GLOBAL CLINICAL ENGINEERING ALLIANCE™

TALK SERIES

The Computer Tomographic Scanner: How Solving a Mathematical Algorithm Won a Nobel Prize in Medicine

Kit Vaughan, University of Cape Town 15 February 2023

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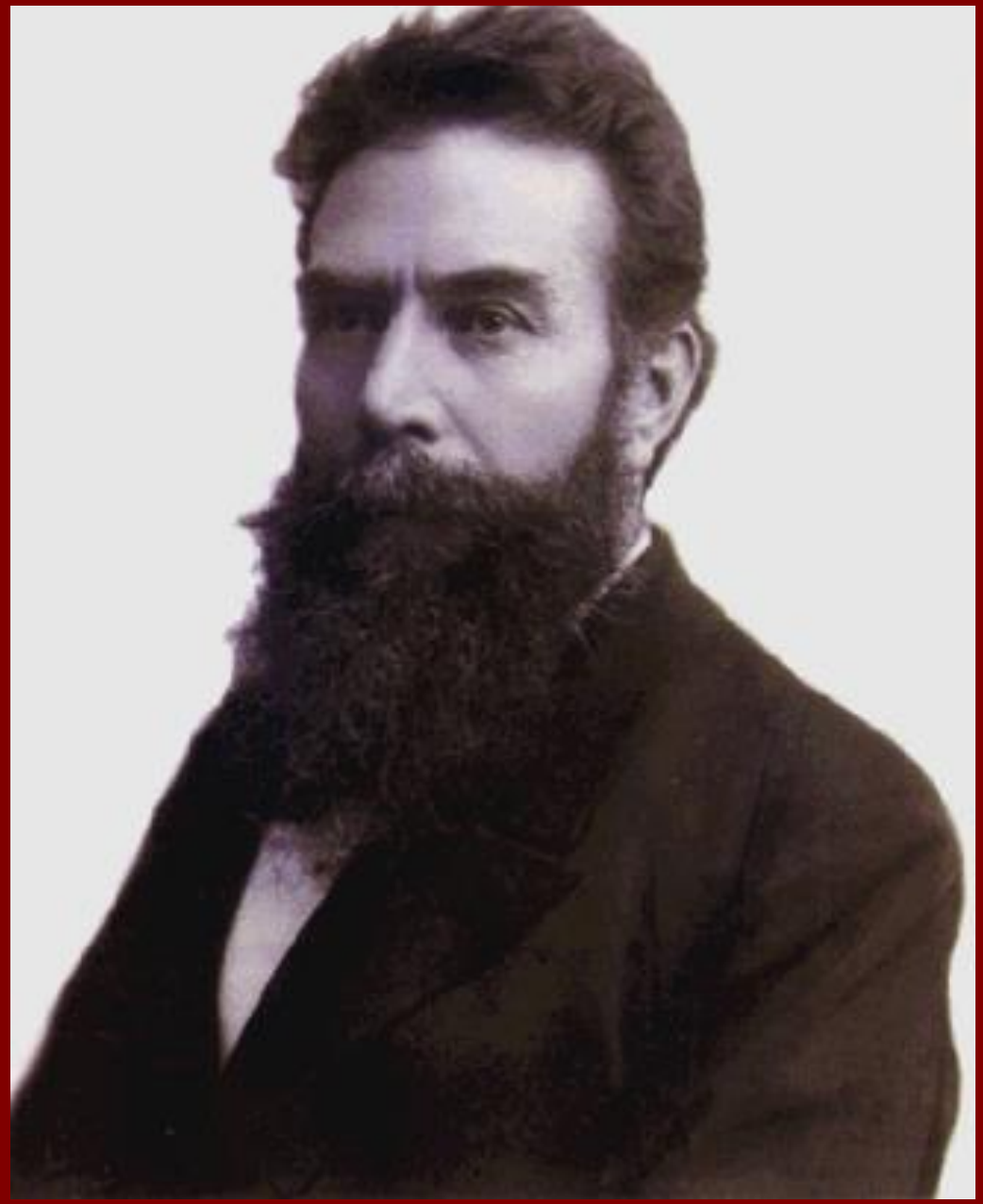
Wilhelm Röntgen

November 1895

He performed an experiment in which invisible cathode rays, generated by electrostatic discharges from within an evacuated glass tube, caused a cardboard screen to fluoresce. He called them X-rays, using the mathematical description for something unknown.



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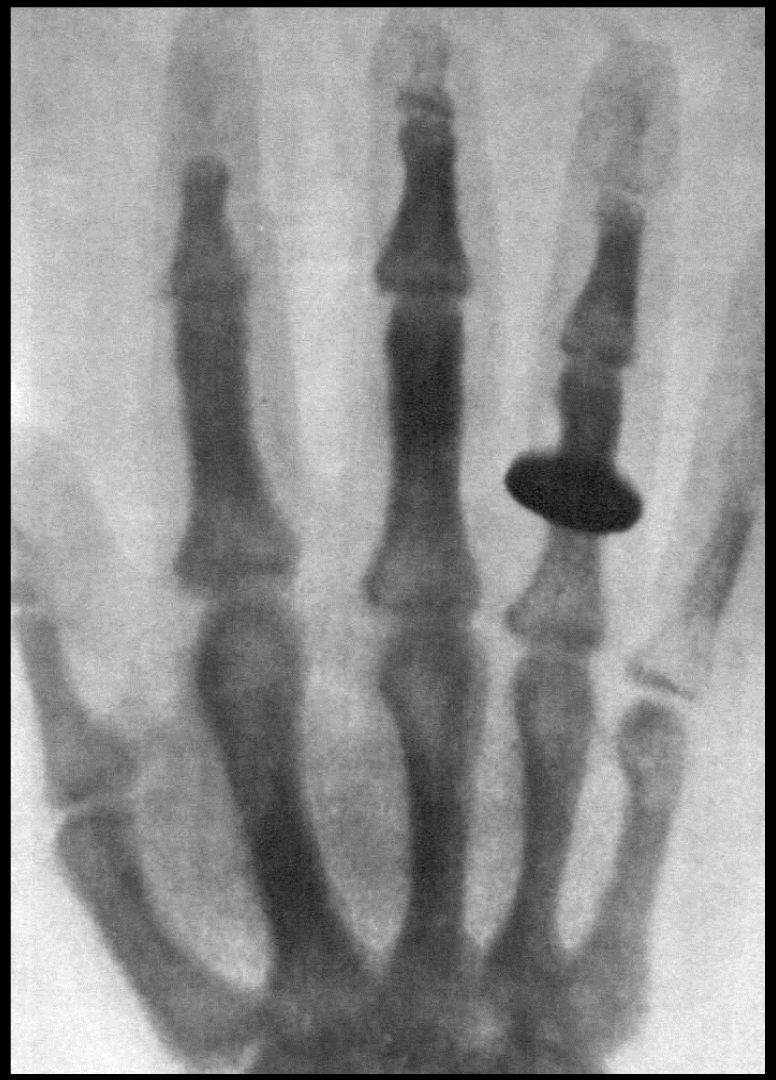

Röntgen’s discovery revolutionised medical diagnosis. Within a few weeks of the appearance of this image of his wife’s hand, the technology was being used by clinicians all over the world.

Wilhelm Conrad Röntgen

Winner of the Nobel Prize for Physics in 1901 for his Discovery of X-Rays

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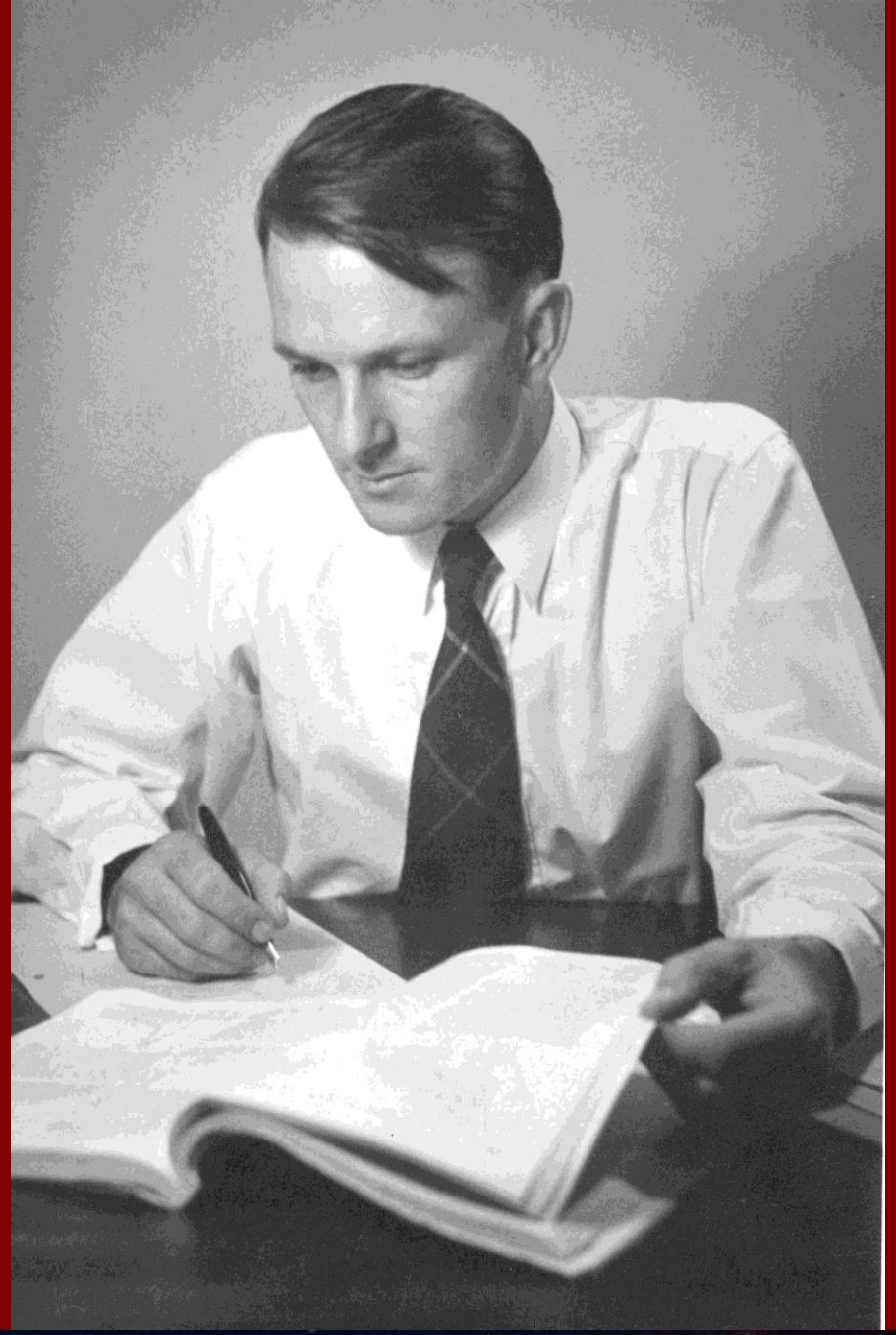
Ten years before Christiaan Barnard performed the world's first heart transplant in 1967, a far more momentous project in medical science took place in Cape Town.

