Early computers in Europe

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ABSTRACT

This paper describes the early history of computers in Europe, notably in Germany, Holland, France, Italy and the Scandinavian countries as well as Great Britain.

Of necessity, in such a short paper, information is given in a fairly short form, but the paper also includes a detailed description of the birth and foundation of the most successful first British commercial computer company—Leo Computers Limited, and this gives an insight into the thinking which lay behind British early computer development.

Three appendices are included which give the names and addresses of the early computer manufacturers and sales organizations in Europe, and short notes on the early computers and calculators.

The development of electronic computers started in Europe earlier than it did in the United States of America.

Developments in Great Britain occurred in the late 1940's at the end of the Second World War, but prior to that Konrad Zuse in Germany, as far back as 1934, started development work on program-controlled machines, and in 1937, jointly with Dr. Schreyer, started development work on electronic computers proper. By 1941 they had completed the first fully operating Model Z3 in electro-mechanical technique; program on punched tape, binary system and floating point arithmetic.

During the Second World War, Konrad Zuse was involved in developing special devices and an improved universal computer, the Z4, with a mechanical memory. These devices were, in fact, the control mechanisms for the V1s and V2s which almost played a decisive part in the war. Fortunately for the British, Zuse had as many bureaucratic troubles as they had encountered, and the delays seriously affected his work.

The firm of Zuse KG was formed in 1949 and the development of other computers, the Z9, Z11, Z22, Z23 and Z25 took place.

As a matter of record, in 1964 Zuse KG became part of the Siemens empire and by 1969 had become wholly owned by Siemens.

It is strange, however, that apart from Zuse's efforts, comparatively little effective computer development took place in Germany on a commercially viable scale, although by now a great deal of IBM equipment is built in Germany.

What was happening elsewhere?

In Italy, Olivetti were becoming involved, in the early 1950's with the development of machines which were variations on their established commercial equipment, but their development was restricted by virtue of the fact that these machines made use of punched paper tape of Olivetti's own design, which had, in fact, square and not round holes and which had no clock track. This made the equipment as a whole incompatible with the competitors' equipment and this was markedly to the disadvantage of Olivetti.

In France, a considerable number of small electronic companies were trying to get on to the computer band wagon. The dominant company was Compagnie des Machines Bull, which could not quite make up its mind whether it wanted to outdate its existing punched card equipment by introducing computers, or whether it should disregard the future of computers altogether.

Everywhere there was confusion between just what a computer was and what a calculator was. The confusion was added to in Europe, as in America, by different tax structures, depending on whether a machine was, in fact, a computer or was classed as a calculator, and the universal practice grew of giving computers names made up from initial letters. The letter 'C' in a name could stand for computer or calculator as it suited the mood and purpose of the time.

In Holland, the Philips organization was involved in prototype computer development and a completely separate company later acquired by Philips and Electrologica, produced a small number of quite viable machines. Philips' problem was one of administration and bureaucracy, coupled with the fact that they supplied from their numerous other companies component parts which were used in computers and the sale of which they had no wish to lose on the basis of a bird in the hand is worth two in the bush.

In Denmark, three types of computers were built at a very early stage. These were reasonably successful,

and would have been even more successful but for Denmark's inability to export them in significant numbers.

The Danish Institute of Computing Machinery built the DASK computer and the GIER computer. The GIER was the first built by Disa Elektronik in Herlev and was known as DISADEC. It was later taken over by the Danish Institute of Computing Machinery in Copenhagen and re-christened GIER.

Gallo Electronics also built a computer called GALLO which, although developed at a very early date, had, in fact, an early demise.

Computer development also took place in Norway, as well as Sweden, and this was geared to the activities of the Great Northern Telegraph Company and its equipment.

One of the fundamental problems with the computers mentioned in the countries above was that the countries all had their own national language and, because of the cost and lack of foresight of the companies concerned in realizing that to sell their machines outside their own country, they had to have a universal language, which as it turned out in the computer field is English, the difficulties of production and economic viability were very considerable.

The countries which had no such language problem were the United States of America and Great Britain, both of which produced computers, sold and operated them, making use of the international language of English, although American English, it must be said, is a little different from British English, both in its spelling and connotations.

Computer development in Great Britain started fairly soon after the Second World War and was particularly based on Manchester University and Cambridge University with off-shoots taking place in the Midlands and London.

It became very fashionable, and still is so, to say that Charles Babbage who about a hundred years ago was a mathematics professor at Cambridge was the father of British computers. This is one of those jolly myths which it is nice to have but is somewhat different from the truth. Presper Eckert told the author that neither he nor John Mauchly had heard of Babbage's Engines at the time they first started work on computers, and probably the same comment might have been made by those people who were working on computers at Manchester, although their Cambridge colleagues could, of course, be expected to have had some influence from Babbage.

Babbage was an individual who was very much misunderstood. He had relatively limited funds and he was accused by his critics of never finishing anything. What actually happened was that before he had finished building one of his many machines, he discovered a better way of doing things and, therefore, there was no purpose in completing that particular machine just for the sake of keeping things orderly. He had a girl-friend who was probably a better mathematician and engineer than he was, and it could well be that such reputation as Babbage enjoyed was as a result of her efforts rather than his own.

The original emphasis in Great Britain, as indeed it was elsewhere, was on the design and production of computers for scientific purposes, and those people involved in this activity delighted in using mathematical terminology instead of simple English, to confuse the public at large and enhance their own reputations and prestige. This had a back-lash effect in Great Britain in that the commercial use of computers was delayed for several years because businessmen did not understand them or realize their potential. Indeed, it was in Llandudno where the author lives, at a conference during the 1950's, that Professor Hartree told the assembled audience that, in his opinion, computers would never be used for business purposes because there would not be enough scientists to operate them. Fortunately, this state of affairs did not exist to the same extent in America, largely because of the practical ability and outlook of Eckert and Mauchly and the fact that Eckert, in particular, had a degree in business studies as well as in electrical engineering, and better understood the thinking and outlook of the American businessman.

