Computer Conservation Society

Aims and objectives

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

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

The aims of the CCS are to

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

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

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

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

Resurrection

The Bulletin of the Computer Conservation Society

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Generous BCS Support for Bombe Rebuild Project

Ernest Morris, Chairman

CCS members will be familiar with the good progress of the Bombe rebuild from the regular reports in *Resurrection* by John Harper, the project manager. It is now physically evident that a great deal has been accomplished, aided throughout by many willing volunteers to whom the CCS is particularly grateful. There has also been financial and practical help from commercial organisations without which the project would have been very difficult.

The electrical work which is now well under way is by no means trivial — the number of parts and connections is, for a layman like me, mind-boggling. It is also expensive, and so the CCS is especially grateful to the British Computer Society for awarding us, out of its Specialist Groups Development Fund, £20,000 to finance the work to be done this year and next. I see in this significant award not only welcome financial support but also a recognition by the institution of which we are a part of the importance of the rebuild of the Bombe as a tribute to the people who worked on and operated the originals (some of whom visit the site occasionally to see and advise) and as a stimulus to the present generation of IT professionals to appreciate the achievements of the pioneers and those who are interpreting and recreating their innovations.

Editor's note: a full report by John Harper on the latest progress of the Bombe Rebuild Project starts on page 7.

AGM

This year's Annual General Meeting will be held on Thursday 29 May in the Director's Suite of the London Science Museum at 1430, and will be followed by a seminar on "Our Computer Heritage" (see Simon Lavington's report on page 7).

News Round-Up

One of the duties facing members who come to the AGM will be the election of a new chairman for the Society, as Ernest Morris has decided to stand down after three energetic years in office. Ernest is to propose Roger Johnson, the Society's first Treasurer, as his replacement.

- 101010101 -

It is with great regret that we announce Doron Swade will no longer be the Science Museum's representative on the Society's Committee, following his retirement from the Science Museum in January. Doron was one of the key figures behind the formation of the Society back in 1989, and has been an inspirational figure for all of us ever since. Happily, the Committee has been able to persuade him to continue his membership of the Committee in his own right.

- 101010101 -

The Science Museum has nominated Xerxes Mazda as Doron's replacement. Dr Mazda was appointed Manager of Collections Access at the Museum in February, with responsibility for strategic direction of the way the Society manages its collection of computing artefacts; for running Blythe House; and for ensuring visitors see more of the collections in more and different ways.

- 101010101 -

George Davis has been nominated to represent the Society in selecting speakers for future JMM Pinkerton Memorial Lectures.

- 101010101 -

Many thanks to those readers who responded to our request for help in converting the electronic form of *Resurrection* from LaTeX to Word format. As a result of a brainstorming session considering all the options suggested, we have had a change of heart, and decided it would be easier and more useful to make past issues available in the more widespread PDF (Portable Document Format) format.

- 101010101 -

Since then, Chris Burton has been doing sterling work converting past issues of *Resurrection* into PDF format. This will allow members wishing to consult past issues to do so without needing to have Microsoft products installed, accessing them by using instead the Adobe Acrobat reader, which is available for free download from the Web at <www.adobe.com>. Issues 4 to 29 are now available in the new format on the Society's FTP site, excluding issues 9, 12 and 24 which have pictures and therefore require additional work. See page 12 for access details.

- 101010101 -

Which computer first had timesharing as an operational feature? This question produced a lively debate at the Society's Ferranti Orion seminar in February. The presenters at the seminar argued for Orion; seminar organiser George Davis claimed that English Electric was working on the same lines at the same time; voices from the floor were heard proposing both Leo and EMI for the honour. Agreement was reached only on the point that IBM and other US computer companies were lagging well behind. Does anyone have the definitive answer?

- 101010101 -

The huge fire which engulfed the centre of Edinburgh earlier this year has had one calamitous effect for computer historians: it destroyed the library of the Turing Institute.

Birkbeck College is currently undertaking a study of the work of AD Booth from the end of the War until he moved to Canada in 1962. Roger Johnson would like to hear from anyone with any information which could assist this project. He can be contacted at <r.johnson@bcs.org.uk>.

- 101010101 -

A World Conference on the History of Computing in Education will be held in Toulouse, France, on 23-26 August 2004. It will form part of the World Computer Congress of the International Federation for Information Processing (IFIP). The Program Committee is now looking for conference papers, to cover the history of computing as it affects educational developments. Further details from Chair Peter Bollerslev at <peter@bollerslev.com>.

- 101010101 -

The Museum of Computing at Swindon (Mocas) opened in February. Described by organiser Jeremy Holt as a "virtual museum", it has no collection of its own, no staff and no premises. It is designed to display equipment collected by others, with the exhibits changing at regular intervals of two to three months. Mocas has opened to the public with a collection from Bletchley Park, including a replica Enigma. More details at <www.mocas.rl.ac.uk>.

- 101010101 -

Editorial contact details

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

Society Activity

Pegasus Working Party

Len Hewitt

We have been unable to run Pegasus since late December because of cooling problems. The refrigerant used in the cooling system has leaked away and poor old Pegasus gets too hot with its closed cooling system. We could remove the hood and air cool it, but I doubt the museum would like the aesthetics of that. Unfortunately there does not seem to be any money in the Museum's budget to cover this problem. The Museum is anxious to get Pegasus up and running as there has been a lot of interest shown with the surge in numbers of visitors since admission charges were dropped.

The fortnightly meetings of the Working Party have continued, led in my absence by Peter Holland. The Working Party members have used the PC simulator for program debugging, and have answered queries from the general public about the machine. It is amazing how many people can claim some association with a Pegasus!

Contact: <leonard.hewitt@ntlworld.com>.

DEC Working Party

Kevin Murrell

National Air Traffic Control Services has kindly donated a PDP-11/44 processor with a pair of RL02 drives. After some head scratching and effort, this is now working, and is being used to run a very early version of Unix. At some stage we would like to produce a display showing the progress of the Unix operating system from machines like this up to the latest Linux systems.

