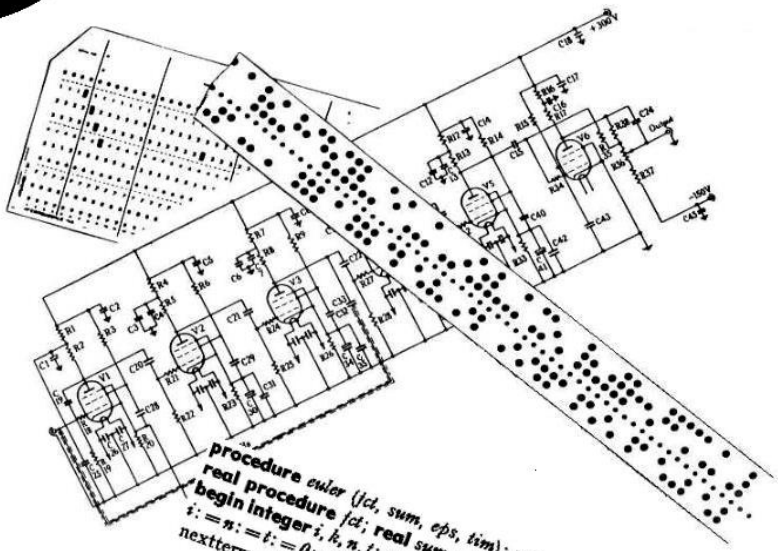
Issue Number 75 Autumn 2016

RESURRECTION

The Journal of the Computer Conservation Society



```
procedure euler (fct, sum, eps, tim); value eps, tim; integer tim;
real procedure fct; real sum, eps;
begin integer i, k, n, t; array m[0:15]; real mn, mp, ds;
    i:=n:=t:=0; m[0]:=fct(0); sum:=m[0]/2;
nextterm: i:=i+1; mn:=fct(i);
    for k:=0 step 1 until n do
        begin mp:=(mn+m[k])/2; m[k]:=mn; mn:=mp end means;
        if (abs(mn)<abs(m[n]))∧(n<15) then
            begin ds:=mn/2; n:=n+1; m[n]:=mn end accept
        else ds:=mn;
    sum:=sum+ds;
    if abs(ds)<eps then t:=t+1 else t:=0;
    if t<tim then go to nexterm
end euler
```

Computer Conservation Society
Aims and objectives

The Computer Conservation Society (CCS) is a co-operative venture between BCS, The Chartered Institute for IT; the Science Museum of London; and the Museum of Science and Industry (MSI) 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 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 BCS, fees from corporate membership, donations and by the free use of the facilities of our founding 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.

The CCS also enjoys a close relationship with the National Museum of Computing.

Resurrection

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Society Activity

EDSAC Replica — *Andrew Herbert*

The team continues work on commissioning main control with James Barr, Tom Toth, John Pratt and John Sanderson taking the lead. Main control can now cycle through the instruction fetch and decode sequence generating correct pulses and generate the correct control signals from orders which have been input from the temporary engineers' switches. The interaction between main control and the coincidence system for store access has been verified and so we are on the threshold of reading programs from store. We have also tested using Peter Linington's short nickel delay lines in place of the temporary "digital tank emulator" PCBs installed for preliminary testing. The clock and digit system is now functioning satisfactorily although we are very aware of weaknesses in the (original) design and the lack of fine adjustment. We plan to make some modifications and build an improved new clock in the coming months. We're also planning for further ducting and cabling for the coaxial cables to connect the store to the storage recirculation system and for the wiring from them to the operators' display units.

An exploded vintage capacitor in the display unit has raised some concerns for future operation and for cleaning. the inside of the unit. It has been returned to Chris Burton for investigation.

A full EDSAC volunteer's meeting took place on 1st October. On the following day we hosted the surviving EDSAC operators (all ladies) to show them progress so far and pick their brains on how the machine was operated day to day.

ICL 2966 — *Delwyn Holroyd*

The second SCP has been brought back to life, primarily so that we have a spare but also with an eye towards eventually running a full CME environment, including VME. The fault in the monitor transformer turned out to be a fuse holder rather than the winding as previously thought, which was a relief. Attention was then turned to the increasingly dim display of the main SCP. After some investigation we have concluded that the CRT itself is getting towards the end of its life. The display is still visible so we are not planning to take any immediate action.

We haven't yet persuaded CME to pick up the second SCP for use as the OPER for the VME regime, and we are now beginning to question whether our configuration is actually supported. One theory is that the SCPs must be on separate DCUs. The CME installation manual is, unfortunately,

rather vague on the details. If any reader has knowledge on the subject, we would be delighted to hear from you.

One of the 7181 VDUs failed a few weeks ago with a faulty EHT power supply. This unit was bought in and therefore not documented. Fortunately, the PCB is single sided and straightforward to reverse engineer, so we have taken the opportunity to create a schematic for it. The original fault was a life expired transistor (only 46 years old!), but having disturbed the unit some of the internal crimped connections are now giving trouble. In the meanwhile, the unit has gone back into service.

Our Computer Heritage — *Simon Lavington*

Did you work for Ferranti in the 1950s? If so, perhaps you could help with some detective work. I am revising the section of the *Our Computer Heritage* website that covers the Ferranti Mark I and Mark I* installations. Some of the delivery dates, which were originally taken from a History written in 1975 by Bernard Swann, seem to be a little awry. Here is what I think is a more accurate story:

Date of customer's order	*Customer name*	*Date of delivery & location of customer's site*
26th Oct. 1948, (confirmed 19/2/49)	MOS (for Manchester University).	12th Feb 1951, Manchester University.
Approx. Dec.1951	University of Toronto	Mostly reached Toronto on 25th April 1952. Drum arrived on 20th Aug.
Late 1951	GCHQ	Approx. Oct. 1953, Cheltenham
11th March 1953	Shell Research Labs, Amsterdam	Mid-June 1954, Amsterdam
Sept 1952 or Sept. 1953?	ARDE	July 1954, Fort Halstead
Sept 1952 or Sept. 1953?	AWRE	Late 1954, Aldermaston
28th July 1954	INAC	6th Jan. 1955 to Naples; to Rome a few weeks later.
Feb 1954	AVRO	Late 1955, Chadderton
??	Armstrong Siddeley Engines	Approx. Nov 1957, Ansty near Coventry

You'll notice some uncertainties and queries. If you can help, or if you know some fascinating details about any of the Mark I or (even better) the Mark I* installations then I'd be very interested to hear from you.

Analytical Engine — *Doron Swade*

The last report described that reverse engineering a coherent and consistent understanding of the Analytical Engine design by examining the main and best-known mechanical drawings has been less than completely successful to date. I also described that to deal with this we have taken a step back to marshal and review all known sources to assess the descriptive completeness of the surviving technical information i.e. whether Babbage's archived technical drawings and manuscripts constitute in their entirety a coherent description of the Engine.

Tim Robinson in the US has been trawling through the entire technical archive and compiling a searchable cross-referenced data base for all surviving technical material. In parallel with this I am conducting a fast-track survey of some twenty manuscript volumes of Babbage's notebooks focussing on material on his notational language (the Mechanical Notation) that he used to describe his machines — this with a view to reading the notational description of the AE designs using the decoded Notation as an interpretative tool to achieve a deeper understanding of the designs. The database and trawling exercise is what has primarily occupied us over the last four months.

An important step forward in the overall project has been the online public release by the Science Museum of the major part of the digitised archive. This has been widely anticipated and welcomed. The Museum's intention is that for the time being the images are only illustrative in that the image resolution is sufficient to identify the drawing and its major features, and higher resolution versions are available on request. The current lower resolution images are sometimes adequate for smaller manuscripts but for the larger sheets the detail of the smaller annotations is insufficiently clear. The work of our small team is not hampered by this as we have access to higher resolution off-line images under licence. The relevance of the public release and the usability of the images affects the volunteer effort of folk wishing to help the project, for which they need access to detailed images. The good news is that the Science Museum intends a higher resolution release of the whole archive for early in 2017, and this will include material already digitised but not yet released online. Feedback in response to the first release has confirmed the wider interest in the project and the presence of fair number volunteers eager to help. We expect to benefit from this effort more fully in the new year when the images will support close reading.

In short, we are retrenching by focussing on identifying, reviewing and indexing all known the technical sources to serve both as a datum and as a research tool in the pursuit of a deeper understanding of the designs.

Galdor Magnetic Tapes

Eight ½" magnetic tapes from Galdor's 1900 system have been successfully read by Delwyn at TNMoC and the data transferred to virtual tapes for G3EE/em1904S. They contain a binary GEORGE 3 MK8.64 (unfortunately no partial source tapes), source for extra features and utilities written by Brian Spoor in the late 1970s, BCPL and PLASYD compilers and an engineering test library with many additional useful programs.

MAXIMOP

Two members of the original MAXIMOP team from QMC (Arthur Dransfield and Bob Jones) have been in touch and have been actively running em1904S, giving us information and advice, plus the odd interesting problem to solve.

From them, we have found that it is possible to run a shared filestore MAXIMOP. QMC ran with a pair of 1904S processors and a cluster of shared EDS60 drives holding the filestore, with a single copy of Communications Manager load sharing between the two linked systems.

Further work was planned this winter on the reverse engineered MAXIMOP source (created a couple of years ago) to eradicate some of the typos; now with some expert help available we might finally get a clean system and create an issue tape (no original has survived) for posterity.

PF56

As a result of the Galdor tapes, we have a treasure trove of PF56 related software. These include a set of DCPs (PF56 Operating Systems) for the 2812, and a set of the On Line Test programs (OLTs) used under those DCPs to test and initialise all of the disc types except the EDS200s. More useful still was a large collection of diagnostic programs used to test the PF56 CPU and various of its peripherals. We previously had four of these diagnostics rekeyed from assembly listings, and this tape revealed a couple of typing mistakes, but only in the spelling of typed error messages.

