Kenneth Thomas Whitby
(6 February 1925 – 14 November 1983)

INTRODUCTION

Kenneth Thomas Whitby was a man of many interests. He was a devoted father, loving husband, devout Christian, Boy Scout leader, Sunday school teacher, small airplane pilot, model airplane builder / flyer, woodworker and cabinet maker, photographer, poet, avid reader, skilled artist and craftsman, rifle and pistol marksman, aerosol instrument developer, enthusiastic student advisor, and atmospheric aerosol modeler. Ken loved to tinker, and always had the latest computer equipment for his computer modeling work. He would have been in seventh heaven with the current computing power! Ken will be especially remembered for developing the multimodal model for atmospheric and other aerosols, and for developing and improving electrical aerosol size measuring instrumentation for submicrometer particles. He trained an

Particle Technology Laboratory members of the early 1970s.

influential group of aerosol scientists and engineers; established the Particle Technology Laboratory, Mechanical Engineering Department, University of Minnesota; and convinced TSI to enter the commercial aerosol instrumentation business. He promoted the powerful iterative aerosol science process of instrument development, laboratory experiments, field measurements, and model development. He practiced a pragmatic engineering approach to aerosol science and technology. He was honored through election to the U.S. National Academy of Engineering and through the establishment of an award given in his name through the American Association for Aerosol Research.

The roots of Ken's engineering mind lay in his love for aeronautics and building model airplanes. In his youth, he was a solitary person, focused on the task at hand, difficult to engage in conversation, and he devoted most of his time, energy, and modest financial resources to his passion for designing and building model airplanes. Most of his friends were fellow airplane builders who talked about little else, and together they flew in competitions, local and national, with many of the people who later built the modern aeronautics industry. Ken did very well, placing high in many competitions. A local newspaper article extols one of his victories, and even at age 17, his future qualities were already apparent, *"Where most boys of his age are content to build their models from canned specifications, Whitby has always had the originality to put together something of his own."*

Although the young Ken was solitary and withdrawn from others, he is recognized today as an open, considerate person who was generous with his time and loved to engage others in conversation. How did this personal transformation occur? In this short description of Ken's life, we summarize his boyhood and teen years, his professional accomplishments, and close with an intimate view of his personality, drawing from an essay he wrote about his path to becoming an engineer, to show how an introverted youth grew to become an aerosol pioneer loved by his colleagues as much for his personal warmth as for professional accomplishments.

Ken picnicking with young folks.

High School Junior Awarded Second Prize In Contest For Model Airplanes At Chicago

Kenneth Whitby Builds Own Gasoline Ship For Entrance In National Meet

Kenneth Whitby, Fond du Lac's ace model airplane builder and designer, has been winning again.

He has just received notice that his gasoline-powered Whitby-designed ship flown in the meet at Chicago last Sunday rated a second place.

The Chicago competition is the biggest of its kind this year with the national races having been cancelled because of war conditions.

The week before that Whitby had competed at West Bend in a meet sponsored by the Milwaukee Exchange club where the same plane also took second.

At the Chicago test he had entered his plane in two different classes—A and B, the distinction being in size of motor used. It was in the B class that he won his second place, while in the Class A meet his ship flew out of sight.

Whitby is a junior in high school and will be 18 years old next February, but already his plane designs are attracting national attention.

He started building planes with rubber-band power about four years ago, but has been competing in the gas motor divisions for the last two years.

Where most boys of his age are content to build their models from canned specifications, Whitby has always had the originality to put together something of his own. The latest plane that he lost at Chicago he considered his masterpiece, but is confident that he can come out with something better.

He has been making most of the contests in this area for some time with a twenty-sixth place in the national contest last year, one of his past records.

He designed and carved folding propellers for his free-flight planes. Folding props reduced drag after the engine shut off and planes glided back to earth.

Rubber-band-powered helicopter.

One of many static models Ken carved and gave to friends.

EARLY YEARS

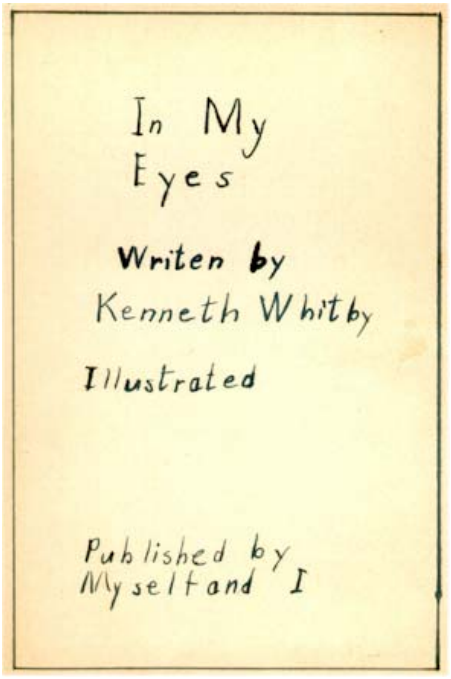
Ken at 4 years old

Kenneth Thomas Whitby was born on 6 February 1925 in rural Fond du Lac, Wisconsin. He was the oldest of 5 children born to Robert Gerhard Whitby and his wife Theresa M. Strebe. Ken's middle name came from his grandfather, Thomas Whitby. His great-grandfather William Whitby was a freight sailor with roots in England. Ken's paternal grandmother's ancestors and his mother's ancestors were all of German origin. They immigrated to the United States in the 1850s and settled in Eastern Wisconsin.

Ken grew up on a farm. His father was a rural mail carrier. With no other boys his age in the neighborhood, he learned to live 'pretty much alone'. He attended eight years of elementary (grade) school in a one-room country school. He began his ninth year of school in September 1939 at Roosevelt High School, Fond du Lac. In an autobiography he wrote in March 1940 for an English class, he noted that Roosevelt had over 1000 students, quite a change from a country school with 13 students. He was the only student from his country school starting at Roosevelt in 1939, so he had to make all new friends. His favorite classes that year were science, social studies, and algebra. He noted that, "Up to this fall and forever I hope, I had a deep seated reverence for getting things done as per order." Ken was no stranger to work. He stated, "I like to go with the threshing machine and crew when harvesting time comes around. My job was blower tending and a dirty job it is."

Ken (front, center) in front of the one-room school where he spent his first 8 years of school.

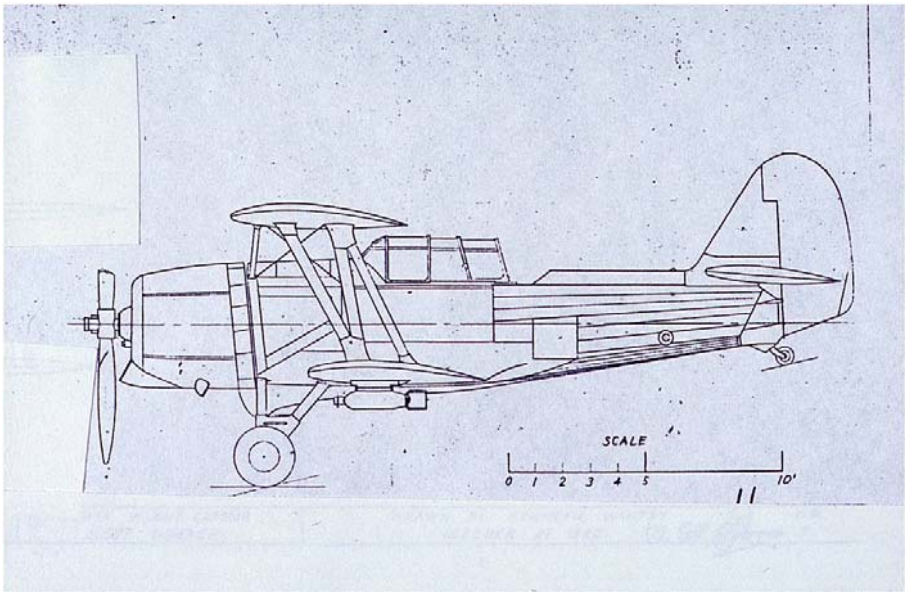
The above quotations and those that follow are from an autobiography Ken wrote when he was 15 years old titled "In My Eyes" for a high school English class. These writings are a snapshot of the teenage Ken and give us considerable insight into the origins of the adult Ken Whitby.