Fortunately, in Great Britain also, we had some people of influence who saw a commercial future for computers. In particular, the name of Vivian Bowden, now Lord Bowden, and Principal of the Manchester College of Technology springs to mind. The author was privileged to enjoy his confidence when they published books at the same time, the books being very different. Bowden's was called "Faster than Thought" and the author's simply "The Electronic Office" which was a description of the use and possibilities of computers.

Since 1957, when Computer Consultants Limited was formed as the first independent consultancy company on computers in Europe, that company and its associated companies have produced almost a hundred internationally recognized reference books on computers which, because of the nature of the industry and its continuous change, had, of necessity, a very short shelf life. It is from these books that the appendices which form part of this paper have been taken, with the permission of the companies concerned.

The scientific computers developed at Manchester included MADAM and at Cambridge, EDSAC, and the English Electric Company produced an early computer called DUCE which had its origin largely in Cambridge.

Manchester University co-operated with the Ferranti organization and produced early machines like the PEGASUS, while EMI relied to a great extent on their own research and produced EMIDEC.

Elliott Brothers at Borehamwood showed a lot of initiative in producing scientific computers and at a

very early stage sought to find ways of using these for commercial purposes with some success, but without the commercial sales back-up to further the enterprise sufficiently in a hardening market.

There were two punched card companies in Great Britain—the Power Samas organization and the Hollerith organization. Both of these companies invested large sums of money in developing machines which they were not quite sure whether to call computers or calculators, and both were surprised to find that what they had produced was already out of date. It is said that it was at that time that Prince Phillip made the pertinent comment that "if it works, it's obsolete." To seek to protect their position, the companies merged to form ICT—International Computers & Tabulators Limited, and some of their early machines made an impact, albeit a short one because of their inability to keep up with research and development.

It may seem strange to an American audience, but IBM had little or no impact in Britain at that time and, indeed, their British organization was very small. This, of course, has now changed, and by now other significant American companies such as Honeywell have made their appearance.

The author was privileged to be asked to make suggestions about Honeywell's entry into Britain, and later Europe, and amongst his working papers are reports that were prepared both for this development and for other significant mergers of European computer companies.

Unquestionably, the greatest single impact made on the British computer field was by an organization that was not concerned with computers at all. It sold cakes and bakery commodities, had some two hundred shops in the London area, and found difficulty in deciding what to bake each night. It was by virtue of the fact that they could not find a suitable computer to carry out their work that they came to design and build their own, and formed Leo Computers Limited. They successfully built and used Leo I for many years, and later produced very advanced versions of the machine before the company ultimately merged with other British computer companies and came under the control of ICL, the, by now, sole remaining British computer company.

The National Cash Register Company had also developed its own computers which were marketed in Britain, and an arrangement was entered into between that company and Elliotts to assemble NCR computers at Elliotts' factories in Britain. This arrangement was expanded to allow for Elliotts' continuing to sell machines for scientific purposes with the same machines, notably the Elliott 803, being sold for commercial purposes by NCR. This arrangement cannot be said to have been altogether successful.

However, to return to the Lyons story. In 1947, two men called Standingford and Thompson, both employed by the Lyons Organisation, decided to study the possibilities of electronic calculators in the office and, to this end, arranged to visit Dr. Goldstine of Princeton University.

Professor Hartree, who was also working on computers at Cambridge heard of this visit and invited Standingford and Thompson to visit him and Dr. Wilkes at Cambridge. Following the visits to Cambridge and America, Thompson and Standingford prepared a report for the Lyons Board and proposed that the company should take an active part in promoting the commercial development of electronic calculators. The Lyons Board decided to donate £2,500 to Cambridge and to lend a man for six months to assist Dr. Wilkes in the activity. Lyons continued their studies during 1948 and the building of EDSAC, the first electronic computer to be built at Cambridge, was nearing its completion.

By November 1948, Lyons had prepared an experimental payroll program which was to be tried out on EDSAC as soon as the computer was ready.

It became quite clear to Lyons by now that it was necessary for them to hold the initiative in this activity and, to do so, they needed staff of their own who were capable of acting on behalf of Lyons. To this end they advertised for the services of an electronic engineer and late in December, J. N. M. Pinkerton was appointed.

By January 1949 they had made practical arrangements for installing a calculator, as it was then called. The clerical staff were told that it was intended to start a computer project, and during the whole of the activity Lyons maintained an excellent staff relationship by keeping their senior, middle management and junior staff fully in the picture as regards their intentions and the progress the activity was making.

For a commercial computer, it had now become obvious to Lyons that it was necessary to have more input/output devices than were customarily intended to be involved with these scientific machines. In April, 1949, therefore, they recommended and, in May, implemented arrangements with Standard Telephones and Cables Limited at Enfield to develop, on their behalf, certain input/output devices.

In May, 1949, EDSAC did its first job of work and a significant step forward had been taken. By July, 1949, Lyons had entered into an arrangement with Wayne Kerr Laboratories Limited to produce panels of electronic circuits on their behalf and to their specification. By August of the same year, Standard Telephones had carried out a survey to ascertain what work was necessary to produce the input/output equipment, and a Mr. E. J. Kaye joined Lyons as assistant to Pinkerton. By the end of the month it had become apparent to Lyons that considerable research was required into the way the clerical work should be organized for the calculator and into techniques of programming. As a result, a start was made on a systematic analysis of clerical work and also on the basic

techniques of data processing and programming. The initiative was very much in the hands of T. R. Thompson and it was his drive and perspicacity which largely led to the success of the operation, but it must be emphasized also that he had had the foresight to appoint excellent people to help him in the activity.