The current PF56 emulator is advancing albeit slowly, even if the use of the typewriter and paper tape reader tests shows that the emulated devices are far from correct, they work acceptably when the interrupt driven DCP uses them. But when the relevant diagnostics try static testing and polling, they are nowhere near correct.

Addressing these deficiencies is the current focus, whilst interrupting the development of the DDE module, as the availability of a number of DDE and Code Converter tests once the basic CPU becomes able to load PF56 binary tapes under the control of a test OS (QAOA).

Also on the Galdor tapes is a small collection of PF56 related 1900 utilities, #SS26, #SS33, #SS40, #SS48, #SS80 and #SS81. These all manage the ICLKHARDFILE or related files which are used to boot and manage the PF56.

GEORGE 2+

We have now managed to reverse engineer a source for GEORGE 2+DOF/1T — the Tarmac Special. This was a customised version to run on a pair of 2950s. These machines were later upgraded to the 2966 which is now working once again at TNMoC.

The project was abandoned due to cost overruns just before it was completed and it isn't known whether it ever 'went live'. The source now matches the binary that was saved, just a case of clearing the bugs out of the system – the position the team was in 1980.

One of us (Brian) was part of that project team. It is hoped that we can demonstrate the system running at TNMoC in the future.

E6RM

With Bob Jones' help, we have cleared the errors (duplicate blocks) on the source tape that we got from Russia. These errors didn't prevent E6RM generation, but stopped #TEAU the editor working. We now understand how to drive #TEAU.

The tape we had contained various updates added by ELWRO for their ODRA systems. We have identified all (we hope) of these updates and removed them to create an ICL E6RM G54 source.

Bob is also creating a set of patches to undo ICL's MOD 155 (terse console messages). He prefers the elegant originals, which we can now incorporate as source changes along with the patches written by Bill and Brian.

E4BM

Now that we can drive #TEAU, a source tape for E4BM has been created from a reverse engineered binary. This is still a bit flaky in that it will generate a binary identical to the original, but fails with altered configurations. Bill will be looking further into this at some time.

Software — *David Holdsworth*

Leo III

John Daines and Ken Kemp have done sterling work on editing the OCR scans of Volume IV of the Leo Manual, which should be linked on-line shortly at *leo.settle.dtdns.net/LeoMan/Manuals.htm*.

On 15th August I met Tacye Phillipson and her colleague Sam Alberti from the National Museum of Scotland. They are very willing to collaborate in experiments to read Leo III magnetic tapes, and keen to gain knowledge about their existing holding. There was mutual appreciation of the issues of making 1960s computing comprehensible and interesting to today's generation. Our team of Leo III volunteers contains an ex-engineer.

Kidsgrove Algol

David Huxtable (an original author) has actually run a tiny program. David and I are collaborating on re-engineering the missing Brick 20, and now have reasonable hopes of success, due in no small part to forays into Blythe House to photograph KDF9 documentation that NPL deposited there long ago. Brian Wichmann has made several visits. The images are now online at *kdf9.settle.dtdns.net/KDF9/kalgol/DavidHo/Blythe.html*.

These documents are primarily design documents and flow diagrams for the code that we have. They clearly indicate the laborious process of software production 50-odd years ago.

Atlas Emulator and the Compiler Compiler — *Dik Leatherdale*

After a long interregnum, the Atlas emulator has taken a few faltering steps forward. The primitive Atlas Job Control system is now running as is a full implementation of input/output spooling, albeit with one remaining known deficiency. A new tutorial introduction has been written for the emulator and is out for inspection but much remains to be done to bring the help system into line with the enhanced emulator.

Re-testing the new developments with existing software revealed a problem. The source code of the Brooker-Morris Compiler Compiler came to grief around ⅓ of the way through. Debugging the Compiler Compiler is (was?) always a nightmare as the code keeps on moving about the address space making it difficult to keep track of what is where. After a few days struggle the fault was found to have been caused by the introduction of spooling. The program asks the operating system what input peripheral is being used. When the wrong answer is returned, things start to go awry. Happily, once found the problem was easily resolved.

We understand from Graham Toal that he is keen to resurrect the Edinburgh port of Compiler Compiler to KDF9, in which he was originally involved.

Bombe — *John Harper*

I can report that our demonstration team has grown in knowledge and number so that we are now able to have three volunteers available on most days. This allows presentations to be available without having to break off for meals etc.

The 'breaking news' is that the Government has given £1,000,000 to the Bletchley Park Trust towards the cost of creating a new, large and comprehensive exhibition in the refurbished Hut 11a.

We have agreed in general terms to work with the Bletchley Park Trust (BPT) to develop a new exhibition together with professional exhibition designers who BPT will engage.

This exhibition has the theme of Enigma cypher breaking and includes the Turing/Welchman Bombe story. It is generally agreed that our rebuild and supportive equipment should be part of this.

As part of our commitment we will also be resurrecting, refurbishing and motorising one of the dummy Bombe replicas first used in the 2001 film 'Enigma'.

Our Bombe Rebuild website is no longer available since Virgin 'pulled the plug'. We have every intention of bringing it up to date on a new site but there always appears to be something more important to attend to.

Meantime and perhaps for the foreseeable future it is our Facebook page that is fully maintained — *www.facebook.com/TuringWelchman-Bombe-Rebuild-Project-831692790209483*.

Harwell Dekatron/WITCH — *Delwyn Holroyd*

We now have a professionally produced introductory video for the machine to run on the new AV system. This was kindly made by Duncan Catterall, son of TNMoC volunteer Philip.

We have replaced one high speed relay in the accumulator sign unit and a small number of store anode resistors.

IBM Group — *Peter Short*

We continue to receive donations of many items of interest principally from ex-IBMers. Since the last update this has included a number of ThinkPads, the contents of two racks of redundant communications equipment from Warwick, three oscilloscopes, a box of unused punch cards, and miscellaneous hardware parts, software and hard copy.

New Display Items

Two items of storage used in System/360 have been identified and added to the S/360 display cabinet. These are a single card of Card Capacitor Read Only Storage (CCROS) from a Model 30 and a piece of Capacitive Read Only Storage (CROS), developed in Hursley, from the Model 50.

The mock-up of the IBM 2984 Cashpoint is complete and out on display.

IBM 2984 Cashpoint

IBM Clock

We have obtained a variable voltage power supply, which will help us to get some of our old IBM clocks working. These clocks are wound by a solenoid, running on 24 volts and activated once a minute. The clock shown here, without its face and hands, is working well, although the contact that powers the solenoid is proving unreliable. In anticipation of sorting this issue and getting at least one more clock up and running we've bought a couple of small, fixed 24 volt power supplies from eBay.

We recently donated a PS/2 P75 portable to a collector and are preparing a number of items to be shipped to the Manchester UK Labs Campus for a new display in reception.

News Round-Up

A change in policy at MSI means that from January onwards, meetings of the CCS North West Group will take place at the Royal Northern College of Music (see page 39).

We will be sorry to leave MSI but we thank them nonetheless for their generosity over very many past years and wish them well.

101010101

News reaches us that one James Newman of (inevitably) Cambridge has recently completed the building of a computer. Nothing newsworthy about that you might think. People build their own PCs every day. Even your editor managed it once. But this isn't just a question of fitting an Intel processor onto a motherboard and hoping for the best, because Mr Newman's "Megaprocessor" has no microprocessor, not even a single integrated circuit, but consists instead of some 14,000 transistors and 10,000 LEDs. It's 10 metres wide, lives in a bungalow and cost a tidy £40,000.

If you're wondering what might be the point (well you would, wouldn't you?) the clue is the 10,000 LEDs. For the aim is to be able to demonstrate how a computer works by running it slowly and observing the lights as information flows around the circuits.

It's an educational tool par excellence, a tour de force and visually, a serious rival to TNMoC's Dekatron. You can't fail to be impressed. Go to *www.megaprocessor.com* and admire.

101010101

If you thought that the world of computers had heard the last of Clive Sinclair, think again. Sir Clive has teamed up with an outfit called Retro Computers Ltd to bring you a new ZX Spectrum-based, handheld games console with 1,000 pre-loaded games. Go to *tinyurl.com/sinveg* and give thanks, or weep according to taste.

101010101

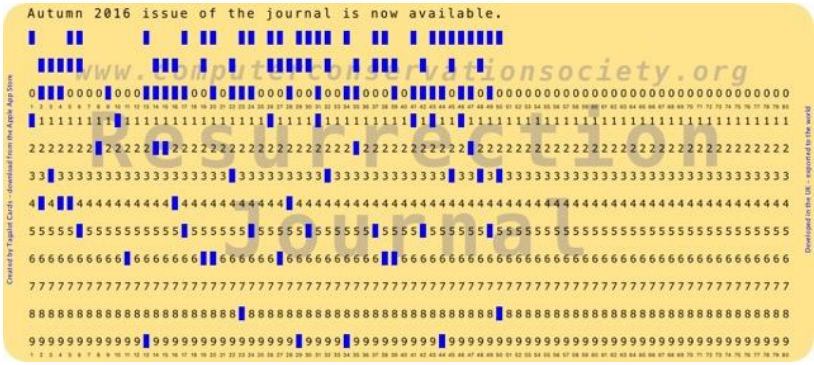
Yet another Apple 1 was sold in August (*Resurrections* passim) this time for $815,000 — see *www.bbc.co.uk/news/technology-37199000*. Although not a record price for an Apple 1 — it doesn't seem to be working — this one is believed to be a pre-production prototype.

101010101

In August many readers will have heard of the passing of Sir Anthony Jay, co-writer of the long-running BBC series *Yes Minister*. He also wrote the script for the 1964 publicity film which introduced the seminal ICT 1900 Series.

101010101

Readers who are also Apple users may be interested in a new App developed by Roger Davis which allows the user to "punch" the images of 80-column Hollerith cards using a graphic of a classic 12 key hand punch. See *www.tagalot.biz/cards.html* for details.



101010101

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.

At *www.computerconservationsociety.org/software/software-index.htm* can be found emulators for historic machines together with associated software and related documents all of which may be downloaded. Note that this part of our website is under development. Further material will be added in due course.