Father: "My father … is well educated and never drank or smoked, and I have never heard him swear or let his temper get away from him."

Earliest Recollections: "… At the age of seven I received a small balsa wood and paper glider that thrilled me to the core, and before my amazed eyes that thing flew. Two months later it was still flying, but the only original part was the rudder. It was probably the most interesting contraption that ever tangled with me at the age of seven. From then on anything mechanical was a gold mine to me."

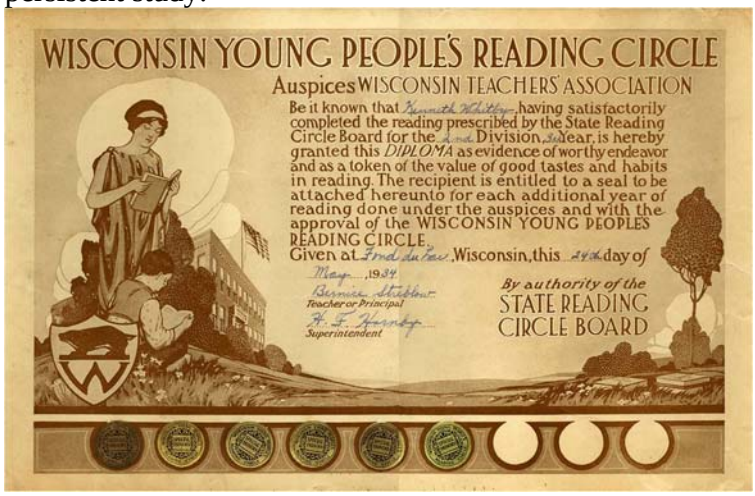
Reading for Enjoyment: "One of my favorite pastimes is reading … We take *Commonwealth Reporter* and *Milwaukee Journal … American* and *Colliers … Women's Home Companion* and … *Legion* and *Eagles … Flying Aces* and *Air Trails.* I have taken out around fifty books since last fall. … *Flying Aces* and *Air Trails* are Aviation and Model magazines and … to me they are about the most interesting of any. My cousin gets three science magazines and so we trade my Aviation for his Science and therefore get the benefits of five magazines…"



Sketch done for a high school class assignment.

Future Plans: "I would like to make Aircraft Designing my life work but this is about as difficult a goal to obtain as can be found. The first requirement is a thorough and complete study of Aerodynamics along with a very complete study of mathematics. The first requirement I have satisfied to some extent by studying all the books on aircraft I could get ahold of and by designing models. To date I have designed nearly 90 planes and I can safely say 80 percent were

entirely satisfactory. The only way I can figure on ever attaining my goal is by hard and persistent study."


WISCONSIN YOUNG PEOPLE'S READING CIRCLE

Auspices WISCONSIN TEACHERS' ASSOCIATION

Be it known that Kenneth Whitby, having satisfactorily completed the reading prescribed by the State Reading Circle Board for the 2nd Division, 3rd Year, is hereby granted this *DIPLOMA* as evidence of worthy endeavor and as a token of the value of good tastes and habits in reading. The recipient is entitled to a seal to be attached hereunto for each additional year of reading done under the auspices and with the approval of the WISCONSIN YOUNG PEOPLES READING CIRCLE.

Given at Fond du Lac, Wisconsin, this 24th day of May, 1934

Bernice Stubbs
Teacher or Principal

H. L. Kumley
Superintendent

By authority of the
STATE READING
CIRCLE BOARD

Reading certificate earned in 1934 (age 9) and for the next 6 years.

What I Like in People: "I think the best quality a person can possess is to tend to business when business is in order and play when play is in order. … I think there would be fewer misunderstandings in this world if everyone would say what they think and not what they think someone else would like. If something is wrong with what I do I don't mind someone saying so because then I can correct myself. I believe in frankness and sticking to the truth completely."

MILITARY SERVICE

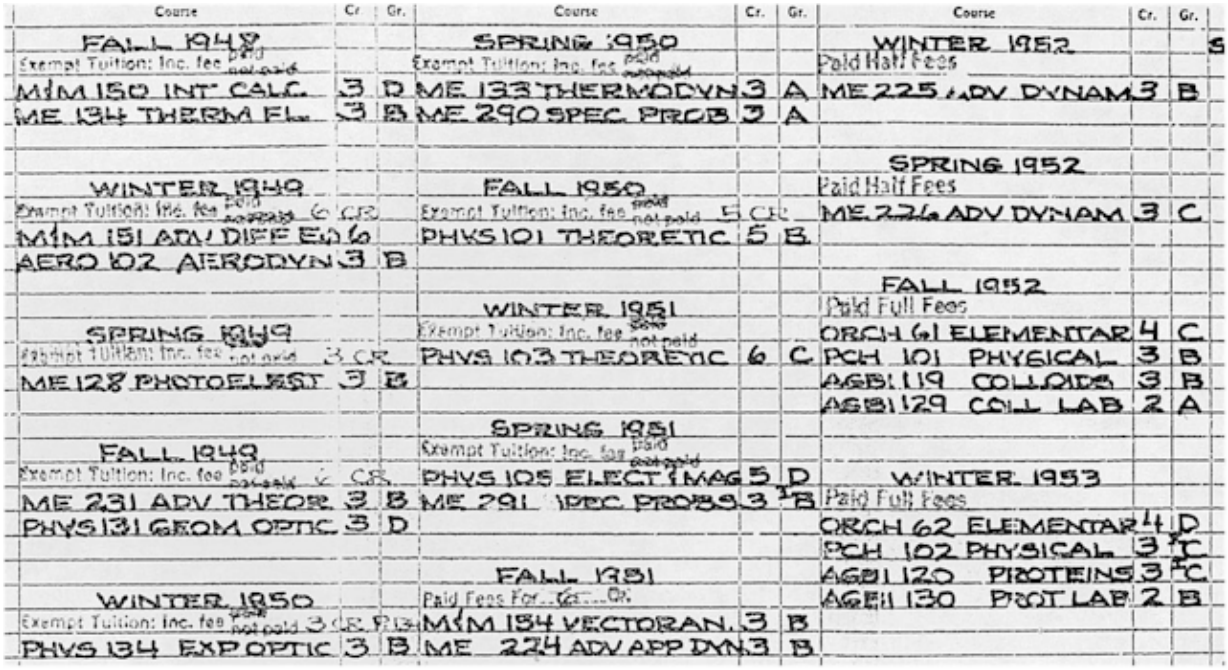
At 16 years old, Ken and a close friend left home in November 1941 to work at Langley Field VA as aircraft model makers while they studied for their high school diplomas. Ken's friend became homesick and Ken's father advised them to return home to finish high school in the traditional way. They returned to Wisconsin on December 7, 1941, the day Japanese planes bombed Pearl Harbor.

