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Sytze VAN HERCK

Born on 30 November 1993 in Leuven (Belgium)

**RE/CONSTRUCTING COMPUTING EXPERIENCES.
FROM “PUNCH GIRLS” IN THE 1940S TO “COMPUTER
BOYS” IN THE 1980S.**

Dissertation defence committee

Dr Andreas Fickers, dissertation supervisor
Professor, Université du Luxembourg

Dr Valérie Schafer, Chairwoman
Professor, Université du Luxembourg

Dr Martin Theobald, Vice-chair
Professor, Université du Luxembourg

Dr Sally Wyatt
Professor, Maastricht University

Dr Aristotle Tympas
Professor, University of Athens



Re/constructing Computing Experiences

From *punch girls* in the 1940s
to *computer boys* in the 1980s

Sytze Van Herck
Centre for Contemporary Digital History,
University of Luxembourg

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For Mare

Abstract

Re/constructing computing experiences from “punch girls” to “computer boys” traces the life cycle of five computing devices between the 1940s and the 1980s, each representing a key development in the history of computing. The experimental media archaeology framework of *Nutzerperspektiven* critically evaluates the type of user sources re/construct. The object’s life cycle traces phases of design, production, sale, installation, application and use, and decommission or re-use. The lens of intersectionality with a focus on gender facilitates (visual) discourse analysis of advertisements to expose stereotypes. User experiences differ because inequalities in computing have at times resulted in occupational segregation, and working conditions varied across case studies.

Computing experiences encompass the object, the environment, and application, and a user, serving as a structure for the case studies. The first case study discusses the accounting departments of Helena Rubinstein which used Remington Rand, and later Powers-Samas, punch card machinery since 1940. Miss Summerell led the Powers room in the London branch from 1955 onward. The second case study centers around a workflow Dr. E. Blatt created for the International Business Machines (IBM) System/360 announced in 1964 used in German clinical chemistry laboratories since 1969. The Digital Equipment Company’s client applications slides form the basis of the next case study and showed several uses of the Programmable Data Processor or PDP-11 in aerospace and commercial aircraft between 1970 and 1980. The final chapter compares

two educational initiatives from the 1980s. By 1981 the BBC Microcomputer kick started the Computer Literacy project in the United Kingdom, first targeting adults but soon entering primary and secondary schools. Apple's *Kids Can't Wait* initiative in the United States equally introduced many children to computing.

Methods from user experience (UX) design and experimental media archaeology supported the re/construction or reenactment of past human-computer interaction. As a study of material culture, the historical case studies were informed by museum objects paired with additional archival sources. The research added phases to the life cycle framework and paired a reflection on the provenance of material objects with a focus on human actors. The case studies in turn demonstrated how sources limited the type of user and computing experiences historians can re/construct.

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Preface

*One day with a great teacher is better
than a thousand days of diligent study*
– Japanese proverb

Some teachers inspire us to follow our passion and it is thanks to mr. Decat and Mrs. Van Gils that I went on to study history. At KU Leuven professor Meijns was such an amazing narrator that I decided to specialize in medieval history. Professor Haemers then taught us to look beyond the great men and heroic battles at ordinary people, shifting my focus to social history. During my one year stay at the Università di Bologna, I learned what role the economy has on our lives from professor Andreolli. Back in Leuven I chose to focus on women's lives and family marriage strategies with great advice from Dr. Bardyn. Then professor Bordalejo inspired me to continue my studies with a Master in Digital Humanities. Through our conversations I deepened my knowledge of gender as a social construct. I am deeply grateful to her for pushing me far out of my comfort zone and encouraging me to present at conferences.

Although the Master in Digital Humanities had a good gender balance, I was surprised by the predominance of male students and professors in computer science. So aside from learning practical skills such as information structures from professor Berendt and data visualisation from one of the best lecturers I know, professor Verbert, my personal experience of walking into the computer science building and feeling seen by

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a large crowd of mostly male, rather stereotypical, computer nerds or geeks motivated me to discover why such great female professors were mostly teaching a male crowd. Encouraged by professor Bordalejo I presented my research at the Digital Humanities Summer School at KU Leuven, where I struggled to answer professor Wyatt's critical questions, making her the ideal candidate for my PhD committee or *comité d'encadrement de thèse* (CET). Since I wanted to continue my research in Digital Humanities and gender, but with a return to my history background, the newly created Centre for Contemporary and Digital History (C²DH) was the ideal research institution for me. I want to thank professor Fickers for accepting my application to become part of the Doctoral Training Unit Digital History and Hermeneutics (DTU DHH) and for supervising this research. When professor Schafer joined the C²DH she taught me how to teach and shared my research interest for women and ICTs. I would like to thank her for her guidance and for presiding the jury during the defence.

Interdisciplinarity was central to the Master in Digital Humanities and the DTU DHH. One of the disciplines I embraced during this research was human-computer interaction (HCI) and user experience design (UX). So while professor Fickers shared his expertise in media history, the HCI team motivated me to focus on the user rather than the mere object. I used UX methods to reenact and capture the user experience. My colleague dr. Morse introduced me to his team led by dr. Lallemand and professor König. They allowed me to brainstorm about user experiments and gave valuable feedback. The original intent of the user experiments was to develop a crowdsourcing platform for people to share their experience with computing devices. I soon realised however that it takes time to build a crowd and that collaboration often works better in person than online. Based on the experience of my colleague dr. Lucchesi, it also became clear to me that managing the website was another full time job, especially since the IT department was already spread thin by other projects. Finally, the website was not the main focus of the research and the General Data Protection Regulation (GDPR) and copyright laws further made sharing sources too complicated for this side project. Nevertheless I learned to conduct user experiments, and three studies proved

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valuable to the research: museum observations, interviews with curators, and reenacting the user experience with the BBC microcomputer and the Apple IIe.

Acknowledgements

While it takes a village to raise a child, it takes a city to finish a PhD. In the next paragraphs I would like to acknowledge the institutions, events, and network behind the scenes.

Researching historical artefacts and especially ordinary objects such as computers means turning to institutions safeguarding this heritage from oblivion. The first museum I visited was the Centre for Computing History (CCH) in Cambridge led by Jason Fitzpatrick and sponsored by the founder of Acorn (see chapter 5) Herman Hauser. One of the volunteers, Adrien Page-Mitchell, gave me a great tour of the exhibitions with personal anecdotes and interesting stories about the origins and donors of both devices on display and in a nearby stockroom. His warm welcome and enthusiasm made me feel part of the team, and I gladly returned one year later for user tests and an interview with Jason Fitzpatrick. Though I will not list all individuals, I am grateful to the group of volunteers who kept the museum running and updated the online collection, thus supporting my research even from a distance.

Another helpful team of volunteers at The National Museum of Computing (TNMOC) helped me set up a visitor observation study on my first visit. During a second visit I discovered that some of the people I encountered in archival documents were the very same volunteers. Thank you Roger Moore for allowing me to put a face on a collaborator of the BBC Master Ecodisc. Please accept my apology for not writing about the Domesday project and other interactive videodiscs. I ran out of time and

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space to give the project its proper place in this dissertation. I am grateful to P.V., one of the early volunteers of TNMOC, for his enthusiastic stories about the Large Systems gallery and IBM restorations. The archivist Brian Aldous, made my short visit worthwhile by providing me with digitised images from Computer Weekly and pointing out an interesting Apple advertisement titled *Why every kid should have an Apple after school*.

Another set of documents about the process behind the development of the BBC Micro, was located in the BBC Written Archives Center (BBC WAC). Archivist Sean Vis helped me pair down the enormous amount of information and kindly allowed me to continue working for one additional week to finish going through most - not all - of the rich material.

The next set of transatlantic institutions required even more careful planning. First I would like to thank Sara Lott from the Computer History Museum (CHM) for pushing me to be more selective, thereby making me prioritise the archive material better. Processing archivist Sydney Olson helped me on-site and allowed me to come in early every day I was there, while also reassuring me about the grave wildfires in the area. The online collection and archival finding aids of the CHM were incredibly helpful, and composed with help from volunteers. I would also like to thank professor Schafer for introducing me to Marc Weber. From our interview I learned a lot about the CHM history, the *Revolution* exhibition, and the process of curating an online and on-site exhibition simultaneously.

Professor Fickers in turn told me about the Media Archaeology Lab (MAL) set up by professor Emerson at the University of Colorado Boulder. Kind strangers are often overlooked, but I am indebted to the military sergeant I met at Denver airport who shared his Uber with me during a snowstorm at 2 a.m. and the kind couple who drove me to the AirBnB safely. The next day, Dr. Libi Streigl and dr. Laura Hunjee Kim welcomed me and helped me set up the Apple IIe user experiment, even recruiting participants. Professor Emerson was kind enough to make time for an interview about this extraordinary lab and later to review my first book chapter and join the jury for my defence.

The final institution I visited in the United States unfortunately ceased to exist during the COVID pandemic. Nevertheless, Microsoft co-founder

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Paul Allen's collection in the Living Computers Museum+Labs (LCM+L) had an impressive *cold room* (see chapter 3) and several minicomputers running which offered me an insight to the sound and smell as well as the sensory experience of machines I had not yet seen in working order. Dorian Bowen prepared archival boxes for me at the last minute, and Dr. Moya was so kind to welcome me and make time for an interview. She described the sensory experience with such a rich vocabulary that I would never be able to recreate. Finally I am grateful to Amelia Roberts who helped me with inquiries while losing her job after the museum closed. I hope all the work of staff and volunteers will one day be restored and reopened for visitors and researchers.

Back in Europe I visited two German institutions: the Heinz-Nixdorf museumsForum (HNF) and the Deutsches Museum (DM). Dr. Stefan Stein told me more about the HNF collection and gave me a tour through the exhibition highlighting good and ethically questionable computer uses. I have not discussed the role of DeHoMag (the German International Business Machines (IBM) branch) in the holocaust, but it certainly deserves more attention. During a three month research trip I was able to study the IBM S/360 model 20 in detail thanks to funding from the DM *Forschungsinstitut für Technik- und Wissenschaftsgeschichte* (FTWG). Dr. Lorenz Kampshulte helped me prepare a museum observation study during my stay and the interview with curator dr. Dahlke offered me more insight into the history of the *Rechner* exhibit built in 1986. Professor Trischler and professor Hashagen gave me feedback during my stay and dr. Röschner helped me find archival documents about IBM for chapter 3.

Aside from the institutions holding research material, I would like to mention some of the most productive research environments and the people maintaining them. The C²DH open space, PhD meeting room, and lounge area allowed me to discuss ideas over coffee, attend lectures and meetings, and find a quiet spot to read. The DHLab was ideal for workshops and the HCI lab facilitated creativity and brainstorming. When the vibrant space distracted me, I enjoyed the silence and comfortable chairs at the Luxembourg Learning Centre (LLC). Co-writing sessions with dr. Fiscarelli were also more productive in the LLC's group work spaces. Thank

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Abbreviations

CET	<i>comité d'encadrement de thèse</i>
DM	<i>Deutsche Mark</i>
KCW	<i>Kids Can't Wait</i>
OED	<i>Oxford English Dictionary</i>
ABC	adopted BASIC for computer
AI	artificial intelligence
AP/FD	autopilot/flight director
BASIC	beginners' all-purpose symbolic instruction code
BBC	British Broadcasting Company
BBC WAC	BBC Written Archives Center
BSS	Broadcasting Support Services
BTM	British Tabulating Machine Company
C²DH	Centre for Contemporary and Digital History
CAD	computer-aided design
CAM	computer-aided manufacturing
CCH	Centre for Computing History
CCHa	CCH archive

Abbreviations

CDC	Control Data Corp.
CEO	chief executive officer
CET	Council for Educational Technology
CHM	Computer History Museum
CHMa	CHM archive
COBOL	common business-oriented language
CPU	central processing unit
CPU Ltd.	Cambridge Processor Unit Ltd.
CRT	cathode-ray tube
CTR	Computing-Tabulating-Recording Company
CUMG	Cambridge University Microprocessor Group
DEC	Digital Equipment Company
DECUS	Digital Equipment Computer Users Society
DES	Department of Education and Science
DM	Deutsches Museum
DMa	DM Archiv
DOS	disk operating system
DSHSS	Doctoral School of Humanities and Social Sciences
DTI	Department of Trade and Industry
DTU DHH	Doctoral Training Unit Digital History and Hermeneutics
EDP	electronic data processing
EIA	Electronic Industries Alliance
EPROM	erasable programmable read-only memory
ESER	<i>Einheitliches System Elektronischer Rechenmaschinen</i>
FA&T	Final Assembly and Test
FASoS	Faculty of Arts and Social Sciences
FORTTRAN	mathematical formula translating system

Abbreviations

FTWG	<i>Forschungsinstitut für Technik- und Wissenschaftsgeschichte</i>
GDPR	General Data Protection Regulation
GE	General Electric
GOÄ	<i>Gebührenordnung für Ärzte</i>
HCI	human-computer interaction
HNF	Heinz-Nixdorf museumsForum
HP	Hewlett-Packard
I.C.T.	International Computers and Tabulators Ltd.
I/O	input/output
IBM	International Business Machines
ICT	information and communication technology
IFPH	International Federation of Public History
INS	inertial navigation system
IRS	Internal Revenue Service
IT	Information Technology
JSON-LD	JavaScript object notation for linked data
LCM+L	Living Computers Museum+Labs
LCM+La	LCM+L archive
LD	linked data
LEAs	Local Education Authorities
LLC	Luxembourg Learning Centre
LSI	large-scale integration
MAL	Media Archaeology Lab
MECC	Minnesota Education Computing Consortium

Abbreviations

MEP	Microelectronics Education Programme
MFCU	multi-function card unit
MIT	Massachusetts Institute of Technology
MOS	metal-oxide semiconductor
MUSE	Micro Users in Secondary Education
NACA	<i>National Association of Cost Accountants Bulletin</i>
NASA	National Aeronautics and Space Administration
NCR	National Cash Register
NEC	National Extension College
NPL	new product line
OCR	optical character recognition
OEM	original equipment manufacturer
OPAC	online public access catalog
PC	personal computer
PDP	programmed data processor
RAM	random-access memory
RAMAC	random access method of accounting and control
RCA	Radio Company of America
ROM	read-only memory
RRCHNM	Roy Rosenzweig Center for History and New Media
RSTS	Resource Time Sharing System
S/360	System/360
SABRE	Semi-automated Business Research Environment
SAGE	Semi-Automatic Ground Environment
SAMAS	Société Anonyme des Machines à Statistiques

Abbreviations

SCOT	social construction of technology
SD-card	secure digital card
SIGCIS	Special Interest Group Computers in Society
SLT	Solid Logic Technology
SPREAD	Systems, Programming, Research, Engineering and Development
SSD	solid state drive
STS	science, technology and society
TMC	Tabulating Machine Company
TNMOC	The National Museum of Computing
TNMOCa	TNMOC archive
TROS	transformer read-only storage
TV	television
UNIVAC	Universal Automatic Computer
UX	user experience design
VAT	value-added tax
VDU	visual display unit
WRE	Weapons Research Establishment

Chapter 1

Introduction

On a cold Thursday afternoon in February, 1969, women seated at rows of International Business Machines (IBM) 24 Card Punches in one of the regional service centers of the Internal Revenue Service (IRS) in the United States were hard at work. One employee had just placed a new stack of controlled and completed 1040 forms on her desk and inserted a set of empty punch cards in the card hopper. The correct program was already in place, and after another drag of her cigarette a new card automatically transferred to the punching station. Carefully reading the tax form she started typing the gross income, tax withheld, and refund claimed. With each keystroke a column of holes was punched onto the card. Once the card was full the reading station duplicated some essential information before the card was added to the stack on the other end. The entire operation took her less than a minute. After an hour or so, she moved the finished cards and forms to another cart, ready for transport to the machine room, where they were transferred onto magnetic tape.¹

1. Original photo female Internal Revenue Service (IRS) worker use IBM keypunch

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The machine room contained a series of cabinet-size tape readers, printers and a control panel, making up one large computer system. However, not all computers would take up an entire room. A computer can in fact refer to three distinctly different meanings according to the *Oxford English Dictionary (OED)*, starting from “a person who makes calculations or computations [...],” to the device itself “performing or facilitating calculation,” and currently defined as a more elaborate electronic machine used to “store, manipulate, and communicate information, perform complex calculations, or control or regulate other devices.”² These three definitions chronologically describe the history of the computer from a human computer to the elaborate machines we now take for granted. However, these devices would not be of any importance without their users. As Grace Hopper pointed out: “I am pleased that history recognises the first to invent something, but I am more concerned with the first person to make it work.”³

The research questions revolve around the people (who?) and the process (how) throughout all stages of a computer’s life cycle, as visualised in figure 1.1. Who designed, produced, sold, or purchased, installed, used, or accessed a computer? How was a computing device announced, and who represented the user? How did a computer interface influence the user experience? The research compares both professional and educational computer applications over time and space. Eventually some computers were decommissioned, while others were reused in another context.

Often, the history of computing focused on inventors, companies and

machine for US Government, Feb 27, 1969, IBM Branch, Box 67, Living Computers Museum+Labs; Right on the Button, Department of the Treasury, Internal Revenue Service, ca. 1960 - ca. 1970, Motion Picture Films, Record Group 58, National Archives at College Park, <https://www.youtube.com/watch?v=10t0GRVGNXo>; Reference Manual IBM 24 Card Punch IBM 26 Printing Card Punch, Dec 1964, Harwood G. Kolsky papers, Lot X3021.2005, Box 08, Folder 03-22, Computer History Museum.

2. *computer*, n., accessed June 21, 2019, <http://www.oed.com/view/Entry/37975>.

3. Paul E. Ceruzzi, *A History of Modern Computing*, History of Computing (Cambridge, MA: MIT Press, 2012), 27.

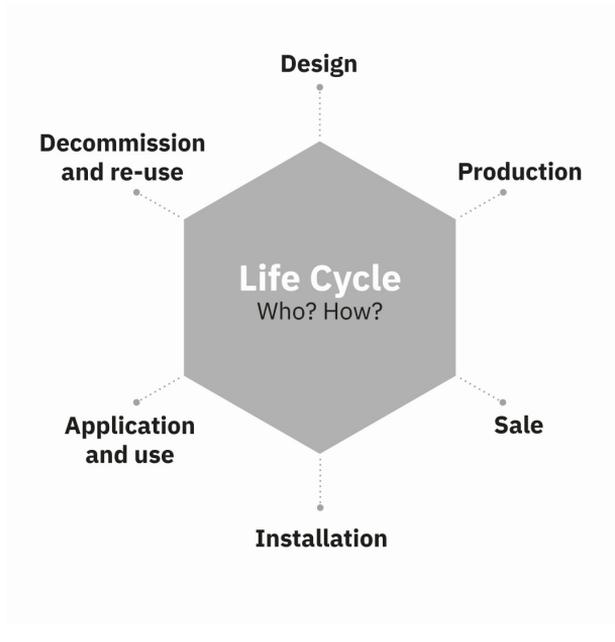


Figure 1.1: Computer life cycle model

their leaders, the development of computer architectures and innovations. Instead, I will pay attention to user groups that have been overlooked in the traditional historical narrative. Placing computers into a broader context, I focus on the societal, business, and labour developments at the basis of new computer models. The production, sales and installation is briefly touched upon, before discussing applications and uses of past machines. Furthermore, the thesis treats the emergence of new occupations or changes in existing labour structures in relation to computer models. I also study the influence of computers on both the work space and workflow of the user. Finally, I will look at sources such as advertisements in order to analyse the image of the idealised and archetype user, and influenced stereotypes of computing such as the *punch girl*, *geek*, and *hacker*.

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In current society, understanding past incentives for designing computers becomes increasingly important as technology permeates people's lives more and more. Historical research can assess the impact computers have had on people and society at large. Moreover, it can expose and counteract the image developed by advertisements of who can own or operate technology, and who cannot. My thesis broadens the narrative to include actors previously ignored. In order to retain a clear focus, the research is limited to five carefully selected case studies of particular computer models, and applications. The original intention was to select one case study for each decade. The timeline in figure 1.2 clearly shows that the first case study spans multiple decades, and the last two occurred in the same decade. Therefore, these two cases will be treated comparatively in a single chapter. Each case study centers around a type of computer and a particular computer model which sold in large numbers, rather than one-off designs for scientific or military organisations.

The story begins in 1940, when punch cards were well established and spread to applications beyond the United States census into the accounting department of companies such as Helena Rubinstein.⁴ In the 1960s computing really took off with the introduction of room-size computers. The System/360 (S/360) from the IBM corporation was announced in 1964 and installed by 1967 in large and middle-sized businesses, as well as clinical chemistry laboratories in Germany.⁵ At the same time, the Digital Equipment Company (DEC) added minicomputers such as the programmed data processor (PDP) to the market. The PDP-11 launched in 1970 in particular allowed large groups of people to directly interact with the machines.⁶ The research ends in the 1980s, with the introduction of a BBC microcomputer in 1981 developed by Acorn Ltd. in classrooms

4. Madame Helena Rubinstein: pioneer in beauty, research scientist, astute businesswoman, Remington Rand promotional and sales materials, 1940, David C. Faloon papers, Lot X3947.2007, Box 1, Computer History Museum.

5. IBM S/360-20 Main-Frame Computer, IBM Deutschland GmbH, 1967, Inventory Nr. 84/487:1-5, Deutsches Museum; Dr. E. Blatt, *Datenverarbeitung im Klinisch-Chemischen Laboratorium* (IBM, 1969), Folder 05, IBM Firmenschriften.

