



AMERICAN INSTITUTE OF MINING,
METALLURGICAL, AND PETROLEUM ENGINEERS

ORAL HISTORY PROGRAM

Stanley Howard: The Human Perpetual Mind

PREFACE

The following oral history is the result of a recorded interview with Stanley Howard conducted by Tom Battle on Monday, March 11th, 2020. This interview is part of the AIME Oral Histories Series.

ABSTRACT

For some, making critical decisions can be a very difficult task. Even at a young age, however, this was not much of an issue for Stanley Howard. From choosing a college out of a pamphlet to deciding to get his Ph.D. in fourth grade, he has always been straight to the point. With his mind constantly curious and active, Stan was always searching for knowledge and adventure. As he reached college, he got immediately involved in research and ROTC. His drive helped him climb the ranks in his professional career.

In this interview, Stan takes a step back to talk about his childhood and his early difficulty with reading. This only motivated and encouraged him to learn absolutely everything he can. In eighth grade, he discovered metallurgy and immediately knew that it was his future. Once mastered, reading seemingly consumed the majority of his childhood, but this did not stop him from having fun.

As he dives into his professional career a bit more, he speaks on the companies he started and what else he gets involved in outside of being a full-time professor. All of his accomplishments led him to the creating of smartphone applications, which he absolutely loves developing. Even to this day, past retirement, he works on these applications. This is not the only post retirement involvement he keeps, as he is still heavily involved with TMS as he has been for years.

Readers are asked to bear in mind that they are reading a transcript of the spoken word, rather than written prose. The following transcript has been reviewed, edited, and approved by the narrator.

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PART 1

00:20 Introduction

Battle:

Good morning. This is Tom Battle at the TMS annual meeting in San Antonio on Monday, March 11th, 2019, and I'm honored to be able to interview Stan Howard for the AIME oral histories series.

Howard:

Well, thank you, Tom. It's an honor to be selected to do this interview. When I first received the invitation, I was surprised I was selected. There are so many people in TMS, and I would like to hear many of those oral histories as well. Many people here have such fantastic careers and so on, and it's just an honor to be here today, and I'm happy to visit with you about whatever you think is significant about my life and career.

00:35 The Power of a Pamphlet - Introduction to The Colorado School of Mines

Battle:

Rather than purely chronological order, I'd like to start with what unites you and I - we both studied under John Hager at the Colorado School of Mines [CSM]. And, to start with, we'll go back to your growing up years. Until coming to Colorado, you'd spent your life in Wyoming.

Howard:

I'm a Wyomingite.

Battle:

And so, how did you get to CSM, and how did that evolve?

Howard:

Well, I got to Colorado School of Mines almost accidentally or serendipitously, perhaps, you might say. It all happened in high school physics class. One afternoon, we met at two o'clock in the afternoon. Doc Rogers threw a pamphlet, or handed a pamphlet, to a good friend of mine, Steve Thomas--whom I'm going to see next week, in fact, we're still friends--and he said to Steve, who was an outstanding student, that he should go to Colorado School of Mines. Steve didn't show much interest, threw the pamphlet down on the table, and I thought, "Maybe I should look at that?" So, I grabbed the pamphlet, and I thought, "Well, that looks good." So, I applied to the Colorado School of Mines. I had thought about Carnegie Mellon and other places. The University of Wyoming had cobwebs on their metallurgy lab door when I was over there visiting, and so--subtle tip that I was not going to the University of Wyoming for metallurgy. And, it was metallurgy, for sure.

02:38 The Highest Degree You Can Get - The Passion for Learning

Battle:

Yes, and we'll talk about that. So, you got to CSM. Did your undergrad evolve the way you expected it to?

Howard:

Well, I was never particularly worried about how college would go. I expected it would go fine, and I was so excited about being in a place like that, where people knew things that I had wanted to know for a long time, well, for four years--a long time when you're a high school student--and it was a quite exciting time. Although the first two years were not anything to do with metallurgy, it was still interesting, and I enjoyed it and made some good friends and really benefited from being down there. It was a wonderful opportunity, and I still think that way about it. It's tremendous education.

Battle:

Now, were you planning to go to graduate school from day one?

Howard:

Yes, I decided to become a PhD when I was in about third grade, and, apparently, my older brother did as well. We never talked about it, but we both have our PhDs in engineering, and it was because my father spent many evenings with my mother in conversation, just sort of anguished conversation about whether he should go back to school or not. And so, one day I asked him, what's the highest degree you can get? And he said, PhD. And so, at that moment, it was settled in my mind. That's what I would do because I never wanted to have that anguished discussion with my wife about going back to school when I was in my thirties.

04:20 Getting Lab Exposure - The Opportunity to Work Under John Hager

Battle:

Then, how did you end up with John?