CCS Chair's Annual Report
Rachel Burnett

I am very pleased to report that we have enjoyed another successful year of activities including our projects, presentations, and other events and publications.

Our Members and our Finances

Membership now stands at around 1500, including about 10% from abroad, and continues to increase. As a Specialist Group of BCS, we are grateful for BCS support, and do not charge a subscription, but each year we do request voluntary donations for our CCS Donations Fund. Many thanks for your generous contributions, which enable us to provide for exceptional funding needs for our computer restoration projects and working groups (such as arranging the transport of HEC-1 for revival and display at its new home at The National Museum of Computing).

Projects

We have 15 active projects on which CCS volunteers are devoting time, expertise and effort, mainly for restoration, reconstruction and support of various computing systems. Progress and achievements are reported regularly in our journal *Resurrection*.

Project guidelines have been introduced, for the purpose of clarifying expectations and facilitating relationships between CCS projects and the museum or other institution where project work is being carried out.

Presentations

This year we have had to move our London venue to BCS premises in Covent Garden. This is because the Science Museum has sold the building housing the Fellows' Library where we have held presentations over the years since our foundation thanks to their generous hospitality. We were sad to leave such an historic venue. It was entirely fitting that our final presentation there on Charles Babbage and Ada Lovelace: *Two Visions of Computing, or, Ada Lovelace, why the fuss?* was by Dr Doron Swade MBE, co-founder of our Society, former curator of computing at the Science Museum, and project leader of the current Analytical Engine project.

Our London presentations are generally in the afternoon, and in Manchester in the early evening, monthly from September through to May. We are now able to upload our London presentations to YouTube.

The Tony Sale Award 2016 for Computer Conservation, which recognises an outstanding engineering achievement of computer conservation and restoration, will be announced at the London CCS meeting in November.

From time to time we are asked to give presentations to other associations on particular aspects of computer conservation, and we are always happy to arrange for a speaker.

Visits

Outside our regular and well-attended London and Manchester presentations on varied subjects, we organised two visits, to which all members and their guests were warmly invited. In April 23 of us attended a presentation at Berlin's Teknikmuseum, hosted by Professor Dr.-Ing. habil. Horst Zuse, son of Konrad Zuse and a distinguished computer scientist himself, who gave us a wonderfully interesting presentation on Konrad Zuse's early machines, and his own work on the replica of the relay-based Zuse Z3.

In September, we were delighted that the Ferranti Argus 700 (Bloodhound) Restoration project team organised a guided visit to the Ferranti Argus 700 at RAF Cosford, near Wolverhampton.

Publications and Website

Our journal *Resurrection* always has top quality content: articles by experts on their specialist areas, news and reports of CCS activities, events and projects. Both current and past issues are available online at the CCS website. Print copies are sent without charge to all BCS members of CCS by agreement with BCS, and to non-BCS members of CCS who pay £10 a year.

Our website *www.computerconservationsociety.org* gives information about the Society, news and our programme. We also notify members by email about our events.

Our former FTP site has been restructured and relocated into our main website. The *Our Computer Heritage* website, providing authoritative technical information on early British computers, at *www.ourcomputerheritage.org* has also been redesigned in similar CCS style.

Committee

In addition to the Chair, Treasurer and Secretary, the Project Leaders, and the Chairman and Secretary of the North West Group, our Committee has long included representatives of the Science Museum and the Museum of Science and Industry, The National Museum of Computing and Bletchley Park Trust, all of whose participation we greatly value. Other long-standing specific formal roles are those of the Meetings Secretary, *Resurrection* & Website Editor, Digital Archivist and Tony Sale Award Co-ordinator. More recently, we have found it helpful to have members who can focus on specific functions as Media Officer, Archives Adviser, Membership Secretary and Projects Co-ordinator.

My sincere thanks to all the Committee, for your spirited participation and hard work, which has made my involvement with the Society, as indeed that of CCS members, continually entertaining and educational, as we listen, reminisce, consider, theorise, learn, argue and (sometimes) agree.

I would also like to thank others for their assistance, including those responsible for maintaining our emailing lists, and our contacts at BCS, especially Mandy Bauer, the Finance team and the room-booking team.

Thanks to our speakers, to our audiences, organisers, and to all of you who support the CCS. We welcome help on organising and administration; do please contact myself or any Officer if you would be willing and able!

My thanks encompass not only the last 12 months but five years, now that my term of office as Chair has come to an end. This is therefore my last report. I have been very happy working with the Committee, as Chair of this association of committed experts and enthusiasts. I look forward to next year's programme and my continuing involvement.

Our New Chair in his Own Words

David Morriss

I graduated in Electrical Engineering from the University of Manchester, Faculty of Technology, in 1964. I was a post graduate trainee with London Transport, working in the department of Mechanical and Electrical Engineering, whose responsibilities covered rolling stock, lifts and escalators. I worked on various Victoria Line projects including the braking and automatic train control systems. I was on a team doing a major project studying design parameters for urban railways during which I became a computer user. Our case studies involved significant amounts of processing on a Leo computer.

In 1966 I applied to a recruitment advertisement from IBM as I wanted to get involved in the industry and I became a systems engineer working mainly with manufacturing customers. I moved into Sales and Marketing and eventually became responsible for IBM UK's business in the Aerospace sector. This was followed by a move to head up one of IBM's two Banking Branches at the time of major automation including country wide networks, automated cheque sorters and on line cash dispensers.

Following various management roles in the UK and IBM EMEA I was appointed Director of Business Plans for the IBM UK Group. This was followed by various General Management roles at home and abroad and membership of the IBM UK Group Board from 1986 until I retired in 1997.

I now pursue a portfolio career involving directorships and consultancy and as a trustee of various charities. I also became very active in both the BCS and the Information Technologists Company, being President in 2005 and Master in 2007/8 respectively. I have just stepped down from a six year stint as a member of the BCS Group Audit Committee. I am also a fellow of the Institution of Engineering and Technology and a Chartered Engineer.

I am very excited by the prospect of chairing the CCS committee.

I have always been interested in history, especially connected with the military and technology. What better forum could there be in which to play an active part in ensuring that the UK's contribution to computing is captured and made available to future generations.

Emidec 2400 and the Graduated Pension Scheme

David Bew

> In 1961 the UK government introduced the State Graduated Pension Scheme, a new scheme supplementing the then Old Age Pension. Based on contributions collected as part of the existing National Insurance system, each £7.10s (men) or £9 (women) paid in entitled the contributor to an additional 6d (2½ pence) per week in future pension. The scheme remained in place until superseded by the State Earnings Related Pension System (SERPS) in 1978. The scheme had no provision for indexation and so the amounts now paid out to former contributors are rather trivial by today's standards.

To administer the new scheme the Ministry of Pensions and National Insurance (MPNI) acquired an Emidec 2400 computer at a cost of £600,000 (roughly £11½m today). In 1961 The Emidec 2400 was considered to be a state of the art machine but was one of only five sold. In time the Ministry was subsumed into the Department of Health and Social Security (DHSS) and the 2400 was replaced by an ICL 1904A which lasted until the end of the scheme. The programs on the Emidec were replicated functionally on the 1904A but so far as I am aware, never developed further. Because the basic aim of the scheme really failed, the advances in developing the computer system to deliver it were never realised.

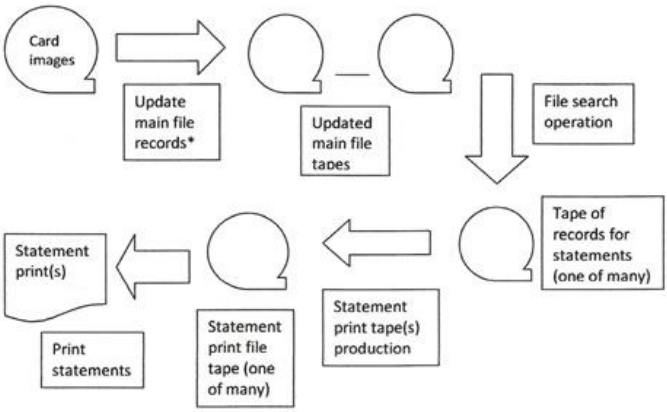
The Emidec 2400 was a 32k x 36-bit word computer, with each word either 6 x 6 bit characters or a signed or unsigned binary integer (in practice a signed integer was generally preferred). Multiwords — up to 15 36-bit words — representing a set of ASCII-coded characters could be operated on using specially designed machine-code orders.

The MPNI Emidec 2400 installation at Longbenton went into live production in July 1962 and was probably the largest and most efficiently operating computer system outside the US, and almost certainly the biggest state-operated computer system (outside the military) of the time. Although the original design was subject to tape wrecks in early production, these were ironed out: the delivered system rarely broke down and the monthly statements almost never went out late. In that sense, it was a very successful system though its benefits were, as has been said already, inadequate.

The system design offered several specialised features to optimise processing. Input of initial records created from tax returns was assembled on inch-wide magnetic tapes, together containing about 26 million records. Punched card information input to the updating process used a card-to-

tape conversion (spooling) system to create card images on input magnetic tape files. These were then read by the update cycle program on a weekly or monthly basis according to the frequency in which the contributor's income was paid. Following the update cycle statements were produced on either a four-week or monthly basis to verify the contributor's additional pension earned. These would either be retained by the employer or passed on directly to the contributor. The statements were produced on perforated edge-fed paper by Xeronic printers with some 48 statements on an A4 page. In the final stages of the Emidec version of the system the main file held over 30 million records.

