



CHURCHILL COLLEGE
CAMBRIDGE



Symposium in Memory of Professor Tony Kelly

Saturday 21 February 2015

Programme & Book of Abstracts



Professor Anthony Kelly, CBE, DL, FRS, FREng (1929—2014)

Professor Anthony Kelly was a founding Fellow of Churchill College and Director of Studies in Natural Sciences at the College until 1967. He subsequently worked for the government at the National Physical Laboratory and then at Imperial Chemical Industries before becoming Vice-Chancellor of Surrey University. Professor Kelly returned to Cambridge in 1994 and in his retirement he devoted his time to the College, taking on the role of Editor of the Churchill 'Review' for many years.

His book 'Strong Solids' (1965) was seminal in the field and as a result of it and his subsequent work and editing activity, he has been referred to as 'The Father of Composite Materials'. His group at Cambridge and later at the National Physical Laboratory established many of the principles of behaviour of fibre composites – particularly the toughness of those with carbon fibres, materials which now displace aluminium alloys as the preferred structural material for advanced aircraft.

This symposium celebrates Tony's life and work with a range of talks from former colleagues and students. Videos and other materials from the event will be available online shortly afterwards at: www.chu.cam.ac.uk/tony-kelly-symposium.

Programme

12.30	Hot buffet lunch, Dining Hall
13.30	Coffee, Wolfson Hall Foyer
13.45	Symposium, Part I
13.45	Professor Archie Howie Memories of Tony, Part I – 1950s Cambridge
14.00	Sir Graeme Davies Memories of Tony at 1960s Cambridge
14.20	Dr Rayner Mayer Personal reminiscences of Tony Kelly in Cambridge and NPL
14.40	Dr Neil McCartney Tony at the National Physical Laboratory
15.00	Professor Sergei Mileiko Tony and Composites today
15.20	Discussion
15.30	Coffee break

16.00	Symposium, Part II
16.00	Professor Jim Castle Memories of Tony at Surrey
16.20	Professor Mike Kelly Memories of Tony at Surrey and his return to Cambridge
16.40	Professor Sir Colin Humphreys Memories of Tony and his return to Cambridge
17.00	Dr Kevin Knowles Crystallography and Crystal Defects, 2nd Edition
17.20	Professor Archie Howie Memories of Tony, Part II — 'retirement' in Cambridge 1994 –2014
17.30	Reminiscences: personal recollections of Tony from the audience
18.00	End of the Symposium

Abstracts

Professor Archie Howie

Memories of Tony, Part I — 1950s Cambridge

Tony's (1950–53) Ph.D. research in W.L. Bragg's Cavendish famous crystallography group was to study the structure of deformed metals using a diffraction technique with a very finely focused X-ray beam. Bragg realised that such a beam would illuminate only a very small number of crystal grains so that instead of diffuse diffraction rings, spotty rings would be observed allowing the size, orientation and strain of the grains to be measured. Tony's main mentor here was Peter Hirsch who had already perfected the equipment and made the first observations with it but was by then mainly engaged on a different project. Tony made several key advances in the X-ray microdiffraction technique - moving from reflection diffraction on rolled samples then to transmission work at ten times faster exposure on thin samples deformed to a known tensile stress and finally switching to transmission electron diffraction. These paved some of the way towards the 1960 breakthrough of Hirsch and Whelan with transmission electron microscopy. As part of the (2012) Bragg centennial celebrations in Adelaide, Tony wrote up an interesting account of his years as a Ph.D. student.

The knowledge that Tony acquired of crystallography and crystal defects became mainstays of his career and later provided the title for a great book aiming to bridge the gulf he found between these two subjects. After shuttling between the UK and the USA and getting exposed to materials science at Northwestern, Tony returned to Cambridge in 1959 as a lecturer in metallurgy and in 1960 a founding Fellow of Churchill College.