Howard:

Well, I ended up working under John Hager quite by accident. Vincent Campos was working for John Hager, at the time, and John was pretty demanding to say, you know, euphemistically. I was working up at Rocky Flats, and he called me in August and asked me if I would be willing to work for him in the fall because there was this opening— Vincent Campos, who was going to change advisors and go work for Paul Harold, he did these ternary phase diagrams on the computer, as I recall--and I said, sure, that'd be great. It turned out to be just a wonderful opportunity for me, and I always enjoyed working for John Hager, although it was demanding. There were a few times I wanted to tell him if he knew how it was to be done, do it himself, but I never said that.

Battle:

And, you worked on mass spec [Mass Spectrometry]?

Howard:

I worked on mass spec with a Knudsen inlet system, and it was a very wonderful piece of equipment. It was brand new at the time, and I ended up maintaining that and operating it for four years. So, it took me some time— The first time I had to fix it, it took me two weeks. But, after that, I could fix it in about a day or so.

Battle:

And, that equipment was there for years, wasn't it?

Howard:

It was there for years, and I still have it, in fact, up at South Dakota now.

Battle:

Well, in my time, one of my colleagues worked with it and spent more time fixing leaks and repairing it than, I think, taking data, but it was a pioneer instrument for a university.

Howard:

It was, and I built a similar unit, with more features, myself, when I became a professor up at South Dakota School of Mines.

06:27 ROTC Involvement – Learning Lots of Very Useful Things

Battle:

And then, as you got toward the end, where you were talking about ROTC [Reserve Officer Training Corps] and going to the Army and all that, was that after bachelors or after PhD?

Howard:

Well, at Colorado School of Mines, we had two years of undergraduate ROTC. And then, in my second year of grad school, you know, if I wanted to continue, I had to join, I needed to join the ROTC program because there was a demand in the draft. I got one of the low numbers, like 140 or something, so I was going. And, when I called the draft board one day and asked them about it, they said I might go to ROTC. I was told I should do it that afternoon, which told me that they were about ready to call me. And, I would've been glad to serve, but I wanted to finish my degree.

Battle:

And, that's how it worked out.

Howard:

It worked out because that was February of my so-called second year of grad school, and so I couldn't start until that fall. It was two more years after that. So, I finished the PhD in four years, did not do a masters. That was waived, one of the few students for whom that was waived.

Battle:

That helps.

Howard:

But, I could have done a masters. I had several publications and met trans by then. So, would not have been that big a demand on me.

Battle:

And, you ended up not going in the Army or in the service?

Howard:

Well, on April 22nd, 1971, I was discharged. I had serious back trouble: I couldn't move for a week at a time; I just lay flat on my back. It turned out to be a muscle spasm, but extremely painful, and nothing the Army wanted anything to do with. So, I was out on the 22nd of April, but I learned lots of very useful things in ROTC.

Battle

Such as?

Howard:

Well, CPM programming. You know, critical path method, and how to develop lesson plans, and how to blow-up bridges, and how to fell trees, how to build a runway, and build a road, and so on. It was all very interesting, I thought.

08:41 Working for Maurie Fuerstenau at the South Dakota School of Mines

Battle:

And then, Dr. Fuerstenau caught up with you.

Howard:

Well, Maurie Fuerstenau was my professor at Colorado School of Mines as an undergraduate and a little bit, perhaps, the first year or so of grad school. I know I took every course he taught. I think it was around 30 hours of hydromet and flotation. And, he had an interesting style of teaching, and I appreciated him and did very well under that style of learning.

Battle:

And then, he wouldn't say "no" when he moved to South Dakota?

Howard:

He went to Utah, first, and then was there a few years and then decided to take the position of Department Head at South Dakota School of Mines, which was his hometown. As a matter of fact, his parents just lived on the other side of the Hill from campus. And, Maurie had Bruce Palmer as a student at the time, a grad student, and Bruce was going to join him and was, in fact, in Rapid City when I went up to interview. But, Bruce was still finishing his PhD, so I was actually the first hire Maurie made at South Dakota. When I went up to interview in August, because I was sort of scrambling for a position with the departure from ROTC,

thinking I would be in the Army for two years--Maury met me basically with a contract and didn't bother with the interview because he knew me so well, and I had done well under him.

10:22 Living on the Family Ranch in Eastern Wyoming

Battle:

So now, before talking about your academic career, let's step back and talk about your childhood a bit and what led you into being an engineer and being a metallurgist. So, you grew up on a relative's farm, right? I'm sorry, the ranch, because your uncle was at the war.

Howard:

Yes, well, the history of the ranch, my grandfather, my mother's father, homesteaded that in 1916. I was born in '45 and, just before that, of course, was the war. My mother's brother, my uncle Jack, was at the ranch, and my father and mother were down in Denver at Buckley. My father was serving as a carpenter then in the military effort, although he was a civilian. When my uncle was called up to go up to Alaska to defend the coastline up there, my parents went to the ranch to take over that. My grandfather lived in Torrington, so the ranch was open for occupancy when my uncle left. My mother loved the ranch: she was five years old when it was homesteaded and very much wanted to be there. And so, my first home was the ranch and in the Prairie in Wyoming, Eastern Wyoming.

Battle:

So, growing up, I assume you had your share of chores, because there were cattle and so on?

