Computer Conservation Society

Aims and objectives

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

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

The aims of the CCS are to

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

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

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

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

The corporate members who are supporting the Society are Digital Equipment, ICL, Unisys and Vaughan Systems.

Resurrection

The Bulletin of the Computer Conservation Society

ISSN 0958 - 7403

Number 18

Autumn 1997

Contents

Editorial

Nicholas Enticknap, Editor

The major news since the last issue is that the negotiations about access arrangements to the Society's computers at Blythe House have been successfully completed, and Working Party restoration activity has started again.

The Science Museum is keen to expand this activity to encompass personal computers — not just the S-100 bus machines looked after by Robin Shirley's Working Party, but all the other early PCs as well. To this end, a room has been set aside at Blythe House. It has already been equipped with the necessary shelving, and the next step is to transfer equipment currently in store into that room.

The Bletchley Park museums complex is proving increasingly popular, with the Society's exhibits — notably the Elliott 803 but also including a range of early personal computers — playing their part. John Sinclair has been the driving force behind the organisation of the Society's room at the Park. John, however, is finding less and less time to devote to this work as his own business has been building up, so Tony Sale is keen to find other volunteers to help out at weekends. Anyone who lives relatively near the Park and would like to assist the Society's work in this way is invited to contact him.

Another highlight of the Bletchley Park Open Days is the replica Colossus, which has proved exceptionally reliable. Work has now started on another similar project, the re-creation of a Turing Bombe. Some 200 of these largely mechanical devices were in use at the Park during the War to help with the message decoding workload.

Moving north to Manchester, the Small Scale Experimental Machine rebuild project is well on schedule to meet its target completion date of June next year — the golden jubilee of the first running of a program on the original machine.

Our editorial coverage this issue starts with an article by Bob Beard on the KDF9 computer, a system that has been comparatively neglected in *Resurrection* till now. We also feature a summary of the technological development of the ICT/ICL 1900 range by Brian Procter. Adding an international flavour, our third feature article is the first of two on the history of computing in China, based on the talk given to the Society by Professor Qiangnan Sun.

News Round-Up

Len Hewitt has taken over as Acting Chairman of the Pegasus Working Party. He is well qualified for the task, having worked for around nine years as an engineer on ICI's Pegasus in the fifties and sixties. His involvement with computers started in 1955 at Ferranti, where he worked on the Mark 1* for just over a year before joining ICI. Later he transferred to the company's programming department, before joining Legal & General to run the company's network. He has been a member of the Pegasus Working Party since 1990.

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A new Working Party has been set up to manage the Turing Bombe replica construction project, with John Harper as Chairman. The Bombe is being built in Hut 11 at Bletchley Park, where the first of the original Bombes was installed in August 1940. The construction project is expected to take two and a half years. The Society is grateful to Quantel, whose generous donation has allowed the work to start.

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Work so far has concentrated on building the frame of the Bombe, which was completed in September, and on making copies of the original drawings, which are both difficult to read and in deteriorating condition. John Harper estimates that the frame accounts for about 1% of the total effort needed, which he thinks will be about 25 man years.

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Visitor numbers are soaring at Bletchley Park, with the average attendance recently being 600 per day, and peak attendance this year being 4500 over one open weekend. Members who have not yet been and would like to go should consult the Forthcoming Events section for dates of upcoming open weekends, which occur every fortnight.

Society Vice-Chairman Tony Sale, the driving force behind the Bletchley Park restoration project, was named IT Personality of the Year at the Comdex UK 97 conference in April.

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In London, access arrangements at Blythe House have now been negotiated and this has allowed Working Party operations to resume, as described in the Society Activity section starting on page 31.

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The Science Museum is planning to display Pegasus in its new "Making of the Modern World" gallery, which will illustrate the development of industrialisation in Britain and will open around the turn of the millennium.

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Still in London, George Davis has enticed a host of big names to speak at the two autumn seminars (see Forthcoming Events). The November event on the early history of the UK software industry will include presentations from Alan Benjamin on SPL, Barney Gibbens on CAP, Sir John Hoskyns on Hoskyns, Bryan Mills on CMG and Len Taylor on CEIR (later Scicon) and Logica. The December event on the history of the NCC will feature John Aris, David Firnberg, Ron McQuaker and John Perkins.

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John Southall is working hard on the organisation of three half day seminars for spring 1998 in the Science Museum, linked together under the theme "The Early History of Computer Networking". Provisional titles are "The Technology", "Networks for Education and Research", and "Applications in Business" and they have the provisional dates of 12 March, 23 April and 28 May. Enquiries to John on 0118 984 2259.

CCS expertise in action, part one: the Friends of Forres Museum in Invernesshire put on an exhibition of computing history during the spring. We were able to give some assistance with a loan of exhibits and information, and they have generously sent a substantial donation towards CCS funds.

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CCS expertise in action, part two: we were approached for help by National Railway Supplies Ltd of Crewe, which provides service for the signalling systems on the railways. They have some test equipment which is controlled by special 8-track paper tape, which had become extremely fragile. We were able to read and duplicate this tape, enabling them to continue their testing schedule. They too gave the CCS a donation.

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Ray Norris of CSIRO in Australia has some ancient logic diagrams, and he has sent us microfiche copies for identification. Initial examination suggests the diagrams may be of Elliott Brothers test equipment for logic packages of the early fifties 400 series computers. Any reader who is interested in further analysis of these diagrams should contact Chris Burton.

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Recently the Society was offered complete working CAD systems based on PDP-11/34 machinery, one from Rugby which was used for flame-cutting diagrams, and the other from Preston used, we believe, in the chemicals industry. Regrettably we have no place to store, let alone, set up, these old workhorses. It is sad to report that they have been scrapped: middle-aged designs like this are not yet old enough to be considered precious artefacts.

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Membership of the Society continues to increase, and now stands at 620.

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CCS member Anne Rooney is writing a book on early personal computers, and would like to hear from members who were involved in any way with them. Dr Rooney can be contacted at 166 Shelford Road, Trumpington, Cambridge CB2 2NE.

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Simulators

Simulators for a variety of historic computers, including Edsac, Elliott 903, Pegasus, the Manchester University Small-Scale Experimental Machine and Zebra, can be found at our FTP site. Access details are on page 35.

The KDF9 Computer — 30 Years On

Bob Beard

This article describes the architecture and technology of the KDF9, and provides a potted history of the development into production and subsequent field installation.

It was 1995 when it was first suggested that I should prepare a talk on this subject. Thirty years earlier, the design of the KDF9 was stable, a dozen or so systems had been installed and a series of enhancements to both hardware and software were being developed.

