

Computer Conservation Society

Aims and objectives

The Computer Conservation Society (CCS) is a co-operative venture between the British Computer Society, the Science Museum of London and the Museum of Science and Industry in Manchester.

The CCS was constituted in September 1989 as a Specialist Group of the British Computer Society (BCS). It is thus covered by the Royal Charter and charitable status of the BCS.

The aims of the CCS are to

- ◇ Promote the conservation of historic computers and to identify existing computers which may need to be archived in the future
- ◇ Develop awareness of the importance of historic computers
- ◇ Encourage research on historic computers and their impact on society

Membership is open to anyone interested in computer conservation and the history of computing.

The CCS is funded and supported by a grant from the BCS, fees from corporate membership, donations, and by the free use of Science Museum facilities. Membership is free but some charges may be made for publications and attendance at seminars and conferences.

There are a number of active Working Parties on specific computer restorations and early computer technologies and software. Younger people are especially encouraged to take part in order to achieve skills transfer.

Resurrection

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News Round-Up

The 2001 AGM of the Society will be held on Thursday 17 May at the Science Museum, starting at 1430. The Pegasus seminar will follow.

- 101010101 -

It has been a bad winter for computer pioneers. Most notably, we lost Tom Kilburn in January. A memorial service for him was held in Manchester on 1 May. Our appreciation of his immense contribution to computing history can be found on page 6.

- 101010101 -

Claude Shannon, the man credited with inventing the bit, died in February at the age of 84. He was one of a small handful of brilliant academics whose work made the computer possible, providing the mathematical foundation for modern information theory.

- 101010101 -

Leo pioneer Leo Fantl died last November aged 76. After joining Lyons in 1948 Leo became a trainee programmer in 1950, and became one of the unsung heroes who turned the innovative Lyons concept into a practical reality. In 1960 he was appointed General Manager of the joint Leo venture with Road Mines in South Africa. He went on to become chairman of Leo Computers in South Africa, and later Managing Director of Sage Computers.

- 101010101 -

Computer Weekly journalist Roisin Woolnough paid a visit to Bletchley Park in March to discuss the Society's Bombe project with John Harper and the Society's exhibits in H Block with John Sinclair. Her articles on these subjects appeared in the newspaper's 5 April and 12 April issues.

- 101010101 -

The last Honeywell Multics systems has retired. Multics was one of the world's first effective multiuser operating systems, and it also set new standards of security. It is said that the name Unix was derived from it, as a pun. The last surviving Multics system was a 6800 which had been run by the Canadian Navy as the hub of its operational command control system. Installed in 1982, it ran continuously from then to 30 October last year.

- 101010101 -

The Secretary asks that members with email facilities who have not given him their address, or notified him of any recent change of address, should contact him at <hamishc@globalnet.co.uk>.

- 101010101 -

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How Should We Be Talking To You?

Hamish Carmichael

Your Committee has spent much time at recent meetings discussing policies for communicating with members. Should we use state-of-the-art technology to improve efficiency and reduce costs? What negative implications would there be? We invited you to give us your views in a questionnaire contained in the last issue. This article summarises the findings of that questionnaire, and the thinking that is emerging as a result. Our proposals are still subject to change: we will put our final decisions to the membership for approval at the AGM.

Questionnaire Responses

We distributed the questionnaire via *Resurrection* issue 24 to the whole membership, which currently stands at 730.

The response was phenomenal: 222 completed forms, representing nearly one third of the membership. We see this as an indication that members are very keenly interested in the welfare of the Society.

Question 1 concerned members' attitudes to a possible annual subscription of £10. The results: 155 (70%) said it would be acceptable, and a further 62 (20%) reluctantly acceptable. Nine (4%) said it would be unacceptable, and eight more (4%) said it would cause them to resign. A few recommended a lower subscription rate for BCS members, or for members prepared to pay a five year subscription.

Two issues arose where we need to set the record straight. One respondent said it was disgraceful that the BCS was not supporting the Society: in fact the Society receives the highest level of grant permitted under BCS rules. Another asked whether the Committee had considered seeking sponsorship: we can assure readers it has been a dominant factor in discussions at every Committee meeting for the past three years.

Question 2 asked whether members have access to the Internet. The result: 185 (83%) do (a few with qualifications), while 33 (15%) do not.

Question 3 asked whether members would be prepared to accept an online version of *Resurrection*. The results: 158 (71%) said Yes; 80 (37%) said they would insist on receiving a paper copy, of whom 54 (24%) said they were prepared to pay for it. Some of the 158 Yes voters said they

would still prefer a paper copy. To satisfy the requirements of all the Yes respondents, *Resurrection* would have to be made available online in at least five different formats.

Question 4 asked whether members would be prepared to receive meeting notices by email. The results: 191 (86%) said Yes, while 27 (12%) said No. Many of the Yes voters said they would prefer to receive notices this way, and several said they would like to be notified by email whenever an online *Resurrection* was produced.

Members with access to email were invited to tell us their email addresses. Adding these to those we already knew yielded a total of 281 addresses.

We then sent a test message to all 281 addresses. It reached 230 members (82%), but not the other 51 (18%). Investigation found there were a variety of reasons for this. Some had changed their ISP; others had written their email addresses illegibly on the questionnaire form, and our attempt at deciphering them was wrong; others had addresses that could not be accessed.

Proposals

The mere idea of a subscription has not offended as many members as the Committee had feared. We assume the respondents' view is typical of that of the membership of the whole. On this basis the Committee proposes to recommend that a voluntary subscription of £10 per annum be adopted as the norm, and that the invitation to pay be worded as a request for a donation, in conjunction with Gift Aid forms to be accumulated with those already held.

We further propose that the membership database be extended to record all Gift Aid forms and payments received from members; and that no member should be forced to resign rather than pay a subscription.

Recognising that a large number of you are not yet online, and also that the publication has attained significant academic status, we intend to continue to publish *Resurrection* on paper. At the same time, we plan to improve and accelerate the conversion of each issue into online form.

Our email experiment has convinced us that a significant number of members cannot be reliably contacted that way. We plan therefore to continue sending out meeting notices and other similar communications on paper for the time being.

Tribute to Tom Kilburn

The computer industry lost one of its most celebrated and distinguished pioneers when Tom Kilburn died on 17 January 2001 aged 79.