6. Ceruzzi, *A History of Modern Computing*, 124.

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throughout the United Kingdom. The BBC Micro will be compared to the Apple IIe, a personal computer from 1983 that was used in classrooms in the United States.⁷

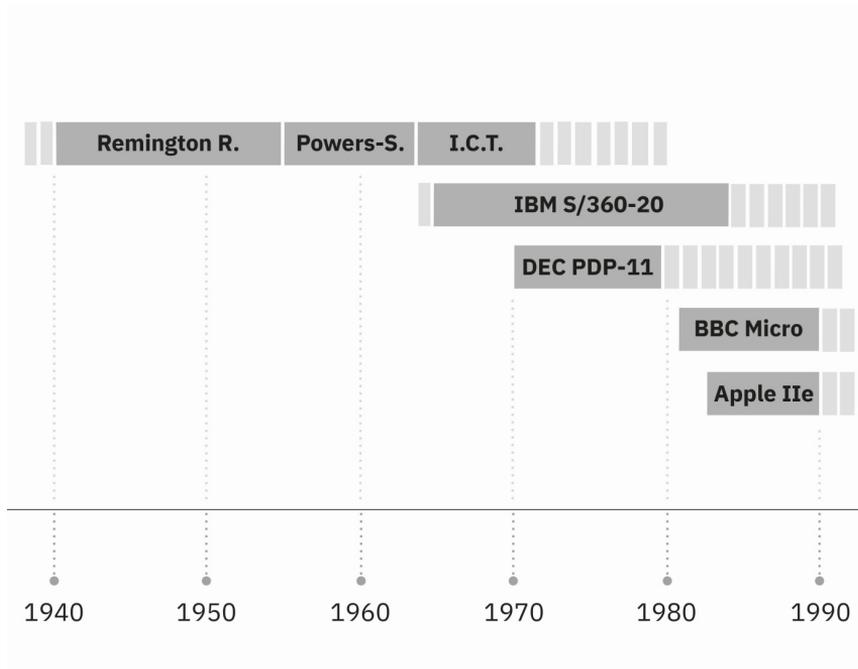


Figure 1.2: Timeline

In short, the research looks into changes and continuity in computer devices, users, and applications, between the 1940s and 1980s. Each case study discusses workforce composition and the emergence of new occupations in relation to the introduction of particular computing devices. Next, the research focuses on the working conditions such as room

7. Classrooms of BBC Micro's have been reconstructed at The National Museum of Computing (TNMOC) and the Centre for Computing History (CCH) in the United Kingdom. In the United States a classroom of Apple IIe's was on display at the Living Computers Museum + Labs (LCM+L) in November 2018.

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size, heat, noise, machine size, office type, as well as the evolution of the work flow. Finally, each chapter ends by answering the question: how does media representation of technology and its users influence gender stereotypes in computing?

1.1 Does Technology Drive History?

The next sections treat the literature review and important concepts that form the theoretical framework for the dissertation. I start from the key question at the basis of the history of technology: “Does technology drive history?”⁸ As a reaction to the traditional narrative focused on inventors, the field of science, technology and society (STS) emerged in the 1980s and developed three theories on the driver of technological change: technological determinism, technology as neutral, and technological constructivism or the social construction of technology (SCOT). After explaining these rather abstract theories from sociology, I introduce a short overview of the history of computing focusing on key developments in the computer industry. The field of human-computer interaction (HCI) equally emerged in the 1980s and places the user firmly at the center of the design process. Both research in STS and HCI began in the 1980s when the PC was introduced. Research does not stand alone in a vacuum outside of society. Both in the 1980s and now, the ubiquity of technology shapes the interpretation of the past. Sociologists and media archaeologists have defined several user perspectives which guide the research towards particular sources that in turn limit the potential analysis of different types of users. Users are often defined by their demographics and the theoretical lens of intersectionality can aid in understanding constructed identities often at the basis of stereotypes shown in advertisements. Furthermore, computer advertisements are analysed with a particular focus on gender stereotypes, so the section on intersectionality includes

8. Merritt Roe Smith and Leo Marx, *Does Technology Drive History? The Dilemma of Technological Determinism* (Cambridge, MA: MIT Press, 1994), <https://books.google.lu/books?id=WWztFfsA-QEC>.

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a separate part about gender. Before moving on to the methodology and sources, a final section of the literature review highlights several studies on the inequality found in computing providing a background for the evolution of the labour market parallel to changes in computer technology.

Previously I referred to three meanings of the term computer ranging from human computers, over simple calculation devices, to a more complex machine. The final definition of interest to this dissertation refers to a computer as follows:

An electronic device (or system of devices) which is used to store, manipulate, and communicate information, perform complex calculations, or control or regulate other devices or machines, and is capable of receiving information (data) and of processing it in accordance with variable procedural instructions (programs or software).⁹

However, the focus of this dissertation will move away from programming languages and software studies. Instead the companies designing and producing computer hardware, and the evolution of computer users and applications will take centre stage. Who designs the technology, who builds it and who uses it? In what context did the design and implementation of computers arise?

Before the computer even existed, people have asked themselves: does technology drive history? Certain narratives centring around hardware development focused on great inventors and theorists, or on the rise and fall of corporations, and have formed the basis of the history of technology, and computing in particular.¹⁰ Criticism on the historical approach revolving around single individuals has come from both gender and social studies, and from the field of STS.¹¹ Sociologists Donald

9. *computer, n.*

10. Ceruzzi, *A History of Modern Computing*.

11. Donald A. MacKenzie and Judy Wajcman, *The Social Shaping of Technology*, 2nd ed. (Milton Keynes: Open University Press, 1999), 10-13; Michel Callon, "Society in the Making: The Study of Technology as a Tool for Sociological Analysis," in *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*,

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MacKenzie and Judy Wajcman argue against the individualistic *great inventor* approach.

New technology, then, typically emerges not from flashes of disembodied inspiration but from existing technology. Even what we might with some justification want to call revolutions in technology often turn out to have been long in the making.¹²

Once we establish that technological change is not independent from society, we need to ask ourselves what lies at the basis of technological change. MacKenzie and Wajcman argue that existing technology actively shapes new technology, supporting their claim with the idea of a technological system.¹³

The technological system is what Thomas Hughes defines as socially constructed and shaping society, where a system contains physical artefacts, organisations, scientific components (books, articles, university programs), legislative artefacts and natural resources or building blocks.¹⁴ He distinguishes seven phases in the history of evolving systems: invention, development, innovation, transfer, growth, competition, and consolidation.¹⁵ These phases are not necessarily sequential and can occur in any order.¹⁶ An important term coined by Hughes called the *reverse salient* stems from uneven development, an area where technology growth seems to lag behind, which provides inventors with an incentive to correct the situation.¹⁷

ed. Wiebe E. Bijker, Thomas P. Hughes, and Trevor J. Pinch (Cambridge, MA: MIT Press, 1987), 83–103.

12. MacKenzie and Wajcman, *The Social Shaping of Technology*, 12.

13. MacKenzie and Wajcman, *The Social Shaping of Technology*, 13.

14. Thomas P. Hughes, “The Evolution of Large Technological Systems,” in *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, ed. Wiebe E. Bijker, Thomas P. Hughes, and Trevor J. Pinch (Cambridge, MA: MIT Press, 1987), 56.

15. Hughes, “The Evolution of Large Technological Systems,” 56.

16. Hughes, “The Evolution of Large Technological Systems,” 57.

17. MacKenzie and Wajcman, *The Social Shaping of Technology*, 17.

The process of the adoption of technology tends to improve the performance of the technology adopted, which leads to the assertion that past events continue to influence future developments.¹⁸ The history of technology can therefore be studied as a path-dependent history. For instance a *QWERTY keyboard* used in mechanical typewriters to prevent keys from being stuck together has persisted in electronic keyboards even though this keyboard layout was no longer necessary.¹⁹

1.1.1 Science, Technology and Society

The traditional narrative focused on inventors and technical innovation does not take into account how technology relates to the surroundings and society at large. In the framework of STS several positions emerged during the 1980s in the subfield of the sociology of technology.²⁰ One common perception states that social change is driven by technology-centred processes, a view that is often named technological determinism.²¹ Although technological determinism is asking a good question, “its typical assumption that technological change is an independent factor” provides an oversimplified answer.²² In the section below I will discuss two additional points of view, namely technology as neutral, and constructivism.

18. MacKenzie and Wajcman, *The Social Shaping of Technology*, 34.

19. MacKenzie and Wajcman, *The Social Shaping of Technology*, 35.

20. Stephen H. Cutcliffe, *Ideas, Machines, and Values: An Introduction to Science, Technology, and Society Studies* (Lanham: Rowman & Littlefield, 2000), 29, <https://books.google.lu/books?id=p1by0bBfL4cC>. This “turn to technology” came back into focus after the publication of two influential studies: Donald A. MacKenzie and Judy Wajcman, *The Social Shaping of Technology: How the Refrigerator Got Its Hum* (Milton Keynes: Open University Press, 1985); Wiebe E. Bijker, Thomas P. Hughes, and Trevor J. Pinch, eds., *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, MA: MIT Press, 1987).

21. Langdon Winner, “Where Technological Determinism Went,” in *Visions of STS: Counterpoints in Science, Technology, and Society Studies*, ed. Stephen H. Cutcliffe and Carl Mitcham (Albany, NY: SUNY Press, February 2001), 11–18.

22. MacKenzie and Wajcman, *The Social Shaping of Technology*, 5.

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Paradoxically, then, the compelling nature of much technological change is best explained by seeing technology not as outside of society, as some versions of technological determinism would have it, but as inextricably part of society.²³

Since the process of technological change does not occur in isolation of society, it is important to understand the relation between technology and the social and economic context and how this affects equality and inequality. However, social scientists and social theorists differ in their approach towards inequality.²⁴

Social scientists study economic and social inequalities based on collectivities such as class, gender and ethnicity, whereas social theorists under influence of postmodernism focus on “identities, subjectivities, and individual agency.”²⁵ The first approach towards the relationship between technology and society is technological determinism and assumes that technologies emerge from nowhere and transform society which leaves “no space for human choice or invention and, moreover, absolves people from responsibility for the technologies they make and use.”²⁶ The second approach considers technology as neutral and asserts that people choose how they use technology, which still implies that the origins of technologies are not problematised. The third approach of constructivism effectively argues that technologies are “constituted by political, economic and cultural processes.”²⁷

The approach of technological constructivism, also referred to as SCOT, has been widely adopted.²⁸ Yet critics have pointed out serious limita-

23. MacKenzie and Wajcman, *The Social Shaping of Technology*, 20.

24. In addition to the social and economic context, the political climate also influences technology as demonstrated in Paul N. Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America*, ed. Wiebe E. Bijker, Trevor Pinch, and Rebecca Slayton, *Inside Technology* (Cambridge, MA: MIT Press, April 1996).

25. Flis Henwood et al., “Critical Perspectives on Technologies, In/equalities and the Information Society,” in *Technology and In/equality: Questioning the Information Society*, ed. Sally Wyatt et al. (London: Routledge, 2000), 7.

26. Henwood et al., “Critical Perspectives,” 9-10.

27. Henwood et al., “Critical Perspectives,” 10.

28. Langdon Winner mentions Harry M. Collins, Trevor Pinch, Wiebe Bijker, Donald

tions to this approach as well. Langdon Winner lists four.

- (1) a disregard for the social consequences of technological choice in focusing on the origins of technology,
- (2) a focus on relevant social actors often ignoring those without a voice yet affected by technology and disregarding back-stage decisions,
- (3) they overlook deeper cultural, intellectual, or economic origins of social choices about technology and
- (4) an interpretive flexibility preventing any moral stance.²⁹

Although the source material does not always allow me to respond to this critique, the research will pay attention to the social consequences (1) especially in regards to workforce composition and working conditions after the introduction of new technology (2). A thorough contextualisation of each computer model should describe the cultural, intellectual, or economic motives behind their different applications (3), also to some extent visible through stereotypes in media representation. A moral stance (4) however, would be inappropriate in a historical dissertation, and more suited for an essay.

1.1.2 The History of Computing

The earliest devices studied in this research are punch card machines which have traditionally been used at the US Census Bureau even before the start of the twentieth century.³⁰ Herman Hollerith, a former employee of the United States Census Bureau, patented two tabulating sys-

MacKenzie, Steven Woolgar, Bruno Latour, Michel Callon, Thomas Hughes and John Law in his critique. Langdon Winner, "Upon Opening the Black Box and Finding It Empty: Social Constructivism and the Philosophy of Technology," *Science, Technology, & Human Values* 18, no. 3 (1993): 364, <https://doi.org/10.1177/016224399301800306>.

29. Winner, "Upon Opening the Black Box and Finding It Empty."

30. Leon E. Truesdell, *The Development of Punch Card Tabulation in the Bureau of the Census 1890-1940 with Outlines of Actual Tabulation Programs* (Washington, DC: U.S. Government Printing Office, 1965), <https://books.google.be/books?id=MGZqAAAAMAAJ&dq>.

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tems over the course of the 1880s.³¹ His original Tabulating Machine Company (TMC) incorporated in 1886 was sold, merged and renamed to the Computing-Tabulating-Recording Company (CTR) Company by 1911 and again changed under Thomas J. Watson Sr. in 1924 to the International Business Machines (IBM).³² By the start of the twentieth century, the punch card machines were transformed to offer an integrating tabulator for accounting operations, effectively adapting the machine for commercial use.³³ The introduction of punch card machines and tabulating equipment changed the composition of the clerical work force, giving rise to the occupation of key punch operators, sometimes referred to as *punch girls*.³⁴ Although employment in clerical occupations doubled between 1960 and 1981, some categories of jobs such as tabulating machine operators disappeared by 1976. In the insurance industry for example, electronic data processing (EDP) related occupations such as programmers and system analysts which were male dominated expanded, however “keypunchers and computer operators expanded after 1961, but leveled off [as systems improved].”³⁵ Overall, the “transition to an automated office results in greater technical and bureaucratic control, as well as in general deskilling.” Heightened control can be manifested in “narrowed skills, increased surveillance and machine monitoring,” as well as “less control over personal space and movement, greater

31. In 1884 he applied for a system using punched paper tape, followed by a card-based system in 1887. Martin Campbell-Kelly, “Punched-Card Machinery,” in *Computing Before Computers*, ed. William Aspray (Iowa State University Press, 1990), 124.

32. Campbell-Kelly, “Punched-Card Machinery,” 135-137.

33. Campbell-Kelly, “Punched-Card Machinery,” 145.

34. See for instance the foreword and the chapter by Thomas Haigh including the analysis of a subversive advertisement titled “The Key-Punch Girls” in Thomas J. Misa, *Gender Codes: Why Women Are Leaving Computing* (Hoboken, NJ: John Wiley & Sons, 2010), x, 62-63, <https://doi.org/10.1002/9780470619926>.

35. Roselyn L. Feldberg and Evelyn Nakano Glenn, “Technology and Work Degradation: Effects of Office Automation on Woman Clerical Workers,” in *Machina Ex Dea: Feminist Perspectives on Technology*, The Athene Series (New York: Pergamon Press, 1983), 62-63.

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standardisation in work, and a heightened division of labor.”³⁶ In a bibliography about the *History of Computing, Computers and the Information Processing Industry*, James Cortada categorises literature on punch card applications into commercial and scientific domains. The entries paint a clear image of the commercial uses of punch cards first in the 1920s and 1930s when accounting far outnumbered other applications, closely followed by the railroad industry and inventory control. Although punch cards in the 1940s were still prominent in accounting, business applications in manufacturing, payroll and personnel departments, as well as sales were on the rise. Furthermore, utility companies expanded their use of punch card equipment in the gas, fuel (including mining and petroleum), water and electricity industry. Scientific applications in the 1930s and 1940s were mostly limited to mathematics and the natural sciences.³⁷ Section 2.2 discusses the use of punch cards in accounting, as one of the most popular applications.

During and after the second World War the stored-program principle where both instructions and data were stored together formed the basis of the general-purpose computers.³⁸ The computer industry of the 1950s and 1960s was known as *IBM and the Seven Dwarfs*, being Burroughs, Control Data Corp. (CDC), General Electric (GE), Honeywell, National Cash Register (NCR), Radio Company of America (RCA) and Universal Automatic Computer (UNIVAC).³⁹ Military and governmental interest was often crucial to overcome economic barriers to create such large

36. Valerie Carter, “Office Technology and Relations of Control in Clerical Work Organization,” in *Women, Work, and Technology: Transformations*, ed. Barbara Drygulski Wright, Myra Marx Ferree, and Gail O. Mellow, Women and Culture Series (Ann Arbor: University of Michigan Press, 1987), 207.

37. James W. Cortada, *A Bibliographic Guide to the History of Computing, Computers, and the Information Processing Industry* (Westport, CT: Greenwood Press, 1990).

38. Ceruzzi, *A History of Modern Computing*, 16-21.

39. J. Gregory and Fritz Barkley, “The Early Computer Industry,” in *50 Years of Army Computing: From ENIAC to MSRC*, ed. Thomas J. Bergin, A Record of a Symposium and Celebration November 13 and 14, 1996 (Aberdeen Proving Ground: DIANE Publishing, 2000), 83, https://books.google.lu/books?id=iAr_Z1B494MC.

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general-purpose computers.⁴⁰ In Germany a new calibration law encouraged clinical laboratories to incorporate computer systems as discussed in section 3.3. Fortunately, healthcare institutions could afford a small general-purpose computer, or connect to larger installations over telephone lines.

The change from batch operating in mainframes to the minicomputer as a personal interactive design are often attributed to the Apollo mission at NASA and its tight deadline.⁴¹ Section 4.2 indeed looks into the use of minicomputers in the aerospace and commercial aircraft industry. The minicomputer introduced engineers, scientists and others to direct interaction with computers.⁴² The main characteristics of a minicomputer were its architecture, size, and price.⁴³ The PDP from the DEC did not only reduce costs by allowing direct memory access, but by publishing specifications and distributing them widely, they encouraged modification by customers, since they could not afford to develop installation hardware or software.⁴⁴

In order to move from mini- to microcomputers and later the personal computer, several developments and forces needed to converge. On the technical level, Ceruzzi identifies microprocessors and memory chips with more capacity developed by semiconductor engineers, in combination with users advocating for public access to computing as the basis of the evolution towards the personal computer.⁴⁵ Intel designed the silicon microprocessor in 1971 after a request from Busicom, a Japanese company specialised in handheld calculators.⁴⁶ Hobbyists then made these microprocessor-based systems practical, for example building their own personal minicomputer encouraged by the July 1974 issue of *Radio-Electronics*.⁴⁷

40. MacKenzie and Wajcman, *The Social Shaping of Technology*, 26.

41. Ceruzzi, *A History of Modern Computing*, 124.

42. Ceruzzi, *A History of Modern Computing*, 24.

43. Ceruzzi, *A History of Modern Computing*, 125.

44. Ceruzzi, *A History of Modern Computing*, 127-129.

45. Ceruzzi, *A History of Modern Computing*, 211.

46. Ceruzzi, *A History of Modern Computing*, 218.

47. Ceruzzi, *A History of Modern Computing*, 224.

The so-called first personal computer was designed by Edward Roberts of the Altair, around the Intel 8080 microprocessor that cost less than \$400.⁴⁸ This machine was not very reliable nor well-designed, but since the specifications were not a company secret, others could improve on it and make their own compatible cards and computers.⁴⁹ By the 1980s personal computers were used in education as section 5.3 discusses.

1.1.3 Human-Computer Interaction

The research area of human-computer interaction (HCI) shifts focus away from the general relation between society and technology towards the interaction between the users and the computer.⁵⁰ The user of the technology has been identified in many ways. Steve Woolgar speaks of configuring the user or defining the identity of imagined users, constraining potential future actions.⁵¹ Whereas Akrich envisions a script or scenario inscribed in technology that attributes “specific competencies, actions, and responsibilities to users and technological artefacts.”⁵² Since users are a heterogeneous group, “designers will, consciously or unconsciously, privilege certain representations of users and use over others.”⁵³

Before the emergence of the HCI research area in the early 1980s, computer specialists themselves made design decisions based on their

48. Ceruzzi, *A History of Modern Computing*, 226.

49. Ceruzzi, *A History of Modern Computing*, 229.

50. John M. Carroll, *Human Computer Interaction*, ed. Mads Soegaard and Rikke Friis Dam, 2013, 21, <https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/human-computer-interaction-brief-intro>.

51. Steve Woolgar, “Configuring the User: The Case of Usability Trials,” in *A Sociology of Monsters: Essays on Power, Technology and Domination*, ed. John Law (London: Routledge, 1991), 59.

52. Madeleine Akrich, “The De-Description of Technical Objects,” in *Shaping Technology/Building Society: Studies in Sociotechnical Change*, ed. Wiebe E. Bijker and John Law (Cambridge, MA: MIT Press, 1992), 207-208.

53. Nelly Oudshoorn and Trevor Pinch, *How Users Matter: the Co-Construction of Users and Technology*, Inside Technology (Cambridge, MA: MIT Press, 2005), 10.

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own ideas of future users. Some even used the I-methodology and envisioned users based on their own experience, making design choices according to their own references.⁵⁴ Furthermore, a designer's own identity is often reflected in the design.⁵⁵ The discourse of designers exposes their prejudices in user configuration and illustrates which users they privilege.

Sociologists and media archaeologists have tried to identify several 'ideal' types of users as concepts to guide research. Andreas Fickers, for example, has identified eight *Nutzerperspektiven*, namely the imagined user, the configured user, the expert user, the amateur user, the remembered user, the re-enacted user, the artistic user, and the simulated user.⁵⁶ Since the research is not concerned with the imagined user, the artistic user, and the simulated user, table 1.1 only contains five user perspectives. Furthermore, the table contains a description or characterisation of each user type, as well as a list of general sources that might mention such users.

In the design, development, and marketing, the configured user becomes most prominent and can be derived from sources such as advertisements, the discourse in user manuals, and descriptions in patents. Furthermore, table 1.1 separates the expert and amateur user mostly based on the difference between the assessment of potential use and forms of actual appropriation. I suggest to group the users included in technical literature, amateur and expert magazines under the term *everyday user*. The everyday user refers to users who adopt technology in their everyday life, which "denotes the routine activities of human existence,

54. Els Rommes, Ellen Van Oost, and Nelly Oudshoorn, "Gender in the Design of the Digital City of Amsterdam," *Information, Communication & Society* 2, no. 4 (January 1999): 476–495, <https://doi.org/10.1080/136911899359510>.

55. Nelly Oudshoorn, Els Rommes, and Marcelle Stienstra, "Configuring the User as Everybody: Gender and Design Cultures in Information and Communication Technologies," *Science, Technology, & Human Values* 29, no. 1 (January 2004): 30–63, <https://doi.org/10.1177/0162243903259190>.

56. Andreas Fickers, "Hands-on! Plädoyer für eine experimentelle Medienarchäologie," *Technikgeschichte* 82, no. 1 (2015): 70–71, <https://orbilu.uni.lu/handle/10993/21281>.

including at work, at home, or in leisure time.”⁵⁷

User Perspectives	Characterisation	General Sources
Configured User	User strategies defined by industry, manufacturer or marketing department and staged in advertising.	Advertising, user manuals, patents.
Experts	Scientific-objective assessment of potential uses (objective promise of performance) based on expert discourse.	Technical literature, product testing magazines, consumer magazines, blogs.
Amateurs	Forms of actual appropriation and use tactics discussed in exchange-oriented publications.	Amateur magazines, fan sites, blogs, how-to manuals/videos, club magazines.
Remembered User	Memories of use co-constructed in oral history interviews or subjective descriptions of user experiences recorded in ego documents.	Oral history interviews, diaries, ego documents, questionnaires.
Re-enacted User	Artificially staged experiments of appropriation and use; making tacit knowledge explicit by reconstruction.	Objects, devices, reconstructions, ethnographic records, scripts, laboratory notes.

