Biography of Norman F. Moody FRSC

Norman Moody, who died in Victoria on October 23rd at the age of 88, was an individual of many talents. His contributions to the University of Toronto were typical of the contributions he made throughout a unique and remarkable scientific career that extended over 45 years. At the University of Toronto was the founding Director of the Institute of Biomedical Electronics, subsequently the Institute of Biomaterials and Biomedical Engineering, and a Professor of Electrical Engineering. All of this was accomplished without any earned degree.

Norman was born at Herne Bay, England, on December 22nd, 1915, in the early stages of the First World War. Without the opportunity of a formal education at a higher level due the economic depression of the early 1930's but with keen interests in radio design, he began his career in the radio repair section of a big London store. In the years before the Second World War, Baird had demonstrated the practical feasibility of Television, and the pentode tube and the superheterodyne receiver had become a reality. In about 1935, Norman joined Halcyon Radio working initially on radio receiver design as a junior engineer and rising to the position of senior TV designer. This was followed by a one-year spell as a design engineer in TV research with Burndept Radio. Television design in those early days was something of an art that demanded special practical skills, an inventive mind and an aptitude for circuit design. Some of his early work related to the design of a projection TV scheme, but the real bread and butter was in the design and sale of commercial TV sets. A good system in those days sold for about 44 guineas, the equivalent of $200 US in the late 1930's. It was during his time with Halcyon Radio that he

met Joan who he subsequently married. At the time of his death they had been married for 64 years.

It was the foresight of the Tizard Committee, of which Professor P.M.S. Blackett was a member, that resulted in the establishment of a secret research station to be devoted to the development of Radar and IFF (Identification Friend or Foe) systems. This embryonic research establishment, first established at Orfordness, was moved to Bawdsey Manor on the coast of Suffolk in May 1936 and was initially called the Bawdsey Research Station. Its location was subsequently changed three times: first, in September 1939, one day before war was declared, to Dundee in Scotland as AMRE (Air Ministry Research Establishment) Dundee; next in May 1940 to Worth Matravers, a couple of miles west of the town of Swanage in Dorset, on the south coast of England and finally in May 1942, to Great Malvern in Worcestershire where it was known as the Telecommunications Research Establishment (TRE).

Norman's talents and expertise as a circuit designer were recognized at an early stage of his career. Around 1939/40, he was one of a very select group scientists and engineers that were asked to join one of the research groups engaged in the development of various types of radar. Amongst this group were two other future Canadians, W.B. Lewis from the Cavendish Laboratories at Cambridge and J. Rennie Whitehead, who had just graduated in Physics from Manchester, where Blackett was Professor of Physics. Norman joined the group centered at the RAF station of St Athen in South Wales where the primary focus was the development of airborne radar. Shortly after joining, around May 1940, he was posted to Worth Matravers to where the main group had been transferred. The circuit design group was primarily headed by Freddie C. Williams from the University of Manchester where he had worked on the development of an automatic curve follower for the Hartree Differential Analyser, a famous mechanical calculator constructed there by Arthur Porter in the early thirties. The development of radar, IFF and other navigational systems were a key factor in determining the outcome of the war in the air. It was with this remarkable research and development group that Norman worked for some six years. Under considerable wartime pressure, Freddie Williams' circuit group solved many problems and contributed many new ideas and these had a major impact on a whole range of projects being developed at TRE. Norman's contributions were a vital part of this work.

It was only after the war that much of the TRE work was declassified. A paper co-authored with Freddie Williams and published in the Journal of IEE in 1946 was a classic, and was partially responsible for Norman being awarded the Kelvin Premium Award in 1948 by the IEE. The paper described details of the Phantastron and Sanatron circuits for achieving high linearity timebases for accurate range-gating. The importance of his work was also indicated by the fact that his monograph on the design of low-power pulse transformers, originally published in 1946 by TRE, was republished some ten years later due to high demand.

Following the war, after spending one year with Standard Telecomm Laboratories in the U.K., Norman, Joan and their young son, who was born in 1941, emigrated to Canada. In 1947 he joined the National Research Council's Chalk River Laboratories, later to become Atomic Energy of Canada, Ltd,. There he established what was to become an outstanding group in nuclear electronics instrumentation. A whole range of measurement instruments were developed which were considerably in advance of those available elsewhere. He also developed methods for generating extremely short pulses and techniques for measuring them.

In 1951 he was asked to return to the UK to work on a secret assignment. When he arrived there he was told, much to his dismay, that he would be working at Fort Halstead in Kent for the Ministry of Supply on the development of systems for atomic weapon measurements. His work there was primarily devoted to developing methods for measuring the rate at which the gamma ray flux increased with time following ignition of an atomic bomb. It involved developing very high-speed electronic circuits that would produce the result before they were

destroyed by the neutron flux. He, along with teams from Canada, the U.K. and Australia were present at the first test at the Monte Bello Islands off the N.W. coast of Australia in 1952. The Canadian team included Dr O.M. Solandt, who later became the first chairman of the Defence Research Board (established in 1947) and which was to play an significant role in Norman's future career. Norman and his family returned to Canada in late 1952.

