A REMISS OF NORBERT WIENER

by Martin Schetzen

Norbert Wiener was my teacher, mentor, and friend. When I learned of the conference on Norbert Wiener, I thought it appropriate to submit my remiss of him and to give my short overall personal view of his life as well as his academic life. He was one of the great intellectuals of our time who wrote original works which opened new fields of thought on subjects such as functions of a real variable, epistemology, mathematical logic, relativity, quantum theory, and the Fourier integral and its applications. He was a child prodigy who received a Ph.D. from Harvard University at the age of nineteen and joined the MIT faculty, He stayed until his death in 1964.

What does one say of a scholar and friend.. Wiener's original interest was biology; but his poor eyesight precluded that since it was mainly a bench science in those days. He thus studied mathematics and specialized in Fourier Transform theory. His studies led to his contributing many new results which he included in a monograph he wrote, *The Fourier Integral and certain of its applications*. In it, he showed deep understanding and insight including his Tauberian theorems in which he even showed application to prime-number theory. He also included his original development of Generalized Harmonic Analysis. When this monograph was published in 1933, it created a minor revolution in mathematical circles because it demonstrated convincingly that the Fourier Integral could be applied to both statistics and analysis which swept away the dividing line between these two fields. This led to his being asked by the NDRC (National Defense Research Committee) to address problems they had during WW II concerning smoothing and prediction in fire control. His report was later declassified and published as the text *Extrapolation, Interpolation and Smoothing of Stationary Time Series* which also contained a heuristic exposition of Wiener's theories. This text too stimulated in a revolution in the development of 'optimum systems' which led to the modern field of Communication Theory.

He was admired by the students but they had difficulties following parts of his lectures. Before he was honored by MIT by being appointed as Institute Professor for his many original contributions, he was required, as all mathematics professors to rotate in teaching each undergraduate mathematics course. His creative mind was always several steps ahead of his students. Thus, once after one of his classes, some students approached him to explain one of his class mathematical derivations. He thought for a second and then wrote the result on the board for them. "But" they explained, "we still don't see the derivation". "Oh", said Wiener, and thought for a moment and then wrote the same result on the board. "We still don't see the derivation" protested the students. This time Wiener thought for a few minutes longer and then wrote the same result on the board. "There", he said, "I've now derived it in three different ways". The students left puzzled. They eventually resolved this problem during study sessions after the class.

Some years before the war, he had joined with a group from the Harvard Medical School where a monthly series of lively and unrestrained discussions on scientific method were held. It was felt essential to have someone such as Wiener who could examine mathematical questions critically. These meetings were similar in their intellectual intensity and rigor to those of the “Vienna Circle” as described by Philipp Frank in his book *Modern Science and its Philosophy*. Over the years, these meetings were followed by ones with other groups. Finally, in 1947, as ideas jelled, Wiener was asked to write a summary description of the ideas discussed concerning human control functions and mechanico-electrical systems designed to replace them. The book he wrote comprises the first clear statement in a lay person's terms of a new science of feedback mechanisms in biologic systems with its many ramifications and implications for science and human existence in general. Wiener chose the word “cybernetics” to described this new science since it derives from the Greek root meaning “steersman” from which also derives the Latin word for “governor”. The full title of the book was *Cybernetics or Control and Communication in the Animal and the Machine.* The book was soon acclaimed as a ‘must’ book for every branch of science. At first some tried to capitalize on the name and wrote papers with titles which included terms such as cyberpsychology in an attempt to attract attention. Wiener, who was a serious scientist, was troubled “Charlatans!” he used to say to me since the articles did not contribute to the theory or applications of Cybernetics. One of the new research areas that did develop however, was in prostheses from which many new electromechanical prosthetic devices have been developed. This opened extended research into robotics. It also stimulated his Ph.D. student, Claude Shannon, who was then working for Bell Telephone Labs, to develop a new theory which he called Information Theory, which became the basis of a new and important field in communications.