Air Traffic Control uses PDP-11 processors for managing radar data and presenting flight approach information to air traffic controllers. When this system is finally retired, in 2004, we will receive a complete working ATC station. The intention is simulate the radar data feed and produce an exciting simulation of a real air traffic control. Nice to know it has taken until now to find a modern system to replace the DEC hardware installed in (I believe) the late seventies.

We have received a yellowing teletype roll showing the log-in procedure on the Arpanet system in 1971 and the log-in to one of the BBN PDP-10 machines. Any advice on copying this very long roll of faded print would

be welcome.
Contact: <kevin@ps8.co.uk>.

Preservation Policy Working Party

Simon Lavington

There has been modest progress on the Computer Conservation Society's project "Auditing Archival Collections". A consortium of partners from the museums, etc has been assembled, with the intention of applying for a grant from a body such as the Heritage Lottery Fund (HLF). A case for support is being drawn up, under a working title which reflects the HLF's preference for activities which (in their words) "make sure that everyone can learn about, have access to and enjoy their heritage". The heritage in question concerns all computers designed and built in Britain during the period 1945-1970. A new working title for the project is thus: "Our Computer Heritage". There would be plenty of opportunity for CCS members to become fully involved.

The CCS has been in discussion with the British Computer Society, to discover whether the BCS would become the main host site for the development of the multimedia web-accessible database which lies at the heart of the project. Our meetings have been very positive; the BCS believes the project to be important and well worth supporting. We are now actively exploring appropriate ways of implementation, with a view to the BCS taking the lead in a bid to the Heritage Lottery Fund for financial assistance.

As I write, the next joint BCS/CCS meeting is on 20 March. Meanwhile, a sub-group is to have discussions with a HLF representative on 12 March. It is certainly hoped to have some definite progress to reveal at the CCS AGM in May.
Contact: <lavis@essex.ac.uk>.

Bombe Rebuild Project

John Harper

The really important news for this issue of *Resurrection* is the grant the BCS has made to our project, as reported on page 2. This has meant that two years extra activity has been funded. This is not quite enough for us to complete the rebuild, but it will take us very close.

The electrical phase of our rebuild is now in full swing. Almost all of the internal cableforms are complete and many have been fitted to the machine. In terms of cableforms and wiring this leaves us to complete just the flexible cables that the WRNS used to plug up menus, and the wiring at the back of each Letchworth Enigma. The former are waiting for mouldings, and these are due shortly. Enigma wiring by contrast will be a long job. There are 36 of these Letchworth Enigmas, and each has over 400 connections. In total around 15,000 soldered connections have to be made.

A vital part of these Enigmas are the three commutators. We are all very pleased to see our first one complete. Now a small team is moulding these in small batches. We need well over a hundred in total, so we expect the work to be spread over many months. However the rate of production is expected to keep up with Enigma assembly, so this is not a problem.

Volume drum assembly will soon be under way. Most parts are now in our hands. All turned brass items have been manufactured commercially. These, together with such things as very small grub screws, have been purchased as batches of 21,000 items. These all have to be assembled. The only remaining major item to sort out is brush manufacture. This will be a very labour-intensive operation. To give some idea, there are 19 strands of 8 thou piano wire in each brush and there are about 21,000 brushes involved. Any day now we expect delivery of 400,000 inches of this special wire, which had to be specially drawn.

We expect drum manufacture and assembly to continue at least until we have the machine working. However this is not a real problem because we can demonstrate live operation with only about a quarter of our drums complete. We hope to ramp up this assembly during the summer, at which time we could do with more help. We envisage making available kits of parts complete with instructions for assembly at home. No special tools are required, but it will need nimble fingers. As was found during WWII, ladies are best at this sort of work, which is much like needlework. If you are able to help please let us know.

This is by no means the complete list of what has been achieved since our last report. For example relay coil winding is making very good progress and we have all Tufnol parts cut to shape and drilled. Tufnol items are used on both the front and the swing gate. In this latter case they provide the horizontal supports for the relays, resistors and similar items. All 228 jacks together with their associated wiring will shortly be mounted on the rear of the machine. This will include for example the

three diagonal boards. This will complete this part of the machine and will represent fully what the WRNS were presented with before they plugged up a menu.

Those who are interested in seeing more of what has been achieved are welcome to visit <www.jharper.demon.co.uk/bombe1.htm>.
Contact: <bombe@jharper.demon.co.uk>.

Bletchley Park Computer Museum

Michelle Collier-Moore

The Computer Museum reopened to the public on 1 February following a six week break. The closure was put to good use as we had some refurbishment to do and we also took the opportunity to rearrange the exhibits. Carpets were cleaned and ceiling tiles repaired—jobs that we had been wanting to do for a while.

At the start of 2002 we had arranged the collection as a time line but this proved difficult to get right, primarily due to the size of some of the computers. Some things can't be moved (for example the 803) so everything else has to fit around it. Also, it's not a good idea to put a DEC PDP-11 in the middle of the room. We decided this approach couldn't work in such a small space so we resolved to find a different way to display the collection.

We settled on themes based upon the common use of the machines but with DEC and Apple having their own areas, as they form a large part of the total collection. The themes chosen were Education, Home and Business.

The Education collection includes the Commodore Pet and the BBC. The Home collection show examples of popular machines including the Sinclair ZX80, ZX81, QL and Spectrum. Business machines are more diverse with desktop computers such as the TeleVideo, various minicomputers and the DEC collection.

The new layout also means that there is much more floor space and easier wheelchair access. The themes seem to make more sense to the visitors. Individual cards describing each machine give dates and basic information.

We also have two Web cameras uploading pictures to our Web site (<www.retrobeep.com>) every 60 seconds and we aim to have as many machines as possible connected to our network and the Internet. We have

an Apple SE/30 connected where visitors are amazed to browse Google on a 10 inch black and white screen. Unfortunately the browser cannot handle the vast majority of today's Web sites.
Contact: <michellecolliermoore@hotmail.com>.

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CCS Collection Policy

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

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

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 12.