We thought the best way of commemorating Tom's immense contribution to our profession was to ask one of his former colleagues to pen a personal reminiscence. This is Peter Hall's tribute:

"Tom and I were the principal players in the long lasting and most fruitful partnership between his group at Manchester University and the computer development team at Ferranti. It began in 1948: I did not come onto the scene until the late 1950s, but I was familiar with the team's work, and had known Freddie Williams since our days at TRE during the war. Our similar wartime backgrounds helped, I think, to establish the relationship between Tom and I. The two teams worked together with the minimum of formal relationships, and our success depended on the trust between the two of us.

"Tom was an inspirational leader, always supporting his team and fighting for their due recognition. Nevertheless he always welcomed seconded members of the Ferranti team, so much so that it seemed from my end that they usually went native! So it became that our staff were almost interchangeable, occasionally moving on to each other's books depending on who had the budget money!

"He did not always give us an easy time: why should he? I remember well the occasion, just before one Christmas, when he rang to say they had discovered a design fault in the Atlas circuit boards and he was sending them all (several hundreds of them) back for an additional diode to be wired into every circuit. This was a major job, but he wanted it done yesterday!

"Tom's real interest was, I think, always in hardware design. After he lost his wife it seemed he lost interest in things, and the sparkle went out of his life. It was very exciting therefore to be able to persuade him to start work again and assist Chris Burton in the rebuilding of the 'Baby' for its 50th anniversary in 1998. One of my most vivid memories from that year was of my two dear friends, Tom, and Charlie Portman from the Ferranti team, poring over the cathode ray tube trying to make out why it did not work. Eventually, of course, they did get it going! Sadly now both Tom and Charlie are no longer with us."

Obituary: Derek Milledge

George Felton

The Society has lost one of its most stalwart supporters in Derek Milledge, who died last year. His career in computing was marked by his dedication and thoroughness in tackling problems, and throughout it he derived great satisfaction from providing services to computer users.

Derek joined the Ferranti London Computer Centre in 1955. There he learnt programming for Pegasus and fully documented its software library, to which he contributed input/output routines, sorting programs and matrix applications. He gave valuable technical support to customers of the Portland Place computing service.

In 1960 Derek started working on basic software, assembler and operating system design for the Ferranti Atlas computer at Manchester University. He set up a computing service for Ferranti on the Atlas in 1962, recruiting and training all the operators, programmers and data preparation staff. He built the service into a profitable business, running four shifts for technical and commercial work.

From 1965 Derek managed the ICT computing services on the Manchester Atlas and the Birmingham 1301. He later installed ICL 1900 systems at both sites and built up commercial computing services on them, reputedly the first in the UK with a turnover of over £1 million a year.

He took over the George 3 operating system soon after its first release in 1969. This became the standard operating system for the larger 1900 machines, and for the later 2960 DME. He was responsible for emulation environments like DME, which allowed the 1900 operating systems to run on 2900 hardware.

Derek took his team to Bracknell in 1973, where he spent the rest of his career with ICL, ultimately becoming systems software manager in 1990.

From 1993 he played a key role in the Computer Conservation Society's work on Pegasus at the Science Museum, and was knowledgeable and persistent in helping to restore its full functionality. His other interests included philately and fine wines, and he was a keen cyclist.

Derek Milledge, software engineer, was born on 2 May 1930 and died on 26 July 2000. He is survived by his former wife Judith, the donor of the Science Museum Pegasus.

Obituary: Bill Elliott

Hugh McGregor Ross

Professor William S Elliott, or Bill Elliott as he was always known, died on 3 May 2000 aged 83. After graduating from Cambridge and some wartime work on radar systems, he became head of the computing division of Elliott Brothers (London) Ltd in 1946.

He wanted to improve the capabilities of manual calculating machines for computing the trajectories of a guided bomb, and this project resulted in the Nicholas computer, with nickel wire recirculating delay line store. This led to the Elliott 401 computer, which at the 1953 Physical Society Exhibition created a stir by operating correctly within two days of being installed there.

Elliott joined Ferranti in 1953 to set up its London laboratory. With no reservoir of people with experience of computers to draw on, Elliott's outstanding contribution was to identify suitable staff in other disciplines and attract them into his team, which by 1956 had grown to over 150.

Here he applied true engineering principles to computer electronics. Instead of merely tackling specific problems, he could foresee an overall engineering objective and guide his staff to develop the individual solution required. The Pegasus computer illustrated this talent: it was the first computer where the user was relieved of the burden of combatting unidentified machine errors.

In 1956 IBM asked Bill to set up and run a new research laboratory in Britain. The team he built up introduced mixed radix arithmetic, micro-programming (to enhance the instruction repertoire), and new solid state techniques to IBM.

In 1961 he moved to academia, joining Professor Maurice Wilkes at Cambridge. There he oversaw as Senior Project Engineer the construction of the Titan computer. This was a joint project with Ferranti, based in part on Atlas. Its object was to provide a computing service with timesharing facilities for the university.

His professional activities included valued contributions to numerous committees. He was a Fellow of the BCS, of the Institute of Physics, of the IEE and of the Royal Academy of Engineering. But it is as an outstanding British contributor to the early decades of the computer revolution that he will be best remembered.

Ferranti's London Computer Centre

Hugh McGregor Ross

Manchester played a key role in the development of the computer, but when it came to selling them Ferranti found it was just too far from the corridors of power. So the company set up a specialist sales and development centre in the heart of London. It was the first operation of its kind anywhere, and it proved indispensable in helping Ferranti create a market for the computer.

This story starts in 1948, when Freddie Williams' team at Manchester University ran the first stored program digital computer. Within two years they had moved on to make a prototype of a real computer. Ferranti was asked in 1950 to make a production version.

Sir Vincent de Ferranti recognised a business opportunity — he was perhaps the first person to see the commercial potential of the computer. It was in the tradition of his family to develop successful business from innovative technological developments in electrical engineering. So he agreed to produce the computer, which became the Ferranti Mark 1*.

Sir Vincent appointed Vivian Bowden to develop the opportunity. Bowden had a remarkably creative mind, a massive intellect and the special quality of being able to see right through any problem, to get to the nub of the matter. He dubbed himself 'the world's first computer salesman'.