Dr Rayner Mayer

Personal reminiscences of Tony Kelly in Cambridge and NPL

I arrived in Cambridge and became a research student of Tony Kelly whom I had never met or heard about, through the unlikely combination of two events separated in both space and time:

- the award of the Ebdon scholarship of the University of Cape Town where I had been a student
- the King Street bridge falling down in Melbourne, Australia in 1963.

It was an exciting and adventurous time because Alan Cottrell had broadened the work of the Department of Metallurgy through appointing bright young researchers such as Robin Nicholson and Tony Kelly. A wide range of topics were now being studied including the use of advanced microscopy, study of strong solids, the potential of fibre reinforcement and the advent of carbon fibres. This was aided and abetted by the proximity of the Cavendish laboratory and especially that of the Electron Microscopy group.

My own research stemmed from the Windscale disaster of 1957, when Alan Cottrell had been the Head of the Materials Division at Harwell. He was now a Board Member of the Atomic Energy Authority. As a result, Alan had involved Tony in a deeper understanding of radiation damage in graphite the moderator in all the UK's nuclear reactor.

Tony made things happen and this in turn involved things happening to Tony and I recall some personal reminiscences of our association. We shall all miss Tony and his manner of getting things done; there was never a dull moment in his presence.

Dr Neil McCartney

Tony at the National Physical Laboratory

The presentation will first attempt to cover the years 1967–1975 when Tony Kelly occupied very senior scientific administrative posts at the National Physical Laboratory (NPL), first as Superintendent of the Division of Inorganic and Metallic Structure, followed by a promotion in 1969 to Deputy Director (Materials). He became a member (1973) and then Chairman (1975–1980) of the Engineering Materials Requirements Board of the Department of Industry which, among other responsibilities, oversaw the funding of materials research at NPL.

After leaving NPL in 1975 Tony continued, over many years, to influence scientific developments in composites at NPL through personal contacts with NPL staff. As quoted (see footnote) in a tribute to celebrate his 80th birthday, he 'has a singular ability to simultaneously take under his wing and continuously challenge his younger colleagues, a combination that makes him an exceptional mentor'. As one of those, fortunate enough to have benefited from guidance and scientific interactions with Tony, I will briefly describe a few examples of his significant influence on my research activities.

Footnote: A full description of Tony's career, honours and awards can be found in the Introduction of the special issue of *Philosophical Magazine* to celebrate his 80th birthday (*Phil. Mag.* **90**, 31–32, 4078–4080 (2010)).

Professor Sergei Mileiko

Tony and Composites today

Two fundamental findings of Tony in the 1960s are as follows:

Fibrous composites are not only glass fibre-reinforced polymers (GFRPs) but they constitute a large family of strong materials that includes metal matrix composites (MMCs), ceramic matrix composites (CMCs) and a number of fibre-reinforced polymers (FRPs).

There are a number of toughening mechanisms in brittle-matrix/brittle-fibre composites, which are based on multiple breakages of the constituents of the composites.

Half a century has passed and now we see a triumph of some of these structural materials, carbon fibre-reinforced polymers (CFRPs) and silicon carbide fibre-reinforced silicon carbide matrices (SiC/SiC composites) being examples, as well as advances in the development of many others. What is the future of composites as a result of these developments? I will try to answer this.

Professor Mike Kelly

Memories of Tony at Surrey and his return to Cambridge

I want to describe my interactions with Tony Kelly in three distinct phases, namely before I went to the University of Surrey, while we were both at The University of Surrey, and on our subsequent return to Cambridge.

In addition to our common interest in materials science and engineering, and later on in climate change, my wife's parents were life-long friends of Tony and Christina, having been almost next-door neighbours in Rutherford Road in the 1960s: as a consequence we were taken into his close circle of friends and they both attended our wedding here in Cambridge. Tony gave me several pieces of avuncular/paternal advice that I continue to value highly. Indeed he was probably the last in a line of my distinguished teachers and mentors.

