by acres and acres of land for picture-taking. I got to the first gate, and the policeman said, "You can't come in here." "I'm here to see Mr. Disney." "What's your name?" "Professor Alyea." "Oh, Professor, come in." Finally, I got to another gate where all the business officials were. "What's your name?" "Professor Alyea." "Oh, Professor, come in, come in." So I got in. So here's a parking lot with only twenty places. Place number one, a painted wooden sign. "Mr. Disney." Place number two, a painted wooden sign. "Professor Alyea."

I spent from nine that morning until five that afternoon with Walt Disney, just the two of us. It was a fascinating experience. He was so nice, so natural, and interesting. We talked about methods and theories of teaching. He said, "You know, Doc, this is not a scientific movie. It's just for fun. But the public will learn several things. One is that the Professor discovered a bouncy material" (it was later called Flubber). "Moreover, he was not an absent-minded professor but a single-minded professor." That was true. You left the movie thinking, "Hey, he was on the ball wasn't

he? He was the only one in that one-horse town who was doing something interesting." By the way, in my contract I specified that they couldn't mention my name, or Princeton. I wasn't going to be the "Absent-minded Professor, Hubert Alyea."

They gave me a huge office, with a desk four times the size of this one. "These are your quarters." (I was going to be out there for a week.) "Can't you give me a smaller office?" "No, Doc, we want you to feel at home." In an adjoining room there was a big library with three pretty secretaries; and then Disney's room was off that. He said, "You can have anything here you want." I said, "I'll take her." He said, "Oh, Doc, you've been around." [laughter]

We went down to lunch, and there were three steps down. Here were twenty-eight people at seven tables. These were big-wigs who had been dickering all morning about Disneyland, True Life, and Disney Toys. I stepped down with Walt Disney. I'd give a couple of hundred dollars to have a moving picture of their faces, as those twenty-eight people turned and looked at me. "Who the hell is that stranger? He doesn't even belong to the club. All morning we have been trying to get to first base, and that guy comes in and gets to home plate." There's no question that was exactly what was going through their minds. I sat down, whereupon two of the twenty-eight jumped up and rushed over. "Hello, Professor Alyea. He taught me chemistry, Mr. Disney." Isn't that a co-incidence?

After lunch Walt Disney took me down to the hangar where the Monorail was being built. He was very enthusiastic about its future. He climbed into the driver's cockpit, and bid me to sit behind, while he demonstrated how to drive it. "You start it with this button, Doc; here's the brake; here's how you control the speed." I viewed this great man playing with his million-dollar toy just like a Father, who has given his little son a toy train for Christmas, plays with it himself, Christmas afternoon. "You better look out, Mr. Disney," I laughingly admonished him, "or you'll own a railroad." "Aw Doc," he replied, "I already own two railroads."

Then I gave a lecture to about 250 people, and Fred MacMurray and June Haver (his wife) watched me. My lecture included audience participation, and June Haver was especially, intelligently responsive. After my lecture, I remarked this to Fred MacMurray (as thoroughly nice in person as he is in his movies) and he remarked, "Yes, whenever I am to give a public speech, I always try it out on my wife, and she gives me good advice." MacMurray also said to me: "I took Chemistry in College, but yours was the first Chemistry lecture I ever understood!" Well, he took it at Carroll College in Milwaukee; and I lectured at Carroll College a few years later to 1200 high school kids at a Science Fair. The head of the Chemistry Department was proudly showing me his new splendid Science Lab. At the conclusion of the tour he said to me: "Doc, I've saved my most interesting item til the last. Do you know who our most famous alumnus is? Fred MacMurray." I responded: "Do you know what he

said about your Chemistry teaching?" [laughter] Just last year (thirty years later) he presented himself to me at a Science Convention in Houston. He enquired of me: "Do you know who I am?" I responded, "Have you improved your Chemistry lectures?"

The Disney Studios sent me a contract, and I was to go out when they were making the movie during that summer. But an actor's strike began, and lasted until the following January. I wrote them in September, sending my speaking commitments in the Fall (about three a week) and asking to be excused from the contract. They replied, "Yes, Doc. Fred MacMurray's been studying your film so much that he is beginning to act like you, and we're getting worried." [laughter]

PROJECTION OF EXPERIMENTS (TOPS)
1958-Expo
1960-TOPS Projector
1989-Tilted TOPS Projector

STURCHIO: Hubert, tell us about the devices you have invented for projecting chemical experiments.

ALYEA: From 1962 to 1971 I published a monthly series, called TOPS (for Tested Overhead Projection Series) in the Journal of Chemical Education, describing how to project about 1000 chemical experiments.

This technique is amazingly inexpensive, and far superior to conventional macro-demonstrations. For 39 years I had been costing the Princeton Chemistry Department about $6000 a year for my macro-lecture demonstrations in Freshman Chemistry ($5000 for my assistant + $1000 for the chemicals). When my assistant retired, and I had three more years to go, I told the Department: "Don't get me another assistant; I will use my new projection techniques). Cost: not $6000 per year, but 15 minutes of my time on Monday + $10 per year for chemicals (e.g., 50 15 minutes of my time on Monday + $10 per year for chemicals (e.g., 50 drops AgNO3-aq, instead of 500 ml, reducing cost of $100 to fifty cents).

