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 voluntary subscriptions from members, a grant from the BCS, fees from corporate membership, donations, and by the free use of Science Museum facilities. 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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Contents

Editorial

Nicholas Enticknap

It is now 30 years since IBM launched MVS, 20 years since British Telecom's monopoly was abolished, and 10 years since the arrival of the 64-bit minicomputer. These and the other anniversaries listed on page 26 remind us that history is being made all the time. The Society itself predates both the launch of Windows 3 and the creation of the World Wide Web.

Which raises a question: what should the country's museums and other bodies be preserving? The Committee of the Society has been addressing this question, and it has become apparent that there is no central database of the items that have been preserved and are on display or in storage. There are many different bodies in the UK alone which have items of interest to students of computing history, each with its own arrangements for access.

The Society has formed a working group to address this issue and to stimulate the development of a centralised database. The composition of the working group can be found in our News Round-up, and a first report on its activity by chairman Simon Lavington is on page 5.

Our News Round-up and Society activity sections also report on the activities of the Bombe and Mil-DAP groups and of the computer section of the Bletchley Park museum complex, on progress on software conservation, and on the revitalisation of our Web site, which is now under the energetic command of Dave Holdsworth.

In London there has been an active meetings programme: we carry in this issue a report on the program verification and semantics seminar last June. The Pegasus is on display at the Science Museum: Doug Brewster recalls in this issue what it was like to use Pegasus in its prime, and outlines some of the things you can do with the Pegasus in South Kensington today.

Our main feature article in this issue recalls an early computer which has received little attention, the one-off Nicholas built by Elliott Brothers at Borehamwood. It ran its first program exactly half a century ago, another anniversary that is well worth recalling this year.

News Round-Up

Applications were the focus of two Society meetings held at the Science Museum last autumn. The 2 October 2001 seminar on early computers in insurance attracted a respectable audience of 35, while the similar event on banking applications on 7 November proved less popular, with 21 attendees.

- 101010101 -

Early warning: the Society will hold its AGM on Thursday 23 May 2002.

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The Society has formed a Preservation Policy Working Group to construct a comprehensive technical information base of British-designed computers for the period 1945-70, and then to associate this base with an audit of all existing artefacts. Simon Lavington is chairing the group, whose other members are Chris Burton, Brian Oakley and Tony Sale.

The Working Group is studying the required scope, resources and methodology for this project. There are plans to hold a one-day workshop of invited experts, to discuss possibilities. Further details can be found in Simon's report on page 5.

- 101010101 -

Dave Holdsworth has taken over responsibility for the Society's Web site, and is in the process of reorganising and revitalising it. He has brought the site under the umbrella of the BCS specialist group system, and members can now access the site at <www.bcs.org.uk/sg/ccs>.

- 101010101 -

The offer to provide Society members with copies of the *IEE Annals of the History of Computing* at a concessionary rate is still open, and anyone interested should contact Hamish Carmichael straightaway. The 60 members who have already signed up for the scheme do not need to reapply.

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Sprightly though he may still be, Meetings Secretary George Davis assures us he is not getting younger, and would appreciate some assistance in organising the Society's London meetings programme. Would anyone who can help please contact either George himself or Society Secretary Hamish Carmichael.

- 101010101 -

At the beginning of April the name 'ICL' will officially cease to exist. Following their strong tradition of not always doing what the management wants or expects, many members and former members of the company intend to mark this event by holding a Wake, prefigured as the biggest ever Friday lunchtime. For details of time and place, watch out for announcements on <www.friendsoficl.org.uk>.

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Society Activity

Preservation Policy Working Group

Simon Lavington

Archival material for early British computers exists in many forms: for example documents, hardware and software. These historical artefacts are held in a variety of places such as: museums and national collections, universities, companies, government establishments, and in the hands of private individuals. Furthermore, each place may have a different style of cataloguing (if any), different curatorial capabilities, and different arrangements for access by computer historians. Finally, the pioneers who designed and used the early computers are fading and, along with them, the knowledge necessary to interpret such artefacts is also disappearing.

The Computer Conservation Society believes that there is a need to take stock, particularly concentrating on the availability of artefacts from British computers designed within the time-frame approximately 1945-70. Two recent initiatives have gone some way towards auditing archival collections. First, the National Computing Collections Listing Project has produced a web-searchable database of the holdings of the major UK museums — see: <www.sciencemuseum.org.uk/ncclp/welcome.htm>. Second, an appeal by the CCS in the autumn of 1999 yielded responses from 89 private individuals, of whom approximately 35% owned material that was of clear historical importance to computers designed within the time-frame of interest.

Knowing that British computers designed within the stated time-frame constitute a closed corpus, it should be possible to construct a comprehensive technical information base and then to associate this base with an audit of all existing artefacts. For each artefact, its location, condition, accessibility, and catalogue reference would be recorded. Such an audit would also clearly reveal gaps in the national collection.