In September, 1949, Mr Simmons, one of the Directors of Lyons, christened the calculating machine "Leo" which stood for Lyons Electronic Office. The Coventry Gauge and Tool Company Limited were asked to commence the manufacture of large delay battery tubes which were going to be the computer's memory.

By the end of the year, Standard Telephones had completed their research work and had indicated the equipment which they considered necessary. All this activity was geared to the production of a pilot Leo computer and, in January 1950, Standard Telephones and the other people concerned with assembling the various units were given their head and the equipment required was to be completed and delivered to Leo by January 1951, that is twelve months later.

During March of 1950, demonstrations were given to the Director, office managers, supervisors and members of the Clerical Staff Committee on the way counting and addition was to be carried out on the calculator, and talks were given to the Lyons office staff on the philosophy of electronics in offices.

The first of the delay tubes were received from the Coventry Gauge and Tool Company and Lyons considered the possibility of having the initial records of their data prepared in binary form to be read by photoelectric readers developed by them for that purpose. The activity was now assuming considerable proportions and in April 1950, Thompson was released by the Lyons Board from his other commitments and allowed to devote his entire time to the Leo project. His first step following this was to appoint Mr. D. T. Caminer to take charge of the programming for Leo.

It is significant that the majority of those who played a part in the early days of Leo, went on to remain with the company, and the tradition of almost joining the Lyons organization for life continued strongly in the computer division also. This differs from the approaches in some other companies. To stay with one company for a very long time may have its virtues, but it also has its drawbacks, because it tends to narrow the experience of the group as a whole unless fresh blood is imported from time to time.

By August 1950, discussions had taken place with Standard Telephones to ascertain whether they should develop Leo on a joint basis, but Standard Telephones were not particularly enthusiastic about this and, in fact, the electronic companies at this time must have been quite diffident about the possibilities of using computers in business, in the face of opposition by such well-known organizations as the National Cash Register Company Limited and other office machine organizations.

There were signs at this time that the question of rights to patents were beginning to raise their heads. It was agreed by Standard Telephones and Lyons that neither party should enter into arrangements for supplying equipment similar to that which had been developed without the agreement of both parties. By October 1950, the progress being made was not satisfactory and was behind schedule. To try and correct this, Pinkerton spent a lot of time at Enfield trying to accelerate production, but this was to no avail. By the end of the year, rethinking was taking place in connection with the Standard Telephones/Lyons arrangement, and Lyons agreed to pay Standard Telephones some additional costs in connection with equipment which had been overlooked in the original specification. Standard Telephones agreed to allow Lyons to obtain equipment previously commissioned from them, elsewhere if it was necessary for them to do so.

While the computer was by no means complete, there were working portions of it which could be seen by January 1951 and, in February 1951, Her Royal Highness, Princess Elizabeth, now Queen Elizabeth II, went to Cadby Hall to see Leo carrying out a simple test program.

By April, it was possible to give demonstrations to the Lyons Directors of Leo doing clerical work, and although they were very behind schedule with their activities, Standard Telephones felt that it would be in the interests of both parties if the patent applications of the two companies were considered together.

In May 1951, a memorandum setting out the scope of the Lyons patents was sent to Standard Telephones and a demonstration was given in June by Standard Telephones at Enfield to some of the Lyons Directors and Executives of the partly assembled auxiliary equipment in operation.

However, despite the difficulties which were arising, by the end of August, Leo was doing some real clerical work, albeit very slowly, and the Cadby Hall Bakeries job was being done on the calculator by September and producing accurate results. However, the difficulties arising from the late delivery of the Standard Telephones equipment had not been resolved by October and, regretfully, Thompson and others discussed the possibility of developing other input/output systems using paper tape in order to keep the work going on schedule.

The Leo computer had engendered so much outside interest by November that the Ministry of Supply was seeking to find out whether Lyons could carry out some ballistic computations on the computer. In November 1951 also, the Cadby Hall Bakeries job, which was the scheduling of an overnight bakery programme for the whole of the production at Cadby Hall, was carried out on the computer completely successfully, and the job was carried out regularly from then on.

At this time, the Leo machine was still being re-

ferred to as a calculator and, in February 1952, a wages demonstration program was carried out on the machine using magnetic tape for the first time. The records on magnetic tape were subsequently printed by teleprinter and more outside enquiries were being made for time on the machine, in particular, the Meteorology Department and the Ministry of Supply.

In May 1952, Professor Hartree made the remark that computers would never be used for business purposes with any degree of success. This undoubtedly carried a lot of weight with people in authority in Britain and must surely have delayed the use of computers in Britain for a significant period.

Up to about this time the Lyons machine had used punched paper tape and magnetic tape, but in June 1952 began the collaboration between Lyons and the Hollerith company. Originally Lyons had intended that the computer should be used for their own activities and they were pursuing the requirements for their own work. Their next objective was to carry out the provisioning of all the London Lyons Tea Shops, as they were called, some two hundred and fifty in all. In this comparatively short space of time, they had also developed their own photo-electric tape reader and this was in use. An increasing number of enquiries were being received from outside organizations for the use of the machine and the range of enquiries were substantially wide.