During that year the problems of managing the changes to the design and planning field modifications became very significant. The result was the formation of a group entitled Post Development Services. It was responsible for formal Design Change Control, replacing the "backs of envelopes" — informal Engineers' Instructions. For my sins I became the manager of this group, my first taste of organisational responsibility and all that it entails.

For several years afterwards many "specials" were developed for the KDF9 in response to requests from customers, a practice which characterised English Electric which sold that which customers asked for, not that which existed in the catalogue. As a result Post Development and Specials Engineering became synonymous, and my team had great fun adding all sorts of oddball features to the KDF9 in and outside the UK.

I had arrived at Kidsgrove in spring 1962 on completion of my National Service. Previously I had worked at ICT (ex Powers Samas, ex Vickers) and had worked with computers, both analogue and digital, from around 1956. I had a hand in the design of the FCC (a relative of the PCC), but the KDF9 was my first real design project since graduating.

The KDF9 computer system

When I arrived in May 1962, the concept and architecture of the KDF9 was largely complete, with the exception of some aspects of the time sharing option, which I subsequently completed in early 1964. The implementation, that is the logic design of the KDF9, was some 80% complete with some parts of Main Control yet to be finalised. That was where I started.

Conceived in the late 1950s, following English Electric's experience with pilot Ace, the Deuce and the KDP10 data processing system, the KDF9 was to be particularly fast at arithmetic (fixed and floating point, single and double precision), would aim to keep all the system resources busy, reducing idle time of both processor and I/O, and employ an elegant memory addressing method allowing rapid indexing for working with data arrays. The architecture and the order code were to be particularly suitable for the efficient compilation of source code.

As good a description as any can be found in the book entitled "Early British Computers" by Simon Lavington, from which the following is extracted.

> "...The second, and historically more interesting large computer to emerge from Kidsgrove was the KDF9.
>
> "This high speed transistor machine was developed by a team under ACD Haley, of which the leading light was RH Allmark. The KDF9 is remarkable because it is the believed to be the first zero-address instruction format computer to have been announced (in 1960). It was first delivered at about the same time (early 1963) as the other famous zero-address computer, the Burroughs B5000 in America. Like many modern pocket calculators, a zero-address machine allows the use of Reverse Polish arithmetic; this offers certain advantages to compiler writers. It is believed that the attention of the English Electric team was first drawn to the zero-address concept through contact with George (General Order Generator), an autocode programming system written for a Deuce computer by the University of Sydney, Australia, in the latter half of the 1950s. George used Reversed Polish, and the KDF9 team were attracted to this convention for the pragmatic reason of wishing to enhance performance by minimising accesses to main store. This may be contrasted with the more 'theoretical' line taken independently by Burroughs. Besides a hardware nesting store or stack — the basic mechanism of a zero-address computer — the KDF9 had other groups of central registers for improving performance which gave it an interesting internal structure. Certain aspects of the stacking idea are now to be seen in many modern computers. Although not pioneering in the strictly chronological sense of machines such as Edsac, the KDF9 is nevertheless worth remembering as a very stimulating example of innovative design. About 29 KDF9 computers were sold between 1963 and 1969..."

Incidentally, the Burroughs machines developed both at this time and subsequently took the 'stack' concept much further and always seemed to me to be a "natural" architecture. I wonder to this day just where Burroughs went wrong although I guess it is down to Bob's-rule 24, "good engineering does not guarantee commercial success" (in contrast to rule 25 "commercial success is not dependent upon good engineering", at least in the short term).

KDF9 in summary had the following features:

- Zero Address instruction format (a first?)
- Reverse Polish notation (for arithmetic operations)
- Stacks used for arithmetic operations and Flow Control (Jumps) and I/O using ferrite cores with a one microsecond cycle
- Separate Arithmetic and Main Controls with instruction prefetch
- Hardware Multiply and Divide occupying a complete cabinet with clock doubled
- Separate I/O control
- A word length of 48 bits, comprising six 8-bit 'syllables' (the precursor of the byte) [these syllables comprised a 2-bit field plus two 3-bit fields, coded in what was termed 'slob-octal' (syllabic octal) in which we became quite expert!]
- A 6-bit character set (plus 2 bits for parity, for I/O only!) which gave eight characters per KDF9 word
- Variable Length instructions comprising one, two or three syllables (thus the KDF9 word could contain six arithmetic instructions, two main store operations, three two syllable instructions or any mix): instructions could span word boundaries but a special compiler feature could force a new word if required
- The 48-bit word could contain the following arithmetic formats:
    - ◇ one 48-bit fixed point (signed) number
    - ◇ two half-length fixed point numbers
    - ◇ half of one double-length fixed point number

- ◇ one 48-bit floating point number (39-bit fraction, 8-bit characteristic, 1-bit sign)
- ◇ two half-length floating point numbers
- ◇ half of one double-length floating-point number

- The 48-bit word could contain eight 6-bit characters
- Microcoded instruction sequences based on two interlaced clocks (P1 and P2) running at 1 MHz, a pulse width of 250 nanoseconds, the machine being 'synchronous', and a minimum instruction time of one microsecond
- A main store with a six microsecond cycle time (48 bits) up to eight times 4096 words with no parity! (equivalent to 196K bytes!)
- An internal register structure, consisting of a 16 word by 48 bit arithmetic 'stack', the 'Nesting Store', a separate 16-word nesting store for subroutine return addresses, a 16-word (the 48 bits organised as 3x16 bits) 'Q' store used for I/O and address modification operations [all quadrupled for the optional Time Sharing feature], all with a cycle time of one microsecond but NO parity!
- A physical technology using single sided printed circuit boards of approximately 6 inches by 8 inches, with 24 pcbs per 'bin', eight bins per 'rack', and two racks per 'cubicle'
- Use of high speed transistors, transformer coupled, diode- transistor logic [+ nor gates], several MAD (multi aperture devices) for complex logic conditions, diode matrix sequencers
- A typical pcb, the BIFF (flip-flop), four per board, using eight transistors and discretes, with 32 gold plated edge fingers
- As a rough approximation, 20,000 transistors per KDF9 system, and 2000 transformers (polo sized toroids)
- A single phase Swinging Choke stabilised Power Supply generating ~750 amps at 5 volts +/−12v, +/−5v...

Notice that there was very little provision for lamps and indicators or any engineering aids.

There was a small panel at the top of Main Control II containing clock controls, and P1 and P2 sequences.

None of the stores had parity!