Within a couple weeks of completing high school, on June 23, 1943, Ken enlisted in the U.S. Navy in Milwaukee. After basic training, he completed a 7-month training program in June 1944 under the U.S. Navy V-12 Unit Program at the University of Wisconsin, Madison. On July 1, 1944, he began a Navy Reserve Officer Training Corp program, University of Minnesota. On February 23, 1946, he earned a Bachelor of Science degree in Naval Technology with High Distinction, at the University of Minnesota, Minneapolis. On that same day, he passed his U.S. Navy physical and was assigned to Newport RI for temporary active duty. He served for 6 months aboard USS Cleveland, a Navy ship based on the East

Coast of the U.S.A. On September 13, 1946, he was released from active duty in Norfolk VA.

EDUCATION

- Elementary school, rural school, Fond du Lac County WI, June 1939.
- High school diploma, Roosevelt High School, Fond du Lac WI, June 1943.
- Basic training, U.S. Navy, November 1943.
- Navy V-12 Unit training, University of Wisconsin, Madison, June 1944.
- Bachelor of Science, Naval Technology, high distinction, Univ of Minnesota, Feb 1946.
- Bachelor of Mechanical Engineering, University of Minnesota, Minneapolis, June 1948.
- Doctor of Philosophy, University of Minnesota, Minneapolis, August 1954:
  Major: mechanical engineering
  Minor: agricultural biochemistry
  Thesis title: The Mechanics of Fine Sieving
  Thesis advisor: Professor N.A. Hall



Course	Cr.	Gr.
FALL 1948		
Exempt Tuition: Inc. fee paid not paid		
M/M 150 INT' CALC.	3	D
ME 134 THERM FL..	3	B
WINTER 1949		
Exempt Tuition: Inc. fee paid not paid 6 CR		
M/M 151 ADV DIFF EQ	6	
AERO 102 AERODYN	3	B
SPRING 1949		
Exempt Tuition: Inc. fee not paid 3 CR		
ME 128 PHOTOELAST	3	B
FALL 1949		
Exempt Tuition: Inc. fee paid not paid 6 CR		
ME 231 ADV THEOR	3	B
PHYS 131 GEOM OPTIC	3	D
WINTER 1950		
Exempt Tuition: Inc. fee paid not paid 3 CR. P/B		
PHYS 134 EXP OPTIC	3	B

Course	Cr.	Gr.
SPRING 1950		
Exempt Tuition: Inc. fee paid not paid		
ME 133 THERMODYN	3	A
ME 290 SPEC PROB	3	A
FALL 1950		
Exempt Tuition: Inc. fee paid not paid 5 CR		
PHYS 101 THEORETIC	5	B
WINTER 1951		
Exempt Tuition: Inc. fee paid not paid		
PHYS 103 THEORETIC	6	C
SPRING 1951		
Exempt Tuition: Inc. fee paid not paid		
PHYS 105 ELECT & MAG	5	D
ME 291 SPEC PROBS	3	B
FALL 1951		
Paid Fees For... CR.		
M/M 154 VECTORAN.	3	B
ME 224 ADV APP DYN	3	B

Course	Cr.	Gr.
WINTER 1952		
Paid Half Fees		
ME 225 ADV DYNAM	3	B
SPRING 1952		
Paid Half Fees		
ME 226 ADV DYNAM	3	C
FALL 1952		
Paid Full Fees		
ORCH 61 ELEMENTAR	4	C
PCH 101 PHYSICAL	3	B
AGBI 119 COLLOIDS	3	B
AGBI 129 COLL LAB	2	A
WINTER 1953		
Paid Full Fees		
ORCH 62 ELEMENTAR	4	D
PCH 102 PHYSICAL	3	C
AGBI 120 PROTEINS	3	C
AGBI 130 PROT LAB	2	B

Ken's university grades were not always the best, as evidenced by the above transcript.

He clearly did not choose courses based on expected grades. His generous supply of poor grades are an inspiration to those students who are not at the top of their class. If Ken could accomplish what he did during his career, you can too. (Appendix A contains what were probably his first and final Resumes).

POWDER AND INDOOR AEROSOLS – THE 1950s

Ken's introduction to particle technology was through his Ph.D. thesis work with the flour milling industry in Minneapolis. His thesis covered the state of the art in flour particle characterization during the period. With this survey work as a basis, Ken then developed better technology to measure the particle size distribution of powder particles, which culminated in the development of a centrifugal size analyzer commercialized by Mine Safety Appliance Company, Pittsburgh. The method was later greatly enhanced by Micromeritics Corporation, GA.


DR. K.T. WHITBY AT PHOTOMICROSCOPE

An important problem of that day was the influence of particle size on the uniformity of cake mixes and other dry-powder premixed food products. In 1955 Ken published his first paper related to indoor air filters. In that paper, he used his new centrifugal method to size particles removed from an air filter. That work continued until 1965, representing a transition of Ken's interests from powder particles to airborne particles.

'A Yard 'n a Half of Dust, Please'

This Guy Measures Dust for Better Hamburgers

★ ★ ★ ★ ★ ★


BIG AND LITTLE analytical balancing sets are being used by Ken Whitby, Graduate student (left), and Eugene Legg, Technology junior. The big one is a standard size. The small one is especially adapted for measuring milling dust particles. It is less expensive, easier to operate and does the job faster than other measuring machines.

By Bob Krauss

Graduate student Ken Whitby spends his time these days measuring specks of dust.

That isn't as silly as it sounds. If Whitby's experiments are successful it someday may mean better and cheaper peanut butter sandwiches, improved hamburgers and Dagwood specials.

But Whitby isn't concerned with what's on the inside of the sandwich so much as the bread on the outside. And the specks of dust he is measuring aren't the kind that blew over Kansas during the drouth. They are milling dust—the part of flour that is ground to fine.

That's the stuff that makes bread soggy. If Whitby's experiments make it possible to separate the dust from good flour, it should help bring out more of that tasty freshness.

And because part of the grain always comes out as dust in the milling process, some of the valuable product is wasted. If Whitby can help eliminate this waste, it would mean more efficient production and cheaper flour.

"Dust control is one of the most pressing problems facing the industry today," says Professor MacKinsie. "But before we can control the dust, we've got to know the size of the particles we are dealing with. That's what Ken is trying to find out."

