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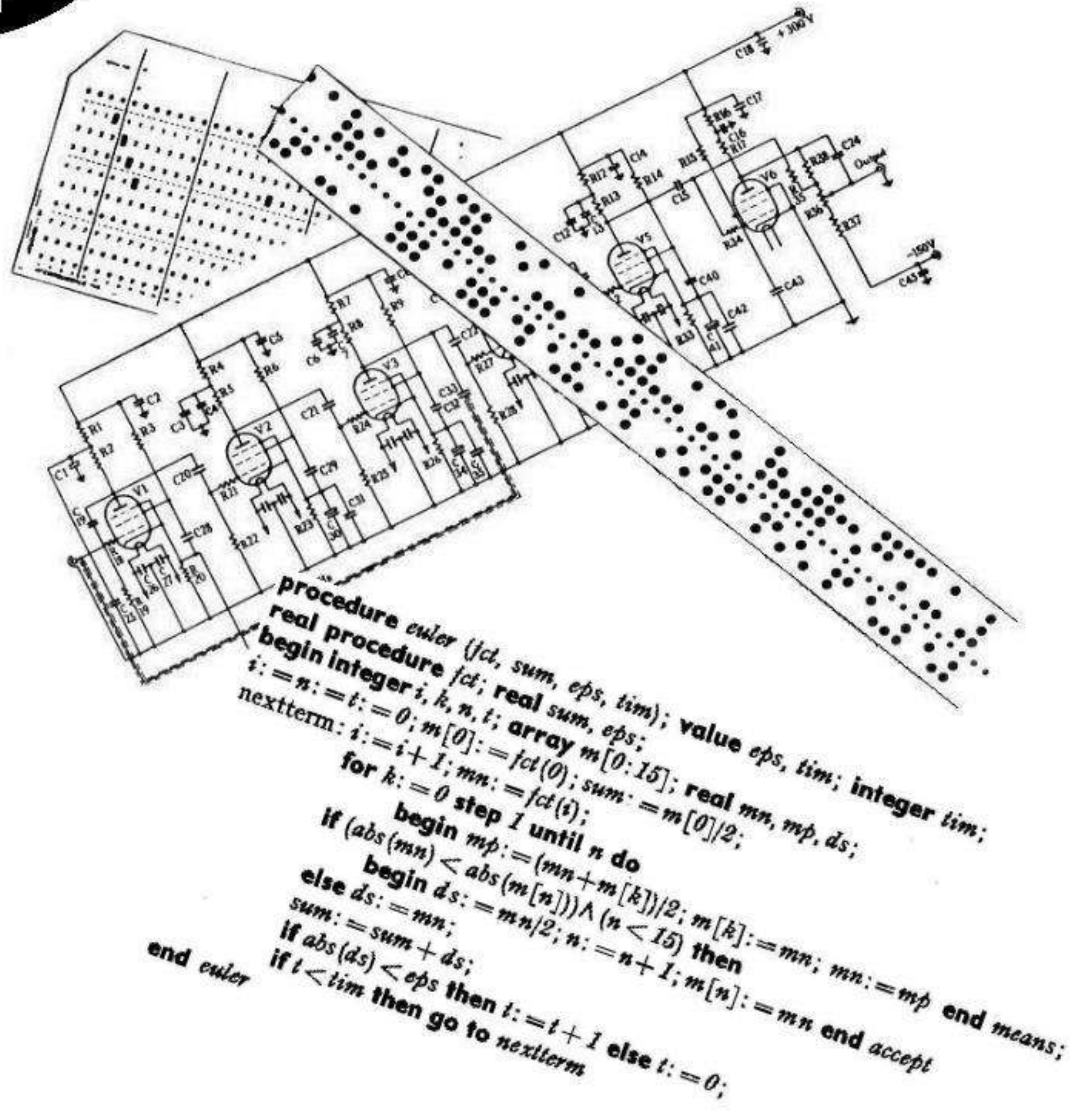

RESURRECTION

The Bulletin of the Computer Conservation Society

Computer Conservation Society

Aims and objectives

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

The CCS was constituted in September 1989 as a Specialist Group of the British Computer Society. 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,

◊ To develop awareness of the importance of historic computers,

◊ To develop expertise in the conservation and restoration of historic computers,

◊ To represent the interests of Computer Conservation Society members with other bodies,

◊ To promote the study of historic computers, their use and the history of the computer industry,

◊ To publish information of relevance to these objectives for the information of Computer Conservation Society members and the wider public.

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 the facilities of both museums. Some charges may be made for publications and attendance at seminars and conferences.

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

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Society Activity

Pegasus Project – *Len Hewitt*

Science Museum conservators ascertained that there were no polychlorinated biphenyls (PCBs) in the exudations near the burned terminal block, much to everyone's relief. Nevertheless, any newly leaking capacitors will need to be removed on the precautionary principle, even though their type number has been ascertained to be free of PCBs. Several heater transformers have leaked a minute amount of potting pitch (not surprising after 60 years of use) and this has caused concern to the conservators. We have to find a way of reassuring them that cosmetic cleaning will be all that is required.

The budget for Pegasus has run out so replacement fuse carriers which contain no asbestos cannot be purchased until there is a renewed budget.

A meeting of museum staff and project team members was held in early April to review the findings so far. It was agreed that the whole machine will be cleaned inside, and this may take several months.

Furthermore, because of to its age, the machine has never been certified electrically to modern standards, and a plan for having it certified as safe by an appropriately qualified consultant will need to be established. Museum electricians will not allow power to be restored until that has been done.

Pegasus Project (Late News) – *Tilly Blyth*

Readers will be delighted to hear that the Science Museum has agreed a commitment to continuing to run the Ferranti Pegasus, but will need to ensure that this is done in line with current Health and Safety legislation. The Museum will remediate asbestos material from the machine and will recruit an electrical consultant to provide regular independent certification to ensure the safety of the Pegasus display. More in the next issue of *Resurrection*.

Elliott 803 Project – *Peter Onion*

The 803 has been properly wired into the mains supply via a lockable isolator. This can be locked "OFF" if the machine is faulty and awaiting the attention of an engineer.

A programme of cooling fan maintenance has been undertaken after the machine turned itself off a couple of times. We found that both the fans in the bottom of one of the CPU cabinets were not running. John Sinclair says that in his experience 803s would run quite happily without any of their fans operating, but this would have been in air conditioned computer rooms. Since then, one fan has been replaced with a spare and two others have been serviced. The other three will be serviced over the next few weeks. Some LCD strip thermometers have been placed in the hot air exhaust grills at the top of all the cabinets to monitor the temperatures.

Most of the existing 803 operators have been given a short refresher session on operating the 803.

Our large collection of 803 maintenance diagrams has been sorted out. Apart from one complete set for use with the machine, the rest will now be put into the TNMOC archive. During this sorting out process two diagrams pertaining to the 803-to-Calcomp plotter connection were located. These will be very useful when we have restored our Calcomp 565 plotter to working order.

An obscure (and potentially long standing) fault in the machine was discovered over the Easter weekend. It first showed up when an H-code program misbehaved when drawing the axes for a graph, and then when floating point numbers were being printed in standard form. By making an instruction by instruction comparison between the behaviour of the real 803 and my 803 emulator (which runs the program correctly) I was able to identify the failing instruction and hence the failed logic core. As is normally the case, the core's output transistor was found to have gone open circuit. With a replacement OC84 installed, the fault was cleared.

The 50th anniversary of the first shipment of the 803B is due this coming winter. The National Museum of Computing is planning a celebration. No details yet, but keep an eye on their website.

Software Conservation – *David Holdsworth*

The KDF9 Walgol project still makes small steps. It is not yet perfect, but it still works well enough to do meaningful demonstrations. I believe that it can also serve as a model on how to rescue assembly language software from line printer listings.

I am hopeful that we shall at last be able to get an archive in which we can preserve historic digital stuff, and this will give confidence that results can be retained long-term.

