Sir Martin Wood OBE FRS DL
The Manor House, Little Wittenham, Abingdon, OXON, OX14 4RA
Email: martin.wood@oxinst.com
Tel: 01865 407 708

Professor Herbert C. Freyhardt
Steinbreite 5B
37085 Goettingen
Germany

8th March 2011

Dear Professor Freyhardt,

I am deeply honoured to be asked to contribute to the letters and papers you are circulating prior to the Centennial Meeting you will be holding in the Netherlands in September.

This short informal contribution describes how the idea of creating Oxford Instruments arose, a few comments about the growth over the years, and finally some comments about the pace of development in the field of superconductivity.

In 1955 I joined the cryo-magnetic group within the Clarendon Laboratory - which is a part of Oxford University. It was set up by Professor Simon, Professor Kurti and Professor Mendelssohn, who came together to Oxford from Germany in the 1930ies, to get away from the Nazi anti-Jewish activities. One objective of the group was to achieve the lowest possible temperature and to pursue various research projects on materials at these ultra-low temperatures which had never been reached before. This was the classic procedure in "curiosity oriented research", indeed I believe the work done in the Clarendon Laboratory at that time, gave rise to that name as a sector of research not initiated by any particular demands of industry or government policy.

We had a helium liquefier, designed and made in the laboratory workshops, which produced 2 litres/ hour, and a motor-generator set which could deliver up to 2 Megawatts of DC power continuously - 5,000A at 400V which could be delivered to any of the three magnet stations. This generator had been used to drive the trams in Manchester in the 1930ies and had not been used for some years since the trams had been replaced by diesel powered buses. It was presented to Professor Kurti by the Manchester Corporation.

One high point in the records of the laboratory was when Kurti's group achieved the world's record low temperature of 10^{-5} K via a new double adiabatic de-magnetizing technique. As time went on, the importance of high magnetic fields became recognised more widely and scientists in other laboratories in the UK began to ask me if I could help over the design and procurement of the specialised magnet coils they wanted. All the skills and equipment needed for the design and manufacture of the specialized coils existed in the Clarendon laboratory. With the permission of Professor Simon, then head of the Department, I undertook to design and oversee the production of the magnets for outside users who supplied the laboratory with the funds for obtaining the materials and paying the costs of the laboratory technicians' overtime. One day a milling machine in the laboratory workshop had a complex part for one of these "outside" magnets blocking its use for some internal laboratory work. The researcher concerned got irate and wanted some work done on the machine in a hurry and a row broke out as to whether the laboratory should accept "external" work at all.

As the argument went on, an old idea resurfaced in my mind. When I was younger, I had worked in two different organisations where bad human relations and generally bad technical planning had destroyed the possibility of efficient production. This little problem in the laboratory stirred old ideas that I would like to start a new company and try to run it on new lines that were forming in my mind. I drew up my courage and broached the question to Professor Kurti – what would he think of my idea of starting a small company – outside the confines of the university - to design and manufacture magnets for these outside research laboratories. I shall never forget his immediate response. He grabbed the epaulet of my jacket, pulled me up close to him and said in his deep strong guttural Hungarian accent "Vot can I do to help you?" followed quickly by "but you must stay and help me here for the next 10 years too". On that deep level of sincere international and academic collaboration Oxford Instruments was born.

That was in 1959. My wife Audrey was an enthusiastic partner from the beginning. One brother-in-law, a solicitor, advised us on all the legal necessities. Another brother-in-law, an accountant, helped frame the necessary financial systems, and Audrey started to learn about book-keeping and administration. We borrowed £200 from my mother-in-law and started a bank account. We printed some letter-headed paper and we were ready to go. Looking back on this episode – some 50 years later – I feel this was quite an appropriate procedure for the first high tech spin out from the University!

