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The Beginning of CT Scanning—A Personal Recollection

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Computerized tomography (CT scanning) has been given considerable publicity in recent years and large sums of money are being spent on the purchase of equipment by hospitals all over the world in addition to that being spent by manufacturers on the development of newer machines with faster scanning times. CT scanning is now a multi-million pound industry and it seems appropriate to recall the very modest beginnings of this activity and the progress made over a very short period.

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 $\frac{1}{2}$ 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. This equipment is shown in Fig. 1 and is now on display in the lobby of EMI's Central Research Laboratory.

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.

Although it took a little longer than had been forecast, the feasibility study achieved all that it had set out to do. By August of 1969 Hounsfield had obtained CRT pictures of simple objects and by November 1969 the feasibility study was completed. Among the specimens that had been examined was a human brain containing a tumour and the picture revealed the tumour clearly. The feasibility of the system had been clearly demonstrated and the next step was to establish how useful this technique would be in clinical practice and in particular whether the additional information which could be obtained over and above that obtained by conventional techniques was clinically significant.

We decided that the Department should invite three clinicians specializing in different areas of radiology to carry out a critical examination of this system by submitting a variety of specimens for examination on Hounsfield's rig and verifying the resulting photographs by sectioning the specimens and comparing what was seen with what was shown on the X-ray pictures. We invited Dr. James Ambrose (Atkinson Morley's Hospital), Dr. (now Professor) Frank Doyle (Hammersmith) and Dr. Louis Kreel (Northwick Park) to take part in these tests and we

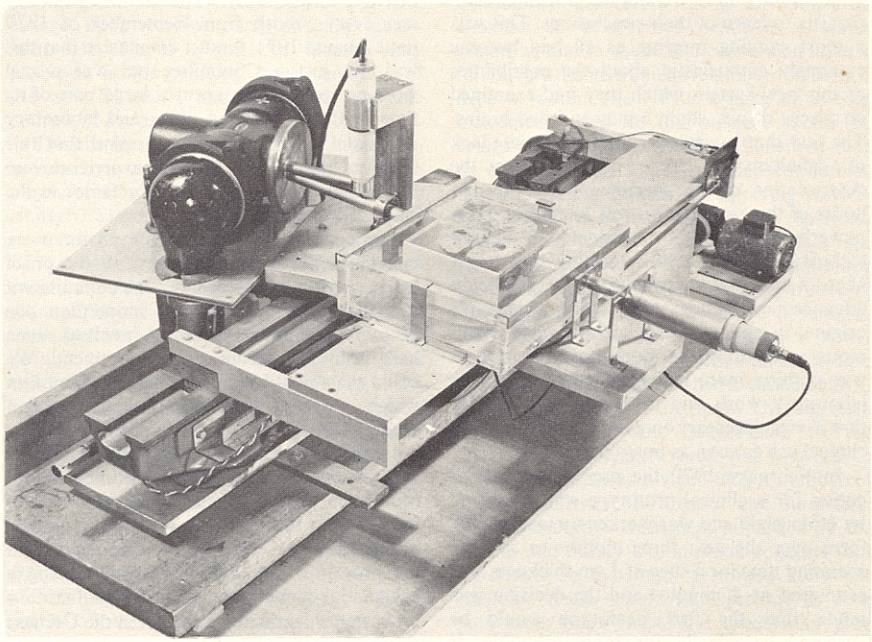

Fig. 1. Laboratory lathe-bed X-ray scanner with portion of pickled human brain in specimen position. (Photo courtesy of EMI Ltd.)