I am currently working on packaging the BBC Domesday data onto flash memory. Now that the Ordnance Survey has put its maps in the public domain, it would seem that there is no longer a copyright problem in this area.

The Hartree Differential Analyser – *Charles Lindsey*

The mechanical Differential Analyser built by Metropolitan Vickers in 1935, to the order of Prof. Hartree at Manchester University, was in regular use on various sites until 1965, and most notably made important contributions to the war effort when used by the Ministry of Supply.

Half of the machine (four of the eight original integrators) now resides in the Science Museum, a quarter of it (two of the eight) is in the Museum of Science and Industry in Manchester and the remaining pieces, in varying states of decay, are also at Manchester. Recently, the BCS has made available £1,000 to enable the Manchester piece to be restored to a working and demonstrable state, and a CCS Working Party, currently consisting of Charles Lindsey, Bill Purvis and Brian Russell, has been formed to make it happen.

We are working to a plan drawn up by Charles Lindsey following a thorough examination of the machine in 1994 (the Museum was unwilling to consider restoration at that time).

Not much progress to report to date - a few minor repairs and provision of means to tension the drive belts properly. The main work is awaiting provision of a three-phase supply to run the motors, and this is hampered by the pressure of umpteen equally worthy demands on the resources of the technical staff at the Museum. In addition, the Museum has seemingly lost some bits of the machine (Museums are not supposed to do that), and there have been difficulties in accessing such records as exist, due to a belief that “if it’s not on the Computer, then it doesn't exist" (CCS members are probably aware, more than most members of the community, of how fallible computerised records can be).

But we live in hope, and for sure we will get there in the end!

Dik Leatherdale adds –

This well-known photograph (Courtesy of Rutherford Laboratory) shows the Differential Analyser in use. We know the man in the foreground is Jack Howlett, later to become the Director of the Atlas Computer Laboratory at Chilton. The man standing on the right is almost certainly Hartree himself. But the real surprise is the man at the back. It would seem that he is Klaus Fuchs who would later achieve a certain notoriety as a convicted Russian spy. On the other hand, this may be quite wrong as I can no longer remember who told me. Can anybody help?

It would be fascinating to know the identity of the young lady and of the follically-challenged man sitting opposite Hartree. I am confident that I can rely on the collective wisdom of CCS members to solve this mystery.

Harwell Dekatron Computer Project – *Tony Frazer*

I have now completed the partial rewiring of racks 4 and 5 and cleaning/replacement of U points.

All store units have been replaced on the racks and repopulated with Dekatrons.

In the case of two store units, the top five stores in each unit have been populated with GC10B Dekatrons, rather than the original GC10A type. This has been done for two reasons: Firstly, we know that we do not have sufficient good GC10A tubes to completely populate the machine and rather than leaving the machine partially populated, we can draw from the supply of GC10B Dekatrons, some of which were stored with the computer and others that have been kindly donated to us. Secondly, the original GC10A Dekatrons are very faint and difficult for visitors to see, whereas the GC10B is much brighter and will help us demonstrate the machine. I also intend to fit GC10B Dekatrons to the accumulator in due course.

My plans for the store exerciser are sufficiently concrete to begin construction of the unit. The main purpose of the store exerciser is to provide a means of repetitively testing racks 4 + 5, connections, relays, lamps and Dekatrons, identifying faults (including intermittent!) for further investigation. It also occurred to us that this will enable us to demonstrate the stores in operation to our visitors while we continue work on other parts of the computer. The store exerciser will be a standalone unit, built on our portable test rack which already has a high tension power supply which will provide the Dekatron anode supply. A detachable harness will connect the store exerciser to racks 4 + 5 while it is in use. The basic operation of the store exerciser will be to choose send or receive lines, select a Dekatron within a store within a store unit. This will be achieved by means of three uniselectors for the store unit, store and Dekatron selections respectively. A series of actions and tests to that Dekatron will be applied under the local control of a PIC and associated circuits which will generate authentic guide pulses and sense whether the cathode voltage goes positive. A possible test sequence may be to send 10 pulse pairs to read a Dekatron's current state, then apply a pulse pair to advance one position, then send a further 10 pulse pairs to read the Dekatron's new state. The store exerciser will be controlled by a laptop computer (also mounted on the rack) by means of a USB-to-parallel interface card and associated circuits to drive the uniselectors and return data from the PIC. An option will be provided to perform marginal tests by reducing the guide pulse amplitude by a preset amount. Test results will be displayed and logged for further analysis.

Eddie has completed adjustment of all relays on the racks, and is now servicing the tape reader feed mechanisms. An authentic stepper circuit has been assembled on a piece of plywood which charges a capacitor through a resistor. Operating the switch dumps the charge from the capacitor into the solenoid of the tape reader, causing the pawl and ratchet wheel to advance the tape one character. Some pawls were found to be hanging downwards rather than engaging with the ratchet wheel - this was easily adjusted. However one reader has a missing spring and another a broken spring, for which we shall need to find or fabricate replacements.

Johan has been fitting a spur to the ring main in the project area, with additional sockets fixed to the floor underneath the computer. We also have an isolator and distribution panel fitted at the bottom rear of the PSU rack, and red warning lamps visible from the front and rear of the computer which are lit whenever the isolator is live. Johan plans to fit a contactor and emergency power cut-out to the spur in the near future.

Ros Mennie (daughter of Dick Barnes, one of the original designers of the computer) is joining the project team and has started examining the software we had recovered from paper tapes that were stored with the machine (and found a bug in my five-hole code to character translation routine!).

CCS Website Information

The Society has its own website, which is located at *www.computerconservationsociety.org*. It contains news items, details of forthcoming events, and also electronic copies of all past issues of *Resurrection*, in both HTML and PDF formats, which can be downloaded for printing. We also have an FTP site at *ftp.cs.man.ac.uk/pub/CCS-Archive*, where there is other material for downloading including simulators for historic machines. Please note that the latter URL is case-sensitive.

ICT 1301 Project – *Rod Brown*

It is with much relief that we are able to confirm that the future of the project is back on track. The threat of a large increase in the rates levied on the building housing the computer has now been removed! The CCS, the BCS and even the BBC supplied so much support for the project that the threat has been withdrawn. The final decision was taken by the Valuation Office in London and was decided in our favour. So many thanks to everybody who got involved and ensured such a positive outcome.

We can now return to the main task of completing the restoration and arranging to show the machine to the public on open days. We hope to confirm the public open day in July of 2010 soon, once insurance cover is arranged.

Due to the rates issue taking up much of the winter, it was with some caution that restoration work restarted on the 24th March, I am glad to report that the machine is mostly functional after such a hard winter. It has run the demonstration program which we use as a yardstick and as a showpiece on open days. At 48 years old, it is always a good sign that we are doing the right things. With just two years to the 50th anniversary of the start of its working life in 1962 we are growing confident that we can complete the software recovery by that date.

The BBC exposure has resulted in several new contacts at the website including a request to deliver a talk to the Kent Branch of the BCS in September.

For more news visit the CCS website or drop by the project's own site at *ict1301.co.uk*

Contact details

Readers wishing to contact the Editor may do so by email to *dik@leatherdale.net*, or by post to 124 Stanley Road, Teddington, TW11 8TX. Queries about all other CCS matters should be addressed to the Secretary, Kevin Murrell, at *kevin.murrell@tnmoc.org*, or by post to 25 Comet Close, Ash Vale, Aldershot, Hants GU12 5SG.

Bombe Rebuild Project - *John Harper*

Training of new recruits to enable demonstrations to be given to the public at weekends continues but we still need more volunteers coming forward. One thing that had not been anticipated was that many of the recruits are existing guides. This is not a problem for us but it does put further strain on manning conducted tours. One can understand these good people because what we are offering is something new and in the warm and dry. Two of the ladies re-training were WRNS operators and to have these demonstrating to the public is something rather special and unique.