By October 1952 Lyons had decided to go ahead with building their own high speed input/output equipment as an alternative to the Standard Telephones equipment because there were increasing fears that this would prove to be unreliable. By the end of the year, early production payroll work was being done and pay slips, produced on pre-printed forms, were being used within the Lyons organization. In January 1953 came a successful full-scale trial of a payroll program and, although there were minor computer faults which were later amended, the operation was initially a success.

The writer believes that much of this success by Lyons with computers arose from their readiness to face realities, and the fact that they themselves had for a long time, as a company, been engaged in organization and method work, and were aware of the necessity for study and planning their operations, rather than just patching them up and doing them in the same old way, albeit with new equipment. In May 1953, the first tabulator was delivered from BTM and a card feed was also delivered the same month. Both pieces of equipment operated successfully, and later that month a demonstration payroll was carried out, printing the result, not on a teleprinter as previously, but on a Hollerith tabulator. By August a draft plan had been prepared in respect of the London Tea Shops Provisioning Application and sufficient use had been made of the computer to appreciate what improvements could be made to the existing equipment. For example, future mercury delay lines would use shorter tubes in which the pulses would be one quarter of a microsecond in width and so reduce the access time to a quarter of that operated in the early days without any loss of capacity. About this time Standard Telephones decided to abandon the project with Lyons and arrangements were made for the re-siting of the equipment.

By the end of 1953 Leo I was operating more than ninety per cent effectively, and a significant number of people were approaching Lyons from outside the organization with a view to hiring computer time and finding out what their future plans were. These included plans for building Leo II, and in February 1954 the amount of coverage given to the success of Leo I, increased enquiries for the new machine.

Outlined proposals for Leo II were finalized and new equipment such as Ferranti Fast Tape Readers were added to the early machine. Lyons then announced that they were prepared to build Leo II for sale or hire to other organizations and that they were forming a subsidiary company, Leo Computers Limited.

The number of staff on the Leo payroll by August 1954 was slightly under ten thousand, and the work for the provisioning of the Tea Shops had been put on the machine, first of all with forty two shops, and later on with nearly two hundred, and this was a success from the start.

By the end of 1954 Bull tabulating equipment had been added to the computer, and the number of enquiries for the purchase of computers and computer time on Leo's own machines, had grown to significant proportions. By now, of course, Leo Computers Limited, have become part of International Computers Limited through various mergers. In the meantime Standard Telephones & Cables Limited (part of ITT) had, in 1958, built their own small computer, the Stantec Zebra. A new transistorized prototype was built six years later, but the company then withdrew from computers. That Leo Computers Limited was a success story was unquestionable. Why was this, when so many computer companies have run into difficulties? Much must have depended on the quality of the people concerned, but the author believes that it was mainly because they knew from the start what they wanted to do, and they went ahead and did it. And eventually knew when to stop trying to keep up with the big boys.

CONCLUSION

What of the future of computers in Europe? The dominant computer manufacturer is undoubtedly IBM, with Honeywell a close second, and with ICL being moderately successful. All the remaining small, individual companies have been swallowed up by these empires, but as competitors there still remains Burroughs, NCR and other American oriented companies.

The future of any individual computer company is damned by the cost of development and the lack of marketing facilities, but there remains the thought that since the early 1960's, with the advent of computer memories, using laser and other techniques, all existing computers are dated—and the size of IBM, for example, makes it virtually impossible for that company ever to switch from these out of date computers to newer, more imaginative equipment which we know is technically possible, and certainly economically viable.

Who knows what the future is?

APPENDIX I—THE NAMES OF MANUFACTURERS AND SALES ORGANIZATIONS OF COMPUTERS WHICH WERE BEING SOLD IN EUROPE IN 1965 AND SHOWING THE ORIGIN OF SOME OF THE EARLY COMPANIES