It is interesting to note how I invented my chemical Projector Adaptor. It was at Expo-58 in Belgium. I had gone there to lecture six hours a day, five days a week, for six months to audiences of

about 200 people. This was in the International, not the American Pavilion. I, and a mock-up of a Nuclear Reactor, were the American Exhibits. My principal lecture was "Atomic Energy: Weapon for Peace." (I also gave it (in French!) on the Paris TV. Varieté wrote me up, calling me the "Einstein-Harold Lloyd"!). [laughter] My translator told me, after my Paris program, "Doc, that was the finest French you ever spoke. I replied, "Guy, that's the finest French I ever will speak." (I can trace my ancestors back to 964 A.D. in Alee-sur-Haute-Cloche near Amiens, France; so the blood of my forefathers coursed through my veins in Paris that day!)

I went to Belgium four months before Expo-58 opened up, to plan and direct the construction of my auditorium. You see, I prefer to stand on nearly the same level as my audience. So I used the curved apron of my 2-foot high platform as my lecture table. It was a convenient arrangement. I similarly designed my lecture platform when I lectured six months at the Seattle 1962 World's Fair.

My lectures were given in compound-fractured French. If, during my lecture I said, for example, "Le carbon est noir," my assistant would repeat it in Dutch for the Flemish in my audience. One day I thought: "Why not project, in color, what I am saying?" Thereafter my audience read, on a projection screen, what I was saying: the upper half in pink (French); the lower half in yellow (Flemish).

This led to an obvious invention. Why not project some of the 6000 experiments I was publishing in the Journal?

Unfortunately this could not be done, because the Projector stage is horizontal, so that if you pour acid on zinc in a petri dish, H2 bubbles rise vertically and will not be seen. So I invented a Projector Adaptor with lenses, mirrors, and a vertical stage, to set on an ordinary Overhead Projector. And a variety of plastic transparent cells in which to carry out reactions, distillations, titrations, electrolysis, etc. And a Manual showing how to project 1000 experiments (see Pages 160-165).

You recognize, of course, a Florence or an Erlenmeyer Flask. Well, this (exhibiting a 3 x 3 x 1-inch clear acrylic twin-cell) is an Alyea. [laughter] It is used in projecting chemical experiments on my Projector Adaptor. Cost, $2.

I have demonstrated my TOPS Projector Adaptor in 80 countries. Once I conducted a Workshop for 35 Teachers at the Chinese University in the New Territory in Hong Kong. Each teacher made my Projector Adaptor, and the reaction cells. They translated instructions into Chinese, and their translation reached Mainland China. A friend of mine, who taught there three summers, told me in 1988: "You know, Hubert, they have your Projector Adaptor in most of the Chinese Universities on the Mainland that I visited. And then, when I went to Mongolia, I discovered one there, too." I guess my Projector Adaptor is a "better mousetrap." [laughter]

For Third World countries, with very limited budgets, I

invented another projector costing about a dollar. No auxiliary Overhead Projector is required. This inexpensive model is suitable for classes of up to 50 pupils. Its projector bulb is a reading-lamp bulb about 1½ inches in diameter, with all but a pin-head of its bulb blackened. This becomes a pin-hole projector (like a pin-hole camera) which projects a well-focused image of the Alyea cell upon a 2-ft. square screen of waxed paper (see Fig.). I demonstrated this, much to the amazement and delight of the Minister of Education of the Transkei (the area of South Africa reserved for the blacks) when I lectured in South Africa twenty years ago.

UNESCO IN BANGKOK (1963)

Let me tell you about a UNESCO project in the Far East in which I was involved. In 1963 I was invited to join a Committee which was to meet in Moscow in 1963. Committee members included, besides myself, [J. Arthur] Campbell of Chem Study, [Leonard] Strong of Chem Bond Approach, an Englishman from the Nuffield Study, an Australian, and two chemists from behind the Iron Curtain [a Russian and a Czechoslavakian]. [Richard] Mayberry of the UNESCO Paris Office was Chairman.

Russia insisted that our meetings be held in Moscow; they were afraid their two chemists might defect if they came to Paris. So, for ten days we met in Moscow. What our committee discussed was setting up a laboratory for Asian High School teachers to bring their chemistry teaching up to date. Mayberry preferred Chem Study, the Nuffield Study, and my Tested Overhead Projection (TOPS). Weeks later, Mayberry travelled around the world looking for a suitable site. He finally chose Chulalongkorn University in Bangkok, where we were provided with a spacious laboratory, about 80 x 100 feet, in which to operate.

The UNESCO International School operated for several decades. UNESCO invited two teachers each from nine different countries: some of these included, I believe, India, Pakistan, Sri Lanka, Indonesia, Taiwan, Malaysia, Singapore, Japan, Israel, Nepal, and Bangladesh.