DAP snippets

Brian M Russell

We went down to Reading to pick up a third Perq-2. However, it turned out to be a Perq-1. Nevertheless, hoping that it had some useful software on its disc, we cleaned it up and powered it on. Eventually its 'Rigid Disc' clattered into life for the first time in 14 years: the boot process went smoothly and... we were presented with a request for a password!

To replace the missing Array Board, we have now acquired two spares. One had been drilled, nailed and glued to a display board! This we have cleaned up and fitted to the Mil-DAP. Unfortunately, the new board is fitted with 64K RAMs whereas the other seven boards have 16K RAMs. They might be compatible; the boards were designed with the upgrade in mind.

The second spare board, like the third Perq, came from Cambridge Parallel Processing. CPP (originally Active Memory Technology, or AMT) is the spin-off company that took the DAP design into production. We have heard that DAPs are still being produced and are still being used. If you find yourself driving down the motorway behind a yellow van that is sticking determinedly to the left or second lane, that van is one of two that contain DAPs. They are looking for cracks in the road and analysing the data in real time at 70 miles an hour!

Contact: <bmrussell@iee.org>.

CCS Web Site Information

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

British Computer Corporation — a 1956 Venture

Hugh McGregor Ross

Normally we only read of success stories. This article recounts an early computer project that failed, or more strictly failed to take off. It is based on the original document in John Coales' own handwriting, which was in my collection and has now been donated to the IEE Archives. Its date must be July 1956[1], and it gives much information about computing then. With all the chief players, and even their wives, now dead, there is a certain added interest in trying to resurrect the story. Here it is.

After World War II the Admiralty decided to set up a research laboratory to develop new technologies. They appointed John F Coales as its director, and put it under Elliott Brothers (London) Ltd, a company with a long record of making fine electrical instruments and, during the war, complex control systems for torpedoes. Coales appointed WS (Bill) Elliott to head the computing department, which was largely using hand calculators.

Elliott soon developed an interest in using digital techniques instead of the prevailing analogue electronic methods [2] which led to his Nicholas and Elliott 401 computers. When Coales had to leave the Laboratory he went to Cambridge, and was soon appointed a Professor in the Engineering School. Bill Elliott followed him, and a short while later was appointed to the Ferranti Computer Department to set up a London Laboratory. The best-known product of this operation was the Pegasus computer; the Laboratory also handled several military projects and introduced other computer innovations.

Relations between Bill Elliott and Brian Pollard, head of the Ferranti Computer Department, were always strained and gradually grew worse, especially after production of Pegasus in Manchester got under way. In furthering his researches Elliott several times visited America, and on one of his transatlantic flights had long conversations with Arthur Samuel,

[1]Establishing the date of this paper shows how small clues have to be followed up. The paper itself is not dated (that is surprising), but a note has been added reading "By JF Coales sometime in 1956, JFC Nov 195?". The paper refers to actual sales up to June. Ian Merry recalls that during July Ferranti gave him a pay rise of £70 to £1470, and that on 10 August he telephoned Bill Elliott — who had just returned from America where he must have been authorised to set up his Laboratory — to be offered a post in IBM, at a salary of £2000. Therefore the paper must have been written in July.

[2]At that time I, assisted by George Felton, was developing in the adjacent laboratory an analogue computer for real time analysis of data from guided weapons trials. Because I soon left for Ferranti it was never written up.

then in a very senior position in IBM. Soon Elliott was approached to set up a new IBM research laboratory in England.

Because of the high mutual regard Coales and Elliott had for each other, it seems clear that Elliott must have sought Coales' advice, and that Coales must have been alarmed at the prospect of a man he regarded as one of Britain's most brilliant computer engineers going off to serve the Americans. Obviously it would have strengthened the American position and weakened the British. Although he was in academia, not industry, Coales' response was to conceive and propose the setting up of a British Computer Corporation, which would secure Elliott by making him the Research Director. This post must have included at least a watching brief over production, which Elliott regarded as very important.

Such a proposal had to be based on an assessment of the potential computer market, about which at that time very little was known. For this Coales must have approached Bernard Swann, sales manager for Ferranti Computers, who shared his views. I did not know of this approach (but see later); the whole thing was done in secrecy [3]. The outcome was the document I have typed out below. This was given to me by Swann a few years before he died (because he and I had kept in close touch with each other over the intervening years and he knew of my interest in the history of British computing).

At that time there was no venture capital available for computers (what a contrast to the Internet Bubble!). The National Research Development Corporation had supported the Elliott 401 and Pegasus computer work, but its remit was to loan capital for the exploitation of Government research, not to fund new ventures. Therefore all Coales could do was ask a senior civil servant (I cannot remember his name) to investigate the possibilities of other sources of Government capital.

After Elliott left IBM he and I maintained close contact, as both working colleagues and friends. Bill himself told me the next stage of the story, shortly before he died. When Coales, Swann and Elliott were satisfied with the draft Proposal, Coales held a dinner for the three of them at which Elliott was to be offered the position of Research Director. All was going well until Coales was called to the telephone. He returned to announce that the civil servant had been unable to find any source of Government or other capital. Elliott told me, "I had to think of my housekeeping bills, so I had to turn the proposal down".

[3] Professor Maurice Wilkes has recently confirmed that this scheme was never mentioned to him, although he is named as one of the proposed Directors.

Proposals for
The British Computer Corporation

Authorised Capital £10,000,000
Issued Capital £5,000,000

Board of Directors

Chairman:- Sir Alan Saunders (other possibilities Mr Robson of ABE Mr Sutherland of Marconis)
Sir Alan Hartley
Sir Ben Lockspeiser
Dr MV Wilkes
Managing Director — *Dr Alexander King of DSIR*
Research Director — *WS Elliott*
Commercial Director and Sales — *BB Swann*

1. Recommend a bid to be made to Sir Vincent Ferranti to take over the London Computing Laboratory and Sales organisation together with the whole of the Pegasus business. Since this business is at present worth about £2m (order book standing at £900,000), presumably a takeover bid of about £500,000 should be attractive.

2. Programme

2.1 (a) The first two to three years effort should be mainly directed to the development of a transistorised, miniaturised high-speed machine with a very large store and multiple input facilities capable of on-demand working as required for business purposes.