Aktiebolaget Addo, Malmo, Sweden.
Svenska Relafabriken ABN., Tyreso, Sweden.
Alwac Computer Division, El-Tronics, Inc., California, U.S.A.
A.E.I. Automation Ltd., Manchester, England.
Bunker Ramo Corp., California, U.S.A.
International Systems Control Ltd., Wembley, England.
Burroughs Corp., Michigan, U.S.A.
Burroughs International S.A., Fribourg, Switzerland.
Cambridge University, Cambridge, England.
Centre National d'Etudes des Telecommunications, Seine, France.
Clary Corp., San Gabriel, California, U.S.A.
Collins Radio Corp., Dallas, Texas, U.S.A.
Compagnie Bull-General Electric, Paris, France.
Compagnie Europeenne d'Automatisme Electronique, Seine, France.
(CIT) Compagnie Industriel des Telecommunications
(CAE) Compagnie d'Automation Electronique
(CSF) Both Subsidiaries of Compagnie de Telegraphie Sans Fil which formed a joint company with Compagnie General Electric.
Computer Engineering Ltd., Hitchin, Herts, England.
Control Data Corp., Minnesota, U.S.A.
Control Data AG., Luzern, Switzerland.
Danish Institute of Computing Machinery, Copenhagen, Denmark.
A/S Regnecentralen, Copenhagen, Denmark.
Disa Electronik A/S, Herlev, Denmark.
Electronic Association Inc., New Jersey, U.S.A.
Electronic Associates Ltd., Burgess Hill, Sussex, England.
Electronic Machine Controls Ltd., Thornton Heath, Surrey, England.
English Electric-Leo-Marconi Computers Ltd., Kidsgrove, Staffs., England.
Elliott Bros. (London) Ltd., Borehamwood, Herts, England.
Facit Electronics AB., Stockholm, Sweden.
Atvidabergs Industrier AB., Stockholm, Sweden.
Ferranti Limited, Hollinwood, England.
Friden Inc., San Leandro, California, U.S.A.
Friden International S.A., Fribourg, Switzerland.
General Electric Corp., Arizona, U.S.A.
International General Electric S.A., Geneva, Switzerland.
General Precision Inc., California, U.S.A.
General Precision Systems Ltd., Ealing, London, England.
General Precision France, Paris, France.
Eurocomp GmbH, Minden, Germany.
Schoppe & Fraeser GmbH, Minden, Germany.
International Business Machines Corp., New York, U.S.A.
IBM World Trade Corp., Paris, France.
International Computers & Tabulators, London, England.
Marconi Instruments Ltd., London, England.
Mercedes Buromaschinen AG., Thuringen, East Germany.
Minneapolis-Honeywell Regulator Co. Inc., Massachusetts, U.S.A.
Honeywell Controls Ltd., London, England.
Monroe International Inc., New Jersey, U.S.A.
Monroe International (UK) Ltd., London, England.
Monroe Calculating Machine Co. France, Paris, France.
Deutsche Monroe/Sweda GmbH, Dusseldorf, Germany.
Monroe Calculating Machine Co. Holland N.V., Amsterdam, Holland.
National Cash Register Co. Inc., Ohio, U.S.A.
National Cash Register Co. Ltd., London, England.
National Physical Laboratory, Middlesex, England.
N.V. Electrologica, Den Haag, Holland.
Olivetti-General Electric SpA, Milan, Italy.
Olympia Werke AG., Wilhelmshaven, Germany.
Philips Gloeilampen Fabrieken N.V., Eindhoven, Holland.
Pisa University, Toscanna, Italy.
Raytheon Corp., California, U.S.A.
Scientific Data Systems Inc., California, U.S.A.
Compagnie Europeenne de Calculateurs Industriels et Scientifiques, Paris, France.
Siemens & Halske Aktiengesellschaft, Munich, Germany.
Societe d'Exploitation et de Recherches Electroniques, Aubergenville, France.
Societe Europeenne pour le Traitement de L'Information, Massy S. et O., France.
Scciete Nouvelle d'Electronique, Paris, France.
Societe d'Electronique et d'Automatisme, Seine, France.
Solartron Electronic Group Ltd., Farnborough, England.
Sperry Rand Corp., New York, U.S.A.
Univac Division of Sperry Rand International Corp., Lausanne, Switzerland.
Standard Elektrik Lorenz AG., Stuttgart, Germany.
Standard Telephones & Cables Ltd., Enfield, England.
Svenska Aeroplan AKT., Linkoping, Sweden.
Technische Hochschule, Munich, Germany.
Telefunken GmbH Konstanz, Germany.
Teleregister Corporation, Connecticut, U.S.A.
Zeisswerke GmbH, Jena, Germany.
Zuse KG., Bad Hersfeld, Germany.

APPENDIX II—LIST OF AND SHORT NOTES ON DIGITAL COMPUTERS USED IN EUROPE IN 1963. (SPECIAL ONE-OFF MACHINES, OF WHICH THERE WERE MANY, ARE NOT INCLUDED)

Name	Manufacturer	Price
Ace	National Physical Laboratory	£ 400,000
Advance II	Advanced Scientific Instruments Inc.	£ 300,000
AEI 1010	Associated Electrical Industries Ltd.	£ 250,000
AEI 959	Associated Electrical Industries Ltd.	
Alwac II	Alwac Computer Div. of El-Tronics Inc.	£ 35,000
Alwac III	Alwac Computer Div. of El-Tronics Inc.	£ 37,000
Alwac IIIE	Alwac Computer Div. of El-Tronics Inc.	£ 40,000
Alwac IV	Alwac Computer Div. of El-Tronics Inc.	£ 50,000
Alwac 800	Alwac Computer Div. of El-Tronics Inc.	