Nine pairs of Chemistry Teachers came to Bangkok for an entire

year, and we taught them there. I passed through Bangkok thirteen different years, and each time I'd always stop, for a week, to demonstrate my Overhead Projection. Every year they would bring in a new group. For a whole year they would work there, and write a laboratory manual and a text book in their native language, how chemistry was being taught all over the world. Then when they returned, say to Sri Lanka, where they were usually from the Teachers Colleges, their government was pledged, to UNESCO, to set up a travelling van. The two Teachers would stock it with chemicals and equipment, and travel around from one little town to the next, wherever chemistry was taught in their country. These two people were promised an ample salary for two years to teach modern chemistry. The last time I went through there, was about ten years ago. That one room in Chulalongkorn University had grown to two two-story brick houses, with a hundred and fifty people. The Thai government was so impressed with its value that it set up its own School.

It was depressing, how little the scientists from the Soviet Union could contribute to our discussion. Apparently most Russian children in their Government Schools were taught the Chemistry the USA taught fifty years ago; a curriculum based on the old Mendelejeff Table, mostly descriptive. On the other hand any schools preparing for a military career apparently were provided with modern equipment and an enlightened curriculum. At our Moscow conference I intended to demonstrate my Overhead Projection (a technique which reduced Princeton's yearly budget for chemical demonstrations from $1000 a year 1930-1969 to $10 yearly from 1970-

1972). I required a simple Overhead Projector. Now colleges like Princeton or Columbia have several hundred of these Projectors on their campuses. But there was not a single one on the University of Moscow campus; we had to improvise one, using an optical bench!

ARMCHAIR CHEMISTRY (1965)

In the 1960s I devised a novel Elementary Chemistry laboratory technique and named it Armchair Chemistry. The following pages show

...the equipment; which, for one student for the entire year fits into a small box, 6 x 4 x 1-inch

...a holder for reagents for each experiment, consisting of five ½-oz. glass dropping bottles taped together, and a block of wood or plastic with holes for accomodating five 20-ml plastic vials and six 12 x 75 mm glass test tubes

...a tray with an elastic strap to hold it securely on the writing-arm of an Armchair

...a one-pint plastic waste bucket

...a 500-ml plastic bottle for water.

Following that page is one sample Experiment chosen from two dozen of the Armchair Chemistry Lab Manual experiments.

The Manual lists the

...chemical reagents required for 3-hours' laboratory

...questions re: observations

...answers to these questions (removable if the teacher prefers).

When the student enters the laboratory, he takes his reagent bottles and block and fills bottles, vials and test tubes required for that day's assignment. He returns to his armchair, puts the

reagents, bottle of water, and waste bucket on the seat of the chair to his right, and fastens the tray to the arm of his Chair. He is now ready to carry on three hours of laboratory without going up for any more reagents. (He takes very little reagent: perhaps a 1 ml scoop of bicarbonate of soda and 1 ml of vinegar for one test.)

I find that 3 hours is too long a stretch for a student to remain in his chair. Usually I have a break every hour, when I take the class into a different section of the classroom to show movies (like Chem Study films), or demonstrate or discuss some difficult aspects of the day's assignment.

In August I worked less than one day to prepare all the reagents for a term of Armchair Chemistry for sixty students.

The Second term in my Chemistry-for-Non-Scientists Course consisted in Student Research using the Armchair Chemistry equipment in the lab (not on the Armchair). These non-science students spent the entire second term lab doing experiments they, themselves, had invented. They worked in pairs. They would come in to see me, and I would spend about ten minutes with each pair. They'd have a list of five experiments that they thought of doing. I would advise them “Try Nos. 2 and 4.” Or, try Nos. 1, 3 and 4.” Or, I think No. 3 will take the whole term.”

In January I said to my two lab assistants, "Get out of the

stock room; I'm going to make the chemicals for the entire term for sixty people." By three o'clock that afternoon I had made all the reagents for sixty students, and we didn't have to go into the stock room once, from January until May. Although they were doing various, different, experiments they needed only approximately 100 reagents and used only drops. This lab experience not only taught them some chemistry, but especially to think for themselves, as we do during Research.

While discussing Armchair Chemistry, I should comment on the Laboratory of Chem Study. I have a great admiration for Chem Study; in fact I was a part-time consultant on it. But it was designed for the top 20% of Elementary Chemistry Students, and often, unfortunately, is given to all. Moreover the Laboratory requirements are far too elaborate, as we discovered when we attempted to give the Chem Study to some Chemistry Teachers in Taiwan. Over 1000 solutions were prescribed. Most High Schools simply do not have enough assistance to prepare them.

UNITED STATES - SOUTH AFRICA LEADER EXCHANGE (1967)

I spent six weeks, with my wife, lecturing about 30 times in South Africa. My first lectures were at a convention of a thousand Science Teachers in Durbin. From there we went on to Kimberly, Elizabethtown, Stellenbosch, Capetown, Pretoria, Johannesburg, and elsewhere (including Lesotho). One of my lectures in Capetown was to 2000 colored (mixed) students.