Professor Sir Colin Humphreys

Memories of Tony and his return to Cambridge

When Tony retired from being the Vice-Chancellor of Surrey University, I invited him to be a Distinguished Research Fellow in the Materials Science Department at Cambridge. This started another phase in Tony's life and I got to know him well. I will recount some adventures we had together, talk about his deep Christian faith and describe his views on global warming, which was his focus and passion in his later years.

Dr Kevin Knowles

Crystallography and Crystal Defects, 2nd Edition

In addition to the book 'Strong Solids', the first edition of which was published by Clarendon Press in 1966 during Tony's period of time at Cambridge as a University Lecturer in the Department of Metallurgy, he wrote another seminal book, 'Crystallography and Crystal Defects' with Geoff Groves. This was first published by Longmans in 1970. Geoff Groves was one of Tony's first Ph.D. students at Cambridge, submitting his thesis on 'Dislocations in magnesium oxide' in 1962. By 1970 Geoff was at the University of Oxford while Tony had migrated to the National Physical Laboratory to Teddington. The book was one of the first to contain a basic account together of crystallography and of structural imperfections in crystals. My own well-thumbed copy of this book bought when I was a postgraduate student is experimental evidence of its use as a book for both reference and for learning.

A revised edition of this book was published in 2000 with Patricia Kidd as a third author. This revised edition was completely retyped, with new sections on polymer systems, quasicrystals and epitaxial crystals, but was otherwise little changed from the original 1970 version, apart from the absence of plates.

The impetus for this second edition came from Tony who recognised that there was a market for an updated version of the book in the twenty first century. Knowing my interest in crystallography, Tony kindly asked me if I was interested in helping him produce this new version. Fortuitously, I had to hand material from lectures I had given on piezoelectricity to final year undergraduates to add to the chapter on tensors, and I had some computer programs and appendices to suggest for a new version to find favour with potential publishers. I also suggested that a set of detailed worked solutions to any problems in the second edition were produced for a web site accompanying the book.

The net result after all these and other changes is the book published by Wiley in February 2012.

In this presentation I will attempt to give an insight into the writing process for this second edition and the subsequent proof reading prior to printing, as well as other aspects, such as the choice of illustrations for the front and back cover.

Professor Archie Howie

Memories of Tony, Part II — 'retirement' in Cambridge 1994–2014

On his return to Cambridge, Tony was appointed to a Distinguished Research Fellowship in the Materials Science Department and re-joined Churchill College. In the intervening years my wife and I had enjoyed several joint holidays with Tony and Christina and a few details of these will be recalled. The loss of Christina in 1997 affected Tony profoundly and increased his involvement with the College. His influence was exercised formally through his very active membership of the Archives Committee and the Wine Committee but even more importantly through personal interaction at all levels.

We all had great respect for his sharp mind and tongue and a warmer admiration for his wit and energy. We also recall the magnificent hospitality at his house on Madingley Road and his remarkably imaginative generosity. He gave substantial financial support to many College activities — particularly to give widows (or widowers) of deceased Fellows the right to come and dine in College. Tony was rarely without some agenda that he wanted to drive forward — examples being his stance on climate change as well as his slightly mischievous campaign to persuade the College to admit undergraduates reading theology. More consistently he never relaxed his efforts to keep open the window that he had created between University research and the burgeoning field of composite engineering, production and use.

Finally, in Tony's memory, I offer a poem in the shape of one of the many bottles that he upended in his lifetime — invariably in good company.

Additional recollections

Emeritus Professor L Murray Gillin

Tony: a personal note to the Memorial Symposium

Arriving in Cambridge from Melbourne in March 1962, I was greeted by Professor Alan Cottrell with the news that he had no Ph.D. place in metal fracture for me. Shock horror! Directed to the top floor to meet a Dr Anthony Kelly, and with much uncertainty, I went into his office and met with a smiling, courteous and welcoming academic. In the continuing 50+ years Tony remained that amazing and welcoming friend – indeed he became a very close and personal mentor and confidant.