Howard:

We were free-ranging kids, but we had no chores. I don't know how my parents, what their philosophy was, but we didn't. I don't ever recall having any. My parents didn't use demands, you know, they used incentive, like compliment or praise, and it seemed to work because I always wanted to just do things that seemed to be my initiative. And so, that's kind of my temperament today as well. I don't want to be told; I'd like to be asked. And, you know, I mean it's an interesting way of raising children. I certainly wish I could have done better at it myself, with my children.

Battle:

So, you were there when your uncle came back from the war and went back to the farm?

Howard:

No, he ended up at Casper doing oil refinery work and so on. So, we were at the ranch. See, that's before my time, I think they went there in about '43. I was born in '45 and my sister in '48, and then we moved into town in 1950. The big town of Lingle, Wyoming, 307 people.

Battle:

And, it's all ranching country all around it?

Howard:

Well, when you go from the ranch, which is North of Lingle by 15 miles, you come across the interstate canal built partly by my great uncle, earlier--that's kind of a family history--and you cross that canal, which takes water from Guernsey Whalen Diversion and the Guernsey dam, there are several irrigation projects. That valley, that North Platte Valley, is a very rich valley and very rich farmland, mostly sugar beets, corn, beans, those sorts of things. So, that's very valuable land. Our land was ranch land, it's about \$200 an acre a few decades back, and now I think it's around \$500 an acre: farmland's thousands per acre.

Howard:

Irrigation makes all the difference in the world. So, we had six sections, so that's six square miles, a little over 3000 acres--we had a little addendum to that--ran about 200 cow-calf pairs, had 25 horses, no pigs or anything like that or sheep.

Battle:

It's amazing your parents didn't see you as a workforce just to keep up all those animals.

Howard:

My grandfather would come out twice a week from Torrington--that's 30, about 25 miles--and my father and mother lived there, of course, and so they took care of the cattle. We had two milk cows, Red and Bossy. They would come in every afternoon to be milked-- I have a lot of memories-- and we had chickens. I had a special way of collecting eggs: I'd go into the chicken coop and close the door quietly and then just jump up and down and scream and yell. And, all the chickens would go fly, and there'd be feathers, you couldn't see through them. But, I got the chickens off the nest, and then I could grab the eggs.

Battle:

That likely shortened their lifetime a little bit.

Howard:

Right. I don't think it did anything for egg production, but it certainly made my life easier as a three-year-old collecting eggs.

15:19 From Lingle to Cheyenne - Moving on From the Ranch

Battle:

So, then you moved into the big city?

Howard:

Moved into Lingle, Wyoming.

Battle:

And, that's where you started schooling?

Howard:

That's where I started school. Moved in 1950. I was a September baby, September 5th, so I started school a year early. I could have waited a year, or my parents could have put me a year later, I think. My mother was, you know, she had five children, so I don't think they were interested in waiting a year and having me around at home if I could go to school. And, my brother was the same, he was September 21st, and he was the same sequence four years apart from me. And so, we started early, and we finished early.

Battle:

And then, so you were there for how many years?

Howard:

Through fifth grade, 1956, a decision had to be made. It was kind of tough for my parents to make a living in Lingle. I think the deciding factor for my father leaving and going down to Cheyenne to work during the week at the airbase was an election. He ran for superintendent of schools. Before the war and before Berkeley, he was a superintendent of schools, taught math, and so on, east of Cheyenne, Carpenter, and Egbert, Wyoming. And so, he ran for superintendent of schools. And, it was a very close election: he lost by three votes; it was finally decided after three days, to Velma Linford. And, when that happened, I think my father realized he had to take employment down in Cheyenne and commuted for several years. And finally, we moved to Cheyenne.

Battle:

That must've been a fun commute. That was a ways, I mean.

Howard:

It's about 93 miles, 93 miles, and in those days, cars were not as reliable and roads as good, but they were okay.

Battle:

Yes, no interstates, or they were just being built at that time.

Howard:

It's Highway 80, I never can remember if it's '85 or '87, but I think it's '85. Yes. You go East to Torrington, 10 miles, and then South 83 miles to Cheyenne.

Battle:

And then, what did you think about moving to Cheyenne? Were you ready for it or —

Howard:

No, I did not want to go to Cheyenne. I had a very nice life in Lingle as a boy. I had good friends. I had one friend who was particularly dear to me, Bob Bahmer. Of course, at that time, it was Bobby Bahmer. And, his parents ran the dairy out east of town, and I would walk out there four miles. Can you imagine that today?

A grade school kid walking down the highway for four miles to go to his friend's house. I always tried to time it early enough in the morning so that I'd intercept the milk truck, the delivery truck, that his brother or father would drive, and I could thumb a ride out. But, there were many days I walked. There was a dirt road as well as a little farther I could walk, but I would walk out there and spend a lot of summer days with Bob. He had an old horse that we would clomp around on. It was idyllic. So many wonderful things we did.

18:44 A Space Nut at Heart: Becoming a Mad Rocket Scientist at a Young Age

Battle:

And then Sputnik happened?