Name	Manufacturer	Price
Amdec	Addressograph Multigraph	£ 30,000
AN/UYK-1	Thompson Ramo Wooldridge Inc.	£ 40,000
Apollo	Ferranti Ltd.	£ 35,000
Arch	Elliott Bros. (London) Ltd.	£ 17,000
Argus 100	Ferranti Ltd.	£ 20,000
Argus 200	Ferranti Ltd.	£ 20,000
ASI 210	Advanced Scientific Instruments Inc.	£ 40,000
ASI 420	Advanced Scientific Instruments Inc.	£ 150,000
AV 41	North American Aviation Inc.	
Atlas		£2 million
Basicpac	Philco	
Bendix D-12	Bendix International Div. of Bendix Corp.	
Bendix G-15	Bendix International Div. of Bendix Corp.	£ 30,000
Bendix G-20	Bendix International Div. of Bendix Corp.	£ 210,000
Bendix G-25	Bendix International Div. of Bendix Corp.	£ 300,000
BESM 1	Made in Russia	
BESM II	Made in Russia	
BISMAC I	Radio Corp. of America	£ 500,000
BISMAC II	Radio Corp. of America	£ 500,000
BRLESC	Ballistic Research Laboratories	
Burroughs 204	Burroughs Corp.	
Burroughs 205	Burroughs Corp.	£ 67,500
Burroughs 220	Burroughs Corp.	£ 160,000
Burroughs 250 VRC and 251 VRC	Burroughs Corp.	£ 140,000
Burroughs 260 and 261		£ 70,000
Burroughs 270 and 271		£ 130,000
Burroughs 280 and 281		£ 140,000
Burroughs B5000		£ 200,000+
Burroughs D825		
Burroughs E101		£ 16,400
Burroughs E102		£ 10,000
Burroughs E103		£ 10,000
Burroughs F2000		
CAB 500	SEA of France	£ 23,675
CAB 600	SEA of France	£ 30,000
CAB 3900	SEA of France	
CE 55	Computer Engineering Ltd.	£ 2,000
CE 102	Computer Engineering Ltd.	£ 10,000
Cellatron SER 2	Mercedes Buromaschinen	£ 9,000
CIFA-3	Institute of Nuclear Physics, Roumania	
CIFA 101	Institute of Nuclear Physics, Roumania	
CITAC 210B	Compagnie Industrielle des Telephones	
Clary DE-60	Clary Corporation	£ 8,000
Clary DE-60M	Clary Corporation	£ 7,000
Computer Control DDP 19	Computer Control	£ 40,000
Computer Control DDP 25	Computer Control	£ 40,000
Control Data 160	Control Data Corp.	£ 30,000
Control Data 160A	Control Data Corp.	£ 50,000+
Control Data 924	Control Data Corp.	£ 110,000
Control Data 1604	Control Data Corp.	£ 380,000
Control Data 3600	Control Data Corp.	£1 million
Control Data 6600	Control Data Corp.	£1,600,000
CXPQ	Philco International Corp.	
D21	Svenska Aeroplan Aktiebolaget	£ 60,000
Datamatic 1000	Honeywell Corp.	£ 584,000
Datatron	Electro Data Corp.	£ 39,800
DB 10	Standard Elektrik Lorenz AG	
DB 40	Standard Elektrik Lorenz AG	£ 50,000
DB 70	Standard Elektrik Lorenz AG	
Deuce I	English Electric Co. Ltd.	£ 45,000
Deuce II	English Electric Co. Ltd.	£ 50,000
Deuce IIA	English Electric Co. Ltd.	£ 55,000
Disadec	Disa Elektronik A/S	£ 41,500
ELEA 2001	Olivetti SpA	
ELEA 6001	Olivetti SpA	£ 29,500
ELEA 9002	Olivetti SpA	
ELEA 9003	Olivetti SpA	£ 236,000
Elecom 120	Underwood Machine Co. Inc.	
Elecom 125	Underwood Machine Co. Inc.	£ 100,000
Electronic Anoc 231R		
Elliott 401	Elliott Brothers (London) Ltd.	£ 15,000
Elliott 402	Elliott Brothers (London) Ltd.	£ 22,000
Elliott 402E	Elliott Brothers (London) Ltd.	£ 25,000
Elliott 402F	Elliott Brothers (London) Ltd.	£ 25,000
Elliott 403	Elliott Brothers (London) Ltd.	£ 100,000
Elliott 502	Elliott Brothers (London) Ltd.	£ 135,000
Elliott 503	Elliott Brothers (London) Ltd.	£ 80,000
Elliott 802	Elliott Brothers (London) Ltd.	£ 17,000
Elliott 803	Elliott Brothers (London) Ltd.	£ 35,000
Elliott 900	Elliott Brothers (London) Ltd.	
Emidec 1100	EMI Electronics Ltd.	£ 180,000
Emidec 1101	EMI Electronics Ltd.	£ 185,000
Emidec 2400	EMI Electronics Ltd.	£ 200,000+
EMI Special	EMI Electronics Ltd.	£ 100,000
EPOS	State Statistical Department, Czechoslovakia	
EPSCO 275		£ 35,000
ER 56	Standard Elektrik Lorenz AG	£ 50,000
ES 92	Standard Elektrik Lorenz AG	
Facit EDP	Facit Electronics AB	£ 120,000
Friden 6010	Friden Inc.	£ 7,850
FX-1		
Gallo		
Gamma 3 & MDE	La Compagnie des Machines Bull	£ 85,000
Gamma 10	De La Rue Bull Machines Ltd.	£ 30,000
Gamma 30	De La Rue Bull Machines Ltd.	£ 100,000
Gamma 60	Compagnie des Machines Bull	£ 500,000+
Gamma 150	Compagnie des Machines Bull	£ 50,000
Gamma 300	Compagnie des Machines Bull	£ 22,000
GE 210	General Electric Co. Inc.	£ 270,000
GE 225	General Electric Co. Inc.	£ 84,000
General Mills EC5	General Mills	
General Mills EC6	General Mills	
George	Argonne National Laboratories	
Hipac 101	Hitachi Ltd.	£ 25,000
Honeywell 290	Honeywell Controls Ltd.	£ 60,000
Honeywell 400	Honeywell Controls Ltd.	£ 120,000
Honeywell 800	Honeywell Controls Ltd.	£ 395,000
Honeywell 1800	Honeywell Controls Ltd.	£ 500,000+