It is the story of the CT scanner

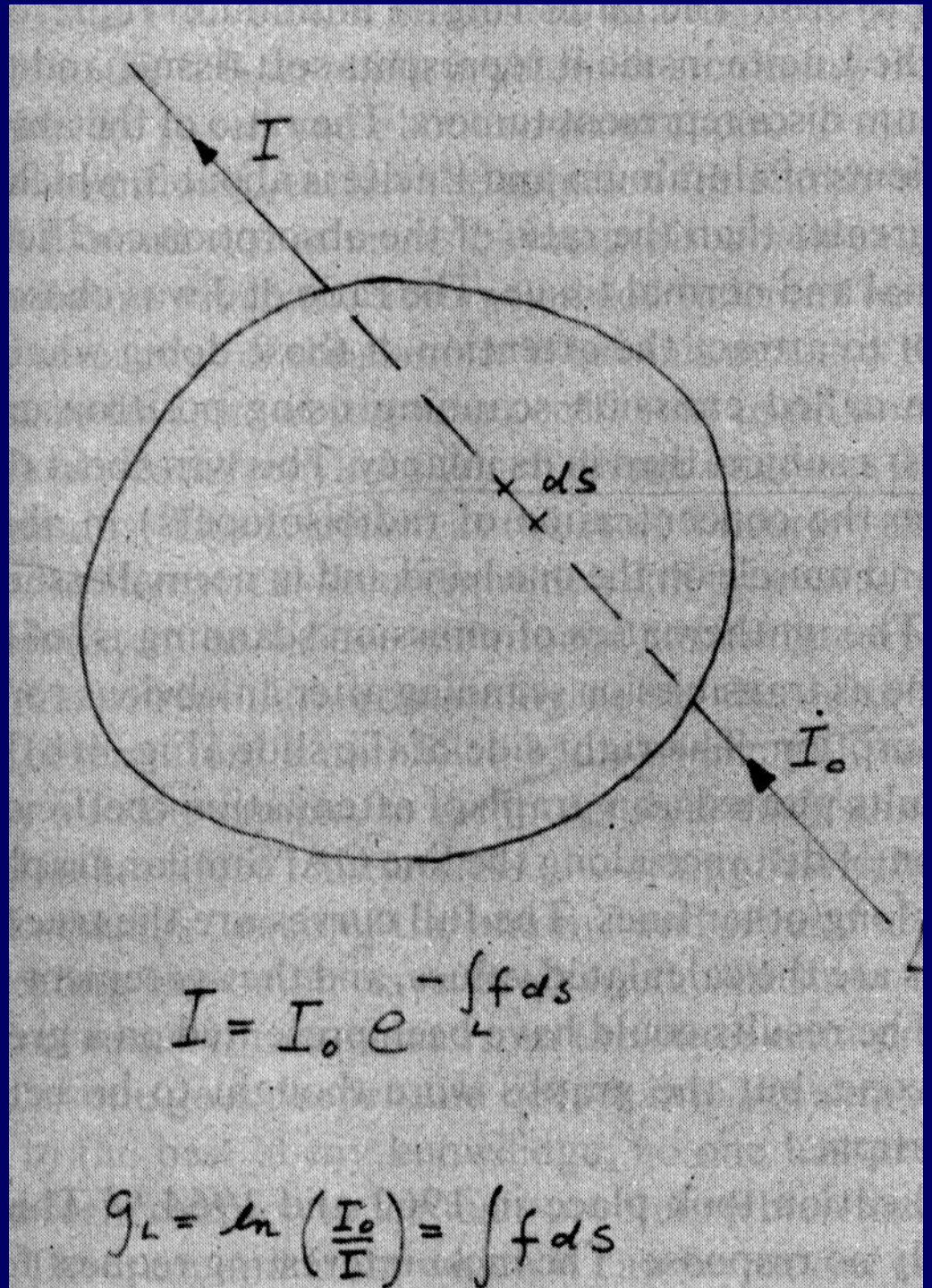


Allan MacLeod Cormack

Born: 23 February 1924

Died: 7 May 1998

Educated at Rondebosch Boys High School and then studied physics at the University of Cape Town and the Cavendish Laboratory at Cambridge University. In 1955 he was seconded to Groote Schuur Hospital as a nuclear physicist.



"It was immediately obvious that the problem was a mathematical one. If a fine beam of γ rays of intensity I_0 is incident on the body and the emerging intensity is I, then the measurable quantity

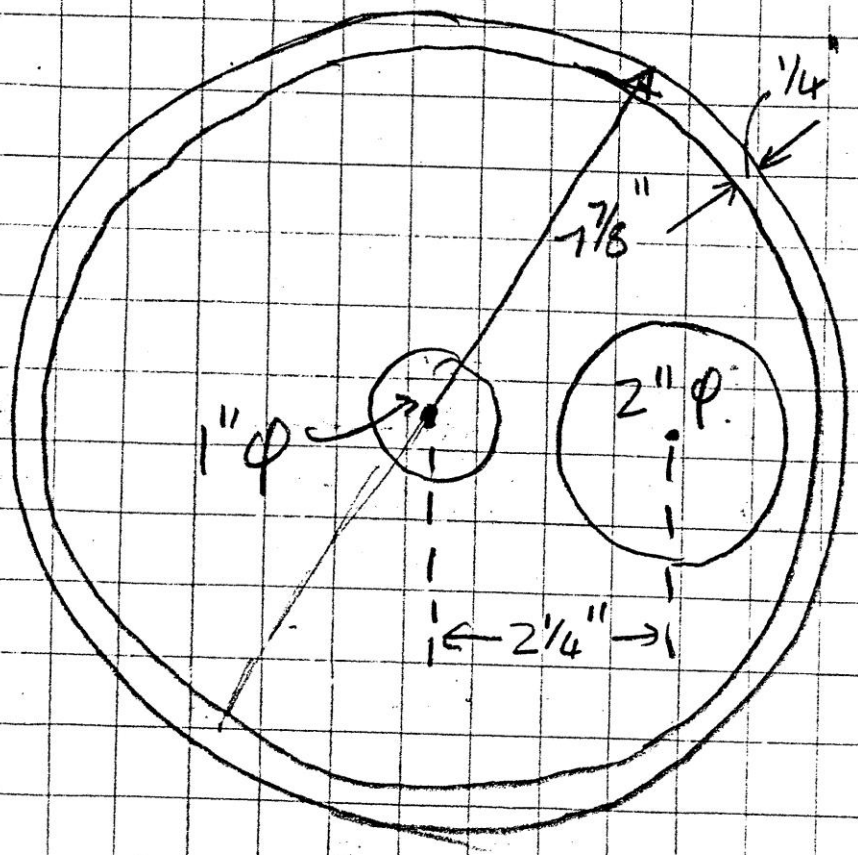
$$g = \ln(I_0/I) = \int_L f.ds$$

where f is the variable absorption coefficient along the line L. Hence, if f is a function in two dimensions, and g is known for all lines intersecting the body, the question is: Can f be determined if g is known?"

Reprinted from JOURNAL OF APPLIED PHYSICS, Vol. 34, No. 9, 2722–2727, September 1963

Representation of a Function by Its Line Integrals, with Some Radiological Applications

A. M. CORMACK
Physics Department, Tufts University, Medford, Massachusetts
(Received 28 January 1963; in final form 26 April 1963)



Outer ring + 2 centre pieces Al

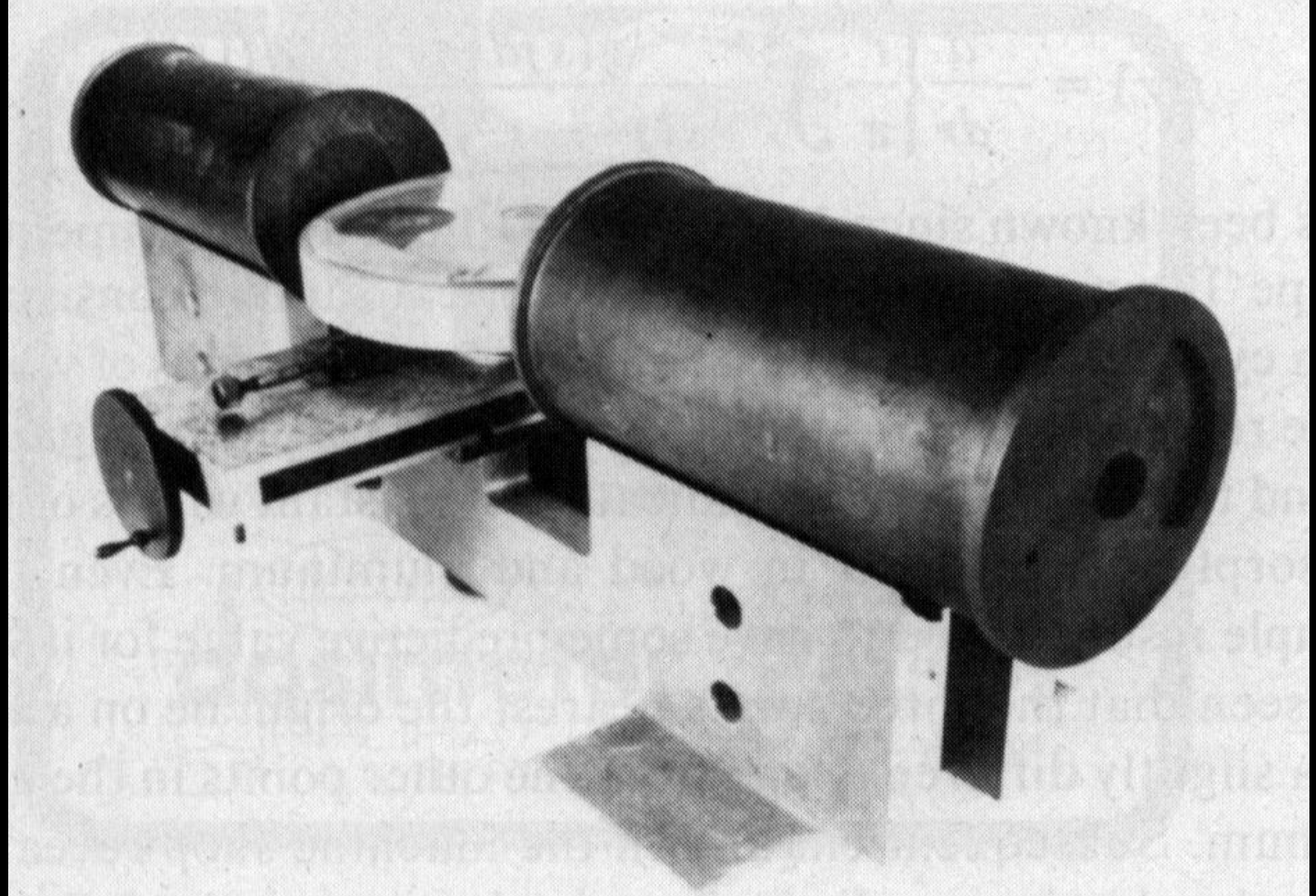
Rest lucite.

Max absorber: $2" + 1" + 2 \times \frac{1}{4}"$ Al $= 3\frac{1}{2}"$ Al

$7\frac{7}{8} - 3\frac{1}{2} = 4\frac{3}{8}"$ lucite.