It is hard to appreciate now that in 1950 practical uses for computers were virtually unknown apart from military applications. I can illustrate this with a little story I heard from Bernard Swann, which has not been published till now.

Bowden, while looking for customers who might be able to use and, it was to be hoped, buy one of these strange and enormous computing engines, thought of the Avro Aeroplane Company, creator of the famous World War Two Lancaster bomber. Like Ferranti, Avro was based in Manchester, and Sir Arthur Vernon Roe, the proprietor, enjoyed good relations with Sir Vincent de Ferranti.

So Bowden called on Sir Arthur, told him of this wonderful new machine, and expressed his vision that it could be used to help design aircraft. Sir Arthur listened attentively, but without in any way committing himself. When Bowden had finished, he said, "Go and tell my Chief Designer and his senior staff about it".

Bowden did just that. The designers did commit themselves: they said they could not see any use for the computer, and they did not want it. When Bowden reported this response to Sir Arthur, he retorted, “Go back and tell them they have GOT to have one!”.

In 1951 Bowden persuaded Bernard Swann to join Ferranti. It is a testimony to Bowden’s extraordinary powers of persuasion that Swann could be prised out of a senior post in the Civil Service (he was a permanent under-secretary at the Board of Trade) to join an activity that was at the time little more than a vision.

Bowden and Swann formulated a strategy, which had three elements. First, Ferranti was in the business of making computers, so a market for them had to be created. Second, to sell computers there had to be recognisable uses for them. Third, applications expertise was the key to success.

Here Swann was drawing on his wartime experience of introducing punched card systems to carry out statistical work for the army in India. There he learnt that it was easier for an army man to learn punched card techniques than for a punched card expert to learn about the army’s statistics. The two men set up an applications group in Manchester to implement this strategy, using the University’s own Mark 1 computer, known as MADM, which went operational in July 1951.

Creation of the London Centre

Within a couple of years Bowden and Swann realised it would be necessary to have a computing centre in London. Bowden had previously worked as a consultant in Westminster, while Swann had worked in Whitehall, so they knew personally most of the leading people in industry and commerce. They found that these decision makers would not travel to Manchester to see such a strange machine as a computer, though it was quite possible to persuade technicians to make the journey.

I came into the picture at this time. I joined Ferranti in September 1953, and was soon moved to London, where I was joined by Conway Berners-Lee and Harry Johnson, both with backgrounds in statistics and operational research, and by Chris Wilson, who later rose to the top of the management tree in ICL. To start with, we worked from improvised offices.

I was then told to set up a London Computer Centre. My remit was to choose a site with two characteristics. First, it must have a good address, to counteract the impression that computers came from a smutty factory

in the provinces. Second, it must have a room large enough to house a Mark 1* computer—which meant seriously large. A Mark 1* comprised two bays of equipment with a control desk between, occupying floor area of 20 by 15 feet, to which had to be added access space and room for much auxiliary equipment.

It was Bernard Swann who found 21 Portland Place. This building was in a 1780s Nash brothers development of a street of town palaces for the very wealthy. It had an imposing entrance with a marble floor, two large rooms downstairs (one with a fine plasterwork ceiling, which we used for presentations and programming courses), and curved stairs to the main room on the first floor.

This room was very grand, with extensive plasterwork and a ceiling painted by Angelica Kaufmann with cherubs and other conceits. The floor, built on great oak beams, could cope with 50 dancers at a ball, but the architects stipulated that a false floor using steel joists had to be built to support the heavy computer.

Meanwhile towards the end of 1953 the National Research Development Corporation asked Ferranti to take over Bill Elliott's packaged computer work and to develop a derivative of the Elliott 401 computer, with significant enhancements by Christopher Strachey, Donald Gillies and Elliott himself. This was to become the Pegasus.

Bill joined Ferranti at this time to set up a London laboratory, and his key men Charles Owen and Hugh Devonald followed him at the start of 1954. It was then decided that our Computer Centre would be equipped with the first Pegasus computer, instead of the planned Mark 1*.

During 1954 engineers, programmers, and applications and sales staff all worked from temporary accommodation while the Pegasus was being built in the Centre. We finally moved into Portland Place in January 1955. The engineers were given a large room, originally the children's nursery, which was on the floor above the computer room. That had the important consequence of establishing good relations between the engineers and the rest of the staff, which was to prove invaluable.

Ferranti started selling Pegasus in August 1955. The first program ran on our Pegasus in October, and we also gave our first programming course during that month. Pegasus was handed over to the users on 23 March 1956, an event that prompted a flood of visitors. Computer engineers came to meet Bill Elliott and his colleagues. Users and programmers also came. Swann brought in leaders of industry to impress them with the machine

in its high quality surroundings. It was very valuable that the engineers could join in the presentations we gave.

Working Practices and Initial Classes of Application

We encouraged cooperation between users of the machine. This policy was remarkably successful: the excitement of exploring the unknown overcame natural competitive instincts. We set up a user program interchange scheme — by late 1958, a document summarising the programs involved ran to 51 pages.

Drawing on Stanley Gill's experience with Edsac at the Cambridge mathematical laboratory, we built up a library of 180 subroutines, extensively tested to be free of error from exceptional conditions. We set up a documentation scheme covering new hardware, programs and applications in about equal proportions: each was written by the expert who was doing the work. After eight years we had about 400 documents, so we averaged one a week. This was by far the most comprehensive documentation activity of the time.

No special consideration was given to fire protection in the computer room, nor to the security of the building. George Felton tells how, when Pegasus was new, he would borrow a front door key on Friday evenings so he could get in during the weekends. Then, alone in the building, he would start up the computer to sum a series to calculate the value of π to a then record 10,024 decimal places. This was a good test of the reliability of Pegasus.

Later on, we accurately scheduled time on the machine so that a visitor could arrive and run his work without undue delay.

The tea room played an important role. Staff and visitors were encouraged to take morning and afternoon breaks at the same time. In this way news about applications and techniques was shared — news of both successes and failures. Thereby we avoided the burden of progress meetings and of reading and writing progress reports.