(b) A Sales organisation such as exists at Ferranti (about six senior engineers and 12 others) should be set up to investigate the problems of potential customers and set up programmes of well established problems.

2.2 If Pegasus were taken over from Ferranti, the parts would be bought out finished from Ferranti, Plessey etc and only a purchasing and assembly organisation would have to be provided.

3. Staff and Space Requirements:-

3.1 Research and Development —

If the Ferranti team can be taken over intact, this is at present about 60 qualified engineers and 50 other ranks, at an annual expenditure of about £250,000 pa. In order to compete fully with IBM this will need to be built up over the next three years to about 200 qualified engineers and 200 other ranks at an annual cost of about £800,000 pa. This will require about 60,000 square feet of floor space.

3.2 Sales organisation

The present Ferranti sales organisation consists of a Sales manager, five seniors and 12 junior engineers. This should be retained and gradually increased to a total annual expenditure of about £250,000 pa. Floor required would be about 12,000 sq ft.

3.3 Manufacturing organisation

For the assembly of 10 Pegasus machines in the first year about 10 qualified engineers and 30 workmen would be required, in a floor area of less than 10,000 sq ft. By the fourth year the number to be assembled should be 50 requiring about 130 men and 30,000 sq ft. See Tables 1 and 2 [at end of paper].

3.4 The aim would be to complete 10 Pegasus in the first year at a value of about £400,000, which would produce a profit of about £50,000. The value of work in progress should not exceed £150,000 in the first year but might gradually rise to £500,000, this being one third of the expected cost of manufacture in the fourth year.

The aim should be to deliver 20 Pegasus in the second year, 30 in the third and 50 in the fourth. In the fourth year work should be beginning on part of a more advanced machine but it is not expected that deliveries of the next machine could begin until 1961 or 1962.

Prospects

In 1955-56 Ferranti obtained orders to a value of £900,000 and in the three months April-June 1956 to a value of nearly £500,000. The Sales manager believes he could get orders for £3,000,000 in 1956-57 and the rate could quite easily go over £5,000,000 per annum.

An investigation of the possible market indicates total sales of at least £100,000,000 which, bearing in mind that there are 2,000,000 clerks in Britain costing about £1000m per annum, appears to be a very conservative figure. This type of equipment is replaced about every five years so

this indicates a domestic business of at least £20m per annum. To this can certainly be added an equal export business if we push ahead with a forceful development programme as provided for in the figures given above.

It is believed that industry will not be really ready for business machines in quantity for about five years and we should therefore aim at an expanding business eventually reaching a total of about £50,000,000 pa of which half might be handled by the British Computer Corporation. An increase of output of much more than 30% per annum is almost certainly impossible and it is most unlikely that growth could be more rapid than given in the attached Table 1, which envisages an annual output of £10,000,000 in 1965-66. If this were achieved the inevitable deficit of the early years would turn to a profit in the 5th or 6th year.

It is believed that both BTM and Powers-Samas are worried about the situation and are probably short of money for financing rentals. It may be for this reason that they cannot put much effort into research and development. For this reason they might welcome such a scheme and be prepared to cooperate. They might like to do some of the manufacture to BCC designs but Plessey is probably the best firm for manufacture and could also be used to assemble complete Pegasus computers.

It is suggested that the best method of operation of the BCC would be for it to be responsible for the design and manufacture of computing equipment in collaboration with BTM and Powers-Samas. It might then sell equipment to BTM and Powers-Samas for them to rent to their customers. In this way the best possible use would be made of the Business Machine Companies' selling organisations and the BCC would not be in competition with them. This might result in some saving of expenditure on BCC's selling organisation.

Capital Required

The attached table shows the build up of the capital required on the basis of overestimating, rather than underestimating, the requirements for research and development and Sales organisation. No doubt some saving could be made but it is cheeseparing which has brought us to our present predicament so it has been thought best to err on the extravagant side rather than the reverse. In any case it is still only a small fraction of IBM's available effort. On the sales and manufacturing side conservative estimates have been given and higher prices might well be charged since £40,000 for Pegasus compares very favourably with IBM. This could reduce the deficit in the early years very considerably.

It has been assumed throughout that all premises are rented. If new building was necessary this would probably cost about £6 per square foot requiring an additional £600,000 capital expenditure during the first five years.

TABLE 1

	No of M/Cs produced	*Sales Receipts £*	*BO Parts £*	*BCC Assembly etc*	*Profits £*	*R&D and Sales Exp £*
1956-57	*10*	*400,000*	*275,000*	*75,000*	*50,000*	*325,000*
1957-58	*20*	*800,000*	*550,000*	*110,000*	*140,000*	*500,000*
1958-59	*30*	*1,200,000*	*750,000*	*150,000*	*300,000*	*750,000*
1959-60	*50*	*2,000,000*	*1,250,000*	*250,000*	*500,000*	*1,000,000*
1960-61	*	*3,000,000*		*2,000,000*	*1,000,000*	*1,000,000*
1961-62	*	*4,000,000*			*1,330,000*	*1,000,000*
1962-63	*	*6,000,000*			*1,500,000*	*1,000,000*
1963-64	*	*8,000,000*		*and so on*		
1964-65	*	*10,000,000*				

** New equipment coming in*

	Profit or Loss £	*Capital Expenditure Plant etc*	*Work in Progress £*	*Total new Capital £*	*Interest at 5% £*	*Total Capital employed £*
56-57	−257,000	*100,000*	*150,000*	*525,000*	*15,000*	*540,000*
57-58	−360,000	*100,000*	*300,000*	*610,000*	*40,000*	*1,190,000*
58-59	−450,000	*100,000*	*400,000*	*650,000*	*80,000*	*1,920,000*
59-60	−500,000	*50,000*	*500,000*	*650,000*	*120,000*	*2,690,000*
60-61	—	*50,000*	*750,000*	*300,000*	*140,000*	*3,130,000*
61-62	+330,000	*100,000*	*1,000,000*	*350,000*	—	*3,480,000*
62-63	+500,000	*100,000*	*1,500,000*	*600,000*	—	*4,080,000*
			and so on			