The computer installation used 20 tape decks to access the main files and used a further four tape decks to hold the update card images. The statement program read four tapes created by a file search process working on the main file tapes and created statement information on four (or exceptionally five) further magnetic tapes which were then read by the programs driving the Xeronic printers. These printers – up to six could be driven together - used a process similar to present-day laser printing and created a page image using a CRT tube to project the image: pages were printed using toner on specially treated paper. The processes of card-to-tape conversion, update and statement production were integrated by a series of interrupts and so-called "console orders" which controlled the creation of input or output tape blocks and initiated each process in turn on first the card image magnetic tapes, and finally producing the statement tapes from tapes created by the main file search process. In this way the four processes could be managed autonomously by a control routine using the console system executive orders to switch from one process to the next. See diagram below:



Graduated Pension Scheme Process Diagram

*Note to diagram – the main file update was in fact, several operations: basically records requiring update within the main file were identified using the id. information in the input card image records. These main file records were then updated. Subsequently the file search operation would identify and select out those records (including updated records) requiring production of statements. The records were identified specifically by three letters of surname and two initials as national insurance numbers were frequently misquoted.

The Emidec 2400 at Longbenton

In the initially delivered system lineprinters and card readers were supplied to print the first versions of the programs and to read in contribution updates. Later this equipment was moved out of the computer room so that more tape decks could be added to improve system efficiency. On the left of the picture the teleprinter desk can be seen where tapes of initial test programs could be read in.

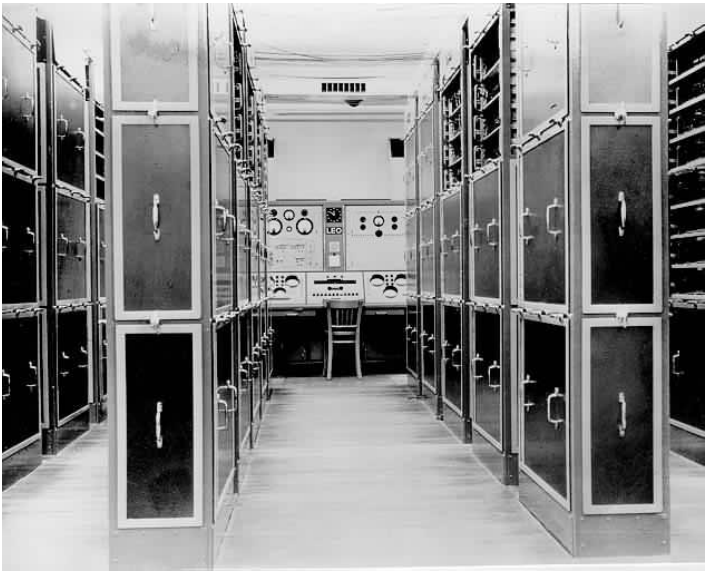
As a programmer I was responsible for resolving any problems with the statement production programs but in practice worked mostly on the replacement ICL 1904A system, writing programs in the ICL 1900 Plan 3 assembler language. These, along with the corresponding input and update programs, were being prototyped on a 1901A specially delivered for the purpose in the last months of my employment.

David Bew is a contributor to the Our Computer Heritage *project. He can be contacted at* david@bew9.orangehome.co.uk*.*

LEO, the First Business Computer

Neville Lyons

The in-house development and production of the LEO Computer illustrates an extraordinary achievement by the Lyons company. The Science Museum recognises this by displaying the few remaining parts of the original LEO in its Information Age Gallery, opened by Her Majesty the Queen in October 2014.



LEO I at Cadby Hall Circa 1952

The Company Background

For much of the 20th century, J Lyons & Co reigned supreme throughout England for its public catering and for its great range of own brand food products. The company was founded in 1887 to improve the quality and pricing of the inferior catering at the national exhibition halls. It was later welcomed by the general public through the famous teashops, flourishing in London and other major towns and cities across the country. The huge Corner House restaurants, with their varied menus, non-stop live music and attractively efficient 'Nippy' waitresses, became popular as venues for family days out in London. Tea, Swiss rolls and ice cream were among many of the high quality Lyons products on the market.

Anyone who lived during that era will doubtless treasure such fond memories. But they will probably be less aware of the organisational

initiatives that helped J Lyons & Co to retain its predominance in the field of catering and food products for close on 100 years.

The Needs for Automation

By 1939 Lyons employed around 30,000 staff across the country. 1,500 were involved in accountancy and other statistical work. An office block at their Cadby Hall, Kensington headquarters had been specifically built to accommodate them. Accounting and clerical efficiency had been a concern of management from the outset. As early as 1910, the company was using calculating machines to assess, from waitresses' bills, the average morning and afternoon spend by customers at each of its teashops.

Prior to the Second World War, the company were ahead of their time in their improvements to management information and clerical procedures, employing highly qualified graduates to mastermind these roles. The leader in this field was John Simmons, who initiated a Systems Research Office to focus on creative organisation and methods. The object was not only to give continuing improvements in office efficiency, but also to provide information to management about profit variations affecting the business. This forward thinking was to prove highly advantageous in the years ahead when electronic automation came to the fore.

Indeed, after the war the sharp rise in office costs made the company realise that some form of automation was essential if these costs were to be brought under control. In 1947 the Lyons board agreed to Simmons's proposal to send to America two senior managers with wide experience of clerical procedures to study the current research into electronic computers. During their stay in the USA, they were put in touch with those who were doing serious work on electronic computing, but this aimed mainly at academic usage. They also heard, much to their surprise, of a computer project that was currently under way in England at Cambridge University!

On their return, the managers made a point of investigating the Cambridge project before reporting back to the Lyons board. The project, known as EDSAC, was designed for academic calculations and quite inappropriate for office work, but they at once appreciated the potential of the new technology, which became a significant aspect of their report. They stressed that electronic machines would hold the key to office efficiency and they put forward three options for the board to consider: either to persuade Cambridge to follow a commercial computing path, or to await machines as they became available from manufacturers, or to develop a machine in-house. They estimated this latter option would cost £100,000, but they claimed it would show a saving in office expenditure of £50,000 per year.

The Proposed Solution and Project Build-up

The board felt the company's influence on machine design was essential if the problems of commercial clerical automation were to be solved successfully. So, they agreed on a middle course: to undertake their own in-house development with the co-operation and technical advice of Cambridge University. Lyons would donate £3,000 (£60,000 in today's money) to EDSAC in return for technical advice on their company project. The Cambridge personalities were understandably apprehensive but agreed to go along with the idea.

Lyons had never employed an electronics engineer. There was a strong electrical department, but its work was largely devoted to providing and regulating the company's power supplies. So they advertised for an electronics engineer to lead their project. This was quickly answered by John Pinkerton, who had recently obtained his PhD at Cambridge. While there, had learned of this extraordinary project which Lyons were planning. He was accepted as the right man for the job and started work in January 1949.

Pinkerton was to be supported by a small team for both hardware and software design, although this terminology was not yet in use. Some were already Lyons employees. A key member was David Caminer, who had worked for the company pre-war, was severely wounded in North Africa and returned to be employed in systems research under John Simmons. He became an automatic choice as leader in program development. Another, Ernest Lenaerts, had served with the RAF on radio countermeasures and was seconded by Simmons to the Cambridge team to gain practical experience of the new electronic technology. He not only learned how EDSAC was constructed but was also able to make a positive contribution to unit circuit design.

The computer project team faced an inevitable dilemma: On the one hand, thought had to be given to clerical uses to enable them to decide how best to build the machine; on the other, some definition was needed of how the machine was to work in order to determine the best approach to clerical applications. Hence, it was recognised from the outset that engineering and programming teams had to progress in parallel, complementing each other's ideas.

The Birth of LEO

During the next three years this technically qualified but inexperienced team designed and built a working model for which Simmons chose the name of LEO, standing for Lyons Electronic Office. The design thinking was initially influenced by EDSAC. A large area at the Cadby Hall headquarters

was vacated and the computer gradually assembled there, piece by piece. During the process carpenters, plumbers, sheet metal and engineer staff toiled in a well organised undertaking on the huge assembly of valves and other large components, together with wiring, ducting and power supplies.

Many difficulties had to be overcome. For example, the first problem tackled was pulse generation and pulse control through the mercury delay tubes, chosen for memory storage. Considerable experimentation was needed and specialised test equipment was not readily available on the limited budget assigned to the project. This led Lenaerts to design and build an oscilloscope, based on one already designed by the Cambridge researchers. For this purpose, he had to resort to a selection of parts, including ex-War Department radar tubes from second-hand dealers. Other problems involved finding the most suitable types of input and output devices, for which trials were conducted with punched cards and paper tape before achieving the most satisfactory method, using magnetic tape.

The logical design of LEO closely resembled that of EDSAC, but it had twice the memory size, with 64 mercury delay tubes, each 5′ 4″ in length with a 1″ diameter bore. LEO differed in construction, with modular design to enable rapid replacement of defective units. More than 6,000 thermionic valves were used, many of the type used in television and radio at that time. The entire machine occupied 5,000 square feet, with air-conditioning.

The computer was controlled from a panel, with several oscilloscopes set up to monitor contents of the storage area. A speaker was installed in the machine and programmers could hear the sounds generated as LEO performed calculations. They became so accustomed to certain frequency variations, that they could detect something was wrong with a program by the sounds produced through the speaker. During the very infrequent periods of relaxation, the team used this speaker arrangement to generate some of the first "computer music".

LEO Becomes Operational

The first operational program, covering Bakery Output Valuation, was run on LEO in September 1951. There were initial handicaps due mainly to failures of thermionic valves and dry joints. Pinkerton's team worked hard on improving hardware, so that by November that year the machine was sufficiently reliable to calculate the weekly production value of bread and other bakery goods such as Swiss Rolls, Kup Kakes and Individual Fruit Pies. This breakthrough established LEO as the first computer in the world to run a routine office job.

However payroll automation was one of the main objectives. Between 1951 and 1953 further work took place on the machine's reliability, bearing in mind that the weekly staff payroll required strictly accurate and timely performance. This milestone came on Christmas Eve 1953. The results were astounding. The task of calculating employees' pay, until now, had taken an experienced clerk eight minutes per employee. LEO had done the job in 1½ seconds.