Howard:

Sputnik happened well after I moved to Cheyenne--that would have been 1957, I think it was February, if I'm not mistaken--but I don't like thinking about it because it was so disturbing to me. I read a lot about astronomy, and, by the time I was in Cheyenne, I was reading about the space wheel and--I think that was von Braun wrote about that--and I guess they thought they needed gravity or something to live in space. So, I was very interested in the satellite program, and I would watch those Vanguard missiles rise off the launchpad at Cape Canaveral and go about three feet and then fall over and blow up. And, it was so aggravating to me because I was such a space nut.

Battle:

Well you must've watched "The Right Stuff."

Howard:

Oh yes.

Battle:

They'd have those early scenes where they show the Russians succeeding and ours just dismally failing.

Howard:

Oh, and the Cold War was vivid in our minds, I mean, I was in Cheyenne, that was the ICBM base.

Battle:

You were a target.

Howard:

Yes, we were a target. And, the Cuban Missile Crisis.

So, in 1960, that was real. We were packing up, headed for the ranch that day. But, at any rate, it was very aggravating to me. You know, some people say, in that era, everyone remembers where you were when Kennedy was assassinated. I don't remember that for sure, but I know exactly where I was and what I felt and what I thought when I heard that the Russians, the Soviets, had launched their satellite: I was on the

third step coming out of the basement; my father was at the top of the stairs and said it down the stairs to me, and I was so angry, I think I said some words I shouldn't have said and went right out the back door outside to sulk. I was very upset.

Battle:

And then, you decided that single-handedly you'd rescue the US rocket program?

Howard:

Yes, well, youth needs a goal, right? So, Bobby was down from Lingle in the summer after that, just a few months, and we were a little bored and, incidentally, I think boredom is a wonderful thing for children because that creates a demand to do something—

Battle:

Be creative?

Howard:

Yes, to be creative. We decided that we should build rockets. And, he went home, and I continued to build rockets. And, I found another friend at junior high school-- by that time that was '57-- Russell Houser. Russell is still a friend today and is still living there in Cheyenne. And, he had all kinds of formulas for rocket fuel and so on. And, we built rockets, lots of rockets, and we found out they blew up just like the Vanguard. And so, we made a lot of bombs, I mean, we'd go so far as to model a rocket that we knew would blow up. Kids are kids.

Battle:

You didn't quite tell your parents you were going to do that, though?

Howard:

Well, my parents were concerned, but they thought allowing me to pursue my scientific interests was in my general interest.

Battle:

So, we do have to ask about your biggest disaster with your rockets?

Howard:

Well, you know, when you make rockets—

Battle:

It was a learning opportunity.

Howard:

One day, for some reason I thought I was going to make an aerial display. I was kind of impressed with the 4th of July aerial bombs, you know, and the big shells that blow up. I was making one of those and, of course, to expedite things, I just used steel pipe, instead of cardboard and all of that, because I knew that would blow apart. So, I had a fuse break, and I was disassembling it; and I was trying to be careful because I knew the risks from static electricity and so on. But, it went off in my hand. I had the steel pipe. Fortunately, it didn't rip apart, but I still have never found the coupling on the end of that. I think it went through this lath ceiling, but it blew a big hole in the sink top, counter top, I had and did some very strange things like melting the wire. The hanger I had, was using to assemble it, and it melted on a plastic sheet in the form of the plastic without melting the plastic. I don't know how that happened yet. But, at any rate, it was quite an explosion. I remember walking up the stairs, I was unwilling to look at my hand because I figured it was gone. But, when my dad ran past me looking for Russell, I thought, well, maybe it's not, or he would have stopped with me. So then, up those stairs, the same stairs that I heard about the Sputnik thing a few years earlier, I was willing to look at my hand, and it was a little bloodied, but it was okay. And, that's why I don't hear very well out of my right ear. But, it blew my shirt off, you know, the front of the shirt off.

Battle:

Did you save the shirt?

Howard:

No. It was a nice shirt. I liked it. I wish I had it. It would be kind of an interesting display item, I guess. If anyone were interested.

24:11 Excellent Role Models - "I Just Can't Express Enough Gratitude"

Battle:

So, obviously, the rocket stories tell us you had to become a metallurgist--and a chemist and, yes, a demolition expert--just to make these devices and power them, and so on. And, another of your formative phases was your interest, as you mentioned, in astronomy but also Greek mythology, or mythology, in general, through your mother. We haven't talked about your mother, but she sounds like she was very educated.