TABLE 2: SPACE REQUIREMENTS

Year	*Research and Development*		*Sales Organisation*		*Manufacturing*		*Total*	
	Staff	*Space*	*Staff*	*Space*	*Staff*	*Space*	*Staff*	*Space*
1956-57	*60+ 50*	*20,000*	*30*	*5,000*	*40*	*10,000*	*180*	*35,000*
1957-58	*100+100*	*30,000*	*40*	*5,000*	*60*	*10,000*	*300*	*45,000*
1958-59	*150+160*	*45,000*	*60*	*8,000*	*80*	*15,000*	*440*	*68,888*
1959-60	*200+200*	*60,000*	*80*	*10,000*	*130*	*20,000*	*610*	*90,000*
1960-61	*400*	*60,000*	*100*	*12,000*	*200*	*30,000*	*700*	*102,000*
				and so on				

Studying this document, and with the benefit of much hindsight, there are several points of interest, quite apart from the fact that as a contemporary document it not only gives many facts and figures not otherwise available, but it also captures much of the expectations of the time.

It seems that in 1956 the value of the pound was 20 or even 30 times what it is today. This would make the price of a Pegasus equivalent to about one million present day pounds.

It is doubtful whether Coales had sought the agreement to serve of the proposed chairman and directors. But the document indicates their standing at the time.

We now know that work on transistorised circuits was being done in Bill Elliott's Laboratory from 1954, initially for military projects. So the programme of work proposed in paragraph 2.1 was not far-fetched. It is also interesting that it included a computer with "a very large store", "multiple input facilities", "on-demand working" and "for business purposes". Could it be that because this project failed, UK computers had to wait a decade for these qualities?

The document proposes an early example of what we now call "outsourcing" for computer elements. An added twist to the story derives from my finding in my pocket diary three entries:

- 19 June 1956: 'To Plessey with Swann'
- 16 July 1956: 'Plessey people here' (ie to see Pegasus at the Portland Place Computer Centre)
- 19 September 1956: 'Pickering Plessey'

I cannot scrape up from my memory anything about the first and third of these entries. Swann did recognise that I had perhaps more knowledge of electronic and mechanical engineering than others in his team, so he may have asked me to vet Plessey's capabilities in those areas. I do have a very faint recollection that when the Plessey men, and they were primarily engineers, not potential customers for Pegasus, came to see the machine it was to form a view on its engineering quality. Because of the close relations between Pegasus sales staff and its engineers who often helped us with customers' visits, it was easy for me to promote a relevant discussion.

However, what this implies is that as early as June (and my diary notes on 26 March 1956: 'noon Pegasus handed over to Users', ie it first became sufficiently reliable for us to be able to bring in potential customers) either

Coales or Swann, or both, were aware of the problems arising about production in the Manchester factory. Certainly the initiative to investigate outsourcing would not have come from that factory. But Swann being an archetypal Whitehall civil servant was very good at devising techniques to bypass troubles. I would actively have shared this approach, but nevertheless he managed to conceal from me anything about Coales' BCC concept.

In his work during the War and while at his Laboratory, and from contacts in the Engineering School at Cambridge University, Coales must have seen some projects go through to industrial production, so may have had some knowledge of the costs of production and the overheads to be applied. Further, the overheads question had been a major bone of contention in the early production of Pegasus, so Elliott informed himself about the subject, even if his ideas were extreme. He several times spoke with me about this at the time, and I have an entry in my diary for 26 July 1956 reading 'Meeting with costing people'. It is probable therefore that the overheads inherent in the figures in the Proposal for both the bought-in items and their assembly were not wildly out.

I think we must assume that all the figures for the manpower and for sales were related to Pegasus and a transistorised and highly enhanced successor. At that time development effort in the Manchester Ferranti group concentrated on Mercury, building on innovations from FC Williams' University team. We have a record that to begin with Swann considered only four Mercurys might be sold — for the nuclear industry was so secretive that we were not aware of their potential interest, and they helped to swell the total to 18. Nor should we assume that Mercury development and business would interest Elliott much.

In section 3.1 the numbers of staff quoted must have referred to Bill Elliott's London Laboratory: we even have a photograph of 102 of them taken at that time. It is doubtful whether Elliott or Swann would have thought it practical to take over the Manchester staff working on Pegasus. Further, we might laugh at the phrase "In order to compete fully with IBM", even if it did refer only to R&D. But it was the case that even six years later some of us in Ferranti did not regard IBM as a competent *computer* company, whatever its other merits (it was before the System 360 broke on the scene).

Study of section 3.2 and the seventh column of Table 1 suggests that Swann's idea for sales expenditure was of the order of only 3% of turnover. This reflects the contemporary Ferranti 5% figure, based on other prod-

ucts, which turned out to be inapplicable to computers — something near 20% at least was found to be needed.

We have to remember that when Pegasus started, with Elliott convinced that it could be produced in quantity, it began with an order from NRDC for 10 machines (not really an order, they merely underwrote it and required to be paid back). By the time of Coales' Proposal orders for Pegasus were being won, and it must have been this that gave Swann confidence to suggest the relatively substantial figures he gave.

While Pegasus became fully operational in March 1956, we had been selling it 'from the drawing board' (the usual practice then) for at least the previous 20 months. The statement by Swann that in the following quarter sales were £500,000 implies about eight Pegasus computers (with extras). Although it has not been possible to find (from records or from my colleagues) confirmation of that sudden flush of orders, I do recall we were having to extend the quoted delivery times. It may have been the first computer example of sales suddenly taking off. It placed a great stress on production, which led to a ban on selling. Without that ban, Swann asserted in later years, the total of 40 Pegasus sales would have doubled. So the total in the Proposal of 110 is not too wide of the mark.

The Proposal correctly suggests that commercial (data processing) usage would not become established until the early 1960s. There is also an interesting discussion about cooperation with Powers-Samas and BTM, which almost certainly reflects Swann's views at the time. But we did not recognise then that their cooperation would be influenced by the very negative effect of computers on their business of making punched card machines and selling cards.