We are not being overly ambitious with the demonstrations currently on offer and we find that just running the machine without it necessarily looking for good stops allows a very impressive demonstration with everything visible working. Only a very few visitors wish to know more and this we can handle off-line. Demonstrations are run to a very strict protocol that we developed during early training sessions. Health and safety of visitors, operators and the machine itself are paramount. Reports are produced after each session and any follow up remedial work recorded.

The present aim is to provide demonstrations every Sunday and then extend this to Saturdays. Two such Sunday sessions have already been run successfully without members of the original team being present and six more are planned throughout the summer. If and when we can recruit and train more volunteers we will provide demonstrations on a more frequent basis.

A few days ago we completed making additional wheel cores for the Typex machine and this allows us to decrypt German Surface fleet messages. We have now had a decrypt printed from a Typex of Scharnhorst's Last Message. This is exactly as it would have appeared during WWII.

For more details please go to *cryptocellar.org/*.

Our website is still at *www.jharper.demon.co.uk/bombe1.htm*

News Round-Up

There has been a great deal of comment in the newspapers and on the Web about Sony's announcement that it is withdrawing from the manufacture of floppy discs. Much of it expressed surprise that, not only are floppy discs still being made, but made in large quantities. The reports unleashed a torrent of readers' reminiscences about long-defunct media, from Zip drives to punched cards. It was, as one correspondent observed, a bit like Monty Python's *Four Yorkshiremen* sketch.

101010101

Tilly Blyth reports that the Science Museum has been successful in the first stage of its Heritage Lottery Fund bid for £6.5M to support the development of two new galleries: Making Modern Communications and Making Modern Science. The communications gallery will include aspects of the history of computing and is targeted to open on the second floor in 2014.

The Science Museum has been collaborating with the British Library on an Oral History of British Science, including interviews with some of Britain's computing pioneers. This includes detailed life story interviews with Geoff Tootill, Raymond Bird, Andy Hopper, Dai Edwards, Tony Brooker, Frank Land and Mary Coombes. You can find out more about the project at: *www.bl.uk/historyofscience* and can see how the interviews are progressing by searching the BL Sound Archive at *www.cadensa.bl.uk* with the project code *C1379*.

101010101

The new head of the Museum of Science and Industry in Manchester is Tony Hill. An inside appointment, Tony Hill has previously held the post of Acting Director. He comments "MOSI is a word-class cultural attraction in waiting. I intend to see that this potential is realised... right at the heart of everything Manchester has to offer".

Redevelopment of the main building is progressing and the replica Manchester Baby computer will be displayed in the new gallery which is expected to open in late autumn.

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In March, during a visit to Bletchley Park, then Culture Secretary Ben Bradshaw announced funding of £250,000 towards urgent repairs of some of the buildings and the estate in general.

101010101

On 11th May, the BBC World Service broadcast an edition of *Digital Planet* in which CCS member Tom Vickers was interviewed at length by his granddaughter Harriet Vickers (of Imperial College) about the life and times of NPL's Pilot ACE computer which ran its first program almost exactly 60 years before. Its role in analysing the causes of the DeHavilland Comet disaster was discussed in detail. The interview can be heard at *www.bbc.co.uk/programmes/p007g9yv#p007st1w* and a covering article may be found at *news.bbc.co.uk/1/hi/technology/8683369.stm* .

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Still with the BBC, Dame Stephanie Shirley was the guest on Radio 4's *Desert Island Discs* on 28th May.

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On 17th June, the Worshipful Company of Information Technologists was granted a Royal Charter in a ceremony at St. Paul's Cathedral.

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The BCS has asked the public to vote for its favourite computer pioneers in a competition based on the BBC's *Great Britons* series of 2002. At *pioneers.bcs.org* five "celebrities" introduce an eclectic list of five pioneers – Ada Lovelace, Alan Turing, Hedy Lamarr, Clive Sinclair and Tim Berners-Lee. The idea is that the five celebrities, well known to the audience, introduce the five pioneers who may not be. Your editor is familiar with the five pioneers, but only one of the celebrities. Such is the nature of fame in the modern world. But then again, perhaps your editor is not a member of the target demographic.

Your chairman, David Hartley comments – "I have to admit to a strong aversion to the current fad of asking the public at large to vote on this, that and the other. In particular, I'm strictly not a fan of *Strictly Come Dancing*. In essence this kind of poll usually ends up with winners being those that most people have heard of rather than those that have achieved the most. I hope readers will be relieved to know that the CCS has not been involved with this exercise. Of the five names cited above, I would personally only rate two of them as being any kind of pioneer in the history of our profession; and I'm not saying which!".

101010101

Pioneer Profile: Andrew Booth

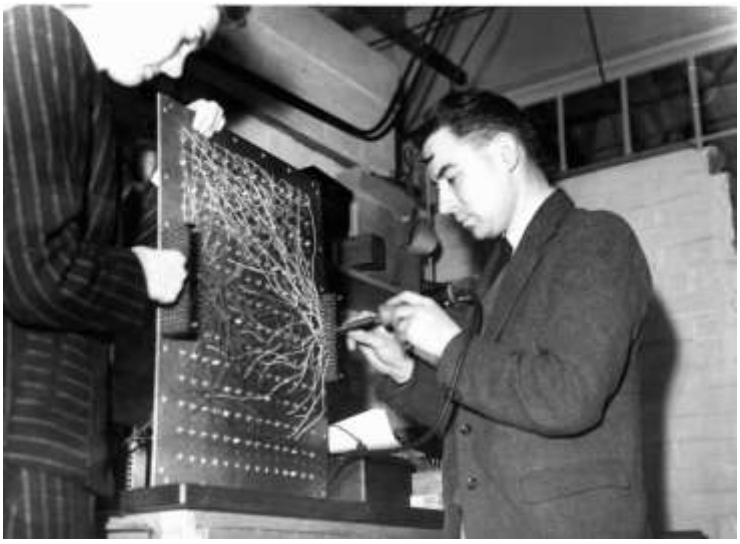
Roger Johnson

Andrew Donald Booth was a distinguished pioneer in the development of computers in the UK. Born on February 11th 1918, he died on November 29th 2009 aged 91 in Canada where he had lived for many years.

Booth received a PhD from the University of Birmingham during WW2 on the crystallography of explosive materials. This work involved solving large sets of complex equations and, tiring of the hours of work involved, he used his natural engineering abilities, probably inherited from his marine engineer father, to build devices to do the calculations. These early efforts at automation brought him to the attention of J D Bernal who was seeking such skills for his research group at Birkbeck.

So in 1945 Booth began his academic career in J D Bernal's laboratory. "Bernal was the best boss that a young man could wish for,' he said. 'If you had ideas and worked hard, he gave support and let you develop in your own way."

By late 1946 Booth was building one of the first computers in the UK, called the Automatic Relay Calculator (ARC). In 1947 Booth spent six months on a Rockefeller Fellowship at Princeton in 1947, hosted by John von Neumann, a friend of J D Bernal. By the end of the visit, he had redesigned ARC to have a von Neumann architecture, the resulting design being usually referred to as ARC2. A key component for the new design was a compact memory. After unsuccessfully trying to adapt an early office dictating machine which employed magnetic oxide coated paper discs, he devised a simple drum made of brass with a nickel coating. This was the world's first rotating storage device for a computer and is now on display in the Science Museum.