I spent a week visiting and lecturing in the Transkei, an area the South African Government had set aside for occupation by blacks (they have their own Parliament Buildings there). The Transkei is as though, in the United States, we had reserved a swath of land 100 miles wide extending from the Mississippi to the Atlantic in which only blacks could live. Unfortunately, the folks who settled there were so primitive and irresponsible that, when the weather turned cold, they cut down the trees and denuded the land (we saw it); so it became barren farm-land.

My opinion of apartheid was radically altered. Oh yes, it is horrible, and must be abolished; but it is not understood in the United States. One vote per person is impossible; some of the blacks are completely unqualified to vote. In the first half-hour after my arrival in South Africa, I went to the local super-market to buy some items for my chemical lectures. When I came to check out, I was out-numbered 5 to 1 by black purchasers, since blacks do the purchasing for the white families they work for. Surprise! I had to wait my turn to check out. In some Texas and Oklahoma stores, at that time, they had separate check-out counters for the

blacks and the whites.

I lectured in the schools in Soweto, the black suburb of Johannesburg, several times. (This was a decade before Soweto became a trouble-spot.) Every black family was provided with a neat little house, so long as they worked in Johannesburg each day. They had a home, with a sense of privacy; a flower-patched lawn, and a vegetable garden. Let me contrast this with black quarters in Trenton, NJ; black families moved from dirty slums into a new spic-and-span apartment building. But no sense of responsibility for its upkeep. Within a couple of years that apartment house becomes as ill-kept as the original slums.

Evelyn and I spent an exciting week in the Kruger National Park, where the animals roam wild, and the people are locked up, in virtual cages each night, to protect them from the wild animals!

My solution for apartheid is this. (Remember, the whites did not wrest South Africa from the blacks: the Dutch and British settlers came into a territory that had been deserted by the blacks.) When a child is born (white, colored or black), a sum of money for his complete education, through High School, should be paid each year to his community school. Each child receives the same amount for his education. (It is the responsibility of his community Board of Education to decide how that money is to be spent.) When the child becomes 20, he takes a Government exam to prove that he is of voting maturity. (Not a difficult exam.) If he passes it, he can vote. If he fails it, he can take a re-exam

each year.

CO-EDUCATION AT PRINCETON (1969)

In 1969, when Princeton was considering becoming Co-educational, a well-known TV personality, a woman, came to Princeton to interview faculty members. (I do not wish to mention her name.) I whole-heartedly endorsed Princeton Co-education, but was one of the few Faculty members brave (or foolish) enough to advocate a 3-year transition rather than the over-night adoption which the Administration was railroading through. I still think it would have been a wiser alternative.

My 45-minute remarks to this TV personality went as follows: Yes, I was for Princeton Co-education, but against the rapid transition, as planned. I wanted to take three years to get us ready for Co-education.

But, I said, if I had a daughter who was seriously interested in Science, I would prefer to have her go to an all-female school. Or a boy, I'd prefer to have him go to an all-male school. There's so much to learn in Science in those first four years, and there's no time to do housekeeping, as now inevitably happens. But I would not have Princeton Co-educational by next fall. I would take a longer time. On the other hand, if I were in the humanities, I would have made Princeton Co-educational twenty years ago. It's absolutely asinine to sit around discussing philosophy and human values and not have any women there to discuss it with you.

The TV commentator was a snide feminist who wanted to make

Princeton immediately Co-educational. On her hour's TV program from New York she played only 15 seconds of my 45-minute statement, enquiring, "What is your recommendation, Professor Alyea," and having me reply: "I would have had Princeton Co-educational twenty years ago." Whenever I see this woman on the TV screen (she has a regular program), I think: how can this woman live with herself?

MY PUBLIC LECTURES (1945-1988)

Lecture 1: ATOMIC ENERGY: WEAPON FOR PEACE (1945-1960)

(A one-and-one-half hour demonstration lecture)

Immediately after World War II, I revised my General Chemistry Textbook (31) and included pages explaining how an Atom Bomb works. I gathered my information from many sources, especially [Henry] Smyth's Report, "Atomic Energy for Military Purposes" (307). I was, of course, like all other scientists much interested in this new knowledge.

Hugh Taylor called me in about it. He said, "Hubert, you can't possibly have published all this." Well, of course I had published it. He said, "It's all top classified material." "Hugh, I got it all out of the newspapers." I had not had any contact with the atomic project. "Well, Hubert I can't understand that," he said.

Now the war was over and I had two thousand people who had worked hard with me. How was I to bid them farewell? I did send out two thousand letters, but that was very impersonal. Now, Smyth had just written his report that very week. I said, "You know what I'm going to do? I'm going to meet all those Gas Officers in four different places. I'll tell them to come hear me, and I'll tell them the story of the Atom Bomb."