Programming and 'Software'

On switch on, the DC voltages were applied in sequence and the system 'reset' although we often found some flag or other which had 'escaped'. A 'boot' process could be initiated from the paper tape reader which forced a nine word read (9x48 bits or 72 6-bit characters) into main store addresses zero through eight. On termination the program counter was set to zero and the instruction fetch sequence executed. The boot program could then call longer routines.

The first test programs were hand crafted in binary, converted to corresponding character (tape) code and punched out on the Flexowriter, modified by a manual tape punch and sticky tape, all using direct addressing which made code changes difficult. In spite of the problems programs up to 100 instructions, say 25 KDF9 words, were written.

A simple 'slob-converter' was written by Jim Lucking which allowed programs to be written in KDF9 syllabic notation, still using direct addressing in 'binary', making it possible to write programs of several hundred instructions. These were used by the development team for many months before the user code compiler became available.

The control program was named 'Director', and was developed by Mike Weatherfield, and a user code compiler written by David Huxtable. Neither was available for the early prototype commissioning.

Formal programs using the KDF9 Assembler level user code compiler ran under the Director. All I/O was privileged Director only, as were some other functions, while test programs could run privileged without a Director.

To my surprise, I became the primary engineering programmer for the development team, more by accident since most of the team were first and foremost electronic and circuit engineers who found 'programming' alien. I had progressed from circuits to logic and found programming most natural and more like a game. I enjoyed the challenge, which was fortunate since there was a desperate need for such talents and my services became indispensable, always an attractive position for the youngest member of a team.

Eventually, professional software became available but as always was more 'brittle' than soft and invariably uninformative when crashing. We resorted to test programs whenever a failing code sequence could be identified but more often than not, we used a suite of special test programs to adjust the KDF9 and then 'gave' the machine to the programmers.

There was very little dialogue between engineers and programmers with Jim and myself forming the primary links. Engineers and programmers had very different views of the world at that time which lasted a very long time — well into System 4 and New Range about which time programming became to be seen as 'engineering' rather than a more esoteric art form.

English Electric had developed a significant application program base in electrical engineering problem solving for obvious reasons. This had spilled into the wider engineering disciplines and other technical areas such as Railway Timetabling (linear programming?) and matrix arithmetic (KDF9's prime forte). Algol and Fortran were well established and available but most application software was developed by customers who were encouraged to share programs, following the Deuce tradition.

From the world of DP a service provided from the earliest days was that of Share Registration from an internal bureau operation. So it was no accident that whilst the design characteristics of the KDF9 lent themselves to computation intensive applications, it was quickly involved in DP where the I/O and time sharing performance attributes were attractive.

During this time all machines were built to contract: none were made for stock! Each customer system was made to order. Components were purchased against a customer contract and held secure, cabinets and pcbs were made to order, and the machine was assembled, tested, packed and installed under the all embracing contract — exactly following the practice used for building Power Stations, Generators and Transformers, English Electric's primary business. I well recall the very first time a computer system appeared ex-assembly with no customer name, well into System 4 production!

Customer Deliveries, 'Specials' and Stories

The first planned delivery was scheduled for Adelaide University, Australia. Delays and engineering problems with the first production machine caused a change, so that the first actual delivery was to Birmingham University in December 1963 — about a year late and still incomplete. By February 1964 the customer was very unhappy and in July the situation came to a head with an agreement to trial the machine exhaustively over a one year period to comprehensive customer defined criteria, including reliability and software availability.

In the meantime, follow up machines were performing better and deliveries ramped up during late 1964 and 1965. Significant customers included a very demanding ICI, several UK Atomic Energy sites, many more universities, the Met Office at Bracknell, NPL at Teddington, as well as commercial customers such as Sun Life of Canada, the latter being one of the largest configurations with the latest high speed magnetic tape units.

One of the most interesting was the National Computing Centre in Manchester, under the direction of Professor Black who was particularly far-sighted. In 1965 he requested that we connect his KDF9 to the KDF9 at Salford University less than two miles away, using some prototype 2.4 Kbyte modems from STC and the first ever coax line from the Post Office! I designed the processor-to-modem pcbs, wrote the programs, and installed and demonstrated the links some time in 1966. Was this the start of networking?

Looking back, other developments of significance included the connection of a remote console (Flexowriter) to simulate unattended operation, remote job control and the like, although the remote console was just across the corridor!

The Met Office, always in the front of technology, requested the connection of a fast plotter which we supplied using the paper tape interface very quickly and successfully. One of the most amusing special requests was for the possible sale of several KDF9s to China. To avoid possible repercussions from the US, all components were to have their markings removed. We tried many potent chemical solutions before the project was called off.

In parallel to the development in cpu architecture, rapid progress was being made in I/O devices, especially random access storage systems. The first Large Fixed Disks from CDC were connected, a RACE and a CRAM competitor were proposed and a fast drum actually connected and supplied.

One lasting lesson I gained from this time resulted from the practice of responding to requests from sales and marketing for quotations to connect such and such a device or feature. Rather than take the request at face value, it became clear that we required to know the nature of the problem being addressed. Often, a better solution could be offered than the one suggested by the customer or the salesman. I developed the philosophy of "please give me your problem not your solution". Even then the real problem needed clarification since the perceived problem was not always the root problem. Was this the beginning of formal systems analysis?

Inevitably there are endless numbers of stories to be recounted, amusing incidents concerning people, technical problems and novel solutions, stories from field incidents but, interestingly, less amusement from the factory and the world of production. Manufacturing always appeared to be very serious, overly concerned with money and time (here speaks a development engineer!) and always with a limited sense of humour.

Given time I would select anecdotes concerning our respected Managing Director, Wilf Scott, and Tom Elliott: a telephone misunderstanding, sweeping the laboratory, and a self-destructing program...

...from Culham (a UKAEA installation), the story of KDF9 floating point and the IBM Stretch computer and the then standard tables for modelling electron flux density in reactors... Subsequently, a visit to another UKAEA site at Winfrith and a trip to Chesil beach...

...the connection of a loud speaker to the prototype and the production of three part harmony (by Ray Lloyd), and my attempt to extend the octaves...

...the accidental discovery by Arthur Saville that if the Main Store core modules were installed 'upside down' the noise margins increased dramatically (was this an accident?)...

...one senior designer being banished from the laboratory for an overnight redesign of the entire I/O cubicle...

...Reg Allmark's brilliant auto-strobe for the nesting stores and my simple (elegant?) cure of the chronic I15 problem...

...the demonstration to Sun Life of the new magnetic tape systems...

...when Security reported a group of senior engineers playing bridge at two in the morning...