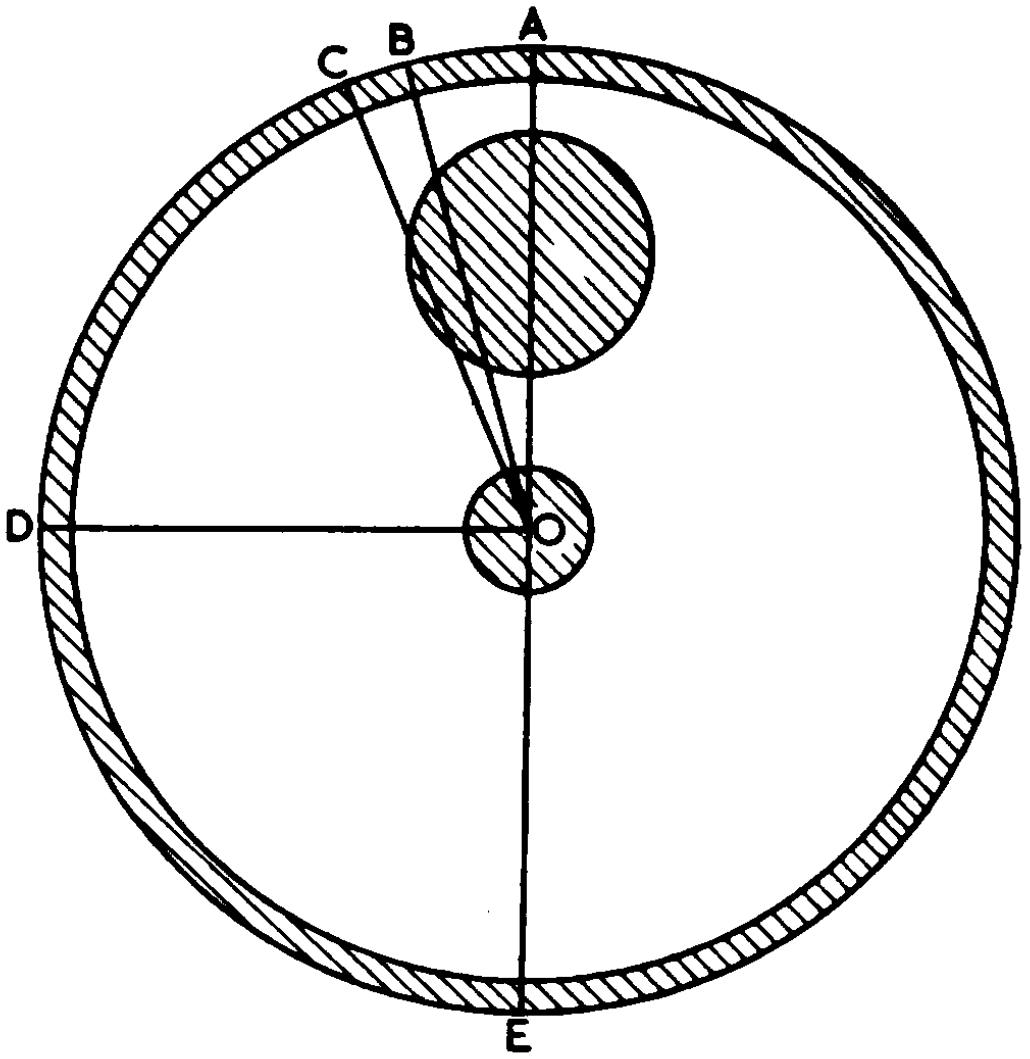
Take $\mu_{Al} = .146\ cm^{-1}$

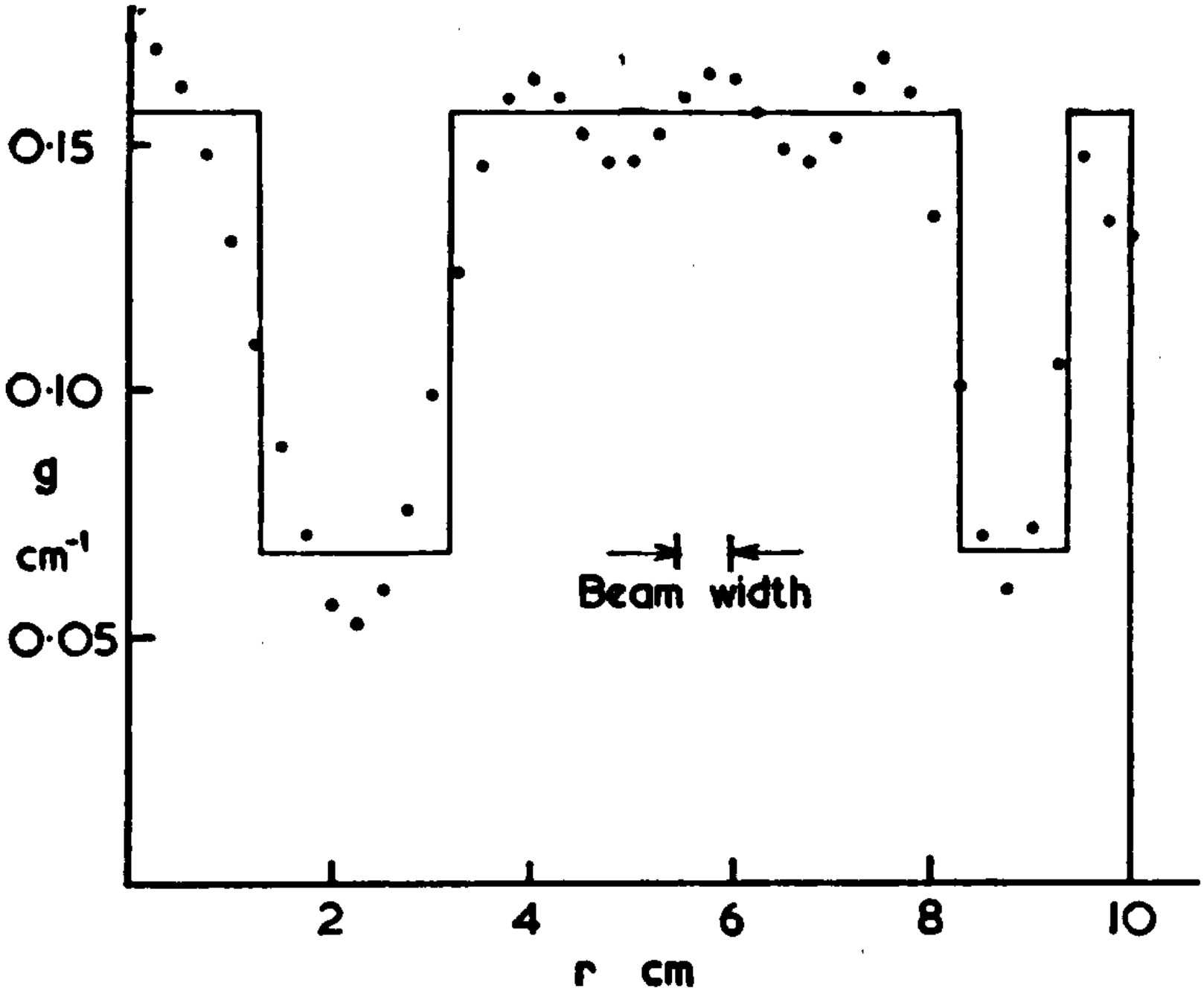
$\mu_{lucite} = .067.$

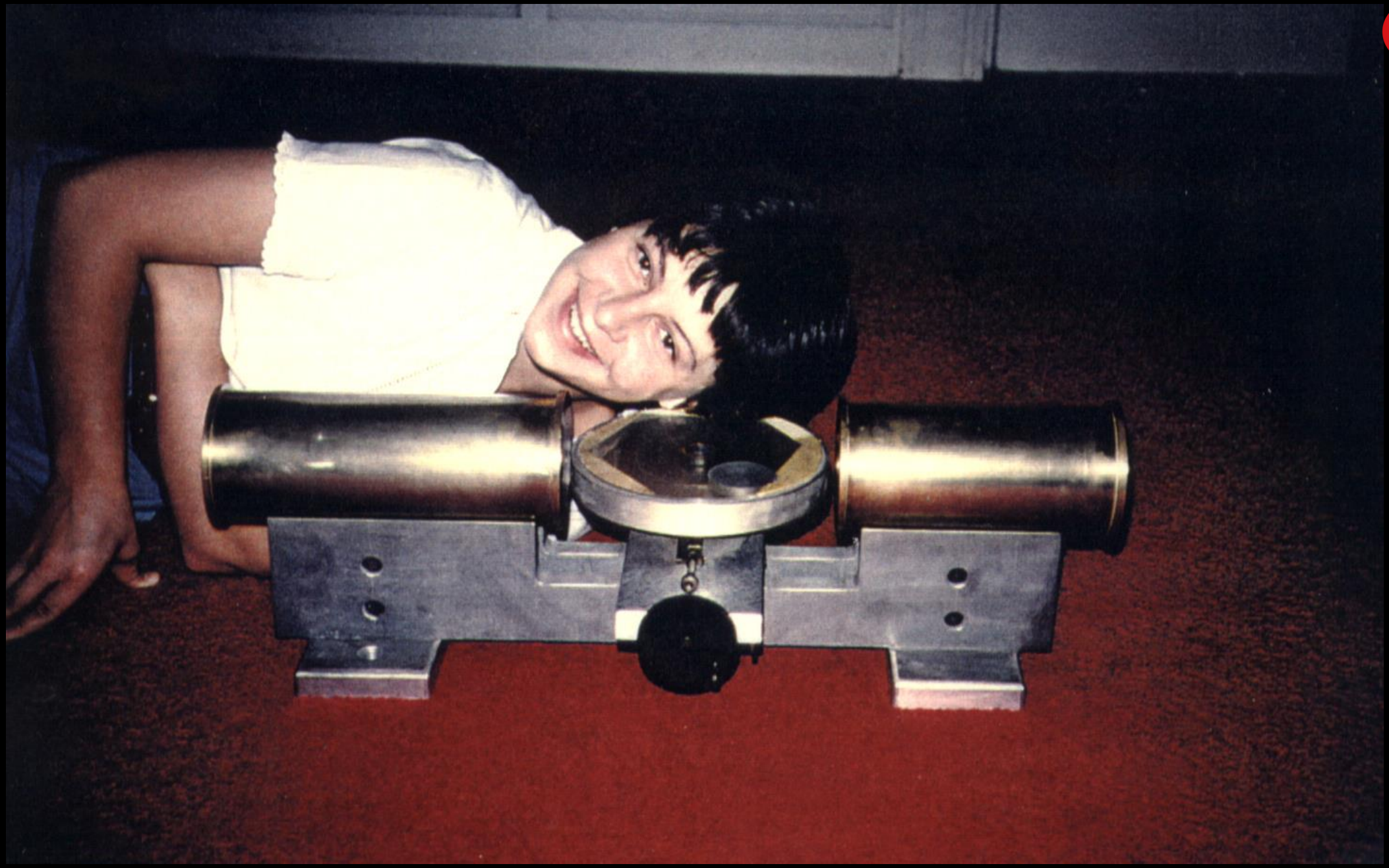


1963 Model CAT-Scanner. Cost ~ $100

FIG. 1. The sample. Hatched areas are aluminum. The unhatched area inside the aluminum ring is Lucite, and outside the ring is air.