Howard:

Yes, I was blessed by having two wonderful parents, and I just can't express enough appreciation for my parents. Neither one is living at this point, but my mother was a graduate of Cornell University, and she studied Greek mythology and Latin. And, my father was a mathematician and bound to be a minister and a philosopher but switched mostly to teaching mathematics and superintendent of schools and that sort of thing. And, carpentry, and he was an electrician, and he was a Renaissance man and a very humble man. Very polite. I never heard either of my parents ever rail or seethe. They were very constructive. My mother was the director of social services in Cheyenne, and they were just wonderful parents. My mother, having a background in Greek mythology--when we were at the ranch, of course, there are no lights to blind you from looking at the sky, and we would lay out in the summertime on blankets or have time outside--my mother would tell stories about the constellations and point out all the stars and tell us the stories from the Iliad and the Odyssey. So, Homer's characters were our heroes, you know, Achilles and Agamemnon. And, you know, when we played as kids, we always wanted to be Achilles or Hector. I want to be Hector, or I want to be Agamemnon. Can't say it. I did pretty well the first time I tried it. But, those were our heroes,

and that's all because of my mother. So, they were tremendous parents, made a tremendous difference to me. I just can't express enough gratitude.

26:53 Finding an Early Passion for Metallurgy- Deciding a Future in the Eighth Grade

Battle:

Now, is it too far to go from metallurgy and Greek mythology to bladesmithing?

Howard:

Well, see, I always wanted to know how things worked. Science and--I don't know where that comes from. One thing I did want to make sure I said during this interview was that I was a slow student. I could not read. I could not use the English language until I was about four. My brothers--I had two older brothers, four and five years older--and we lived at the ranch. I did not speak English until, you know, recognizable English until age three or four. And, I had words, but I just had my kind of own language, and my brothers interpreted for me, I guess. My mother kind of understood that. And, when I went to grade school, the first-grade teacher did not teach me to read or my class. There were two classes. One learned; one didn't. So, it was the start of fourth grade, third or fourth grade, we had remedial reading. And, I remember my mother actually volunteered to come in and teach us. I learned to read in about third grade. But, I was always interested in how things worked. And, one of the wonderful things that happened to me was my brother, when I was in junior high school, brought home to me a book that the high school had thrown away on chemistry lab experiments. I still have it, and it had all these wonderful experiments that you could do and a whole list of all the equipment you needed for chemistry experiments. And, I just poured through that. I just desperately wanted to have that chem lab, and when I added up the price of all the equipment, it was like 60 bucks. Or maybe it was \$200; I don't know. Anyway, it was just an unattainable number, and so, I thought I'd make my own glassware. So, on a snow day, I cranked up the wood range down in the basement, got the vacuum cleaner and threw some coal in and some pop bottles, and started melting glass. And, before long, I was down in the library, state library and Carnegie library--bless Carnegie for providing that library in Cheyenne and the state library--and I read prolifically. I lived in those libraries. I was sorry when they closed at five o'clock at the state library. And then, I found out all this metallurgy information about metallurgical furnaces. And so, by eighth grade, it was definite in my mind that I was going to be a metallurgist, and I loved high temperatures. I'd always liked fire and heat, you know, what youth doesn't?

Battle:

So, you decided on a PhD at that time?

Howard:

Yes, PhD was decided in fourth grade, and metallurgy was decided in eighth grade. And so, the first time I ever melted a large quantity of glass in a separate room I had where I could do such things in this wonderful home that my parents bought, I put in the steel rod, or iron rod, rolled a ball of glass and blew a perfect sphere. But, I never was able to do it as easily again -- first-time beginner's luck.

30:22 How Reading and Self-Teaching Gave Howard a Head Start for College

Battle:

And so, you did obviously well enough in high school to get into CSM, which has pretty high standards. It sounds like you learned--your first couple of years at CSM may have been boring cause you already knew the math and chemistry and physics, I suspect. You said, on your own, as well.

Howard:

Yes. I learned a lot of things on my own and with my father's help. My father being a mathematician, and I was in advanced math, I was always blessed with being very good at math. I think I could do all the times tables before I could read, probably, but it wasn't an unusual schedule. It's just that my reading was delayed. But, I knew calculus and all of that when I went, and I taught myself chemistry. My good friend Russell, and Steve Johnson, we sat out in the apple tree, we got a high school chemistry book, and we read that. That's what we did.

Battle:

So, your recreational reading.

Howard:

We sat out in the apple tree and read that chemistry book one page at a time, you know, and poured over it and discussed it and thought about it. So, we were conversing in chemistry by eighth grade. And, I also read a lot. One of my favorite books was Alison Butts, Metallurgical Problems. And, I just found a copy of that on eBay, and I bought it. And, when I opened up that book and looked in there, I just thought, holy smokes, I remember this page.

Battle:

It took you back.

Howard:

The thing that I was most interested in it was flame temperature. They did not call it; he did not call it, adiabatic flame temperature but flame temperature. And, my father and I sat at the dining room table pouring over that book many nights. So, when I went to Colorado School of Mines, I had these questions like, "Where does the heat transfer coefficient come from?" And, I didn't learn that until grad school. John Hager covered it one day in a lecture, and I'm like, "Oh, that's where the number, how you get the number." I knew how to use the number. I didn't know where it came from.

Battle:

Right. So, now we've talked about the CSM years. So, now you show up in Rapid City. You'd never been there before except to interview.