There is one final and abiding memory of the Birmingham KDF9 and its associated long-lasting problems (ask Peter Stanley!). This concerns a program which emulated the Ferranti Mercury computer. The Mercury was obviously fitted with a speaker for diagnostics (?) not fitted on the KDF9. Thus on any failure, the emulator would simply print repeatedly on the KDF9 Flexowriter

"HOOT!"

"HOOT!"

"HOOT!"

which explains to this day my dislike of uninformative software and the failure of programmers to recognise the inevitable fallibility of our physical creations, including software itself! This story does, however, have a happy ending. Eventually the problems were solved and the customer, like many others, became vocal supporters of the KDF9 system forming an active KDF9 users group.

Development personnel circa 1962-5

Mentioned in the text — Jim Lucking, Reg Allmark, Albert Nicholson, Ray Lloyd, Mike Weatherfield, Dave Huxtable, Arthur Saville.

Other members of the development team and associates from CED and Manufacturing include Frank Conners, Ned Abbot, Denis Caton, Wilf Owen, Robin Craig, Ray Ellison, John Roach, Ken Patterson, Dusty Binfield, Peter Wright, Noel Wesson, Maurice Hanks, John Barrett, Dave Morris, Stuart Gould, and Jeremy Walker, under the direction of Colin Haley and the Senior Project Engineer, Reg Allmark.

Editor's note: this is an edited version of the talk given by the author to the North West Group of the Society at the Museum of Science and Industry, Manchester, on 1 October 1996.

The Dawn of Chinese Computing

Qiangnan Sun

Computer history in China began with a 12 year plan for scientific and technological development which was unveiled in 1956. This article charts the nation's progress over the next four decades.

It is 40 years since China started developing a computer industry, and we have now entered the fifth decade of our march to computerisation. Thanks to the "open door" policy, the pace of development has quickened significantly in recent years with the encouragement of computer use and the application of new foreign technologies. This article, however, concentrates on the early period of China's computer history, when self-reliance was strongly emphasised.

The history of China's computer industry can be divided into three periods: the Initial Period, from 1956 to 1971; the Transformation Period, from 1972 to 1979; and the Open and Growth Period, from 1980 to the present.

Initial Period — 1956-71

In the Initial Period, work started by building products based on foreign computers and steadily evolved to the point where we were designing computers ourselves. Computer systems of three generations — vacuum tube, transistor and integrated circuit — were manufactured successively. Specialised teams for R&D, education, hardware manufacture and component production grew out of nothing.

The main accomplishments of this period can be summarised as follows:

- In 1956, the government drew up a 12 year plan for scientific and technological development, in which the computer was designated as one of the key projects. This initiative started the epoch of computerisation in China.
- During the period 1957-59 the first computer research institutes and computer manufacturers were founded and courses in universities and colleges established.

- In August 1958, the first vacuum tube computer, the DJS-1 (or 103), became operational. Just over a year later, in September 1959, the much larger DJS-2 (or 104) was successfully introduced. Both were modelled on Soviet originals.
- In 1958, the first computer technical journal, *Developments in Electronic Computers*, started publication in Beijing.
- In 1960, the first computer technical conference was held in Shanghai.
- In 1962, the first computer society, the Electronic Computer Professional Society of the Chinese Institute of Electronics (CIE), was established.
- At the end of 1961, the first computer delegation was sent to a Western country (the UK). The delegation was organised by CIE.
- In 1965, the first transistorised computers (109B, DJS-21, 441B, DJS-5 and X-2) were launched, one after another in less than a year.
- In 1966, a computer made in China (DJS-5) was sent abroad (to Japan) and exhibited to a foreign public for the first time.
- In 1973, the first large-scale integrated circuit computers, DJS-11 (or 150) and 655 (or TQ-6) went into operation.

The main features of the Initial Period were:

- The computer industry advanced freely and without restraint. It was characterised by a variety of machines, small production runs and a narrow field of application.
- Over 100 models were developed in this period, but only a tenth of them were put into production, and only two enjoyed a production run of over 100.
- The main users were military and research organisations. The main applications were complicated calculations for aerospace, nuclear energy, and large construction projects.

By the end of the Initial Period in 1971, about 500 computers were installed in China. There were about 20 factories, and the total industry workforce was around 20,000.

Transformation Period — 1972-79

This period gained its name because it marked the transformation from research to industrial development and production. At the beginning of the period, many policies for promoting the development of the computer industry and of applications were formulated and put into effect.

The major policies were:

- to "develop computer applications extensively" (1972)
- to develop ranges of computers, including mainframes and minicomputers (1973)
- to strengthen the development of peripherals and software (1973)
- to develop microcomputers (1974)
- to develop Chinese character information processing systems (1974)

The main accomplishments of this period can be summarised as follows:

- Four models of Series 200 mainframes were developed between 1973 and 1979.
- More than 10 models of Series 100 minicomputers were developed between 1973 and 1979.
- The first large-scale integrated circuit computers, DJS-11 and 655, were completed and put into use in 1973.
- The first microcomputer, DJS-050, was launched in 1977.
- The first national conference on computer applications was held in 1979.
- The number of computer manufacturers increased significantly. Many new local computer factories and research institutes went into operation, and many specialised peripherals factories were set up.

The main features of the Transformation Period were:

- Computers of large, medium and small size were successively developed by the united efforts of factories, research institutes and universities under centralised planning and control.

- The method of developing and manufacturing computers was transformed from a research activity to an industrial process.
- The scope of computer applications was extended to include process control, automatic testing, data processing, information management and retrieval, and computer-aided design, though all these were in limited use. Most machines were installed in research institutes and universities.

During this period the number of computers installed in China increased from 500 to 2000. The number of factories making computers and peripherals reached about 100, and the total number of employees rose to 45,000.

Open and Growth Period — 1980 to date

In 1979, the State Administration of Computer Industry was established, and the First National Meeting of Planning for Computer Industry was held. The experiences of over 20 years of developing China's computer industry were evaluated.

Since then, due to the implementation of the policy of "Domestically, make economy active. Internationally, open to the world", the pace of computerisation was quickened by encouraging exploitation by government and by introducing and applying new foreign technology and equipment.

The main accomplishments of the computer industry in this period can be summarised as follows:

- The policy "to grow through application" was implemented throughout the country.
- The planning and implementation of the initial Chinese computer industry complex took place.
- Vigorous efforts were made to shorten the time lag behind the state of the art by technology transfers and joint ventures.
- The construction of the first batch of import production lines was approved by the government in early 1981. The products concerned, all of which were introduced from Europe, included minicomputers, hard disc drives, floppy disc drives and dot matrix printers.
- The first computer services company, China Computer Technical Service Corporation, was founded in 1980.