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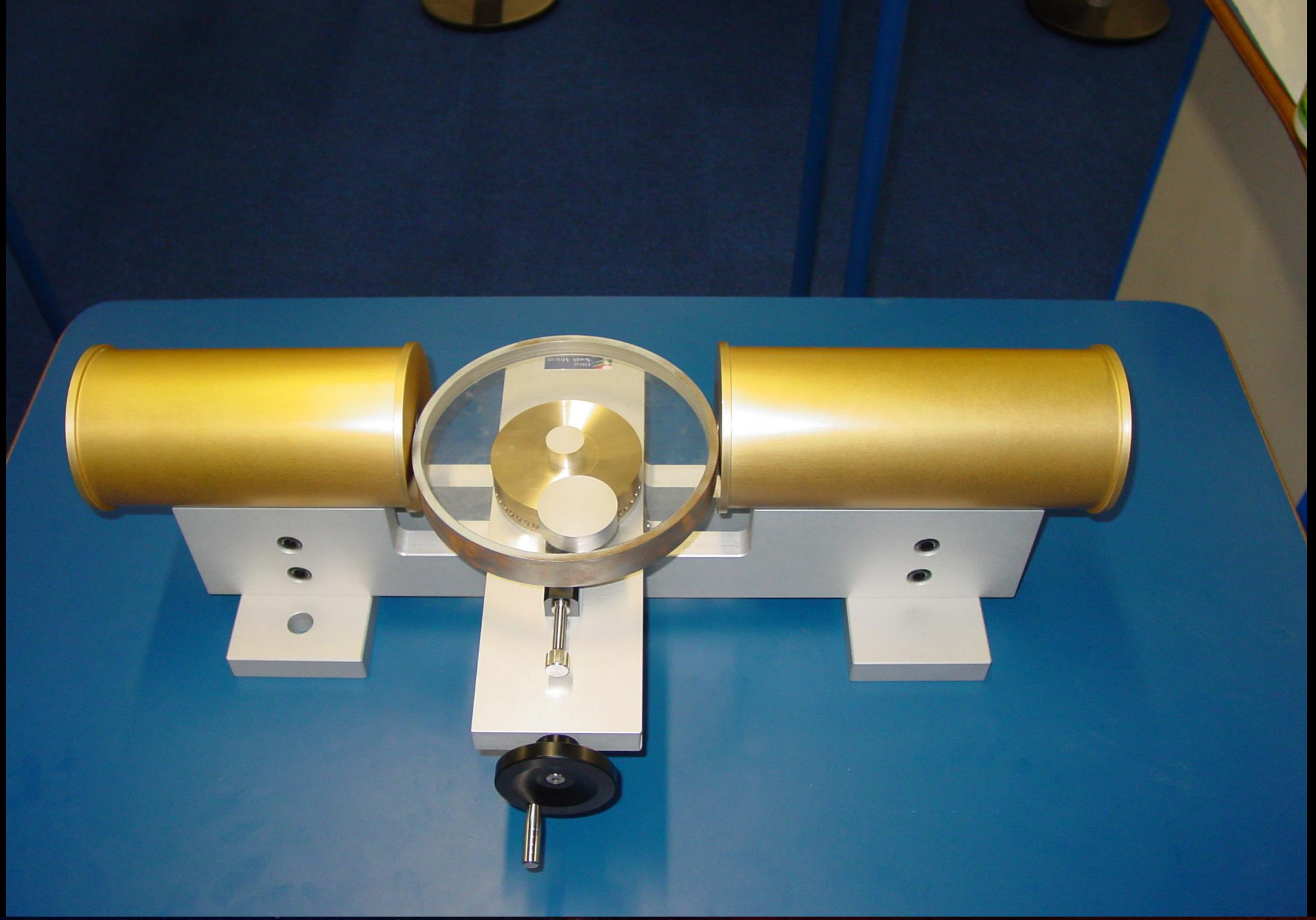


Are Reprint Requests a Good Gauge of Recognition?

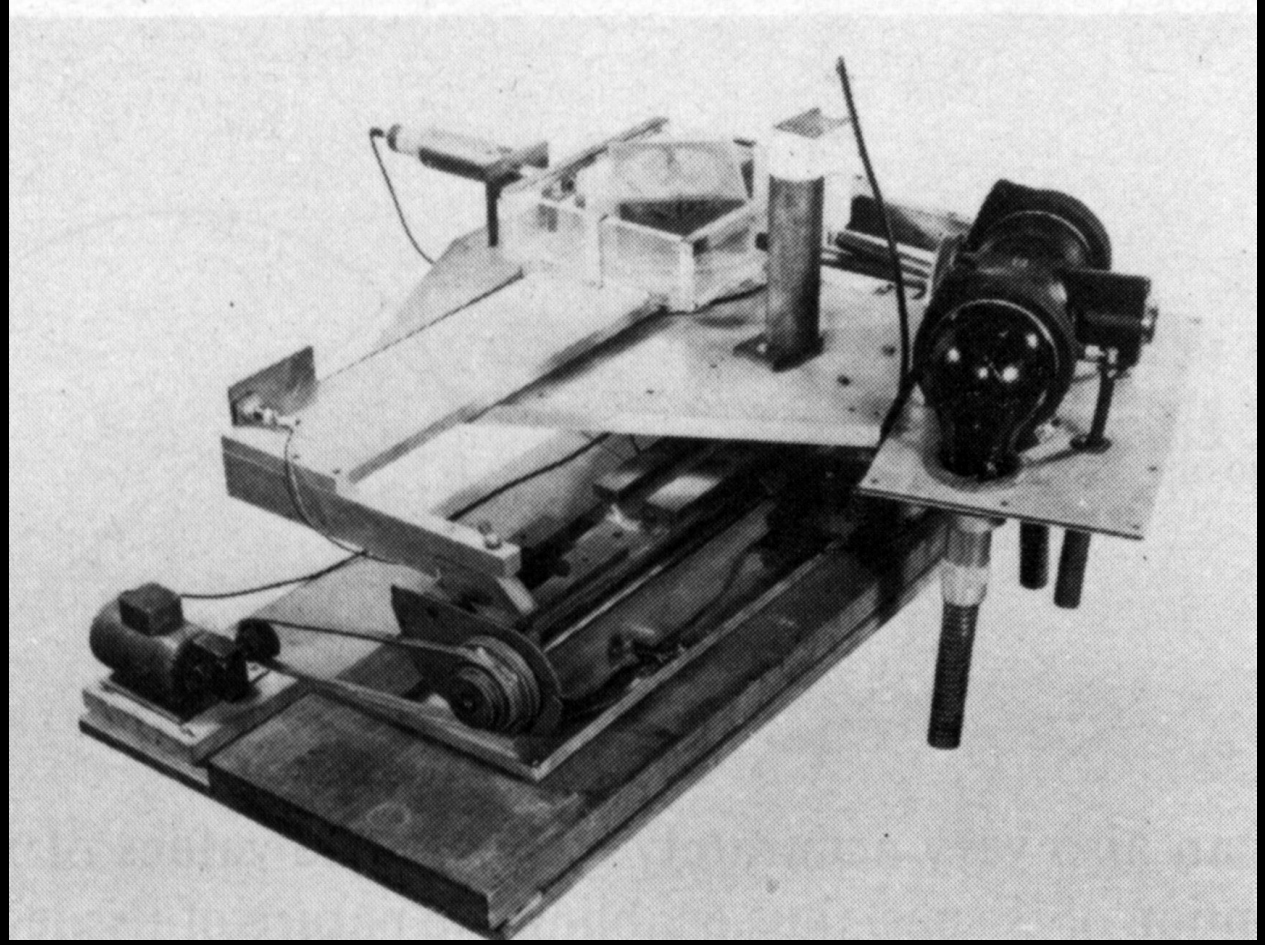
"Publication took place in 1963 and 1964. There was virtually no response. The most interesting request for a reprint (there was one other) came from the Swiss Centre for Avalanche Research who thought the method could be used to find skiers buried under the snow!"

Godfrey Hounsfield

Born: 28 August 1919

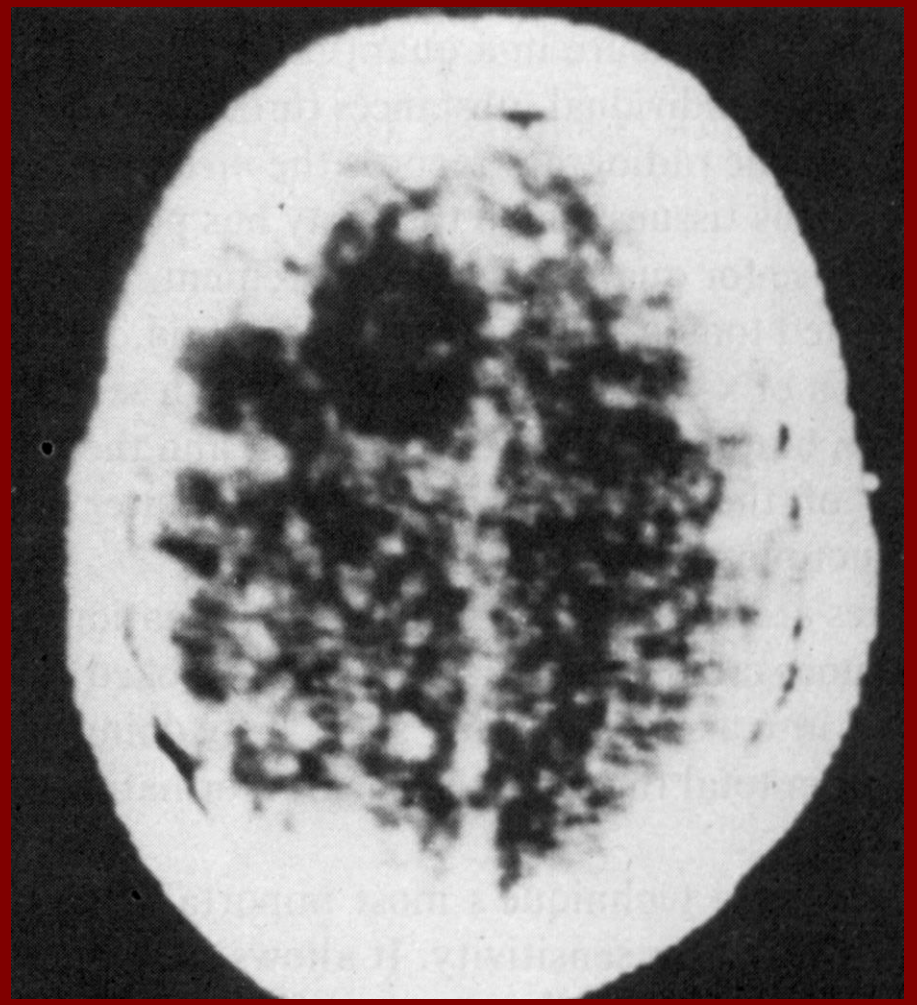
Died: 12 August 2004

Educated in the Royal Air Force during World War II and then as an electrical engineer at Faraday House College in London. He worked for EMI research laboratories and began work on a brain scanner in the late 1960s.