A project to provide both a corpus information base and an archival audit is certainly an ambitious undertaking. Anyone who doubts this should read the retrospective article on the archival work of the Charles Babbage Institute in the USA, which appears in the current issue of the *Annals of the History of Computing*. Undismayed, the CCS has a Working Group which is now studying the required scope, resources and methodology for this project. It is planned to hold a one-day Workshop of invited experts, to discuss possibilities. Anyone interested is asked to contact Simon Lavington (see inside back cover for contact details).

Bletchley Park computer exhibition

John Sinclair

We are about 15 members now. About half are very active: they are at the Park every weekend, sometimes on both Saturday and Sunday and even during times the Park is closed to visitors.

We have formed an association called "The Computer Museum at Bletchley Park Association". This is primarily to allow us to start a bank account without incurring any tax problems, to keep what monies we have under proper control.

We have received some income from the sale of unwanted equipment, and a few donations for work we have done. We have also spent money — £150 — to pay a removals company to bring about 30 nearly new office desks from London. These desks have transformed the museum room, so it was money well spent. Some of my members are also looking at sponsorship in either money or goods, mainly via advertising on our Web site <retrobeep.com>.

I have got the Park Trustees to recognise that we are all "Volunteers", and *not* a "group" such as the boat or railway groups. This means we are not liable for insurance risks and problems such as someone damaging themselves in our museum room. It also means we do not have to pay for heating, floor space or other facilities, something the Park is trying to get other groups to do.

Late last year a document was sent out to all groups to sign. There are various conditions that each group must agree to, and so far I don't think anyone has signed. Fortunately we do not now need to comply with any of the requirements of this document.

Bombe Rebuild Project

John Harper

The test rig consisting of four Letchworth Enigmas and one carry mechanism that we referred to in the last report has now had various 'outings'. It was, for example, demonstrated at a recent lecture that we gave at Bletchley Park to our local IEE group, and at an internal Team meeting held at

Nortel Networks recently. The lecture at Bletchley Park was significantly oversubscribed but at the same time appears to have been well received. This was in spite of many visitors having to stand or sit on the floor.

This test rig is now almost mechanically complete with just two cam follower assemblies yet to fit. As I write this report at the beginning of February 2002, these are due shortly.

Our next outing is the talk to be given to the Northern Branch of the CCS on 19 March 2002. For more details, please contact Ben Gunn. By then, we hope to have the test rig mechanically complete.

On the weekend of 20-21 April the Rebuild Team will be present in the Bombe Hut at Bletchley Park to welcome visitors. This is a normal opening weekend at the Park and it would be a good weekend to arrange a visit if you were considering one around this time. Our aim is to have most of the 36 Letchworth Enigmas in place by then, but there is a lot of assembly work to take place off site prior to this. Forecasting exactly what we might achieve in 11 weeks is not easy, but we will certainly have a lot to show and demonstrate to visitors by then. We have very few shortages to complete this phase of the rebuild, and it is hoped that these will be sorted out without causing any delays.

On the electrical side steady progress is being made with the cableforms and coil winding. We now have all the winding wire we require due to a generous donation by a manufacturer. However, our search for BTM Multi-relays has not been successful, so we have decided to re-manufacture these ourselves. Certain component parts have already been made and others are being planned. The only problem left to solve is whether we can recover and refit precious metal contact points. The alternative is to make new items. It might be a case of recovering the metal and recasting this into the correct sizes. However, we are still investigating.

We have now made a good start on the drums. The covers for these are made in brass and we have been fortunate in that one of our team has managed to have these spun in Switzerland to very high accuracy. Fixing and ventilating holes have still to be drilled and a jig is under construction. Members of our team will then drill and enlarge the 4500 or so holes.

The drum brushes are held in place by small brass pins. These are threaded at each end. A pilot batch of 2000 has been made on a CNC machine generously operated by one of our supporting companies. There is a hand operation required to complete these pins.

The mounting discs require a drilling jig which has been made to mark out the complicated pattern of brush mounting holes and the drilling of these mounting discs will commence shortly.

Other activities are in hand but space considerations limit what can be said at this time.

As before, any readers who feel they would like to help or find out more about our Project can find our details inside the back cover, or via our Web site at: <www.jharper.demon.co.uk/bombe1.htm>.

Mil-DAP Working Party

Brian Russell

There has been minimal progress on the Mil-DAP over the Christmas period. What has been done has centred on taking stock of our collection of 8-inch floppy discs. Some are new and unused, some are in Perq compatible format, and some appear not to be readable on a Perq.

In addition to the two machines we have at West Gorton, we have been offered two more Perqs! One, a Perq-1, is here in Manchester; the other, a Perq-2, is in Reading. We cannot make use of four Perqs, but are hopeful of salvaging the hard disc from one as it may hold some of the software that we are missing. If you know of anyone with whom the CCS has contact who would like a Perq, either in its entirety or as spare parts, I would be pleased to put you in touch with the owner (my contact details are inside the back cover). We also have a surplus 5.25-inch floppy disc drive with power supply in a freestanding enclosure.