Admittedly the Proposal contains the sentence "A Sales organisation such as exists at Ferranti ... should be set up to investigate problems of potential customers and set up programmes of well established problems" (which we would now phrase 'set up and establish applications programs'). However, above all, the Proposal does not recognise the cost of software support and the training of customers' programmers needed for any computer business — for the simple reason that it was a lesson we still had to learn, the very hard way.

Whatever we might now feel about its apparent naivety, there is no doubt that it was a much more fully worked out business plan than anyone in Ferranti Computers was accustomed to.

Edsger Dijkstra remembered

Brian Shearing

On a rain-swept blustery Thursday evening in November 2002, a singular event took place at the offices of Sun Microsystems in the City of London. Friends, associates and admirers gathered to pay tribute to Edsger Wybe Dijkstra, the great Dutch computer scientist, who died in Nuenen in the Netherlands on 6 August.

The meeting was organised by the Advanced Programming Specialist Group of the British Computer Society, with help from the Society and from the Computer Conservation Society. The occasion was made the more special by the presence of Mrs Maria Dijkstra-Debets, who was Guest of Honour. In his closing remarks Professor John Florentin, Chairman of the Advanced Programming Group, described the meeting as the most moving BCS event he had attended.

The tribute started with a talk entitled 'From Algol 60 to Software Engineering' by Professor Brian Randell, Emeritus Professor of Computing Science and Senior Research Investigator at the University of Newcastle, given "as a way of marking my debt of gratitude to Edsger".

Brian related how a lecture by Edsger in England about Algol 60 compilation led to Brian spending a week in Amsterdam discussing the Algol compiler that he and LJ Russell were building for the KDF9 computer manufactured by the English Electric Company. Meetings were intensive, each morning and afternoon. But at lunchtimes there was always a break. Edsger claimed that the effort of talking English for a full day was more than anyone could reasonably be expected to make. Brian summarised this first working week with Edsger as "undoubtedly the most important week in my professional life".

Randell and Russell asked Edsger for advice before writing their book *Algol 60 Implementation* (Academic Press, 1964). Edsger suggested that just describing design decisions was not enough. What was interesting was to describe the alternatives considered, to describe why each choice of alternatives was made, and to assess in retrospect how each decision turned out. Brian reported that he has passed this advice to every one of his students ever since.

Brian described how the 'gang of seven' which included Edsger and himself, and later became a gang of eight, came to prepare and sign the minority report that appeared in the first editions of the Algol 68 Report

and which starts with the words: "We regard the current Report on Algorithmic Language Algol 68 as the fruit of an effort to apply a methodology for language definition to a newly designed programming language. We regard the effort as an experiment and professional honesty compels us to state that in our considered opinion we judge the experiment to be a failure in both respects."

One view expressed by some of the signatories during the preparation of the minority report, though not included in the final text, was the suggestion that Simula 67 had more in the way of good ideas than Algol 68. There is an echo of this sentiment in the final technical sentence, which reads: "This forces upon us the conclusion that, regarded as a programming tool, the language must be regarded as obsolete".

Brian told many tales of shared laughter as well as work, including the description by his daughter of Edsger as "the man who drinks beer and milk together, and lies on the floor."

Brian then introduced a short clip from a video of a lecture given by Edsger at the University of Newcastle on 10 September 1992, in which Edsger talks of the early awakenings of his interest in mathematics and its beauty. His mother, Brechtje Kluyver, was a mathematician and Dijkstra recalls a childhood bath time when he became fascinated with trying to calculate what proportions a piece of paper had to have if its folded shape retained the proportions. His first guess of 1·5 did not work, but his mother showed him that simply writing down the wrong equation '$1{\cdot}5 \times 1{\cdot}5 = 2$' was a basis for discovering the right solution.

The video was followed by a second, introduced by Sir Tony Hoare, Emeritus Professor of Oxford University and Senior Researcher at Microsoft Research, Cambridge. It covered much of Edsger's time in Texas, following his acceptance in 1984 of the Schlumberger Centennial Chair in Computing Science at the University of Texas at Austin. The video included shots of the Volkswagen bus in which he and Maria enjoyed visiting US national parks, and which he dubbed the Touring Machine.

Pithy observations on computers and programming in the video were complemented by a selection of Edsger's noteworthy remarks reprinted in a beautifully produced booklet that each attendee of the evening's tribute received. The booklet was prepared by Martin Campbell-Kelly, with help from the BCS publication department.

The videos were followed by a contribution by Mike Woodger, now retired from the National Physical Laboratory. He told how he had first

met Edsger in 1959 in Copenhagen, of further encounters in Amsterdam, Rome, Munich, and Oslo, and of being a member of the Algol 68 gang of eight. He concluded with a story of Edsger's thoughtfulness. Mike was struggling to draft a paper late one night at a hotel in Oslo. Edsger was returning from a late night walk when he noticed the one room with a light still on. He deduced whose light it was and why it was still burning. He climbed the stairs, knocked on Mike's door, and offered to help.

Brian Shearing spoke next, emphasising that Edsger's designs were not only elegant, educational, and inspirational but also of immense utility to practising programmers.

He cited Edsger's standard classroom example of an algorithm for calculating an integral square root, which has been faster than standard library routines for a quarter of a century, only being overtaken by the latest floating-point hardware. He also mentioned Dijkstra's zip-fastener algorithm, first introduced for mapping two-dimensional arrays onto secondary storage in early Algol compilers, but of increasing relevance when manipulating large images in today's paged, cached main memories.

He concluded with an anecdote of a lively but good-natured exchange between Edsger and Niklaus Wirth at a conference in Zurich in 1994, at which Niklaus complained of the 'little bit of magic' that seemed present in every one of Edsger's designs, and how difficult he found teaching students to get rabbits out of hats. Edsger's response was to bellow "No rabbits! No hats!" and to suggest that Niklaus teach his students to think before he taught them to program. This is an echo of a paper written by Edsger in 1975 entitled *On the teaching of programming, ie on the teaching of thinking* (EWD473).