Name	Manufacturer	Price
IBM 305	IBM Corporation	£ 65,000
IBM 305 II	IBM Corporation	£ 40,000
IBM 630X	IBM Corporation	
IBM 650	IBM Corporation	£ 70,000+
IBM 701	IBM Corporation	
IBM 702	IBM Corporation	
IBM 704	IBM Corporation	£ 600,000
IBM 705 I	IBM Corporation	£ 533,400
IBM 705 II	IBM Corporation	£ 533,500
IBM 705 III	IBM Corporation	£ 540,000
IBM 709	IBM Corporation	£ 866,700
IBM 832	IBM Corporation	
IBM 1401	IBM Corporation	£ 120,000
IBM 1410	IBM Corporation	£ 150,000+
IBM 1440	IBM Corporation	£ 30,000
IBM 1620	IBM Corporation	£ 35,000
IBM 1620 Mark II	IBM Corporation	
IBM 1710	IBM Corporation	
IBM 7010	IBM Corporation	
IBM 7030	IBM Corporation	£1,500,000
IBM 7034	IBM Corporation	
IBM 7040	IBM Corporation	£ 305,500
IBM 7044	IBM Corporation	£ 350,000
IBM 7070	IBM Corporation	£ 450,000
IBM 7072	IBM Corporation	£ 400,000
IBM 7074	IBM Corporation	£ 450,000
IBM 7080	IBM Corporation	£ 840,000+
IBM 7090	IBM Corporation	£1 million
IBM 7094	IBM Corporation	£1 million
IBM 7701	IBM Corporation	
IBM 7750	IBM Corporation	
IBM 7950	IBM Corporation	
IBM 8000	IBM Corporation	
ICT 1200	International Computers & Tabulators Limited	£ 25,000
ICT 1201	International Computers & Tabulators Limited	£ 33,000
ICT 1202	International Computers & Tabulators Limited	£ 45,000
ICT 1300	International Computers & Tabulators Limited	£ 45,000
ICT 1301	International Computers & Tabulators Limited	£ 65,000+
ICT 1400	International Computers & Tabulators Limited	
ICT 1500	International Computers & Tabulators Limited	£ 75,000
ITT 7300 ADX	International Telegraph	£ 266,700
KA 21	Standard Elektrik Lorenz	£ 40,000
KDF 6	English Electric Co.	£ 60,000
KDF 9	English Electric Co.	£ 120,000
KDN 2	English Electric Co.	£ 20,000
KDP 10	English Electric Co.	£ 400,000
Kiev	Academy of Science of the Ukrainian Soviet Republic	
KL 901	Societe Nouvelle d'Electronique	
Leo I	Leo Computers Ltd.	£ 95,000
Leo II	Leo Computers Ltd.	£ 95,000
Leo III	Leo Computers Ltd.	£ 200,000
L-3060	General Precision, Librascope Div.	
Librascope ATC	General Precision, Librascope Div.	
Librascope 500	General Precision, Librascope Div.	
M1, 2, 3	Made in Russia	
M20	Made in Russia	
Madam Mk I	Manchester University	£ 40,000
Madam Mk II	Ferranti Ltd.	£ 45,000
Maddam	Burroughs Corp.	
Magloc 1	Sperry Gyroscope Co. Ltd.	
Maniac II		
Mercury	Ferranti Ltd.	£ 120,000
Merlin	Brookhaven Inc.	
MESM	Ukrainian Academy of Sciences	
Metrovick 950	Metropolitan-Vickers Electrical Co. Ltd.	£ 20,000
Micropac	R.C.A.	
Miniac	Marchant Calculations Inc.	£ 28,400
Minsk 1 & 2	Made in Russia	
Mobidic	Sylvania Electric Systems	
Monrobot Mk VI	Monroe Calculating Machine Co.	£ 33,700
Monrobot IX	Monroe Calculating Machine Co.	£ 5,000
Monrobot X	Monroe Calculating Machine Co.	£ 14,200
Monrobot XI	Monroe Calculating Machine Co.	£ 12,500
Monrobot MU	Monroe Calculating Machine Co.	£ 250,000
Narec	U.S. Naval Research Laboratories	
National 102	National Cash Register Co.	
National 107	National Cash Register Co.	
NCR 303	National Cash Register Co.	£ 50,000
NCR 304	National Cash Register Co.	£ 285,000
NCR 310	National Cash Register Co.	£ 32,000
NCR 315	National Cash Register Co.	£ 120,000
NCR 390	National Cash Register Co.	£ 25,000
National Elliott 405	Elliott Bros. Ltd.	£ 120,000
National Elliott 405M	Elliott Bros. Ltd.	£ 130,000
OKI	OKI Electric Industry Co. Ltd.	
Omega 203	Olympia Werke AG	£ 44,500
Oracle	Oak Ridge and Argonne	
Ordvac	University of Illinois	
Orion	Ferranti Ltd.	£ 300,000
Packard Bell 250	Packard Bell Electronics	£ 20,000
Packard Bell 350	Packard Bell Electronics	£ 40,000
Packard Bell 440	Packard Bell Electronics	£ 30,000
Panellit ISI 609	Panellit Ltd.	
PDP 1	Digital Equipment Corp.	£ 60,000
PDP 3	Digital Equipment Corp.	£ 58,700
PDP 4	Digital Equipment Corp.	£ 17,400
Pegasus 1	Ferranti Ltd.	£ 50,000
Pegasus 2	Ferranti Ltd.	£ 120,000
Perm	Technische Hochschule	
Perseus	Ferranti Ltd.	£ 150,000
Philco 1000	Philco Corp.	£ 83,000
Philco 2000/210	Philco Corp.	£ 533,000
Philco 2000/211	Philco Corp.	£ 666,000
Philco 2000/212	Philco Corp.	£ 840,000
Philco 2400/410	Philco Corp.	£ 120,000
PICO	Honeywell	
Pluto	Ferranti	
Prodac 510	Westinghouse & Univac Division of Sperry Rand	
Prodac 580	Westinghouse & Univac Division of Sperry Rand	