Software conservation

Dave Holdsworth

We recently received a system for a Leo III on paper tape. These tapes have now been copied into files that each constitute an image of one of the tapes. The intention is to produce an emulator for Leo III so that we can resurrect the heyday of Lyons' Electronic Office. We need contact with someone who can provide details of the machine's instruction set and other system aspects.

This exercise has been undertaken in the sure knowledge that once the data is just a byte stream, we can keep it for ever, awaiting an enthusiast to implement an emulation. This can be done in a manner similar to that which we used for the ICL 1900.

At present we have no contacts who might know who is the owner of the intellectual property rights in this material. However, copyright in computer generated material only lasts for 50 years from its creation, so the material will soon be in the public domain.

We hope to perform a similar preservation on a paper tape-based PDP-8 system.

Simulators

Simulators for a variety of historic computers, including Edsac, Elliott 903, Pegasus, the Manchester University Small-Scale Experimental Machine and Zebra, can be found at our FTP site. Access details are on page 21.

Nicholas, the Forgotten Elliott Project

Ed Hersom

This article was sparked by Hugh McGregor Ross's obituary of Bill Elliott in *Resurrection* issue 25. The author feels that Hugh's brief reference to the Nicholas computer does not do justice to an interesting story, a story which has rarely been told as Nicholas was never intended to be a production machine. Here is that story, told by the only survivor of the design team.

In the early 1950s the research laboratories of Elliott Brothers (London) Ltd at Borehamwood comprised seven divisions, two of which were developing digital hardware — Computing, and Circuits (the latter name was probably chosen to give little indication of the project it was engaged in).

In addition there was a small Theory Group, headed by Norman Hill. I was next in seniority, and we also had a few mathematicians and a couple of girls doing manual calculations on one electromechanical machine (a Marchant) and one purely mechanical one (a Brunsviga). We also had use of an electromechanical differential analyser with four or possibly six ball-and-disc integrators. Our work was to support the seven research divisions.

In November 1951 Ron Millership of the Physics Division showed me a nickel delay line storing a single pulse. I immediately realised that a store made with these devices would be much cheaper than the mercury tubes being used elsewhere (such as on Cambridge's Edsac and the National Physical Laboratory's Pilot ACE). Charles Owen of the Circuits Division had by then developed a set of prototype printed circuit boards (known then as plates), using subminiature valves embodying the usual Boolean operations (AND, OR, etc) used in arithmetical and control operations.

With this background one of our mathematicians, Bruce Bambrough, was despatched to the Royal Aircraft Establishment (RAE) at Farnborough to discuss a purely computing project. That was at the end of 1951 or maybe in early 1952. Next day he came into my office and, after a brief explanation of the RAE project, said, "for the money they talked about we could build a machine to do the job". That was how the Nicholas project started.

After some further discussion between Bruce and myself and between Bruce and Charles, we sketched out a specification for a general purpose stored program computer, and I put it as a proposition to Norman Hill. Note that it was designed by a committee of three which never once met!

I know nothing about the financial background, but I did quickly get the go-ahead to build the machine. Then in March 1952, Charles went down with mumps. We thought that was a disaster at the time, but in his three weeks of convalescence he drew out on a single sheet of paper (about 4' by 3') the complete logic diagram of the machine, which Bruce then christened Nicholas (as a pun on nickel). The diagram showed the interconnections of nearly 80 plates.

Members of the Theory Group took home bare plates and back-wired them ready for two 'wire-women' to assemble the components. Just nine months after Charles fell ill, Nicholas ran its first program. That was in December 1952.

Nicholas used nickel delay lines for storage. Total capacity was 1024 32-bit words (4 kilobytes). Each line held 16 words, and they were arranged as eight loops of eight lines connected in series with repeater amplifiers between them. The lines used the original system of longitudinal magnetostrictive stress waves. A 65th line stored one pulse and acted as the 'pendulum' for the computer clock. There was no backing store. The lines were stored in a tall aluminium cabinet, about 6' high. Each line was a loosely coiled spiral of nickel wire, held by paper strips about half an inch above an 18 inch square aluminium plate. These plates had holes in the centre to facilitate air circulation in the cabinet.

The plates were held horizontally in the cabinet, and spaced vertically about an inch apart. The 65th line was in the centre, so that it was at the average temperature. The whole cabinet took 20 minutes to half an hour to warm up before the temperature was stable enough for the delay lines to work properly. There was no temperature control or forced air circulation — the cabinet was just a draughtproof box.

Near each end of a wire there was a transducer made of a small coil around the wire and a fixed permanent magnet (for pulse-shaping). There were absorbers of plastic foam right at the ends of the wires to suppress any wave being reflected.

In contrast, the contemporary Elliott 401 (which first ran in March 1953) only used short nickel delay lines for its central registers: it relied upon a 1000 word magnetic disc for its main storage.

Nicholas was equipped with two 5-hole paper tape readers — called Main and Auxiliary. When an input command *I* was executed the five bits corresponding to the five holes on the tape in the Main reader were fed into the five least significant bits of the accumulator, and the tape advanced one row. To input a longer string there had to be a series of *I*s, each followed by several *D*s (doubles, ie left shifts).