The first class of application in our selling technique developed as we had hoped it would. Vivian Bowden persuaded the Society of British Aircraft Constructors to set up an aircraft computer design committee. The main technical input came from the National Physical Laboratory, especially Wilkinson and Woodger, as a derivative of their work on the Pilot ACE. There were 10 men from aircraft design offices, and I took over from Bowden to explain what computers could and could not do.

I passed on the designers' requirements to our programmers. The work required the development of numerical analysis techniques, especially using matrices. In response we developed, under George Felton's leadership, an interpretative scheme to simplify writing of matrix calculations. We also developed the Autocode technology originated by Brooker at Manchester to permit quick writing of programs for problems that could be expressed as formulae — what we produced was a kind of forerunner to Fortran. We sold 10 Pegasus systems to aircraft firms.

Our second class of application led to an unexpected result. Bowden identified actuarial calculations, for life insurance and annuities, as a possible field of activity for computers. After much effort, he persuaded the directors of the Royal Insurance Company (Ferranti's insurers) to second one of their staff to study this possibility.

I still remember Tony Baker's look of terror on joining our group of crazy men and women. But he was an extremely capable actuary. After a few months study, he reported that computers were not suitable for actuarial calculations, but might substantially reduce the amount of paperwork in the life offices.

This prompted Ferranti to start development of magnetic tape as a storage medium. At the time digital recording on tape was not yet established. But by February 1958 we were able to publish a sales document for a magnetic tape system attached to Pegasus and demonstrate that it was operational at our Computer Centre. It was the first such system to be sufficiently free from errors to be satisfactory.

What surprises now is, first, the extent of the detail in that document about the means for attaining error-free operation; and second the absence of information about software techniques. We subsequently developed routines, largely under the guidance of Conway Berners-Lee, for sorting and for updating files with amendments, the most fundamental process in modern data processing. We sold 14 Pegasus computers configured with magnetic tape systems.

Our third early class of selling application was operational research, which may be described as the use of mathematical techniques to solve management problems where there are many interrelated variables and constraints. A report by Conway Berners-Lee dated 1964 lists 31 Ferranti projects that used OR techniques in a wide variety of businesses. Shell saved £2 million in optimising refinery work, while BP said its use of this technique "had a significant effect on the national economy". We sold

seven Pegasus systems for this type of activity.

Mercury and data transmission

The Mercury computer was Ferranti's second joint activity with Manchester University. At the time it was the most powerful computer in the world. The basic software for it came from the University, with some contribution from a Ferranti group in Manchester. But most of the applications software was produced at Portland Place, and we did all the selling. With this machine again we established a user program interchange scheme and a fully developed library of subroutines.

Swann used to tell a story against himself about Mercury. During negotiations with NRDC for funding the project (which ultimately fell through), he wrote a memo estimating that four of these large machines might be sold. In the event Chris Wilson and Harry Johnson sold 18. Swann was emphasising the difficulty of forecasting the market for computers, and for making business plans.

The unexpected sales success came for two reasons. First, the atomic energy organisations took 10 systems. Second, the performance/price ratio of Mercury was exceptionally high. We can see now that it was underpriced, as insufficient allowance had been made for the cost of software support.

Another activity at Portland Place was the development of data transmission. Throughout my time there I maintained good relations with the engineers in the Post Office (now British Telecom), and this bore fruit in many different ways.

In March 1961 we devised with Alan Croisedale a data link whereby telex machines, then in use in every business, could be used to transmit the punched tapes used with our computers. This is said to be the first practical data link for remote computer use.

The primary error control depended on the Ferranti tape code using odd parity for numerical characters, and this was tested by the input routines. Although slow, this was useful for program development and trial runs. And it was not that slow: a September 1962 document refers to a Ferranti installation sending three quarters of a million characters each way every day with these data links.

During 1961 modems for sending computer data over telephone lines first appeared. Within a year we had developed with the engineers at

Bracknell sophisticated punched tape copying links using telephone lines. They gave a useful speed of 105 characters per second. The error control was like that of magnetic tape, with transmission in blocks and automatic retransmission when any error was detected, such that the error did not appear in the copied tape. These experiments paved the way for computer networks with remote access.

Financial Aspects

There were two key financial aspects. First, all staff were paid on a salaried basis, with no commissions, bonuses, or even overtime payments. This made possible the close cooperation between everyone, whether engineers, programmers or sales staff.

Second, Ferranti's costing practice allowed 10% of the selling price of any product for marketing. This was suitable for selling transformers to electricity boards, but failed totally to reflect the costs of software support for computers. It was a consequence of the activity being engineering-led.

When the Portland Place Centre was set up such little evidence as there was suggested it would not make a profit. The initial budget was £45,000 per annum: this was calculated on the assumption that we would need 10 programmers, five maintenance engineers and 10 support staff. The two striking things about this are, first, that average loaded salaries were at the time around £2000; and second, that you needed five full time engineers to keep one Mark 1* going.

By 1963 there were in fact 60 staff at Portland Place, and the income from the sale of computing time at £50 per hour was £140,000. It was this that made possible the applications development and software support. We had learnt that the software support needed to sell any computer was very expensive: this unplanned-for income covered the cost.

In all, we sold between 45 and 50 computers from Portland Place during its decade of operation. The Centre certainly succeeded in fulfilling the purpose for which it was sent up.

Editor's note: this article is based on a talk given by the author to the Society at the the Science Museum on 24 October 2000.

Dawn of the Data Processing Age

Hamish Carmichael

If the CCS is concerned with the archaeology of computing, we are in this article concerned with the pre-archaeology. Indeed, we are almost back to the protoplasm stage, well before the arrival of the computer and right at the beginning of the data processing era. It all began in the late 1880s...

Increasingly it seems a shame that the glories of the punched card era have almost completely gone. There is an entire set of physical skills that was once very common and is now almost entirely forgotten. Juggling a pack of cards: the smooth efficiency with which one slipped a rubber band off the pack of cards onto the left wrist and then back again—they don't even make the right size of rubber band today!

From my own experience—I spent a year as an operator of Power Samas punched card machines—I cannot think of anything in my career in computing which has matched, for sheer exhilaration, the feeling of keeping a sorter running at a full 600 cards a minute without interruption. Picking the cards out of the stackers without getting a wreck and keeping the hopper topped up, and remembering where you're coming from and where you're going to. That was real Wild West stuff!