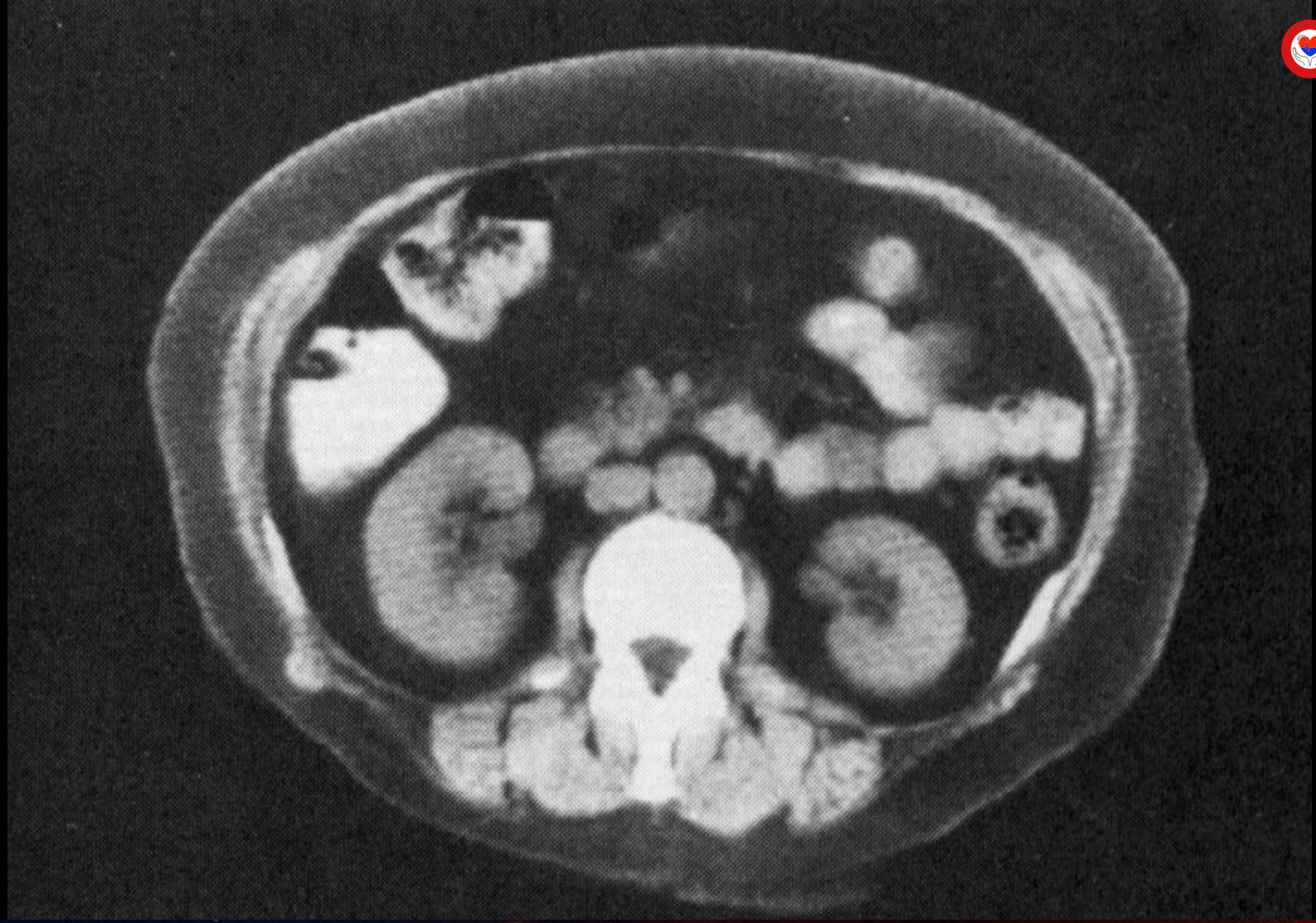


Hounsfield's first system used gamma rays and required 28,000 measurements, taking 9 days. Pictures took 2.5 hours to be processed. X-rays reduced collection time to 9 hours.

The first clinical brain scanner was installed at Atkinson Morley's Hospital in London in 1971.



On 1 October 1971, the first patient studied by the EMI scanner was a woman who had a suspected brain lesion. The image clearly showed a dark circular cyst.



Nobel Prize...from idea born in Cape

Education Reporter

THE idea which won the 1979 Nobel Prize for Medicine was born at Groote Schuur Hospital and developed in the Physics Department at the University of Cape Town.

Its creator, Professor Allan Macleod Cormack, is a former Rondebosch Boys' High School pupil, a University of Cape Town graduate and now head of the physics department at Tufts University in Massachussetts.

STRONG

Professor Cormack's ties with the University of Cape Town go back a long way and are still strong. He earned his BSc and a distinction in physics there in 1944, a MSc with first-class honours in 1945, lectured there for seven years and the present registrar of the university, Mr Len Read is married to his sister.

'He was very much a product of our physics department,' said Professor Robin Cherry, a professor of physics at UCT, today.

'I was one of his students and he supervised my masters. He was an excellent lecturer, a very enthusiastic and vital sort of person.'

Professor Cherry said the first X-ray re-

PROFESSOR Allan McLeod Cormack co-winner of the Nobel Prize for medicine.

five-year-old Professor Cormack said in the 1950s there was no nuclear physicists at Groote Schuur who could work on this sort of thing.

'I am not a medical man but the ideas I developed there were able to give doctors a clear look at delicate body tissues,' said Professor Cormack, who, unusually for a Nobel Prize winner, has never taken a doctoral degree.

LAGGED

He did not develop a working system because computer technology at that time lagged behind his ideas. It was only later that British Nobel Prize co-winner, Dr Godfrey Hounsfield, later invented a working tomography system which is now used in large hospitals to 'see' cancer and brain disease — although at frighteningly high costs.

Professor Cormack was born in Johannesburg in 1924. After graduating at UCT he studied for two years at Cambridge and later went to Harvard as a research fellow.

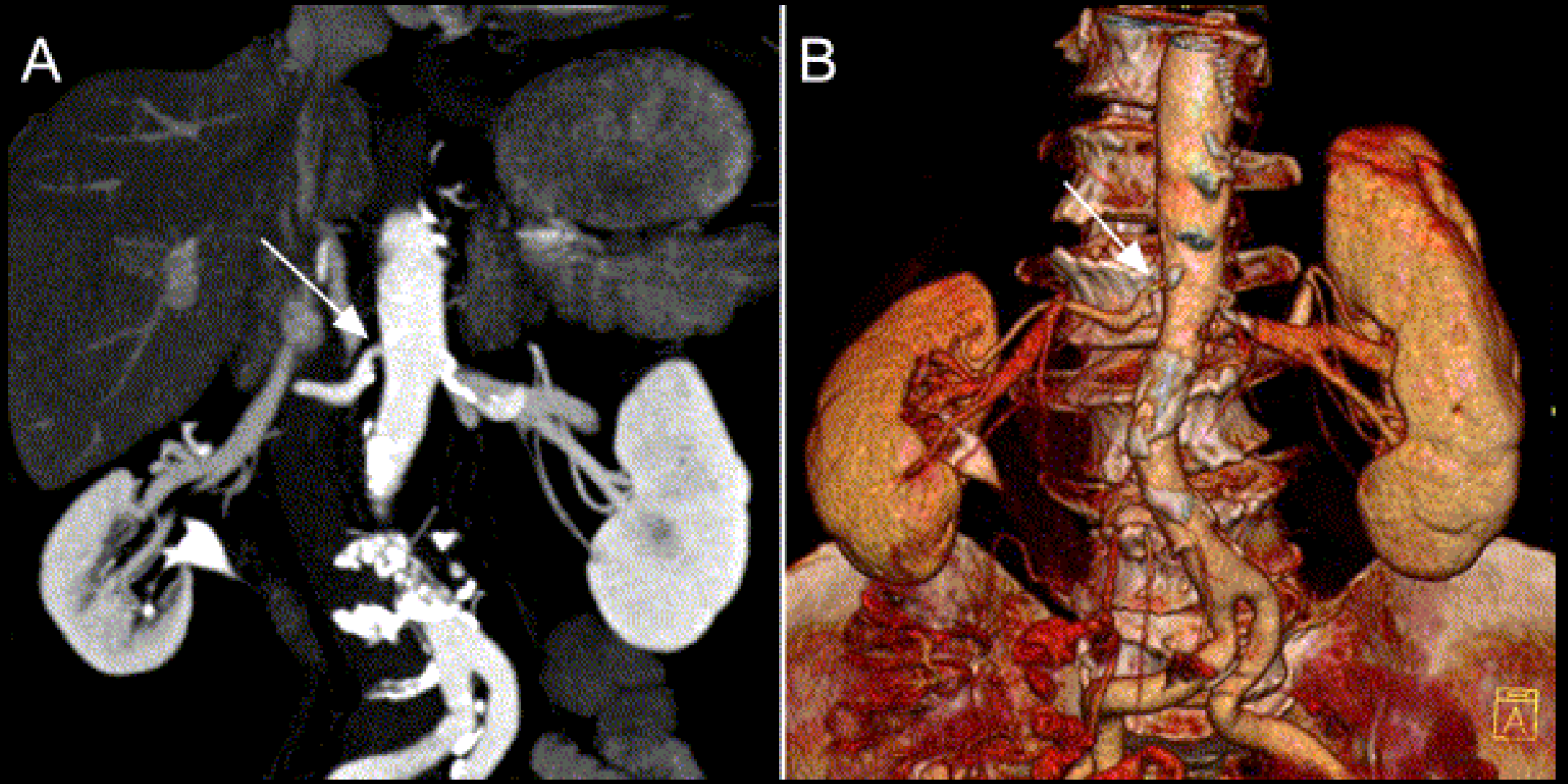
He joined the staff of the physics department at Tufts University in 1957, became a full professor in 1964 and a United States citizen in 1966.