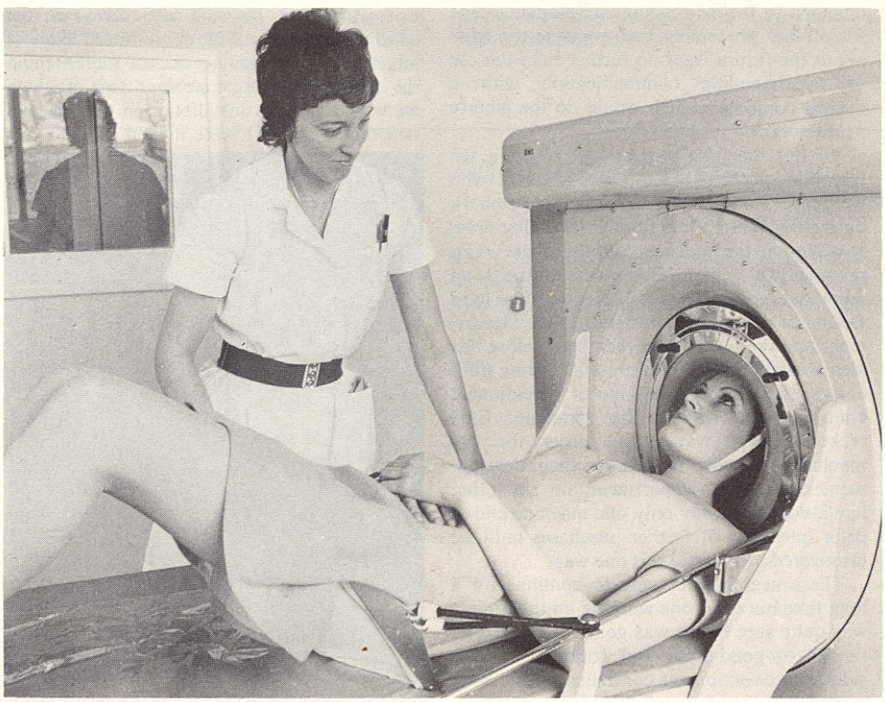

Fig. 2. Mk 1 brain scanner installed at Atkinson Morley Hospital, September 1971 definition 80 × 80 later on 160×160. (Photo courtesy of EMI Ltd.)

agreed with EMI to share the cost of the "picture service" again on a 50/50 basis. It still took 24 hours to scan a specimen. The detector readings were recorded on punched paper tape which then had to be taken to the big EMI computer for processing. This produced yet another paper tape which was used to control the CRT display. Nevertheless, even then the pictures were being calculated and displayed on an 80 × 80 matrix with absorption coefficient accuracies of about 2 or 3%.

In January 1970 we met with the three radiologists to learn of their conclusions. This was a most exciting meeting as all had become extremely enthusiastic about the possibilities of this new system which they had examined on pieces of pig, some bones and two brains. The fact that it was possible to associate lack of definition on some pictures with the deterioration of the specimen during the 24 hours of the examination was one of the most powerful indicators of the potential of the new technique. It was at this meeting that I first heard it said that this was the most significant advance in radiography since Röntgen's original invention. The clinicians were unanimous in assuring the Department that there was nothing more to be gained from further laboratory work and in urging us and EMI that it was necessary to get an equipment into clinical use as soon as possible.

In February 1970 the provisional specification for a clinical prototype was submitted by Hounsfield and was worked up into its final form over the next three months or so. The scanning time for a slice of 1 cm thickness was estimated as 4 minutes and the decision was made that the first prototype would be designed specifically for brain scanning. It must be remembered also that there was no thought at this time of having a computer integral with the scanner. The machine was intended to record readings on magnetic tape for off-line processing and even the thoughts about the future went no further than the use of telephone-line communication with a central computer which would do the picture processing.

By this time the project had come to the attention of the EMI top management who were far from sure that they wanted to embark on a risky venture in a totally unfamiliar area. It was some time during 1970 that there was a possibility of selling off the whole idea to an American company and it needed some hard talking between the senior staff of the Department and the EMI board members before this idea was dropped. We were still having difficulties, though, over the kind of development contract that was to be arranged. EMI reckoned they wanted an order for five machines in order to recover their development costs. The Department, on the other hand, wanted to buy only one machine and to defer questions of further purchases until we discovered how useful this one was.