Table 1.1: User types defined by Andreas Fickers, “Hands-on! Plädoyer für eine experimentelle Medienarchäologie,” *Technikgeschichte* 82, no. 1 (2015): 70-71.

Margrethe Aune identifies four phases in the process of domesticating technology or how “technology is adapted to everyday life [and] everyday life’s adaption to the technology”: appropriation, objectification, incorporation, and conversion.⁵⁸ Appropriation refers to the reason for acquiring a computer, whereas objectification studies how a user perceives the computer and the physical location of the object. Incorporation demon-

57. Merete Lie and Knut H. Soerensen, eds., *Making Technology our own? Domesticating Technology into Everyday Life*, 2nd ed. (Oslo: Scandinavian University Press, 2002).

58. Margrethe Aune, “The Computer in Everyday Life: Patterns of Domestication of a New Technology,” in *Making Technology our own? Domesticating Technology into Everyday Life*, 2nd ed., ed. Merete Lie and Knut H. Soerensen (Oslo: Scandinavian University Press, 2002), 93-94.

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strates the impact of a computer on patterns of use, whereas conversion refers to the values and culture of the user presented to the world.⁵⁹

The remembered and re-enacted users reflect on, or reconstruct their past experience of working with computers. First and foremost, the remembered user appears in the research through existing oral history interviews and museum observations.⁶⁰ Second, I will include re-enacted users through experiments with preserved and operational computers maintained and accessible in museums and labs. Although user types are idealised versions of actual users, they can point out some interesting differences in the perception and use of computing devices. In addition, some of the facets of the identity of an ideal or real user, can be found in the intersectionality framework explained next.

1.1.4 Intersectionality and Gender

Stereotypes in the media representations of computer users in particular function mostly in a framework of intersectionality, a concept developed by Kimberlé Crenshaw in her study of violence against women of colour.⁶¹ The *OED* defines the sociological use of intersectionality as:

The interconnected nature of social categorisations such as race, class, and gender, regarded as creating overlapping and interdependent systems of discrimination or disadvantage; a theoretical approach based on such a premise.⁶²

Constructions of identity need to acknowledge intragroup differences. Furthermore Crenshaw distinguishes structural, political, and represen-

59. Aune, "Computer in Everyday Life," 95.

60. For instance from one of the following collections: *Archives of IT*, <https://archivesit.org.uk/>; *Oral Histories*, accessed November 22, 2021, <https://computerhistory.org/oral-histories/>; *Oral History of British science*, accessed November 22, 2021, <https://sounds.bl.uk/Oral-history/Science>.

61. Kimberle Crenshaw, "Mapping the Margins: Intersectionality, Identity Politics, and Violence against Women of Color," *Stanford Law Review* 43, no. 6 (1991): 1241–1299, <https://doi.org/10.2307/1229039>.

62. *intersectionality, n.*, 2015, <https://www.oed.com/view/Entry/429843>.

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tational intersectionality focusing on institutions, political affiliations and discourse respectively.⁶³ As Roopika Risam explains in *Beyond the Borders* intersectionality can provide the necessary framework to “identify strategies for greater intellectual diversity in the field.”⁶⁴ Furthermore, “as a lens for scholarship in the digital humanities, intersectionality resists binary logic, encourages complex analysis, and foregrounds difference.”⁶⁵ Therefore, intersectionality forms the theoretical framework for the influence of media representation of technology and its users on gender stereotypes in computing.

In my research, gender refers to the psychological and sociological use of the term which originated in the United States, and is defined by the *OED* as follows:

The state of being male or female as expressed by social or cultural distinctions and differences, rather than biological ones; the collective attributes or traits associated with a particular sex, or determined as a result of one’s sex.⁶⁶

In order to understand how we think about gender, gender theorists study “how binaristic understandings of femininity and masculinity shape the ways we perceive gender, and how the assumption of heterosexuality determines the ways we constitute that femininity and masculinity.”⁶⁷ Individuals get an assigned place in a binary structure of gender, which in Western societies often privileges the male over the female.⁶⁸ Gender can also be analysed through the feminist lens where gender is treated as the cultural or social construction of sex, whereas sociology and anthropology understand gender as a set of meanings that sexes assume in

63. Crenshaw, “Mapping the Margins.”

64. Roopika Risam, “Beyond the Margins: Intersectionality and the Digital Humanities,” *DHQ: Digital Humanities Quarterly* 9, no. 2 (January 2015): 3, <http://www.digitalhumanities.org/dhq/vol1/9/2/000208/000208.html>.

65. Risam, “Beyond the Margins,” 3.

66. *gender*, n., 2011, <https://www.oed.com/view/Entry/77468>.

67. Anne Cranny-Francis, Wendy Waring, and Pam Stavropoulos, *Gender Studies: Terms and Debates* (Basingstoke: Palgrave, 2003), ix.

68. Cranny-Francis, Waring, and Stavropoulos, *Gender studies*.

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particular societies.⁶⁹ In addition to gender, other factors of intersectionality such as sexuality, ethnicity, nationality, race and class will be taken into account.

1.1.5 Inequality in Computing

Inequality in computing can be studied on several levels, not in the least at the level of financial, physical and occupational access to computing. Sally Wyatt and Graham Thomas studied access, usage and control of the internet and suggest “that inequalities in consumption patterns are not only a function of, inter alia, place, education, race, income and gender, but are also bound up with the structures of the production of the Internet itself.”⁷⁰ Too often researchers assume a trickle-down or catch-up vision where the initial inequalities of access and use disappear or reduce after the establishment of a technology.⁷¹ The trickle-down theory however displays three main fallacies, since growth is not evenly distributed, does not continue and does not imply a decrease in inequality.⁷²

When people enter the labour market, inequality presents itself mostly in terms of occupational segregation. One model to understand an occupation’s composition is the dual-queuing process described by Barbara Reskin and Patricia Roos. In this model labour queues indicate how employers rank groups of employees in terms of preferability, and job queues describe how employees rank jobs in terms of attractiveness.⁷³ In this dynamic we can also understand how the gender balance changed for the field of computing over the last century.

69. Cranny-Francis, Waring, and Stavropoulos, *Gender studies*.

70. Graham Thomas and Sally Wyatt, “Access is not the only Problem: Using and Controlling the Internet,” in *Technology and Inequality: Questioning the Information Society*, ed. Sally Wyatt et al. (London: Routledge, 2000), 23.

71. Thomas and Wyatt, “Access is not the only Problem,” 27.

72. Thomas and Wyatt, “Access is not the only Problem,” 27-31.

73. Barbara F. Reskin and Patricia A. Roos, *Job Queues, Gender Queues: Explaining Women’s Inroads Into Male Occupations*, *Women in the Political Economy* (Philadelphia: Temple University Press, 1990), 29, https://books.google.lu/books?id=aZJGo_3sInIC.

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In the 1940s, computer operation and programming was viewed as women's work - but by the 1960s, as computing gained prominence and influence, men displaced the thousands of women who had been pioneers in a feminized field of endeavor, and the field acquired a distinctly masculine image.⁷⁴

This change in perception and composition of computer operation and programming occurred in both British and American projects, employing women first as human computers performing manual calculations and later as computer operators and programmers.⁷⁵ Yet from the mid-1960s onward, "labor shortages first helped women stay in the field, then eventually removed them from it" as a consequence of the rise in status and pay.⁷⁶

Despite women entering the field of computing in the 1970s and 1980s, they constituted less than one-third of the entire workforce.⁷⁷ They only entered specific computer occupations including as system analysts, programmers, operators, and data-entry operators and were employed in "lower-paid specialties, while men monopolized the higher-paid jobs."⁷⁸ Employers resorted to women because of a shortage of male computer specialists during the 1970s, which was exacerbated by men leaving the occupation due to declining rewards.⁷⁹ On the one hand, the increased need for "people" skills of system analysts traditionally associated with women, probably encouraged employers to hire women instead of men.⁸⁰ Women on the other hand were drawn to the field of systems analysis be-

74. Marie Hicks, *Programmed Inequality: How Britain Discarded Women Technologists and Lost Its Edge in Computing* (Cambridge, MA: MIT Press, 2017), 1.

75. Hicks, *Programmed Inequality*, 21.

76. Hicks, *Programmed Inequality*, 102.

77. Katherine M. Donato, "Programming for Change? The Growing Demand for Woman Systems Analysts," in *Job Queues, Gender Queues: Explaining Women's Inroads Into Male Occupations*, ed. Barbara F. Reskin and Patricia A. Roos, *Women in the Political Economy* (Philadelphia: Temple University Press, 1990), 170.

78. Donato, "Woman System Analysts," 170, 182.

79. Donato, "Woman System Analysts," 181.

80. Donato, "Woman System Analysts," 181.

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cause of “growing job opportunities and projections of continued growth and by the rewards that the occupation offers.”⁸¹

1.2 Re/constructing Computing Experiences

Computers, users, and applications have evolved between the 1940s and the 1980s. Applications were no longer limited to the military, scientific, and government domain. By the end of the 1980s, computers had permeated society and people of all ages, experts and amateurs, started using computers in their everyday lives. Since the research covers such a diverse and vast array of machines, users, and applications, the scope needs to be clearly delineated.

This research approach “(1) adapts both a retro and current view of a case or case studies, (2) incorporates existing data sources and develops new ones, and (3) generates both specific and general types of knowledge.”⁸² In general, case studies lend themselves well to exploratory research of a general phenomenon, yet still provide in depth knowledge and can potentially uncover causal relations.⁸³ Michael M. Widdersheim distinguishes between studies of the distant past (history), and those of the present (case study), which in turn rely on different types of sources and result in other types of knowledge. In reality such a strict separation between past and present is unnecessary, especially since the historical case study research strategy combines both. The main difference between the two lies in the availability of and approach to sources.

History as a research strategy “relies on archival documents to describe and explain phenomena from a time that can no longer be observed directly or from which few if any observers still exist,” and results in unique

81. Donato, “Woman System Analysts,” 181.

82. Michael M. Widdersheim, “Historical Case Study: A Research Strategy for Diachronic Analysis,” *Library and Information Science Research* 40, no. 2 (2018): 144, <https://doi.org/10.1016/j.lisr.2018.06.003>.

83. John Gerring, *Case Study Research: Principles and Practices* (Cambridge: Cambridge University Press, 2007), quoted in Widdersheim, “Historical Case Study,” 145.

or ideographic knowledge “specific to a particular case or cases.”⁸⁴ Case studies however, rely “on existing documents such as reports or source materials,” but they also “generate new source materials such as interview transcripts, survey responses, and fieldwork notes from first-hand observations.”⁸⁵ My research falls into the categories of a comparative case study and of comparative history, therefore qualifying as a *historical case study*. The cases cover institutions and corporations from the United Kingdom, the United States, and Germany, spanning roughly fifty years between the start of the 1940s and the end of the 1980s. Therefore, the research is composed of several cases with both spatial and temporal variation in contemporary history. These variations allow for a complex narrative, rather than a reductionist, or oversimplified, history of computing.

1.2.1 Case Studies in Material Culture

First and foremost, objects take centre stage for each case. Therefore, the research can be classified as the study of *material culture*. The focus on the physical attributes of objects originates in art history where Jules David Prown developed a method involving three stages: description, deduction (of connections between people and objects) and to a smaller extent speculation of why the object came into use.⁸⁶ Material culture studies objects that form an integral part of human experience.⁸⁷

Initially, each case study represented a type of computer that differed in medium used, size, price, and application domains. In this stage, the five cases centered around: punch card equipment, a mainframe, a mini-computer, microcomputer, and a personal computer. After exploratory visits to several museums in the United Kingdom, Germany, and the United

84. Craig J. Calhoun, *Dictionary of the Social Sciences* (Oxford: University Press, 2002), 224, quoted in Widdersheim, “Historical Case Study,” 145.

85. Widdersheim, “Historical Case Study,” 145.

86. Karen Harvey, *History and Material Culture: A Student’s Guide to Approaching Alternative Sources* (London: Routledge, February 2013), 2.

87. Harvey, *History and Material Culture*, 3.

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States, I refined the selection to specific computer manufacturers and models. In chronological order, the first case study focuses on Remington Rand and Powers-Samas equipment for punch cards; the second case study revolves around IBM's S/360 as one of the first and highly successful mainframes; third, a popular minicomputer developed by the DEC, called the PDP-11, lies at the basis of the next case; fourth, classrooms full of BBC Micros in two British museums illustrated the importance of this microcomputer in the United Kingdom; and finally, the fifth case study looks into the Apple IIe personal computer.

Aside from the selection of computing devices for each case study, this research focuses on the occupational segregation, working conditions and media representation of computer users. Therefore, this research is object-driven rather than object-centered, since its main objective lies in reconnecting objects to their historical contexts.⁸⁸ In material culture "objects tend to be meaningful, rather than merely communicating meaning."⁸⁹ Their very materiality causes objects to play a role in "creating and shaping experiences, identities and relationships."⁹⁰ At the basis of material culture lies the following assumption:

Human-made objects reflect, consciously or unconsciously, directly or indirectly, the beliefs of the individuals who commissioned, fabricated, purchased or used them, and by extension, the beliefs of the larger society to which these individuals belonged.⁹¹

In order to understand objects in context, Henry Glassie identified three master contexts of objects to study, namely "creation, communi-

88. Bernard L. Herman, *The Stolen House* (Charlottesville, University Press of Virginia, 1992), 7, <https://books.google.lu/books?id=irmGQgAACAAJ>, quoted in Harvey, *History and Material Culture*, 2.

89. Daniel Miller and Christopher Tilley, "Editorial," *Journal of Material Culture* 1, no. 1 (March 1996): 8, <https://doi.org/10.1177/135918359600100101>.

90. Harvey, *History and Material Culture*, 5.

91. Jules David Prown, "The Truth of Material Culture: History or Fiction?," in *History from Things: Essays on Material Culture* (Washington, DC: Smithsonian Institution, June 2013), 1, quoted in Harvey, *History and Material Culture*, 6.

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cation and consumption” which translates to design, production, sales, installation, applications and use of computing devices.⁹² One context particularly important to historians and missing from Glassie’s master contexts however is the phase of decommission or reuse. This cycle of recurrent events as visualised in figure 1.1 lies at the basis of the comparison between the distinct computer models.

Each computer was paired with a particular application, based on the user types introduced by Andreas Fickers and the initial exploration of archival sources. The punch card equipment from both Remington Rand in the United States and Powers-Samas in the United Kingdom was promoted and used at Helena Rubinstein’s make-up concern for accounting during the 1940s and 1950s. Particular IBM S/360 programs were written for a clinical chemistry laboratory at the university hospital of Tübingen and in German healthcare generally from the end of the 1960s onward. In the 1970s the American company DEC sold their PDP-11s to several North-American airlines, as well as the aerospace agency NASA. Then in the 1980s computers entered education with the introduction of the BBC Micro in primary and secondary schools in the United Kingdom, and Apple’s IIe following suit in the United States.

In the overview provided in table 1.2, each case study and application is paired with the user perspectives they represent, as well as the type of source containing information that pertains to certain users. Firstly, sources for all case studies contain information about the configured user in both advertisements and manuals. Secondly, technical literature for the expert user is most easily found for IBM’s S/360, whereas magazines for the avid amateur focused more on the most recent case studies such as DEC’s PDP-11, and the BBC Micro and Apple IIe. Third, an exceptional find of ego documents recorded the use of Powers-Samas equipment in Helena Rubinstein’s punch operator room in London. Furthermore, oral history interviews in existing repositories also co-construct the remembered user for the BBC Micro and Apple IIe case study. Finally, I have

92. Henry Glassie, *Material Culture* (Bloomington: Indiana University Press, 1999), 48, quoted in Harvey, *History and Material Culture*, 11.

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staged experiments with both the microcomputer and the personal computer to study the re-enacted user.

Case Study	Sources	User Type	Application
Punched Cards	Advertisement, Manuals Ego Documents	Configured Remembered	Accounting at Helena Rubinstein in London
IBM S/360	Advertisement, Manuals Technical Literature	Configured Experts	German Healthcare Clinical Chemistry Laboratory
DEC PDP-11 Industry	Advertisement, Manuals	Configured	American Aerospace
BBC Micro Apple IIe	Advertisement, Manuals Magazine Interviews User Experiments	Configured Amateurs Remembered Reenacted	Education in the United States and the United Kingdom

Table 1.2: Case studies

1.2.2 Source Collection and Content Analysis

Since the research is object-driven, I will first discuss two methods in material culture, namely object biographies and life cycle studies. Furthermore, the museum visits served as the basis for the selection of computing devices for the cases outlined earlier. Understanding the use and application of these machines required further archival research. The second section will therefore focus on the selection of archival sources, as well as source annotation and content analysis. Content analysis can be split into discourse analysis for textual sources, visual analysis for images and advertisements, and multi-modal discourse analysis for sources combining (moving) images, text, and other modes of displaying information.

Museum Objects

Within the category of objects, two subcategories can be defined: artefacts made by humans and specimens found in nature. However, specimens can also refer to “something that will be viewed, studied and collected” therefore receiving special attention and receiving some sort of legitimisation.⁹³ My research project focuses mostly on artefacts studied based on the specific method called a life cycle study, which can be combined with an object biography for specific case studies. Karin Dannehl explains that this methodology studies the complete trajectory of an object from production, over distribution to consumption and sets out the stages in the life cycle of these objects either highlighting generic features (life cycle study) or considering exceptional features (object biography) of one specific object or a set of objects. Surviving objects are the exception even if they are used to describe generic features, and often the routines of use are removed within museums to protect the artefacts. As a result, the context of use is often lost for museum objects.⁹⁴ Yet museums are essential for the research of object since “the experiences of weight, surface texture, sound and smell are part of the physicality of objects. They are an essential part of what artefacts have to offer the historian.”⁹⁵ Harvey herself describes the main steps in the research process of material culture as including a description of the object itself, its place in the historic context and the place of the object in a socio-cultural context.⁹⁶

In order to study the physical objects in detail and select particular computer models, I visited several museums. The collections of museums with a particular focus on computer history suited this research better than the collections of general scientific museums or museums of

93. Eilean Hooper-Greenhill, *Museums and the Interpretation of Visual Culture*, Museum Meanings 4 (London: Routledge, 2000), 106.

94. Karin Dannehl, “Object Biographies: From Production to Consumption,” in *History and Material Culture: A Student’s Guide to Approaching Alternative Sources* (London: Routledge, February 2013), 123, 127.

95. Dannehl, “Object Biographies,” 130.

96. Harvey, *History and Material Culture*, 15.

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technology. In the following paragraphs, museums and their collections are grouped by country in accordance with the research process.

The Centre for Computing History (CCH) in Cambridge is open to the public since 2013, and received the United Kingdom national museum accreditation in 2019. The museum's accreditation guarantees not only attention to the public displays, but also a strategy for managing and conserving objects and sources that are not on display. Since exhibitions are highly curated, a view of machines in storage can reveal just how much of the collection is hidden from the general public. Fortunately, I was allowed access to the computers in storage with the added expertise of one of the main curators who could remember the origins well as life cycle of many objects. At the CCH, I first realised how important the BBC Micro was in the United Kingdom's history of computing thanks to the curator's personal account and enthusiasm, as well as the 80s classroom display and racks full of microcomputers in the depot. Furthermore, The National Museum of Computing (TNMOC) in Bletchley Park also taught children to program in BASIC on the BBC Micros in their classroom.

In Germany I visited the Heinz-Nixdorf museumsForum (HNF) in Paderborn and the section *Informatik* of the Deutsches Museum (DM) in Munich. In both German museums, mainframes such as the *Einheitliches System Elektronischer Rechenmaschinen* (ESER) 1055 from the former German Democratic Republic or East Germany, and the IBM S/360 model 20 from the former Federal Republic of Germany or West-Germany caught my attention. Researchers from the *Forschungsinstitut für Wissenschafts- und Technikgeschichte* at the DM however advised against such a comparison. Professor Ulf Hashagen, who co-curated the collection of the HNF, said that few additional sources exist for the ESER 1055.⁹⁷ Furthermore, professor Helmut Trischler mentioned that other researchers were already focusing on the history of computing in the former Soviet Union, and East Germany in particular.⁹⁸ A final argument against such a comparison is

97. Professor Dr. Ulf Hashagen was curator and head of the scientific department at the HNF between 1993 and 2000, and currently leads the *Forschungsinstitut für Technik- und Wissenschaftsgeschichte*.

98. Professor Dr. Helmut Trischler is the head of research at the Deutsches Museum in

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that the East-German computer falls outside the scope of the mainframe case study, since the ESER 1055 was only compatible and therefore comparable with a later model of the IBM mainframe, the System/370 which was introduced about a decade later. Instead, the IBM S/360 model 20 was selected for the mainframe case study, mainly due to its international success, and widespread adoption.

The third series of museum visits to the United States required more preparation. The final selection of case studies was therefore based on literature and the archival finding aids of the Computer History Museum (CHM) in Mountain View, California. Their core collection came from The Computer Museum in Boston, which in turn continued the computer history collection of the DEC in Maynard Massachusetts.⁹⁹ Since DEC was a small but successful manufacturer of minicomputers, with the PDP-series and the PDP-11 in particular now representing the third case. Furthermore, the museum also dedicated an entire gallery to the IBM S/360 in their permanent exhibition *Revolution: 2000 years of computing* which opened in 2011. The red thread throughout all United States museums was the presence of one or more computers from the 1980s until the present. When preparing a user experiment at the Media Archaeology Lab (MAL) started by professor Emerson at the University of Boulder Colorado, I decided on the Apple IIe because of the availability of original software and user manuals alongside the PC itself. The Living Computers Museum+Labs (LCM+L) in Seattle confirmed the selection of the Apple IIe for a comparison with the BBC micro in education, since it dedicated a special exhibition to the American classroom of the 1980s in November 2018 and showed mostly Apple IIe's for visitors to interact with.

Munich, professor of modern history and the history of technology at Ludwig-Maximilians-Universität Munich, and one of the directors of the Rachel Carson Center. The following volume covers computing in Eastern Europe: Christopher Leslie and Martin Schmitt, eds., "Histories of Computing in Eastern Europe," IFIP Advances in Information and Communication Technology (Cham: Springer International Publishing, 2019), <https://doi.org/10.1007/978-3-030-29160-0>.

