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Memoirs of a Computer Pioneer

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developed the practice of recruiting university graduates and training them for managerial duties at a time when this was rather unusual in British industry. They had a reputation for being go-ahead and Thompson and his colleague had just come back from a tour of the United States where they had been on the look-out for new ideas. They had heard about digital computers and had at once perceived the value that these machines might have for business purposes. However, unlike others who saw computers as having value principally for large-scale record keeping in banks and insurance companies, Thompson felt that they would have immediate application for the more mundane forms of business accountancy such as payroll preparation. He met various people in the United States who were working in the computer area, but none who could help his company acquire a machine within a reasonable time. One of the places that he visited was the Institute for Advanced Study at Princeton, and it was there that he learnt from Goldstine of our existence. Hence the visit. Thompson recalled later that I showed him some pulses on a cathode ray tube and remarked that I was not entirely satisfied with their shape. Although Thompson had had a scientific education—he had obtained a first class with a distinction in Schedule B in the Mathematical Tripos at Cambridge—he was no engineer, and comparing our pulses with some very inferior ones that he had seen at Princeton, he was led to ask the question "Are they too square?" However, it soon became clear both that we had created a good impression and that Lyons were serious about computers. On 11 November we had a visit from a deputation led by Mr G. C. Booth, a very senior and almost legendary figure in Lyons—at that time he was over 80—and including besides Mr Thompson and Mr H. H. G. Bennett. Mr Booth quickly came to the point. They would like to contribute to our funds to the extent of £3,000 and give us the services of an assistant for a year if we would in return undertake to put them in the way of constructing a computer for their own use. This was a most generous offer and I had no hesitation in accepting it at once. The sum may not sound a large one by modern standards, but it came at a moment when the natural growth of the project would have been checked if further money had not become available. Lyons were as good as their word. In a couple of days' time I had the cheque, which I sent straight on to the University Treasurer, and an official announcement appeared in the University Reporter on 2 December. The custom was still maintained in those days of adding the names of those who made gifts to the list of benefactors of the University, and I think that it caused Lyons some surprise, but I hope also pleasure, when the name of

their company was so added. The assistant that Lyons had promised us was Mr E. G. Lennaerts and he joined us without delay. He had been pulled off another project on which he was working, namely the automatic vending of sausages cooked, or rather re-heated, to a sizzling state by a diathermic furnace. He stayed with us for a lot more than the year originally contemplated and helped us a great deal. Later Lyons made him their maintenance manager.

The connection between Lyons and Cambridge was strengthened when Lyons were joined by J. M. M. Pinkerton, who became the chief engineer of their computer project. Pinkerton, like so many of us, had worked on radar during the war, and was at the relevant time finishing his Ph.D. thesis at the Cavendish Laboratory. He was working under Ratcliffe on the physics of ultra-sonic wave propagation in liquids, and I had cultivated his acquaintance when I was designing the mercury batteries, although the tempo of the EDSAC project was such that I had to be careful not to be drawn into interesting physical byways. I was delighted when Pinkerton decided to accept the offer that Lyons made him, since I felt that the engineering side of their activities would then be in safe hands, and this indeed proved to be the case. While with Lyons, Pinkerton was responsible for the design of LEO 1 and also for the successor machines LEO 2 and LEO 3.

In the years 1947 and 1948 the important thing was to press ahead with the project that had been started. The lines on which it should proceed were early determined, and no radical change was possible even if it had been desirable. We kept contact with other British groups working in the area, but they too were preoccupied with their own projects. From time to time information came through about the progress being made by groups in the United States, but we were not in close touch with them. Starting in April 1949, the United States Office of Naval Research began to issue a news letter which proved of great value as a channel of communication.

When the EDSAC project was well under way I paid a visit to Manchester. Williams and Kilburn gave me a run-down of what they were doing and then asked how it compared with what we were doing. There was, of course, terminology apart, little difference except for the fundamental one that they were using a cathode ray tube memory instead of a mercury memory. The project at Manchester had, in fact, grown out of original research on the cathode ray tube memory initiated by Williams when still at TRE. Like everyone else who had considered the design of a memory based on a cathode ray tube, Williams realized that the pattern of charge used to store the information would need regeneration from time to time as leakage took place. The originality

built. To Renwick, however, fell the main load of incorporating them in the growing machine and making them work. Often retrospective modifications to what had been built were necessary as further experience brought weaknesses to light. Eckert had made the remark in a lecture at the Moore School before I arrived that the ENIAC was designed in a considerable hurry. The same was true of the EDSAC. I computed that, if we had given the same attention to the design of the individual units as can be given to the design of a radar set or a television set, construction would have taken over twenty years. One had to cut corners and accept any unit that did its job even if one felt that the design was not optimal. Some of the units, such as the storage units (Panel 1), were repeated many times, but most of the units occurred in small numbers or were unique. The same circuits were, of course, used repeatedly on the panels but often with small changes, since we simply did not know enough at that time to achieve standardization. The EDSAC was like an early hand-built motor car in which parts were not interchangeable. The stage at which computers could be built from standardized and interchangeable plug-in units, each containing a number of gates and flip-flops, had not then been reached.

In spite of the bad weather at the beginning of 1947, and continuing post-war shortages, we made surprisingly rapid progress. Towards the end of May 1947, following a short course of lectures that Hartree had given in the University, I gave a demonstration of pulses circulating in a mercury tank. By that time we had a rack half full of tested chassis. At that time I was busy designing a "half adder". This occupied one chassis, and there were ultimately four of them in the machine altogether, two in the accumulator connected so as to constitute a full adder, one for counting words as they went by in a memory tank, and one for the program counter. I shall never forget the thrill I experienced when the half adder worked for the first time and I saw, on a cathode ray tube, the characteristic pattern of binary counting. I had had some difficulty in getting the half adder going and this made me realize that a circuit engineer coming to digital engineering for the first time had a few things to learn. In particular it was necessary to design the circuits so that they would handle transients correctly. In radar and television the waveforms could be treated as though they were recurrent, and this problem did not arise. I wondered how easy it was going to be to communicate the new know-how to other engineers; in fact, when the time came, it spread like wildfire.

Towards the end of July 1947 we had a visit from Mr T. R. Thompson and a colleague from J. Lyons and Company, the caterers. Lyons had