I already knew many of the people in this specialised field of research, and three projects cropped up quite soon. One was at the UK Atomic Energy Research Laboratory at Harwell, which wanted a magnet for neutron spectroscopy in a space allocated in a beam line from a reactor. The second request came from an ex-Clarendon physicist at the Royal Radar Research Establishment at Malvern. He needed a magnet for secret naval research projects, and he had the lead/acid batteries from a decommissioned submarine installed and ready to supply the high current low voltage power suitable for efficient magnet coils. The third project emanated from the Nuclear Fusion Research Group of the Atomic Energy Authority which asked for 39 helically wound copper coils for modulating the magnetic field in the first "mirror machine" to be constructed there.

Work began in our upgraded garden shed, where a retired Clarendon Technician came when needed. He worked with a second-hand lathe and a special winding machine he had invented for making the copper pancake coils in the Clarendon. He was able to borrow this and we received a great deal more help and advice from there as well. Audrey became proficient at laying up fibreglass for magnet cases and spacers, and the projects proceeded slowly. We lived in a delightful part of Oxford where industrial activity would never be allowed. Fortunately we had a big garden and I planted trees around the workshop and our illegal activities were never discovered.

We delivered the first two magnets in the summer of 1961, and there was no hurry about the coils for the "mirror machine", so Audrey and I set off to attend the first International Conference on High Magnetic Fields at MIT. A number of physicists and engineers were working on special magnets for their research and gave papers, and held discussions on their designs and their achievements and problems. I talked about my new concentric helix copper solenoid in the Clarendon – an advance from the "Bitter" magnets at MIT. Beside this, there had been a lot of work on new superconducting materials - almost all in the USA, because liquid helium was much more available there. Small crystals of new materials and some small magnet coils had been fabricated and tested, and in the weeks leading up to the conference there were rumours of several important discoveries. As the days of the conference went on, extreme interest built up concerning what would be reported in an extra session which was hurriedly scheduled for the Friday afternoon – at a time when many participants would normally have left for home.

The session took place in the Kresge Auditorium. The atmosphere became tense with several research people from big laboratories trying to catch the eye of the chairman to have a few minutes to report fresh results of tests made during the last few days. Reports came from the Bell Telephone Laboratories at Murray Hill, The National Bureau of Standards at Boulder Colorado, the General Electric Research laboratory at Schenectady, the Oak Ridge National Laboratory, and the Institute of Applied Physics at Giessen in Germany. There was a lot of trial and error in the search for new superconducting materials – experiences and theories were in short supply. Bernd Matthias working in the Bell Telephone Laboratories, a great believer in intuition and experiment, concocted thousands of possible superconducting materials and was once referred to as the only living medieval alchemist. They all had results relating to newly discovered materials, tests on trial coils, and predictions of the coming importance of superconducting magnets. The hall was filled with excited expectation. The stairways were blocked with people sitting on them. People were phoning in from their labs around the country with their data taken only minutes before. The chairman said he felt like the referee in a football match. History was clearly being made.

Later that evening, in the New York subway, on our way to Brooklyn, Audrey and I came to the conclusion that superconducting magnets were going to be the future for high magnetic fields - and for our microscopic company. Our potential market for high magnetic fields had increased by perhaps three orders of magnitude. We decided then and there to try this brand new technology. On arriving home we ordered 1 pound weight of NbZr wire from the Wah Chang Corporation which had managed to draw this unusual alloy into 1mm diameter wire. Extrapolating from the design of our copper-wound magnets, I designed a coil to use almost all this wire, which arrived in England in March 1962. I wound the magnet overnight and prepared to test it. Professor Kurti provided the necessary equipment in the Clarendon – the glass cryostat, the liquid helium, a transfer tube, a voltmeter, an ammeter, a rheostat to control the current and a corner of a laboratory. I brought in the battery from my car and the test began. As the temperature dropped, the resistance of the magnet fell in the normal way, until at a magic moment the voltage needle suddenly dropped to zero while the ammeter remained steady, and I felt the same feeling of incredulity as Kamerlingh-Onnes must have experienced all those years ago.