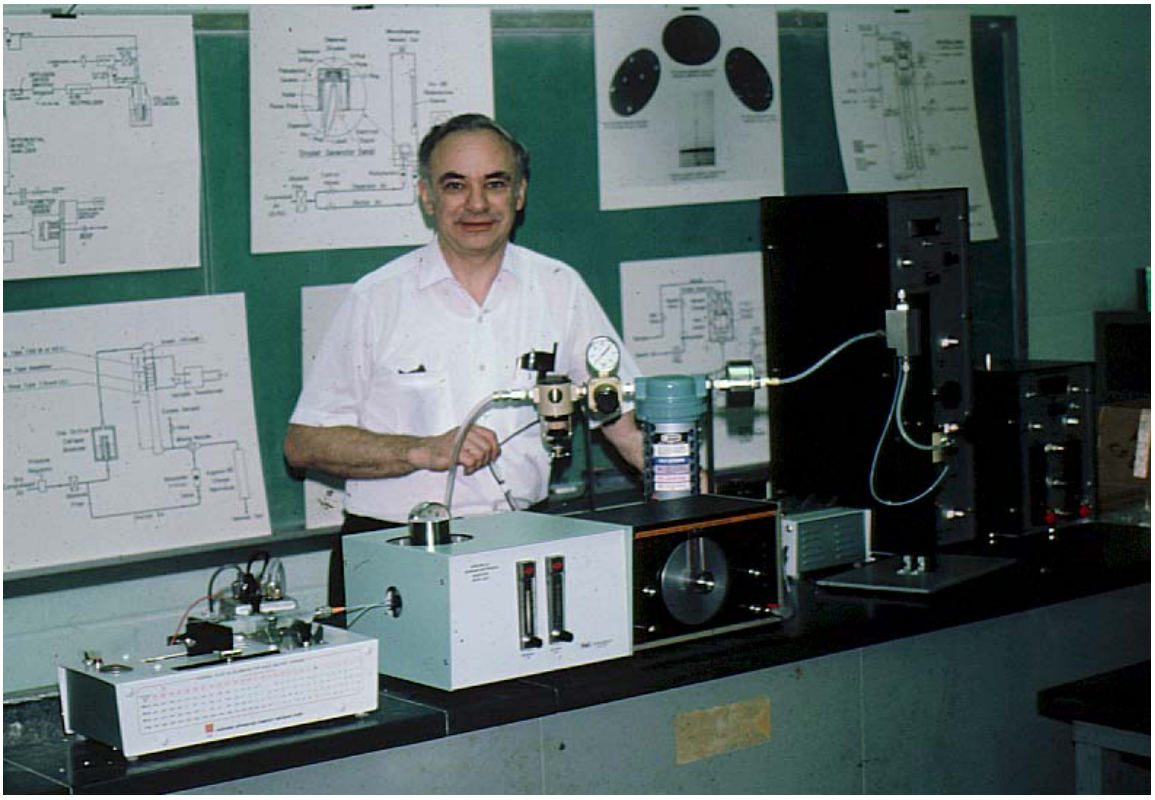
Whitby and his assistant, Eugene Legg, Technlogy junior, have been trying since last summer. "Measuring a particle of dust isn't as easy as it sounds," says Whitby. "The obvious method would be be to look through a microsope. But that's hard on the eyes and the equipment is too expensive for commercial use.

"What we are trying to develop is an inexpensive machine that is simple to operate and does the job in a hurry. Nobody yet has been able to adapt one for use in the milling industry because the particles are too light."

But Whitby thinks he might be getting close. He is experimenting now with what he calls an analytical balance set. The idea for the machine isn't new but Whitby has simplified it and cut it down to practical size.

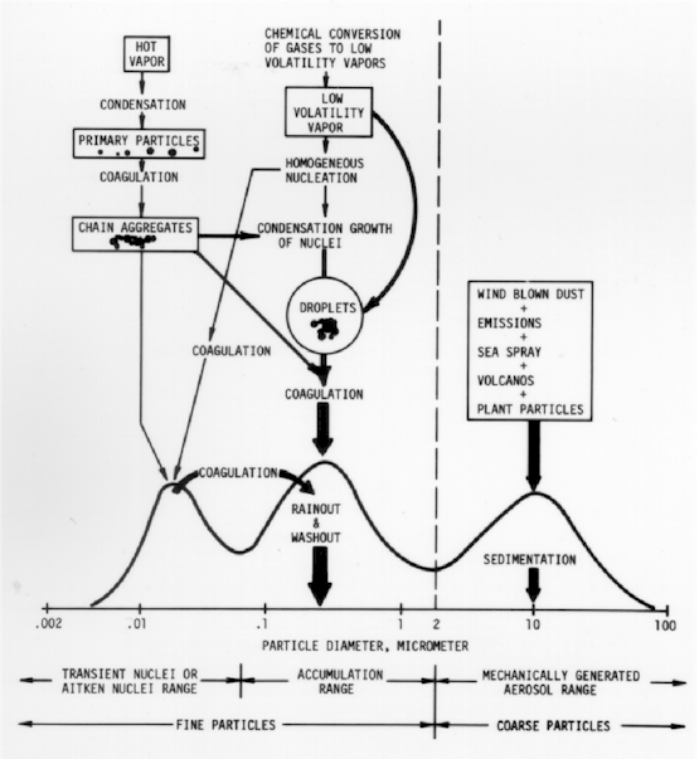
AEROSOL SIZE DISTRIBUTIONS AND INSTRUMENT DEVELOPMENT – 1960 - 1974

In 1960, Ken received a grant from the U.S. Public Health Service (USPHS) that lasted 14 years and led to the development of the electrical aerosol analyzer (EAA). The grant was called 'Generation and Decay of Small Ions'. Whitby *et al.* (1964) described initial work on an electrical aerosol analyzer to measure particle size distributions in the diameter range 0.005 to 1 micrometer. Whitby and Clark (1966) reported progress on the new instrument. These documents record the beginning of Ken's interest in aerosol instrument development. In 1967, Thermo-Systems Incorporated (name later changed to TSI Incorporated) introduced the EAA as their first commercial aerosol instrument. This work led directly to the development of the 'portable' EAA, also commercialized by TSI in the early 1970s.



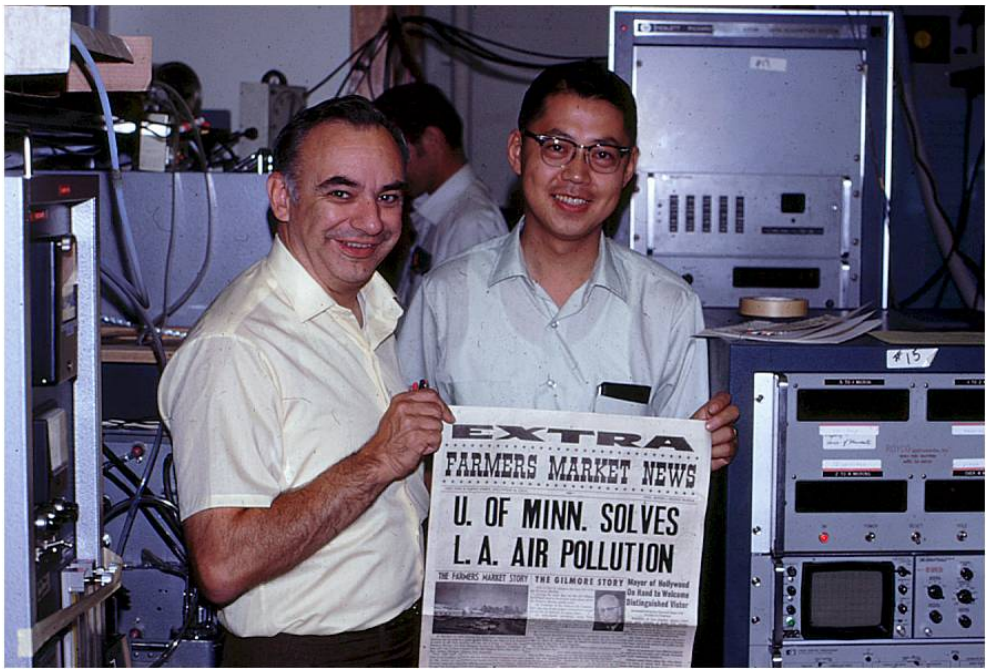
Ken Whitby and his colleague Benjamin Liu received another grant in 1962 from U.S. Atomic Energy Commission that proved to be equally long-lived and led to the development of the differential mobility analyzer (DMA, Whitby 1975a, 1975b). TSI introduced the commercial version, called an electrostatic classifier, in 1975. This instrument became one of the two primary components of the differential mobility particle sizer (DMPS) introduced by TSI in the mid-1980s and scanning mobility particle sizer (SMPS) introduced by TSI in the mid-1990s. The SMPS remains today the primary measurement method for aerosol particle size distributions in the 3 – 300nm diameter range.