99. Victoria Rozycki, *The Computer Museum Archive*, February 2015, <http://tcm.computerhistory.org/>.

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Although many museums displayed punch card machines, the decision to focus on Remington Rand and Powers-Samas was based on the archival research, rather than the museum visits. At the Shustek Center of the CHM in Fremont, California, I found an advertisement focused on the use of the Remington Rand Synchronomatic at Helena Rubinstein's company. Later I discovered an entire folder at the CCH donated by a former employee of Helena Rubinstein who managed a staff of fifty punch card operators in London. Aside from material objects, the availability of archival sources further determined the selection of case studies and computer applications in particular.

Archival Sources

In the United States, the first archive visit was the CHM archive (CHMa) in the Shushtek center mentioned previously. Not only does the CHM website offer a general search through the metadata of their items, but they also make archival finding aids available to browse through different collections. I first focused on the collections concerning DEC, followed by the IBM S/360, and finally miscellaneous sources related to punch card equipment and the Apple IIe. The most prominent source for IBM were the manuals from the S/360 bibliography to which most system summaries and hardware manuals belonged. The DEC sources however consisted of correspondence with and meeting reports for Ken Olsen, CEO of the minicomputer manufacturer. A rather exceptional collection of company photographs shows the myriad of applications for the PDP-11 amongst others. Finally, for nearly all case studies a number of advertisements and user guides were included in the collection. The second large archive on the itinerary belonged to the LCM+L (LCM+La). Rather than having the option to browse the collection without a predefined set of key terms, the museum used an online public access catalog (OPAC). An unexpected find in this collections was the book cover image taken from the perspective of a female punch card operator at the IRS in 1962.

In Germany, the archivist of the DM Archiv (DMA) pointed out a *Ver-*

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waltungsarchiv containing correspondence related to the acquisition of computers in the *Informatik* exhibition. Aside from the letter related to the IBM S/360 model 20 on display, it also included another offer for the same machine that was turned down by the museum. The second archive collection relevant for this research were the *Firmenschriften* for IBM containing German advertisements for the S/360, as well as a *Bildcatalog* showing the production plant and process, the company history, and the photographs used in advertisements.

In the United Kingdom, the most interesting collection from TNMOC archive (TNMOCa) was the fully digitised photo archive of the *Computer Weekly* magazine, as well as the integral archive of the *BeeBug* magazine which centered specifically around the BBC Micro. The archive also contained software, of which especially the business software 'VIEW' developed by Acornsoft for the BBC Micro was useful. The CCH archive (CCHa) has an extensive online catalogue that can be searched and browsed similar to browsing a file directory. Furthermore, objects are also linked to related software, magazines, and sources in the catalogue. Next to software and manuals, the main find mentioned earlier was a box containing particular instructions, notes and punch cards, as well as advertisements from the accounting division of Helena Rubinstein in London. Finally, the BBC Written Archives Center (BBC WAC) was the only corporate archive consulted for this research, with the exception of DEC's company papers at the CHMa. The archive collection mainly contained meeting notes and correspondence between the BBC and Acorn, who developed and produced the BBC Micro. Some advertisements were also included, as well as several independent consultancy reports looking into: distribution and customer relations, production management, marketing strategies, and Acornsoft. Furthermore, another collection focused on *The Computer Programme*, the 1980s television show that kick started *The Computer Literacy Project* and the creation of the BBC's microcomputer.

Due to the large geographical distribution of archives and museums and the confines of the research budget, the duration of archive visits was often limited. As a result, each visit was meticulously prepared and analysis postponed until after the visit. Before the visit selected sources

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were listed in a spreadsheet, and after a first inspection of sources I decided on whether to photograph the item or not.¹⁰⁰ In the spreadsheet I indicated which items were actually consulted and photographed. After each day at the archive or museum, between 200 and 700 photographs were transferred onto an external 2TB SSD drive and my laptop, keeping the original file names to preserve the original order into a folder for each institution. Table 1.3 provides an overview of the number of photographs as well as the file size for each museum or archive folder.

Institution	Photos	Size (in GB)
BBC Written Archives Centre (BBC WAC)	5,324	17.16
Centre for Computing History (CCH)	618	2.42
Centre for Computing History archive (CCHa)	1,726	6
Computer History Museum (CHM)	434	1.59
Computer History Museum archive (CHMa)	2,574	9.78
Deutsches Museum (DM)	266	1.01
Deutsches Museum archiv (DMa)	578	2.03
Heinz-Nixdorf museumsForum (HNF)	895	3.46
Living Computers Museum+Labs (LCM+L)	437	1.64
Living Computers Museum+Labs archive (LCM+La)	3,528	13.26
Media Archaeology Lab (MAL)	596	2.05
The National Museum of Computing History (TNMOC)	470	1.85
The National Museum of Computing History archive (TNMOCa)	635	5.73

Table 1.3: Digital collection

In combination with the photographs of museum objects, I gathered over 18.000 images as well as personal notes made during the visit and

100. All digitised sources were photographed with a Fujifilm X20 camera in FinePix Text setting or full-automatic SD+ mode.

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the spreadsheets containing short descriptions, dates, location (i.e. collection, box, and folder) and identifiers such as the catalogue number or bar-code. In order to group photographs in accordance with the original items in the collection and correctly reference primary sources, as well as to locate the relevant sources during the writing phase, this personal digital collection needed to be organised, annotated, and have metadata inserted. The metadata needed to be rigid enough to relocate a source, yet flexible enough to reorganise and recombine sources according to topic to facilitate the analysis.

Museum and Archive Workflow

For archive visits, I brought: a camera, SD-card reader, and external hard drive to transfer and back-up the photographs, the reMarkable e-ink tablet to take notes, MacBook to go over the list of items and quickly look up additional information, and chargers for each just in case. In museums I carried a camera, tablet to take notes on guided tours, and smartphone to record functioning computers.

The workflow developed for documenting a single machine started with an overview photograph of the setup, then detailed images of each component or peripheral such as the screen, keyboard, or mouse, followed by the object description. The bottom of the mouse in particular, and in some cases, exceptional inscriptions or signs of wear were also interesting, such as the names of schools printed on some of the BBC Micro computers. Furthermore, a photograph taken from the side helped to grasp the dimensions of the object. Photographs of archival sources included the folder or item number where possible, at least for the first and/or last photograph of the same source to distinguish them later on. Furthermore, respecting the order of a source by photographing one page, folder, or object after the other saved time in comparing notes to photographs later on.

After the archive and museum visit, I developed a collection in Tropy for each case study.¹⁰¹ Tropy was developed by the Roy Rosenzweig Cen-

101. The workflow and use of digital asset management tool Tropy was first described

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ter for History and New Media (RRCHNM), who also developed the bibliography management tool Zotero.¹⁰² While browsing all photographs, I would write down the file names of the selection, and then upload them to the specific collection. In the next stage photographs would be grouped and enriched with metadata including the correct source (e.g. museum or archive), as well as rights (e.g. educational, non-commercial use only) determined by the institution's policy. For each source or institution I created a separate metadata template based on the information available in the catalogue of the institution and additional research needs. I also added some tags such as image, mainframe, or user manual to filter items later on. Notes were very useful for transcribing any text on the image (except for full pages, unless very valuable), but can also be used to formulate ideas or thoughts, and will show up in search results. Besides transcribing sources, Tropy makes comparisons between sources from different institutions easier since tags help to discover links between sources. Nevertheless, tags also further de-contextualise sources from the original order in the archive and the collection the original source belonged to. Tagging is always a trade-off between few but broad terms, and many but narrow terms; consistency and maintaining the overview are key.

Although the metadata adheres to existing linked data (LD) ontologies, sharing photographs is complicated by copyright laws and institutional policies. The metadata can only be exported to JSON-LD or Omeka S, a web publication system from the same developers. Files are stored locally which prevents both synchronisation between different machines and collaboration with others. Fortunately, the range of media Tropy can

in this blogpost: Sytze Van Herck, *Annotating Sources: Digital Asset Management for Historians*, May 2019, <https://dhh.uni.lu/2019/05/23/annotating-sources-digital-asset-management-for-historians/> and an entire book chapter will be dedicated to digital asset management in Andreas Fickers and Juliane Tatarinov, eds., *Digital History and Hermeneutics: Between Theory and Practice* (De Gruyter Oldenbourg, 2022), <https://www.degruyter.com/document/isbn/9783110723991/html>.

102. This dissertation was typeset in LaTeX using Overleaf, with automated references imported from Zotero. The font used throughout the publications - and chosen deliberately - is called IBM Plex.

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import, as well as remote access and cloud storage are underway.¹⁰³ For now, the strength of Tropy is the improved navigation of large photo collections with a powerful search, tag and annotation. Although organising sources, adding metadata, tagging and transcribing is time consuming, data asset management tools definitely save time in the final and crucial writing phase.

In short, the following simple solutions might benefit other researchers working with a large and diverse collection of sources. Selecting sources based on an archive catalog before the archive visit, and adding check boxes to track which items are actually added to the researcher's personal collection, speeds up the process on site. Sources can be digitised by scanning, photographing, or recording, depending on the available tools and the needs of the project. Do not forget to obtain permission or check the institutional policy for digitising sources. For texts, a portable or on-site scanner might result in a higher quality needed for optical character recognition (OCR), but scanning is often more time consuming and expensive if institutions charge for the service. When photographing texts, choose the appropriate camera setting; consider the perspective to grasp the dimensions of objects, or use methods from archaeology to track dimensions and colours for high-quality scientific photographs; photographing images can be challenging in terms of lighting, especially in darker archives. Any historian or archivist knows to respect the original order of sources in archives (*respect des fonds, respect de l'ordre*), which translates to: digitising sources sequentially, including the locator or ID where possible, retaining the file name assigned by the camera, and using a good structure of file folders (e.g. grouped by archive). Based on the available information from archives, museums, or in the source itself, adding metadata is useful for later analysis and proper source references. Whether sources are organised in spreadsheets or digital asset management software is less relevant, than the ability to group and regroup photographs of items, annotate sources, and filter and search

103. Sean Takats, *Next Steps for Tropy*, October 2018, <https://tropy.org/blog/next-steps>.

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the collection.

Discourse Analysis

A method for describing each case study according to standardised criteria “facilitates the comparison of [cases] according to the same measures.”¹⁰⁴ Depending on the type of source, a different form of discourse analysis will be applied. Discourse analysis can be applied to both text and (audio)visual material and is especially important in answering questions on occupational segregation, the perception of working conditions and the influence of media representation on gender stereotypes. The notion of discourse and the method of discourse analysis refers to Foucault’s definition of discourse as “groups of statements that structure the way a thing is thought and the way we act on the basis of that thinking.”¹⁰⁵ In the following paragraphs, general discourse analysis is discussed first, followed by visual discourse analysis for images, and multi-modal discourse analysis for sources combining several types of discourse.

Gillian Rose identifies two forms of discourse analysis, where discourse analysis I focuses on “the notion of discourse as articulated through various kinds of visual images and verbal texts” and is mostly concerned with “discourse, discursive formations and their productivity,” whereas discourse analysis II looks at “material practices of institutions” which concerns itself with “issues of power, regimes of truth, institutions and technologies.”¹⁰⁶ Since discourse can be articulated in different forms, the notion of intertextuality is also important in this context. Meanings of a discursive image or text also depend on “meanings carried by other images and texts,” therefore referring to this concept of *intertextuality*.¹⁰⁷ The main component of a discourse analysis (I) takes into account the rhetorical organisation of the discourse. In order to analyse the rhetor-

104. Widdersheim, “Historical Case Study,” 148.

105. Gillian Rose, *Visual Methodologies: An Introduction to Researching with Visual Materials*, 4th ed. (London: SAGE, 2016), 187.

106. Rose, *Visual Methodologies*, 192.

107. Rose, *Visual Methodologies*, 188.

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ical organisation, a researcher needs to forget preconceptions and immerse in the material identifying themes and connections between these themes and key concepts.¹⁰⁸ This focus on the production of meanings and things also looks at how a particular discourse works to persuade.¹⁰⁹ A discourse often contains certain contradictions and complexity which should come to the surface in an analysis, together with a reading of the *invisible*, since “absences can be as productive as explicitly naming; invisibility can have just as powerful effects as visibility.”¹¹⁰ Furthermore, the social production of a text should be taken into account as well, exposing not only the institutional location or authority of the speaker or creator, but also the assumed audience of a discourse.¹¹¹ In discourse analysis II, Rose distinguishes two main concepts Foucault introduced, namely institutional apparatus or “forms of power/knowledge that constitute the institutions,” and institutional technologies or “practical techniques used to practice that power/knowledge.”¹¹²

Visual culture focuses on two dimensional instead of three dimensional objects and looks into the “relationship between the object and the subject - the seen and the seer.”¹¹³ Because this methodology studies processes of interpretation and the assigning of meaning, it is particularly suited to study the influence of media representation of technology and its users on gender and other stereotypes. Creating meaning can be explained through the hermeneutic circle described by Hans-Georg Gadamer where “the whole is a circular question and answer process” moving between whole and part, past and present, and constant checking and rechecking.¹¹⁴ The visual discourse analysis therefore involves the study of semiotics and composition, as well as research into

108. Rose, *Visual Methodologies*, 205-206.

109. Rose, *Visual Methodologies*, 206-209.

110. Rose, *Visual Methodologies*, 212-213.

111. Rose, *Visual Methodologies*, 214-215.

112. Rose, *Visual Methodologies*, 223.

113. Hooper-Greenhill, *Museums and the Interpretation of Visual Culture*, 108.

114. Hans-Georg Gadamer and David Edward Linge, *Philosophical Hermeneutics* (Berkeley: University of California Press, 1976), quoted in Hooper-Greenhill, *Museums and the Interpretation of Visual Culture*, 117.

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the interplay of text and image. Gillian Rose proposes four sites of a critical visual methodology starting from the production, looking at the image itself, its circulation and its audiencing at the technological, compositional and social level.¹¹⁵ In the specific case of advertisements, semiology or social semiotics is particularly “concerned with the social effects of meaning.”¹¹⁶ As Robert Goldman assesses in agreement with Judith Williamson, “we tend to take for granted the deep social assumptions embedded in advertisements: we do not ordinarily recognise them as a sphere of ideology.”¹¹⁷ Yet in lying bare these social assumptions it is important to recognise our own viewing practices.

1.2.3 Reenacting the User Experience

At the start of the research project, the user experiments were meant to provide a basis for an online crowdsourcing platform. This website would contain all project data and sources for others to explore, contribute, and analyse. Unfortunately the platform never materialized due to legal constraints, limited resources, and mainly time limitations.¹¹⁸ In total I have performed five different user tests, of which only two were actually incorporated in this dissertation.

The first user test studies collaboration in a university classroom setting and consisted of an observation and a brief questionnaire. Another contextual enquiry was carried out in an existing crowdsourcing project of a municipal archive, looking into the motivation and learning curve of volunteers who digitised sources. These two user studies were closely connected to the crowdsourcing platform and have not been added to the dissertation. I observed visitor interaction in two museums with the *fly on the wall* method. The original aim of the museum observations in The Na-

115. Rose, *Visual Methodologies*, 24-26.

116. Rose, *Visual Methodologies*, 107.

117. Judith Williamson, *Decoding Advertisements: Ideology and Meaning in Advertising* (London: Boyars, 1978); Robert Goldman, *Reading Ads socially* (London: Routledge, 1992), 1.

118. See also Preface.

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tional Museum of Computing (TNMOC) and the Deutsches Museum (DM) was to support the design of the information display on the website and the structure of metadata. Instead I learned about the devices people of different ages leaned towards, I heard what visitors found surprising or interesting, and realised that some visitors remembered their personal experience prompted by the computers on display. Although I have not created a customer journey map, persona, or storyboards based on the observation for the design of the online platform, I certainly came to understand the museum as a place for the reenacted and remembered user, and the location for a very particular type of re-use of the small fraction of the remaining computers kept in working order.

The visitor observation forced me to reflect upon the influence of curators. They determine which devices are deemed important and need to be preserved or displayed. Curators also determine the narrative of the history of computers. This narrative has changed over time and differs based on the location and founding story of the museum. As a result, I decided to interview a curator from almost all museums I visited and consulted for the research. Two remaining user tests which have been added to the dissertation were these curator interviews, and a reenactment for the Apple IIe and BBC Microcomputer.

The semi-structured interviews touched upon questions such as how the collection came into existence, the basis for the selection of objects on display and in the collection, and whether curators viewed computers as objects on display, or as devices visitors could and should interact with. Despite similar topics throughout all interviews, the semi-structured nature of interviews allowed me to vary emphasis and ask further questions depending on the answers and my knowledge of the institution and collection at hand. In order to cover the entire visitor experience I asked curators to create a customer (or rather visitor) journey map, which often prompted them to elaborate on the decisions behind the exhibition itinerary or acquisition story of certain objects.¹¹⁹

119. The list of questions and the visitor journey map template have been added to the appendix.

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The user experiment with the BBC Microcomputer and Apple IIe required most preparation and truly reenacted the user experience of two early personal computers. This final user experiment fits into hands on media history as a “physical exploration of technologies as a means of understanding how technologies have changed, and how they have changed us.”¹²⁰ First, the experiment required forty year old computers with floppy disks and disk drives in working order, preferably with staff support at hand in case technology failed. Lori Emerson notes that spaces for a hands-on experimental media archaeology such as the Media Archaeology Lab (MAL) position themselves as an “anti-museum museum,” where devices are functional and can be “turned on and actively played with, opened up, tinkered with, experimented with, [...]”¹²¹ I had to experiment first to prepare some minor instructions for participants. For the experiment with the Apple IIe at the MAL the available software was catalogued and emulators allowed me to prepare some instructions before the visit. At the Centre for Computing History (CCH) I chose software on-site or tested interactive video disks for the BBC Master during a previous visit to The National Museum of Computing (TNMOC). Aside from clear instructions and observation sheets, I prepared questions for participants to reflect upon their experience. Participants were recruited either in the museum, or by the lab manager of the MAL. With a videocamera and *cravate* microphone from the university’s media lab, I recorded the entire setting, including the computer display, whereas the facial expression of participants was recorded with my smartphone. Afterwards, the facial expression video was inserted into the video recording of the set-up to see both simultaneously for analysis. Rather than transcribing the videos, I used my notes from the observation sheets and edited the videos of all participants. The compilation placed different participants

120. John Ellis and Nick Hall, “Introduction: What is Hands On Media History?,” in *Hands on Media History* (London: Routledge, 2019), 1, <https://doi.org/10.4324/9781351247412>.

121. Lori Emerson, “The Media Archaeology Lab as Platform for Undoing and Reimagining Media History,” in *Hands on Media History* (London: Routledge, 2019), 181, <https://doi.org/10.4324/9781351247412>.

performing the same tasks sequentially to compare positive and negative experiences at each stage of the reenactment. Their reflections on the process during the interview after the experiment were also added to the end of the compilation video.¹²² As John Ellis notes, “editing is famously an interactive process of trying out combinations of material to find out what works best as a meaningful whole.”¹²³ A second compilation for the BBC Micro and BBC Master computer will be published on the Centre for Contemporary and Digital History (C²DH) website and resented at the 2022 International Federation of Public History (IFPH) conference in Berlin. Observations from the reenactments are included throughout the chapters and in the conclusion.

Summary

Re/constructing computing experiences from *punch girls* to *computer boys* traces the life cycle of five computing devices between the 1940s and the 1980s. Informed by the social construction of technology (SCOT) in the academic domain of science, technology and society (STS), each device represents a key development in the history of computing. Human-computer interaction brings users to the forefront and the framework of *Nutzerperspektiven* from experimental media archaeology critically evaluates which type of user sources (re)construct. Case studies are structured according to six phases of an objects’ life cycle answering research questions concerning design, production, sale, installation, application and use, and decommission or reuse. Three additional research questions inquire into user stereotypes in advertisements, occupational segregation, and the working conditions of computer users. The lens of intersectionality with a focus on gender facilitates the (visual) discourse anal-

122. The full report of the Apple IIe reenactment is available here: Sytze Van Herck, *Experimental Media Archaeology featuring the Apple IIe*, January 2019, <https://www.c2dh.uni.lu/thinking/experimental-media-archaeology-featuring-apple-ii>

123. Ellis and Hall, “Introduction,” 22.

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ysis of advertisements. User experiences differ because of inequalities in computing which have at times resulted in occupational segregation.

Computer experiences encompass the object, the environment, an application and a user. Methods from user experience design (UX) design supported the reconstruction or reenactment of past human-computer interaction. The first case study discusses the accounting departments of Helena Rubinstein which used Remington Rand, and later Powers-Samas, punch card machinery since 1940. The second case study centers around the IBM System/360 announced in 1964 and used in German clinical chemistry laboratories since 1969. The Digital Equipment Company's PDP-11 was used in aerospace and commercial aircraft between 1970 and 1980. The final chapter compares two educational initiatives from the 1980s. By 1981 the BBC Microcomputer kick started the Computer Literacy project in the United Kingdom, first targeting adults but soon entering primary and secondary schools. Apple's *Kids Can't Wait* initiative in the United States equally introduced many children to computing. As a study of material culture, the historical case studies are informed by museum objects, paired with additional archival sources. Due to the large geographical dispersion of objects and sources, a digital collection supported the analysis. The data asset management software Tropy structured the research data set for each case study.

Chapter 2

Punch Cards in Accounting: the Powers-Samas room at Helena Rubinstein

Punch cards were first used for information processing in the United States Census of 1890, and the invention of punched card machinery is usually attributed to Herman Hollerith. Furthermore, historians and museum curators generally assume that inspiration for punch cards in information processing came from the Jacquard loom which weaves a pattern according to holes in cards that are strung together.¹ Interestingly, the invention of the Jacquard Loom and of punch cards machines are also attributed to others. In *Women Hold Up Two Thirds of the Sky* Autumn Stanley explains that women are rarely considered inventors of technology, but in order for that to change, “the *definition of technology would change* from what men do to what *people* do,” and what constitutes “*significant*

1. See Truesdell, *The Development of Punch Card Tabulation in the Bureau of the Census 1890-1940 with Outlines of Actual Tabulation Programs*, 31. Both the Computer History Museum in Mountain View, California, in the United States, and the Heinz-Nixdorf MuseumsForum in Paderborn, Germany, display (parts of) the Jacquard Loom next to punch card machines.