Bureau Applications Commence

News of this 'electronic brain' spread throughout many industries and government departments and was received enthusiastically. Lyons soon organised a bureau, commissioned to perform a range of tasks on LEO. In fact, LEO undertook the first recorded bureau job on any computer in the UK; quite remarkable considering this was a prototype model! This task was on behalf of the Ordnance Board who were given facilities for carrying out ballistic computations. The work was shrouded in secrecy at the time, but it was later revealed that the calculations performed by the programming team were associated with the trajectories of the Black Knight rocket.

Another large and more complex calculation job for the defence industries was undertaken on behalf of De Havilland and later revealed to be for simulations of the guidance system for the Blue Streak missile. One of the LEO team, Derek Hemy, who had a high security clearance having worked on Signals Intelligence during the war, did not become aware of its purpose until after he had left Lyons!

In 1955, after the Chancellor's budget speech, a courier delivered to Cadby Hall the parameters of the new taxation. All other work had to be taken off the machine while LEO processed new tax tables overnight for delivery to Inland Revenue the following morning, a process that had previously taken weeks by hand. For the British Transport Commission, LEO worked out the distances between each of the 7000 goods depots, for the purpose of rationalising charges. This was the longest program and had to be performed over many evenings covering 18 months when LEO was not otherwise engaged. Had the job been undertaken manually, it was estimated that 50 clerks would have taken five years to complete it!

Consolidation and Development of LEO II

The company had always planned for more than one machine. The success of the LEO prototype, which became known as LEO I, was now well recognised, so Pinkerton submitted in May 1954 outline proposals for the building of LEO II and the Board soon gave approval. The development of LEO II followed essentially the same design methods as had been used for

LEO I, but several changes were made in the light of experience. These included improving the store cycle speed to nearly four times that of LEO I by decreasing the dimensions of the mercury delay tubes. In the later models of LEO II, storage architecture was improved by use of ferrite core storage; and transistors were used for the first time in some of the circuitry.

One of the more novel features of Leo II at this time, compared with machines such as EDSAC, was the provision of multiple input and output channels. Hence, the system could simultaneously read from more than one input device, send output to more than one output peripheral and carry out calculations. In a payroll, for example, the computer would be printing the payslip of employee 1, while calculating the pay of employee 2 and reading the data for employee 3.

Lyons had their first use of LEO II in July 1957 when their model was installed ironically in the very building that had been built at Cadby Hall some 20 years earlier to accommodate the increasing number of clerical staff!

Improvements to Business Efficiency

The Lyons management were interested in putting LEO to work on applications that would contribute directly to improving the efficiency with which the business could be run. So, for the next main application after payroll, they selected the processing of teashop orders. Up to now, each teashop would submit its orders by telephone to Cadby Hall every morning for delivery the next day, based largely upon the previous day's sales. The system had been carefully honed over the years and proved efficient within the limitations of the existing technology. But, it was not, for example, possible for management to detect and report speedily any significant changes in ordering patterns or trends in trading, nor was there information available to enable the performance of shops to be monitored.

Some of these limitations could now be resolved by computer application, effectively streamlining the system. Each teashop would compile sets of monthly standing orders for each product and these would be stored as data on the computer. The shop manageress would supply daily changes in these standing orders by phone call to the computer operators at selected times each afternoon. These would be punched directly onto cards and their accuracy would be checked back to the manageresses. Such changes would then be processed against the standing orders to produce the loading and despatch schedules needed to supply the shops in time for next morning's trade. For the benefit of management, it was now possible to provide timely reports based on the standing orders, identifying

significant changes in the trading patterns to be expected in the next month.

This application was to hail the first pseudo on-line commercial system to be run on a computer. Moreover, LEO was now being used as a management tool, not just a clerical processor.

Leo Computers Ltd

By the mid-1950s, the great interest shown by large well-known companies in the LEO project led the Lyons board, at the initiative of John Simmons, to consider maximising its commercial possibilities. It was decided to form a subsidiary company to manufacture, sell and lease electronic computers and to provide other associated services. This was a major departure from the core business of catering and food manufacture, but a natural decision for the company. It was experienced in diversifying into other activities such as vehicle assembly, carton manufacture, printing and laundry to avoid being dependent on others for their supplies. The decision to create a computer manufacturing facility was an opportunity to exploit Lyons' unique office expertise and to benefit financially.

Thus LEO Computers Ltd was born in November 1954, the event receiving wide media publicity. The Lyons staff who had worked on LEO were formally transferred to this new company, now to be based at Minerva Road, Acton. The increasing volume of external interest in LEO gave rise to the need for considerable staffing of engineers, physicists and mathematicians. LEO Computers Ltd instituted an intense recruiting programme and full-time training courses.

Leo II Bureau Applications and Sales

The bureau service that had initially operated using the Cadby Hall computer was transferred to LEO Computers Ltd, who installed for this purpose a LEO II machine in offices they had acquired above Whiteley's Department Store, Queensway. One notable bureau job run on LEO II, later the subject of a documentary film, was the weekly payroll for the Ford Motor Company's 21,000 employees at Dagenham, Essex. By 1958, LEO was not only processing the Lyons payroll, but also those of others,

LEO II at WD & HO Wills, c1rca 1956

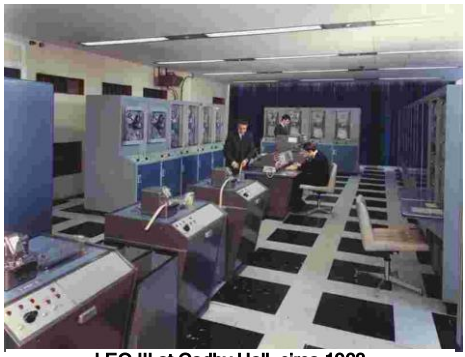
including Ford, Kodak and Tate & Lyle.

In February 1956, a LEO II model became the first sale of a commercial computer in the UK. The purchaser was the cigarette manufacturer, WD & HO Wills. This was probably influenced by the fact that the Lyons co-founders, Salmon & Gluckstein, had a tobacco industry background and some of the Lyons directors had continuing business connections. But relationships with other organisations that purchased LEO II between 1957 and 1961 were less obvious, though no less interesting. These included British Oxygen, Standard Motors and Ministry of Pensions as well as Ford Motors who had already experienced the bureau activity.

So now to LEO III

By the early 1960's, the J Lyons company had ample proof not only of LEO's ability to relieve the repetitive and uneconomic nature of clerical work, but also its value in assisting management decision-making, through the success of the teashop and stock analysis jobs. The company had by now used LEO I continuously since 1951. They already had LEO II in use since 1957 and this would become fully loaded when LEO I was retired.

By 1962, Leo Computers Ltd had completed development of its next generation computer, LEO III. It was one hundred times faster than LEO I and for the first time, an operating system that became known as 'The Master Routine' was used to control its more sophisticated features. Well ahead of its time, it could claim to be the only truly multi-programming computer commercially available, incorporating many new features, some of which would be adopted eventually throughout the computer industry.



LEO III at Cadby Hall, circa 1963

LEO III was fully transistorised (using over 100,000 transistors and semiconductor diodes) and capable of undertaking up to 13 jobs simultaneously. A new program language was devised for use with LEO III, to express in simple terms the procedures to be carried out to do any job. This new Clear Language for Expressing Orders (CLEO) brought about a dramatic improvement in program development since it needed less skill in its use.

It was now for the company to decide on how best to employ LEO III to extend the automation of their business applications. A plan was agreed

involving several new clerical applications relating to the Tea, Bakery and Ice Cream Divisions, with substantial manpower savings. The Lyons board agreed to place an order for a LEO III and this began operation at Cadby Hall in 1963.

Leo Computers Ltd had already delivered the first LEO III machine in April 1962 to Whiteley's for the bureau activity, where later that year it performed its first bureau job for the textile company, Courtaulds.

LEO III sales hit the Markets in the UK and Abroad

While sales of LEO II outside the Lyons group had totalled nine models, sales of LEO III reached 57 models. The diverse nature of the purchasing organisations is quite remarkable. They included Dunlop Rubber, BOC, Cerebos, HJ Heinz, Ever Ready, Kayser-Bondor, Royal Bank of Scotland, South Western Gas Board, Tote Investors, Board of Trade, Customs & Excise, Inland Revenue, the GPO and HM Dockyards.

The very first sales delivery of LEO III was an adventurous step forward. It took place in May 1962 as an export to Johannesburg. Leo Computers Ltd had set their sights on the S African and Australian markets as showing the most export promise. In Johannesburg, they set up an office in partnership with the Rand Mining Group, with a view to processing their administrative functions and becoming a marketing agency for LEO in that part of the world. The LEO III model was air freighted to Johannesburg, where two experienced engineers who had worked for LEO Computers since 1957 took charge of the installation process. Eventually, LEO not only took on all the Rand Group work but also the bureau functions for other mining groups, who between them owned more than 50 mines.

LEO III was also exported to three Australian companies including the Shell Group, who purchased two of the machines. Sir Samuel Salmon, the Managing Director of J Lyons & Co, handed over their first model at their Melbourne offices. After the handover, the machine played a few bars of Waltzing Matilda and then worked on four programs simultaneously. Incidentally, LEO's musical prowess had previously been demonstrated during a visit of the Duke of Edinburgh to the Whiteley's bureau in 1960. LEO had been computing the payroll for Army and Air Force officers. Just as the Duke was departing, it burst into *The Sailors' Hornpipe*!

Three models of LEO III were exported to Czechoslovakia, while still behind the Iron Curtain. The purchasers were State Railways, a Steelworks and the office of Social Security. These computers were used for more than 10 years and were highly acclaimed for their reliability. The Czech

computer engineers had been trained by Leo Computers Ltd and were capable of dealing with any eventuality.

The largest order for LEO III came from the GPO (forerunners of British Telecom). They eventually had 14 models, which undertook such tasks as telephone billing in the National Data Processing Service Centres across the country. Even after production stopped in 1968, it had to be re-started to satisfy the GPO's urgent needs. Seven LEO IIIs remained in service with GPO until 1981. HM Dockyards were also an important purchaser of LEO III, with models installed at Portsmouth, Chatham, Devonport and Rosyth.