So I scheduled four meetings to personally bid my Gas Officers "Goodbye": a 1½ hour demonstration lecture entitled "Atomic Energy: Weapon for Peace." In Englewood for North Jersey, in Princeton for

mid-Jersey, in the Camden area, and in Atlantic City for South Jersey. About 6000, including families of the Gas Officers, attended. But it initiated a project which was to consume most of my life for the next twenty years. The subject-matter changed constantly, as new material was declassified.

I went everywhere, talking about how ultimate, complete, and total destruction an atom bomb war would be. No one would believe me. And I said, "The Russians will have it in five years." I wouldn't say it quite that way, as you'll see in a minute.

After each lecture I would receive advice from two classes of Princetonians. One group, old Princetonian medical doctors, advised: "Doc, if you don't slow down, you won't last five years." Now they're all dead. The younger doctors said: "Doc, if you had slowed down, you wouldn't have lasted five years." [laughter] I think the sons knew more than the fathers. And another group would come up and say, "Doc, you're an idiot. The Russians won't have it in five years. General [Leslie Richard] Groves says they're a bunch of peasants, and it'll take twenty-five years for them to have it." I said, "You didn't listen carefully to what I said. I quoted [Ed] Condon, [Eugene] Wigner, and [Hans] Bethe in their article in 'One World of None' that the Russians would have it in five years." Well, the Russians had it in four and a half. It was not because of the Germans helping them. I don't think that at all. There were so many different ways of solving the Atom Bomb problem, but all of them difficult.

Between 1945 and 1965 I gave this Atomic Energy lecture 2640 times, for the Atomic Energy Commission, the Department of State, and to the general public. In it I explained conventional and Nuclear explosives, and why the latter could annihilate Mankind. I talked, on an average, four times a week. If you read this, you'll just be amazed how, physically, I survived. But it was because I was so desperately trying to tell them how total and complete atomic warfare was. I know when [Eugene] Wigner telephoned me, when he was trying to get people to build atom bomb shelters, "Eugene," I said, "the first minute that an atom bomb drops, I hope that I'm going to be killed." Survival would be so horrible.

So I went everywhere preaching this. For example, I flew ten thousand miles just amongst the islands of Hawaii, and lectured there fifty-six times the last three months. I was everywhere in Hawaii. I lectured once to six thousand GIs for four hours in the hangar that had been bombed at Pearl Harbor, eight years before on December 7, 1941. It was a memorial service, and they brought these six thousand GIs into the hangar. The unfortunate thing, in 1941, was that when the Japanese came, in the Pearl Harbor attack, the boys didn't know what was happening. They were having breakfast, and they rushed out to see what was going on. And the planes came in, and the GIs were mowed down. If they'd stayed inside, they wouldn't have been killed. I gave them a talk that I'd given at many other armed-forces places in Hawaii before. I gave them a two-

hour talk on atomic energy, and why it was different from poison arrows. And as I came out, all the Brigadier Generals came up and said, "Hey, Doc, you haven't told the whole story. You told us more at Wheeler Airforce base." So I responded: "Okay. Turn them around and I'll give them some more stories." So they turned all six thousand around and marched them back in again, and I started all over again. And I told them some new stuff. The six thousand GIs loved it because they didn't have to be marching around in the hot sun; I loved it because I love to talk.

I also described the fantastic peace-time uses of isotopes. Re: Nuclear Reactors, I deplored the misguided environmentalists (generally commendable) who stymied progress with Nuclear Reactors by championing laws that set permissible levels of radioactivity in a Nuclear Reactor plant below that of the radioactivity in the NY Grand Central Station (it has radioactive granite).

I estimate that I have given this lecture face-to-face to over 3 million people. In Pearl Harbor, on December 7, 1949, I gave it as a 4-hour Memorial lecture to six thousand military personnel. And, with Burgess Meredith in 1954, I gave it in a TV show to an estimated audience of 64 million people (more than listened to Sarah Bernhardt during her entire lifetime). [laughter] I gave this Atomic Energy demonstration lecture six months each, six times a day, five days a week in Belgium Expo-58, and the Seattle World's Fair. For the Department of State and the Atomic Energy Commission, six times a day, five days a week for six weeks each in Taipei,

Bangkok, Athens, Zagreb, Belgrade, Cairo, Istanbul, Baghdad, Tehran, and Leningrad. Five two-month visits to India. Six weeks as a Leader Exchange in South Africa. Twenty-two visits, about two months each, to Mexico. Visits of one or two weeks to Australia, New Zealand, Indonesia, Singapore, Japan, Malaysia, and about forty other countries.

I preached from 1945 until 1958. I stopped the Atom Bomb talk after Expo-58 in Belgium because I felt by then people understood the problem.

In California I was challenged that I couldn't have given it that many times. "There aren't that many days in the year." I listed fifteen different places where I lectured for the Atomic Energy Commission, the Department of State, UNESCO, Fulbright. I went down the line. I pointed out where I had lectured, at each place at least six weeks, six one-hour lectures each day, six days a week. That was how it ended up to be over five thousand Atomic Energy + Lucky Accident lectures.