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technology would change.” Finally, “*the classification of many women’s invention would change,*” meaning: “women’s creation of or contribution to many inventions significant by either or both definitions would be acknowledged.”²

In the same book chapter, Madame Jacquard is credited for the invention of the Jacquard Loom based on a (dubious) claim of Russell H. Conwell.³ Contrary to the belief that the Jacquard Loom was the original inspiration for punch card machinery, Truesdell states that no reference to the loom is made before 1896, whereas Hollerith first filled for patent on September 23, 1884.⁴ Furthermore, Truesdell credits John Shaw Billings as “the originator, the *discoverer*” who came up with the idea of using punch cards for vital statistics of the United States census and Hollerith as the *inventor* who built the machine to implement this idea.⁵

Hollerith’s business began as a one-man act with the United States census as most important customer. He only “set up a machine shop, hired workers, and began to piece equipment together,” when his product picked up and formalized a subsidiary “to work on the New York Central Railroad project.” His Tabulating Machine Company (TMC) capitalized “on December 3, 1896 at \$100,000.”⁶ After the United States Census

2. Autumn Stanley, “Women Hold Up Two-Thirds of the Sky: Notes for a Revised History of Technology,” in *Sex / machine: readings in culture, gender, and technology*, ed. Patrick D. Hopkins, The Indiana Series in the Philosophy of Technology (Bloomington: Indiana university press, 1998), 17-18.

3. Conwell, Jessie Hayden. 1926 (c.1865). Inaugural Editorial, Ladies’ Department, *Minneapolis Daily Chronicle*, weekly ed., *Conwell’s Star of the North. Russell H. Conwell and his work*. Ed. Agnes Rush Burr. Philadelphia: J.C. Winston, pp. 141-144; Conwell, Russell H. 1968 (1877) *Acres of Diamonds*, Kansas City, MO: Hallmark, quoted in Stanley, “Women Hold Up Two-Thirds of the Sky,” 22.

4. Herman Hollerith, Apparatus for Compiling Statistics, US Patent 395,783, filed September 23, 1884, and issued January 8, 1889; Truesdell, *The Development of Punch Card Tabulation in the Bureau of the Census 1890-1940 with Outlines of Actual Tabulation Programs*, 27.

5. Truesdell, *The Development of Punch Card Tabulation in the Bureau of the Census 1890-1940 with Outlines of Actual Tabulation Programs*, 33.

6. James W. Cortada, *Before the Computer: IBM, NCR, Burroughs, and Remington Rand and the Industry They Created, 1865-1956* (Princeton, NJ: Princeton University Press,

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Bureau moved to different equipment, railroads became Hollerith's main customers and to keep up with demand he contracted other manufacturers to increase production. In Europe he created the British Tabulating Machine Company (BTM) to formalize sales and operations. Then in 1911, Hollerith needed "capital to continue expanding and supplying the needs of existing customers," and merged with other companies to form the Computing-Tabulating-Recording Company (CTR), of which Thomas J. Watson (Sr.) became the manager.⁷ The firm eventually became known as International Business Machines (IBM).

When Hollerith started losing business from the United States Census Bureau, another inventor started a similar trajectory and became his main competitor. However, James Legrand Powers had an entirely different background from Herman Hollerith. James Legrand Powers was born in 1871 in Odessa, a port town on the coast of the Black Sea currently situated in Ukraine, but under Russian rule in the second half of the nineteenth century. The town was demilitarised after the Crimean War in the Treaty of Paris of 1856 until 1870 when Russia denounced the treaty after the defeat of France in the French-Prussian war. Russia regained full control of Odessa and the region after the Treaty of Berlin in 1878.⁸ After graduating from the Technical School of Odessa, James L. Powers made scientific instruments for the University of Odessa.⁹ He emigrated to the United States in 1889 perhaps for opportunistic reasons, because of the political and military instability, or linked to several pogroms in Odessa (in 1871 and 1881 while he lived there) which meant many Jews making up around 37% of the population fled from 1882 onward.¹⁰ Aside from work-

1993), 52.

7. Cortada, *Before the Computer*, 54-55.

8. See Martin Campbell-Kelly, "Powers, James," in *Encyclopedia of Computer Science* (John Wiley & Sons, January 2003), 1419, <https://dl.acm.org/doi/10.5555/1074100.1074706>. Evolution of Odessa in the second half of the 19th Century, see *Putzger Historischer Weltatlas*. Berlin: Conelsen Verlag, 103 Ed., 2008, p.132, 144-145; Wikipedia's "Treaty of Paris (1856)," "Treaty of London (1871)," "Treaty of Berlin (1879)," and "Odessa" entries.

9. Campbell-Kelly, "Powers, James."

10. Wikipedia's "Odessa" entry and *Jewish community of Odessa*, accessed June 15,

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ing at Western Electric as an engineer, he was one of the machine shop experts of the United States Census Bureau and started working on an automatic card-punching machine in 1907. Four years later he founded the Powers Tabulating Machine Company, later the Powers Accounting Machine Company. James L. Powers filed several patents starting in 1910 for a combined punching and counting mechanism, several (mechanisms for) perforating machines, as well as (elements of) tabulating machines, and three machines combining either printing or typewriting with perforating.¹¹ He cannot take sole credit for all machines and inventions however, since he was aided by W.W. Lasker.¹² After his death in 1927, the company was acquired by Remington Rand.¹³ In the United Kingdom the equivalent of Powers was first called the Accounting and Tabulating Machine Company of Great Britain, founded in 1915. In 1929 this company merged with the French sales agency Société Anonyme des Machines à Statistiques (SAMAS) founded in 1922 to become Powers-Samas Accounting Machine Ltd.

The introduction set the stage by answering who started the rival companies and amassed the capital, personnel, and resources to design and produce punch card equipment. Section 2.1 begins with an advertisement analysis centred around a Remington Rand leaflet featuring their Synchro-Matic bookkeeping and punch card installation for accounting at Helena Rubinstein's cosmetic concern.¹⁴ The advertisement shows how

2021, https://dbs.anumuseum.org.il/skn/en/c6/e224090/Place/Odessa_.

11. Patents by James Powers, US Patents 992,245, 992,246, 1,086,397, 1,100,986, 1,138,314, 1,177,651, 1,224,413, 1,236,481, 1,242,721, 1,245,502, 1,271,614, 1,299,022, 1,312,807, 1,317,458, 1,388,299, 1,665,218, 1,836,039, first filed April 8, 1908, and last issued December 15, 1931. Find full patents here:<http://patft.uspto.gov/netahtml/PTO/search-adv.htm>.

12. Campbell-Kelly, "Powers, James."

13. Campbell-Kelly, "Powers, James." Campbell-Kelly states that Powers retired and passed away only in 1935, however his obituary appeared in 1927: "James Powers," *The New York Times* (New York), November 1927, chap. Obituaries, <https://nyti.ms/3erKXtS>.

14. *Madame Helena Rubinstein: pioneer in beauty, research scientist, astute businesswoman*, (Buffalo, New York: Remington Rand, Inc.), 1940, David C. Faloon papers, Lot X3947.2007, Box 1, Catalog 102683284, Computer History Museum, Mountain View

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the system was announced, who represented the user and how the equipment was described. Section 2.1.1 first describes Helena Rubinstein's public image and her actual biography, thus demonstrating who had the means to purchase the rather expensive equipment. Furthermore, I discuss surprising parallels between the beauty industry and the data processing industry (section 2.1.2). The advertisement also nicely illustrates the workflow and provides examples of input and output, and includes an image of the employees that operated the punch card equipment in the billing department (sections 2.1.3 and 2.1.4).

Section 2.2 is based on a folder from the manager heading the Powers-Samas room at the Helena Rubinstein branch in London.¹⁵ Her folder of notebooks, a manual, and working documents illustrates who controlled the workflow, who provided input data and drafted reports, as well as who the results were reported to. Based on a draft written to recruit personnel for the Powers-Samas installation and notes of staff names especially in comparison with supervisor names of other departments, the source also highlights the occupational segregation in accounting and keypunching. The outline of the procedure in accounting at Helena Rubinstein in London illustrates how the installation was operated. Section 2.3 describes the elements that make up a typical punch card installation and discuss how punch card equipment functioned.¹⁶ Because the entire chapter evolves around Remington Rand and Powers-Samas equipment used at the billing department of Helena Rubinstein in both the United States and the United Kingdom, two machines used in accounting are discussed in detail.

(hereafter cited as David C. Faloon papers).

15. "Powers-Samas and ICT Documentation," Box FB56, CH28274, Centre for Computing History, Cambridge (hereafter cited as Powers-Samas and ICT Documentation), <http://www.computinghistory.org.uk/det/28274/Powers-Samas-ICT-Documentation/>.

16. *Powers Reference Manual: Data applicable to Powers Accounting Machines Methods and Applications*, (Buffalo, New York: Remington Rand Inc.), 1930, David C. Faloon papers, Box 1, Catalog 102683290.

2.1 Madame Helena Rubinstein automating her business

Remington Rand advertised its Synchro-Matic automated bookkeeping system, promoting the Remington 80 and 45-column punch in the United States in the 1940s to comptrollers who headed divisions responsible for billing and sales accounting. Based on use cases by some of its existing clients, the adding - bookkeeping - tabulating machines division of Remington Rand in Buffalo, New York sold its products to the likes of Helena Rubinstein Inc. and Freeman Shoes for Men, marketing their customer's companies in the process.¹⁷ These advertisements illustrate the type of company purchasing punch card equipment, what the equipment was used for, who operated it, who used the reports of such operations, and how the machines worked.

The booklet of twelve pages on the use of punch card equipment at Helena Rubinstein was probably given to potential customers by sales representatives. In the first five pages the focus is on Helena Rubinstein as a person, as a business, and then as user of the Synchro-Matic system. In the final pages two machines and the documents and punch cards they produce are demonstrated, followed by an overview of reports generated for executives, and a letter by the head of the bookkeeping department at Helena Rubinstein thanking Remington Rand for its installation of the system enumerating all of the advantages. On the final page is a list of potential applications for the Punch and Bookkeeping Machine, as well as the request to contact the nearest office for a demonstration.

17. *Madame Helena Rubinstein* (Buffalo, New York: Remington Rand Inc.), 1940, David C. Faloon papers; *Freeman Shoes for Men* (Buffalo, New York: Remington Rand Inc.), 1940, David C. Faloon papers, Box 2, Catalog 102683284.

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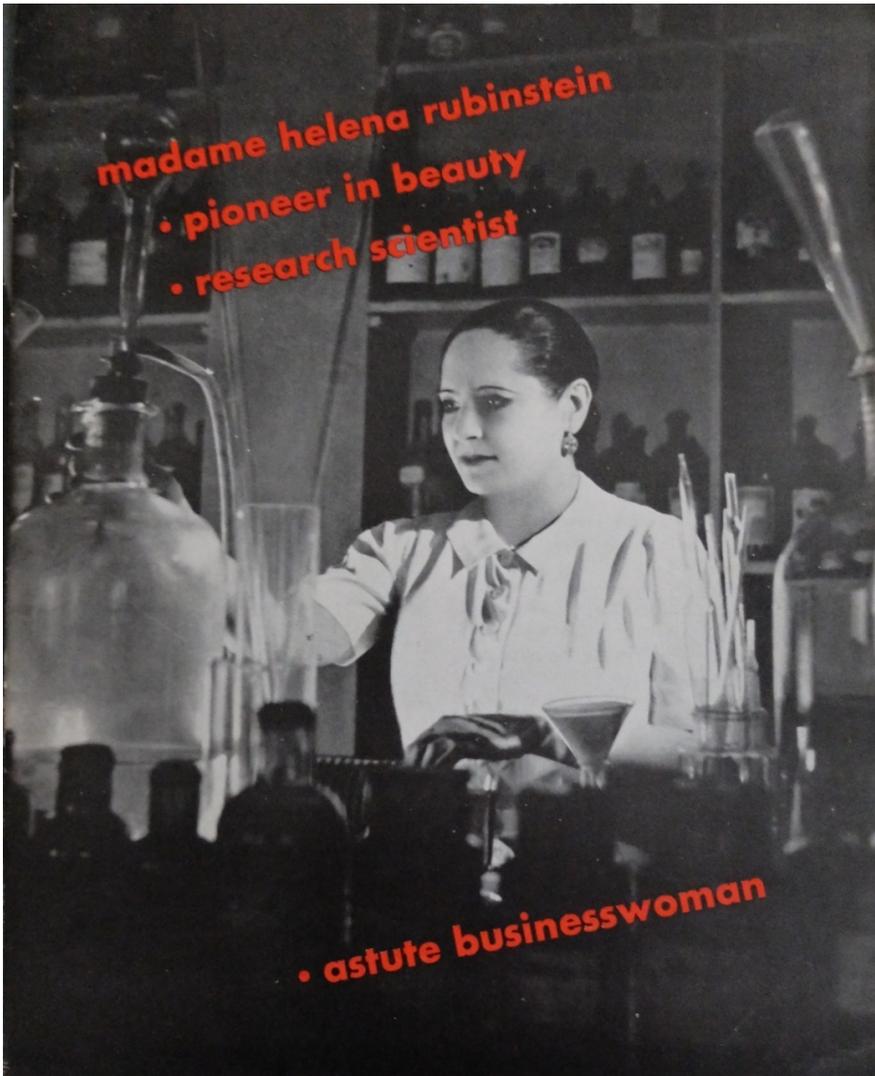


Figure 2.1: *Madame Helena Rubinstein*, (Buffalo, New York: Remington Rand, Inc.), 1940, David C. Faloon papers.

2.1.1 Pioneer in beauty, research scientist, astute businesswoman

The front cover illustrated in figure 2.1 introduces Madame Helena Rubinstein as “a pioneer in beauty, a research scientist, and an astute businesswoman.” She is pictured in her signature chignon, kohl-rimmed eyes and red lipstick, wearing extravagant earrings, dressed in a white button-up lab coat with shelves full of pharmaceutical bottles behind her and standing in front of a table with chemical equipment and more pharmaceutical bottles looking at her product brewing. The detailed composition of the advertisement carefully constructs the public image of Helena Rubinstein and the company she founded and personified. Not all claims made in the advertisement are based in reality however. Indeed the cosmetics industry at large and Madame Helena Rubinstein’s public image in particular was founded on myths.

Firstly, her autobiography explains her use of *Madame*. When Rubinstein asked her friend Coco Chanel why she never married her lover, she allegedly replied: “I am Mademoiselle Chanel and I shall remain so, just as you will always be Madame Rubinstein. These are our rightful titles.”¹⁸ Madame thus serves as a title and contains two important references: a link to France’s luxury industry rather than cosmetic’s stigma as only for women of the street and actresses, and her marriage to Edward Titus, who is credited for suggesting the title.¹⁹ Although Helena Rubinstein re-

18. Helena Rubinstein, *My Life For Beauty* (New York: Simon / Schuster, 1966), 70, quoted in Ruth Brandon, *Ugly Beauty: The Ugly Face of the Beauty Business* (HarperCollins, February 2011), Chapter 1, Part II.

19. The stigma of cosmetics in the nineteenth century is discussed in Brandon, *Ugly Beauty*, Chapter 1, Part II. The suggestion that Edward Titus came up with the title “Madame” is discussed in a podcast by Brian Kenny, *How Helena Rubinstein Used Tall Tales to Turn Cosmetics into a Luxury Brand*, accessed June 2, 2020, <http://hbswk.hbs.edu/item/how-helena-rubinstein-used-tall-tales-to-turn-cosmetics-into-a-luxury-brand> based on an interview with Geoffrey Jones who also co-authored the following case study: Geoffrey G. Jones and Kathy Choi, *Helena Rubinstein: Making Up the Modern Woman*, Case Study 3171196-PDF-ENG (Harvard Business Review, April 2017), 4, <https://store.hbr.org/product/helena->

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tained her own surname, rather than assuming the name of her first husband, Edward Titus did play a part in her public image as he wrote many of her first advertisements where he also portrayed her as a scientist.²⁰

Secondly, the advertisement's claim that Helena Rubinstein was a pioneer in beauty bears some truth as she established many of the beauty industry's key ideas including the myth of different skin types such as oily, dry, and normal skin, or "for particular hours of the day or night."²¹ Another marketing technique finds origins in Helena Rubinstein's approach by using fear of aging as a selling point.²² Throughout her life, well into her nineties, Rubinstein consistently lied about her own age.²³ "The matriarchy of the beauty business" as *Life Magazine* mentioned in 1941 lay in the hands of "Helena Rubinstein, Elizabeth Arden, and Estée Lauder" and would last well into the 1950s. Helena Rubinstein thus had a pioneering role in the cosmetics industry.

Thirdly, the front cover of the advertisement portrays and calls Helena Rubinstein a research scientist. As Ruth Brandon mentions in her book *Ugly Beauty*, this image was no accident. "She always projected herself as a qualified scientific professional, was constantly photographed in white lab coats amid test tubes and Bunsen burners, emphasized her products' quasi-medical aspects."²⁴ In reality, Chaja, who later changed her name to Helena, grew up in Kazimierz, Krakow's Jewish ghetto, attending a local Jewish school. As a poor girl from an orthodox background, she was expected to marry and bear children. "Medical school could never have been anything but a dream." When Chaja refused the candidate her father suggested, she fled to Vienna to live with her aunt. She then sailed on to Australia from Genova in 1896 to help her cousin. In 1903 she started

rubinstein - making - up - the - modern - woman / 317116. The case study in turn references who describes a conversation between Edward Titus and Helena Rubinstein without any clear references.

20. Michèle Fitoussi, *Helena Rubinstein: The Woman who Invented Beauty* (London: Gallic Books, 2013), 97.

21. Brandon, *Ugly Beauty*, Chapter 1, Part I.

22. Kenny, *How Helena Rubinstein Used Tall Tales to Turn Cosmetics into a Luxury Brand*.

23. Brandon, *Ugly Beauty*, Chapter 1, Part I.

24. Brandon, *Ugly Beauty*, Chapter 1, Part I.

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her business in Melbourne making face cream. Her only training was a brief tour of Europe's skin-care specialists in Wiesbaden, Vienna, Paris, and Berlin from June to September in 1905.²⁵ In fact, women previously created their own simple cosmetics. As a "familiar domestic craft, with cheap raw materials" face creams presented a "tempting, and unintimidating, female business proposition."²⁶ In stark opposition to her public image as a research scientist, "Helena Rubinstein always referred to her workbench as her 'kitchen.'"²⁷

Finally, the description of Helena Rubinstein as an astute businesswoman holds true in her approach to the 1929 market crash. She sold the American branch of her company right before the market crash under the guise of trying to keep her marriage. She managed to cash out at \$7,300,000 on December 11, 1928, only to see her American branch now owned by Lehman Brothers losing shares because of a poorly executed mass market strategy combined with the market crash and Great Depression. Helena Rubinstein managed to buy her shares back three years later, making a profit of about \$5,800,000.²⁸

2.1.2 The Matriarchy of the Beauty Business

The following two pages of the advertisement were titled "astute businesswoman whose equally astute associates have adopted SYNCHROMATIC for customer billing," and organised in two columns of text on each

25. Brandon, *Ugly Beauty*, Chapter 1, Part I.

26. Brandon, *Ugly Beauty*, Chapter 1, Part I.

27. Brandon, *Ugly Beauty*, Chapter 1, Part I.

28. Mentioned in the podcast by Kenny, *How Helena Rubinstein Used Tall Tales to Turn Cosmetics into a Luxury Brand* which is based on an interview with Geoffrey Jones who also co-authored the following case study: Jones and Choi, *Helena Rubinstein*, 4. The case study mentions the Helena Rubinstein Inc. 1928 Lehman Deal Book, Lehman Brothers Records, *Baker Library*, Harvard Business School, p.65. The Helena Rubinstein, Inc., 1967 item is part of Series II. Administrative records, 1877-2007, under subseries II.1 Office File - Client files, 1927-1986, Box 421, Folder 5, Manuscript 783 1868-1986 L523 as mentioned here: <https://hollisarchives.lib.harvard.edu/repositories/11/resources/457>.

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page. Centered at the bottom of two pages is an image of a Helena Rubinstein salon covering seven stories at 715 Fifth Avenue in New York. The text first highlights her exceptional position as an ingenious woman heading “a world-wide organization, built entirely by their own resources, employing 3,000 people and ranking second in yearly sales.” Next, the advertisement tells her partly fictional personal story from her upbringing in a well-to-do family in Poland, her study of medicine at the University of Zurich, and the move to Australia selling “a skin clearing cream made by the family physician, a doctor in Hungary” in her first shop in Melbourne. The growth of her business is mentioned in terms of the number of shops selling her many products made in six factories and her various luxurious salons. She is credited for “bringing the sterilized atmosphere of the laboratory into beauty culture,” based on “intensive research under the great chemists and dermatologists” from Europe. Nearly all of these quotes have been contradicted, although the expansion of the company and her strategy of creating a public image based on the laboratory atmosphere are based on facts rather than fiction.

Her favorite photographs showed her in her white coat in a laboratory, one of the great women scientist of the world engaged in a ceaseless search for more potent ingredients. But she knew, even if she did not choose to remember, that her vaunted medical studies amounted to a two-month tour of visits to selected practitioners.²⁹

The advertisement then goes on to discuss her approach to directing the enterprise, attributing the success of her company to the training of - presumably female - “young and attractive demonstrators” and “salesmen” who were also thoroughly trained in beauty culture. A short description of all potential beauty procedures at the New York salon pictured is followed by Rubinstein’s new products based on her research into ingredients and formulae. Finally, the text ends with two further founding myths of the beauty industry credited to Helena Rubinstein. First, “she was one

29. Brandon, *Ugly Beauty*, Chapter 1, Part IV.

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of the first to advocate different make-up colors to harmonize with different costumes, occasions, and seasons.” Second, the advertisement establishes her pioneering role in the “importance of diet to beauty.”