Tony offered me research on the strength and fracture of single crystal graphite - a material not then of interest to my parent laboratory, Aeronautical Research Laboratories in Melbourne. Building on the initial studies of Earl Freise, Tony and I showed the presence of simple symmetrical twin boundaries is responsible for the low fracture strength of these crystals. An electron beam furnace was constructed for use with a tensile testing machine, and, at temperatures above 2200 °C we demonstrated the fracture strength of single crystals increases with associated annihilation of twin boundaries. This deformation mechanism was demonstrated as applicable in pyrolytic graphite and later at ARL in carbon fibres.

In 1964 Tony introduced me to Dr William Watt of RAE Farnborough who had recently pyrolysed polyacrilonytile fibres to produce high strength, high modulus carbon fibres. Tony was so excited to bring some samples back for testing in our high temperature tensile facility.

Supervision with Tony was always problematic. If your appointment was signed 'Kelly', then the session was formal and direct, if signed 'AK' one could look forward to a mutually positive discussion, and if signed 'Tony' one had produced some valuable results. However, when seeking to understand unusual results, Tony would take his pen and say "well, now, let's go back to first principles". That was an amazing learning experience.

Let me briefly describe the amazing legacy of this work with Tony to the current Australian aircraft industry. On my return to ARL, in February 1965, I was given a free hand to continue research into deformation of carbon fibres. Over the next 7 years I led a multi-laboratory program to research: carbon fibre manufacture; strengthening

mechanisms; and carbon-fibre composites. In 1989 an Advanced Composites Cooperative Research Centre was established with industry partners, research institutes, university centres and Government to research, develop, design and manufacture high performance aircraft structures using Australian technology. On holiday, Tony visited CRC each year. Using the concept of 'Demonstrator' technology in the CRC, Hawker de Havilland (Aus) designed, built and quality assured the CFC moveable trailing edges of the world's most advanced new aircraft, the super-efficient Boeing 787 'Dreamliner'. Hawker de Havilland has contracts for 3.0% of 787 structure-value and contract participation in the program for the life of the 787 type, equivalent to \$4 billion over 30 years.

Australia now has a sustainable aircraft industry built progressively from the fundamental research on graphite crystals and composites pioneered in Tony's laboratory in Cambridge.

I sincerely and emotionally honour the memory of a great materials scientist, my personal friend and mentor.

— Emeritus Professor L Murray Gillin AM, Ph.D. (Cantab.), 13th February 2015.

Paul Kelly

Eulogy: Tony Kelly

Dad was born into a Catholic family of Irish descent, his mother a nurse who converted to Catholicism on marriage. Dad's father was a veteran of the First World War trenches and witnessed his own brother's death at the Somme. He was a mathematician who taught Navigators in the RAF during the inter war years and World War Two.

Dad's mother was strong and determined, whilst he always told us that he didn't really understand his father until he had seen the 1969 Richard Attenborough film 'Oh what a lovely war'. Dad grew up with these very different parents and his elder sister Helen. His academic promise was clear at 13 when he corrected a Physics teacher's workings on the board. Dad later admiringly commented on the gracious and perhaps sensible teacher's admission to the class that "yes, Kelly was right.."

Dad's academic achievement and independent thought continued throughout his life with the publication of his final paper for the Global Warming Policy Foundation being published last week. This paper entitled 'Climate Policy and the Poor' aims to show that the measures currently being taken to reduce emissions of CO₂ from fossil fuels are directly harming the poor, both in the developing and developed world.

The foundations for my father's academic development were laid when he entered Reading University at 17 gaining a First in Physics followed by a Ph.D. from Trinity College Cambridge.