Nowadays I suppose the only things that we know punch cards for are lecture notes, shopping lists, and, most important of all, bookmarks¹!

I shall start right at the beginning. I haven't managed to confirm what Hollerith got his doctorate in—I suspect it was electrical engineering—but he was a Princeton man. My information comes partly from the *Electrical Engineer* magazine and partly from *Scientific American*—its 30 August 1890 issue contains a good introduction to the whole process.

During the latter part of 1889 the United States Census Board organised a trial of three mechanical systems for counting the 1890 census. Hollerith got involved because he had been an enumerator on the 1880 census which was still being counted in 1889 (some things don't change all that much). His equipment won out, and was used for the 1890 census.

To obtain the census data, 50,000 enumerators were sent out, and they brought around 15 million forms back.

The first stage was to put the data on these forms through machines,

¹...and, more recently, Florida elections!

which were confusingly also called enumerators. They had a number of dial counters arranged in the upper part of the back frame. The counters had two hands, with each counting round 100 segments. The minute hand, as it were, counted up to 100 and then the hour hand ticked over one. So each dial could record up to 10,000. At that point someone had to write down on a piece of paper that you had got a carry-over, and then you started from one again.

There were 21 counters on the enumerator machine. To drive them, the operator had a small key-pad with 20 typewriter keys. These numbers permitted counting the number of people in a household up to 20. The 21st counter was for any household with more than 20 people in it, and except in the state of Utah there weren't a great many of those.

At this stage of the process the operators were simply counting how many people there were in each household. It was a preliminary count just to get the totals right before they started on analysis. They got through the whole 15 million forms twice in six weeks, and arrived at a population total of around 62 million.

This in itself caused trouble because, with American pride in big things, the average American believed that, by 1890, the population must have got up to 75 million. To find that it was only 62 million was an insult to the national psyche! But they counted up twice and it turned out they had got it absolutely right.

Some of the operational statistics are pretty impressive as well. For an operator to count over 50,000 sheets in a seven hour day is good going.

After this preliminary stage the forms were then punched. This is the stage where punched cards first came into it.

The very first punch was the pantograph punch, so called because, when the operator made a large movement with the control knob, the punch mechanism moved by a smaller but proportional amount. Under the knob was a pointer, which the operator positioned, one after the other, over the desired holes in a printed platen or template at the front of the machine. The actual card was in a bed attached to the frame, and when the operator depressed his handle above each chosen guide hole, the punch knife was driven down to make the equivalent hole in the card.

That was a fairly complicated punching mechanism. Later on we all became accustomed to the punch operator looking at the data sheet all the time and punching away like mad, as there was no need to look at the actual keys that were doing the punching. But on the pantograph punch

you had to keep moving your eyes from the data sheet across to where your pointer was before you punched it.

The data in the card was interestingly arranged, not in fields of vertical columns as we later became accustomed to, but in zones so that all the holes corresponding to a particular fact were in the same part of the card. So the holes for “Sex” — M or F — were in one part of the card, and for age group — 0, 5, 10, 15 and so forth — in another part.

The facts recorded for each individual were as you would expect. In addition to the punched records, separate manual records were kept for the deaf, the blind and the insane, and separate processing was done for people who had died within the earlier part of the year of the census.

Despite the complexity of the punching process, the operators averaged 766 cards per day with typically 17 holes per card. The fastest operator got up to 1400 cards a day, a very impressive rate.

Those holes were spread across 20 columns of the card. In addition, there were at the left-hand side of the card four columns which were gang-punched with a number corresponding to the enumeration area. The gang-punching was done by an elegant machine which allowed you to place moveable punch knives in the appropriate holes in the block. You could place six to eight cards in a tray and then bring down a handle to force the knife-block down on top of them. The machine was designed to be operated either by hand or by foot.

The main part of the analysis work was done on a different machine, which had several interesting components. The counters were similar, but this time there were 40 of them on the standard machine.

Because each counter was an integral unit and they all were powered through the frame of the analysis machine, the number of counters wasn't fixed. Shortly after the United States count in 1890, a census was held in Imperial Russia. The machines they used there went up to at least 41 counters, and may have gone higher (a photograph of one of them turned up miraculously in about 1962, and was published in one of the last editions of the *Power Samas Gazette*).

To operate the analysis machine the operator put a card into a bed with his left hand and operated a handle with his right. The handle brought down a block of sensing pins on top of the card. Each time a sensing pin passed through a hole in the card it established an electrical contact by dipping into a small cup of mercury under the hole. The impulses from those cups were fed into the back of the machine.

That led to the first instance I am aware of in our industry of operator sabotage. When life was getting particularly intense for the operators, some of them found that, with an eye dropper, you could lift a drop of mercury out of one of the holes and lose it in the nearby spittoon. It would take some time before the engineer could replenish the mercury and get the machine back into operation.

The machine had a back cover like a great wardrobe door. If you opened it, you would see nothing but a series of what they called binding posts (I suppose we would call them terminals nowadays). There was one behind every counter. In the middle of the machine there was a set of terminals corresponding to all the pins of the sensing mechanism. In the simplest way of operating, you took a wire from the binding pin corresponding to the hole you were interested in to the terminal of the counter on which you wanted to record.

In the bottom of the machine at the back, there were rows of relays. You could lead a wire from a particular punch position to one of the inputs of a relay, choose another punch position to lead to the other input of that relay, and take the output of that relay either to a counter or to another relay. That gave quite a strong analytical capability in one passage of the cards through the sensing process.

The sorting machine provided another level of analysis. It had 26 boxes, and those boxes were also wired from the appropriate terminals on the back of the machine, so that when you sensed a card the connection would go through the back of the machine to a solenoid on the lid of the appropriate box. That lid would flip up and the operator then knew where to put that card so that, in the course of sensing the cards for one series of counts, you were also sorting the cards for the next level of analysis. So there was quite a degree of subtlety possible via quite a simple physical process. (I think it would have helped if the operators had had three hands!)

The analysis work started at the beginning of July and, to start with, the operators were processing 3500 cards per day (measured in standard seven hour days), with five readings from each card. At the end of a batch of cards, the operators had to transcribe the readings that were clocked up on the counters.

By the end of July, when they had been working on it for a month, the average had gone up to dramatically to 7000 cards a day with nine readings. The most expert operators at that stage were getting up to 9400 cards a day, so they must have been pulling the handle down at a fair clip.