STURCHIO: It's quite a pace.

ALYEA: There was no urgency in the Lucky Accident lecture. The Atom Bomb talk was almost like missionary work. I forgot myself; that I was wearing out. Which I was.

Lecture 2: LUCKY ACCIDENTS, GREAT DISCOVERIES, and the PREPARED MIND (1960-1988)

(A one-and-one-half hour Demonstration Lecture)

By 1965 most people understood the Atom Bomb threat so I switched to another lecture (which I gave about 4000 times) entitled "Lucky Accidents, Great Discoveries, and the Prepared Mind." Its content, too, was constantly revised.

Lectures 1 and 2. Lecture 3: TEACHING TECHNIQUES (1960-1988)

Since 1945 I received, yearly, about 350 invitations to lecture, and accepted about 150 of them per year. Most of them were not remunerative (Universities), covering travelling expenses only. In fact I declined a number of proposals for being listed on any commercial lecture circuit.

I once rejected a TV contract which would have paid me nearly ten times my Princeton Full Professor's salary which then, in 1964, was $8000/year. I was to be on Amoco's Edward R. Morrow Show for thirty-nine 1¼-minute chemistry experiments at $2000 each ($78,000/year). No, I much preferred being a Teacher, rejecting any other profession, miserly though my University salary was. Happily, my wife, Evelyn, shared my preference.

This decision sounds irrational. But subsequently I invented inexpensive ways of teaching chemistry; for example, projecting chemical experiments a hundred times cheaper than the conventional macro-demonstrations. As a result, I was invited by many agencies (UNESCO, Fulbright, the Atomic Energy Commission, the Department of State, the Peace Corps, the Edison Foundation, the American-South

African Leader Exchange, and Science-Teacher Groups of a number of countries), met at the Airport of each country by Chemistry Teachers, intent on convincing my wife and me that their country was most interesting. (All travelling expenses paid.) A million dollars could not have purchased such a satisfying experience. Yes, I made the right choice.

Below is a map prepared by the Chem Department Secretaries for a celebration of my Eightieth Birthday. It shows many of the countries in which I have lectured.

STUDENT STUDY HABITS (1920-1972)

Princeton students' learning habits changed from decade to decade. In the 1920s Princeton University was an educational Country Club. Many of its students came from private schools: Andover, Exeter, Deerfield, Lawrenceville, etc., and continued their (good) study-habits in Princeton. You were assumed to be bright enough to earn a gentleman's B; an A-grade marked you as a grind or genius. And learning was a pleasurable experience.

In 1929 the Depression struck. Learning became a serious task. One boy wrote in the Daily Princetonian as follows: "Something has got to be done about this; this is the third time this month Dad's written to me asking for money." [laughter] Education became the touchstone, after graduation, to success. I began teaching during this period; and it was fun to excite students to think as we do in scientific research. It was a happy decade in which to teach.

War years, 1940-1945, were a teacher's nightmare. The students were a bunch of neurotics scared (rightly so) that they were being prepared to go into the trenches as staff sergeants (which occurred). Probably those five years should be labelled "Learning under tension."

The five years after the War (1945-1949) were just as bad, in another way. Returning GIs were interested in only one thing: their grades. Not in learning. An ex-GI would appear in my office and complain: "I was given only 95, and my roommate, who answered question 8 the same as I, got 96. He received credit for the same answer that was marked wrong on my paper".

So we would sit down and re-grade his paper. It always ended up 94 ! (You can always spot some error!) And of course the disgruntled pupil never returned !.

In 1950 an amazing change occurred. I came home that first day and said to Evelyn: “You know, the students are completely different today. They are genuinely interested in what I tell them ! This excitement for learning lasted for the next dozen years.

But, by 1970, the struggle for high grades, so as to get into the best Graduate, Medical, or Law school led to a scramble not only for higher grades, but to electing easier courses.

STURCHIO: It’s certainly has been interesting. We’d like to thank you very much for taking the time.

ALYEA: Thank YOU for coming and listening to me.
END OF TAPE, Side 9

PUBLICATIONS

HUBERT ALYEA - PUBLICATIONS
(Chronological Index)

1. The Inhibitive Action of Alcohols on the Oxidation of Sodium Sulfite (with Hans L. J. Backström). J.Am.Chem. Soc., 51, 90-109 (1929). 1929

2. A Capillary Gas Valve. J.Am.Chem.Soc., 52, 1936-1937 (1930). 1930

3. Synthesis of Phosgene by Light and by Alpha Radiation (with S. C. Lind). J.Am.Chem.Soc., 52, 1853-1868 (1930).

4. Zündung von Knallgas bei niedrigen Druckduch warmen Quartz (with F. Haber). Naturwissenschaften, 18, 441-443 (1930).

5. Chain Reactions Produced by Light and by Alpha Radiation. J.Am.Chem.Soc., 52, 2743-2745 (1930).

6. Ueber die Zündung von Knallgas durch quartz oder Porzellan bei Minderdruck (with F. Haber). Zeits fur Physikalische Chemie, Abt. B, 10, 193-204 (1930).