The Auxiliary reader had its contacts (which were mechanical 'peckers') directly connected to the control section of the machine. This reader was only used at boot time, when control was switched to it. It then issued a string of *I*s and *D*s and store commands until a complete program was read in and stored in memory. The code on the tape in the Main reader was the so-called Initial Orders (*IO*s). When the Auxiliary reader was finished, control was passed to these *IO*s, and they generated a program enabling Nicholas to read in a binary coded tape via the Main reader.

Initially both readers were electrical/mechanical devices whose peckers rapidly destroyed a tape. The Main reader was quickly replaced by a home-made photoelectric device, which was crude but surprisingly reliable.

The *IO*s were written by Brighid Rose (now Mrs Simpkin). She claims to be the first programmer employed by Elliotts (the term was not then in use). Brighid went on to code the guided bomb project, which had to be done using the old teleprinter code (CCITT Alphabet No 2), not ASCII.

George Felton joined us when Nicholas was operational, but still incomplete, and he managed to shorten these *IO*s. We realised that, if they could be made even shorter, the inadequate Auxiliary reader could be replaced by a standard stepper switch — a 50-way Uniselector common on telephone exchanges at that time. One morning George announced, "If the *I* instruction could be replaced by a combination of *D* and *I*, I could reduce the auxiliary tape to the required length" (the required length was determined by the number of commands which could be wired in around the stepper switch).

When we turned to Charles' logic diagram, we found that he had specified a connection to one of the plates just to prevent this occurring! I made the necessary disconnection, while George punched out a new auxiliary tape. The mod worked, so the tape reader was replaced by a Uniselector and life became less fraught!

This change was the only one ever found necessary to Charles' original drawing, which speaks volumes for the quality of his work.

Ruth Felton had joined us before George, but had been employed on other work. Now she joined the Nicholas team, and devised what we called the Translation Input (*TI*) — what would now be called an assembler. A visiting IBM executive who was touring computer installations worldwide told us ours was the first site he had seen where such a program was actually in use.

George Felton subsequently developed the Nicholas subroutine library. He has said it was much influenced by the library developed at Cambridge University for Edsac.

Output from Nicholas went either to a standard teleprinter (of the type designed by Creed in 1908 or thereabouts) or to a standard Creed paper tape punch. This machine punched a 5-hole tape which was as wide as 7-hole. In the extra width it printed the alphanumeric character it had just punched, slightly displaced along the tape. When not used for production output, it could be used by programmers to punch their own tapes, and this printing capability allowed them to check easily what they had punched. I believe this was another world first. We also had a standard Creed tape reader which could be used for copying tapes or for printing them on the teleprinter.

A program tape held two instructions per line, the line being terminated by the 'carriage return' and 'line feed' characters and the pair of instructions being separated by a comma. Nicholas translated each pair of instructions into two 16-bit half words, comprising six bits for the op code and 10 for the address, and stored the result as one word.

To recap, Bruce Bambrough had the original idea for Nicholas, and did much of the chasing work to get all the equipment delivered. The wizard Charles Owen designed it. I, the only survivor of the trio, played a modest part in the early days. I put up to my superiors the idea that we could satisfy the RAE computing project by building Nicholas to do the job, but my main contribution was to get the machine up and running and to keep it going for the next five years or so.

One of my decisions was the word length of 32 bits. The choice was between 16 and 32, and as Nicholas was a serial machine the decision had little effect on the overall cost. It had to be fixed point — anything else would have been far too expensive.

I decided that the binary point should be two from the most significant end, because I expected to be undertaking a lot of trigonometrical calculations such as axis conversions. The most significant bit would be the sign, and the one next to it the overflow bit (I never gave the idea of a separate register for overflow a single thought, again on economy grounds). The overflow bit also allowed a function like sin(x) to equal 1, or even slightly more due to rounding error, without causing severe mistakes.

I think I have mentioned everyone who played a significant part in those early days. We were naturally supported by many laboratory technicians, who actually produced the hardware.

Nicholas provided a valuable in-house computing service for the Theory Group at Borehamwood until 1958. It was also used by customers, who could hire time at one old penny a second (£15 per hour). Peter Hunt from the de Havilland Aircraft Company used it to perform flutter calculations with 10x10 matrices for the Comet, the world's first jet airliner.

Nicholas can lay claim to a small part in computer history as well. As George Felton acknowledged in his talk at the opening of the Pegasus section at the London Science Museum in May 2001, our experience with Nicholas played a significant part in the design thinking behind Pegasus.

Editor's note: the author wishes to acknowledge the encouragement and assistance of George Felton and Professor Simon Lavington in the preparation of this article.

Editorial contact details

Readers wishing to contact the Editor may do so by fax to 020 8715 0484 or by email to <wk@nenticknap.fsnet.co.uk>.