The analysis machine had a mechanism so that, if a card went through which was not completely punched in accordance with the wiring that had been set up on the machine, a bell would ring to let the operator know that this was a defective card, so he could refer back to the input documentation to see what had gone wrong. Otherwise the thing went “ting” for every card put through it.

In the later months the daily averages shot up to astonishing levels. I think the dexterity achieved by those operators was really quite remarkable. They managed 1800 cards an hour, which is a card every two seconds, more or less.

The Census Board did comparisons between the speed they were achieving in analysing the punch cards and the speed of the manual transcription of the cards for deaf, blind and insane people. They found that the card punching process was up to 50% faster than a manual transcription and up to eight times faster than hand sorting of the written cards for those subsets. They saved at least half a million dollars on that stage.

Examples of the combinations they achieved by linking successive counters through the relays include males under one year old, white males under 10 years old, white males born in Pennsylvania, and even white male butchers born in Pennsylvania with mothers born in Germany. It was not bad going to achieve that sort of thing in one pass of the data through the machine.

The Hollerith census machines proved the capabilities of the punched card concept. The real flourishing was to come later. In this country, one of the most exciting moments was when what was later to become ICT and ICL got the contract to do the 1911 census. Having got the contract, the company was told that what was to become IBM—friendly as always—wasn’t going to allow them to have any of the census machines to do it with. So we had to build our own machines from scratch. But that’s another story.

This is an edited version of a talk given by the author to the Society at the London Science Museum on 13 October 1999.

Mil-DAP Resurrection Project

Brian M Russell

The Society's latest restoration project involves a military version of the ICL Distributed Array Processor. In this article the Working Party Chairman describes the historical background to the DAP computer, outlines the case for restoring the Mil-DAP version we have acquired, and summarises the progress of the project to date.

In the beginning, there were serial machines. One bit of calculation was done at a time; the entire machine was dedicated to pushing data through a single bit mill, one bit at a time.

It was soon realised that most real calculations required multi-bit arithmetic. As hardware costs fell, it became realistic to provide sufficient adders to handle a complete word in parallel. Hence the parallel machine was born. The word length was fixed at 12 bits, 32 bits or whatever. The chosen length was adequate for many calculations, insufficient for some and grossly extravagant for most small numbers.

Machines with parallel mills also performed store accesses in parallel. The store word length was usually the same as the processing word length, so storage locations holding small numbers had wasted bits. All that the processor did was change the contents of the store. Some method of input and output was provided, either from the processor (memory mapped I/O) or from the store (direct memory access, or DMA).

This arrangement, with store and processor as separate units, became known as the von Neumann architecture. With ferrite core technology, line drivers and sense amplifiers dominated both the cost and the physical size of the storage, so a monolithic store was sensible.

Then semiconductor store arrived. Initially this provided 1K bits in a single integrated circuit. There was no longer any need for the (expensive) common drive logic. It therefore became feasible to fragment the memory and distribute it among the processing logic. One of the first systems to adopt this architecture was the Distributed Array Processor (DAP).

There were several DAP variants, starting with the Pilot-DAP. Next came the MSI-DAP (or Big-DAP), then the Mini-DAP and Mil-DAP. All put the minimum of processing logic with the minimum of store into a unit called a Processing Element (PE). This comprised a single store chip

and a bit-serial processor. So the machine carried out arithmetic in much the same way as the original, well-understood serial computers, but it did it on 1024 or 4096 different numbers in parallel.

This form of parallel processing, known as Single Instruction Multiple Data (SIMD), was very successful, I believe, because it was relatively easy for the human mind to comprehend, particularly a mind brought up on conventional serial processors.

That the DAP was successful can be inferred from the number of imitators. At least six competitors had appeared by the end of 1984, namely Staran, Illiac IV, Clip, MPP, Scape and Grid. Even Fujitsu showed keen interest.

Later DAP designs were the VLSI-DAP, or V-DAP (considered a failure since the the design was abandoned) and the AMT DAP-510 (a success: Active Memory Technology put it into production and sold it, and indeed its successors are still selling). These later models put parallel processors (4-bit and 8-bit respectively) into the parallel processing array.

The ultimate DAP would have put the processor onto the same chip as the memory. With a 1 Mbit memory, the processor would have had access to a row interface 1 Kbit wide.

This never happened. When it was suggested to semiconductor manufacturers, the reply was along the lines of ‘You are not putting that noisy random logic near my sensitive read amplifiers!’. If we could have overcome this objection, the next question would have been ‘How many million do you want?’.

The performance of the DAP was unbelievable. Or rather, the cost/performance ratio was unbelievable - so unbelievable that very few people took the trouble to understand the machine enough to actually believe, buy the thing and use it.

At this time, around 1984-87, a Mini-DAP running Sobel operators was achieving between 1000 and 2000 mips for a cost of under £100,000. At around the same time, the Met Office bought a CDC supercomputer, which delivered only 3500 mips, for £5 million. Running Mandelbrot sets on a Mini-DAP achieved in 50 seconds what was being done on a DEC VAX 850 in 17 hours (that’s a factor of 1200), which shows the advantage of using a parallel computer on a naturally parallel problem.

That the DAP was seen as technologically significant is amply illustrated by the stencil marking on the side of our Mil-DAP - ‘The Queen’s Award for Technology’.

Why Resurrect the Mil-DAP?

In the 1970s and 1980s, the military took an interest in the DAP, and one or more were supplied to the Royal Signals and Radar Establishment (now the Defence Evaluation Research Agency) at Malvern. This led to the production of the Mil-DAP. The Mini-DAP was supplied in commercial cabinetry; the Mil-DAP used the same logic, but was repackaged into a black box suitable for use in ships, aeroplanes or helicopters.

When our Mil-DAP was pensioned off in 1998, Chris Burton was standing by the gate and acquired nearly a complete set of hardware, so many thanks to Chris for being in the right place at the right time! What he picked up was one Mil-DAP black box minus a single array board, plus a Perq workstation (minus disc drives) that acted as host computer in the lab and some associated bits and pieces.

The DAP was the world's first parallel processing architecture, and the DAP team (namely Stewart Reddaway and David Hunt) hold the 12 key patents to prove it. The Pilot-DAP was therefore the world's first parallel processing computer.