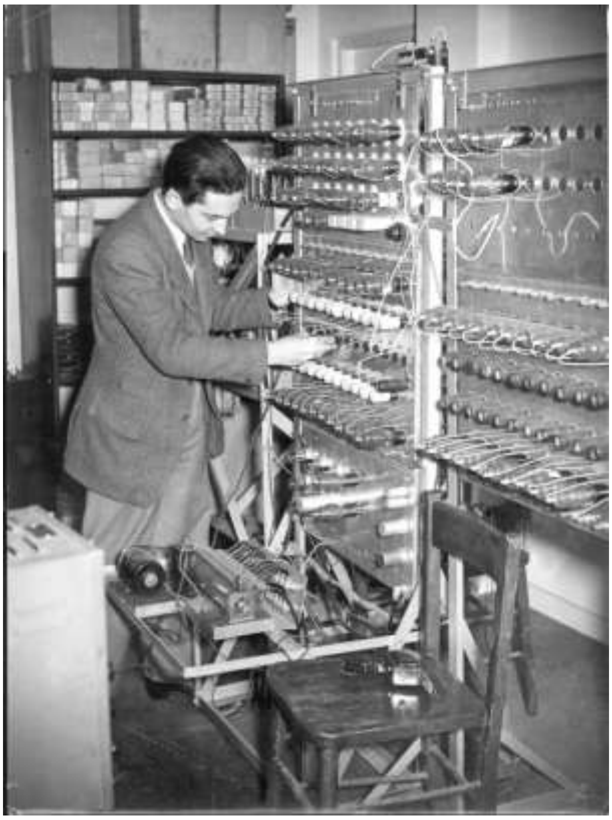


Booth in early 1946 working on ARC1

Booth worked with limited resources, both human and financial, and concentrated on building smaller machines. He had a radical ambition for that time of building a computer that was cheap enough that each university could own one! This was at a time when the NPL ACE was being talked of (at least at NPL) as sufficient for all the UK's needs!

During 1948 he switched to an all-electronic design which was called the Simple Electronic Computer (SEC). It used another, larger drum as its main memory, also now owned by the Science Museum.

Around 1950 he received a grant to work on behalf of the National Physical Laboratory investigating the construction of desk calculating machines. This project seems to have ended prematurely without a full prototype being built.



Norman Kitz and the SEC showing a drum

SEC was built at the same time by a research assistant, Norman Kitz, who later worked on DEUCE at NPL. From there he moved to Bell Punch and designed the world's first electronic desktop calculator, called ANITA. So possibly, Booth's vision acted as the inspiration to the young Kitz for his later work.

In 1951, SEC was followed by Booth's All Purpose Electronic Computer (APEC). In March 1951, a three man team led by Dr Raymond "Dickie" Bird from British Tabulating Machines (BTM) copied Booth's circuitry. Returning to BTM's factory at Letchworth they added extra I/O interfaces and named the resulting computer, the Hollerith Electronic Computer (HEC). This prototype computer is one of the world's earliest surviving electronic computers and is now in store in the Birmingham Museum.

BTM moved ahead rapidly getting HEC to work by the end of 1951. Raymond Bird recollects that Booth's circuitry needed little or no changes for incorporation in the new BTM computer.

BTM management decided that the HEC would go to the Business Efficiency Exhibition in October 1953 and so a new machine (HEC2) had to be built contained in a smart metal cabinet suitable for the public to see. The successor was the HEC4 which was a commercial data processing machine of which over 70 were sold in the UK and abroad. At the end of the 1950s this was the UK's best selling computer by volume. After BTM merged with Powers SAMAS to form ICT the HEC4 became the ICT 1200 range.

ICT 1201

Booth not only built innovative small computers but he and his wife were also interesting in pioneering applications. At the start of his fellowship in March 1947, Booth had paid a courtesy visit to Warren Weaver, then Director of Natural Sciences Division at the Rockefeller Foundation which was funding the visit. During a conversation about the possibility of the Foundation funding a computer for London University, Weaver suggested that funding could be provided if the computer was used, not for numerical calculation, but for the study of natural language translation. This was a hugely ambitious challenge for the tiny machines in those days and Booth used the money to build his relay computer (ARC2). He continued to work over the next 15 years on natural language processing and published and edited numerous books and papers.

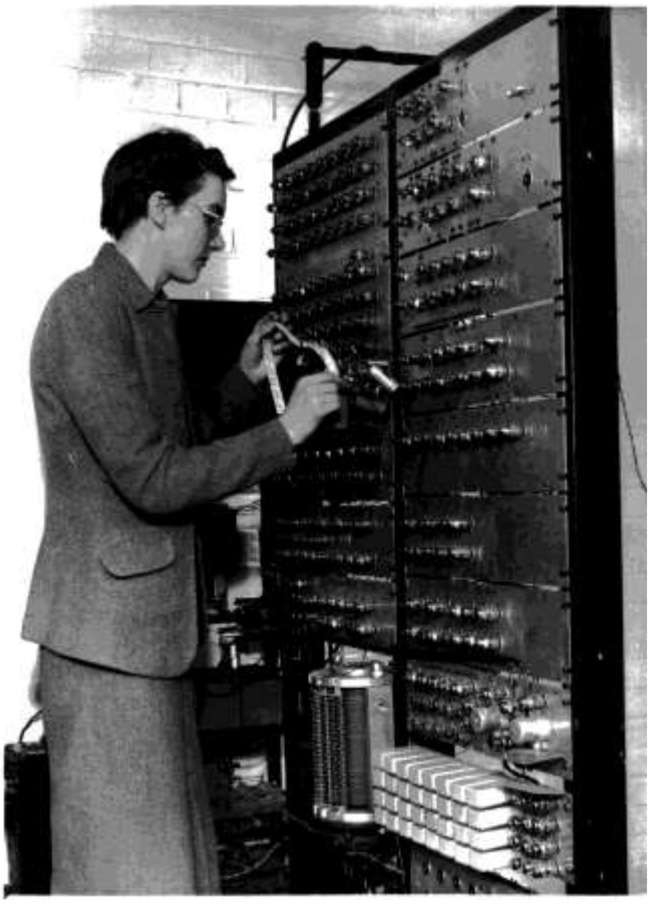
Booth's research on improving computer performance resulted in the Booth Multiplier – still found inside Intel processors today. If the drum reflected Booth's engineering talent, then the Booth multiplier was a demonstration of his mathematical skill. When Booth visited von Neumann in 1947 he obtained details of von Neumann's design for both a hardware multiplier and divider. Booth described them in a later interview as "a beautiful divider" but the multiplier as "an abortion". When Booth asked von Neumann why he had not used a similar approach in his multiplier as in the divider, von Neumann assured him it was a theoretical impossibility and Booth accepted the great man's opinion. When he was designing the APEC computer in 1950 Booth realised that von Neumann was wrong and, over tea with his wife in a central London cafe, he designed a non-restoring binary multiplier which, with a subsequent minor modification by a colleague, is the Booth multiplier which is still in use today.

Basically the Booth multiplier follows the usual method for long multiplication of summing partial products. However it also uses the trick that to multiply in decimal by a string of 9s it is possible to left shift an appropriate number of places and subtract the multiplier from the result. This works even better in binary!

"Looking back," he said when he became a Fellow of Birkbeck College in 2004, "it's interesting to find that the only features of the early computers that are still in use are the magnetic storage devices and the multiplication algorithm, which we pioneered at Birkbeck."

In October 1957 Birkbeck's Electronic Computation Research Laboratory became the Department of Numerical Automation, headed by Booth. It is believed to be the first of its kind, as no other university at that time had an academic department dedicated to the study and teaching of computing - elsewhere it was still the role of computer laboratories. The department was also one of the first to offer a degree course in computing – the MSc in Numerical Automation. Today it forms Birkbeck's Department of Computer Science and Information Systems.

Following a disagreement at Birkbeck College, he moved to Canada in 1962, where he occupied several high-level university posts including being President of Lakehead University. In 1949 he married Dr Kathleen Britten who was then his research assistant and was one of the early female computer pioneers and who wrote an important early book on computer programming.



Kathleen Booth working on APEC

Reminiscences of the IBM 1401

John Smith

In his seminal work *ICL a Business and Technical History*, Martin Campbell-Kelly describes the IBM 1401 as the computer which finally convinced the users of punched card equipment that the computer was a viable business tool. The production figures for the 1401 outstripped any other machine of its time by a country mile. Without the 1401's revenue, there might have been no System 360 and it was the 360 which established IBM's dominance of the industry for a generation. Whether you consider that a good thing or not is a matter for you, but the 1401 was an impressive achievement by any yardstick. Here, we consider this important machine for the first time within the pages of *Resurrection*.