7. The Role Played by Adsorbed Gases in Initiating Reaction Chains: The Combination of Hydrogen and Oxygen. J.Am.Chem. Soc., 53, 1324-1336 (1931). 1931

8. A Comparison of Organic Inhibitors in Chain Reactions (with K. K. Jeu). J.Am.Chem.Soc., 55, 575-588 (1933). 1933

9. Kinetics of Hydrogen-Oxygen Low Pressure Explosion (with A. A. Frost). J.Am.Chem.Soc., 55, 3227-3233 (1933).

10. Inhibitors in the Decomposition of Hydrogen Peroxide by Catalase (with J. Pace). J.Am.Chem.Soc., 55, 4801-4806 (1933).

11. The Low Pressure Explosion Limits of Deuterium and Oxygen (with A. A. Frost). J.Am.Chem.Soc., 56, 1251-1252 (1934). 1934

12. BOOK - A Laboratory Manual in General Chemistry (with W. Foster). Revised fourth edition, Princeton University Press, April, 1935. 1935

13. Bibliography for General Chemistry from Several Periodicals, Part I. J.Chem.Educ., 13, 76-80 (1936). 1936

14. Bibliography for General Chemistry from Several Periodicals, Part II. J.Chem.Educ., 13, 540-544 (1936).

15. Chemistry and Industrial Chemistry (invited article). New International Year Book, Funk and Wagnalls, pages 132-141 (1938). 1938

16. Lantern Slide Techniques. J.Chem.Educ., 16, 308-312 (1939). (Auto-focusing Device. An automatic slide-changer.) 1939

17. Bibliography for General Chemistry from Several Periodicals, Part III. J.Chem.Educ., 16, 435-440 (1939).

18. A Simplified Nomenclature for the Proton Transfer Concept of Acids. J.Chem.Educ., 16, 535-538 (1939).

19. Chemistry (invited article). New International Year Book, Funk and Wagnalls, page 122 (1939).

20. Industrial Chemistry (invited article). New International Year Book, Funk and Wagnalls, page 127 (1939).

21. A Capillary Flowmeter. Ind.Eng.Chem., Anal.Ed., 12, 686 (1940). 1940

22. An Apparatus for Photoelectric Titrations. J.Chem.Educ., 18, 57 (1940).

23. Concerning Lantern Slides. J.Chem.Educ., 17, 546 (1940). (A film-strip of 400 slides for General Chemistry for $20.)

24. Chemistry and Industrial Chemistry (invited articles). New International Year Book, Funk and Wagnalls, pages 116-125 (1940).

25. Determination of Oxygen in Tank Hydrogen. Ind.Eng.Chem., Anal.Ed., 13, 104 (1941). 1941

26. Copying Devices with an Argus Camera. J.Chem.Educ., 18, 236 (1941).

27. Lecture Demonstrations in General Chemistry (with S. B. Arenson). J.Chem.Educ., 18, 168 (1941).

28. A Résumé of the Proton Transfer Concept of Acids and Bases. J.Chem.Educ., 18, 206-209 (1941).

29. The Electron Microscope. J.Chem.Educ., 18, 236-237 (1941).

30. Technics in Visual Education. Report New England Assoc. of Chemistry Teachers, 42, 204-209 (1941).

31. BOOK - An Introduction to General Chemistry, second edition (a revision of text by William Foster, Princeton University Press, 1931). D. van Nostrand Co., Inc., 1941.

32. The Function of General Chemistry. J.Chem.Educ., 18, 309-310 (1941).

33. Chemistry and Industrial Chemistry (invited article). New International Year Book, Funk and Wagnalls, pages 104-111 (1941).
34. Methyl Methacrylate Polymerization: Peroxide Catalysis and the Oxidation of Hydroquinone Inhibitor (with J. J. Gartland, Jr., and H. R. Graham, Jr.). Ind.Eng.Chem., 34, 458-460 (1942). 1942

35. Visual Education. The Science Counselor, June 1942, three pages. (Domino effect, sugar isomers.)

36. Potential Energy Curves in General Chemistry. J.Chem. Educ., 19, 337-339 (1942).

37. Articles on Bombs, Chemistry, Petroleum, Plastics, and Rubber. New International Year Book, Funk and Wagnalls, pages 83, 120-129, 532-534, 551-552 (1943). 1943

38. Articles on Chemistry, Industrial Chemistry, Explosives, Plastics, Rubber. New International Year Book, Funk and Wagnalls, pages 72, 105-118, 492-493, 550-552 (1944). 1944
39. BOOK - Poisons: Their Chemical Identification and Treatments (with V. J. Brookes). D. van Nostrand Co., Inc., New York, 1946. 1946

40. BOOK - An Introduction to General Chemistry, third edition. D. van Nostrand Co., Inc., New York, 1947. 1947
41. Demonstration Techniques. J.Chem.Educ., 249-250 (1948). (A light-box stage.) 1948

42. The Single Science Course at Princeton University. Science in General Education, E. J. McGrath (editor). Wm. C. Brown Co., Dubuque, Iowa, pages 124-139 (1948).