Unfortunately, the Pilot was lost when Active Memory Technology was taken over by the Cambridge Corporation, now renamed Cambridge Parallel Processing (CPP - this company continues to sell DAPs to this day). We believe the five Big-DAPs are lost too. The Mil-DAP is therefore the nearest thing we are likely to find to the first ever parallel processor. Can it be resurrected and made to run?

In attempting this, we have gone beyond the DIY approach that enabled Chris Burton to re-create 'Baby' from scratch. If we were to attempt to rebuild the Pilot-DAP, we could probably do it that way—it was built from simple gate-level ICs and the first generation of 1Kbit dynamic RAMs (though finding 1024 of them would be a problem).

However, with Mil-DAP, which dates from the early 1980s, we have moved into the area of custom chips. The 32x32 array of PEs (1024 in all) are packaged on eight array boards, each with eight PE chips holding 16 PEs. Recreating the PE chips using custom chip technology would be prohibitively expensive.

In theory, it might be possible to recreate them using modern Field Programmable Gate Arrays (FPGAs). This, though, would probably take more time and effort to achieve than I or anyone else has. The Mil-DAP, and probably any subsequent machine, takes computer conservation out of the realm of re-creation and firmly into the realm of preservation. Once

a VLSI machine has gone, it is gone forever.

Progress to Date

Since last May, Bob Whittaker and I have been resurrecting the Mil-DAP. I thank Bob for providing moral support to keep me going as well as for helping with the dirty work.

The ‘heavy gang’ has moved the machine (the DAP itself, the Perq, fans, cables and so on) to the back workshop next to the laboratory at West Gorton - our thanks to them. We have opened every box and used vacuum cleaning, water, cloths and cotton wool buds to clean out most of the dust. The fans were in a particularly bad state.

The cables had been stuck up with duct tape and were obnoxiously sticky. I took them home one at a time and cleaned them up. I found water was ineffective, and detergent did not improve things, but eventually white spirit did the job, washed down immediately with detergent. Conservators may shudder, but these are mil-spec cables, which were intended to stand up to solvents, fuel and army boots. The cables can be handled now.

Electrician Barry England fitted plugs to the Mil-DAP itself, once we had sorted out which end of the filter was input. I nearly chopped off the wrong cable end and fitted things the wrong way round, but it did not feel right and I kept at it until it made sense. My thanks to Barry.

Harry Gibbons provided us with two Winchester hard discs, which came from a Mitel SX2000 telephone exchange. They are a Rodime R03055 and a Seagate ST251-1. We have now fitted them to the PERQ. Thanks to Harry ² for the discs and to Bob for finding a Web site with all the details. At 45Mb each, they have slightly greater capacity than the original Micropolis 35Mb drives, but are physically compatible, and should work once the drive tables are suitably configured.

Tony Duell has sent me one of his spare disc interface boards, together with enough documentation to fit it and start the powering up process (slowly!). My thanks to Tony. We have reached the end of the bootstrap sequence, but cannot proceed further as we do not yet have any software to load.

In a recent clear out at West Gorton, we found an 8” floppy disc. This has doubled our stock! If any reader has any 8” floppy discs, we would be grateful to receive them.

²Harry Gibbons has now retired — we wish him well.

Recently, Jon Gogan has kindly let us have another Perq, complete with software and manuals (something to do with space in his mother's house being at a premium!). Thank you, Jon. We plan to clean up and restart this machine, and then use it to transfer software to the DAP's Perq. After that, we will have no further use for the machine (except possibly as spares), so if anyone would like a Type 2 Perq, please contact me.

The next step will be to try powering up the DAP itself. Disconnecting the power supply unit to test it in isolation would be difficult, so we will probably unplug the boards—the risk of disturbing the cabling is less than the risk of blowing everything up if the power supply is faulty.

After that, we will have all the equipment tested for electrical safety. Then we will be ready to start on the software, almost...

Request for Help

We still need a replacement for the missing array board. I appeal to anyone who knows the whereabouts of any DAP parts to contact me. The board we are missing is number K110, GA2V1, PBN 80090190. I have an offer from David Hunt at CPP that, if we cannot find a board from any other source, we can borrow the one board CPP has kept in its DAP Technology museum. Our thanks to David and CPP for this offer.

We do now have the POS operating system for the Perq, but we have none of the DAP-specific software. We particularly require the three low level programs—the HCU-CP (Host Control Unit—Control Program), the MCU-CP (Master Control Unit—Control Program) and the DAP Device Driver. If anyone can give us copies of these then, with help from CPP, we should be able to get something to run on the DAP.

Generally, any DAP artefacts—boards, software, documentation—or just recollections of the machine will be greatly appreciated. Does anyone know to which customers the various DAP machines were supplied? Does anyone want to volunteer to help with the resurrection project?

We would like to move the DAP out from the workshop into some more computer-friendly environment. We had an offer of space for it at Manchester University—thanks to Louis Blanchard—and agreed we would clean up the machine and have it safety tested before putting it in his machine room. This offer cannot be expected to hold forever, but I believe it is unreasonable to take the machine to the university (or anywhere else) unless there is a feasible route to resurrection. Only now, with a little help from

you out there, might resurrection be achievable.

Editor's Note: Brian can be contacted by phone on 0161 652 6475, by email at <bmrussell@ieee.org>, or by post to 5 Briarmere Walk, Chadderton, Oldham OL9 6SH.

CCS Web site information

The Society has its own World Wide Web (WWW) site: it is located at **<http://www.cs.man.ac.uk/CCS/>**. This is in addition to the FTP site at **<ftp.cs.man.ac.uk/pub/CCS-Archive>** (please note that these URLs are case-sensitive). Our Web site includes information about the SSEM project as well as selected papers from *Resurrection*. Readers can download files, including issues of *Resurrection* and simulators for historic machines.

Society Activity

Small-Scale Experimental Machine Project

Chris Burton

The Manchester ‘Baby’ continues in good health, and is shown off at regular intervals by a very loyal band of demonstrators. It is a pleasure to go to the Museum of Science and Industry in Manchester on a Tuesday to see and hear enthusiastic volunteers explaining the mysteries of cathode ray tube storage and so on to sixth forms, toddlers and senior citizens. The machine remains remarkably stable, with the occasional unexplained malfunction, but normally if it ain’t broke, we don’t fix it. George Roylance is doing an invaluable job of preparing training material for our successors, and we are still getting offers of old parts to put into our spares stock for the future.