Howard:

Oh, no, Rapid City was a vacation spot for my family. The ranch, North Lingle there, it's probably 180 miles to the Black Hills, and that was one of our favorite vacation spots. So, we'd go to Hot Springs (SD) quite often and stay there and swim in Evans Plunge, and so I was quite familiar with the Black Hills. It always seemed like a vacation spot. So, when I went up to interview and thought I might live there, it was sort of surrealistic in a way. I never intended to stay close to home, but, you know, I have. I've stayed between

Denver and Rapid City my career, and I always thought I'd go to Pittsburgh, make steel. That's what I thought I'd do.

33:30 Work Hard: Play Hard - Flamethrowers and Icicles

Battle:

So, going back again to your CSM years, when I was there, I didn't realize there was a class in flame throwers. Apparently, you invented that.

Howard:

Well, that's actually in my Cheyenne time before that. Jim Robinson had asked me to mention that. He had heard this story before, and, last night at dinner, he'd asked me to be sure to include that in this interview. Being interested in all things scientific, one of the things I wanted to do, as a youth and junior high and those years transitioning to high school, was build a turbine jet engine. But, of course, it's far beyond my mechanical abilities as a youth or even an adult at this point. I could not build a turbine engine, but they were fascinating to me. I was just fascinated. But, I thought, well, maybe I could make a ramjet. So, I got a steel tube and conduit, actually, and necked it down and put a spark plug in it and got an IV bottle from the hospital trash--can you imagine going to a hospital and getting an old IV bottle?--filled it with kerosene, which you should never do, but I did, and then ran a hose down to the steel pipe. And, I bolted it to the floor because I figured it would take off. And then, I got the vacuum cleaner and blew?? through there. It turned out it just was a wonderful flame thrower. I put it in the garage, bolted to the garage floor and opened up the garage doors, adjacent the sidewalk, and we'd fill it up with kerosene and then fire it. And, what it would do is it make a ball of flame about eight feet in diameter. And, the wind was always just right that it would just slowly roll down the sidewalk and extinguish itself over about a hundred feet. Fortunately, no pedestrians.

Battle:

I was thinking you were doing that in your basement.

Howard:

No, that was outside, summer days, but I don't think it ever developed much power. I could see that that wasn't going to amount to much of anything, but it was an interesting kind of flame thrower, it turned out. We enjoyed all that. In CSM, there was another story that people found, Jim had found, interesting, and that was, it was so cold down there in the wintertime as it is in Wyoming and South Dakota. One cold spell we decided we'd capitalize on. I lived in a third-floor apartment. We had a veranda three floors up. And, I thought, "You know; we should just grow an icicle." So, I got a big trashcan, plastic trashcan, about 30-gallon, 40-gallon, and put a drip on it over the edge. And, we grew an icicle about six feet in diameter and three floors high, and we started putting food coloring in it. We grew the whole thing. It was just huge. And so, then, as it does in Colorado, shortly after it was 70 degrees out, we're down to underneath it taking a picture, and I heard a crack, and I said, "Everybody step back under the concrete overhang," and that whole thing came down, chunks of ice about the size of Volkswagens coming down. But, that was a fun experiment.

Battle:

Yes. Obviously, you had too much time on your hands.

Howard:

Well, yes, we didn't have much time at Colorado School of Mines. You know, we took 168 credit hours.

Battle:

You work hard, and you play hard.

Howard:

Yes, yes. That's what they said. Yes. Work hard; play hard. That was the goal.

37:06 A Natural Born Teacher - Becoming a Professor at the South Dakota School of Mines

Battle:

So, then let's move into the South Dakota years. So, you show up, you'd done student teaching, you'd been a TA [teaching assistant] or something?

Howard:

No, I never was a TA. I always had research. I was an RA [research assistant] at Colorado School of Mines and the St. Joe Fellow. I appreciate that. Yes. And, I had a National Education Defense Act as a result of Sputnik, so it paid off later. A benefit. \$1,450, I think, I got. And, my first stipend was \$222.22 a month, and I was never better off. My wife worked, and we had married student housing. I spent a lot of my time down at the First National Bank in Denver doing loans and stock transactions and hanging out at Bache Incorporated (stock brokerage). So, I was able to invest. I started investing when I was in seventh grade. Always liked investments, interest.

Battle:

And, that's valuable for an engineer to know, at least something about the real world. So, when you came to Rapid City, you developed, well, they assigned you, classes to teach.

Howard:

They surely did. I taught 14 credit hours the second semester I was there.

Battle:

Were there, at least, previous notes from professors, or did you have to start from scratch?

Howard:

Well, when I started teaching, I thought I was going to teach just like the best professors I had at Colorado School of Mines.

Battle:

A bit from each of them?

Howard:

Yes. Or I would model after one or another, and I would just correct what I thought they did wrong. But, after about a week of that, you realize you can't be somebody else. You have to be yourself. And so, I quickly adapted to that thinking and started teaching my own style.

Battle:

And, you pretty much created all your notes, your lecture notes, from scratch, or did you have some?