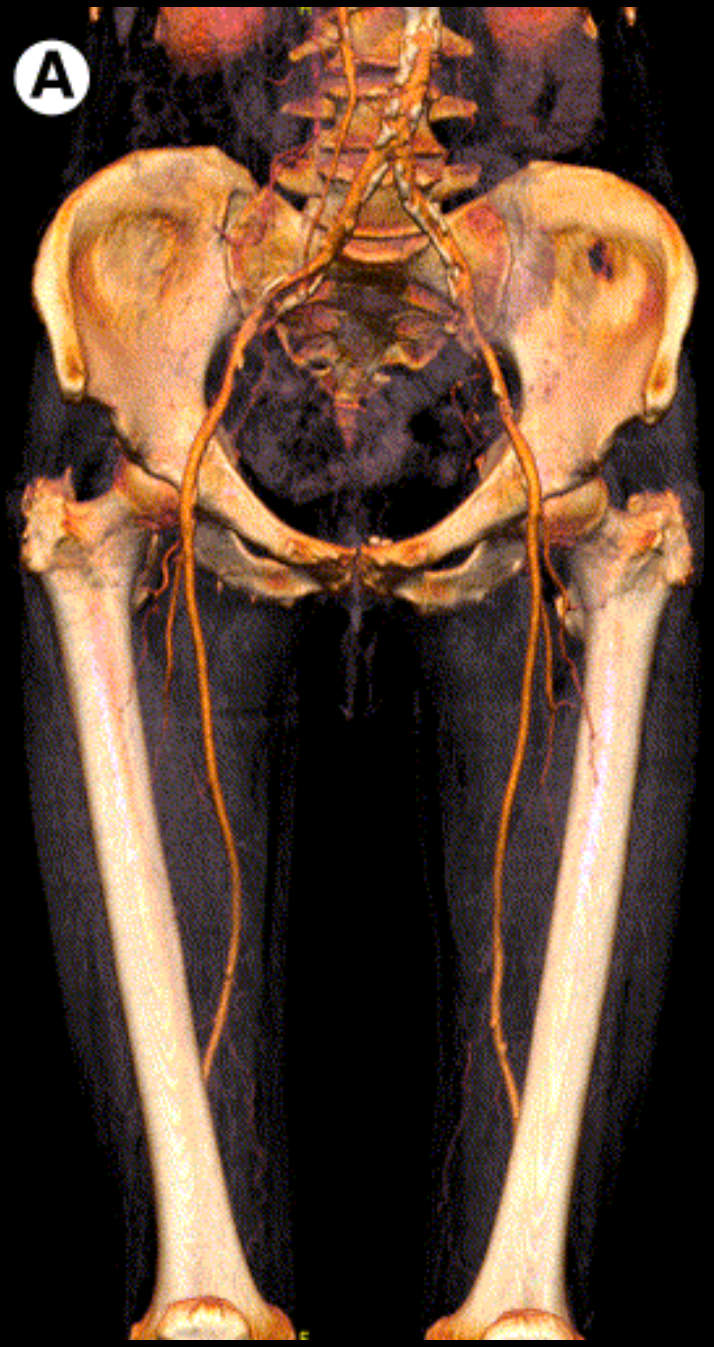
He and his wife Barbara

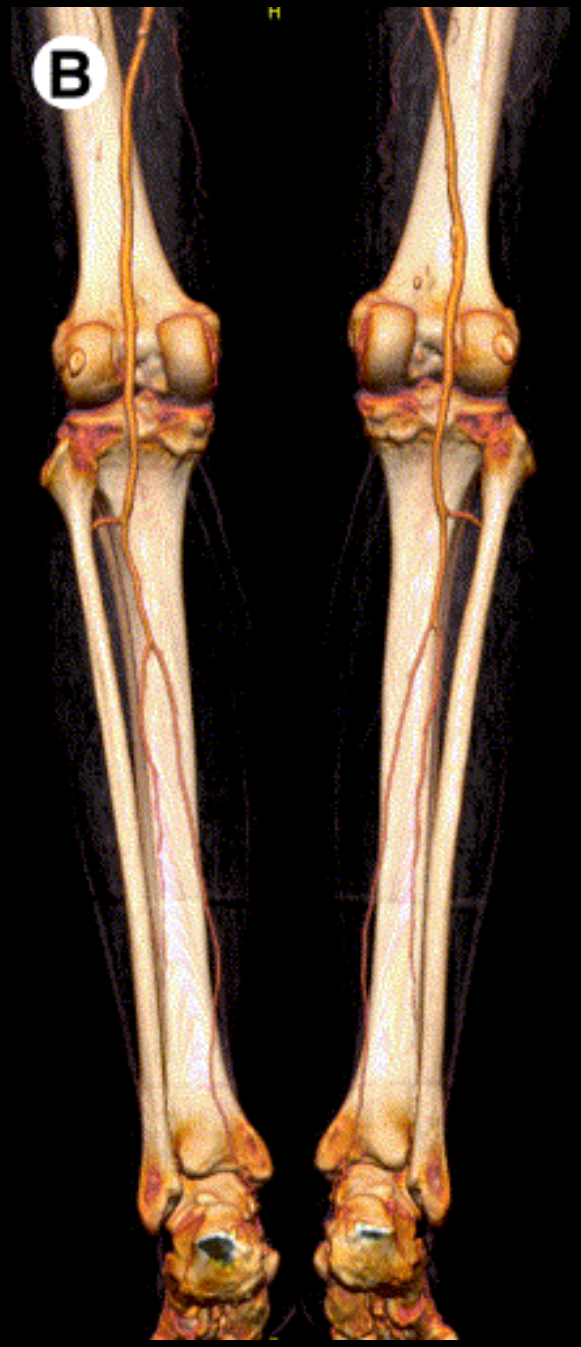
Allan MacLeod Cormack

Godfrey Newbold Hounsfield

Joint Winners of the Nobel Prize for Medicine in 1979 for their work in Pioneering the Development of Computer Tomography

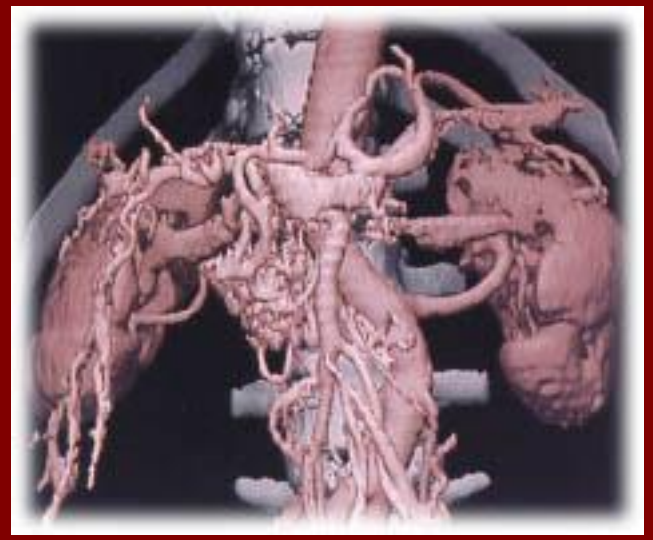

A
B





Computer Tomography provides two huge benefits over conventional X-rays:

1. Tissues of a wide variety of densities can be seen and segmented
2. Structures can be viewed in 3D



The Anatomy of Writing a Book

A Personal Odyssey

"Twelve Questions to Ask Me"

1.

Where did the original idea come from to write a book about UCT alumnus, Allan MacLeod Cormack ?

"Strange how so few eyes bother to look at even the brightest stars"

BRENDAN KENNELLY

Ireland's only Nobel Laureate in science founded, together with Cockcroft, the kind of accelerator-based nuclear physics that has grown to giant proportions in CERN and elsewhere. Subsequently he returned to his alma mater in Dublin and modestly devoted the rest of his career to teaching the subject that he loved. A life grounded in deep convictions, expressed in selfless service, is honoured in this affectionate account of his life by a former colleague. The proceeds will support an undergraduate prize or scholarship.

Vincent J. McBrierty MRIA *is an Emeritus Professor and former Professor of Polymer Physics in the Physics Department of Trinity College Dublin. His distinguished research career was followed by a period as Vice President for Research and Academic Affairs in the Sultanate of Oman, and he has written extensively on education, science and technology policy.*

Ernest Thomas Sinton Walton 1903–1995

VINCENT J. McBRIERTY

Ernest Thomas Sinton

Walton

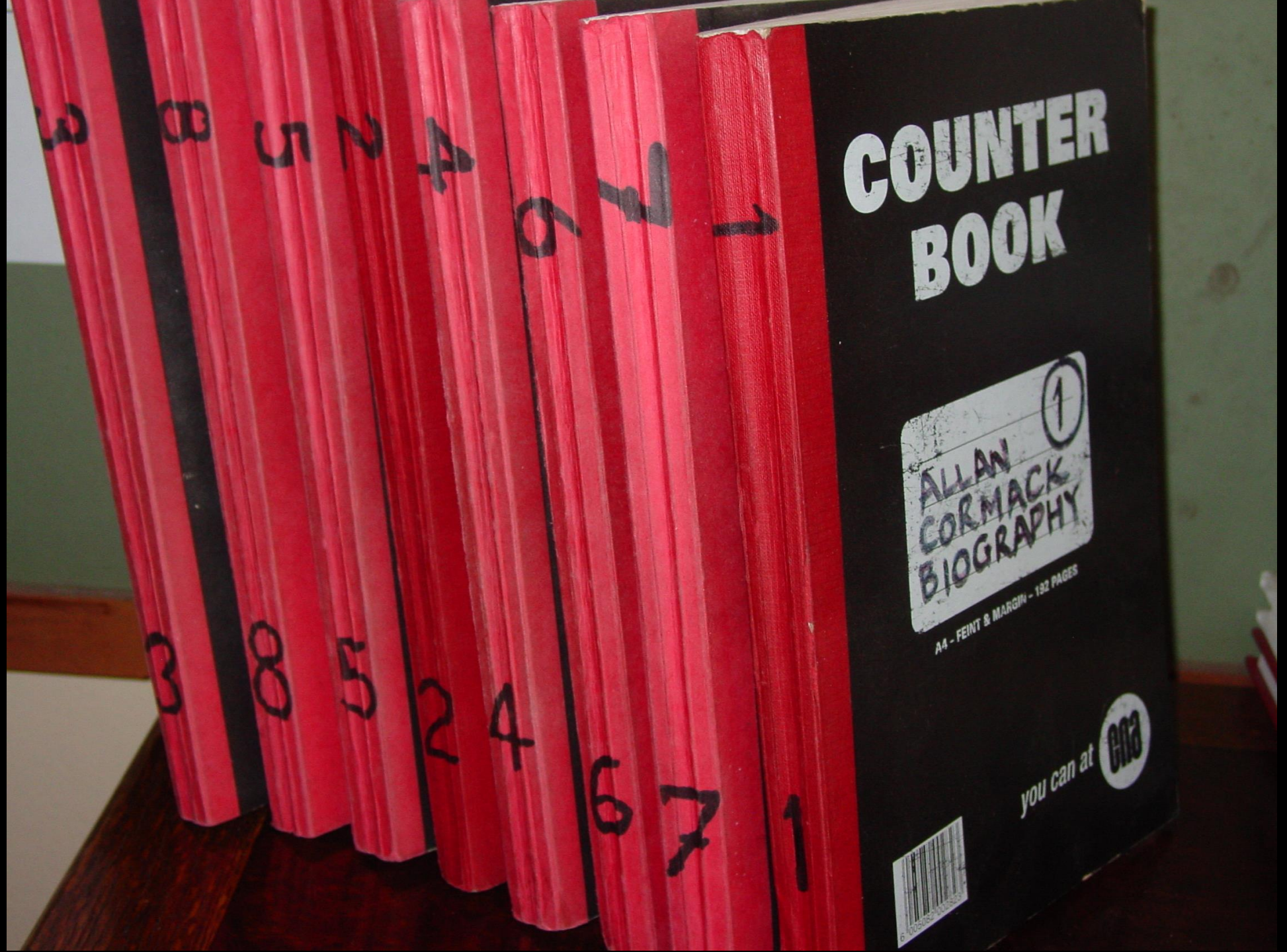
1903–1995

THE IRISH SCIENTIST

VINCENT J. McBRIERTY

2.

What method did you use to organize all your material on Cormack ?



3.

Was it difficult to secure a contract with a reputable publisher ?

Securing a Publishing Contract

Sent proposal to three international publishers: Oxford University Press, Cambridge University Press, Institute of Physics

Rejection

Sent proposal to local publisher: Jonathan Ball

Rejection

Securing a Publishing Contract

Identified an international publisher that specialised in Nobel Laureates:
Imperial College Press

Accept

UCT Press, an imprint of Juta, approached Imperial College Press with an offer to be the local publisher

Accept

4.

Did you have to travel far and wide to conduct background research for the book ?

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5.