Set-backs, Competition and Mergers

But despite the success of LEO, the parent company was now finding it increasingly difficult to fund research and development of LEO Computers Ltd. Revenues from the sales were barely covering production and marketing costs. Any small profits were inadequate for the continuing research budget.

When Leo Computers Ltd was launched in 1954, only two other UK computer manufacturers, Ferranti and Elliott Brothers were considered to be possible competitors. But their products were aimed towards the scientific market. By the early 1960s the number of other computer manufacturers in the UK had increased quite dramatically, with companies such as EMI, English Electric, Standard Telephones and Cables, ICT, Burroughs, in competition. Moreover, the USA had made great advances in computer technology, with R & D budgets far in excess of those in the UK, resulting in products that were well engineered, packaged, marketed and advertised. The Americans' strong domestic base enabled them to enter the UK market with ease, their systems being technically superior and often less expensive. IBM already had a factory at Greenock and they were to become predominant in the UK industrial market in the next few years.

By 1962, the Lyons board were concentrating on other business plans more in keeping with their food and catering businesses, which had been suffering considerable downturns in profit. They also recognised that they had underestimated the pitfalls of becoming involved in high technology products and were now unable to compete on equal terms with the electronic giants. Hence, they realised that Leo Computers Ltd would not be able to survive independently. Negotiations were soon put in hand for a merger with English Electric and this took effect in early 1963. But further pressure led to more restructuring. English Electric Leo Computers was soon to become English Electric Leo Marconi and eventually merging in 1968 with International Computers and Tabulators (ICT) and other electronics companies to form International Computers Ltd (ICL).

Many of the LEO III models mentioned earlier were made after the mergers in the 1960's and continued in use into the next decade.

End of an Era

LEO I, the prototype, had operated for the parent company at Cadby Hall from 1951 until 6pm on Monday 4th January 1965 when, after 14 years of continuous service, the computer was quietly closed down. The LEO III model which had been installed at Cadby Hall in 1963 remained in operation until 1972, when it was replaced, somewhat ironically, by an IBM model.

For Lyons, the mergers marked the end of an era of technological achievement, which had played a direct and important role in the development of the UK's commercial computer industry. Nobody could have predicted the rapid growth and the increments of computer power that would follow.

It seems extraordinary that a company which dominated the national food and catering scene for 100 years could also figure among the pioneers of British computers. The initiative and enterprise of J Lyons & Co led to the use of the computer as an effective management tool not only for their company but for British business in general.

The Guinness Book of World Records provides a fitting epitaph to the story of LEO, with an entry reading:

The first ever business computer was LEO 1(Lyons Electronic Office). It began operations in November 1951 at the Lyons headquarters, London, UK

Keeping LEO in the Public Eye

The Science Museum's new Information Age Gallery, opened by Her Majesty the Queen in October 2014, includes display of some circuitry from LEO 1, together with an 'interactive audio experience', telling the story of the world's first computer used for business applications.

The LEO era was looked upon with much pride and affection by all who were part of it. This feeling still remains, with continuity provided by the Leo Computers Society, whose members have been employed on LEO at some stage in its progress. Periodical reunions take place, including a celebration of the 60th anniversary of the birth of LEO I, held in November 2011 at the Science Museum, London and sponsored by Google. A further celebration of the 65th anniversary was held in April 2016 at Middle Temple Hall, when it was learnt that a LEO memorial stone is to be placed by

Hammersmith and Fulham Borough Council in Lyons Walk, which runs between Olympia and the site of the old Cadby Hall.

It was also announced that, thanks to some generous funding by the Association of Information Technology Trust, a 3-year post-graduate research project at Middlesex University will cover the history and philosophy of computing, focussing on the LEO I and its later versions LEO II and III.

The importance given to making the younger generation aware of this past technology is highly commendable. So much is taken for granted in the world today, but if the LEO pioneering spirit had not led the way, who knows whether the smart-phone and other high tech devices would ever have seen the light of day!!

This article was first published in 2015 in the Journal of the Royal Signals Institution, of which the author is a member, having served as a regular army officer for 31 years. We are grateful to RSI for their permission to republish it.

Neville Lyons' grandfather was a cousin of Sir Joseph Lyons (always known as Joe), co-founder of J Lyons & Co. This family connection prompted the author to carry out extensive research into that company's wide-ranging history of innovation and trend-setting; he now gives a series of talks on the subject. He can be contacted at neville.lyons@btinternet.com

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.

Members who move house or change email address should notify Membership Secretary Dave Goodwin (dave.goodwin@gmail.com) of their new address. Those who are also members of BCS, however, need only notify their change of address to BCS, separate notification to the CCS being unnecessary.

Queries about all other CCS matters should be addressed to the Secretary, Roger Johnson at *r.johnson@bcs.org.uk*, or by post to 9 Chipstead Park Close, Sevenoaks, TN13 2SJ.

Multiple Curtas
Herbert Bruderer

> Concerning the discovery in Switzerland of original drawings and patent documents of a previously unknown version of the Curta, a parallel mechanical pocket calculator.

The smart circular Curta, which looks like a fine pepper mill, is believed to be the world's smallest mechanical four-function calculator. Its inventor, the highly gifted Austrian engineer Curt Herzstark, developed the drawings in the Buchenwald concentration camp. This very precise machine was produced from 1947 to 1971 in Mauren (Liechtenstein).

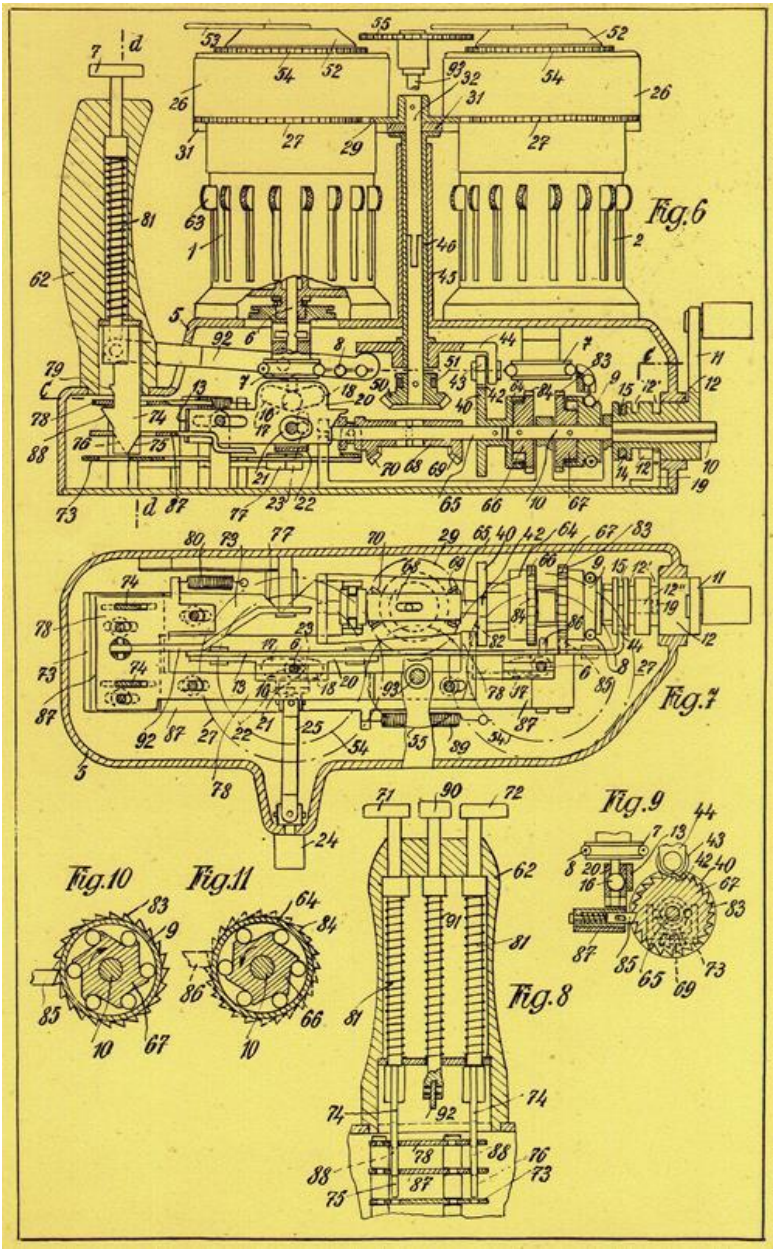
There are two models, Curta I and the larger Curta II. The stepped drum machine is able to carry out all four basic arithmetic operations (addition, subtraction, multiplication, division). Even today, the devices are still fully operational. In a recent first-hand account Elmar Maier writes about improvements of the device and its planned electrification.

In November 2015 I examined Curt Herzstark's legacy now located at the Beck Museum in Pfäffikon, Switzerland. It was quite a surprise when I discovered that the almost forgotten Austrian engineer had designed multiple Curtas. There are high quality original drawings and patent documents. The first Austrian patent application for the multiple calculator was already made in December 1949.

Double, four-fold and five-fold Curta

According to the papers found there are several types of the world's smallest mechanical parallel calculator: a vertical double Curta, a horizontal double Curta (see next page), a linear four-fold machine, and a circular five-fold calculating device. It is likely that Herzstark built prototypes but they were not preserved. To our knowledge the multiple Curtas have not been mass-produced. In the early 1950s the inventor had already left his company Contina AG (producer of Curtas I and II). He had been cheated by the Nazi board of directors.