The IBM 1401 Data Processing System introduced in October 1959 was one of the most successful products IBM ever announced. About 15,000 1401 family computers were manufactured and delivered worldwide in the 1960s, far exceeding initial expectations. By March 1961, after only a single year of full production, 2,800 machines had already been delivered to customers. By 1964, 40% of all existing computers were IBM 1401 family machines.

The goal of the 1401 design was to offer a flexible business computer of at least three times the speed and at a lower cost than the ubiquitous card based unit-record accounting machines of the 1950s such as the IBM 407 and 604. By exploiting new computer technology and using magnetic tape for data storage, IBM achieved this goal. An additional aim was to provide the scientific data processing market with an offline machine that could handle input and output efficiently and allow the big scientific machines, in particular the IBM 7090 series, to get on with what they did best: crunching numbers.

The 1401 was a second generation machine based on diode-transistor logic (DTL). Discrete components (transistors, resistors, ...) were mounted on single sided printed circuit boards, which were inserted into sockets on hinged swing out racks. Memory was based on magnetic cores. The 1401 system came with a card reader/punch designated the IBM 1402, a line printer designated the IBM 1403 and up to six magnetic tape units. Four sizes of core store were offered of 1.4K, 4K, 8K and 16K locations respectively.

I first came across the IBM 1401 at the beginning of 1964 when I joined C-E-I-R Inc, a small US consultancy company with a branch in London. The company had a 1401 which it used in conjunction with the IBM 7090 Bureau machine in Newman Street. Our operation was situated in a building just across the road from the IBM bureau. Our 1401 was, if I remember correctly, a 8K machine which came with the usual 1402 card reader/punch, 1403 line printer and several magnetic tape units (I can't remember exactly how many). We also had a full range of card processing and paper handling machines e.g. sorters, tabulators, collators, bursters etc.

The 1401 was a character machine, that is to say it held instructions and data in variable length strings of characters rather than in fixed length words. Data could consist of any number of characters and instructions were of variable length up to a maximum of eight characters. Word mark flags attached to characters defined the boundaries among the various data and instruction fields; when set, a word mark indicated the first character of a data or instruction string.

The use of variable length fields made for efficient use of the limited core store available. However execution speeds tended to be slow due to the need to fetch characters and handle them one at a time. For example, to add two 10 digit numbers together involved about 40 machine cycles. With a basic clock speed of 87 kHz the 1401 would take about half a millisecond to complete the 10 digit add. From a programming point of view one also had to be aware of field lengths; for instance, when using a two address instruction to compare two data items one had to be careful to ensure that the two data fields were of equal length.

Characters were coded in IBM's six bit Binary Coded Decimal (BCD). The six bits were called A, B, 8, 4, 2, and 1. The A and B bits were zone bits and the 8, 4, 2, 1 were numeric bits. Memory was addressed via a string of three characters. The decimal address between 000 and 999 was specified by the numeric bits of these characters. The zone bits of the high order character specified an increment - A for 1,000, B for 2,000 and A and B for 3,000, giving an addressability of 4,000 in all. The zone bits of the low order character specified increments of 4,000, 8,000 or 12,000 to address 16,000 characters. The zone bits of the middle character in the address were used to specify index registers, one of many optional features.

There were 31 primary instructions of six different lengths: one, two, four, five, seven and eight characters respectively. One character instructions consisted of only an opcode. Two character instructions consisted of an opcode and a modifier. Four character instructions consisted of an opcode followed by an address, five character instructions an opcode, address and modifier, seven character instructions an opcode followed by two addresses and eight character instructions an opcode, two addresses and a modifier.

Data was entered on punched cards. Each card had 80 columns with 12 punch locations in each. Each column contained one character or a blank. Characters were encoded as follows. The top three positions of a column were called zone punch positions. A decimal digit had no zone punch, a letter one zone punch and a special character two zone punches. This allowed about 50 different characters to be represented. This was enough for all practical purposes, but not enough to include both upper and lower case. We were thus restricted to working all the time in capitals.

The 1401 did not have an operating system as such. You simply stacked your card deck, consisting of program cards followed by data, into the input hopper of the 1402 and pressed LOAD. The 1402 read in your cards, progressed the job as far as possible, and then halted. The 1402 could read at a rate of 800 cards per minute and punch cards at a rate of 250 cards per minute. The loading process was actually as follows. When the LOAD button was pressed, the first card was read, by hardware, into the first 80 locations in core. A word mark was set in location 1 and execution of the first instruction initiated. The loading program then bootstrapped itself into the first 300 or so locations of core, using SET WORDMARK and READ CARD instructions and went on to load the user's card deck, finally transferring control over to the user's program. The whole process was controlled by sense switches set on the 1401 console.

The machine came with the following software. At the lowest level there was a Symbolic Programming System. Then there was Autocoder, which we mostly used, a Report Program Generator (RPG), a Sort and two high level languages COBOL and FORTRAN. IBM also provided software that emulated the various plug board configurations of the old 407 accounting machine, which provided useful backward compatibility.

The 1403 line printer was a minor marvel. It incorporated a swiftly moving horizontal chain, similar in appearance to a bicycle chain, holding engrave typefaces. There were 132 electronically timed hammers spaced along the printing line. The impact of a hammer pressed the paper and ink ribbon against a type character causing it to print. The chain principle achieved a perfect alignment of the printed line and greatly reduced the number of sets of characters needed. (In fact there were three complete character sets on the chain.) Gone were the days of wobbly lines of print. The quality of the reports produced was outstanding. Another impressive feature was the dual speed carriage which provided the ability to skip over blank spaces on forms and documents at speeds far in excess of normal 600 lines per minute printing rate. The page skip was so rapid that, in positioning the paper to the next page, the printer literally threw the paper up into the air.

The fanfold paper we used had horizontal bars as background, always in pale green. This shade was easy to ignore when you wanted to ignore it and to see when you wanted to see it. It also provided a restful contrast for the black printed text. The paper was usually 14 inches wide with perforations across the sheet every 11 inches, so that it would fold out easily and could be ‘burst’ into separate pages if necessary. Printing was at a fixed pitch, 10 characters per inch horizontally and six characters per inch vertically. To produce multiple copies we used multipart paper. Up to four copies including the original could be produced this way. We had a ‘decollator’ to separate the copies and discard the carbon paper.

Although it has been said that the 1401 killed off punched cards, we were still very much a card shop. All programs as well as many data files were held on cards. The cards were prepared by a separate punched card department employing half a dozen punch girls. One girl punched the cards while a second verified them by re-punching them on a verifying machine. If the verification was successful the machine cut a small nick in the side of the card to show that it had been verified. Programmers looked after their own card decks. We had metal card trays to hold the cards.

Use of cards might seem clumsy but in fact it proved quite convenient and flexible. Each card contained either a single instruction or a discrete piece of data (it was possible to have multi-card instructions). Editing a program or data file was simple: you removed a card, changed it and then reinserted it physically into the deck at the same position. If, for any reason the deck got out of order – it could happen if you dropped the deck, you could restore the order using the sorter because each card would normally contain a serial number in the last eight columns. Moreover you could ask for the cards to be interpreted on the interpreter. A line of print would then appear along the top of the card so that you could read what was on the card and check that it was correct. Card decks could be listed on the Tabulator so that programs could be inspected at very little cost before being submitted for a run. We even had a simple program to scan for obvious logical errors in a program before submitting it for compilation.

I was recruited into the scientific division of the company where most of the work was FORTRAN based and ran on the 7090 under the FORTRAN Monitor system. This, a primitive operating system by today's standards, read each job's card images in sequence off the input tape (always logical unit 5– don't ask me why), ran the job according to the options indicated on the control cards, and output the results onto the output tape (logical unit 6). FORTRAN was compiled into FORTRAN Assembly Language (FAP) which in turn was assembled into object code. Any data supplied, which could of course be located on another tape, was run if indicated. The control cards specified what type of run was required e.g. Were listings required? Etc.