Did you write the manuscript in long-hand or enter it directly via the keyboard ?

development of computer assisted tomography had also
Di Chiro arranged for a panel of pioneers. (168) Their pioneers
included William Oldendorf, Allan Cormack and Ron
Bracewell who reminisced about their early ex-
periences (Figure 6.*). This was the first time Allan
met Oldendorf. was interested
Fascinated to learn
why it was this creative neurologist had shared the
Albert and Mary Lasker Award with Godfrey Hounsfield
in 1975. A fourth pioneer, David Kuhl of Philadelphia
was scheduled to be one of the panellists but
was unable to travel to Bethesda. (169) He was
familiar with the neurologist's publication in 1960
describing a method to detect discontinuities in density (110).
While Allan recognised the contributions of his fellow
panellist, he also came to realised that Oldendorf did not

6.

How important was it to have a good editor ?

My son, the editor

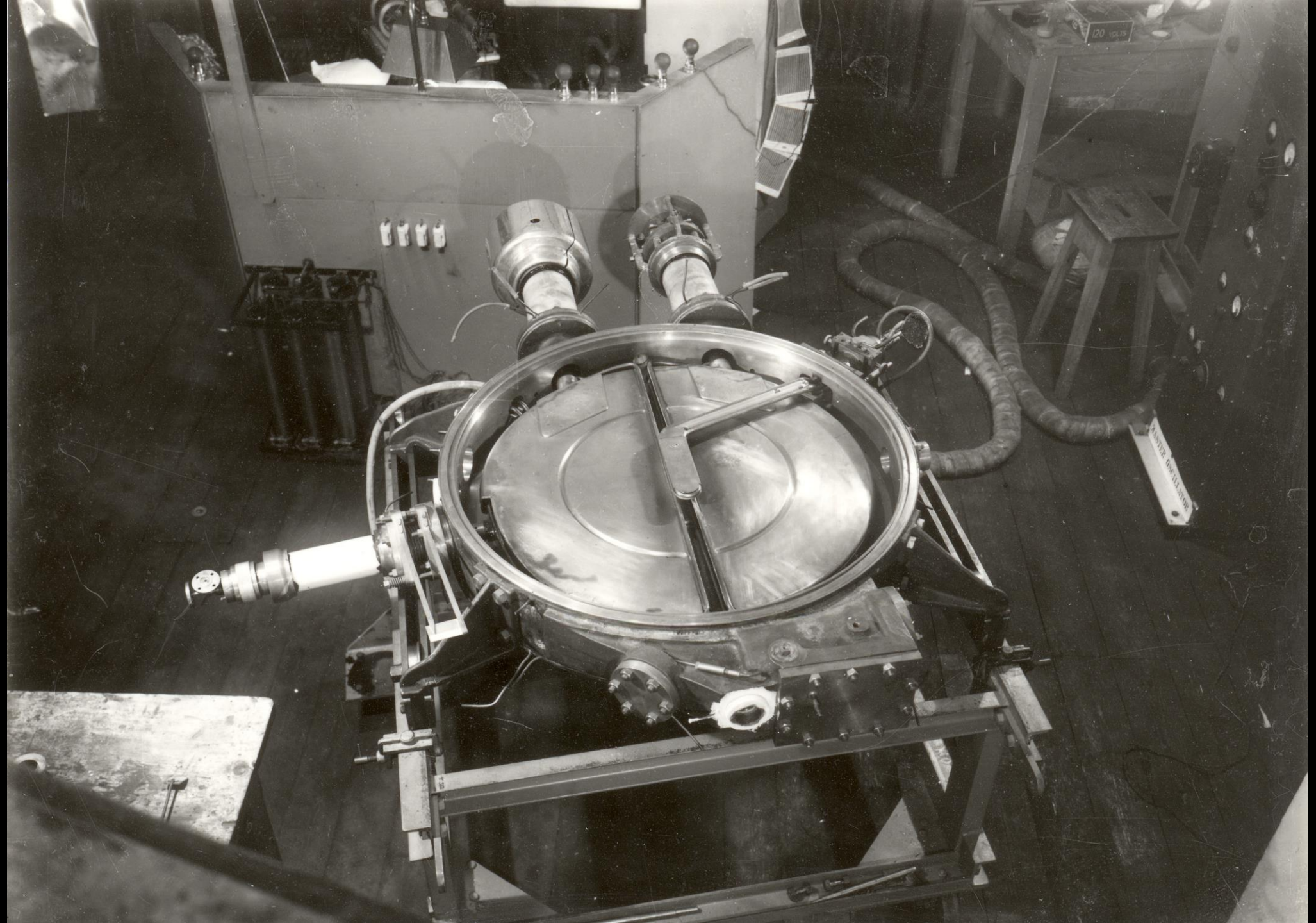
"Beware the adverb. It is the bad writer's favourite weapon! Why use it at all when there is a more accurate verb or adjective – and there usually is – at your disposal?"

Another comment was: "This section is riddled with clichés, Dad. You're beginning to sound like Trevor Quirk!"

"There is a significant improvement from the previous draft. The prose is clear and concise, unfettered by needless adverbs, and the style is clean and consistent throughout. Overall, I really enjoyed reading this chapter: it is an informative and engaging read".

7.

What role did the illustrations play in the project ?



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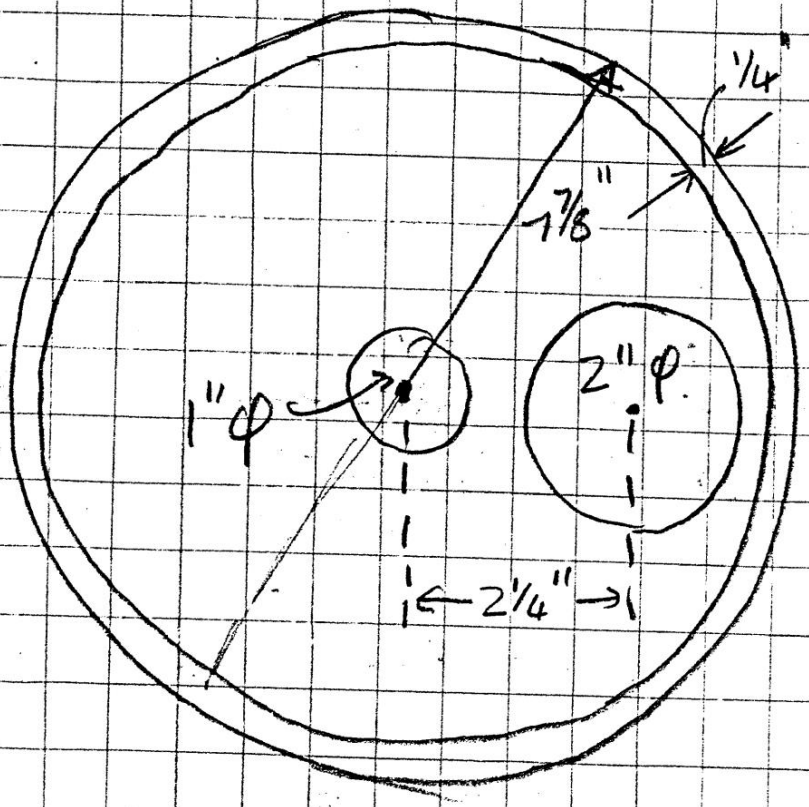

Outer ring + 2 centre pieces Al

Rest lucite.

Max absorber: $2" + 1" + 2 \times \frac{1}{4}"$ Al $= 3\frac{1}{2}"$ Al

$7\frac{7}{8} - 3\frac{1}{2} = 4\frac{3}{8}"$ lucite.

Table $\mu_{Al} = .146\ cm^{-1}$

$\mu_{lucite} = .067$.

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8.

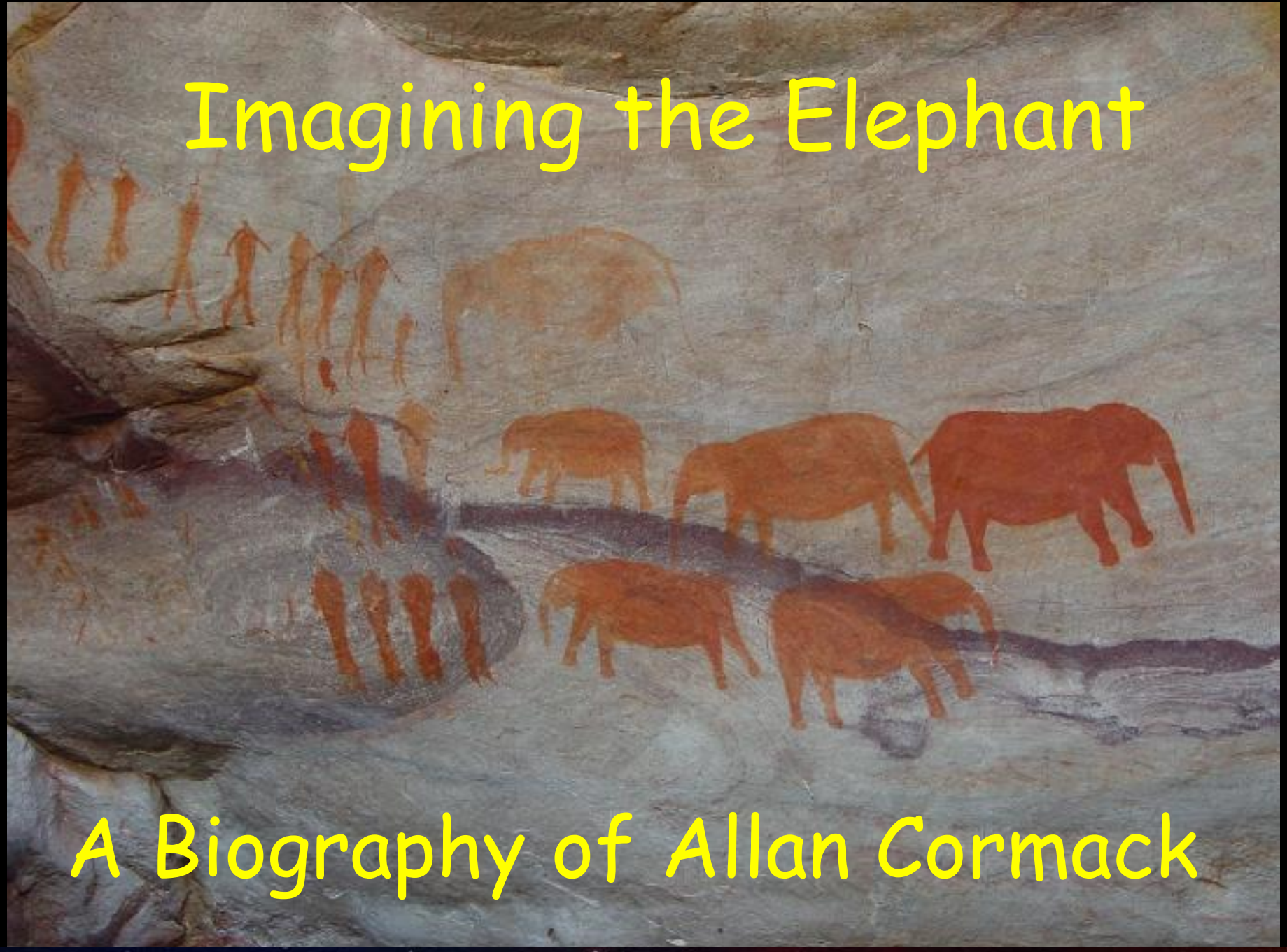
Was it difficult to come up with a title that captured the essence of the book ?