The evening concluded with Tony Hoare, another member of the gang of eight, presenting a small sample of the many contributions Edsger made to computer programming. Tony considered only one year, running from June 1974 to June 1975, and selected just five of the 70 papers Edsger wrote during that time. (By coincidence, the paper cited in the previous paragraph came from the same year.)

EWD418 is entitled *Guarded commands, non-determinacy and a calculus for the derivation of programs.* Edsger reported how in a single night "all the pieces fell into place" and how the ACM insisted he drop the word 'calculus' from the title. This was the paper that led to the book *A Discipline of Programming* (Prentice-Hall 1976).

EWD426 is entitled *Self-stabilizing systems in spite of distributed con-*

trol and shows how a system can recover once errors have occurred and have propagated in a manner that might appear to leave the mechanism irrecoverably broken. It led to a whole subculture of computing science, and an ACM award that Edsger appreciated particularly.

EWD464 is *A new elephant built from mosquitoes humming in harmony* and launched the class of algorithm subsequently known as systolic, since data passes through the system much like blood through the chambers of the heart. At the time Edsger was a research fellow with Burroughs Computers of Detroit, and some of the elephants became the subject of patent applications.

EWD492 is *On-the-fly garbage collection: an exercise in multiprocessing.* Edsger chose this topic because of the scale of its challenge. The nodes of his solution require no fewer than four 'colours' to discriminate their states. The importance of this contribution to modern garbage-collecting virtual machines and run-time environments would be hard to overestimate.

EWD498 is a reflective piece entitled *How do we tell truths that might hurt?* in which Edsger discusses how we should treat the unpleasant facts that computer science sometimes reveals. Edsger himself never shirked the truth, even though he failed to endear himself to the community of technical programmers by declaring that technical programming is the easiest branch of the discipline, nor to others when declaring Fortran to be an infantile disorder and PL/1 a terminal disease.

Tony concluded by remarking that although Edsger is irreplaceable, his truths live on.

During the meeting John Florentin announced that the Council of the British Computer Society has decided to establish a Charitable Fund to provide educational bursaries for those in post secondary education, renewable for up to three consecutive years, and to provide grants for the disabled to purchase equipment or services in support of a career in IT. The trustees have agreed that a bursary or bursaries be established in honour of Edsger W Dijkstra.

Editor's note: Brian Shearing represented the Advanced Programming Specialist Group of the British Computer Society on the organising committee for the Dijkstra tribute meeting.

Deciphering Ancient Floppy Discs

Kevin Murrell

We volunteers at the Bletchley Park computer museum are often asked if we have bootable discs for computer systems that an enthusiast is trying to repair or resurrect. Sometimes we are presented with a more challenging query.

On one occasion two visitors arrived at the museum with two boxes of 5.25" floppy discs which they suspected had been written on an early 1980s computer system running CP/M. They did not know what machine had been used, and had no technical information about the discs.

Our visitors hoped that the discs contained a database of census returns taken from Hertfordshire in 1851. The data had originally been stored on punched cards, then transferred to a DEC VAX, and finally transferred to floppy disc.

The discs were double sided, double density. Many had sticky labels that referred to file names of files which had apparently been stored on drives B and D. Visibly it could be seen that the discs were soft sectored.

We tried first to read the discs on various CP/M machines we had in the museum. An RML 380Z, an Intel Superbrain, an Osborne II, a Televideo TS803 and a Kaypro II all failed to read the discs.

We did have limited success with an original Osborne I: it listed the directory, but failed to list the data files. That was a help: we could now determine that each disc contained a ***.DES file and a ***.QRY file. The .DES file seemed very small, the .QRY file much larger.

There are two very useful programs available for dealing with CP/M files — *22Disk* and *Anadisk*. *22Disk* can, when provided with a disc layout definition file, be used to copy files from a suitably identified disc. *Anadisk* allows the physical disc tracks and sectors to be examined.

Anadisk reported that the discs had 48 tracks per inch (tpi), that each track contained 16 sectors, and that the sector size was 128 bytes (so disc capacity was 73,728 bytes per side). It also recognised the floppy as a CP/M disc — albeit non-bootable.

I was particularly impressed with *Anadisk*. Consider that I was using a very modern PC with a 96 tpi 5.25" drive. While I started both programs running under Windows XP, I was able to use them from MS-DOS by creating a simple 3.5" boot floppy running MS-DOS 5.0.

Given the likely age of the discs I had expected a big problem: the original disc hardware would probably have used FM (frequency modulation) encoding, whereas all modern systems use MFM (modified FM). Happily with the combination of *Anadisk* and my PC hardware I could read the discs.

Using *Anadisk* I was able to identify that the first three tracks were blank, which I discovered later would have contained CP/M if these were bootable discs. Track 4 contained a directory structure. Thankfully the discs did contain readable ASCII data.

Using the sector view in *Anadisk* we were able to determine the relationship between the physical sequence of sectors around the track and the logical sequence. The sectors were numbered in the sequence 1, 4, 7, 10, 13, 16, 3, 6, 9, 12, 15, 2, 5, 8, 11, 14. The idea was that once the disc controller had read sector 1 and processed it, sector 2 should just about be coming under the read head. If the sectors had been placed in sequential order, the slow controller would miss sector 2 and have to wait for the disc to spin around once before catching it next time!

The simple directory structure included the file name and extension, and up to 16 allocated blocks per file. The directory entry was repeated for files that used more than 16 allocation units.

Each side of the disc was in the same format, but not linked in any manner. I would imagine the disc drive originally used had two heads, but appeared to the operating system as two independent drives.

I constructed a disc definition for *22Disk* using the information gathered from *Anadisk*, but was unable to read anything other than the directory from the discs. *Anadisk* does however include a function to make a copy of the sectors from a disc and dump them to a file.

I wrote a C program to analyse that dump file, and reconstruct the original files back on to my host XP system. Initially the directory was read and a list of files created, with a link to each file's allocated blocks. Then an output file was created for each original file name, and each allocated block dumped into the file. This routine also mapped logical sectors onto physical sectors.