One of the advances that the FORTRAN language introduced was the independent compilation of subroutines. This meant you could divide up your program into convenient chunks and compile them separately so that, if successful, a routine did not have to be compiled again; you could re-submit it in object form on the next run. This saved a considerable amount of machine time which was an important consideration for us and our clients who were paying for it. The compiled code came back to you in the form of re-locatable binary code, multi-punched on cards, which you simply included in your input deck in the appropriate place for the next run.

Source FORTRAN cards were laid out as follows. Column 1 was used to indicate a comment in the program. Columns 2 to 6 were used for the instruction's numeric label, if any. Column 7 was used to indicate a continuation of the previous card. Columns 8 through 72 contained the body of the instruction, and columns 73 through 80 were reserved for the card serial number if any. The re-locatable object cards, which came back after a successful compilation, were laid out in rows rather than columns. Each row contained two of the 36 bit words of the 7090's object program, punched into the first 72 columns of the card. Again the last eight columns were reserved for card serial number. End of file was indicated by a 7-8 punch.

Although I have said we lived in a card environment, we did of course use a lot of magnetic tape as well. We had a tape library with a full time tape librarian to handle all the tapes. There always seemed to be a shortage of tapes because people kept those assigned to them much longer than they needed to. So we were constantly being asked whether we could release our tapes so that they could be re-used.

In the commercial field we developed some applications which were quite large for the time. For instance we did a production control run for Standard Telephones and Cables (STC). Every fortnight their staff came with the orders for the next period. Our software did a parts explosion and calculated the stock that needed to be ordered from the factory for the next production period, a run which took several hours to complete – usually in the middle of the night. On the scientific side we scheduled BP's tanker fleet each week. Many of these applications involved large volumes of printed output for which the 1403 was ideally suited.

We also did a lot of linear programming work on a proprietary software system called LP90. LP90 used a solution method based on the 'product form of the inverse', a clever piece of mathematics which obviated the need to invert the matrix on each iteration of the algorithm. Data elements were entered in card image form, having been first loaded on the 1401. The run was controlled by 'agendum cards' read from the 7090's online card reader. Various output reports could be produced, some of which were processed further by FORTRAN based post-processor programs. The success of LP90 was in fact what had motivated C-E-I-R Inc to set up a base in London in the first place. It enabled London based clients like BP to do their LP90 runs locally rather than in New York. BP and other Oil majors had many planning problems that lent themselves to linear programming, e.g. blending gasolines into required products for maximum profit and optimising the allocation of crude to several refineries taking into account various capacity constraints. They were attracted to LP90 as one of the most powerful LP codes available at the time.

Most of these large applications were run on the 7090 using the 1401 merely to load cards onto tape and print the output. But we did use the 1401 on its own for a variety of smaller jobs, mostly internal, e.g. payroll, time sheet analysis, draft invoice production, tape accounting etc.

We also used the Control and Simulation Language (CSL) developed by Esso and IBM to develop some fairly large simulation programs. This must have been one of the first implementations of the CSL language. The compiler, which took several passes, ran on our 1401 and generated an intermediate FORTRAN deck suitable for input to the 7090. Simple corrections and additions could be made to the intermediate FORTRAN to save the time and expense of re-compiling from the CSL source.

I joined C-E-I- R at a time when commercial computer bureaus were in their heyday. Mainframe computers were incredibly expensive. It is difficult now to remember just how expensive they were. An IBM 7090 for instance cost several million pounds and few firms could afford to own one outright. They were constrained instead to buy time if they wanted access to significant computing resources. Even so computing was expensive: the Newman Street 7090 was charged out at several hundred pounds per hour, equivalent to several thousand of today's pounds.

As the Sixties progressed computing costs started coming down and the case for computer bureaus weakened as companies increasingly began to acquire their own machines. Then in the mid-1960s, IBM introduced the 360 range and the 7090/1401 combination began to look old fashioned. The 360 could access its data and programs randomly because it had a large disk store and a sophisticated operating system. Moreover IBM based the 360 on the eight bit byte (and EBCDIC) instead of the 6 bit character. This allowed a larger range of characters to be represented. At a stroke it made previous IBM machines, and all their competitors, obsolete.

At this time IBM tried to interest C-E-I-R in a top of the range 360/67, but the company decided instead to buy the cheaper CDC 3200 machine. The days of the 1401 were numbered. Then BP bought the company and the company changed its name to Scientific Control Systems. The bureau part of the company moved to Britannic House in the City where BP had a large Univac 1100 installation. At this point punched cards finally began to disappear from the scene. The Univac had a large drum – FASTRAN – on which our programs were permanently held so our large card decks were suddenly reduced to small sets of update cards. This was also the time when VDU terminals and networks were being introduced. The world was changing fast. The IBM 1401 had served its purpose and was withdrawn by IBM in February 1971. But part of it lived on for many years in the shape of that wonderful 1403 line printer.

Editor's note: John Smith started his career at British European Airways in 1960 after studying Mathematics at Cambridge. At BEA he specified and developed one of the first computer-based discrete event Monte Carlo simulations, which ran on the EMIDEC 1100 computer. John then moved to C-E-I-R Ltd in Newman Street in London's West End to work on a variety of simulation and other scientific projects using the IBM1401 and 7090 computers. He can be contacted at john.u.m.smith@googlemail.com .

ICL 1904S Emulator, and a Plea for Information

Brian Spoor

Another ICL 1900 emulator? Does the world need another 1900 emulator? This one is different. It aims to get as close to the original hardware as possible. Very much an engineers' view. So then - not better, not worse, just a very different and challenging approach.

A vast team of two, Bill Gallagher and myself, have been working on a 1904S emulator for the past three years. It runs on both Windows (XP upwards) and Linux platforms.

ICL 1900 installation at Swansea University

The first year of the project was mainly discussions about practicality, method, final aims and so on. We have a fixed division on responsibilities; Bill writes the code (in C++) and I provide deeper 1900 knowledge and break it. We are both users of the GEORGE 3 Executive Emulator (by David Holdsworth and Delwyn Holroyd) and have been running the system for several years, but we wanted to go further than it allowed (and was likely to - discussions with Delwyn).

Our system is still at development status. We were hoping for an alpha test release mid to late 2009, but have been side-tracked several times from the main project, each one of which has improved our knowledge and will add to the final product.

The aim is to emulate a 1904S (also 4A/3T) processor at hardware level, running as near as we can determine at the speed of the original, with the processor code being separate from each peripheral and connecting via a Standard Interface using TCP/IP. The peripheral timing is also being set to match that of the originals.

The development system has been running reliably for some considerable time. The processor passes the #FLIT processor test and we can run both E6RM and EWG3 executives, with GEORGE 2, MAXIMOP (including a recent eight hour run of G2/MAXIMOP with a simulated workload) and GEORGE 3. It is working reasonably well with the following peripherals:-

- TR1916 – Paper Tape Reader
- TP1925 – Paper Tape Punch
- LP1933 – Line Pinter
- CR1912 – Card Reader
- CP1920 – Card Punch
- MT2504 – 9-track Magnetic Tape
- DA2802 – EDS8
- GP1934 – Graph Plotter
- MX7007 – Multiplexor (nine lines)
- ID7180 – Local VDU Controller

The following peripherals work, but are known to have problems of varying severity:-

- UX7070 – Uniplexor (async)
- FD2806 – Fixed Disc System (Bryant 2B)
- DR1964 – Slow Drum
- HD2851 – High Speed Drum

We have a temporary fiddle that allows the use of the existing G3EE 7903 java program as CC7903 (Communications Processor) to permit the testing of Communications Manager programs under E6RM.