The magnet produced a magnetic field of 4.1 Tesla in the 1.8cm bore of the magnet. We were in the superconducting magnet business! We reported this test in the New Scientist and soon received enquiries from physicists around the world, keen to work in high magnetic fields but without the major power installations the old copper magnet systems needed. Such was the humble beginning of the first serious high tech "spin out" from Oxford University.

Since then the growth of Oxford Instruments has been a series of triumphs and disasters – with the triumphs far outweighing the disasters. Most early disasters came from the variability of the early superconducting materials. No one knew about "flux jumps" or how to protect magnet coils from "quenches" and a series of other unknown hazards. Scientific research based on nuclear magnetic resonance spectroscopy - NMR - provided a major boost, with Oxford's Professor Rex Richards from the physical chemistry department being world famous in this field – and a strong supporter of Oxford Instruments.

In the late 1970s we made the first MRI magnets. MRI has been described as the greatest advance in medical diagnostics since Dr. Wilhelm Roentgen discovered X-Rays in 1895. The first few MRI magnets were again constructed of copper strip cooled by circulating water. But in 1980 we made the first superconducting whole body magnet and our market grew rapidly.

Initially when we were the only manufacturer in the world, all the major suppliers of X-Ray equipment came to us for their MRI magnets, but as the numbers went up, most of them slowly succeeded in making their own. We always worked particularly well with Siemens and we formed a licensing arrangement, which worked well for some time.

Eventually the volume of business continued to grow and we formed a 15 year joint venture with them. At the end of this time the need for new capital for semi-automatic production methods and other new manufacturing procedures, persuaded both parties that it would be sensible for Siemens to take over the whole MRI magnet business.

Although the company is best known for superconducting magnets and cryogenic equipment, it is the world's leading supplier of superconducting wire for commercial purposes and the ITER project. The company also has a leading position in dry cryogenics, which provides refrigeration down to the millikelvin range but avoids the need for liquid helium.

Closely involved with leading research scientists and keeping abreast of scientific literature, the staff of Oxford Instruments develops innovative equipment in other fields such as nano-fabrication and spectroscopic analysis using X-Ray fluorescence and optical emission spectroscopy.

Given the quite extraordinary property of loss-free conduction of electricity, it is surprising that superconductivity has not made a greater impact in a wider range of technologies and industries. The increasing range of new materials with unknown long term properties and the demand for reliability in new products are among the brakes on the development of new products. Nevertheless the increasing cost of energy serves as a strong incentive for the introduction of superconductivity in a range of developments. Dr Henry Kolm, one of the early pioneers in the field of superconductivity became a strong critic of the slow pace of development first in his paper "The Prolonged Adolescence of Superconductivity" in 1973, followed then by "The Interminable Adolescence of Superconductivity" in 1988. He compares the discovery of superconductivity with the invention of the wheel, and compares the lack of applications of one, with the total ubiquity of the other. He complains of the root problem of "intellectual immaturity, our incredible inability to adapt to fundamental change in less than a human generation". Higher temperature superconductors, improved refrigeration technology and a deeper appreciation of the value of energy may change our attitudes to superconductivity in the future.

Martin Wood

Bibliography:

1. Audrey Wood: "Magnetic Venture" – pub. Oxford University Press (2001). ISBN 978-0-19-924108-8
2. Henry H. Kolm: "The Prolonged Adolescence of Superconductivity". Reprinted from Technology Review Volume 75, Number 4, February 1973. Copyright 1973, Alumni Association Massachusetts Institute of Technology Cambridge, Massachusetts 02139.
3. Henry H. Kolm: "The Interminable Adolescence of Superconductivity". Journal of Superconductivity, Vol.1, Nº4, 1988.

ESNF comment: *We consider this letter to be a document of historical value. Therefore, we also provide access to the scan of the original.*