One of Wiener’s deep concerns were about moral and ethical issues. Wiener immediately recognized possible moral and ethical consequences such as those described in the Czech play *R.U.R.* by Karel Cacek in 1923. He discusses them in his book *God and Golem, Inc*., MIT, 1964. He also wrote a book, *The Tempter*, in 1959 expressing his ethical concerns that exist between the ideal of science and the competitive forces of industry.

Another outgrowth of Wiener’s ideas is presented in his text *Extrapolation, Interpolation and Smoothing of Stationary Time Series* from which a whole new approach to the design of optimum systems arose. Originally, only linear systems were considered in the development of ‘optimum systems’ since linear system theory was developed. However, it was soon recognized that significant improvements could often be made with nonlinear systems. The specific property of a linear system that enables basic mathematical analysis to be employed is that it can be characterized by a unique function referred to as its impulse response. This is not true for nonlinear systems. In fact, to completely characterize a nonlinear system requires its response to every possible input function. Wiener solved this problem by his developments in random theory by

optimally characterizing a nonlinear system (in the mean-square sense) with a Gaussian input.

He used his developments in this field to the study of the role of nonlinear processes in physics such as gas and plasma theory in statistical mechanisms. Wiener presented this work in the form of lectures at M.I.T. to a group of Prof. Y.W. Lee's students, of which I was part, who published them as the text *Nonlinear Problems in Random Theory*. Since Wiener's eyesight was so poor, it was decided to photograph and tape each lecture after which a few students would work together at reconstructing his lectures and correcting any blackboard errors. This became somewhat of a problem since Wiener often would make an error in writing an equation rapidly on the board. Instead of going back to correct the error as others would do, he would continue to write the next equation in his mathematical development. However, in writing the new equation, he would mentally correct the error in the previous equation, but, in his haste he would make an error in the new equation. This would continue in equation after equation until the very last equation in his development. Before writing the last equation, he would stop and say "We must be very careful here ... very careful." He would then think for a few minutes and then exclaim "I have it!" and write the last equation with no errors. His mind worked so fast that he was reviewing the whole development to make certain all errors were corrected so that the final result was correct. The students learned a great deal in writing the text for publication. The Volterra functional theory was the basis of this work. Later, the Volterra theory was fully developed as a practical system theory on its own by me in my text, *The Volterra and Wiener Theories of Nonlinear Systems* in which I also extended Wiener's theory to the determination of the optimum nonlinear system for a given desired response to a given input for arbitrary error criteria.

Long before his death in Stockholm on March, 1964, it was decided, as a celebration on the occasion of his seventieth birthday, November 26, 1964, to publish a collection of his own work rather than a series of invited papers. The published volume *Selected Papers of Norbert Wiener* brings together his important mathematical and technical writings previously only available only in journal form. An authentic flavor of Wiener can be obtained from his autobiography *I am a Mathematician*, 1956, MIT.

His genius, scholarship, and friendship is sorely missed.

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Below is a bibliography for those interested in learning more of Wiener and his works.

BIBLIOGRAPHY

N. Wiener, *The Fourier Integral and some of it Applications,* Dover Publications Inc., New York.

N. Wiener, *Extrapolation, Interpolation, and Smoothing of Stationary Time Series with Engineering Applications*, The Technology Press of The Massachusetts Institute of Technology and John Wiley & Sons, Inc. New York, 3rd printing, January, 1957.

P. Frank, *Modern Science and its Philosophy*, Harvard University Press, Cambridge, 1950.

N. Wiener, *Cybernetics, or Control and Communication in Animal and the Machine*, The Technology Press of The Massachusetts Institute of Technology and John Wiley & Sons, Inc. New York, 1948.

N. Wiener, *Nonlinear Problems in Random Theory,* The Technology Press of The Massachusetts Institute of Technology and John Wiley & Sons, Inc. New York, 1958.

M. Schetzen, *The Volterra & Wiener Theories of Nonlinear Systems,* Reprint Edition with additional material, Krieger Publishing Co, 1989, Original Edition, John Wiley, 1980

N. Wiener, *The Tempter,* Random House, 1959.

N. Wiener, *God & Golem, Inc,* The MIT Press, 1964.

N. Wiener, *I am a Mathematician*, The MIT Press 1956