The peripheral code is currently built in as per G3EE as part of the initial development process. We have had fun and games with the SI, mainly due to a lack of information – any further information welcome. The alpha release is on hold until the peripherals are separated out.

One of our side-tracks was to create a 1901A (hand-switch only) processor. More work is required to finalise it, but it will run programs loaded from standard binary card images under E1HS executive. This processor will be able to share the same SI peripherals (as appropriate) that are being developed for the 1904S.

Work is proceeding on the separation of peripherals, ready for an alpha test release, for which the 1901A with the simple E1HS executive as a useful test bed.

The current side-track is a PF56 (GPC) emulator, which with the appropriate DCP (we have a selection) and hardware modules, will either act as a 2812 disc controller (EDS30/EDS60/EDS200) or 7903 communications processor

During the course of the project, we have so far accumulated a collection of manuals and software the majority of which we have made available on my web site *www.icl1900.co.uk/preserve/index.html*. It is far from a full set, so any additions are welcome.

Without G3EE we couldn't have got anywhere with this project. In our opinion for a quick flavour of GEORGE 3, G3EE is far simpler to load and run - we are trying to give an authentic feel to the emulator. As such it will not be as user friendly to set up (or run). Thanks again to David and Delwyn.

Now the plea for help

While looking at diagrams and perusing technical manuals, we have come across some (new to us) features of the 1900 hardware that have surprised us. We are looking for further information on them from anybody who might have any memories, documents or knowledge.

In addition to the normal User and Executive modes, we have found details of a Priority Mode that can interrupt Executive and can run for a limited time. This appears to be entered via a Real Time interrupt via fast task switching (no saving of accumulators as per normal executive entry) and can run for a limited time before a time-out interrupt. The exit seems to be via an F=164/X=4 hardware order which is only valid in Priority Mode, there also appears to be an F=174P hardware instruction available, which we assume is to be used instead of the F=157 (PERI) extracode (not available in Priority Mode). This appears to be range compatible, in that we have found similar features in the 1902A/1903A hardware description.

We have been reliably informed (a site engineer) that this feature was used on a 1903A to drive an automated warehouse picking and packing system (connected to the priority channel via a standard interface) for a CWS warehouse in Birtley, but we have no knowledge of the software side.

What we have found appears to match the description of the priority member 5 in sub-programming in *TP 4095 Central Processors, April 1968,* a feature subsequently withdrawn in the description of sub-programming in *Publication Notice 11 of TP 4322 Plan Reference, April 1976*.

Does anybody know:-

1. Why/when the feature was withdrawn?
2. Any other systems using this feature??
3. Knowledge of programming Priority Mode?
4. Could any SI be linked to the Real Time Interrupt? Or was this the use (on a 1904A/S) for the unused SI channels 22 and 23.

There is also a set of hardware monitor modes which allow tracing and trapping of user mode events, and also appear to provide an executive trace facility. For the user mode, it seems that a program can be single-shotted by Executive, with a monitor event after each user mode instruction. There are other levels, including a modified NULL instruction (F=123/X=7) which causes a monitor event if the appropriate mode is set.

The executives we have do not support these facilities. Does anybody know where/how, or why they were used?

We have also come across Executive Mode instructions F=152/F=153/F=154 which appear to be unused in normal executives. They provide a hardware pattern search facility (again they seem to be range compatible). Where they ever used? If so what for?

The drawings show that many hundreds of signals were made visible via a large number of lights (many hundreds) – are there any pictures, copies of light-maps or other relevant information out there?

Any further information welcome.

Editor's note: Brian Spoor started his IT career in 1973 as a trainee programmer with the Liverpool Victoria Friendly Society (now LV.com) on their ICL 1904A direct from school after A-levels, having turned down a job offer from IBM. He moved to North East Thames Regional Health Authority as a systems programmer respomsible for the installation of GEORGE 3 on a yet to be delivered 1904S (the new computer centre not yet being complete), and from there to ICL Dataskil on the GEORGE 2+ development. He can be contacted at brian@fcs.eu.com.

Obituary: Sandy Douglas

Frank Land and Bill Olle

The computing world will mourn the passing of Sandy Douglas on 29th April 2010. At the same time it will celebrate his achievements in computing over a long life which started with his discovery of computers whilst studying mathematics at Cambridge University in the early 1950s. He kept that interest and made contributions to our understanding until the last years of his life.

After graduating in Mathematics from Trinity College, Sandy joined the Cambridge University Mathematical Laboratory. For his PhD, he chose in 1952 to work on man-machine interactions and illustrated his theme with OXO (a game based on noughts and crosses). This was the first ever interactive computer game. It displayed the state of the game on a cathode ray screen, and permitted a player to respond to the computer's moves.

In 1957, he moved from Trinity College to Leeds University and there established the first Computer Laboratory. It was at Leeds University that Sandy first became interested in the application of computers to business problems. This led directly to his being head-hunted as technical director of CEIR in 1960. He subsequently also became Research Director at LEASCO.

Then came a move to the London School of Economics. Sandy's inaugural lecture entitled *Computers and Society* set out his prescient views on the role of computers, noting for example the threat they posed to the citizen in a surveillance society. This lecture highlighted Sandy's interest and concerns, shown from his earliest days in computing, in understanding the bigger issues related to the role of computers in society.

Writing in the October 1970 issue of the Science Journal, Sandy asked "Would we be happy under an efficient tyranny - one in which every movement and action of the citizen was recorded, analysed, cross-checked instantaneously and no incident, no matter how trivial, ever forgotten?" Today's debate on the role computers play in the transformation of society and its governance underline Sandy's concerns expressed decades ago.

These interests led him to help found the British Computer Society (BCS). He served as President of the BCS in 1971-72 and as a founding committee member of the Computer Conservation Society until 2003.

Letter to the Editor

From David Yates

I enjoyed Professor Sir Tony Hoare's article in Issue 48 of *Resurrection*, and would like to make some comments on his recollections regarding the work on Russian–English machine translation at the National Physical Laboratory in the 1960s, to which I contributed.

ACE in about 1963, complete with magnetic tape decks on the right

First on a factual point: it was the ACE computer, not its predecessor the Pilot ACE, which the group used; Pilot ACE had been closed down in 1956, some key parts being given to the Science Museum. He is not the first to confuse these two machines. More importantly though, I don't know why he says "I was not surprised five years later when the translation project was closed down in failure".

To summarise the work of the project briefly, it was given a good start in the form of a copy of a Russian–English technical dictionary on magnetic tape developed at Harvard University. This was converted and considerably extended at NPL for use on ACE. We wrote software to read in Russian text (on punched cards), to sort the words of the text into alphabetical order, to look them up serially in the magnetic tape dictionary, appending copies of all relevant dictionary entries to each word, and then to sort this augmented text back into the original order.

Further programs identified and dealt appropriately with any idiomatic word groups, and carried out a limited syntactic analysis of the Russian text and a synthesis of the English, for example inserting English auxiliary verbs and prepositions, selecting English equivalents where possible on the basis of grammatical clues, dealing with words not found in the dictionary (where more can be done than one might imagine), and so on. The final program in the suite output the English text on paper tape, which was fed off-line to a printer. Where necessary, alternative English equivalents for a single Russian word appeared on the print-out as a vertical list of not more than three items.

All this complex software worked smoothly, provided ACE and its somewhat temperamental magnetic tape system were in a co-operative mood. At the end of the project in 1967 the quality of the output was assessed by using the system to translate technical papers sent in by outsiders and asking them to rate the usefulness of the results. This led to a range of assessments, summarised in the project's final report, perhaps a little rosily, as "mostly good enough, with a few obscurities".

Particularly bearing in mind the primitive state of the technology at the time, I feel overall this cannot fairly be described as a failure. More details, including a sample of the English output, are given in my book on the history of computing at NPL, *Turing's Legacy*, Science Museum, 1997, pp.93-100.