It was six men of Indostan,
To learning much inclined,
Who went to see the Elephant
(Though all of them were blind),
That each by observation
Might satisfy his mind.

John Godfrey Saxe

"Bob Marr and I toyed briefly with the idea of a follow-up meeting, until we realized that, unusually for scientific meetings, the first one had been so successful that another one was not needed - like the proverbial six blind men, we had all recognized the elephant together"

Paul Lauterbur



Imagining the Elephant

A Biography of Allan Cormack

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9.

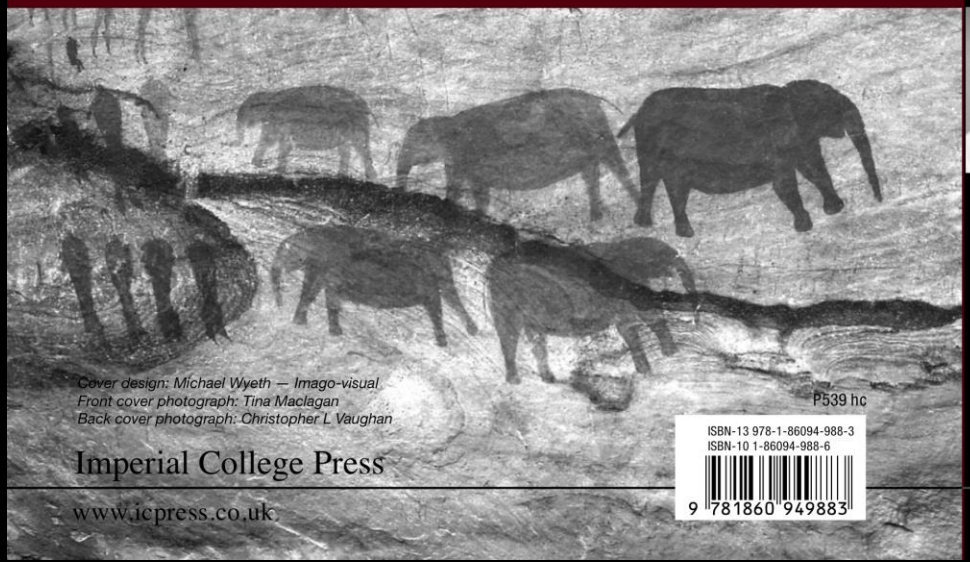
Should you judge a book by its cover ?

Imagining the Elephant

A Biography of Allan MacLeod Cormack

Imagining the Elephant is a biography of Allan MacLeod Cormack, a physicist who was awarded the Nobel Prize for Medicine in 1979 for his pioneering contributions to the development of the computer assisted tomography (CAT) scanner, an honour he shared with Godfrey Hounsfield. A modest genius who was also a dedicated family man, the book is a celebration of Cormack's life and work. It begins with his ancestral roots in the far north of Scotland, and then chronicles his birth and early years in South Africa, his education at the University of Cape Town (UCT) and Cambridge University, and his subsequent academic appointments at UCT and Tufts University in Boston, USA. It details his discovery of the problem at Cape Town in 1956, traces his scientific footsteps all the way to Stockholm in December 1979, and then extends the odyssey to his pursuits beyond the Nobel Prize.

Christopher L (Kit) Vaughan has held the Hyman Goldberg Chair in Biomedical Engineering at the University of Cape Town since 1996, and currently serves as Director of the Medical Imaging Research Unit and Deputy Dean for Research and Postgraduate Affairs in the Faculty of Health Sciences. His research is funded by the National Institutes of Health in the USA and involves the development of a novel mammography system, based on digital X-rays, to detect breast cancer. In 2006, he was elected a Fellow of the International Academy for Medical and Biological Engineering.



Cover design: Michael Wyeth — Imago-visual
Front cover photograph: Tina Maclagan
Back cover photograph: Christopher L Vaughan

P539 hc

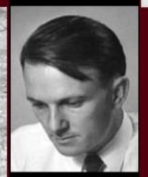
ISBN-13 978-1-86094-988-3
ISBN-10 1-86094-988-6

Imperial College Press

www.icpress.co.uk

Imagining the Elephant

A Biography of Allan MacLeod Cormack



Christopher L Vaughan

ICP

Imagining the Elephant

A Biography of Allan MacLeod Cormack

Christopher L Vaughan

Imperial College Press

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10.

What was the most enjoyable part of the book launches ?

Book Launches

9 Jun 2008 Cape Town, South Africa

31 Jul 2008 Cambridge, England

6 Aug 2008 Boston, USA

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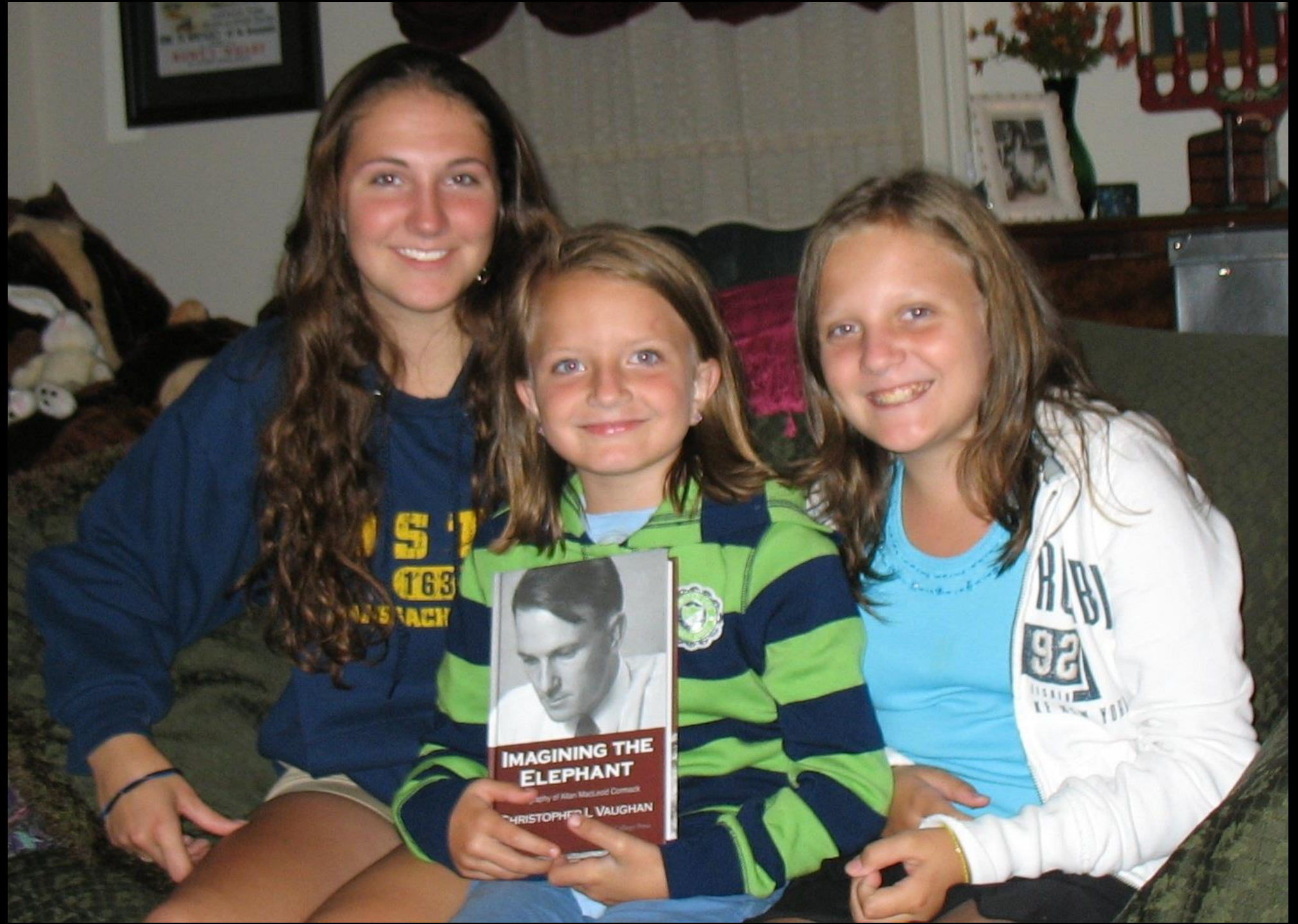

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11.

Have you had any book reviews that have surprised you ?

The NEW ENGLAND JOURNAL of MEDICINE

BOOK REVIEWS

IMAGINING THE ELEPHANT: A BIOGRAPHY OF ALLAN MACLEOD CORMACK

By Christopher L. Vaughan. 304 pp., illustrated. London, Imperial College Press, 2008. $48. ISBN 978-1-86094-988-3.

The narrative is written in an accessible style that aims at an audience wider than the scientific community alone, but when scientific discussion is called for, it is done expertly and lucidly. Those interested in the history of science are indebted to Vaughan for producing this wonderful biography of Allan Cormack and for creating an expert and vivid description of one of the two streams of discovery that led to the invention of CT.

12.

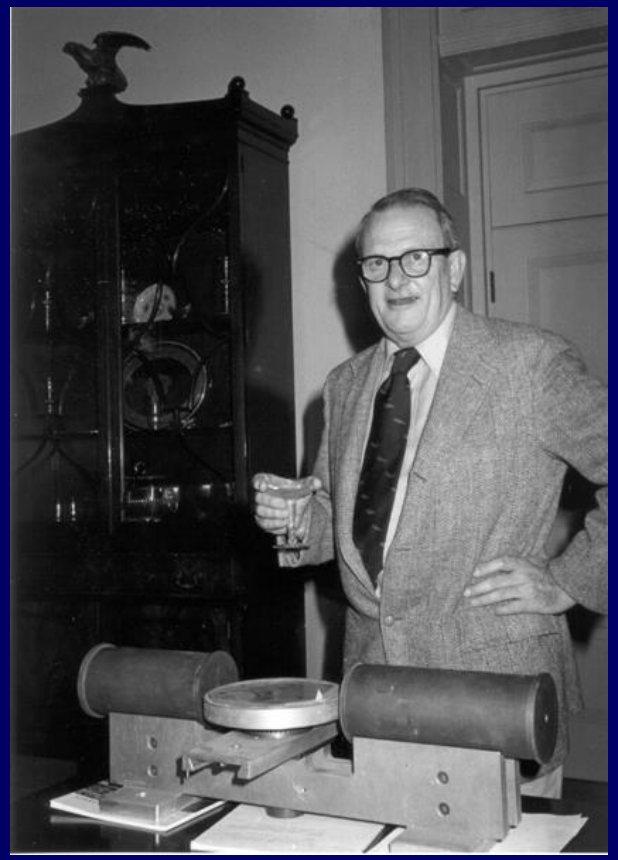
Do you have a favourite passage in the book ?

Two Favourite Passages

page 51 Climbing with Aaron Klug

page 209 A night at the Drake Hotel

Medical imaging – visualisation of the interior of the human body – began with the discovery of X-rays by Wilhelm Röntgen over 120 years ago.



The CT scanner is widely recognised as one of the major medical discoveries of the 20th century. As we begin the third decade of the 21st century, Allan Cormack continues to inspire us with the idea that it is possible to perform world-class research here on the southern tip of Africa.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