Before moving on to discussing the use of Synchro-Matics in billing at Helena Rubinstein, I want to briefly elaborate on parallels between the beauty industry and the computer industry in terms of gender balance. After comparing the evolution of Helena Rubinstein’s company and that of her contemporary Eugène Schiller from L’Oreal, who’s company came to own Rubinstein’s by the end of the twentieth century, Brandon concludes as follows:

When Helena Rubinstein started out in business, men held the upper hand, financially and socially. And men decreed that respectable women should go unpainted. Over the next half-century, the beauty industry ran hand in hand with women’s progress toward an equal place in the public world. [...] Today the wheel has come full circle. [...] Ironically, although women’s independence and equality are enshrined in law, their appearance is once again under someone else’s control. And that someone is usually a man.³⁰

Whether those men are plastic surgeons, or CEO’s of big beauty concerns, the matriarchy of the beauty industry in the first half of the twentieth century is long gone.³¹ So too have the female data entry clerks made way for the computer boys.³²

2.1.3 The Billing Department

Figure 2.2 shows the billing office in Buffalo, New York where four female operators sit at a row of desks typing away on the Model 80B Remington Electrified Fanfold Billing Machine with carbon roll attachment which is

30. Brandon, *Ugly Beauty*, Chapter 6, Part IV.

31. Brandon, *Ugly Beauty*.

32. Nathan Ensmenger’s *Computer Boys*, references to chapters of Schlombs and others in *Gender Codes*.

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connected to the Automatic Electric Punch. Aside from the machines and its users, the image is interesting because it shows the spatial arrangement. Corina Schlombs illustrated how “social and cultural ideas - not the technologies - shaped which kind of data processing work was done by women or by men, and under which conditions,” based on different spatial arrangements and opposite gender balance between the United States and Germany.³³

In Germany, [...] [punch card equipment] was located in separate rooms that were extremely noisy and dominated by heavy machinery - with the rationale of protecting other departments from the noise. In such an environment, tabulating rooms became male-dominated technical dungeons, and punch-card operations turned into a male-only profession. [...] [Whereas in the United States], tabulating machines were installed in open areas, with wall paneling and other architectural features that reduced noise levels in the punched-card area as well as in the surrounding departments, turning American punch-card departments into environments suitable for their female employees.³⁴

The image of the billing department in figure 2.2 seems to confirm the observation Corinna Schlombs made of the average American punch-card department as embedded in an open office. It is featured on the bottom left of the following two pages in the advertisement titled “four Synchro-Matics replaced five competitive bookkeeping machines on this billing job...” continuing on the bottom right page next to the image “since installation time, billing volume is up 30% and is being handled without overtime or additional equipment.” The two-column text on each page

33. Corinna Schlombs, “A Gendered Job Carousel: Employment Effects of Computer Automation,” in *Gender Codes: Why Women Are Leaving Computing*, ed. Thomas J. Misa (Hoboken, NJ: John Wiley & Sons, 2010), 76,79, <https://doi.org/10.1002/9780470619926.ch4>.

34. Schlombs, “A Gendered Job Carousel,” 79.

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is preceded by a hand-filled wholesale order form and followed by an example of a typed out invoice.

[...] [The operator] prepares bills from the order blank at the retail price, producing seven copies of each continues form invoice ... and – without extra time or effort – a tabulating card of each item on the invoice. [...] Thus, the bills are prepared and tabulating cards are simultaneously punched for each item of the invoice together with a card for the net amount of the invoice. These cards are then used to actuate tabulating machines for the automatic preparation of the necessary sales accounting records.³⁵



Figure 2.2: Four female operators handling billing at desks equipped with the Remington 80 billing machine connected to a 45-column punch to the left of each operator's desk. *Madame Helena Rubinstein*, (Buffalo, New York: Remington Rand, Inc.), 1940, David C. Faloon papers.

After describing the general procedure, the advertisement lists those features that make the procedure profitable. First, the Repeat Punch feature stores information such as the date, invoice number and customer's number for each item on the invoice to be punched on each card of the

35. *Madame Helena Rubinstein*, (Buffalo, New York: Remington Rand, Inc.), 1940, David C. Faloon papers.

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invoice. Furthermore, the text emphasizes the speed and accuracy of synchronising billing and sales accounting. On the next page, results and advantages are once again repeated. The operator's productivity is measured in the average number of completed bills (150) and tabulation cards (1,400) each day and the installation's savings are expressed in the number of machines it replaces (five competitive bookkeeping machines and three punches). The automation of the office thus went hand-in-hand with increased surveillance and the monitoring of keypuncher's productivity.³⁶ Since productivity was so easy to control, the women operating keypunches were under constant pressure, yet data entry "still necessitated high concentration and accuracy under tight time pressure."³⁷

The most important result of the new system according to the advertisement however is that "the Order and Billing Departments are ahead of the Shipping Department for the first time in the history of Helena Rubinstein, Inc." Aside from the previously mentioned features that are repeated in the list of advantages, two items relate directly to the working conditions of female operators.

2. The light touch made possible by the fully electrified keyboard of the Remington Billing Machine results in maximum production with minimum operator fatigue. [...]
5. SYNCHRO-MATIC provides very real clerical savings, of course. [...].³⁸

The haptic feedback or sense of touch of keyboards has greatly diminished over the last century. From old typewriters where keys are mechanically connected to hammers that hit the connected letter to the ink-ribbon and stamp letters onto paper, to contemporary touchscreens without any feedback other than a prerecorded soundtrack, typing on an electrified keyboard required less effort than mechanical typewriters or keypunches. Although the fifth advantage listed in the advertisement

36. Carter, "Clerical Work Organization," 207.

37. Schlombs, "A Gendered Job Carousel," 86.

38. *Madame Helena Rubinstein* (Buffalo, New York: Remington Rand Inc.), 1940, David C. Faloon papers.

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mentions clerical savings, the advertisement makes no literal reference to replacing human labour with machines. Instead, punch-card work was generally considered “low skill, and low paid,” and the “feminization of office work went hand in hand with its routinization and mechanization; both helped organizations to decrease their labor costs.”³⁹

2.1.4 From Invoice to Management Report

The advertisement then provides examples of seven identical invoices on carbon copies and how each item links to individual punch cards. The Remington 80 machine produced “a seven-part continuous form, every copy a clear impression of the electrically impelled keys” as the header next to the machine implied. A stack of seven invoices took up the centre of the left page and each invoice was labelled according to their purpose (e.g. the original invoice, the copy for the bookkeeping department, and for the statistical record department, a shipping order, a factory file copy, a packing slip and the shipping checking copy). Red arrows pointing towards areas of the original invoice indicate which items are “automatically repeat-punched” such as the invoice number, date, customer number and order number. On the adjacent page, the 45-column punch is shown in the right hand corner as can be seen in figure 2.2 produced cards “automatically and completely punched for every item on the bill,” and one card for the total all using the same layout. These cards were connected to the invoices on the previous page by a red line and will be discussed in more detail in the next section.

Furthermore, “high-speed, low-cost Numerical Tabulating Machines” produced daily, weekly and monthly reports which were shown on the next three pages. First, two pages show examples of “detailed analyses tabulated at 100 cards per minute” to “provide the control that permits faster executive decisions.” Given the target audience of this advertisement, it makes sense to devote more space to the type of reports executives can expect from the system. The narrative of executive control and

39. Schlombs, “A Gendered Job Carousel,” 79,81.

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the omission of the work required to prepare the cards and operate the tabulator renders the role of largely female keypunchers and tabulator operators invisible. Next to each example a short description explains the procedure and each report is labeled with the frequency (daily, monthly, semi-monthly, semi-annually and annually). The left page shows reports based on the net total cards such as net wholesale sales either by territory or by account, whereas the procedure for reports on the right page is slightly more complicated. A comparative sales statement by account is based on monthly summary cards, whereas finished goods sent to stock need to be manually punched for each entry. Key punching was thus often defined as manual labour. Finally, the analysis of gross sales based on withdrawals from stock can use item cards generated automatically in the billing department. On the next page an example of an operating report is based on a combination of item cards and cards punched for returned goods to tabulate net retail sales by product.

After examples from punch cards and reports, the booklet continues with “operating reports like these are the principal reason for enthusiastic management reports like this.” The letter from W. McLaughlin, comptroller at Helena Rubinstein is addressed to Remington Rand’s Tabulating Machines Division and reads like a summary of all key selling points mentioned in previous pages. The letter, addressing Remington Rand as “Gentlemen,” starts by describing the previous workflow and machines, the current system and its positive evaluation both in terms of increased volume, and flexibility, as well as savings. Finally, the installation staff was praised for their planning and assistance in training employees. Whether this letter truly originated from the comptroller of Helena Rubinstein is doubtful, but it highlights once again the target audience of managers and executives who were in charge of ordering equipment and overseeing operations.

The back page of the booklet shows the Punch and Bookkeeping Machine in their integrated desks as seen in figure 2.3, followed by a list of rather typical punch card applications such as commercial and public utility billing, accounts payable, welfare accounting, inventory, and payroll. The advertisement’s goal of selling the system becomes explicit in the fi-

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nal statement. “See the Savings SYNCHRO-MATIC Can Deliver to YOU ... For Complete Demonstration, Phone or Write Our Nearest Branch Office TODAY!”



Figure 2.3: Remington Rand Model 80B Electrified Fanfold Billing Machine and 45-Column Automatic Electric Punch. *Madame Helena Rubinstein*, (Buffalo, New York: Remington Rand, Inc.), 1940, David C. Faloon papers.

2.2 Accounting at Helena Rubinstein in London

Even twentyfive years after the advertisement of the SYNCHRO-MATIC circulated in the United States, Helena Rubinstein Ltd. in the United King-

dom adopted a similar system. On July 1, 1955, the Wholesale department based in London established a new administrative routine and performed “all Invoicing and Crediting with very few exceptions [with] Powers-Samas Accounting Machinery,” the main exception being export. The Powers-Samas and International Computers and Tabulators Ltd. (I.C.T.) documentation donated to the Centre for Computing History (CCH) in Cambridge by John Howard in 2013 provides the necessary information about the installation.⁴⁰

This section is based on the career of John’s sister in law, Miss Audrey Summerell, and her responsibility as manager of the Powers-Samas Room in Grafton Street, London.⁴¹ After a brief biography of Miss Summerell, this section describes the installation of the Powers-Samas equipment and the newly established workflow both within the Powers Samas Room and across departments of Helena Rubinstein Ltd..

2.2.1 Mrs. Audrey Williams neé Summerell

Before marrying into the Williams family, Audrey Summerell worked for Burroughs Wellcome & Co. at Euston Road in London where she became familiar with both the Payroll and the Sales Ledger performed on Powers-Samas equipment.⁴² Based on her previous experience, she then moved to Helena Rubinstein Ltd. in 1955 and managed the new installation together with “a staff of around fifty machine operators.”⁴³

In 1963, Helena Rubinstein Ltd. changed to I.C.T. equipment when Miss Summerell’s team moved to the new facility at Molesey. The original equipment thus remained in use for four years after Powers-Samas

40. B.S. Forter and W.F. Menhinick, memorandum, “Wholesale Department (United Kingdom Sales Only) New Administrative Routine,” 1955, Powers-Samas and ICT Documentation.

41. Powers-Samas and ICT Documentation, <http://www.computinghistory.org.uk/det/28274/Powers-Samas-ICT-Documentation/>.

42. A. Summerell, “Notes on Tabulators, Sales Ledger, Payroll,” 11 November 1951, Powers-Samas and ICT Documentation.

43. Powers-Samas and ICT Documentation, <http://www.computinghistory.org.uk/det/28274/Powers-Samas-ICT-Documentation/>.

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merged and eight years in total. Miss Summerell continued in the same function until “Helena Rubinstein transferred its data processing activities to ‘Messrs Applied Computer Techniques Limited’ on 31st May 1972, at which point Mrs. Williams was declared redundant.” After twenty years of working with Powers-Samas equipment in and around London, she moved to Eastbourne working for the Dental Estimates Board.⁴⁴

2.2.2 The Powers-Samas Room

Contrary to the findings of Corinna Schlombs and figure 2.2 showing the billing department of Helena Rubinstein in New York where punch operators worked in an open office, the consistent naming of the Powers-Samas Room in London clearly indicates a separate space housing the equipment. However, the enclosed office housing Powers-Samas equipment in the United Kingdom provided a working space for a team of female punch operators, whereas in Germany Corinna Schlombs described an all-male punch operator team. Thus although the occupational gender segregation in the United Kingdom resembled that of the United States, the office architecture in London is similar to that of Germany.

According to Miss Summerell's notebook, on April 20, 1955, she estimated that two punches and the automatic verifier would arrive on May 21.⁴⁵ Furthermore, her notes also indicate that carpet was ordered for the floor beneath the tabulator, perhaps to muffle the noise of the machine. She meticulously wrote down the size of each piece of equipment and each cabinet according in imperial units of measurement which remained in use in the United Kingdom until 1965.⁴⁶ The Powers-Samas room was furnished with:

44. Powers-Samas and ICT Documentation, <http://www.computinghistory.org.uk/det/28274/Powers-Samas-ICT-Documentation/>.

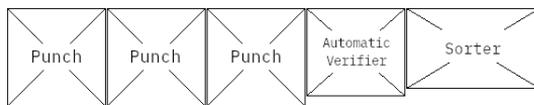
45. A.P. Summerell, notebook, Powers-Samas and ICT Documentation.

46. *Imperial units*, 2020, <https://www.britannica.com/topic/Imperial-unit#ref239325>.

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punches	3'6" x 3'6"	107 cm x 107 cm
automatic verifier	3'6" x 3'	107 cm x 91 cm
sorter	4'8" x 2'10"	142 cm x 86 cm
tabulator	5'6" x 4'5"	168 cm x 135 cm
files	3'4 ¼" x 2'4 ¼"	102 cm x 72 cm
card storage cabinets	1'8 ½" x 1'5"	52 cm x 43 cm

Since no plan of the actual layout was included in the documentation, I calculated the smallest possible size of a room which could house the equipment mentioned above. When lining up most of the equipment to one side and the cabinets as well as the tabulator on another side of the room leaving a one meter corridor in between, the minimum size of the Powers Room would be 22.75 m².



Powers-Samas Room

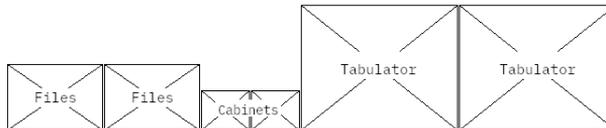


Figure 2.4: Potential Powers-Samas Room Layout. Designed by the author based on the sizes and quantities mentioned in A.P. Summerell, notebook, Powers-Samas and ICT Documentation.

For the Sales Ledger routine, Mr. Menhinick composed a list of tasks for Miss Summerell in order to prepare for the change in equipment and routine. First, the card designs needed to be approved, followed by a list of supplies to order such as zincos, cards, white guide cards for indexing, additional cabinets and trays for ledger filing.⁴⁷

47. Other examples of card design include an invoice card, an invoice leading card, a

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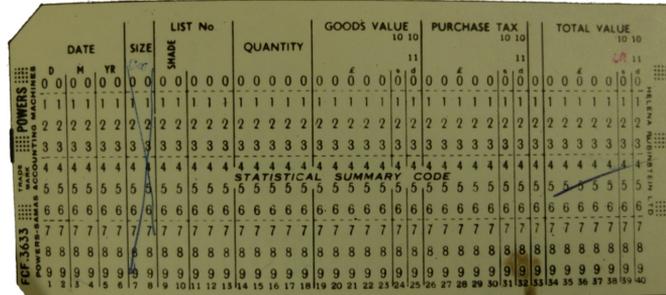


Figure 2.5: Powers, punch card, “Statistical Summary Code,” Powers-Samas and ICT Documentation.

Furthermore, Mr. Menhinick asked for a design of the connection boxes and stationary. Miss Summerell needed to order a special type for both tabulators and check existing accounts for method of payment. Punching documents needed to be prepared for Name & Address cards, Balance cards, and ensuring “that the Account No. can be clearly coded on all yellows.”

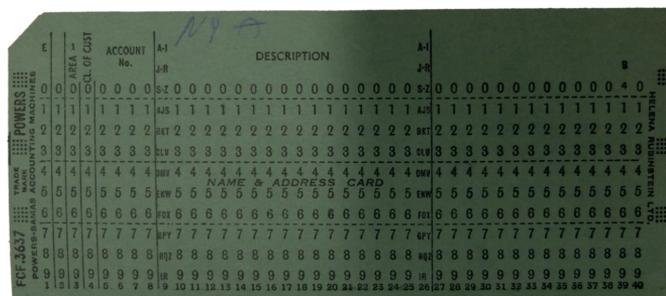


Figure 2.6: Powers, punch card, “Name & Address Card,” Powers-Samas and ICT Documentation.

name and address card, and a customers summary card. Remington Rand, “Card designs,” 1945-1965, David C. Faloon papers, Box 2, Catalog 102683291.

PUNCH CARDS IN ACCOUNTING

Finally, Mr. Menhinick asked Miss Summerell to prepare the control book, card codes, and new account numbers. Cards would be delivered by December 1954.⁴⁸ Then on January 10, 1955, another list of required supplies was added to the document outlining the *Invoicing and Statistical Routines for Powers-Samas equipment*. Aside from twelve packs of interfold paper, and six tabulating ribbons, three types of cabinets were mentioned: two card storage cabinets, two connection box cabinets, and three cabinets for automatic key punches. Finally, two card per unit files, twenty-four spring clips, and twenty-six trays were ordered. The document also mentions chairs for the punch and tabulator operators and requests an estimate of the number of guide cards for the Card per Unit File. The total cost of all the supplies amounted to £151 which would translate to about £3,988 today.⁴⁹ The supplies listed here illustrate that a punch card installation required additional material on top of the equipment itself. As the cover illustration shows, the storage of punch cards occupied a significant part of the office environment.

The Powers-Samas Room could not operate without a staff though, so in Miss Summerell's notebook she included the following job advertisement: "Powers Samas experienced P Op required for new 40 col installation in famous cosmetic company in W. End of London. Opportunity will be given to operate all other machines with prospects of promotion."⁵⁰

Soon new colleagues joined Miss Clark who worked on the tabulator and the sorter, Kay who was assigned punching and the sorter, as well as pulling cards together with Jean, Gerda who worked on orders and punching, Miss Walters who did the checking, Anne handling phone calls and Mrs. Hammord together with Cynthia in charge of filing. Miss Summerell's notebook mentions Laura Crone, Anne Mason, Anne Marshall,

48. Helena Rubinstein Ltd., memorandum, "Suggested Sales Ledger Routine," Powers-Samas and ICT Documentation.

48. Helena Rubinstein Ltd., memorandum, "Invoicing and Statistical Routines for Powers-Samas Equipment," Powers-Samas and ICT Documentation.

49. Based on inflation calculated by the CPI Inflation Calculator. <https://www.in2013dollars.com/uk/inflation/1955?amount=1>.

50. A.P. Summerell, notebook, Powers-Samas and ICT Documentation.

PUNCH CARDS IN ACCOUNTING

Doris Clarck, Dorreen Lacey, Jean Woodward, Jean Magnus, and Margaret. All employees in the Powers-Samas room went by female names and their title indicates some were married while others were not. Marital status thus did not affect their employment. Only sixteen employees working in the Powers-Samas Room were mentioned, so perhaps the group Miss Summerell managed grew to fifty operators as mentioned by her brother-in-law in later years.⁵¹

2.2.3 Departmental and Internal Workflow

The Wholesale Department

The work of the Powers-Samas Room depended on the preparatory work of the Wholesale department which also needed to adapt to a new administrative routine. The document outlining the new routine titled *Wholesale Department (United Kingdom Sales Only). New Administrative Routine*. listed nine different types of orders: post orders, telephone orders, salon and hairdressing stock orders, salon and hairdressing bulk orders and cubicle stock, agents supplied from the salon, credit notes, no charge dockets, claims, and samples.⁵²

Usually Miss Wallace from the Sales Department received orders and examined them, followed by Miss Walters who was responsible for extracting show material details. Next Miss Wallace passed the orders to Miss Summerell who inserted the customer's account number from circular index cards. Prices of preparations were checked based on the list number and if the list number was missing it should be added. For salon and hairdressing stock orders, each department would be allocated an account number and treated as outside customers as in the previous example. The bulk orders and cubicle stock for salons and hairdressing however could not be invoiced by the Powers system so they were treated

51. A.P. Summerell, notebook, Powers-Samas and ICT Documentation. <http://www.computinghistory.org.uk/det/28274/Powers-Samas-ICT-Documentation/>

52. B.S. Forter and W.F. Menhinick, "New Administrative Routine," 1955, Powers-Samas and ICT Documentation.

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according to the previous routine by Miss Wallace.⁵³ When agents are supplied from the salon, the procedure went as follows:

The “POWERS” organisation will arrange for the wholesalers to be invoiced and for the salon account to be credited. The invoices to the customer will be sent by post and the credit note for the salon will be passed down thereto at the end of the day. The authorization for the release of stock from the salon for supply to agents, will come from the Sales Department.⁵⁴

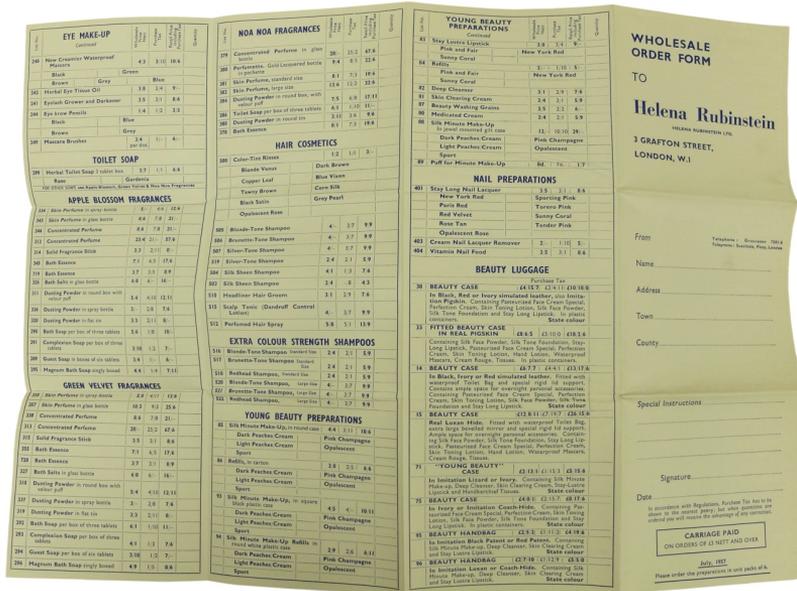


Figure 2.7: Helena Rubinstein Ltd., “Wholesale Order Form,” July 1957, Powers-Samas and ICT Documentation.