43. BOOK - Editor, Chemistry Sections (500 pages), Colliers Encyclopedia, P. F. Collier and Son, Corp., New York, 1950. 1950
44. The Single-Science Course (with K. Sato). Tokyo Inst. Tech. Reprint, pages 124-139 (1950).

45. Spectacular Science: Demonstration Techniques. N. J. Science Teachers Assoc. Report., pages 1-8 (1951). 1951

46. Lecture Techniques. The Science Counselor, 14, 75-76; 104-105 (1951).
47. The Terminal Course in Chemistry. J.Chem.Educ., 29, 219-221 (1952). 1952

48. Reflections on the Atom Bomb. Theology Today, 9, 348-352 (1952).

49. A Magnetic Study of Polymerization Retardation (with J. L. Ihrig). J.Am.Chem.Soc., 75, 2917 (1953). 1953

50. Educational Ills. The Chemist, 31, 429-432 (1954). 1954

51. Tested Demonstrations in General Chemistry. J.Chem. Educ., 32, 28-29 (1955). 1955

52. Chemical Reactions. J.Chem.Educ., 32 (January 1955), 11-14A.
53. Oxygen. J.Chem.Ed., 32 (February 1955), 15-16.

54. Hydrogen. J.Chem.Ed., 32 (March 1955), 25-26.

55. Atomic Energy: Weapon for Peace. Ann. Dentistry, 14, 5-11 (1955).

56. Water, Acids, Bases, Salts. J.Chem.Educ., 32 (April 1955), 19-20.

57. States of Matter: Solutions. J.Chem.Educ., 32 (May 1955), 27-28.

58. Ionization. J.Chem.Educ., 32 (June 1955), 15-16.

59. Energy. J.Chem.Educ., 32 (July 1955), 11-12.
60. Equilibrium, Oxidation and Reduction. J.Chem.Educ., 32 (August 1955), 9-10.

61. Atomic Structure, Radioactivity. J.Chem.Educ., 32 (September 1955), 17-18.
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272. BOOK - Armchair Chemistry, a programmed Laboratory Manual. 1963-1991

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HUBERT ALYEA - PUBLICATIONS

(Subject Index)

BOOKS

(See Chronological Index for further information)

12. A Laboratory Manual in General Chemistry.
31. An Introduction to General Chemistry; new editions in 1935, 1941, 1947.
39. Poisons: identification and emergency treatments.
43. Chemistry section, Collier's Encyclopedia (about 100 pages).
80. Tested Demonstrations in General Chemistry; new editions in 1957, 1958, 1959, 1960, 1962, 1965.
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PHYSICAL CHEMISTRY RESEARCH PAPERS

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5. Chain reactions produced by light and by alpha radiation.
6. Uber die zundung knallgas durch quartz oder porzellan bei minderdruck (with F. Haber).

7. The role played by absorbed gases in initiating reaction chains: combination of hydrogen and oxygen.
8. A comparison of organic inhibitors in chain reactions.
9. Kinetics of hydrogen-oxygen low-pressure explosion.
10. Inhibitors in the decomposition of hydrogen peroxide by catalase.
11. The low-pressure explosion limits of deuterium and oxygen.
34. Methyl methacrylate polymerization, peroxide catalysis, and the oxidation of hydroquinone inhibitor.
49. A magnetic study of polymerization retardation.
275. Bombardment of monomolecular films of As, Sb, and Bi with free radicals (H and CH3) at different temperatures.

INVENTED GADGETS

2. A capillary gas-valve.
16. An automatic slide-changer.
21. A capillary flow-meter.
22. An apparatus for photoelectric titrations.
25. Determination of oxygen in tank-hydrogen.
26. Copying devices with an Argus camera.
41. A light stage.

MACRO-DEMONSTRATIONS

27. Lecture demonstrations in General Chemistry.
30. Techniques in visual education.
35. Visual education.
41. Visual education.
45. Spectacular Science: demonstration techniques.
46. Lecture techniques.
51. - 71., 75. - 90. Tested Demonstrations. J.Chem.Educ.
81. - 92., 94. - 105., 109. - 119., 121. - 128. Demonstration Abstracts. J.Chem.Educ.
129. Bromination of acrolein (burned bacon).
131. Burning phosphorus in air.
153. Lectures and demonstrations in chemistry (in Japanese).
186. Lecture demonstration techniques in chemistry.

PROJECTION

23. Concerning lantern slides: a 400-slide film-strip.
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MISCELLANEOUS

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29. The electron microscope.
36. Potential energy curves in general chemistry.
48. Reflections on the atom bomb.
72. Nuclear reactors in the United States.