Herbert Bruderer is a computer scientist and historian of technology formerly a member of the department of computer science at ETH Zurich. Contact at bruderer@retired.ethz.ch

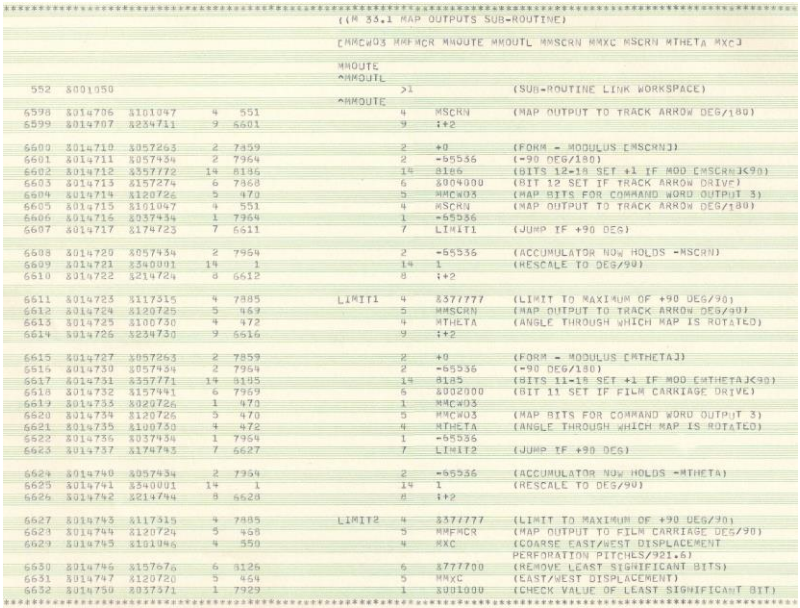


Double Curta. This design drawing shows one of the four arrangements proposed by its inventor, Curt Herzstark: a horizontal duplex mechanical pocket calculator.

Recovering a Music-Ruled Computer Listing

Terry Froggatt

I have recently finished scanning and OCRing the listing of the Jaguar aircraft flight program, written for an 8K Elliott 920M in SIR assembly code. It was originally written in around 1970 on Flexowriters, with the benefit of mechanical tabulation giving neat columns of SIR and lower-case letters for readable (albeit relatively few) comments. Below is a page of the version just scanned which is dated 1981 and has copious (and sometimes misleading) comments. It was assembled in 1983, seemingly on a GEC 4080. This assembly could have been performed using the normal SIR assembler inside the 900-series simulator (which I know was available for the 4080), but the indications are that a cross-assembler was written to assemble 900 SIR directly on the 4080. If any readers know more about this cross-assembler, please let me know at *ccs2@tjf.org.uk*.



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                                        ((M 33.1 MAP OUTPUTS SUB-ROUTINE)

                                        [MMCW03 MMFMCR MMOUTE MMOUTL MMSCRN MMXC MSCRN MTHETA MXCJ

                                        MMOUTE
                                        ^MMOUTL
  552  &001050                                    >1              (SUB-ROUTINE LINK WORKSPACE)

 6598  &014706  &101047    4   551                 4   MSCRN       (MAP OUTPUT TO TRACK ARROW DEG/180)
 6599  &014707  &234711    9  6601                 9   I+2

 6600  &014710  &057263    2  7859                 2   +0          (FORM - MODULUS [MSCRN])
 6601  &014711  &057434    2  7964                 2   -65536      (-90 DEG/180)
 6602  &014712  &357772   14  8186                 14  8186        (BITS 12-18 SET +1 IF MOD [MSCRN]K90)
 6603  &014713  &157274    6  7868                 6   &004000     (BIT 12 SET IF TRACK ARROW DRIVE)
 6604  &014714  &120726    5   470                 5   MMCW03      (MAP BITS FOR COMMAND WORD OUTPUT 3)
 6605  &014715  &101047    4   551                 4   MSCRN       (MAP OUTPUT TO TRACK ARROW DEG/180)
 6606  &014716  &037434    1  7964                 1   -65536
 6607  &014717  &174723    7  6611                 7   LIMIT1      (JUMP IF +90 DEG)

 6608  &014720  &057434    2  7964                 2   -65536      (ACCUMULATOR NOW HOLDS -MSCRN)
 6609  &014721  &340001   14     1                 14  1           (RESCALE TO DEG/90)
 6610  &014722  &214724    8  6612                 8   I+2

 6611  &014723  &117315    4  7885    LIMIT1       4   &377777     (LIMIT TO MAXIMUM OF +90 DEG/90)
 6612  &014724  &120725    5   469                 5   MMSCRN      (MAP OUTPUT TO TRACK ARROW DEG/90)
 6613  &014725  &100730    4   472                 4   MTHETA      (ANGLE THROUGH WHICH MAP IS ROTATED)
 6614  &014726  &234730    9  6616                 9   I+2

 6615  &014727  &057263    2  7859                 2   +0          (FORM - MODULUS [MTHETA])
 6616  &014730  &057434    2  7964                 2   -65536      (-90 DEG/180)
 6617  &014731  &357771   14  8185                 14  8185        (BITS 11-18 SET +1 IF MOD [MTHETA]K90)
 6618  &014732  &157441    6  7969                 6   &002000     (BIT 11 SET IF FILM CARRIAGE DRIVE)
 6619  &014733  &020726    1   470                 1   MMCW03
 6620  &014734  &120726    5   470                 5   MMCW03      (MAP BITS FOR COMMAND WORD OUTPUT 3)
 6621  &014735  &100730    4   472                 4   MTHETA      (ANGLE THROUGH WHICH MAP IS ROTATED)
 6622  &014736  &037434    1  7964                 1   -65536
 6623  &014737  &174743    7  6627                 7   LIMIT2      (JUMP IF +90 DEG)

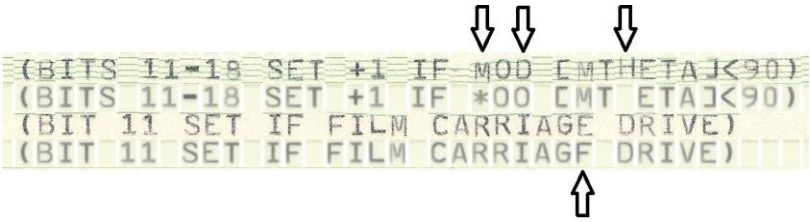
 6624  &014740  &057434    2  7964                 2   -65536      (ACCUMULATOR NOW HOLDS -MTHETA)
 6625  &014741  &340001   14     1                 14  1           (RESCALE TO DEG/90)
 6626  &014742  &214744    8  6628                 8   I+2