At the invitation of Dr Solandt, Norman established a basic circuits research section at the Defence Research Board's research facilities, Defence Research Telecommunication Establishment, (DRTE) in Ottawa. The section was primarily devoted to understanding and exploiting the use of transistors, which had been invented just a few years before. The development of Doppler radar, computers, and ionospheric sounding satellites, topside sounders, were important parts of the applications. The section and its successors developed a whole series of satellites whose lifespan greatly exceeded all expectations. Moreover, under David Florida it developed a unique floating-point-based computer transistorized computer system for analyzing the data from the satellites.

In 1958 Arthur Porter was appointed Dean of Engineering at the University of Saskatchewan. One of his early challenges was to improve research image of the Electrical Engineering department. Fortunately, the position of Head of the Electrical Engineering Department had become vacant. Arthur was familiar with Norman's reputation, having known him since 1943 during Norman's work at TRE in Great Malvern. He persuaded Norman to apply for the position. Subsequently, he approached President John Spinks and recommended that Norman should be offered the position. Of course a major difficulty was the fact that Norman had no academic degree or academic experience and Dr Spinks was somewhat aghast at the idea of having a senior faculty member listed in the University Calendar without degree. A way around the impasse was found by awarding Norman an honorary Bachelor of Engineering degree. Thus, in 1959, the academic phase of Norman's career began.

It was around that time that his interest in the application of electrical engineering to medicine began and developed. Arthur Porter was instrumental in introducing him to William Feindel a neurosurgeon who had studied under Wilder Penfield in Montreal. He had been appointed to the new University Hospital in Saskatoon to establish a neurosurgery department and was interested in developing means for measuring cerebral blood flow and performing brain scanning using isotopes. However, he lacked the means of designing and building suitable instrumentation and that is where Norman came to his rescue. Norman's interest in the application of engineering to medicine rapidly expanded and he supervised a number of students working in this new interface area. Amongst these was Doug Barber, later to become one of the founders of Linear Technology (subsequently Gennum Corp.), in Ontario. His master's thesis was devoted to problems associated with blood flow measurement using the dye dilution technique. At the University of Saskatchewan Norman developed a graduate degree program in biomedical engineering: - probably the first in Canada, and supervised several graduate students in this new area.

Meanwhile, in 1961 Arthur Porter had been offered a position at University of Toronto to establish a new department of Industrial Engineering. He realized that there was interest in the collaboration between engineering and medicine, particularly through the department of Electrical Engineering. Arthur persuaded the then Dean of Engineering, Dean McLaughlin and Dean of Medicine, Dean Hamilton, that the establishment of a new Institute would foster this relationship. Their acceptance of this notion resulted in the suggestion that Norman be appointed as Professor of Electrical Engineering with the objective of establishing an Institute of Biomedical Electronics.

As a result Norman and his family moved to Toronto in 1962 and the Institute of Biomedical Electronics was established. It was the first such institute in Canada. Attending the

first meeting of the Council of the Institute were Council members Charles Best, Jim Ham, Gordon Slemon, Harold Johns and the Deans of Engineering and Medicine. Most of the initial faculty appointments were through the Department of Electrical Engineering, but some were through other departments such as Pharmacology. One of these was E. Llewellyn Thomas (Tommy), who became the first Associate Director of the Institute.

Norman's interests were far ranging and, along with an extensive program in medical electronics and an initial foray into ultrasound tomography, he continued some work on semiconductor devices and their circuits. This included the writing of a book, *Semiconductors and Their Circuits*, published by English Universities Press in 1966. He supervised many graduate students at the masters and Ph.D. levels and they learnt much from the meticulous care with which he conducted research, his insistence on scientific integrity and his attention to detail.

It was in 1975 that he decided to step down as Director of the institute that he had founded. However, he continued to contribute to the University by founding and directing a biomedical instrumentation development unit (BIDU) within the Institute. In 1977 he took early retirement, sold his log cabin in Picton, Ontario to two faculty members in the Institute, and headed west to Victoria. There, he continued academic work at the University of Victoria through an appointment as an Adjunct Professor of Physics. But now he was free to pursue a hobby that had been in the process of development since his Toronto years. Using a workshop that included a lathe with special gear cutting attachments, Norman taught himself to become a horologist, specializing in antique clocks. It is said that one of the first things he did in this regard when he arrived in Victoria was to purchase 50 lbs of brass. He undertook the construction of three clocks. One of these was a grandfather clock circa. 1750; another was a William Congreve clock, patented by Sir William Congreve in 1808. For the Congreve clock, which was known to be somewhat inaccurate, Norman provided an electronic nudge scheme to improve its time-keeping. All three clocks were designed to last many generations, were beautifully engineered and were fully documented. They reflected the care with which he performed scientific work throughout his career, as well as his insistence on excellence in design and building, together with good documentation.

Norman was made a Fellow of the IEE (London) in 1962, elected a Fellow of the Royal Society of Canada in 1972, made a Fellow of the Canadian Medical and Biological Engineering Society in 1978 and remained as a Professor Emeritus since his retirement from the University of Toronto in 1977. Along with his many scientific papers, he had several patents devoted to circuit design, some just subsequent to the war with Freddie Williams, and some as a result of his work at the Defence Research Board in Ottawa. In addition to the affection and joy of his ever expanding family, music was one of Norman's great enjoyments in life, and this was enhanced by his ability to design and build a high-fi system to interface with his cherished Quad electrostatic loud speakers.

Prepared by Richard S.C. Cobbold, FRSC, November 26, 2004