Program Verification and Semantics: Early Work

Teresa Numerico and Jonathan Bowen

A seminar discussing the origins of program verification and semantics was held at the Science Museum, London on 5 June 2001. It was organized with the co-operation of the British Computer Society (BCS) and the Computer Conservation Society (CCS), and proved an instructive and enjoyable afternoon for the hundred or so people that attended the meeting.

Participating in the meeting were some of the pioneers and most important scientists in the fields of program verification and semantics and some of the most important historians of computing in Great Britain. It was a unique occasion that allowed the mingling of these two groups of people with an interest in computer science.

The organization of Professor Jonathan Bowen, Professor Cliff Jones and George Davis created a good rapport between the audience and the speakers, whose presentations about their experiences in the field of formal methods ranged from formal lectures to personal reminiscences. It was a historical event in itself: the special atmosphere allowed the audience to participate with interesting questions and reminiscences of their own.

After an introductory speech by Chris Burton on the aims of the CCS, Jonathan Bowen outlined briefly the history of formal methods from Aristotle's logic to the use of Tony Hoare's assertions method in present debugging techniques, via the achievements of Alan Turing and Christopher Strachey.

The main speakers at the meeting were Sir Tony Hoare (Queen's University Belfast, Oxford University and Microsoft Research Cambridge), Joe Stoy (Oxford University Computing Laboratory), Professor Robin Milner (Edinburgh and Cambridge Universities), and Professor Peter Landin (Queen Mary University of London).

Tony Hoare gave a talk titled *Assertions: a personal perspective.* It was an excursus on his long and successful career, in and out of industry and academia. During his training in humanities, language and statistics, he became interested in mathematical logic and its power, under the supervision of John Lucas.

When he started his career in industry, at Elliott Brothers in 1960, he led a team that designed and delivered the first compiler for Algol 60. He attributed his success to the fact that the compiler used Algol itself as the design language. He became interested in axiomatic theory, reading Bertrand Russell's *Introduction to Mathematical Philosophy*, and realized that computer programs could also be expressed and defined using assertions, known as preconditions and postconditions, relative to the results that were expected at the launch and termination of a program.

From 1968 he pursued his research into assertions in an academic setting, first at Queen's University in Belfast and then from 1977 for 22 years at Oxford University, till he joined Microsoft in 1999. While he was working in a university environment he could persevere in his research considering his objectives as long-term achievements. When he went back into industry, he found that assertions are in widespread use: in a range of products they comprise between 1% and 10% of the code volume. Their primary role is to act as a test oracle, a definition of when and under what circumstances a test on that specific program is considered a failure.

According to him there are still a lot of challenges to face, like the extension of assertions to cover some characteristics of the object-oriented languages, such as inheritance, overriding and pointer manipulation. His belief however is that in the future assertional methods will be used as a design tool to evaluate the quality of programs. Keeping this aim in mind, it is still very important to concentrate on academic long-term research objectives[1].

Joe Stoy's talk was entitled *The beginnings of formal semantics at Oxford*, in which he described in detail the creation and the results of the Programming Research Group (PRG) at Oxford University. The group was the outcome of a strong battle between Leslie Fox and Christopher Strachey who, at the beginning of the 1960s, had opposing views with regard to computing machines and the most appropriate use of them.

According to Strachey, programming demanded a great deal of mathematical and theoretical study, while Leslie Fox believed that it was mainly a practical activity that was not suitable for undergraduates. In fact Fox was intensely against the practice adopted at MIT of using almost half of the available machines to teach students the programming principles and techniques. Strachey's major objective was the definition of the basic concepts that allowed the description of all the parts of a programming language in term of mathematical declarative expressions, so that it would not be necessary to postulate an "evaluating mechanism".

[1] An edited version of Sir Tony Hoare's talk was published in *Resurrection* issue 26 on pages 4-12.

The contact between Strachey and Dana Scott was fruitful both for themselves and for the whole PRG. Scott's work on lattice semantics allowed the use of typed lambda calculus and, from 1969, of type-free formal calculus. Strachey himself underlined Dana's role in his results when reporting progress to the Science Research Council (SRC) in 1970.

Stoy mentioned many PRG graduate students who made important contributions to research in the field, during the 1970s, but reported also that Strachey was seriously worried about the distance between programming practice in industry and programming theory studied at university.

However, Stoy emphasized the increased importance of simplicity and of functional programming in industrial software production. Even if he started to work with the group by chance, being a physicist who happened to attend the right party at the right time, he has enjoyed being a member of the PRG.

Robin Milner has an established reputation for three distinct and complete achievements, which had a marked effect on the theory and practice of computer science: LCF, the mechanization of Scott's logic of computable functions, probably the first theoretically based yet practical tool for machine-assisted proof construction; ML, the first language to include polymorphic type inference together with a type-safe exception-handling mechanism; and CCS, a general theory of concurrency. He was the third speaker at the meeting and gave a talk with the title *Concept and formality in computing.*

He spoke about how his scientific life divided into four major interests: program verification, semantics, process algebra and models of interactions. The starting point was the necessity of testing large programs, and the desire to mechanize the program verification procedure. With this purpose in mind, he created a resolution theorem prover that worked well, and gave him the clear belief that he needed science and not luck!