Name	Manufacturer	Price
Poseidon	Ferranti	
Rand Johniac	Remington Rand Univac	
Raycom	Datamatic Corporation	£ 85,000
RCA Bismac	Radio Corporation of America	£ 500,000
RCA 301	Radio Corporation of America	£ 100,000
RCA 501	Radio Corporation of America	£ 300,000
RCA 601	Radio Corporation of America	£ 650,000
RCA 604	Radio Corporation of America	
Readix	Idaho-Maryland	
Recomp II	North American Aviation Inc.	£ 31,700
Recomp II	North American Aviation Inc.	£ 21,700
Royal Precision LGP 30	Royal McBee Corp.	£ 18,000
Royal Precision RPC 4000	Royal McBee Corp.	£ 29,200
Royal Precision RPC 9000	Royal McBee Corp.	£ 40,000
SA 100	Wayne Kerr Corp.	£ 1,750
SDS 910	Scientific Data Systems	£ 14,000
SDS 920	Scientific Data Systems	£ 30,000
SDS 930	Scientific Data Systems	
SEA 3900 (CAB 3900)	Societe pour l'Exploitation des Procedes SEA	£ 105,000+
Setun	Made in Russia	
Siemens 2002	Siemens & Halske	£ 100,000
Sirius	Ferranti Ltd.	£ 17,000
Stantec Zebra	Standard Telephones & Cables	£ 28,000
Strela	Made in Russia	
Storekeeper	Electronic Machine Control Ltd.	£ 4,750
Sylvania 9400	Sylvania Electronic Products Inc.	£ 900,000
TAC (Marconi)	Marconi Ltd.	£ 10,000
Teleregister Telefile		
Tosbac 3100	Tokyo Shibaura Electric Co.	
Tosbac 4200	Tokyo Shibaura Electric Co.	
TR 4	Telefunken GmbH	£ 300,000
TR 5	Telefunken GmbH	
Trice	Packard Bell Electronics	£ 250,000
TRW 33	Thompson Ramo Wooldridge Inc.	
TRW 130	See AN/UYK 1	
TRW 230	Thompson Ramo Wooldridge Inc.	
TRW 300	Thompson Ramo Wooldridge Inc.	£ 50,000
TRW 330	Thompson Ramo Wooldridge Inc.	
TRW 400	Thompson Ramo Wooldridge Inc.	£ 666,000
TRW 530	Thompson Ramo Wooldridge Inc.	
Univac File Computer 0 & 1	Remington Rand Univac	£ 100,000
Univac 1	Remington Rand Univac	£ 426,700
Univac II	Remington Rand Univac	£ 500,000
Univac III	Remington Rand Univac	£ 333,000
Univac 120	Remington Rand Univac	£ 32,700
Univac 422	Remington Rand Univac	£ 16,500
Univac 490	Remington Rand Univac	£ 350,000+
Univac 1101-1105	Remington Rand Univac	£ 500,000
Univac 1107	Remington Rand Univac	£ 833,400
Univac 1218	Remington Rand Univac	
Univac Larc	Remington Rand Univac	£1,800,000
Univac Larc II	Remington Rand Univac	£2 million
USS 80/90	Remington Rand Univac	£ 66,700
USS 11	Remington Rand Univac	£ 130,000+
USSC-STEP	Remington Rand Univac	£ 113,400
Ural 1	Made in Russia	
Ural 2	Made in Russia	
Ural 4	Made in Russia	
Verdan	North American Aviation Inc.	
Wegematic 1000	Aktiebolaget Addo	
X 1	N.V. Electrologica	£ 110,000
ZRA 1	Zeisswerke GmbH	£ 40,000
Zuse 11	Zuse KG	£ 10,000
Zuse 22	Zuse KG	
Zuse 23	Zuse KG	£ 33,000
Zuse 31	Zuse KG	£ 40,000
Zuse 64	Zuse KG	£ 20,000
Zuse 80	Zuse KG	£ 21,000

APPENDIX III—LIST OF AND SHORT NOTES ON CALCULATORS USED IN EUROPE IN 1963 (SPECIAL ONE-OFF MACHINES, OF WHICH THERE WERE MANY, ARE NOT INCLUDED)

Name	Manufacturer	Price
Bull Gamma 3	De La Rue Bull Machines Ltd.	£ 10,000
Bull Gamma C33	De La Rue Bull Machines Ltd.	£ 3,800
Bull Gamma G172	De La Rue Bull Machines Ltd.	£ 7,000
Bull Gamma G300	De La Rue Bull Machines Ltd.	£ 11,500
Bull Gamma G322	De La Rue Bull Machines Ltd.	£ 7,500
Deciplex	Southern Instruments Ltd.	
Deciplex K1011	Southern Instruments Ltd.	
Deciplex K1012-A	Southern Instruments Ltd.	
Deciplex K1013	Southern Instruments Ltd.	
IBM 602	IBM United Kingdom Ltd.	£ 5,000+
IBM 602A	IBM United Kingdom Ltd.	£ 5,000+
IBM 604	IBM United Kingdom Ltd.	£ 7,500+
IBM 609	IBM United Kingdom Ltd.	£ 14,000+
IBM 626	IBM United Kingdom Ltd.	£ 6,000
IBM 628	IBM United Kingdom Ltd.	£ 17,500+
IBM 632	IBM United Kingdom Ltd.	£ 2,500
IBM 644	IBM United Kingdom Ltd.	
IBM 3000	IBM United Kingdom Ltd.	
ICT 542	International Computers & Tabulators Ltd.	£ 8,100
ICT 544—EMP	International Computers & Tabulators Ltd.	
ICT 547—EMP	International Computers & Tabulators Ltd.	
ICT 548—EMP	International Computers & Tabulators Ltd.	
ICT 549—EMP	International Computers & Tabulators Ltd.	
ICT 550	International Computers & Tabulators Ltd.	£ 13,200
ICT 550/2	International Computers & Tabulators Ltd.	£ 13,200
ICT 555	International Computers & Tabulators Ltd.	£ 25,000
ICT 556—PCC	International Computers & Tabulators Ltd.	£ 20,000
ICT 557—PCC	International Computers & Tabulators Ltd.	
ICT 558	International Computers & Tabulators Ltd.	£ 15,100+
Univac 1004	Remington Rand Limited	£ 20,750+

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