 6627  &014743  &117315    4  7885    LIMIT2       4   &377777     (LIMIT TO MAXIMUM OF +90 DEG/90)
 6628  &014744  &120724    5   468                 5   MMFMCR      (MAP OUTPUT TO FILM CARRIAGE DEG/90)
 6629  &014745  &101046    4   550                 4   MXC         (COARSE EAST/WEST DISPLACEMENT
                                                                    PERFORATION PITCHES/921.6)
 6630  &014746  &157676    6  3126                 6   &777700     (REMOVE LEAST SIGNIFICANT BITS)
 6631  &014747  &120720    5   464                 5   MMXC        (EAST/WEST DISPLACEMENT)
 6632  &014750  &037571    1  7929                 1   &001000     (CHECK VALUE OF LEAST SIGNIFICANT BIT)
```

As has been reported elsewhere in previous issues of *Resurrection*, standard OCR software has difficulty with listings on "music-ruled" paper, so I wrote my own OCR software, which actually exploits the music rules to compensate for scanning alignment errors and to locate the text. The listing is in the style typical for assembler listings of the 1980s, with the SIR assembly code and comments on the right half of each page and the corresponding store addresses (in decimal and octal) and machine code (in octal and instruction format) on the left.

My OCR software knows that it is only looking for digits or certain symbols on the left side of each page, so the typical error rate was about one error per page, the errors being detected by comparing the two formats. These columns include the addresses but not the values of literal constants. Luckily there was a separate listing of literal addresses and literal constants, sorted by value, which I was able to OCR and sort back into address order. Both the addresses and constants were given in hex, decimal and octal, so here I was able to correct OCR errors automatically by voting. This enabled me to complete a binary tape of the whole program.

Recovering the SIR source code and the comments required substantial proof-reading and some manual correction. I was able to check pages as I completed them, using the SIR assembler, and I wrote two more programs to spot errors. Firstly, a program to interlace lines of the original scanned image with lines reverse-OCRed from the (supposedly) corresponding SIR text file, making it far easier to compare the files than using two screens or windows. This sample reveals four errors.



Secondly a program to sort and count all strings in the SIR text file, which helped locate occasional OCR-misspellings of a frequent word in comments. Assembling the resulting SIR code in my 900 simulator gave exactly the same binary tape as from the left half page, proving that the SIR was correct, (or at worst contained perhaps a consistently misspelt identifier).

There remains the possibility that there are OCR errors in the SIR comments, which the human reader's eye will probably overlook too. But I'm pretty sure that there will be less of these than there are pre-existing (non-OCR) errors in the comments, for example there are at least six zeros which should be letter O. There were 7625 errors detected in 11663 lines overall, so typically well below one correction per line.

The resulting program runs in my simulator and on my real 903. I now have to resist the temptation to buy various parts of the Jaguar aircraft cockpit avionics whenever they appear on e-bay. A couple of the projected moving maps have been on eBay recently, but they need 300W 200V @ 400Hz, plus a complicated interface unit.

40 Years Ago ….
From the Pages of Computer Weekly
Brian Aldous – TNMoC Archivist

Coral 66 compiler from CSS: The latest company to cater for the increasing popularity of Coral 66 is CSS International, the UK branch of the US bureau National CSS. (CW513 p9)

Image processor highlight at show: An advanced image processing system from Plessey is one of the computer industry highlights at Farnborough '76, which opens to the public on September 9th. (CW514 p1)

UK survey aims to show Coral's worth: An independent UK evaluation of Coral 66 against the standard real time language specifications of the US Department of Defense is deliberately aimed at producing evidence for the DoD that the language is, after all, extensible, and thus worthy of adoption as standard for the UK armed services. (CW514 p9)

ICL 2900 breaks into Europe: Two major orders for extensive terminal networks built around ICL 2960 mainframes mark the long-awaited first penetration of the commercial user market in continental Europe by the large 2900 machines. The orders, foreshadowed in Computer Weekly four months ago, have both come from France, theoretically the stronghold of the indigenous CII-HB. (CW515 p1)

Nationwide order system planned for UK bookshops: A Nationwide on-line order entry System for UK bookshops is likely to be operational early next year. (CW515 p56)

EPSS exchanges to go into operation: All three exchanges on the Post Office's Experimental Packet Switched Service are now operational and each user linked to the network can communicate with each other. (CW516 p11)

UK launch of reading wand: An optical character reading wand, the P130, designed to be used with most types of intelligent terminal, including the IBM 3270, is now available in the UK from Recognition Equipment. (CW517 p1)

The first Cray installation passes tests: The first Cray 1 supercomputer to be installed on a customer site successfully completed its six-month evaluation period on October 1st at the Los Alamos Scientific Laboratory in New Mexico. (CW518 p1)

Reminiscing Orion ...: What promises to be a night of tearful reminiscences is being arranged for October 22nd, when, it is hoped, an Orion reunion will be held at London's White's Hotel for anyone who worked on the now legendary Orion computer — either as a user or as a supplier. (CW518 p12)

EEC picks 2900 system: The final decision on the new computer for the EEC Commission's Luxembourg centre has now been taken, and as expected, the contract has gone to ICL. The £3.5 million order is understood to be for a 2980 running under the VME/B operating system. (CW519 p1)

Intel new single board system: To enhance the SBC 80/10 microcomputer introduced in February, Intel has launched the SBC 80/20, which adds new facilities to the earlier system's concept of a complete OEM computer on a single printed circuit board. (CW520 p16)

Birmingham calls for museum pieces: An appeal for computer processors, peripherals and terminals which were significant landmarks in the history of the computer industry, has been launched by Birmingham's Science and Industry Museum. (CW522 p11)

Joint board set up to plan networks: Cutbacks in funds for both the Science Research Council and the Computer Board, which pays for university computers, has led to the formation of a joint SRC and Computer Board unit responsible for planning university and research council computer networks. (CW522 p40)

First overseas order for CTL 8000s: A West German printing firm has placed the first order outside the UK for Computer Technology's Series 8000 on-line systems. The customer, E C Baumann KG, of Kulmbuch, Bavaria is paying DM 1.5 million (about £350,000) for two 8050s and one 8030 which it will use to edit text for photo typesetting. (CW523 p10)

Scanner challenge to EMI: Challenging EMI on its home ground in the X-ray body and brain scanner business is the US firm Ohio-Nuclear with its Deltascan. (CW523 p19)

IBM launches DIY mini range: The IBM minicomputer products line is to be called Series 1 and is being marketed as a do-it-yourself mini system aimed at experienced computer users. The first two products of what had previously been known as Peachtree were officially announced, this week, as predicted in Computer Weekly. (CW524 p1)

RAE contract goes to DEC: A contract for a system to handle large-scale air flow computations for the Royal Aircraft Establishment at Farnborough has now been awarded to Digital Equipment, although the power of the system is greater than one Atlas – the minimum size needed for a government project to be considered as a case for ICL single tendering. (CW525 p1)

And 50 Years Ago ….

On 22nd September 1966 the very first edition of Computer Weekly was published. A selection of the headlines from those first editions can be seen below.

Beating Mersey Traffic Jams: After two years of research, Liverpool City Council have placed a £200,000 contract, subject to Ministry of Transport approval, with Plessey Automation for a traffic congestion control scheme to keep vehicles moving around the approaches to the Mersey Tunnel. (CW001 p1)

Biggest Rail Computer Order for ICT: The plan for a rationalised computer system for British Rail took an important step forward last week with the announcement of a £lm order for two ICT 1906 machines to be located at Crewe and Peterborough. (CW001 p4)

Nottingham steps up KDF 9 power: As a result of recommendations in the Flowers Report, the KDF9 computer at Nottingham University has been increased in size and is now comparable with the large machines at the UK Atomic Energy Authority's establishments at Culham and Winfrith. (CW001 p11)

GEC machine for MRC centre: The first blooming of the Flowers Report recommendation that the Medical Research Council should buy computing equipment and establish its own EDP centre was seen last week when a £280,000 order was awarded to GEC Computers and Automation Ltd. A Series 90, Model 300 computer is to be supplied for the MRC's new unit in North London. (CW002 p1)

Printers designed for System 4: A range of lineprinters are now being manufactured by English Electric-Leo-Marconi for System 4 computers. The four models cover print speeds of 750 to 1,350 LPM and each speed is available with either 132 or 160 print columns. (CW002 p4)

Pension Ministry chooses EELM 4-70s: The contract for two computers at the Ministry of Social Security's central office in Newcastle has been won by English Electric-Leo-Marconi. Two System 4-70 machines are to be installed in 1968. Value of the order is £lm. (CW003 p1)

Biggest US Air Force EDP order: Tenders are due in this month for the biggest data processing equipment contract ever placed by a US armed forces department. It is for 135 computer systems of various sizes for the Air Force and the cost is over $100m. (CW003 p6)

Fortran translator for Argus: A new Fortran translator will shortly be available from Ferranti for real time, on-line process control applications of their Argus computers. It is believed that the Argus Fortran will be the first to provide facilities for reading plant measurements and setting plant controls to the appropriate values. (CW003 p10)

Mystery of second Cambridge ATLAS: An air of mystery surrounds reports that Cambridge University is to acquire a second Atlas computer. If such a plan were in hand it would probably be as a result of preliminary talks that are known to have taken place about work on computer-aided design. (CW004 p1)

Powerful new language for 1900: A new programming language, designed to simplify the changeover from mechanical tabulators to computer systems, is now available to ICT 1900 users. Known as Nicol, Nineteen Hundred Commercial Language, it is claimed to be as powerful as any commercial language and able to handle all normal business applications with much greater ease. (CW005 p1)

Small Multi-job machine aimed at UK market: A cost performance better than any other machine, the ultimate in modular structure, the most highly developed interface available. These are among the claims made by Mr I.M. Barron, managing director of Computer Technology Ltd, for his company's Modular One computer. (CW005 p12)

Elliott's proposal for 'big machine': Proposals have been made by Elliott-Automation for a computer complex suitable for use in the regional computer centres recommended by the Flowers Report. A new computer, the NCR Elliott 4150, would act as a "number cruncher'' in conjunction with peripheral 4100 computers which would act as local machines with full multi-access facilities. (CW006 p1)

Big defence orders for IBM 4Pi: A military version of the IBM 360 series and the first IBM computer to use integrated circuit techniques has been announced in the US. (CW007 p12)

Development on Titan project: During the next few months an increasing number of users of the Titan computer at Cambridge University Mathematical Laboratory will have immediate access to it through remote consoles. Seven of the 10 remote terminals have so far been connected at the same time to the system. (CW008 p1)

EAL Hybrid System at City University: London's City University is to add an EAL Type 690 hybrid system to its existing ICT 1905 computer. The cost will be around £97,000 and the first applications envisaged are for real time control experiments on the four wind tunnels at the university's Department of Aeronautics. (CW010 p12)

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Forthcoming Events

London Seminar Programme

17th Nov 2016 (N.b. Monday)	Sale Award Ceremony + Presentation from the Winner	
15th Dec 2016	Computer Films	Dan Hayton & Kevin Murrell
19th Jan 2017	History of Enterprise Systems	Geoff Sharman
16th Feb 2017	Simulation Models of Historical Computers — Atlas, MU5 and CDC 6600	Roland Ibbett

London meetings take place at the BCS in Southampton Street. Covent Garden starting at 14:30. Southampton Street is immediately south of (downhill from) Covent Garden market. The door can be found under an ornate Victorian clock.

You are strongly advised to use the BCS event booking service to reserve a place at CCS London seminars. Web links can be found at *www.computerconservationsociety.org/lecture.htm*.

For queries about London meetings please contact The CCS secretary Roger Johnson (contact details inside back cover).

Manchester Seminar Programme

15th Nov 2016	The Unknown Alan Turing	Dermot Turing
17th Jan 2017	A Search Through the Bins of Computer History	David Eglin
21st Feb 2017	The History of the Semiconductor Revolution	Steve Hill

For the remainder of 2016 North West Group meetings take place in the Conference Centre at MSI — the Museum of Science and Industry in Manchester — usually starting at 17:30; tea is served from 17:00.

From January, the meeting venue will be the conference room of the Royal Northern College of Music, Booth St East M13 9RD: 17:00 for 17:30.

For queries about Manchester meetings please contact 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/lecture.htm*. Details are also published at in the events calendar at *www.bcs.org.*

Museums

MSI : Demonstrations of the replica Small-Scale Experimental Machine at the Museum of Science and Industry in Manchester are run every Tuesday, Wednesday and Sunday between 12:00 and 14:00. Admission is free. See *www.msimanchester.org.uk* for more details.

Bletchley Park : daily. Exhibition of wartime code-breaking equipment and procedures, including the replica Bombe, plus tours of the wartime buildings. Go to *www.bletchleypark.org.uk* to check details of times, admission charges and special events.

The National Museum of Computing : Colossus Galleries open daily 10.30-17.00; full Museum open Thursday, Saturday and Sunday 12.00-17.00. Situated on the Bletchley Park campus, TNMoC covers the development of computing from the "rebuilt" Colossus codebreaking machine via the Harwell Dekatron (the world's oldest working computer) to the present day. From ICL mainframes to hand-held computers. Please note TNMoC is independent of Bletchley Park Trust and there is a separate admission charge. Visitors do not need to visit Bletchley Park Trust to visit TNMoC See *www.tnmoc.org* for more details.

Science Museum :

There is an excellent display of computing and mathematics machines on the second floor. The *Information Age* gallery explores "Six Networks which Changed the World" and includes a CDC 6600 computer and its Russian equivalent, the BESM-6 as well as Pilot ACE, arguably the world's third oldest surviving computer. Other galleries include displays of ICT card-sorters and Cray supercomputers. Admission is free. See *www.sciencemuseum.org.uk* for more details.

Other Museums :

At *www.computerconservationsociety.org/museums.htm* can be found brief descriptions of various UK computing museums which may be of interest to members.

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