Tom Kilburn’s death has naturally saddened the team, but we are happy that our replica is a public memorial to him and to FC Williams.

Bombe Rebuild Project

John Harper

One of the problems we have encountered with this rebuild is the lack of recent visible progress at Bletchley Park. This is inevitable with the way that manufacturing has to be carried out. Most of the work can be split into ‘high tech’ or labour intensive. With the volume and precision required of many of the mechanical parts we have to use modern machines to achieve the standards required. At the other extreme, there are many repetitive ‘hand tool’ jobs that need to be carried out, and our volunteers wish to do this either at home or at a centre close to where they live.

This situation will exist for a little longer, but will change during the second half of 2001. Construction can be split into two groups, mechanical and ‘electro’.

On the mechanical side numerous sub-assemblies are taking shape around the country, with the first likely to be complete and ready to fit into our frame this summer. In fact the end of the mechanical section is almost in sight, albeit some way off. As I write, 90% of all mechanical parts have been assigned for manufacture, and the rest will be placed within the next few weeks. We anticipate that most of the mechanical sub-assemblies will

be fitted towards the end of 2001, when power can be applied to make units operate or rotate.

The ‘electro’ construction and assembly will take place after the mechanical, mostly in 2002 though much of the work has already started. Cableform construction is progressing well with perhaps a third of the work completed. Relay rewinding and refurbishing has just commenced, and items such as timing and circuit breaker cams have been completed well ahead of schedule.

Our team is made up entirely of volunteers, so while we have objectives we wish to achieve, we are not working to absolute deadlines. To do so would work against us, because part of the fun and self-satisfaction would be lost. There is a real chance of having a working Bombe in 2003, but none of us wishes to be held to this.

Our previous requests for help have been very successful. We now just need access to CNC machines or automatic lathes to make the high volume, mainly ‘electro’ parts still outstanding. This sort of machinery has a high capital cost and has to be kept busy to earn its keep. Sometimes however the workload falls off, when time might be found for our parts to be made.

Readers who feel they can help, or would like to find out more about our Project, can find my contact details inside the back cover.

Pegasus Working Party

Len Hewitt

After some initial problems following the recabling, Pegasus is now running its test programs, and the site is 90% complete. It should be viewable by the end of April, and ready for the grand opening in May.

S-100 Bus Working Party

Robin Shirley

We have acquired an Ithaca DPS-1 system with sundry discs, tapes and software. The Science Museum has acquired rather more from the same source, including an ICL PC1 and early Ungermann-Bass Ethernet switching systems.

With the demise of storage at Bletchley Park, the issue of basic preservation is once again becoming extremely pressing.

Letters to the Editor

Dear Editor,

When I was at school in the late forties (including 1950), someone (I don't remember who or where from) gave us a talk about an analogue electrical (not electronic) device for solving sets of linear simultaneous equations. I believe it could solve up to 10 equations in 10 unknowns.

Does anyone know more about it?

Yours sincerely,

Michael Bramson

Wembley

Middlesex

20 October 2000

Dear Editor,

I have read the condensed transcript of Tony Wix's talk in *Resurrection* issue 24 with great interest. However, there is one point where I feel that the information is incorrect and needs correcting, so we have in *Resurrection* a true historical record.

I refer to ICT's last printer mechanism, the 667. Tony wrote that 'Echo' Organ had closed down the project. This is true, but it was resurrected for the ICL 2903 system as the 2411/3 line printer. The performance at 600 lines per minute was indeed inadequate, but at 300 lpm the Miniature Front Stop Hammers performed well and turned out to be very reliable.

Using multi-part paper was expected to cause problems, so the sales literature limited the specification to four part paper. Unfortunately a few salesmen did not pass this limitation on to the customer, which caused some embarrassment.

The customer-removable barrel turned out to be very popular. Not only was it good for demonstrating to visitors but it had a real practical advantage when it came to cleaning, replacement and having different character sets readily available.

Initially the cost of the mechanism running at the reduced speed of 300 lpm was thought to be too high. However when integrated into the 2903 the overall cost was kept within acceptable limits. The 2903 had a unique feature which allowed the full microprocessor power to be available

to service peripherals without any significant switching overheads.

Therefore the only supporting electronics which went with the 667 mechanism were the hammer drivers, a shift register and a few pickup sensors. The rest of the functions, such as which print hammers to fire or how far the paper was to throw, were performed either in the main microcode or in a very small amount of dedicated support hardware. For example, there was no paper loop required to control paper throw. This was all built into the microcode and the 1900 executive.

Well over 1000 of these 667 mechanisms were delivered, and they performed reliably for many years. A resurrection in the full sense.

I have discussed this point with Tony, who comments “The 667 printer failed to meet the marketing requirements on cost performance at 600 lpm. However, on reflection, the mechanism was resurrected and downrated to 300 lpm on the 2903, where its high cost was part compensated by 2903 electronics cost savings”.

John Harper

then ICL 2903 Electronic Hardware Development Manager

by email

19 March 2001

<p style="text-align: center;">Editorial contact details</p> <p>Readers wishing to contact the Editor may do so by fax to 020 8715 0484 or by e-mail to <NEnticknap@compuserve.com>.</p>

Forthcoming Events

Every Tuesday at 1200 and 1400 Demonstrations of the replica Small-Scale Experimental Machine at Manchester Museum of Science and Industry

12-13 May 2001, and fortnightly thereafter Guided tours and exhibition at Bletchley Park, price £3.00, or £2.00 for concessions

Exhibition of wartime code-breaking equipment and procedures, including the replica Colossus, plus 90 minute tours of the wartime buildings

17 May 2001 Pegasus seminar at London Science Museum, starting 1500

North West Group meetings take place in the Conference room at the Manchester Museum of Science and Industry, Liverpool Road, Manchester, starting at 1730; tea is served from 1700.

Queries about London meetings should be addressed to George Davis on 020 8681 7784, and about Manchester meetings to William Gunn on 01663 764997 or at <bengunn@compuserve.com>.

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