- The first software company, China Computer Software Corporation, was founded a year later in 1981.
- The government formulated a plan to create 12 large national information and business systems. They include systems for national economy information, post and telecommunications, railway operation, electronic banking, electric power, finance and taxation, civil aviation, public security, weather forecasting, and science and technology information retrieval.
- The government decided on a plan for a number of *Gold* projects. They include *Gold-Bridge* (a national medium speed communications network system), *Gold-Card* (a credit cards system) and *Gold-Customs* (a customs network system).
- The focal point of the computer industry gradually shifted to the microcomputer. The unit sales volume reached 1.1 million in 1995, an increase of 53% over the 718,000 of 1994.
- China's computer industry grew very rapidly. The compound annual growth rate over the period 1981-90 was 70%, and over 1991-95 58.5%. It is expected that the annual growth rate will be 28% from 1996 to the year 2000.
- Since 1993, a favourable balance in foreign trade has been achieved. In the period January to November 1995, the total value of imported computer products was $2.2 billion, while exported products were worth $4.05 billion. These represent increases of 11% and 45% respectively over 1994. But the exports are mainly various kinds of computer parts.
- Powerful large scale computers and supercomputers were developed and manufactured by ourselves and put to good use. They include the Model 757 large-scale computer rated at 10 Mflops (1983), the *Yinhe* (Galaxy) supercomputer rated at 100 Mflops (December 1983), and the *Yinhe II* supercomputer rated at 1 Gflops (November 1992).
- Powerful multiprocessors were developed and manufactured by ourselves and put to good use. They include the *Shuguang-1* (Dawn-1) symmetric multiprocessor with up to 16 processing nodes (October 1993) and the *Shuguang-1000* massively parallel processor (MPP)

with 36 processing nodes (May 1995) and 2.5 Gflops peak performance. A more powerful system, the *Shuguang-3000* MPP, is planned for completion in 1998, with a performance of 300 Gflops.

- In 1995 about 20% of the PC market was accounted for by home computers.

The main features of this period have been:

- The computer industry has been developing under the guidance of the open policy, and has been fuelled by the needs of growing applications. During the period, radical change has occurred in computer production and use.
- The focus of research work has changed from hardware products to systems.
- The areas of computer use have changed from research, defence and a small number of industries to cover the whole of Chinese society.

In 1995 the total number of computer companies reached 15,000 while the workforce had increased to about 300,000. There were over 1000 manufacturers employing between them 100,000 people, over 1000 software companies with a combined workforce of 80,000, about 13,000 services and sales companies providing 120,000 jobs, and 50 R&D institutes.

The number of computers installed has grown rapidly over the period. In 1994 there were 500 mainframes sold in China, 1900 minicomputers and 7200 workstations, along with 718,000 microcomputers. So the number of computers installed in that one year exceeded the total installed in both the early periods combined.

Editor's note: an article describing the development of the major early Chinese computer systems will appear in the next issue of Resurrection. Both articles are based on the talk given by Professor Sun to the Society at Birkbeck College on 16 May 1996.

The Technological Evolution of the 1900 Range

Brian Procter

This article outlines the technology changes which took place during the 1900's lifetime and traces some of their impacts on machine specifications and design.

Like most successful product ranges, the 1900s exhibited a mixture of innovative leaps forward followed by periods of consolidation and evolution.

At the outset, in contrast to today's position where a manufacturer can call on many specialist component and tools suppliers, ICT had to do almost everything itself.

ICT engineers selected circuit families and often collaborated with semiconductor manufacturers to specify them. ICT designed the Printed Circuit Board (PCB) technology for mounting and interconnecting the logic circuits, and also the next level of interconnect between the PCBs. The individual processor designs were mapped onto this construction technology. ICT designed the cabling, power, cooling and cabinets which went to make up the complete processor product.

Design tools are needed to aid the design engineers and to present information to manufacturing. The design tools and the hardware technology must be matched. Over the period of the 1900 series there was a great increase in the complexity of the design process made possible by a continuing investment in design tools.

Manufacturing faced various challenges. Over the period, the technologies demanded increasingly complex structures with tighter tolerances. At the same time volumes increased tenfold and average product costs reduced by perhaps threefold.

To be successful, all these factors had to be right and in the right time. It is tribute to the skill and dedication of the engineering staff in ICT/ICL that such an undertaking could be sustained by a relatively small workforce in comparison to our global competitors.

Deliveries of the 1900 series started in 1965, and continued until it was superseded by the 2900 series in the mid-seventies. There were five different subseries, as follows: i) original; ii) E and F; iii) A; iv) S; and v) T. Architecturally we can add a sixth, consisting of the 2903/2904 and its successor, the ME29.

The initial priorities were to expand the FP6000 implementation to cover a range and to introduce a broad range of systems quickly.

The technology chosen was a derivative of that used for FP6000. This technology was in turn an evolution of that previously used by Ferranti: it was robust and well understood. The circuits were based on the FP6000 but used more reliable silicon transistors. Computers that used transistors were referred to as "Second Generation", to distinguish them from the previous generation which used valves. Although early integrated circuits were available, their performance was low and lack of practical experience would have made them a risky choice.

The PCBs were simple, with two sided tracking only and without plated through holes to interconnect the sides.

All the logic design was done manually. Logical connection information and layout was entered to a computer which generated wiring lists.

The backplane was connected using direct point-to-point wiring. Wires were pre-cut to standard lengths. To make the wiring process semi-automatic, a machine presented the wiring list one wire at a time. An operator on one side of the machine inserted the wire. An operator on the other side used a jig to test that the wire had been connected between the correct pins.

The original series built using this technology comprised the 1901, 1902, 1903, 1904 and 1906 for commercial applications, spanning a performance range of 1:26, and the 1905, 1907 and 1909 for scientific and engineering work.

The scientific machines were variants of the commercial systems with added hardware for floating point operations. The larger members of the range carried different model numbers, while the smaller members just had a feature number for the added hardware. (An exception was the 1909 which was a special package based on the 1905.) This approach to the scientific market and the nomenclature was carried forward to subsequent members of the range.

The 1904, in the middle of the range, was our version of the FP6000: the main differences were the addition of the 1900 Standard Interface and the use of anglicised technology.

The 1906 was a new design. It incorporated hardware registers and additional data flow to boost the performance. Performance of the 1906 was about 50% higher than the 1904. A variant of the 1906 with a faster store gave a further 35% performance boost.

