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Chapter 6
Miracles with very little money

The lathe-bed prototype and designing the Mk1 EMI-scanner

Bill Ingham describes Godfrey's early work on CT scanning as *miracles with very little money*. In October 1968 Godfrey's 3D X-ray project had funding and so he could begin building a prototype to test his ideas. He had only £5,000 instead of the £20,000 that he had asked for, so he had to be very careful with the funds. Instead of making a purpose-built prototype, he saved money by adapting the lathe that was left over from his large thin-film store project. The aim of the project was to prove *that the theory works in practice with currently available components*, by testing whether or not the scans were as accurate as he predicted. Using available components saved money, but it meant that the prototype scanner took a long time to take each scan.

34 COMPUTERISED 3D RADIOGRAPH

OBJECTIVE — TARGET DATE

PHASE 1

Construction of a simple test jig in which an object is rotated in front of a fixed radioactive source, measurements taken and accuracy assessed. Also preliminary study of the computer program for picture reconstruction. — March 1969

PHASE 2

Development of computer program and construction of a picture of a known test object by computer.

PHASE 2 is not yet financially supported; it is hoped that this will be obtained from the Ministry of Health.

Quarterly report, 31 October 1968
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Godfrey's first test used gamma rays from a small radioactive source. If radiation (also known as a beam of photons) is generated by an X-ray tube it is called X-rays, but exactly the same photons coming from a

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radioactive source are known as gamma rays. Using gamma rays costs less than using an X-ray tube. The source contained americium, which emits a beam similar to a medical X-ray tube. The source and detector moved backwards and forwards, driven by the lead screw of the lathe. They passed on either side of a turntable, which rotated in one degree steps until a full 180 degrees had been covered. The object to be scanned was placed on the turntable. The measured data was punched onto paper tape and then fed into a mainframe computer. The americium source gave a much smaller number of photons per second than an X-ray tube, and so it took nine days to take a picture. It was a far cry from modern CT scanners in terms of speed.

Incidentally, the pitch of the lead screw in the lathe set the distance between the X-ray beams, and it was the reason why the picture was 80×80 points.

Filming the lathe bed
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This photo was taken during the filming of EMI's "Scanner Story" in 1977. It shows the lathe bed mounted on a wooden bench. Left to right are Stephen Bates, Peter Langstone, and Godfrey. The lathe-bed prototype is currently on display in the library at the BIR.

In the following photo, the X-ray tube is at the top left, a pickled brain is in the centre, and the detector is at the bottom right. The detector is a sodium iodide crystal, which converts X-rays into visible light, followed by a photo-multiplier. The brain is in a box filled with formaldehyde

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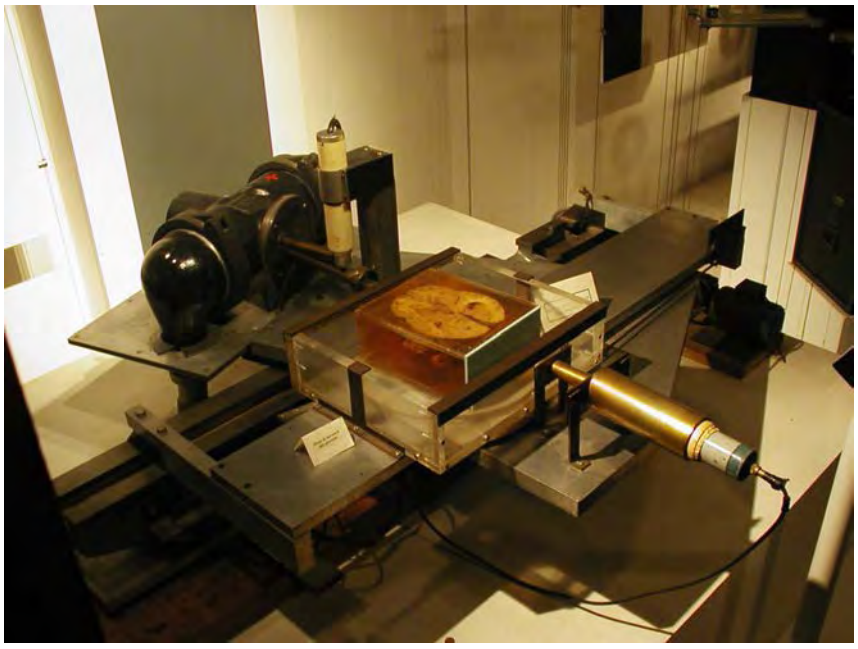
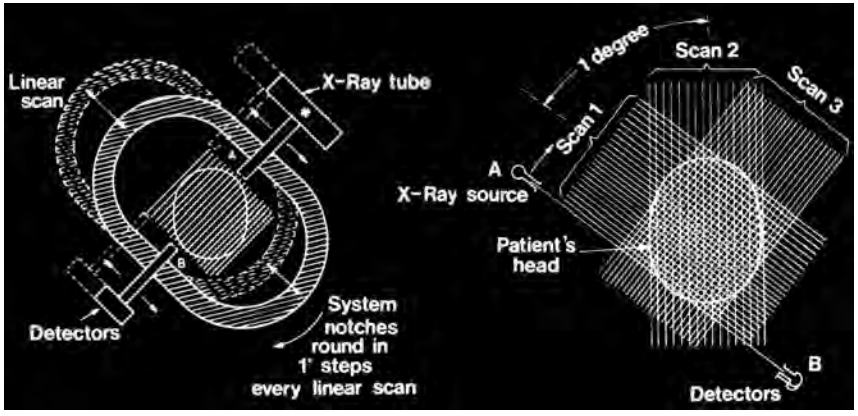


The lathe bed and pickled brain
(Courtesy of Peter Walters)

surrounded by a larger clear plastic box which can be filled with water. The water keeps the X-ray readings within a small range.