Howard:

I did, well, I have all my notes from Colorado School of Mines to this day, I have every one. After I became a serious student--I wasn't that organized as a freshman or sophomore. But, as a junior and senior, I was fastidious. I had to be, and, you know, I started getting all A's as opposed to just learning the material. I was destined to be; I was determined to be, you know, know everything. Well, because I was in metallurgy then, I wasn't just doing all this preparatory work. It's not as interesting. But, I still have all those notes. And, I tried to pattern after those. But, after a short time, you realize, first of all, I couldn't use Denbigh as a thermo book because the Colorado School of Mines and metallurgical thermo, that's third thermo course stuff, not the first, and I was teaching students the first thermo course. So, I used Mackowiak for a while; and then, Gaskell later came out with his book, and I used it. But, I wrote all my notes, and then I'd redo my notes, and after about the third year, you realize you don't need notes. So, I haven't used notes for any of my classes after about third year. I just go in, and I can lecture, start to finish, any one of 10 classes. It's just natural.

Battle:

Yup. It's ingrained in your memory.

Howard:

Yes, it's, I mean, who needs notes to teach heat transfer? I mean, my goodness. You know, I can derive all the equations. I can tell you what page number they're on and where Gibbs-Helmholtz equation is in Gaskell.

Battle:

And, they're still using Bird, Stewart, and Lightfoot. Well, I don't know about right now.

Howard:

Well, I used Geiger's book, [crosstalk] Gordon Geiger and Poirier. Geiger & Poirier.

Battle:

And then, Gaskell's Thermodynamics.

Howard:

Yes, and I've written my own thermo book, too. It's online, or at least the first half of it is.

Battle:

So, your record was teaching 14 credit hours in a single semester?

Howard:

Yes. I even taught physical metallurgy once, and I'm not a physical metallurgist. But, we were in transition, faculty transition period, and I was asked to jump in that class a week or two into the semester. And, you know, I mean, I'm not totally ignorant of physical metallurgy, I have some, and so I taught that in the lab. But, it's not my forte, and it's not my particular interest.

Battle:

But, you realized quickly that you're probably more knowledgeable than the students. So, they don't realize you're not an expert in the subject if you're confident?

Howard:

Right.

But, that's an old story about, saying about, how you don't learn, really learn, something until you have to teach it.

Howard:

Oh, there is no doubt I benefitted greatly in knowing thermo and heat transfer by teaching. No doubt. That's a great satisfaction to me. I just always wanted to know how things work and how the world worked. And, to this day, when I go to sleep at night, I think about, "Isn't it wonderful that I have been able to acquire that knowledge from other people, other giants, you know; I'm not the giant but Denbigh and Gibbs and those people." I mean, it's just fantastic to think that I've been afforded the opportunity to just learn this stuff. It's just wonderful. It's just thrilling to me.

Battle:

Well then, as I think you've said, to see the students catch it. Thermodynamics is a subject that either you get it or you don't, and there are different ways to get it. A lot of subjects, I think, are like that: one approach may work great with one student, but another student is still totally out to sea.

Howard:

Well, I am an educator, and I've certainly come to recognize students learn differently. They do, but it's a great satisfaction to teach students and help them learn this material. I just went back into teaching after being retired for a couple of years because I wanted to have that interaction with the students. It's thrilling. It's exciting to me. I enjoy it greatly.

44:05 Beyond Research – Writing and Publishing

Battle:

Now, what was the focus at South Dakota? Was it you do research X percent of your time or your teaching?

Howard:

Well, it's evolved over the years. When I first went up there, I remember telling the president in the interview that I had with him that we needed to get more research. So, we were all excited about research and doing more of it. In the last few years, I mean, it's, particularly now, very demanding.

Battle:

[Crosstalk] The publish or perish kind of thing?

Howard:

Yes, very demanding standards. But, we contract for a certain percentage, each semester, each year, how much research, how much teaching, and so on. I'm out of that now. I'm just teaching part-time, but I'm there 50 hours a week, writing and publishing.

Battle:

Only 50.

Howard:

Yes. I always like to say the nice thing about teaching is you could do your 80 hours whenever you wanted. Very flexible. And, that's what we did. We did every day, every day we were down at school.

Battle:

And so, talk about a little, your research. It sounds like you were fortunate enough to be able to continue your PhD work or with similar equipment to your masters thesis research?.

Howard:

Yes.

Battle:

And, not everyone gets that opportunity. Some of them never want to see it again, whatever they worked on.

Howard:

Right. Well, I built my own equipment.

Battle:

You knew it backwards and forwards.

Howard:

Yes, yes. So, I built a Knudsen inlet system, a valved Knudsen inlet system, where I could actually change the composition inside the crucible in the Knudsen cell as I monitored the ion currents or the effusate, with mass spec. So, you could start with a pure metal, like pure gold, and start dropping alloy additions and--pre-weighed, so you'd know the composition--then you could track the ion current of gold and measure activities directly. Very nice for multi-component systems.

Battle:

I remember they did a lot of chlorides at CSM, or was that a little after you? Did you get into Chlorides or—

Howard:

Well, Bob Hill worked in the gold chloride system on that 30/12 mass spec, as I recall the number was, and I never had much to do with that.