The 1903 was a simplification of the 1904. Extracodes were substituted for expensive hardware operations, and smaller configurations were supported. Performance was about 40% that of the 1904.

The 1902 was a 1903 fitted with a slower, cheaper store. The net performance was half that of the 1903.

The 1901 was a further simplification. It used a serial/parallel data flow and the base model used switches for operator control in place of the console typewriter of the other 1900s. Performance was half that of the 1902.

All peripherals were connected via the 1900 Standard Interface. The use of the Standard Interface made it possible to separate the development and lifespan of the peripherals from the processors, and to re-use peripherals across different machines in the range.

The initial wave of systems were furnished with a comprehensive range of peripheral types, with the notable exception of exchangeable discs. Many of these peripherals had long lives and continued in active use over several successive processor generations.

The punched card and printer mechanisms were ICT designs, which drew on the company's traditional electromechanical skills in punched card tabulators. Magnetic tape transports came from a variety of suppliers over the years including DRI (UK), C des C (France) and CDC (USA), later MPI. Drums and fixed disc stores came from a number of manufacturers including DataProducts and Bryant. Exchangeable discs, introduced about 1966, were from CDC and DRI (these were used on the 1901 and 2903 only).

The first development of the 1900 range was the E/F series - the 1904E, 1905E, 1906E, 1907E and the similarly numbered F machines.

The E/F series used the same basic technology as the original machines, but pioneered several architectural improvements, as follows.

- The extended addressing modes introduced with the 1906 and 1907 were spread across the whole of the upper half of the 1900 range. These allowed programs (including their data) of larger than 32K 24-bit words, reinforcing the requirement for the larger physical stores which were offered on the E/F series.

- Dual processors were introduced: in fact the 1906E was a dual processor 1904E. This approach provided increased throughput compared with the original 1906 with the additional benefits of resilience against

CPU failure and the ability for customers to upgrade from installed 1904E systems.

- A 1904E was used in the development labs in Manchester to develop the 1900 paging feature which was incorporated in the large A series machines.

The E/F series was a mini-range in its own right, built round a single central design core. Variants included:

- optional hardware registers for the 1900 accumulators (which provided about a 20% performance gain);
- alternative stores of 2 microseconds and 1 microsecond (the difference between the E and F models, worth about 25% performance);
- a floating point unit for the odd-numbered models;
- the use of dual processors for the 1906 and 1907 E/F models, as mentioned above. The economies in development of this approach yielded benefits in price and timeliness to market.

At this juncture we will interrupt our journey through the 1900 range to look at an aspect of processor design which is strongly affected by the interplay of machine architecture and hardware technology.

A processor typically has to perform a sequence of internal operations in order to obey an instruction in a program. During each step in the sequence it is necessary to tell internal controls what action to take. There will typically be many hundreds of internal controls and their operation will depend on many factors: type of program instruction, position in the sequence, results so far, and so on.

The implementation of these control mechanisms is a crucial part of the overall design, strongly influencing speed and cost. They can easily occupy as much as half the processor logic.

There are two main classification of control systems. In a "hardwired" control system the sequences and derived controls are implemented using the standard logic family. Many optimisation techniques are used to reduce the size, often at the expense of increased complexity. The "microprogram store" approach regularises the controls into a single store, analogous to the storage of instructions in a program.

The pre-A series machines used discrete component logic which was relatively expensive, especially for storage. Designing a specialised fixed store implementation was good value where there were large numbers of controls, as in the 1906/7 and the E/F series.

The 1906/7 used a "classical" bit-mapped approach where controls are mapped rather directly to bit positions in the microprogram word (96 bits wide in this case). The E/F series used a coded approach where fields in the microprogram word controlled groups of actions. The E/F store was 48 bits wide.

The overheads of the fixed store implementation were too high for the cheaper 1901/2/3, which all used the hardwired approach.

The A, S and T machines used Small to Medium Scale Integration (SSI/MSI) integrated circuit families. They offered cheaper logic but did not provide any fast, cheap storage components. It was therefore quicker and more cost effective to implement hardwired control, and the A/S/T models all used this method.

By the time of the 2903 and ME29, integrated circuit technology could provide memory components which could be used to hold microprograms. Their relatively low cost allowed large microprogram stores and they had the great benefit of being soft-loadable. This allowed a blurring of the distinction between low-level control microprogram functions and parts of the Executive functionality. This was used to great effect in such areas as the 2903 Direct Data Entry feature.

We now resume our journey through the 1900 range with the A Series. These were a major landmark as they marked the move to Integrated Circuit technology.

By the time of the A Series machines, there were two emerging integrated circuit families with the speed required to meet the needs of the 1900 range. The two families were TTL and MECL.

The TTL family was pioneered by Texas Instruments and subsequently taken up by many semiconductor companies. Stevenage Labs led the early ICT work with an experimental TTL 1900 built in 1966.

Motorola had been developing the MECL2.5 range. The ICT engineers in Manchester developed a novel way of using these circuits and a collaboration between ICT and Motorola ensued. This led to the development of the Motorola MECL10k range, which is still made today.

The speed and small size of ICs forced a fundamental re-examination of the whole packaging technology. Two approaches were developed.

- For TTL, a modular approach to PCBs was adopted with four different sizes of board. Much of the interconnection moved from the backplane on to tracking on the PCB. The benefit was increased speed: the disadvantage was that there were now many board types to design and support. PCBs were four layer and had plated through holes. The backplane was wrap wired.

- For MECL10k, the interconnect used "series matched transmission lines". One or two ICs were mounted on plug-in cards which contained the series matching resistors. The plug-ins were interconnected by a multi-layer platter which matched the transmission line.

The handling of the complexity of the new technologies was made possible by equally significant advances in design tools. Particular mention can be made of the tracking system used to route interconnections in the platters automatically.

Handling the multi-layer boards demanded a massive jump in manufacturing capability. The PCB plant in Kidsgrove embarked on a series of process developments and investments which moved it into world-class, a position it has continued to maintain.

Computers that used ICs were termed "Third Generation Computers". ICT was among the first computer companies in the world to adopt these IC technologies and turn them into products with the A series. It had the effect of moving the 1900 technology base from conservative to leading edge.

TTL technology was used for the 1901A to 1904A. The fast but more expensive MECL10k was used for the 1906A.

All machines had optional floating point capability.

The 1904A and 1906A had paging capability and optional High Speed Mode I/O channels (these were used to attach fast drums, primarily for paging).

As previously, the 1902A and 1903A machines were based on a common processor design but used different store systems. The 1902A used cheaper timing circuits and ran at a slower clock rate.