Creating interaction between man and machines implied use of the formality of the program structure in order to avoid misunderstandings. The machine-assisted formal reasoning obliged the human programmer to express goals, devise proof strategies, and define the notion of composing strategies together. He was influenced by Scott and McCarthy and spent one year at Stanford (1971-72) working in the concurrency field.

In his view there is a balance between formal semantics and programming practice. He has belonged to different research communities and declared he had influenced and had been influenced by all of his colleagues.

He was very conscious of the dilemma between formality in languages and the need of quick and reasonable results in the actual practice of programming.

Peter Landin gave the last talk with the provocative title of *Why are things so complicated?*. It was a very personal recollection of thoughts about the beginnings of his scholarly career, which started at the end of the 1950s. He was much influenced by McCarthy and started to study Lisp when the most common language was Fortran.

Lisp was very different from the other contemporary languages because it was based on a functional calculus and distinguished clearly between a function as a procedure and all its arguments. He reminded the audience of Marvin Minsky's hostility against lambda calculus and Algol, while he was writing some theoretical papers related to them. He remembered how difficult it was to deal with delay lines and drums and gave the flavour of the past times. The audience had the impression that a piece of the computing history was dancing in front of them.

At the end of the meeting, Cliff Jones drew some conclusions. The ability to prove mathematically that a program correctly implements its specification is increasingly important, even if there is still a lot to do in order to guarantee that security and safety-critical applications perform correctly. The major points of importance were:

- The long-term objectives in research, that were not comparable with the urgency of short-term results of software engineering companies
- The results obtained through academic achievements used subsequently in industrial practice, confirming that academic ideas can be successful with patience
- The never-ending tension between theory and practice in using formal methods
- The importance of belonging to a scientific community in order to achieve outstanding results
- The profitable interactions between some US universities, scientists such as Scott and McCarthy, and UK research groups.

Further information on the seminar, including a selection of photographs, can be found at <http://vmoc.museophile.sbu.ac.uk/pvs01/>.

Uses of the Science Museum Pegasus

Doug Brewster

Now that a Pegasus has been resurrected and is fully operational in the London Science Museum, it is an appropriate time to recall how the machine was used during its heyday, and to discuss how visitors can use it today.

Extensive and complicated calculations have always been central to engineering. The arrival of Pegasus opened up the prospect of carrying out such calculations automatically. That would allow engineers such as myself to examine a wider selection of different solutions, and also, most importantly, should ensure a considerable reduction in the number of errors.

But it soon became clear that a large number of suitable programs would have to be written before much of this gain could be realised. In the event, it took us many hours of effort to deal with the problems that arose in writing these programs, the nature and intransigence of which could not have been realistically anticipated.

Nonetheless, the Pegasus autocode was to us its most important feature. It allowed those of us to whom the concept of electronic computation was entirely new to realise that a significant and helpful development was now on the horizon, and helped encourage computer use outside the ranks of those expert in computer theory and technology.

It may be of interest to recap on some of the work that was carried out during the early 1960s using autocode programs. It included:

- Stresses in reinforced concrete bridge decks formed from skew slabs. This programs was initiated by the Concrete Society at Wexham Springs and carried out at Northampton Polytechnic in London (now part of City University) and Southampton University. Some of the results were used by British Rail. An almost identical project was independently pursued at the same time in Bratislava using an Elliott 803.

- Charts for the design of reinforced concrete beams and columns, prepared by the Concrete Society using the Pegasus at Northampton Polytechnic.

- Design of reinforced concrete chimneys: this work was again carried out at Northampton Polytechnic.
- Design of reinforced concrete reservoirs: this involved calculations for working details. The program was run at Battersea Polytechnic (now part of Surrey University).
- Design of part of the containment structure for the thetatron experiment at Culham. This program was developed by Ferranti and run at the company's bureau at Portland Place.
- Elastic analysis of rectangular slabs: calculations carried out at Battersea Polytechnic.
- Calculation of bending moments and shear forces arising in beams of several spans under the application of a range of different loading requirements. This program was developed at Southampton University and run at the Newman Street bureau in London.
- Program to prepare concrete reinforcement bar bending schedules, order lists and weighting (written in Extended Mercury Autocode).

Some of these programs were subsequently improved for use on the later Ferranti Sirius at Newman Street, and on the still more powerful Ferranti Atlas in London's Gordon Square.

The autocode interpreter used to write the original versions of these programs is available today in the Science Museum on 5-hole paper tape. There are four sample programs given in the original Pegasus explanatory manual, and they are provided again on 5-hole tape as data ready to run.

The straightforward logic of the autocode encourages a recreational approach to its use. The Society's Pegasus Working Party has developed four other sample programs: for identifying days of the week; for calculating Pascal's triangle; for Fibonacci numbers; and for primes.