These negotiations were to continue for a long time but everyone working on the project was quite sure that it was going to go on and, thanks to good faith and courage on both sides, the development continued apace. EMI were very conscious of their lack of experience in the medical field and were keen to take all the advice they could get. It was decided to set up an advisory team to review EMI's design work on the prototype. This consisted of Evan Lennon, Owen McCabe, an engineer from our X-ray Section, and myself from the Department; Brian Keane, a hospital physicist from Royal Sussex County Hospital, and Dr. James Ambrose from Atkinson Morley's Hospital which had been chosen as the home for the prototype, plus, of course, Godfrey Hounsfield and various members of his design team as it grew over the ensuing months.

This key advisory team came together for the first time in July 1970 and subsequently met every month from September of 1970 until August 1971. I must emphasize that this was not just a Committee but was a real working team which spent a large part of its time in EMI's drawing office and laboratory and there is no doubt in my mind that this infusion of practical hospital experience into the design process was a major factor in the success of the prototype.

Although those close to the project were convinced of its eventual success, the proof lay in clinical experience and the commitment of public funds to anything more than one prototype without this proof involved some hard thinking within the Department. We could see a possible commitment of about £¼m which was big money in those days and a major share of our R & D budget. Eventually a compromise began to emerge between EMI and ourselves whereby the Department would order one prototype and place a "letter of intent" for a further four which would only be confirmed after satisfactory experience with the prototype, so EMI were also making a substantial commitment as an "act of faith".

At that time the total market in the UK was thought to be about 12 machines. Eyes began to turn towards the USA and near the end of 1970 EMI decided to build a second prototype at their own expense to place in the USA. Following this decision the form of the contract changed a little more. Our "letter of intent" was changed to one of underwriting the costs of the four machines, two of which we would take for installation in the UK and two of which EMI were invited to sell overseas. Provision for the recovery of our investment by a royalty agreement was also built into the contract. In the event this contract was not signed until July 1971 but the work was going on all the time and the prototype was installed in Atkinson Morley's Hospital in September 1971 (Fig. 2).

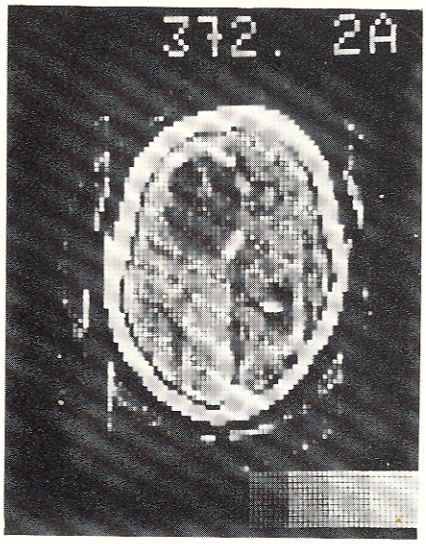

Fig. 3. Early brain scan on Mk 1 Atkinson Morley machine, showing tumour. (Photo courtesy of EMI Ltd.)

I left the project early in 1971, my place being taken by Dr. Norman Slark, still under the direction of Cliff Gregory, but the story would not be complete without adding a few things that happened after that time. In October 1971 the first clinical pictures were taken (Fig. 3). Remember that readings were collected on magnetic tape during the course of the day and taken to EMI's factory at Hayes for processing during the night. A processed tape was then taken back in the morning so that the clinicians could view the results of the previous day's examinations. By February 1972 we had received a report from Dr. Ambrose which described the scanner as successful and we were able to confirm our "letter of intent". It was also at about this time that it was decided that local processing would be necessary and also that programming developments made this feasible.

In April 1972 Godfrey Hounsfield and James Ambrose described the EMI scanner and the first clinical results to an excited audience at the Annual Congress of the British Institute of Radiology. The story from there on is told in more than 1000 papers published to date. CT scanning is practically an industry in itself. More than 1200 scanners are installed world-wide. Professional meetings concerned only with CT scanning are commonplace and two international journals devoted exclusively to this subject are published.

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