Whitby and Liu (1969) presented a paper at the 7th International Conference on Condensation and Ice Nuclei in Prague summarizing research on atmospheric aerosol size distributions. This



Trimodal size distribution and related processes.

topic continued as a core interest for the remainder of Ken's life. In 1969, Ken and his group participated in a landmark cooperative air pollution measurement project in Pasadena CA. Data from this program led to the discovery of the multimodal nature of atmospheric aerosol size distributions, reported for the first time in 3 papers that appeared in *Journal of Colloid and Interface Science* by Whitby *et al.* (1972a), Whitby *et al.* (1972b), and Husar *et al.* (1972). This discovery is arguably one of the most important findings about atmospheric aerosols during the past century. The Pasadena 1969 smog project was the first in a long series of field measurements by Ken's Minnesota group, including Fort Collins CO (1970), Denver CO (1971), Aerosol Characterization Experiment (ACHEX, CA, 1972), St Louis MO (1973), and Milford MI (1975). All of these field experiments used an evolving set of instruments known as the Minnesota Aerosol Analyzing System. A key paper (Whitby, 1978) summarized experimental size distributions of atmospheric aerosols obtained to that date. The data from these programs formed the basis for the next phase of Ken's career.



Whitby and Liu enjoying a gag 'newspaper' in Pasadena CA during the smog measurement project of 1969.

ANALYSIS OF FIELD DATA AND MODEL DEVELOPMENT – 1974 - 1983

In a paper authored by Willeke and Whitby (1975), we see early stages of the final phase of Ken's career. The topic was size distribution interpretation of atmospheric aerosols, which relied heavily on computer modeling. Ken was an early user of computers to analyze large amounts of data.

Ken's modeling work, in cooperation with a large list of colleagues, included nucleation rates, aerosol size distribution formation, aerosol volume formation rates in coal-fired power plant plumes, and aerosol formation by photochemical systems. It included parametric measurement of submicrometer atmospheric aerosols, multimodal nature of atmospheric aerosols, nucleation rates in the atmosphere, formation of combustion aerosols, and growth of nuclei-mode aerosols into the accumulation mode. His later models included aerosol formation in urban plumes and atmospheric aerosol growth rates using lumped-mode aerosol dynamics. Variants of his model are still used today for atmospheric and other aerosol modeling applications. In 1981, Ken worked on development of DISTFIT, a size distribution-fitting software program for atmospheric aerosols. After his death DISTFIT was commercialized, and is still available today.

The transition from Ken's instrument development/field measurement phase to his modeling phase was not a dramatic event. Throughout his career, he continually combined theory and modeling with experimental laboratory and field measurements.

PERSONAL PHILOSOPHY AND CHARACTERISTICS

- Warning to his students: "Never take an unexercised instrument into the field."
- "A factor of 30 is the maximum particle diameter range that any single aerosol sizing instrument can measure well. To measure a wider range of particle sizes requires more than one instrument."
- "Keep your model development well grounded with field measurements."
- "When writing a paper, replace general statements with specific data whenever possible."
- "Never depend completely on automated instruments. A five-second glance at a particle sample with a microscope may teach you more than years of automated measurements."
- "Ten measurements with an instrument that has ± 50% error is a more reliable estimate of truth than one measurement with an instrument that has ± 5% error."
- Ken emphasized the importance of thoroughly understanding particle statistics, the primary subject of his first-quarter particle technology course. He often talked about the importance of the central limit theorem.

- While standing at the foot of a 250-meter smokestack, watching smoke and steam billowing from the stack on a cold Minnesota winter day, Ken quietly remarked, "Humbling, isn't it!"

- Ken openly shared partially developed ideas with others, whether students or colleagues.

- Ken liked to correct those who called him a scientist, "I'm an engineer, not a scientist." In his mind, the difference seemed to be that engineers usually strive to use science for the good of fellow humans, while scientists often strive to push the frontier of science forward for the sake of science itself.

- Ken did not believe in interfering with or nagging students (see Tables 1 and 2). He gave them lots of room to develop their talents. Some students thrived under such freedom. Others grumbled about never seeing Ken when they needed his approval.

One of his students remembers a day in 1965 when he had not been able to find Ken to obtain approval for the next development phase of the electrical aerosol analyzer. Ken traveled a lot. It had been a couple months since Ken had been available for such a discussion. That morning, the student met Ken to let him know about his frustration. Ken listened patiently for five minutes while the student unloaded his thoughts. Then Ken asked, "What do you think is the problem?" The student told him. Ken then asked, "What are the solutions?" The student gave him several possible solutions. Ken then asked, "Which of those solutions do you think is best?" The student told him which he liked best. Ken's final words on the subject were, "Go ahead. Do it." In that short period, Ken taught his student to have confidence in himself and to go ahead with his own ideas without waiting for a supervisor to 'give permission'. Ken then spent the remainder of the hour talking about his latest ideas and visits with scientists from all over the world. The student left Ken's office that day not only empowered to do what he thought was best but convinced that he should devote his career to aerosol instrumentation. Powerful stuff!

- Ken said that aerosol instrument development is like pulling yourself up by your bootstraps. You first build the very best instrument you can build. You then find there is no way to calibrate your instrument, so you must build the very best aerosol generator or calibration system you can build. Now you can calibrate your 'best' instrument, but it does not compare very well with your reference aerosol calibrator, so you learn how to build a better instrument. You then continue the process, 'pulling yourself up by your bootstraps'.

- Ken taught graduate students to perform a successful feasibility study for a project before writing a proposal for research funds. The subsequent funded programs resulting from those feasibility studies were almost always successful. He emphasized the importance of this advice by suggesting that 10 successful research programs would not erase the memory of one unsuccessful project in the minds of colleagues. This must have played a major role in Ken's thoughts when he agonized over whether the multi-modal nature of atmospheric aerosol particles was really true or simply an artifact of the measuring instruments.

- Ken had an uncanny intuition. During field trips, where positioning of mobile laboratories was critical to catch the scent of the effluent from smoke stacks miles away, he had an unusual ability to anticipate the weather and find the optimal sampling location. This ability to read the weather partly originated in his youth flying free-flight gas-powered airplanes, where an understanding of winds and weather patterns was necessary to prevent planes from climbing too high and being carried away in changing weather patterns.