Tony Hoare replies

And I too enjoyed your summary of the achievements of the NPL Russian-English Machine Translation project. I am sorry that I applied the word "failure" just to this project, when many other larger projects in other countries also were brought to an end at around the same time. We can see now that the original hopes of these projects were not matched by the power and capacity of the machines available at the time.

My own pessimism was due to my estimate of the size of the dictionary required for translation, the number of phrases as well as words. I thought the problem would be exacerbated in the scientific literature, where the constant invention of new technical terms is an essential indicator of the progress of scientific understanding. It is wonderful that these problems are now, 50 years later, being decisively overcome.

Computing in Canada: Building a Digital Future

Book review by Dik Leatherdale

If one were to ask the average CCS member about the history of computing in Canada, after a frown and a moment's thought, most could perhaps bring to mind the origins of the ICT 1900. Some might mention Strachey's adventures with the Ferranti Mark 1 and the design of the St Lawrence Seaway. Particularly assiduous readers of *Resurrection* will recall the invention of the trackball in 1952. But there is, it would seem, a great deal more to the history of computing in Canada than that.

Like many countries, Canada was quick to realise the significance of the invention of the computer and was anxious to establish a presence in the industry. Various public-sector projects were authorised in an attempt to kick-start a Canadian industry, but somehow, it failed to develop to the point of viability. Of course, the problems faced by the Canadians were much the same as those faced by the UK. But, whereas IBM UK started from nothing in 1951, Canada had been included within the IBM sphere of influence when it and BTM divided up the word between them in 1902. So IBM was well established there at the dawn of the computer age. This and the fact that Canada was (and is) treated by US industry as an extension of their home market, suggests that the Canadians inevitably had to work under the handicap of US hegemony.

The most interesting section of the book, from a UK perspective, is that which concerns Ferranti-Packard and the FP6000. The authors show some restraint in telling the story of the ICT takeover of the machine, suggesting that, had it been left to Ferranti-Packard, the level of sales might have been less than spectacular. Other sources are less generous and betray a bitterness not entirely unjustified by events. But from the ashes came I.P. Sharp Associates a software house/bureau which prospered well into the 1980s and which will be known to many readers.

The second half of the book deals with the microprocessor and PC age. Initially the Canadians did well – hands up, who knew that Commodore was Canadian? But once again, the IBM steamroller – this time in the shape of the PC – swept almost everything into oblivion.

So, a story of heroic struggle and modest achievement. But a story not without interest and not without parallels in the UK.

Computing in Canada: Building a Digital Future by Zbigniew Stachniak and Scott M. Campbell. Softback 100pp. Available from *Transformation@technomuses.ca* at $25 or $12.50 download.

Forthcoming Events

London Seminar Programme

16 Sep 2010	Research Machines	John Leighfield
28 Oct 2010	Computers & Communications	John Naughton & Bill Thomson
18 Nov 2010	Konrad Zuse and the Origins of the Computer	Horst Zuse

London meetings take place in the Director's Suite of the Science Museum, starting at 14:30. The Director's Suite entrance is in Exhibition Road, next to the exit from the tunnel from South Kensington Station, on the left as you come up the steps. Queries about London meetings should be addressed to Roger Johnson at *r.johnson@bcs.org.uk*, or by post to Roger at Birkbeck College, Malet Street, London WC1E 7HX.

Manchester Seminar Programme

26 Oct 2010	Ferranti Argus: Bloodhound on my Trail: Open Innovation in a Closed World (18:30 – 21:00)	Jonathan Aylen
16 Nov 2010	The LEO Story	Gordon Foulger
18 Jan 2011	The Harwell Dekatron Computer	Kevin Murrell & Tony Frazer
15 Feb 2011	The Physical Aspects of Disc Recording	Steve Hill
15 Mar 2011	The Evolution of Radar Systems	Frank Barker

North West Group meetings take place in the Conference Room at MOSI – the Museum of Science and Industry in Manchester – usually starting at 17:30; tea is served from 17:00. Queries about Manchester meetings should go to Gordon Adshead at *gordon@adshead.com.*

Details are subject to change. Members wishing to attend any meeting are advised to check the events page on the Society website at *www.computerconservationsociety.org* for final details which will be published in advance of each event. Details will also be published on the BCS website (in the BCS events calendar) and in the Events Diary columns of *Computing* and *Computer Weekly*.

Museums

MOSI : Demonstrations of the replica Small-Scale Experimental Machine at the Museum of Science and Industry in Manchester have been suspended due to development work in the museum. Resumption is likely to be late summer.

Bletchley Park : daily. Guided tours and exhibitions, price £10.00, or £8.00 for concessions (children under 12, free). Exhibition of wartime code-breaking equipment and procedures, including the replica Bombe and replica Colossus, plus tours of the wartime buildings. Go to *www.bletchleypark.org.uk* to check details of times and special events.

The National Museum of Computing : Thursday and Saturdays from 13:00. Entry to the Museum is included in the admission price for Bletchley Park. The Museum covers the development of computing from the wartime Colossus computer to the present day and from ICL mainframes to hand-held computers. See *www.tnmoc.org* for more details.

Science Museum :. Pegasus "in steam" days have been suspended for the time being. Please refer to the society website for updates.

North West Group contact details

Chairman Tom Hinchliffe: Tel: 01663 765040.
Email: *tom.h@dsl.pipex.com*
Secretary Gordon Adshead Tel: 01625 549770.
Email: *gordon@adshead.com*

Committee of the Society

Chairman: **Dr David Hartley FBCS CEng**: david.hartley@clare.cam.ac.uk
Secretary & Leader DEC Project: **Kevin Murrell**: kevin.murrell@tnmoc.org
Treasurer: **Dan Hayton**: daniel@newcomen.demon.co.uk
Chairman, North West Group: **Tom Hinchliffe:** tom.h@dsl.pipex.com
Editor, Resurrection: **Dik Leatherdale MBCS**: dik@leatherdale.net
Website Editor: **Alan Thomson**: alan.thomson@bcs.org
Archivist: **Hamish Carmichael FBCS**: hamishc@globalnet.co.uk
Meetings Secretary: **Dr Roger Johnson FBCS**: r.johnson@bcs.org.uk
Digital Archivist & Leader, Our Computer Heritage Project:
Professor Simon Lavington FBCS FIEE CEng: lavis@essex.ac.uk
Science Museum representative: **Dr Tilly Blyth**: tilly.blyth@nmsi.ac.uk
MOSI representative: **Catherine Rushmore**: c.rushmore@mosi.org.uk
Codes and Ciphers Heritage Trust representative: **Pete Chilvers**:
pete@pchilvers.plus.com
Leader Colossus Project: **Tony Sale Hon FBCS**: tsale@qufaro.demon.co.uk
Leader, Elliott 401 Project: **Chris Burton CEng FIEE FBCS**:
cpb@envex.demon.co.uk
Leader, Bombe Rebuild Project: **John Harper Hon FBCS CEng MIEE**:
bombe@jharper.demon.co.uk
Leader, Elliott 803 Project: **Peter Onion**: peter.onion@btinternet.com
Leader, Pegasus Project: **Len Hewitt MBCS**: leonard.hewitt@ntlworld.com
Leader, Software Conservation Project: **Dr Dave Holdsworth CEng Hon FBCS**:
ecldh@leeds.ac.uk
Leader, 1301 Project: **Rod Brown**: sayhi-torod@shedlanz.co.uk
Leader, Harwell Dekatron Computer Project: **Tony Frazer**: tony.frazer@tnmoc.org
Leader, Diferential Analyser Project.: **Dr Charles Lindsey**: chl@clerew.man.ac.uk
Professor Martin Campbell-Kelly: m.campbell-kelly@warwick.ac.uk
Peter Holland: p.holland@talktalk.net
Dr Doron Swade CEng FBCS MBE: doron.swade@blueyonder.co.uk

Point of Contact

Readers who have general queries to put to the Society should address them to the Secretary (see page 8 for postal address). Members who move house should notify Kevin Murrell 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 is therefore maintained separately.

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