The X-ray tube and detector are driven from side to side across the plastic box, and then a turntable (with the brain on it) rotates by one degree. This process repeats until the turntable has rotated 180 degrees. The reason why Godfrey needed side to side movements and rotation is shown in the following diagram. The right-hand half of the diagram shows what Godfrey was aiming at. Each of the "scan 2" vertical lines through the patient's head is an X-ray beam that measures the absorption of the parts



Method for scanning the brain
(Copyright EMI Music)

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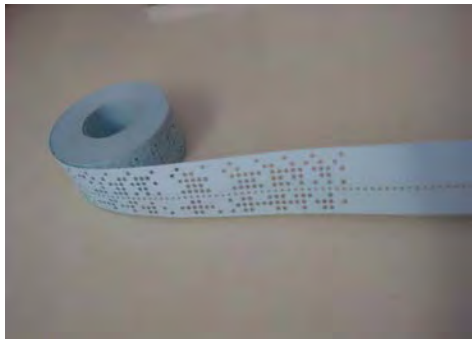
of the brain along that line. Those vertical lines are measured during the side to side movement of the scanner. Godfrey's brain scanner, and his lathe-bed prototype, repeated this side to side movement many times, with a one degree rotation after each one. This measures other paths such as "scan 3" in the diagram.

The left-hand half of the diagram shows that when scanning a living patient, the whole scanner rotates around the patient. In the lathe bed the pickled brain was rotated on the turntable, which is the easiest method when the brain is not attached to a living body.

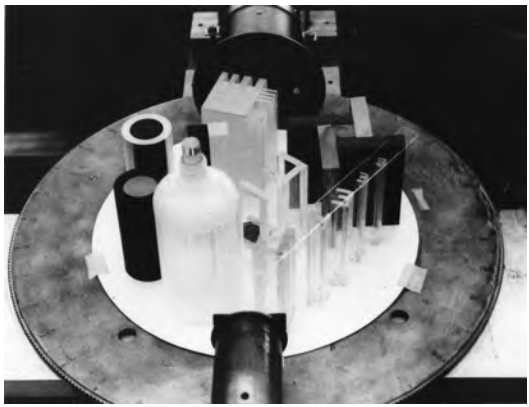


X-ray measurements from the lathe bed were stored on paper tape
(Photo courtesy of Richard Waltham; tape courtesy of Terry Froggatt)

The project had little money, so Godfrey borrowed a paper-tape punch to store the data. Measuring the absorption at 160 positions during each side to side scan and repeating that at 180 different angles gave 28,800 readings for each CT scan. This used about sixty metres of paper tape for each scan.

The reconstruction method was steadily improved from November 1967 onwards. Stephen Bates says that *the subsequent feasibility study extended the size of the matrix to the maximum that could be achieved using the time-sharing system due to its inherent memory limitations. I no longer have notes on this phase of work but I believe that the maximum*

Gamma ray scan



Test objects on the rotating turntable

(Both photos copyright EMI Music)
This scan shows objects in a different layout from those on the right.

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size achieved was 32 by 32. Artificial random noise was added into the simulated edge readings in order to better represent a real situation with noise present on physical readings. All of this again suggested that Godfrey's idea was robust and capable of generating a practical system.

A gamma ray scan was taken in about February 1969.

There was no way of viewing the scan as a picture at this stage, so it was viewed as a printout of numbers. The photo on the previous page was taken several months later, after the DHSS had contributed towards the cost of constructing a viewer and buying an X-ray tube. The X-ray tube helped the lathe bed to more accurately model the proposed clinical scanner. It was low power to save money, and it shortened the time for taking a scan to nine hours.

Gordon Higson described the project from the DHSS viewpoint*: The Department of Health first became aware of CT scanning when Cliff Gregory was visited by Godfrey Hounsfield of EMI during 1968 and was introduced to Hounsfield's ideas for obtaining sectional pictures of the body by the use of a narrow beam of X-rays. He had in mind the location of tumours of about 1 mm in size and the use of his technique for mass screening and he came seeking a first view of the clinical potential of the technique. Gregory steered him away from the idea of mass screening and suggested that the application of the new technique to the location of abnormalities of the order of ½ cm size in the brain should be the first priority. In October 1968, EMI submitted a formal request to the Department for support of the costs involved in proving the feasibility of Hounsfield's ideas and examination of this was a job that was given to me when I joined DHSS.*

In January 1969, Gregory, myself and Dr Evan Lennon, a radiologist who was at that time on the staff of the Department, visited the EMI Laboratories at Hayes to discuss the scheme and see Hounsfield's equipment in action. At that time it consisted of a gamma-ray source and a Geiger tube detector, both fixed, and an old machine tool indexing table on which the specimen was mounted.

The equipment took about two days to examine a specimen and the first pictures were of various metal and plastic objects in a bowl of water. The feasibility study on which we eventually agreed was aimed at developing this equipment into a form in which biological specimens could be examined which involved changing to the use of an X-ray source in place of the mono-energetic gamma-ray source and the use of a CRT for picture display. We agreed a programme which was expected to take about six months with the relatively modest cost shared between EMI and DHSS. [Extracted from Higson G. Personal recollections. BIR Bulletin 1979;5(1).]

Evan Lennon's comment after visiting EMI in January 1969 was, *I remember being struck by the simplicity, not to mention crudity, of what was on view*. They asked Godfrey what a clinical scanner could do, and