In the 1950s Dad spent much time working in the USA at the Universities of Illinois and Northwestern, though returning briefly to marry our mother Christina Margaret Dunleavy in 1956. They enjoyed their new life in USA visiting 34 states and making lifelong friends. However, America palled with the still birth of our eldest brother John Francis and the call of Alan Cottrell to come back to Cambridge. Dad now put down roots, becoming a founding fellow of Churchill and all his surviving children were born in Cambridge and indeed christened in this very church.

Our childhood was punctuated by many 'experiments' and consequences of his developing career and moves to the National Physical Laboratory and then the University of Surrey.

His growing prominence was reflected in the series of graduate students from all over the world, several of whom we are touched to see today, who joined us at home where Dad decided to test our, and their abilities, by devising obstacle races and competitive games

of badminton. We were certainly the only boys in Thames Ditton whose train set carried loads of nails made from reinforced glass. At Sunday lunches we spoke in French, were taught about wine and active political discussion was encouraged.

This willingness to embrace ideas and question that so enriched our meal times was evident throughout his career. Whilst at Surrey University he had the great foresight to persuade the university to buy the land on which he then established the very successful Surrey Research Park. This gave the university a solid foundation enabling it to go from strength to strength. Dad's polymath nature was also evident with his determination to introduce the Degree in Dance studies against formidable opposition.

Many later trips with my father inevitably involved engagement with the local art or renowned artist no matter of what style. Earnest evening discussions of the art or history of that particular region would always prevail.

As children it was at sailing that Dad really showed his tenacity and drive to us. Starting in small dinghies during summer holidays on the Ouse and above all in Cornwall – we took it in turns to spend time with him in his boats or play on the beach – this progressed to larger yachts and sailing in The Solent. Later we did some offshore sea cruising culminating with trips to The Algarve and a 4 full day non-stop sail to Cobh in Ireland.

Going sailing with Dad was not an activity for the faint-hearted as he pursued it with his typical steely determination and a fully engaged rigorous approach! On one voyage sailing in France Dad had trouble pulling up the anchor discovering that it had failed and part of it had fallen off. Most people would have put it down to experience – Dad, who has been described as the Father of Composite Materials, put it down to metal fatigue. A quick examination back in a metallurgy lab and a carefully worded letter to the manufacturer on suitable headed paper resulted in a new anchor!

Dad's retirement from Surrey in 1994 and final return to Cambridge, Churchill and the Department of Materials Science & Metallurgy was overshadowed by the illness and early death of our mother. He nursed her with characteristic resolve, teaching himself to cook - learning the craft like a scientist to look after her. He missed her terribly, but became a pretty good cook and avid vegetable grower. Forgiving his complete disregard for 'Use By Dates' and sometimes unorthodox dishes such as 'Turkey Bone Soup' or the home grown pickled cucumber...we never quite knew how long the cucumber had been pickled...was it 2008? or 2003 ?... or was it actually cucumber?? Until sadly the last couple of years, when he started losing interest, the suppers at Madingley Road were always accompanied by the finest of wines, some of which he had laid down in the college cellars as the first Wine Steward in the 1960s.

He also showed courage in combatting his own deafness, undergoing replacement hip and knee operations, taking particular interest in the materials used, and in his refusal to allow his stroke last year to incapacitate him.

He remained interested and interesting throughout his retirement — decorating Madingley Road, collecting paintings of seascapes, studying the science of climate change, passionately and energetically questioning.

In fact, a few days ago, I found the menu from the last College guest night on Dad's desk annotated with his comments on each course. We are grateful that he died peacefully in his own bed and in his own house. Hospitality was always a feature of my parents' lives and my earliest memories are of taking food around a gathering of adults. There will be one last drinks party at Madingley Road this afternoon to which you are all invited.

Dad with God's blessing may you now be reunited with Mum and Rest in Peace.

— Read at Tony Kelly's funeral.