A large number of engineering problems require the solution of simultaneous equations. You can do this on Pegasus by using the Matrix Interpretive Scheme, a copy of which is available and ready for use on 5-hole paper tape. Of the various functions included in the Scheme, we have selected two as examples: addition, and inversion with multiplication. The programs with associated data are again ready for use.

A typical Pegasus installation needed equipment allowing the preparation and editing of 5-hole paper tape for both programs and data. At the

Science Museum there is a Creed tape handling device, which will read and print a tape, will allow characters to be entered and edited onto a tape, and will allow copying of a tape.

We also have a PC486 personal computer with Pegasus emulator, which is quicker and easier to use than the Creed device. The emulator accepts an ASCII text file, translates it into Ferranti format and punches the result onto paper tape ready for reading into the Pegasus. It can also be used to emulate all the other Pegasus capabilities, including the autocode and the matrix interpretations.

CCS Web Site Information

The Society has its own World Wide Web (WWW) site: it is located at <www.bcs.org.uk/sg/ccs/>. This is in addition to the FTP site at <ftp.cs.man.ac.uk/pub/CCS-Archive> (please note that this latter URL is case-sensitive). The 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.

Cost-justifying Computers: Early Thinking

Hugh McGregor Ross

The primary thrust of work with stored program computers throughout the 1950s was to enhance their multi-purpose capability. Merely by loading a different program into the memory, the machine could be made to tackle another application. This was the great excitement of the stored program concept, and the most fundamental contrast with other electronic machines, of which Eniac was the most remarkable example.

There was more to this development than enthusiasm: there was also an underlying economic drive. In Ferranti we had quickly discovered the enormous cost of developing hardware for any computer. By the end of the decade we had begun to recognise — the hard way and belatedly — the cost of developing software as well. The only way to recover this cost was to spread it over many sales. Because no single community of users could be foreseen, that meant making each machine usable for many applications.

I described in *Resurrection* issue 25[1] how at the start of the decade no application (discounting military uses) had been identified that would justify the cost of a computer. By about 1955, we had established, for example, by trials at our own factory at Hollinwood that wages calculation alone would not justify the use of a computer. A wider range of uses was essential.

Accordingly, a major aspect of our work at Ferranti was to establish new applications, primarily by intensive efforts to encourage users to write new types of program. Some other firms, particularly English Electric and Elliott, were pursuing the same objective.

This quest for generality extended to the basic software, with operating systems and even programming languages becoming more multi-purpose. The apogee of this process can be seen in products such as IBM's OS and Microsoft's DOS. Both exploited the fact that processing power and memory capacity had expanded so greatly that they could be used very inefficiently. I recall hiring time on an IBM 360/40 in 1977 when I was obviously paying more for the machine to run around its operating system than to process my application.

The drive towards this generality came from much more than merely the need to spread the cost of development. The justification for every sale

[1] "Ferranti's London Computer Centre", pages 9-15.

during the era of Ferranti's Mark 1, Mercury, Pegasus, Perseus, Orion, Sirius and Atlas computers (and possibly also the following eras of the ICL 1900 and 2900 ranges) was dependent upon the purchaser using a multiplicity of programs to serve a variety of applications.

But by no means all computer development during the 1950s went down this route: some work was done on single purpose computers. The 152 project at Elliott Brothers Laboratories was a pioneering example, but I believe single purpose computer design really took off when design techniques using modular logic units were adopted in Bill Elliott's Ferranti laboratory in London. With systems like this, though the program was still held in store and instructions could still be changed during a processing run, there was little emphasis on replacing whole programs.

One of the earliest examples I can recall is a proposal by John Bennett and Harry Cotton in February 1955 for a computer specifically designed to do mapping calculations for the Ordnance Survey[2].

Readers may know of other early examples. I believe that by around 1955 Leon Bagrit's foresight that special purpose computers could be used for the automation of process control in factories may have been bearing fruit. Another possible example from Bill Elliott's laboratory is the work by Jack Pletts and Harry Johnson on air defence missiles and guided weapons systems. These later became important lines of business for the Ferranti divisions at Wythenshawe and Edinburgh.

Harry Johnson also proposed a scheme using a special purpose computer for air traffic control. This became the Apollo computer, which was installed at the Prestwick Air Traffic Control Centre and gave over 21 years service[3]. Other similar developments made when the London laboratory moved to Bracknell led to the Hermes, Poseidon (specifically for naval use) and Argus computers. All of these were paid for by the taxpayer — you and me.

A different approach from both general purpose and single purpose developments was adopted by Standard Telephones and Cables (STC) for

[2]John Bennett has recounted how a senior military officer from the OS was invited to visit the Manchester University Mark 1 computer to see how wonderful computers were. On the day he went the computer failed to work at all, despite frantic efforts by the engineers. The OS stuck to punched cards!

[3]Harry Johnson's original flight information store proposed a large magnetic drum and controller, with input and output channels to the operators. It was FPC2 (Ferranti Packaged Computer number 1 became Pegasus; FPC3 became Perseus). By the time it was implemented as Apollo, using transistors rather than thermionic valves, it had become more like a computer. Attempts to adapt it for more general use came to nothing. The air traffic control work was extended for some years, with Ferranti making equipment for operational use and for training controllers; exports were made to Holland, Denmark, Taiwan and Australia.

telegraph message switching systems. This was a hybrid solution, using off-the-peg hardware for one specific application.