Battle:

Well, what were the major things you were measuring?

Howard:

I was doing thermodynamic activities of liquid metallic solutions.

Battle:

There was little or no data on most of those systems before [Crosstalk]

Howard:

That's true, that's true.

Battle:

Or were you narrowing down the error bars on—

Howard:

Well, a little of both.

46:58 The Birth of Group V Metals, Inc.

Battle:

And then, what other new research did you get into as you, kind of, built that part of your career?

Howard:

Well, we were doing multi-component solutions, germanium, gold. I mean, those are easy to do with the mass spec. The vapor pressures are all about right. So, copper, germanium, gold, silver are nice selections, nice systems to work in. It's been interesting to me over the years that, of late, people are looking at those things for solders. So, I see that my work's kind of cited in some of those articles. It's gratifying. But, I never stood still; I did a lot of different things. I guess one might say I'm bored easily or, once I learned how something works, I want to move on and do something different. And, I've done a lot of different things over the years, so we can talk about that as you would like.

Battle:

At length, and some of that is what the funding agencies are looking for at a given time to certain extent, right? If you had to rely, I don't know if you relied, much on NSF [National Science Foundation] money or Bureau of Mines or things like that, where they're looking for certain things, whether it's what you really wanted to do or not.

Howard:

Well, sometimes it's difficult to get funding at a school that doesn't have that history. And, I used to cast about for different types of different areas, for funding, and I've done a lot of different things. But, one of the more interesting things I find some satisfaction in having done was-- I developed it with colleagues, Wendell Dunn in particular-- a chlorination process for processing tantalum and making tantalum products and niobium. It's called Group Five Metals. We ran it in Rapid City.

Battle:

Wendell Dunn used to work for DuPont.

Howard:

Yes. He worked up in Gore.

Battle:

So, titanium tetrachloride.

Howard:

Right. Yes, I met Wendell in--and Wendell was one of the people I really wanted to mention in this interview--I met him in 1980, as I recall, in Chicago at the TMS meeting. And, it was very odd: I didn't believe he was for real at first because we're doing a social gathering there at TMS, and I came across him, and I saw his badge, and it said Spearfish, South Dakota, which is 50 miles from me. And, I asked him about that, and I said, "What kind of metallurgy do you do?" And he said, "I do chlorination metallurgy," which I was interested in, and I'd written proposals on and done some work in. And, I couldn't believe that somebody would be in Spearfish, South Dakota, doing chlorination metallurgy. Well, it turned out Wendell and I and a friend of mine, Dan Carda, and Glen Stone started this company, Group Five Metals, shortly after that because people were bringing in tantalum compounds to have us evaluate them from the Black Hills. So, we decided we'd just start a company. Well, Dan Carda and I decided to do that. Then Wendell joined us. Good thing because Wendell knew what he was doing.

Battle:

He had more enthusiasm than you had.

Howard:

And, he had a lot of experience.

Battle:

Was he retired then?

Howard:

Yes. Wendell and Gore were friends at DuPont. Gore-Tex. Wendell brought into my office one day a stack of Gore-Tex stock issues, big sheets, probably an inch and a half thick. He just said, "I was taking these to the bank; I thought you might want to look at them." I don't know what that was worth, but it was a considerable sum.

Battle:

Yes. So, I mean, I remember the stories of Gore-Tex, developed at DuPont. They really didn't seem to see a future in it, and they let Gore take the patents with him if I recall.

Howard:

Yes. And then, he tried to, as Wendell tells the story, he tried to get someone to buy the technology. And, they said, we'll just loan you the money, you should do it, the banker told him. So, that's how Gore-Tex started. But, Wendell was a great partner. I enjoyed working with Wendell. And, we were quite successful in producing ultra-high or very-high purity niobium oxides. That was the business; it turned out a year later. And, we originally thought we'd make tantalum metal, which we did, but the market was to take niobium oxide from Colombia and tin slags from Malaysia and turn it into niobium oxide, high purity, for lenses and lithium-niobate switches.

Battle:

How long did that company last or your involvement with them?

Howard:

Well, it ran for three, four years, and then it was sold off. We were a licensing company, and the operating company sold it. So, it disappeared from Rapid City.

Battle:

And, how much of your extra--your second hundred percent of your time--did you spend with that?

Howard:

I spent a lot of time as a consultant working on that project.

Battle:

Did you get into the financial stuff with your interest in—

Howard:

It was very much worth our time, and we were very much involved. Actually, Wendell's son was a member of our corporation, and he was a graduate of the Wharton School of Business, and he advised us in some very important ways to succeed. Very grateful to him.

Battle:

So, you sold that because of the kind of the market conditions?

Howard:

Well, it was the operating company's choice. They sold it, and we were just the licensing company. And so, we sold, at that point, we sold the licensing information with it. So, we were out of the business. We're not really operators; we develop technology, basically.

Battle:

Tried to have fun.

Howard:

[Affirmation.]