- Ken possessed a rural mid-western American work ethic. He could easily become single-mindedly focused on his work. By example, he led his students to work hard to ensure success. In Berkeley CA in 1972, during shakedown tests for the Air Resources Board (ARB) Aerosol Characterization Experiment (ACHEX), there was much work to be done. All systems were not yet working properly on the semi-trailer that was to contain the world's most sophisticated atmospheric aerosol research laboratory. The time for planning had passed; now it was time to make it all work. Ken laid on his back on the floor more than one day, a screwdriver in one hand and a soldering iron in the other, trying to make the correct electrical connections to the underside of a Digital Equipment Corporation PDP 8 minicomputer. Ken worked just as long and hard each day - in his shirtsleeves, getting his hands dirty - as any of his graduate students.

- Like his father before him, Ken valued education and encouraged others to challenge difficult subjects by thorough study. He challenged his son Evan to pursue his Ph.D. while he was still a junior in high school. But Ken also knew when it was time to stop studying and time to start tinkering in the lab. For some of his more academically-minded students he had to prod them out of the library and into the lab. This balance of thorough study and creative engineer made him an extremely effective researcher.

- Every visitor to Ken's office noticed an open pocketknife resting conveniently on his desk. As he sat talking, he often picked up the knife, playing with it in his hands. On an initial visit, the knife was somewhat threatening. Was this an old habit left over from his rural boyhood?

Ken died of a heart attack 14 November 1983 at the University of Minnesota Hospital. He was just 58 years old. He was professionally active until the end.

WHAT MAKES AN ENGINEER: Development of Ken's Personal and Professional Traits

In addition to his professional accomplishments, Ken is remembered for his warm personality and concern for others. He was generous with his time, professionally mentored many students, and he often invited his students who had no local family to celebrate holidays with his family. This concern for nurturing young students is reflected in the AAAR award given in his name, which is given to a young researcher.

One of many gatherings in Ken's home with his students, primarily those with no local families.

Ken describes in his own words the development of many of his character traits that later would be recognized by his peers. In addition to the class essay he wrote at age 15 titled "In My Eyes", which represents a snapshot of who he was at age 15, another essay written during his freshman year at college titled "What Makes an Engineer" provides additional insight into the origins and development of many of his professional traits. "What Makes An Engineer" also gives a glimpse, in Ken's own words, of the socially withdrawn person he had become.

"What Makes an Engineer"

"From the time that I was born, fate seems to have wanted to make an engineer of me. My earliest recollections are of mechanical toys or of painful encounters with machinery. Even though I did plenty of damage in my first years, I soon began to build in the haphazard way of childhood. … my first serious attempt at construction was a boat. … The results of my efforts I called a boat only because I was prejudiced. This combination submarine and swimming pool soon became the flagship of a numerically large navy. …

This carefree happy life was soon to be ended; for my family, like many others, was hit by the depression. We moved to a poorer home and suffered a general reduction in our living standards. The neighborhood into which we moved, however, was one of independent and fairly well to do farmers. To them the fact that we were on relief or were receiving any kind of assistance was an unpardonable sin. When I started school I was met by a bewildering array of cold stares. If I tried to get into the baseball games or the pointless conversations that boys love so well, I was made to feel like an unwelcome intruder. At first I tried to fight back, but finding that ten to one odds were too painful, I gradually took to avoiding and ignoring my tormentors. If I had had something that boys admire, perhaps I might have won their respect, but what I had was both meager and shabby. Again I used my constructive ability to duplicate the things that I couldn't buy. On several occasions I used my mechanical aptitude to confound my proud rivals. Once I bought, for a quarter, a sled that had been wrecked by an automobile. I imagine that the former owner had some unpleasant thoughts after I repaired the sled and beat him in hill races. In a somewhat similar manner, I built a bicycle out of parts that I collected from every source, by every means. Outside of the fact that the tires had to be pumped up every half hour, it worked fairly well.

I was gradually depending more on my own resources and less on social relations for amusement. I soon developed a taste for books, especially science and travel. My fondness for travel literature was due not only to my natural curiosity, but to the fact that a slim purse kept me close to home. For me reading can and has taken the place of experience. Unlike most people I always possessed the urge to try out everything that I read or saw. Therefore, every new book on boats, airplanes or electricity was followed by a batch of successful or unsuccessful gadgets, depending on your point of view. The material for these experiments was acquired from many sources. When a radio burnt out a tube or a friend decided to junk a radio, an electric motor, or any other thing that I could carry, I immediately put in my bid. If I got a hold of any money I bought screws, glue, and wood instead of candy, and technical books instead of comics. Typical of the devices that I built was a homemade telegraph set connecting the kitchen with my basement workshop. My mother was supposed to use this unreliable outfit, whenever she wanted me to run some errand. After a few obliging trials, however, she resorted to the tried and true method of yelling down the hot air radiator.

Sometime between the time we moved to this neighborhood and the time I was in the sixth grade, my interest in aviation became dominant. Probably the reason for the triumph of model building over my other hobbies was that it satisfied my creative and competitive urge, to the greatest degree. I derive a distinct pleasure in creating a new design and then watching it streak skyward as delicately balanced as a swallow. Later, when I began to enter my planes in competition, I also obtained the rich thrill of victory. By victory I mean not only the victory at the flying field but also the victory I had won in the workshop at the drawing board. I think that this internal pride in solving tough problems is what keeps most of the unknown aeronautical engineers at their jobs. Most people can't understand the important part that the model airplane hobby has played in my life. In fact, several years ago, as a result of successes in model designing, I won a civil service job in an aeronautical laboratory. Since I was only sixteen, homesickness and a desire to finish high school brought me home.

During the five years that I had lived in this neighborhood I had built a narrow and idealistic viewpoint from reading and meditation. Therefore, when I began high school, I was brought to earth with a sudden and distasteful jolt. Being accepted as an equal was new, and to be frank, a little confusing. I found myself avoiding people simply because I couldn't talk to them on common ground. I knew to [too] much about science, books, and models and not enough about the things that make up life of the ordinary boy. To be sure my better than average knowledge of science made my mathematics and science courses almost too easy for me. I'm afraid that some teachers gave me grades from pure amazement. As an example; I once got an A in physics by building and showing to my teacher a working electric motor one fourth of an inch square and a half inch long.

Even though I did gain pride in my mechanical achievements I wished with all my heart that I could be like the other fellows. Many times I have tried to get up enough courage to get to a dance or party only to find that the mental barrier created during previous years was to [too] strong. I hope that some day I may feel at home with my fellow humans."

Although Ken's childhood experiences formed his engineering mind and disciplines, it left him socially withdrawn. Soon after this essay was written and while serving in the Navy, Ken was involuntarily thrown together with a roommate, Dean Fredrikson, who would not only become a close, lifelong friend, but would inspire a dramatic change in his personality and deepest beliefs.

Ken attending Bible study aboard ship during Navy days.