53. B.S. Forter and W.F. Menhinick, “New Administrative Routine,” 1955, Powers-Samas and ICT Documentation.

54. B.S. Forter and W.F. Menhinick, “New Administrative Routine,” 1955, Powers-Samas and ICT Documentation.

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Either Mr. Bolton, Miss Wallace or Mrs. Griver was responsible for signing the authorisation, and the salon needed to check the credit notes for such authorisation and to check quantities. For returned goods, Mrs. Sutton passed on the details to Miss Summerell who would then create a credit note following the invoice procedure. Miss Wallace however was responsible for any communication with the customer regarding credit notes. A temporary procedure for no charge dockets was put in place to keep track of stock movements. Rather than sending the documents directly to the factory, they were collected by Mrs. Sutton by half past three. who presented them for checking to either Mr. Menhinick or Miss Lindberg by four o'clock. The factory office would change the finished stock card kept there if "Stock Movement" was indicated on the docket. Claims due to loss, damage or theft would be written by Miss Wallace and "an invoice without purchase tax would be prepared by the 'Powers' Staff." As for samples the procedure was similar to releasing salon stock for agents except the salon would be credited and the invoice sent to a sample account without purchase tax.⁵⁵

The administrative routine of the Wholesale Department also mentioned the Powers Room and the people in charge.

As supervisor of this room, Miss Summerill [sic] will be responsible to Mr. Manhinick [sic], that the technical routine laid down is adhered to. [...] The tabulation i.e. (printing) of invoices will take place from 11.30 a.m. tot 3 p.m. and no orders for invoicing can be accepted by the "POWERS" room after 3 p.m.⁵⁶

I will discuss the technical routine in the next section, but the administrative routine for the wholesale department already mentions who received information from the Powers-Samas Room. First, the factory was

55. B.S. Forter and W.F. Menhinick, "New Administrative Routine," 1955, Powers-Samas and ICT Documentation.

56. B.S. Forter and W.F. Menhinick, "New Administrative Routine," 1955, Powers-Samas and ICT Documentation.

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sent the “daily tabulation of net stock movements.” Mr. Menhinick and Mr. Forter each received a yellow copy of the “daily total of net sales represented by the goods value of all the invoices tabulated that day.” The monthly tabulations of “total net sales per customer and per representative’s area; the total number of units of each preparation sold” was used to calculate commission and to provide sales information to the sales department and representatives.

From five carbon copies for each invoice, the final three consisting of a white packing slip, blue factory copy, and yellow office copy go to the factory and once the goods are dispatched, the office copy is filed in the Grafton Street office. The first two invoice copies - the customer’s copy and the pink account’s copy - in combination “with a total of the goods value, purchase tax, total value of all the invoices” were “sent up to the Accounts Office IN ONE BATCH DAILY.”⁵⁷ These guidelines indicate that the accounts office was located above the Powers-Samas room, which could mean that the machines were located in the basement or at the very least that the location of offices could have represented the corporate hierarchy.

The new routine for the accounts department was arranged with Mr. Menhinick and Miss Lindberg but no details are mentioned. The responsibility for extracting statistical and stock information passed from the factory office to the Powers Department, and only “the finished goods stock cards should be kept up to date from the daily sales lists received from the “POWERS” room.” If representatives withdraw stock from their agents, and after approval for credit from Mr. Bolton, Mrs. Sutton “will send details to the “POWERS” Room for the issue of a credit to the Agent.” The factory office then needed to deduct items from existing stock cards to keep track.⁵⁸ Furthermore, Mr. Tone was notified by Mr. Forter on June 21, 1955, to make sure that all deliveries were dealt with on the old system before July 1, so that the factory could signal out of stock items

57. B.S. Forter and W.F. Menhinick, “New Administrative Routine,” 1955, Powers-Samas and ICT Documentation.

58. B.S. Forter and W.F. Menhinick, “New Administrative Routine,” 1955, Powers-Samas and ICT Documentation.

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the description confirms that most staff in the Punch Card room were female, but the term “girls” most likely does not reflect the age of the workers. Cards are called back if necessary and the errors corrected before noon.⁶⁰

In a second stage starting at eleven thirty and interrupted by the lunch break between twelve thirty and one thirty. Invoices are tabulated until three o'clock in the afternoon, the sheet feed device ensures that invoices are printed on the correct stationery. Then if the totals agree with the sales ledger they are posted. Punch operators then use a copy of the invoices to punch a Customers Total Card for each invoice which are eventually filed away for control purposes until the end of the month. Between three o'clock and three thirty the sales ledger cards for customers are punched and sorted, and between three thirty and a quarter to four the sales ledger is tabulated in the third stage. At the same time, the item cards are sorted to list number and shade. The name and address cards are refiled between three thirty and four thirty and the leader cards are destroyed. In the fourth stage the sales ledger tabulation is “passed to the punch operators who will punch and verify Daily Statistical Summary Cards for each list number” between three and four o'clock in the afternoon. The MC and size code are punched between four o'clock and half past four and in the final stage these cards are tabulated by list number to check with totals from previous tabulations (item card, invoices, customers total card) between half past four and five o'clock. The daily routine confirms that a normal working day of eight hours with a one hour lunch break followed a fixed structure with many standardized and repetitive tasks.⁶¹

60. A.P. Summerell, notebook, Powers-Samas and ICT Documentation.

61. A.P. Summerell, notebook, Powers-Samas and ICT Documentation; Helena Rubinstein Ltd., memorandum, “Invoicing and Statistical Routines for Powers-Samas equipment,” Powers-Samas and ICT Documentation.

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and purchase tax for each list number or item for the entire month and are finally “sorted and tabulated by Size code for the required quantity figures of each size.”⁶²

A punch card titled "CUSTOMERS SUMMARY CARD". It has columns for DATE, INVOICE No., ACCOUNT No., PURCHASER, and GOODS VALUE. The data is represented by a grid of numbers (0-9) and dashes (-) corresponding to punch holes.

(a) Customers Summary Card

A punch card titled "SALES LEDGER CARD". It has columns for LIST No., DESCRIPTION, RETAIL PRICE, NET PRICE, QTY, GOODS VALUE, PURCHASE TAX, and TOTAL VALUE. The data is represented by a grid of numbers and dashes.

(b) Sales Ledger Card

A punch card titled "LEDGER CARD". It has columns for ACCOUNT No., DATE, REF. No., DESCRIPTION, and VALUE. The data is represented by a grid of numbers and dashes.

(c) Ledger Card

A punch card titled "STATISTICAL SUMMARY CODE". It has columns for DATE, LIST No., QUANTITY, GOODS VALUE, PURCHASE TAX, and TOTAL VALUE. The data is represented by a grid of numbers and dashes.

(d) Statistical Summary Code

Figure 2.11: Powers, punch cards, Powers-Samas and ICT Documentation.

2.2.4 The Tabulator for 40-Column Cards

At the start of each tabulation, the operator needed to insert the correct connection box, and set automatic total controls as well as listing or totals only control at the front of the machine (see figure 2.12). On top of the machine the nought splits, hammer stops, print controls and other button controls were also set by the punch operator. Then at the back of the machine, the operator could choose between setting a stop before or after the total. Finally the paper carriage spacing was set and paper was

62. A.P. Summerell, notebook, Powers-Samas and ICT Documentation; Helena Rubinstein Ltd., memorandum, “Invoicing and Statistical Routines for Powers-Samas equipment,” Powers-Samas and ICT Documentation.

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inserted in the carriage, punched cards were placed in the magazine, and the machine was switched on.

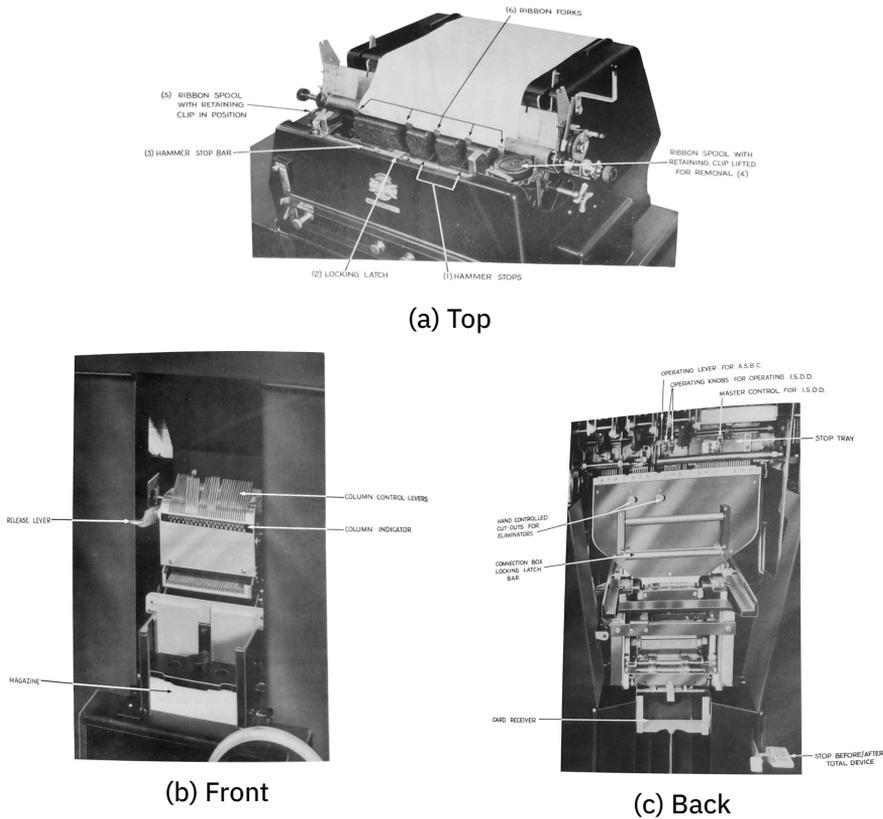


Figure 2.12: Illustrated Parts of the Powers-Samas Tabulator. *The Tabulator for 36 and 40-column cards*, (London: Powers-Samas Accounting Machines (Sales) Ltd.), Powers-Samas and ICT Documentation.

62. *The Tabulator for 36 and 40-column cards*, (London: Powers-Samas Accounting Machines (Sales) Ltd.), Powers-Samas and ICT Documentation.

2.3 Punch Card Applications and Installations

After the introduction of Herman Hollerith’s tabulating machines used for the United States census since 1890, punch cards spread to a number of other applications. To illustrate which commercial applications rose to prominence in the 1940s, I assigned topics based on the title and description of 131 publications mentioned in James Cortada’s bibliography.⁶³ Most publications fell under accounting and were published in journals such as the *National Association of Cost Accountants Bulletin* (NACA), *Journal of Accounting*, and *Journal of Accountancy*.

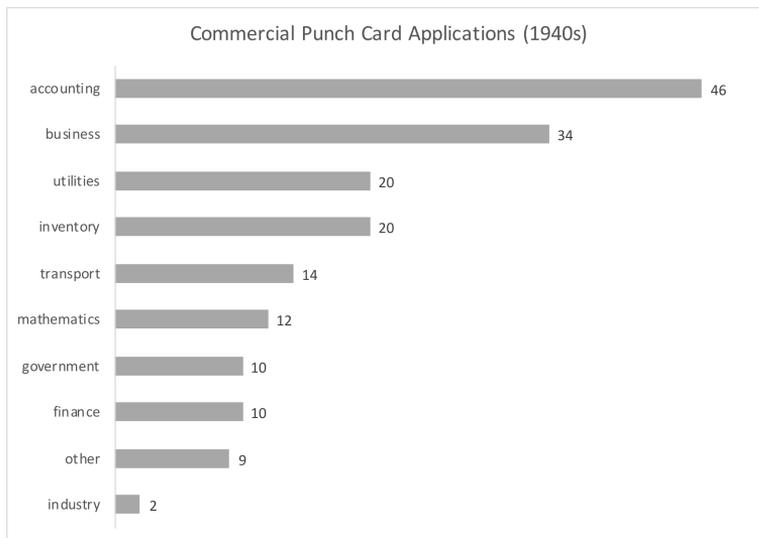


Figure 2.13: Commercial Punch Card Applications in the 1940s.⁶⁴

In comparison to the previous two decades, the number of account-

63. Cortada, *A Bibliographic Guide to the History of Computing*.

64. Cortada, *A Bibliographic Guide to the History of Computing*.

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ing publications increased from thirty-seven to forty-six, and business applications rose spectacularly from eleven to thirty-four publications from the 1940s. General accounting applications increased from twenty-one to thirty-three publications, with a slight increase in billing, but a decrease in trust and cost accounting. While business publications on office applications disappeared entirely in the 1940s, publications on manufacturing, payroll, and sales all increased.

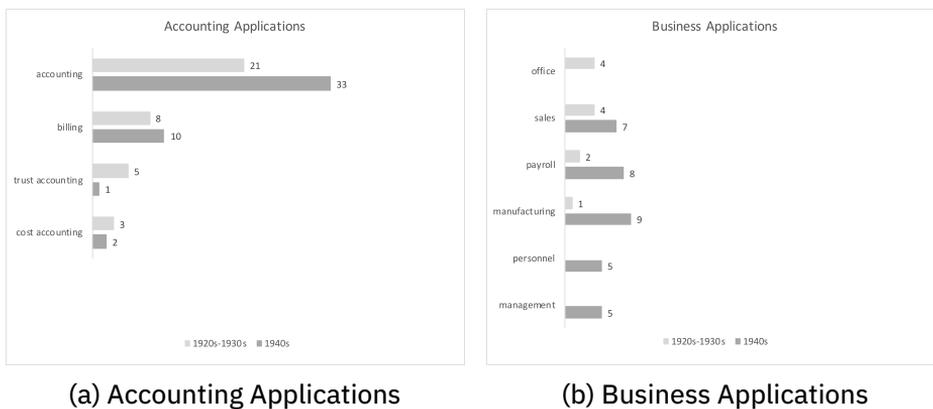


Figure 2.14: Comparison of Accounting and Business Applications for Punch Card Machines in the 1920-1930s and the 1940s based on Cortada, *A Bibliographic Guide to the History of Computing*.

2.3.1 A typical installation

Since each data processing task required a different machine, an office installation needed equipment for “*recording, tabulating, and sorting*” data. Data was recorded on paper cards by punching holes in specific locations using a keypunch which remained “in use in essentially the same form for well over half a century and was a common sight in computer departments as late as the 1970s.” Next, stacks of cards were sorted based on particular fields. Finally, the tabulator summarized and tabulated the

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data.⁶⁵

Punch cards varied in size, color, layout, number of columns and type of perforation. In the 1890 United States census, punch cards recorded nonnumerical data for each citizen on a $6\frac{5}{8}$ " x $3\frac{1}{4}$ " card (or 17 x 8 cm). For numerical information the card design changed to vertical columns which each represented a single decimal digit. Hollerith eventually standardized 45-column cards of $7\frac{3}{8}$ " x $3\frac{1}{4}$ " (or 19 x 8 cm). Two top rows indicated "the sign of a number, or other control information" and the remaining rows 0-9 recorded "the value of a digit."⁶⁶ Until 1928 "both Hollerith and Powers machines had used a common 45-column card format" making round perforations, whereas IBM switched to rectangular perforations meaning a card could fit 80-columns. "Remington Rand responded in 1930 by introducing a 90-column card."⁶⁷ The 90-column card had the same size, but recorded numerical information differently than Hollerith cards. "Numerical designations are expressed by single hole punchings and also by combined hole punchings. [...] a single hole punch to express an odd digit, a combined hole punch to express an even digit."⁶⁸

The *Powers Reference Manual* from the 1930s includes a long list of card specifications. Cards came in eight different solid colors (manila, red, salmon, blue, green, brown, buff, purple), with the option to add a colored stripe at the top edge of the card in seven colors (all but manila), or even smaller stripes in any location printed horizontally. A table compared contrast between stripe colors and card colors to indicate which combinations were good, fair, or bad. Cards were generally printed with black ink which could be replaced by red or green ink, certain fields could

65. Martin Campbell-Kelly, "Punched card," in *Encyclopedia of Computer Science* (John Wiley & Sons, January 2003), 1489, <https://dl.acm.org/doi/abs/10.5555/1074100.1074746>.

66. Martin Campbell-Kelly, "Punched card machinery," in *Encyclopedia of Computer Science* (John Wiley & Sons, January 2003), 1487, <https://dl.acm.org/doi/abs/10.5555/1074100.1074747>.

67. Campbell-Kelly, "Punched card," 1490.

68. "Bulletin C-1: Remington Rand Powers 90-Column Card," in *Powers Reference Manual* (Buffalo, New York: Remington Rand Inc.), 1930, David C. Faloon papers.

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be printed bold, and cards could be consecutively numbered.⁶⁹ Furthermore, the layout of cards depended on their application. The reference manual lists twenty-four Powers' cards, eighteen Remington Rand cards, and must have included sixty card examples in total, listing the application (i.e. expense distribution and accounts payable, payroll and payroll distribution, trust accounting) and class of business (i.e. equipment manufacturer, paper and paper-products manufacturer, financial) for each.

Powers offered at least ten punches in the 1930s, including for different types of punch cards such as the automatic punch and the 90-column punch, the alphabetical punch and the visible punch, as well punches with specific functions such as the reproducing punch, the summary card punch, the printing punch, and the printing multiplying punch. Finally, the punch installation used at Helena Rubinstein in the United States and the United Kingdom (see sections 2.1 and 2.2) synchronised an electric punch with a bookkeeping machine.⁷⁰ Each bulletin shows an image of the equipment with a brief description, followed by a list of operating features and advantages, as well as specifications such as size (height, weight, space occupied, working area), keyboard, color, etc.. The last page usually contains the keyboard layout or an example of punch cards and reports.

Sorters grouped cards based on "classes of information punched on the cards" and "dropped sorted cards into hoppers by subject."⁷¹ Powers provided a sorter for 45-column cards (see figure 2.15), another sorter that could switch between 45-column and 90-column cards, and finally a sorter that also counted the number of cards per subject.⁷² As with other sorters, twelve pins sense the position of the holes in a column.

69. "Bulletin C-1: Remington Rand Powers 90-Column Card," in *Powers Reference Manual* (Buffalo, New York: Remington Rand Inc.), 1930, David C. Faloon papers.

70. "Bulletin P-1 to P-10 (except P-5)," in *Powers Reference Manual* (Buffalo, New York: Remington Rand Inc.), 1930, David C. Faloon papers.

71. Cortada, *Before the Computer*, 46.

72. "Bulletin S-1: Powers Standard Sorters 45 and 90-Column Card," and "Bulletin S-3: Remington Rand Counting Sorter," in *Powers Reference Manual* (Buffalo, New York: Remington Rand Inc.), 1930, David C. Faloon papers.

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The sorting criterion is determined by the operator who sets the selector to a specified column, also known as indexing. The sorted cards fall into the sorting rack which “consists of twelve, steel, card compartments mounted on a rolling truck.”⁷³



Figure 2.15: Powers Model 20 Sorter. “Bulletin S-1: Powers Standard Sorters 45 and 90-Column Card,” in *Powers Reference Manual* (Buffalo, New York: Remington Rand Inc.), 1930, David C. Faloon papers.

The reference manual stresses how the design is based on scientific studies “to require the absolute minimum of clerical attention, to afford ease and simplicity of operation, and to obtain the highest sorting production.” The manual, similar to the advertisement discussed in section 2.1, stresses that one person can operate several sorters.⁷⁴ Key punch operators were thus classified as clerical workers in a 1930s manual.

Tabulators counted information stored on punched cards and were expanded with mathematical functions during the 1920s and 1930s.⁷⁵

73. “Bulletin S-1: Powers Standard Sorters 45 and 90-Column Card,” in *Powers Reference Manual* (Buffalo, New York: Remington Rand Inc.), 1930, David C. Faloon papers.

74. “Bulletin S-1: Powers Standard Sorters 45 and 90-Column Card,” in *Powers Reference Manual* (Buffalo, New York: Remington Rand Inc.), 1930, David C. Faloon papers.

75. Cortada, *Before the Computer*, 46.

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Powers machines listed in 1930 had mathematical functions such as direct subtraction, as well as automatic sub and grand total control, but the manual also devoted an entire bulletin to the compensating spacing carriage and the constant spacing carriage which respectively space forms and items on printed output.⁷⁶

Continued enhancements to basic technologies originally worked out before World War I broadened the applicability of punched card equipment in the 1920s. Encouragement from customers simply enticed vendors to develop product lines further, usually by adding functions. These advancements in turn heated up competition for existing markets while successfully forcing vendors to seek a broader customer base with new product offerings.⁷⁷

Aside from punches, sorters, and tabulators, eventually a multiplying punch, an interpreter, and a collator were developed.⁷⁸ The multiplying punch could calculate and print the product of two numbers from a single card and punch the result on the same card. The interpreter typed the information represented on cards in human-readable form along the top of the same card. Finally, a collator could insert or remove cards from a deck.⁷⁹ The Powers reference manual does not mention a multiplying punch nor a collator, but it does include an interpreter for both alphabetical and numerical data.⁸⁰

76. "Bulletin T-3: Remington Rand Powers Direct Subtraction," "Bulletin T-4: Remington Rand Powers Automatic Sub and Grand Total Control," and "Bulletin T-5: Remington Rand Powers Compensating Spacing Carriage and Constant Spacing Carriage," in *Powers Reference Manual* (Buffalo, New York: Remington Rand Inc.), 1930, David C. Faloon papers.

77. Cortada, *Before the Computer*, 106.

78. Campbell-Kelly, "Punched card," 1490.

79. Cortada, *Before the Computer*, 46.

80. "Bulletin G-2: Type 212 Interpreter 45 and 90 Columns...Alphabetical and Numerical," in *Powers Reference Manual* (Buffalo, New York: Remington Rand Inc.), 1930, David C. Faloon papers.

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In order to satisfy the burgeoning demand for punched card data processing in public administration and private enterprise, many new “auxiliary” machines were introduced to supplement the basic punched card setup. These new machines included the multiplying punch, the interpreter, and the collator. As well as new machines, there were evolutionary improvements in the specification, speed, and reliability of the existing machines.⁸¹

In the following two sections, the products marketed by Remington Rand in the 1940s in collaboration with two of their clients, Helena Rubinstein and Freeman Shoes, are discussed in detail. The Electric Punch which was synchronized with the Bookkeeping Machine was central to the Synchro-Matic system marketed by Remington Rand as discussed in section 2.1. Furthermore, the installation most likely worked in conjunction with the Powers Numerical Tabulator to generate reports.

Electric Punch Synchronized with Bookkeeping Machine

In *Before the Computer*, James Cortada describes the competition between IBM and Powers as a chronological list of product improvements, thus stating: as a reaction to the electronic duplicating keypunch developed by the predecessor of IBM in 1924, “Powers countered with an electronic keyboard punch and the first synchromatic installation that allowed simultaneous typing of data on a typewriter and punching on cards” in 1925.⁸² While employees interacted with a typewriter-like Remington bookkeeping machine, the Powers electric punch produced several punch cards containing the same information.