STC pioneered in 1956 the automation of switching centres — what we nowadays call nodes in a store-and-forward telecomms network — by giant hardwired digital machines named Strad. By 1964 a division had been set up to take this development further using stored program computers. These computers would carry out only one process: accept telegrams over a multiplicity of lines; store them; for each telegram identify from a header the destination address; choose the appropriate outgoing line; and forward the telegram.

By this time Digital Equipment Corporation (DEC) had evolved the PDP-8 — a genuine multi-purpose computer which, within its intentionally limited capacity, was remarkably effective. The hardware was a mix of discrete components and Large Scale Integration (LSI) modules, which allowed DEC to manufacture and sell the machine in quantity. So its development costs, which including the LSI units must have been substantial, could be divided by 100 or more and became an insignificant part of the per-unit selling price.

On these grounds I as general manager of the STC division chose the PDP-8 as a means to make and market more versatile and economic automated message switching centres. In effect, I bought a brilliant computer for a price which included only a tiny fraction of its development costs. In order to establish a viable business, we added hardware and loaded into memory a single optimised program suite. Although the PDP-8s were the heart and brains of each switching system, they accounted for only around 20% of the total selling price.

We evolved a special basic operating system to suit our application. I think it was written in machine code! This had the benefit of using less memory while being very fast, and it could be highly perfected to avoid software bugs. It also exploited a feature, which was I think unique at that time, of an interrupt facility within the computer. This was used to sample the incoming signals on the telegraph lines, over which the computer had no control, so that the characters could be assembled and put into core store ready for processing. The whole system worked in real time.

By 1979, well beyond my time at STC, the company had sold no fewer than 51 major switching systems and 94 simpler ones. The larger systems used more powerful computers than the PDP-8, but the smaller ones continued to use later versions of the same computer.

In the great majority of these switching systems STC continued the practice of employing a general purpose computer for a single purpose application. Were there any other examples elsewhere which led to commercial success, before the arrival of computers on a chip and of word processors?

CCS Collection Policy

The Committee of the Society has formulated a policy statement concerning procedures for dealing with computers of historical interest that come to the Society's attention. This is published in full below.

1. The Society has no Collection of its own, and no premises in which to house one. There is no intention to change this.
2. When the Society hears of historic equipment which is becoming available for conservation, it will attempt to find a suitable home for it in one of the following major collections:
    - The Bletchley Park Museum Trust
    - The Science Museum, South Kensington
    - The Museum of Science and Industry, Manchester
3. The Society will also alert other collections to the availability of surplus equipment, where the major collections are unable to offer to house it, if it fits the appropriate area of interest. Members who know of such collections are asked to ensure that the Secretary is aware of their location and subject matter.

Anniversaries in 2002

It is now quarter of a century since practical personal computers first arrived in the UK and started to revolutionise the usage of computers in business. Significant information technology anniversaries this year include:

- **150th** Death of Ada, Lady Lovelace, credited as the world's first programmer, in 1852
- **100th** Birth of Walter Houser Brattain, co-inventor of transistor, in 1902
- **75th** Birth of Robert Noyce, one of inventors of microchip, in 1927
- **50th** Elliott's Nicholas computer became operational (see pages 10-14), in 1952
- **40th** Introduction of two major Ferranti products, Argus and Orion, in 1962
- **30th** Introduction of daisywheel printer by Diablo, in 1972
- **30th** IBM popularises virtual storage with the launch of VM and what was to become MVS, in 1972
- **30th** Release of Pick operating system, in 1972
- **25th** Launch of DEC VAX 32-bit minicomputer range, in 1977
- **25th** Launch of Commodore Pet personal computer, in 1977
- **25th** UK launch of Apple II personal computer, in 1977
- **20th** End of British Telecom's monopoly as Mercury Telecommunications granted licence, in 1982
- **10th** Launch of DEC Alpha, the first 64-bit microprocessor, in 1992
- **10th** Launch by Storage Technology of first virtual disc subsystem, Iceberg, in 1992
- **10th** Death of Grace Hopper, another programming pioneer, in 1992

Forthcoming Events

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

Every weekend 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

19 March 2002 NWG meeting titled "The Turing Bombe Rebuild Project"

Speaker John Harper

20-21 April 2002 Turing Bombe Rebuild Project demonstration

for more details see report on page 7

23 May 2002 CCS Annual General Meeting

starts 1415

23 May 2002 seminar on "Rapid Analytical Machinery", covering various automated code-breaking machines

starts 1430, following AGM

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 <william.gunn@ntlworld.com>.

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Members who move house should notify Hamish Carmichael of their new address to ensure that they continue to receive copies of *Resurrection.* Those who are also members of the BCS should note that the CCS membership is different from the BCS list and so needs to be maintained separately.

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