Dean's consistent lifestyle and concern for others eventually led Ken to an independent study of the Bible. Dean relates that Ken was introverted and difficult to engage in conversation. But Dean also acknowledged that Ken had a dogged determination to know the truth about everything, whether or not the truth was pleasant (a trait we recognize in Ken's professional life). As a result of this determined mindset, Ken did his own independent Bible study, and after some time, one night in the solitude of his room, sitting at his desk, Ken concluded that what is presented in the Bible is correct. Ken then participated in Bible studies with Dean and others, and he became such a committed Christian that he applied to the Presbyterian Church in 1948 to become a full-time, missionary. Fortunately for the aerosol community, he was turned down because his wife Juanita had been previously divorced. None the less, Ken served throughout his life in lay ministry, first as a Boy Scout leader, then as Sunday school teacher and superintendent, and later as a faculty advisor to Inter-Varsity Christian Fellowship at the University of Minnesota. Ken and Juanita also generously supported missionaries throughout their lives.

Ken's Christian conversion deeply affected his thinking. He expressed many of his new believes and philosophy to his future wife in letters and valentines when they were dating. An excerpt from one such letter gives an example of the deep thinker he became. The closing paragraph from the following excerpt is printed on his gravestone.

Ken with his Boy Scouts.

"That is why we can only live when we can turn outward to the lasting sign of God's great creation. The majesty and patience of a rose tinted cloud at eventide puts the brakes on the relentless energy of our minds. We find peace and rest: and are refreshed. The other night as I rode home in the rain I was want to shrink from it as from a great danger. But the soft caress of the raindrop is one of friendship. Then it was I rejoiced and shook hands with the night and rejoiced that things were right. In my prayer tonight I shall ask God that He may turn our attention to these simple things that are the easy-chairs of the mind. That we may rest our heads on the pillow of the eternal God who has given us of the riches of creation.

Though the winds of time rustle the leaves of death we know that no one, but God, knows from where life came or whither it goest. It is, but the privilege of man to walk with it a little way and then to depart."

First date with Juanita

MARRIAGE, FAMILY LIFE, HOBBIES, EDUCATION

Ken's courtship of Juanita began in a rather unorthodox manner. On his first date with his future wife, Ken took Juanita flying in a single-engine airplane. Juanita was attracted to his serious attitude and wisdom. On the third date, she told Ken she had been married before. This nearly ended their relationship, but on July 31, 1948, they married.

Ken and Juanita had one daughter and three sons, all born in Minneapolis:

Children (tallest to shortest): Susan, Dean (named in honor of Dean Fredrikson), Dale, Evan.

In his 1940 autobiography, "In My Eyes", Ken said he had so many hobbies that he didn't know which to work on when he had spare time. His first hobby was designing, building, and flying model airplanes built from scratch of balsa wood, tissue, dope, glue, and wire. As he built and flew each airplane, he was always thinking about how to build a better one next time. Model airplane magazines taught him a lot about design. He taught his children to build airplanes from orange crate wood and card stock. Ken still loved this hobby in his later years.

Ken sketched and painted, always had a camera in hand and spent hours in his dark room. He made much of the everyday furniture in his home, and continued woodworking to the end. He was an adult leader for the Boy Scouts. He enjoyed camping trips, sometimes with scouts, with student members of Christian groups he advised, or with his family. He enjoyed concerts and visiting art museums. He often played classical records on the family phonograph during evening meals. Every Saturday morning he put on his apron and made waffles from his own recipe that won him a 4-H ribbon when he was young. This weekly waffle meal is remembered

warmly by all his children, and making waffles is the social meal of choice in his extended family. He learned to use computers in his professional life earlier than most people of his generation, and was an early-adopter, always using the latest computer equipment. He would have been in seventh heaven with all of the advanced PCs available today!

Ken learned the value of advanced education from his father, and he passed it on to his students and his children. In his autobiography “In My Eyes” he notes:

“One of my most persistent ambitions is to go to college. … My father went to college and has always been respected for it.”

Ken continued this emphasis on education, foregoing luxuries to ensure his children received good educations, both during K-12 and also supporting his children financially through their first 4 years of college. His son Evan notes that even when still in 11th grade in high school, Ken was already challenging him to pursue a Ph. D.

KEN WHITBY WILL BE REMEMBERED FOR …

Ken Whitby will be remembered professionally for the following accomplishments:

- For developing the multimodal model for atmospheric and many other aerosols.
- For developing and improving electrical aerosol size measuring instrumentation for submicrometer particles.
- For developing and training a core group of aerosol scientists and engineers.
- For establishing the Particle Technology Laboratory, Mechanical Engineering Department, University of Minnesota.
- For influencing TSI to enter the commercial aerosol instrument business.
- For promoting the powerful iterative aerosol science process of instrument development, laboratory experiments, field measurements, and model development.
- For his pragmatic engineering approach to aerosol science and technology.

Ken Whitby will be remembered personally for his selfless interest in helping his students and colleagues.

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Whitby K.T., B.Y.H. Liu, R.B. Husar, and N.J. Barsic (1972b) The Minnesota Aerosol-Analyzing System Used in the Los Angeles Smog Project. *J. of Colloid and Interface Sci.* 39:136-164.

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Appendix A: First and Final Resumes

UNIVERSITY OF MINNESOTA
INSTITUTE OF TECHNOLOGY
MINNEAPOLIS

PLACEMENT SERVICE

KENNETH THOMAS WHITBY

Degrees: Bachelor of Science in Naval Technology, 1946.
Bachelor of Mechanical Engineering, 1948.

Preferred Fields: Teaching. Sales.

Personal and Family Data: Born February 6, 1925, Fond du Lac, Wisconsin. Height, 5 ft. 8½ in. Weight, 160. Single. Health, Excellent. Protestant.
Interests or Hobbies: Photography, Model Aircraft, Swimming, Handicraft.
Special Talent or Accomplishment: Private Pilot, Typist, Rifle and Pistol Marksman.
Ancestry: Mother and Father, German.
Father's Occupation: Rural Mail Carrier.

Experience:
Industrial: U. S. Government, Langley Field, Virginia: 1 month, 1941: Underaircraft modelmaker, Civil Service.
University of Minnesota: September, 1946, to present; Instructor in Heat Power Laboratory.
Military: U. S. Navy: 1943-1946: V-12 College Training Program for 28 months at University of Minnesota: Engineering Officer for 7 months aboard Navy landing craft.

High School Information: Fond du Lac Senior High School, Fond du Lac, Wisconsin.
Activities: Model Club, Rifle Club.
Honors: Honor Roll for 4 years.

College Information:
Other Colleges Attended: University of Wisconsin, Madison, Wisconsin, 1943-44.
Activities: Rifle Club (1, 2), NROTC (1, 2, 3), Phi Eta Sigma (1), University Flying Club (2, 3), B.S. in N.T. with High Distinction, Boy Scout Master (3, 4), Sunday School Teacher (4).
Engineering and Scientific Societies: Institute of Aeronautical Sciences, American Society of Mechanical Engineers, Student Member.
Portion of College Expense Earned: 75 per cent.

References:
Prof. F. B. Rowley, Head of Mechanical Engineering Department, University of Minnesota.
Prof. A. O. Lee, Mechanical Engineering Department, University of Minnesota.
Mr. Lawrence A. Solberg, Mechanical Engineering Department, University of Minnesota.
Mr. Herbert E. Kann, 1546 E. Minnehaha Parkway, Minneapolis, Minnesota.

Employment Information:
College Address: 3644 17th Avenue South, Minneapolis, Minnesota.
Home Address: 110 East Cotton Street, Fond du Lac, Wisconsin.
Available for Employment: June, 1948.

Scholastic information will be furnished upon request.