The 1901A used a new compact design incorporating a printer in the same housing as the processor. It had a new, low cost Twin Exchangeable Disc system (TEDS) made by DRI.

To maximise its performance the 1906A used a system of asynchronous timing in which the internal beat rate of the machine changed according to the operation it was performing.

The S Series was the last to span the entire 1900 range. By the time of the T Series, the larger machine requirements were being fulfilled by the new 2900 range. However, as 2900 was being introduced with the larger models first, the lower part of the 1900 range continued to sell and was refreshed by the T Series.

The S series was a comprehensive upgrade across the 1900 range. The enhancements were all evolutionary, but significant in their scale.

- The 1906S received a spectacularly fast store made by Plessey using plated wire technology and cycling in 250 nanoseconds (more than twice as fast as previous stores). This gave the 1906S a 40% performance uplift.
- The 1904S made selective use of the new, faster Schottky STTL logic to obtain a 30% performance boost.
- The 1903S got much extended store capability and a PAC fast peripheral channel with more SIs.
- The 1902S and 1901S got larger configurations and faster throughput.

The T Series was introduced to keep the lower members of the range competitive. Performance upgrades were achieved by rebadging the next higher machine, so a 1903T was based on the 1904A and so on. All the machines had semiconductor stores. The 1901T and 1902T got Integrated Disc Controllers to reduce total configuration costs and floorspace.

The 1900 machines were positioned as what we would today call "mainframe" systems. ICL was determined to enter a rapidly growing new segment characterised by companies which were too small to have a DP department. Computing needed to be made simpler.

The 2903 range and ME29 range were developed for this segment. A robust, inexpensive architecture was needed, and the elegance and simplicity of the 1900 architecture fitted the bill well.

The naming, market positioning and projection of the machines distanced them from the 1900 range. From a customer viewpoint they were not 1900s (or at least, not primarily 1900s). However, from an architectural and engineering viewpoint it is clear that under the Hot Tango skin beat a 1900 heart.

The 2903 employed an evolution of the TTL technology used in the A series. The first semiconductor store components were just becoming available from Intel and it was decided to exploit them with a soft microprogrammed design. The 2903 was one of the first machines in the world to use this technology, as we became painfully aware when Intel ran into difficulties — truly the "bleeding edge".

The 2903 introduced a whole string of innovations: a semiconductor main store; a semiconductor control store addressed as part of the main store; a video console; Direct Data Entry in parallel with other operations; new Fixed and Exchangeable Discs; and a new shape.

The 2903 was an overnight success. It was later joined by the 2904 which provided a twofold power boost.

The 2903 was designed with data routes capable of upgrading to eight bits for compatibility with 2900. An experimental 2900 version was developed at Dalkeith but did not go into production.

The ME29 succeeded the 2903 and was also a soft microprogrammed machine. It resulted from a collaboration with Palyn Associates on an emulator known as Emmy. Emmy used MECL technology. The ME29 was split into two models, the 35 and 45, with different performance and configuration options. The 35 had similar performance to 2904, while the 45 was 80% faster.

The 1900 range was sold over a period of more than a decade from 1964. The architecture continued in the 2903 and ME29 ranges, extending the total lifetime to some 25 years. In fact, more than 30 years on, orders are still being taken in 1997 for 1900 applications to run on Series 39 machines under CME*.

The 1900 range was undoubtedly a success story for ICT/ICL. While many people and groups contributed, its success owes a great deal to the skill and dedication of engineering teams throughout the company. The hardware and software product engineers, tools and support engineers and manufacturing engineers created and sustained a complete range. And they did it with a fraction of the resources employed by our competitors.

Editor's Note: this is an edited version of the talk given by the author to the Society during the ICT/ICL 1900 seminar on 30 May 1996.

Historical Jottings

The history books tell us of Eniac and Edsac, Univac and Leo. But there were also early computing developments outside the UK and USA. The first Australian computer was actually a close contemporary of Edsac. This machine, Csirac, has been on display at the University of Melbourne since 14 June 1996, the 40th anniversary of its initial commissioning.

Csirac, or CSIR Mark I as it was originally called, was designed and built at the CSIR (now CSIRO) Radiophysics Laboratory in Sydney by a research group led by Maston Beard and Trevor Pearcey. It was inspired by developments in the UK: Pearcey had spent some time at Manchester University with Professor Hartree. The valve-based machine ran its first test programs in late 1949, and is believed to be the fifth electronic stored program computer ever developed. Csirac was officially opened in 1951.

The machine operated more than 1000 times faster than the best contemporary mechanical calculators. Its specification included a 1KHz cycle time, a memory of 768 20-bit words, and a subsidiary store of 2K words. Csirac used 30,000 watts of electricity and weighed 7000 kilograms.

There is a web page at http://csirac.cs.latrobe.edu.au for readers who would like to know more.

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George Davis writes: History sometimes needs rewriting. The “von Neumann machine” design, for example, may have owed little to von Neumann. Now the “Williams tube”, the CRT memory system for the Ferranti Mark I and other early computers, proves to have been invented not by Professor (later Sir) Freddie Williams on his own, but jointly with his colleague Dr (later Professor) Tom Kilburn: this is confirmed by the fact that the royalty income received from the NRDC at the time was chared equally between them. This information emerged from a modestly reluctant Kilburn during preparatory research for the 50th anniversary celebrations next June of the running of the first ever computer program (written by Kilburn). So will the device be known in future as the “Williams-Kilburn Tube”? Probably not — old habits die hard. It will still be called “Williams”, even though some of us know better, whether or not it was featuring as the memory component of a von Neumann machine!

Elliott 803 Working Party

John Sinclair, Chairman

The installation work on the Elliott 803 in Blythe House is now complete. We have cut the holes in the false floor and installed and connected the underfloor cables.

The Elliott 803 at Bletchley Park continues to run well: it even survived the high temperatures of the summer without adverse effects. We have completed all of the restoration work on the machine, and are now into a programme of routine maintenance to keep it running smoothly.

We achieved a minor triumph in August when we compiled an Algol program written by Peter Onion. Running the compiler is the acid test of any 803, as it is entered on a paper tape that is fully six inches in diameter. To our delight, the program compiled and ran as it should without any problems.

London Pegasus Working Party

Len Hewitt, Acting Chairman

There was a large turnout to a meeting on 29 May 1997, which arranged all the items at Blythe House into workable layout. Work did not start on the reconnection of Pegasus until 15 August. On 3 September power was applied using the schedule prepared by Chris Burton for the 1990 switch-on. Apart from some main fuses blowing for no apparent reasons there were no cabling problems. The alternator revolved in the correct direction. With HT applied we found we had no monitor display, but this turned out to be caused by the monitor slipping forward on its rails. Once we pushed it into place we had a machine with line parity errors, but all systems were go.