Obituary

The Father of Composite Materials

Anthony Kelly was born in Hillingdon, Middlesex on 25 January 1929. His mother Violet Vaughan was a nurse who converted to Catholicism on marriage and his father was a veteran of the First World War trenches and witnessed his own brother's death at the Somme. His father, Group Captain Vincent Gerald Kelly was a graduate mathematician who joined the RAF in the Twenties to train navigators. At the age of 13, the young Anthony Kelly corrected his physics teacher's workings on the board; the said teacher then admitting to the class that "yes, Kelly was right".

Entering Reading University at the age of 17, he obtained two first class honours BSc degrees - General and Special (Physics) and then followed this with a Ph.D. at Trinity College Cambridge in 1953. His thesis was concerned with the plastic deformation of metals examined by X-ray microbeam diffraction. He then worked at the University of Illinois and at Birmingham University before spending three years as an Associate Professor of Metallurgy and Materials Science at Northwestern University, Chicago. He returned to Cambridge in 1959 to take up an appointment as a University Lecturer where, in addition to innovative teaching, he built up a very active research group working on the strength of materials. As a Founding Fellow of Churchill College, he was Director of Studies in Metallurgy and Materials Science, but also had the time and energy to play a key part in setting up the college wine cellar.

He then demonstrated his restless tendencies when in 1967 he moved to a number of roles in government science for eight years, becoming Superintendent of the Materials Division of the National Physical Laboratory and then Deputy Director in 1969. He later claimed that he was following Sir Edward Bullard's advice "not to fight the Civil Service system but to use it". The NPL proved an excellent platform for him to develop and apply his knowledge of the strength of materials more widely. Stimulated by early work at Farnborough, his research focused increasingly and fruitfully on the kind of high performing composite materials (such as plastic reinforced with carbon fibre) which have made such an impact on modern life, from vehicles on land, sea and air to buildings, bridges and engines. He received an Sc.D. from the University of Cambridge in 1968 and was elected a Fellow of the Royal Society in 1973 at the age of 43.

In 1975, he moved again, this time to the University of Surrey as only its second Vice-Chancellor. During his tenure from 1975—1994, the number of full-time students at Surrey increased from 3,000 to 7,000 with a significant increase in the proportion of

postgraduate students. During the 1980s the University developed a large network of associated institutions awarding Surrey degrees (notably the Roehampton Institute and St. Mary's College Twickenham, both now universities in their own right) and at that time it became one of the foremost validating universities in the country.

Although Surrey's annual income rose from £6m to £63m between 1975 and 1994 – a significant real increase – the 1980s were not an easy time to be a Vice-Chancellor. In the infamous University Grants Committee (UGC) cuts of 1981, Surrey suffered one of the highest reductions in government funding, in spite of being at the forefront of establishing links between higher education and industry. Professor Kelly responded to the situation with characteristic determination, closing a number of academic departments (rather than spreading the pain evenly which would not have been in the long term interests of the University) and further increasing the University's income from non-government sources. At this and other times, conversations in the Vice-Chancellor's office could be challenging but, as Sir Austin Pearce (then a Pro-Chancellor and a former Chairman of British Aerospace) said many years later, when presenting Anthony Kelly for the degree of D.Univ. honoris causa "when he digs his heels in he is invariably right".

A notable feature of the University's strategy in the 1980s was the development of the Surrey Research Park. Anthony Kelly had first conceived the idea during a sabbatical term in Switzerland in 1979 and a small group (including in particular Jerry Leonard, University Treasurer and Leonard Kail, University Secretary) took the development forward. It was at around the same time that Anthony Kelly became the first Chairman of Surrey Satellite Technology. It is fitting that the building at the entrance to the Research Park which accommodates start-up companies is named the Anthony Kelly Technology Centre.