Now we could look properly at the original files. The .DES file turned out to contain a description of the format of the .QRY files, and to include field names, data types and field lengths. The .QRY files contain data formatted according to the .DES file description.

We have now read all the discs and passed on the data to our visitors.

The ICL Archive

Hamish Carmichael

The ICL Archive is the name given to a very varied collection of material in the custody of the Science Museum, South Kensington. Physically it is housed in Blythe House in West Kensington, which contains many of the reserve collections of the Science Museum and other national museums.

Blythe House is in itself a fascinating building, being one of the earliest purpose-built office blocks in London. It was opened in the late 1890s to accommodate the staff of the Post Office Savings Bank, when it was realised that a workload involving very large numbers of very low-value transactions would require previously unachievable levels of clerical efficiency. In Blythe House the Archive is not generally accessible, though access for scholars should present no problems.

The nucleus of the collection came from the former ICL Company Museum in Stevenage. There a mixture of material was accumulated under the intelligent and far-sighted guidance of the late Bertie Bellringer, and expanded under his successor Gordon Collinson. This originally covered the products and history of the British Tabulating Machine Co Ltd (BTM), which began in 1904 with the formulation of a consortium to promote the sale and use in Great Britain of punched card machines imported from the United States.

In 1958/59 BTM merged with Powers-Samas to become International Computers and Tabulators (ICT). The Powers company also dated back to the beginning of the 20th century, when a different family of wholly mechanical punched card machines was developed by an engineer called James Powers. In the ensuing years the company museum added a representative assortment of Powers equipment to the collection.

Both BTM and Powers had made first steps into the computer business, and during the 1960s most of the other British computer manufacturers formed alliances with either ICT or the rival English Electric consortium. The museum thereby acquired a rather random collection of material from many other manufacturers. Then in 1968 the two major industry groups were merged into a single entity, ICL, and from that time on the company's hardware and software products are well documented.

Material was at various stages deposited with the museum from the Customer Engineering Training School in Letchworth, from the Head Office Library and Information Service in Putney, from the Education Di-

vision Library at Beaumont College, and from elsewhere. The late John Pinkerton handed over much fascinating material from the files which he had meticulously maintained over many years. Gaps have also been filled from time to time by a number of donations from other individuals.

During the late 1980s the museum building in Stevenage had to be demolished, and the collection had largely to be dispersed. Wherever possible machines, with relevant documentation, were returned to civic museums close to where they had been originally built, in Manchester, Croydon, and Letchworth.

There remained a great deal of punched card equipment which could not be dispersed in this way. It was therefore naturally donated to the Science Museum, and many of these machines are now housed in the Museum's reserve collection at Wroughton, near Swindon.

The main body of the documentation, however, was kept together, and separately lodged for safe keeping with the Science Museum Library. It now represents a pretty good record of the history of the last major British computer manufacturer, and a probably unrivalled record of the preceding history of the punched card industry.

During 2000 the Society received a plea for help with cataloguing this collection. Such work would be a natural follow-on to the cataloguing of the whole of the Science Museum's computing collection which was conducted in the early days of this Society by Tony Sale and Harold Gearing. As I was already in the process of taking over from Harold as the Society's archivist, and as my whole working career had been in ICL, I eagerly volunteered for the task.

Over the following two and a half years I have visited Blythe House about once every fortnight, disturbed a lot of dust, made many interesting discoveries, and re-encountered a lot of old friends. I have been able to reprise all the technical side of my career, from the whole range of Powers equipment on which I started, to all the computers I have ever programmed — the PCC, FCC (otherwise known as the 558), 1201/1202, 1301, 1900 series, and the 2900 and Series 39 families.

People from the Ferranti tradition would find that their experience is equally well represented, and there is much also from EMI. Other machines covered include KDF9, System 4, Leo, Elliott, Stantec Zebra, Deuce — in short, virtually every name that has occurred in the British computing industry.

I found particular interest in a number of papers on computer design

from the late 1940s, when the idea of storage in a computer, and the form it might take, was still an open question.

The collection occupies about 20 four-shelf cabinets, and each shelf holds two rows, one behind the other, of files, manuals, file-boxes, or other material, so I suppose it amounts to something over 500 shelf-feet. It is not designed to be readily accessible, but then the purpose of preserving it is to be able to serve future historians and researchers, rather than to provide immediate answers to current questions.

At the present time the catalogue to the Archive has just been mounted on the Society's Web site, though further work is needed to make this more convenient to access and search. Further cataloguing is proceeding on a miscellaneous assemblage of other material, so the job begins to seem as unending as painting the Forth Bridge — but it's a lot more interesting!

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Contributors to this issue can be contacted by email as follows:

- Brian Shearing at <ShearingBH@aol.com>
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Hugh Ross does not have email.

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

Forthcoming Events

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

Weekday afternoons and every weekend Guided tours and exhibition at Bletchley Park, price £6.00, or £5.00 for children and concessions

Exhibition of wartime code-breaking equipment and procedures, including the replica Colossus, plus 60 minute tours of the wartime buildings

29 May 2003 at 1430 AGM, followed by seminar on "Our Computer Heritage"

23 September 2003 NWG Audio/Video evening

Will include footage of the SSEM Rebuild and of Pegasus

21 October 2003 NWG meeting: Computers at Jodrell Bank

Speaker Dr I Morrison

25 November 2003 NWG meeting: Other Machines at Bletchley Park

Speakers Tony Sale and Brian Oakley

27 January 2004 NWG meeting: Software and User Experience of Orion 1

Speakers to be confirmed

23-26 August 2004 IFIP World Conference on History of Computing in Education

Contact Roger Johnson for details: see also News Round-up page 5

The AGM and following meeting will take place in the Director's Suite of the Science Museum. The North West Group meetings will take place in the Conference room at the Manchester Museum of Science and Industry, Liverpool Road, Manchester, starting at 1730; tea is served from 1700.

Queries about Manchester meetings should be addressed to William Gunn on 01663 764997 or at <william.gunn@ntlworld.com>.

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Committee of the Society (contd)

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

Resurrection is the bulletin of the Computer Conservation Society. Copies of the current issue are available from the Secretary for £5.00 each.

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