Over the next few weeks we resolved many minor problems, and at the date of writing I am convinced we have a machine that we can run reliably in future. We have run all the test programs up to the drum tests successfully. The drum tests run, but produce known failures. What we have to do now is apply marginal tests to build up the reliability. We also need to ensure the spare packages are working, particularly the nickel lines.

We have a keen team and I think we should all be pleased at the progress made. The location seems to be able to handle the heat output of Pegasus without any noticeable increase in the ambient temperature, even though there is no refrigeration cooling plant running.

Elliott 401 Working Party

Chris Burton, Chairman

Encouraged by a more adaptable policy regarding access to the system at Blythe Road, very good progress has been made on the primary task, namely the elucidation of the authentic logic diagram. The team of Maurice Hill and Peter Holland first attempted to identify changes from the original Elliott diagrams, but this proved tedious and error-prone. They then took on the daunting task of tracing *every* wire in the logic cabinets and writing down the "string list". They have completed this and have now marked up the original diagrams.

The next step will be to transcribe these to AutoCad format for use as our reference set of diagrams. These will be superior to the originals, not only because they correspond with the actual machine, but also because they carry important information such as the physical pin numbers. The team will now look at the peripherals console to verify the diagrams and consolidate the interconnection with the main CPU. After that, the next major task will be to start on resuscitating the power supplies.

Small-Scale Experimental Machine

Chris Burton

The replica machine is almost complete physically. The Cathode Ray Tube store has been very troublesome to commission, but is now working reasonably reliably. In order to commission the computer independently from the three CRTs, we have provided semiconductor-technology dummy stores which can be switched in in place of the authentic stores. Using these, the team members were successfully running programs on the machine by June.

Several problems with the CRT store have been overcome by careful attention to earthing, screening, noise suppression, and selection of CRTs which have not deteriorated in the intervening years. At a late stage it was learned that at least one 12 inch tube was in use in mid-1948, and fortunately we have been able to acquire two. A personal computer interfaced to the store subsystems has made testing less laborious than it was in 1947/48. The main store was made reliable enough by late September that we were able to run programs for nearly an hour using all three CRTs. However, much more work remains to be done to make this performance consistent and reliably demonstrable by the target date of 21 June 1998.

Media interest has increased during the year, with TV, radio and newspaper crews ever hovering. Major planning for the celebrations next June is being coordinated by Manchester University — details can be seen at http://www.cs.man.ac.uk/mark1. During September, there was a live worldwide web broadcast (a "webcast") of the lecture about the rebuild, on location in front of the machine. Anyone with a suitably high performance PC and modem can see and hear the lecture by browsing to http://www.dslabs.co.uk/computer50.

Letters to the Editor

Dear Editor,

A chance remark at a CCS meeting about it taking three weeks to change a program on the Eniac led me to investigate what Hartree did with it.

His article in *Nature* in 1946 mentioned the use of Eniac to solve three simultaneous non-linear ordinary differential equations with awkward two-point boundary conditions, but it was not until 1948 that a full description appeared in "The Laminar Boundary Layer in Compressible Flow" by WF Cope and DR Hartree FRS in *Phil. Trans. Roy. Soc.* 241, pp1-69.

There are really two kinds of set-up time — to create the wiring connections from a given problem, and to change over from one problem to another.

I could find no mention of either kind of program set-up time, but am sure that it was far less than I needed to convert it first to Pascal and then to run on Martin Campbell-Kelly's Edsac simulator.

To my surprise it occupied over 80% of Edsac's store of 1K instructions and ran 15 times slower than on Eniac. I suppose this is in keeping with the view of Eniac as a network of 20 processors having only one storage location each, and hence being able to do quite a lot of logic on problems with small amounts of data.

Yours sincerely,

Don Hunter
Elmdon
26 July 1997

Editorial fax number

Readers wishing to contact the Editor may do so by fax, on 0181-715 0484.

FTP, Web and E-mail Addresses

The Society has its own World Wide Web (WWW) site: it is located at **http://www.cs.man.ac.uk/CCS/**. This is in addition to the FTP site at **ftp.cs.man.ac.uk/pub/CCS-Archive**. The pages of information at our Web site include information about the SSEM rebuild project as well as selected papers from *Resurrection*. Full access to the FTP archive is also available for downloading files, including the current and all past issues of *Resurrection* and simulators for historic machines.

Many readers will also be interested in WWW sites run by other bodies concerned with the history of information technology. The Universal Resource Locators for a few of these organisations are as follows:

Bletchley Park (contains information on Colossus)
http://www.cranfield.ac.uk/CCC/BPark/
Manchester University (for its early computers)
http://www.cs.man.ac.uk/mark1/
Science Museum
http://www.nmsi.ac.uk/
National Archive for the History of Computing
http://www.man.ac.uk/Science_Engineering/CHSTM/nahc.htm
The Virtual Museum of Computing (a rich source of links to other computer history resources)
http://www.comlab.ox.ac.uk/archive/other/museums/computing.html

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Forthcoming Events

8-9 November 1997, and fortnightly thereafter Guided tours and exhibition at Bletchley Park, price £3.00, or £2.00 for concessions

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

4 November 1997 North West Group meeting

"The Development of Computer Graphics" by R Hubble

6 November 1997 London afternoon seminar

"Early History of the UK Software Industry"

4 December 1997 London afternoon seminar

"History of the National Computing Centre"

10 February 1998 North West Group meeting

"The Argus Computer and Process Control" by M Gribble

24 May 1998 North West Group meeting

"Computing in Russia" by Doron Swade

The London afternoon seminars will take place at the Science Museum, starting at 1400 hours. The North West Group November meeting will take place in the Manchester University Computer Department Lecture Theatre, starting at 1830 hours: the 1998 meetings will take place in the Conference room at the Manchester Museum of Science and Industry, starting at the earlier time of 1730 hours.

Queries about the autumn London meetings should be addressed to George Davis on 0181 681 7784, and about Manchester meetings to William Gunn on 01663 764997.

Resurrection is the bulletin of the Computer Conservation Society and is distributed free to members. Additional copies are £3.00 each, or £10.00 for a subscription covering four issues.

Editor – Nicholas Enticknap
Typesetting – Nicholas Enticknap
Typesetting design – Adrian Johnstone
Cover design – Tony Sale
Printed by the British Computer Society

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