Feb. 25, 1983

BIOGRAPHICAL SKETCH

Kenneth T. Whitby, Professor of Mechanical Engineering and
Director of the Environmental Division
Mechanical Engineering Department
University of Minnesota
111 Church St. S.E.
Minneapolis, MN 55455
Telephone: (612) 373 3049

Personal Information

Born February 15, 1925 Fond du Lac, Wisconsin, USA.
Married to Juanita Bergstresser Whitby, Four children.
Home address: 2943 Quail Ave. North, Minneapolis, MN 55422
Telephone: (612) 588 1813

Education

Bachelor of Science Naval Technology, Univ. of Minnesota	February, 1946
Bachelor of Mechanical Engineering	June, 1948
Ph. D. Mechanical Engineering Major - Mechanical Engineering Minor - Bio-chemistry	August, 1954

Employment

Instructor, University of Minnesota	1946-1952
Research Associate, University of Minnesota	1954-1958
Assistant Professor, University of Minnesota	1958-1962
Director, Particle Technology Laboratory	1959-1972
Associate Professor, University of Minnesota	1962-1966
Professor, University of Minnesota	1966-
Director, Environmental Division, Mechanical Engineering	1971-

Teaching Experience

Mechanical Engineering Department, University of Minnesota

Laboratory courses, Flour Milling, Thermodynamics, Combustion, Fluid Mechanics, Particle Technology, Aerosol Physics, Sprays and Atomization, Air Pollution, Industrial Ventilation and Contamination

Control, Air Pollution Measurement, Environmental Engineering for Engineers and SLA. Have developed nine new course. Also have taught special particle technology courses in industry and in several foreign countries including Germany, Sweden, Chile and Finland.

Contributions to the University

Establishment of the Particle Technology Laboratory in 1952. This laboratory has since become internationally known for its work in particle technology and air pollution. It has trained the largest number of people in the particle technology field in the USA during the last several decades.

Service on numerous environmentally-related committees both within and without IT.

Development of nine new courses in the Particle Technology and Environmental areas during the past 20 years.

Major Consulting Work

Pillsbury Mills	1951-1954
General Mills	1953-1955
Mine Safety Appliances Co.	1955-1956
Minneapolis-Honeywell	1957-1963
AEC Division of Biology and Medicine	1958-1967
3M Company	1963-1972
USPHS Air Pollution Grants Advisory Committee	1966-1969
Oak Ridge National Laboratory	1966-1970
Member ad hoc panel of National Research Council on Emissions from Stationary Sources	1970-1971
Member ad hoc panel of National Research Council on Airborne Particulates	1972-1978
Member of Chemistry and Physics Advisory Comm. EPA	1972-1976
Member USA-USSR Working group no. 1 on Air Pollution	1974-1976

Major Research Interests

Particle Technology and Aerosol Physics. This includes particle size analysis, processing of particles, studies of electric charge on powder and aerosol particles, atomization, particle drying, aerosol generation, automatic instruments for aerosol size distribution measurement, electrical phenomena associated with aerosols, gas cleaning, atmospheric aerosols, photochemical aerosols, air purification, and aerosol modeling.

Patents

MSA-Whitby Centrifuge Sedimentation Analyzer

Trajectory Type Air Classifier
Sonic Jet Ion Generator
Electrostatic Sampler
Aerosol Mass Meter
Precision Aerosol Divider
Electrical Aerosol Size Distribution Analyzer
Other Industrial Patents

Memberships

Member ASME, APCA, ASHARE, GAeF, Sigma Xi, New York Academy of Science, National Academy of Engineering, Listed in Who's Who in America

Fellowships and Honors

Quaker Oats Fellowship	1952-1954
USPHS Special Fellowship	1967-1968
Teaching Fellowship Chalmers University, Sweden	1980
Lecture Fellowship Government of Chile	1981
Lectureship Finnish Academy of Sciences	1982
Election to National Academy of Engineering	1978

Publications

Numerous papers and reports in leading journals in the field of particle technology and air pollution. (See separate list of publications)

Appendix B: Ph.D. graduates for which Kenneth T. Whitby was primary advisor, all majoring in mechanical engineering, University of Minnesota

1.	1963	LaVerne W. Rees	A Study of a Mixture of Small Unipolar Ions and Homogeneous Aerosols in a Flow System
2.	1967	Henry Hao-Sheng Yu	Stratified Flow in Horizontal Ducts
3.	1967	Andrew R. McFarland	Comminution of Particulates by the Mechanism of Impaction
4.	1971	Rudolf B. Husar	Coagulation of Knudsen Aerosols
5.	1971	Ruben A. Garcia	Diffusion Losses in Long Vertical Channels
6.	1971	Earl O. Knutson	The Distribution of Electric Charge Among the Particles of an Artificially Charged Aerosol
7.	1972	William E. Clark	Measurements of Aerosol Produced by the Photochemical Oxidation of SO_2 in Air
8.	1974	Henry A. Hanson	The Deliquescent Properties of Aerosols
9.	1975	Arshanapalli K. Rao	Experimental Study of Inertial Impactors
10.	1977	George M. Sverdrup	Parametric Measurement of Submicron Atmospheric Aerosol Size Distributions
11.	1977	Nicholas J. Barsic	Size Distributions and Concentration of Fine Particles Produced by Propane-Air Combustion in a Controlled Humidity Environment
12.	1982	Rajagopal Vijayakumar	Ultrafine Aerosol Generation Using a Premixed Flat Flame
13.	1983	Oluwale A. Adumade	Mobilities of Aggregates of Particles

Appendix C: Master's graduates for which Kenneth T. Whitby was primary advisor, all majoring in mechanical engineering, University of Minnesota

1.	????	Jason Carl Annis	Uncertain, may have gotten MS from KTW
2.	1960	Andrew R. McFarland	Plan B – No thesis
3.	1962	Dale Lundgren	The Effect of Particle Electrostatic Charge on Filtration Efficiency
4.	1966	Richard A. Vomela	The Charging and Mobility of Chain Aggregate Smoke Particles
5.	1966	William E. Clark	The Concentration and Size Distribution of Atmospheric Aerosols
6.	1967	Gilmore J. Sem	Plan B – No thesis
7.	1970	Rolf D. Anderson	Plan B – No thesis
8.	1970	Atluri S. Prasad	Plan B – No thesis
9.	1971	Ramesh K. Gupta	Plan B – No thesis
10.	1971	Arshanapalli K. Rao	Unknown
11.	1971	Ramakrishna R. Pulimamidi	Unknown
12.	1971	James R. Pasch	Unknown
13.	1973	George M. Sverdrup	Plan B – No thesis
14.	1977	Rajagopal Vijayakumar	Plan B – No thesis
15.	1978	Joseph L. Wolf	The Design of a Mobile Air Pollution Research Laboratory
16.	1978	Jon P. Sandstedt	Unknown
17.	1979	James E. McCormack	Plan B – No thesis
18.	1982	Rashid Hameed	A Rotating Coarse Particle Sampling Probe

Biography prepared by Evan R. Whitby
based largely on G.J. Sem and E.R. Whitby (2000)
Kenneth Thomas Whitby, a pioneer of aerosol characterization,
in History of Aerosol Science, *edited by O. Preining and E.J. Davis,*
Austrian Academy of Sciences, Vienna, 438pp