Surrey was one of the first universities to introduce a staff appraisal scheme in response to the 1985 Jarratt Report on the management of higher education and was also one of the first to draw up a strategic plan, long before all universities were required to do so by the Funding Council. Anthony Kelly was a strong advocate of the professional training year which has made a major contribution to Surrey's consistently high graduate employment record. He had the interests of students at heart and he was meticulous in developing good relationships with the Students' Union. He was a champion of student sport and could often be found on the Manor Park sports fields on a Saturday afternoon cheering on one of the University's teams. He encouraged the development of a broader range of subjects in the University – for example the introduction of Dance Studies, a controversial move at the time.

Unusually among Vice-Chancellors, Professor Kelly continued to make a significant contribution to his own discipline. He is widely recognized for having founded and

developed the field of strong solids made from composite materials, now extensively used in industry. Hence he is known as the 'Father of Composite Materials'. He was elected to the Fellowship of Engineering (now the Royal Academy of Engineering) in 1979, to the National Academy of Engineering of the USA in 1986 and to the Academia Europaea in 1990. He received many international prizes and awards and honorary doctorates from Birmingham, Reading and Surrey, Hanyan University in South Korea and Navarra University in Spain. He received the President's Medal of the Royal Academy of Engineering in 2011 in recognition of a lifetime of significant achievement throughout a career spanning more than sixty years. His major book, *Strong Solids* (first published in 1965, third edition 1986) is still regarded as the seminal work in the field. An international symposium *Advanced Materials in the Marketplace* (organised by Professor Michael Kelly and Professor Jim Castle) was held at the University in 1994 to mark his retirement. He was Chairman of the Joint Standing Committee on Structural Safety of the Institutions of Civil and Structural Engineering from 1988 to 1998.

At another event held to mark Anthony Kelly's retirement, HRH The Duke of Kent (Chancellor of the University) commented on his ability, as an experienced yachtsman, to chart a course through choppy waters – an ability which helped to steer the University through a difficult period following the 1981 UGC cuts. Those who worked with Tony Kelly recognise that much of his success as an academic leader derived from his unusual personality – he could be stubborn and erratic but always with a measure of personal charm that left you respecting him even after a bruising disagreement. He also had amazing energy, organisational capability and drive to get things done.

On his retirement from the University, Tony and his wife Christina (who sadly died in 1997) returned to live in Cambridge. He soon became actively involved as a Fellow of Churchill College (having been elected as an Extraordinary Fellow of the college in 1985) and as an Emeritus Professor and Distinguished Research Fellow in the University's Department of Materials Science and Metallurgy. He became a well-known and respected figure at Churchill, editing the College's *Review* for many years. He served as President of the Institution of Materials in 1996–97. He was lonely without his beloved wife and recognised the problem of loneliness in later years with a characteristically generous benefaction of a fund at Churchill College to enable the widows and widowers of Fellows to continue to dine in College.

He continued to work and publish throughout the rest of his life. He was a scientist of the old school, who took 'Nullius in verba' as a matter of daily practice. He was properly sceptical until the real world data confirmed his or others' ideas. He was not impressed by the modern tendency to use incomplete data to weave elaborate stories that could be

undone by hard data, or worse, were not capable of falsification. He led the successful effort to get 43 Fellows to petition the Council of the Royal Society to modify its public stance on climate science in 2010. He played a key role in helping the Global Warming Policy Foundation get set up and was a founding and active member of its Academic Advisory Council. He spent his later years as a critic of some aspects of climate science where the consequential actions seemed to him to be doing more harm than good to humanity. His final paper 'Climate Policy and the Poor' was published a week after his death.

Professor Kelly was for a number of years a Vice-President of the Royal National Institute for the Deaf. He was appointed CBE in 1988 and a Surrey DL in 1993. Although from a devout Roman Catholic background, he did not allow his faith to intrude on his role as the head of a secular institution, while nevertheless encouraging the development of an ecumenical approach to the university chaplaincy. He was appointed a Knight of St Gregory in 1992.

Anthony Kelly died peacefully in his sleep at home on 3 June 2014 at the age of 85. He leaves three sons and a daughter.



Department of Metallurgy, University of Cambridge, 1966