“As the descriptive data, either alphabetical or numerical, and the correlated amounts are printed by the Bookkeeping Machine - they are simultaneously recorded in the proper column or columns of the tabulat-

81. Campbell-Kelly, “Punched card,” 1490.

82. Cortada, *Before the Computer*, 106.

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ing card.”⁸³ Data is only transmitted onto cards if the control bar makes the electrical contacts. The reference manual lists four advantages of the system: low operating costs, flexibility, speed, and precision. Low operating costs because work that was previously performed by two operators can now be done by one person, and because simultaneous operation reduces operating time. Flexibility and speed are further emphasised by reducing “two formerly separate mechanical accounting procedures [...] to a single operation,” and through ensuring that the punch cards are ready for tabulating sooner. Finally precision alludes to the possibility to check tabulating cards against control cards from the Remington Bookkeeping Machine.⁸⁴

Powers Numerical Tabulator

The numerical tabulator translates and prints the information on punch cards “in any statement form desired” including sub- and grand totals printed directly under the same unit. “The only clerical attention necessary is the insertion of cards and forms - operations that may be performed easily and quickly even while the machine is running.”⁸⁵ The tabulator can hold 625 cards in the feeding magazine and 850 cards in the receiving magazine, as well as produce up to six legible carbon copies. Furthermore, the machine accepts both “continuous form sheets such as fanfold or flat-pack paper [...] as well as cut forms.” The operating features and advantages mention the design and ergonomics such as the convenient location of controls and the proper height for printing at 50½” (or 128 cm) from the floor. “No fatiguing posture required to observe the

83. “Bulletin P-6: Remington Rand Powers Electric Punch Synchronized with Bookkeeping Machine,” in *Powers Reference Manual* (Buffalo, New York: Remington Rand Inc.), 1930, David C. Faloon papers.

84. “Bulletin P-6: Remington Rand Powers Electric Punch Synchronized with Bookkeeping Machine,” in *Powers Reference Manual* (Buffalo, New York: Remington Rand Inc.), 1930, David C. Faloon papers.

85. “Bulletin T-10: Powers Numerical Tabulator (Five Units - 45 Column),” in *Powers Reference Manual* (Buffalo, New York: Remington Rand Inc.), 1930, David C. Faloon papers.

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tabulated results.” Although most operators probably no longer needed to bend over to read results, the height still required them to stand rather than sit next to the machine. The multiple translator mentioned earlier means wiring was no longer needed. Finally the bulletin stresses how compact the machine is at only six square feet (or 0.56 m²) and its constant speed of eighty to a hundred cards per minute, as well as the operations of direct subtraction and grand totals.⁸⁶



Figure 2.16: Powers Numerical Tabulator. “Bulletin T-6: Type 285 Tabulator 90 Column Numerical ... 85 Printing Sectors,” in *Powers Reference Manual* (Buffalo, New York: Remington Rand Inc.), 1930, David C. Faloon papers.

86. “Bulletin T-10: Powers Numerical Tabulator (Five Units - 45 Column),” in *Powers Reference Manual* (Buffalo, New York: Remington Rand Inc.), 1930, David C. Faloon papers.

Summary

Both James Powers, inventor of punch card equipment and founder of the Powers company, and Helena Rubinstein, founder of a cosmetic's concern, embody the American dream of emigrating from Europe and starting successful businesses. Powers equipment changed little in the first half of the twentieth century and Remington Rand acquired the business in the United States by the 1930s when Helena Rubinstein promoted their bookkeeping machines. A quarter century later the same equipment from the British equivalent company called Powers-Samas was installed in the London branch of Helena Rubinstein for accounting. One of the matriarchs of the beauty industry targeting female customers thus served as a case study for punch card equipment and the predominantly female workforce of keypunchers using these early computing devices.

Operators working in the Powers-Samas room at Helena Rubinstein in London worked between nine in the morning and five o'clock in the afternoon in a noisy room performing the same consecutive set of tasks day in day out. The recruitment advertisement promised some possibilities for promotion. Most female keypunchers and operators could still continue working after marriage. The upward mobility was however limited to occupations within the Powers-Samas room. Yet when punch card equipment was replaced by other technology at the beginning of the 1970s, so too were the female keypunchers.

The advertisement analysis illustrates the public image Helena Rubinstein upheld and her numerous strategies for projecting authority in both research and business by subverting predominantly male stereotypes of the medical expert and businessman. The target audience of (male) comptrollers or executives in accounting were expected to purchase punch card equipment operated in large part by a female workforce. The Remington Rand advertisement appealed to these mostly male executives by promising more control through technology rendering the work of female keypunchers and operators partially invisible by focusing less on the process and more on reports generated by the machines.

Chapter 3

The System/360 in Healthcare: the German Clinical Chemistry Laboratory

Going into the computer room is a very striking thing. It's a really different environment. [...] It's really loud and it's cold and you can smell, it smells like computers [...]. It's like machine oil and hot dust on plastic wires. It's a very distinctive computery smell and it's very overwhelming. It's very loud and overwhelming and there's all these computers that are running and whirring and blinking. [...] And it's a very physical, visceral experience in there.¹

The computer room, the cold room, the machine room, all describe the space that housed the computer system in the 1960s and 1970s. Figure 3.1 shows the interior of the computer room housing one of the

1. Cynde Moya, (Collections Manager, Living Computers: Museum + Labs), interview by Sytze Van Herck, November 23, 2018, Seattle, Washington.

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smaller International Business Machines (IBM) System/360 (S/360) installations.² A similar space that would compare to this room nowadays often houses servers. Access to the computer room in the 1960s or server space now is strictly limited to those who need to operate the machines. In the 1960s the computer room was often the only air-conditioned environment in the office, and server spaces still require air-conditioning. Electricity requirements for such large rooms of equipment mean that separate circuits need to be installed in order to run the machines. The security measures, temperature difference, electrical requirements, and noise pale in comparison to the smell of 1960s computers. No current analogy with server spaces that smell clean, neutral and non-distinct, can adequately describe the smell of 1960s mainframes. Dr. Moya's description of "machine oil and hot dust on plastic wires" comes close.³

The cover image and opening paragraph of the introduction illustrate the preparation of data for mainframes processing tax returns for the Internal Revenue Service (IRS). Mostly female keypunchers entered data for over 100 million taxpayers onto 400 million cards per year since the mid-1960s.⁴ One of the largest punch card equipment and computer manufacturers in the 1960s was IBM with a 70% market share. As the company grew out of Herman Hollerith's tabulating machines, IBM continued to use punch cards for input and output, changing little to the card layout between the 1930s until at least the end of the 1960s.⁵ The IRS for instance only replaced punch cards with direct data entry onto drums or disks in 1976. Interestingly, Paul Ceruzzi noted the importance of sound to establish a productive rhythm, leading managers to reintroduce the

2. Photograph, "IBM System/360 Modell 20, Magnetplatten, Magnetbänder," *IBM Bildkatalog* (Stuttgart: IBM Deutschland GmbH, 1981), Bild-Nr. D-106, Datenverarbeitung 10, Internationale Büro-Maschinen-Gesellschaft Deutschland, IBM Deutschland GmbH, Firmenschriften, FS003269/1-261, Deutsches Museum Archiv, München (hereafter cited as IBM Firmenschriften).

3. Moya, (Collections Manager, Living Computers: Museum + Labs), interview by Sytze Van Herck.

4. Ceruzzi, *A History of Modern Computing*, 119.

5. Ceruzzi, *A History of Modern Computing*, 111.

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rattling noise of keypunches to maintain high rates of data entry.⁶



Figure 3.1: Photograph, “IBM System/360 Modell 20, Magnetplatten, Magnetbänder,” *IBM Bildkatalog* (Stuttgart: IBM Deutschland GmbH, 1981), Bild-Nr. D-106, Datenverarbeitung 10, IBM Firmenschriften.

In order to “stay ahead in the computer market,” IBM planned to develop a new product line (NPL), which was only later named System/360.⁷ Emerson W. Pugh, who led the development of magnetic film memory for the S/360, explains the rationale behind the name of the product family in one of his publications on IBM’s history.⁸ The name System refers

6. Ceruzzi, *A History of Modern Computing*, 120.

7. Thomas A. Wise, “IBM’s \$5,000,000,000 Gamble,” *Fortune Magazine*, September 1966, 118, <http://www.cedix.de/Literature/History/FiveMillGamble1.pdf>.

8. Emerson W. Pugh, interview by Sheldon Hochheiser, November 14, 2009, Interview #521 for the IEEE History Center, https://ethw.org/Oral-History:Emerson_W._Pugh.

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to “an aggregation of interchangeable hardware units” with full program compatibility as opposed to previous series of “processors with peripheral equipment.”⁹ The number 360 alludes to the “number of degrees in a circle,” and represents “the ability of each computer to handle all applications.”¹⁰ The distinction between scientific and business computers no longer made sense. “Scientific users increasingly needed the alphanumeric and peripheral powers of business systems, and business users needed the logical and computational powers of scientific machines.”¹¹

The chairman of IBM, Thomas J. Watson, Jr., announced the S/360 at a press conference in Poughkeepsie on April 7, 1964. He described the event as “the most significant product announcement in IBM history” in the company newspaper.¹² The folder accompanying the product announcement represented the configured users IBM envisioned for the S/360 as four people embodying different applications. The stereotyped users in this folder present an interesting case for a (visual) discourse analysis in section 3.1. After briefly describing the technical features of the S/360, the analysis unravels each user personification individually. Since the announcement preceded the production of the machines, the section details the design, production, and sales stages of the product life cycle.

Historian and former IBM sales employee, James W. Cortada, describes what happened once the S/360 was announced in 1964.

The delay between announcement and shipping date gave customers and suppliers time to determine which models made sense to acquire, get them approved and budgeted, allowed time for the physical planning on where to house them, make

9. Emerson W. Pugh, *Building IBM: Shaping an Industry and Its Technology* (Cambridge, MA: MIT Press, 1995), 275, <https://books.google.lu/books?id=Bc8BGhS0awgC>.

10. Pugh, *Building IBM*, 275.

11. B. O. Evans, “Introduction to SPREAD Report,” *Annals of the History of Computing* 5, no. 1 (1983): 4.

12. IBM News Extra, April 7, 1964, Harwood G. Kolsky papers, Lot X3021.2005, Box 09, Folder 102634603, Computer History Museum.

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changes to air conditioners in data centers, train staff, complete software remediation, and so forth.¹³

Ordering and installing the mainframe processor and all peripherals attached required significant changes to both the physical space and the workflow. Section 3.2 focuses on planning the installation of a mainframe and the resulting office rebuild, as well as the changes to workflow for re-trained or newly hired staff.

A research stay at the Deutsches Museum (DM) in 2019 provided the main incentive for selecting the IBM S/360 as a case study for this chapter on mainframe computers. The exposition showcased a rare complete S/360 model 20 on a raised platform reminiscent of the raised floors in computer rooms of the 1960s. Other S/360s on display in the Computer History Museum (CHM) only exhibited components, whereas the IBM S/360 model 30 in the Living Computers Museum+Labs (LCM+L) was still under restoration at the time of my visit in 2018. The archive of the DM furthermore offered valuable sources within the *Firmenschriften* collection and the *Verwaltungsarchiv*.¹⁴ As a result, this case study focuses on the use of the IBM S/360 in German healthcare (section 3.3).

In the United States the Massachusetts Blue Cross also relied on mainframe computers to process customer records for medical insurance and won the bid to administer Medicare when the Social Security Act passed in 1965. By the end of the 1960s, Blue Cross had installed three S/360s. “Forty-three tape drives handled the records, and computer operations went on twenty-four hours a day, seven days a week.”¹⁵ In Germany, the introduction of a calibration law in the 1970s similarly motivated clinical-chemistry laboratories to use the S/360 for processing test results. Since smaller laboratories could not afford to purchase and install their own

13. James W. Cortada, *IBM: The Rise and Fall and Reinvention of a Global Icon*, History of Computing (Cambridge, MA: MIT Press, March 2019), 219. For peripherals the delay varied between six to nine months, for mainframes shipping would only start 18 to 24 months after the announcement.

14. IBM Firmenschriften; Verwaltungsarchiv, Deutsches Museum, München.

15. Ceruzzi, *A History of Modern Computing*, 113.

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computer, IBM also offered a time-sharing system, CALL/360 (see 3.3.1).¹⁶ In time sharing systems “each user had the illusion that a complete machine and its software” was accessible via a data station.¹⁷ Although all programs and data sets were accessible to the user, time sharing pushed the physical limits of computers.¹⁸ In fact, “how fast or slow one person’s job ran depended on who else was using the machine and what kind of jobs they were doing.”¹⁹

Although both IBM and competitors achieved limited compatibility on similar machines with different power, full compatibility on an entire system family had never been achieved.²⁰ However, “compatibility depended as much on developing compatible programs or ‘software’ as it did on hardware” and peripherals.²¹ Furthermore, peripherals were not optimised for all machines.²² Customers preferred systems they could upgrade according to their needs, adding larger compatible processors which ran the same software and peripheral equipment.²³

Based on a study of a proposed workflow for the clinical-chemical laboratory centred around IBM equipment of 1969 and the description of a program in IBM’s CALL/360 software library, section 3.3.2 explains how the introduction of computers changed the work of medical professionals. The visualisation of the workflow from patient admission to the communication of results and sending invoices in figure 3.6 answers research questions such as who controlled the flow of work and provided input data? How did software transform input and output data? Who drafted reports and how did the interface influence the workflow?

16. Hansjörgen Hägele, *CALL/360 Beschreibende Statistik mit dem Programm Häufigkeitsanalyse* (Stuttgart: IBM Deutschland GmbH, April 1974), Folder 06, IBM Firmenschriften; *Call/360 Datenfernverarbeitung im Teilnehmersystem* (Stuttgart: IBM Deutschland GmbH), Folder 06, IBM Firmenschriften.

17. Ceruzzi, *A History of Modern Computing*, 154.

18. Ceruzzi, *A History of Modern Computing*, 154.

19. Ceruzzi, *A History of Modern Computing*, 117.

20. Wise, “IBM’s \$5,000,000,000 Gamble.”

21. Wise, “IBM’s \$5,000,000,000 Gamble.”

22. Evans, “Introduction to SPREAD,” 4.

23. Cortada, *IBM*, 207.

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Elaborating on the functioning of all mainframe components, the German healthcare application is followed by an overview of the S/360. One of the main features of the product family were these so-called modular building blocks and reliance on existing mediums such as punch cards, tape readers, and eventually disk storage for data entry, data storage and programming. Section 3.4 discusses the proposed components of the system family in detail. The dimensions and user interface of components provide an insight into the experience and working conditions of users. Furthermore, IBM provided many more services through the Data Processing Division and later Field Engineering, “sometimes bundled within hardware contracts and less often separately priced (especially before 1970).”²⁴

Developing the S/360 fundamentally changed the company. In order to develop the product line, IBM hired over 60,000 staff members making up a third of the employees and spent 4.5 billion dollars to rent machines, space, and equipment for five new plants in the United States and internationally. In an article titled *IBM's \$5,000,000,000 Gamble*, Thomas Wise describes the risk of introducing the S/360 as follows:

The decision committed I.B.M. to laying out money in sums that read like the federal budget — some \$5 billion over a period of four years. [...] The new System/360 was intended to obsolete virtually all other existing computers—including those being offered by I.B.M. itself.²⁵

The announcement and promised availability of six main machines at the same time tightened the schedule even further.²⁶ In November 1966 the model 20 at the low end of the system family was added to the list and developed at the Böblingen plant in Germany. Section 3.5 focuses on the S/360 model 20 as an example of the internationalisation of the com-

24. Jeffrey R. Yost, *Making IT work: a History of the Computer Services Industry*, History of Computing (Cambridge, MA: MIT Press, 2017), 177.

25. Wise, “IBM's \$5,000,000,000 Gamble.”

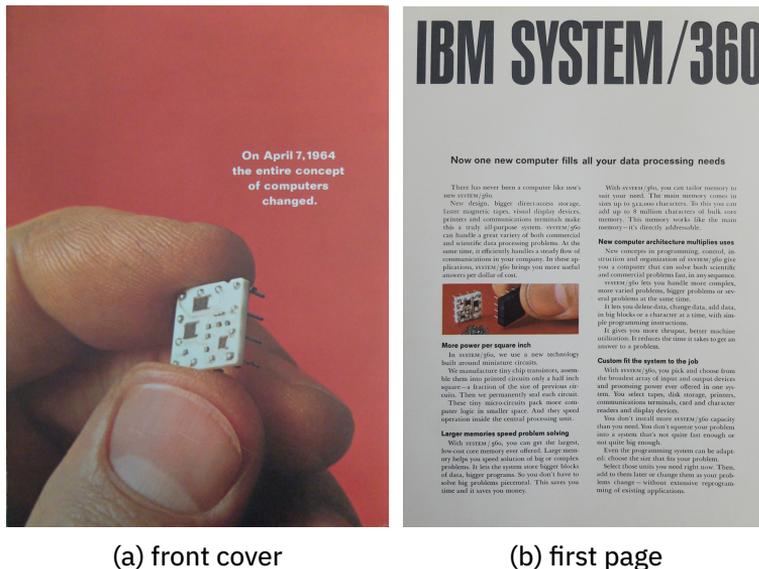
26. Wise, “IBM's \$5,000,000,000 Gamble.”

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puter industry, as well as the rising interest and integration of computers in small businesses.

3.1 S/360 Applications and Users

The vision of the design team and especially the marketing team of their ideal configured user becomes clear through a detailed visual discourse analysis of the announcement folder from 1964.²⁷



(a) front cover

(b) first page

Figure 3.2: Leaflet, "IBM System/360," 7th April 1964, New Product Line papers.

27. For a definition of user perspectives developed by Andreas Fickers, see table 1.1. Leaflet, "IBM System/360," 7th April 1964, Collection of New Product Line (NPL) 360 papers, Harwood G. Kolsky papers, Lot X3021.2005, Box 09, Folder 11-02, Catalog 102634603, Computer History Museum, Mountain View (hereafter cited as New Product Line papers).

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On the front cover, a miniaturised semi-conductor is held between index-finger and thumb to demonstrate how small computer chips had become, “the entire concept of computers” had changed. The folder then opens to reveal half of an image on the left and on the right-hand side a text titled “IBM SYSTEM/360” in bold capitals at the top of the page. A bold subtitle then states “Now one computer fills all your data processing needs.” The text in two columns is then split into an introductory paragraph with another detailed image of a hand seemingly covering the chip shown on the front cover of the advertisement with a black cap, and four sections titled: “more power per square inch,” “larger memories speed problem solving,” “new computer architecture multiplies uses,” and “custom fit the system to the job.”

3.1.1 Data Processing Applications

The introductory paragraph of the folder makes use of adjectives such as new, bigger, and faster, and emphasises efficiency and economy, mentioning three data processing problems the system can solve: commercial, scientific, and communication issues. In explaining the production process and benefits of miniature circuits the text suddenly switches to the first-person plural *we* underscoring in-house expertise for instance by changing the manufacturing process to build their own circuits rather than outsourcing the production of this component. The change in manufacturing fits into IBM’s vertically integrated business model.²⁸ The announcement indicates a strive towards “more power per square inch” seemingly complying with a fairly new idea in the electronics industry at the time, that was published one year later and eventually became known as Moore’s law. “The object was to miniaturize electronics equipment to

28. In this case the vertical integration of chips into the production process works backward since this component is manufactured before the assembly of computers. Vertical integration strengthens the supply chain and can reduce production costs. See Evan Tarver, *Horizontal vs. Vertical Integration: What’s the Difference?*, <https://www.investopedia.com/ask/answers/051315/what-difference-between-horizontal-integration-and-vertical-integration.asp>.

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include increasingly complex electronics functions in limited space with minimum weight.”²⁹

In the next section on expanded memory capabilities the text emphasises size with terms such as larg(er/est), and big(ger), as well as speed, and low-cost resulting in the typical adagium of “time is money.” IBM also claimed to *tailor* the system to the needs of the customer. The third section on the system’s multiple uses contains one enumeration after the other whether in terms of concepts, problems, data, or once again, speed. Finally, the fourth section expands on the idea of tailoring the system by stating that customers or users can “custom fit the system to the job” with vocabulary such as “pick and choose,” “select,” and “adapted,” as well as a do’s and don’ts structure.

Once potential customers read about the technical advancements on the right-hand side of the page, this page folds open once more and on the inside of the folder the full image is revealed taking up two-thirds of the page with another text on the remaining one-third including some cut-outs of the large image. The main image of interest to the research question regarding occupational segregation as shown in figure 3.3 is taken from an almost aerial perspective with a circular composition of peripherals and the central processing unit (CPU) as well as the printer-keyboard for interacting with the CPU placed in the middle. Within the Stone-henge-like circle of machines, four white people each holding an artifact and dressed to reflect a certain profession or at a more abstract level an activity similar to ancient gods or saints represent a personification of the four *problems* the S/360 supposedly solves.

From left to right, the first man in black shoes and trousers, a white shirt and black tie with silver pin is unrolling a dark blue paper likely containing technical drawings. The second man is wearing a black business suit with a white shirt and white handkerchief in his breast pocket. Peering through his glasses he is studying the pages of a large ring-bound

29. Gordon E. Moore, “Cramming More Components onto Integrated Circuits,” *Electronics* 38, no. 8 (April 1965), <https://archive.computerhistory.org/resources/access/text/2017/03/102770822-05-01-acc.pdf>.

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folder. The third man in safety-boots, brown trousers, a blue shirt, and yellow safety hat is holding antique calipers to measure the diameter of a pale gray tube. Finally, the only woman on the left is wearing sturdy brown heels, a light skin-coloured nylon stockings, black pencil skirt and black sleeve-less cardigan over a white blouse holding a black rotary dial telephone in her right hand and pressing the receiver against her left ear.



Figure 3.3: Leaflet, “IBM System/360,” 7th April 1964, New Product Line papers.

In the right-top corner of the image a circular logo contains several triangles pointing in all wind directions as an abstraction of a compass referencing the 360 degrees that underscore how the system covers all applications.³⁰ The main light source is placed in the southeast as if to mimic sunrise, the beginning of a new day. Although the system came in dusty-blue and burnt orange, the colour palette of the image adheres

30. See the explanation of the System/360 name by E. Pugh in the introduction of chapter 3.

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to the sunrise metaphor with burnt orange and beige machines against a yellow ochre backdrop.

3.1.2 User Personifications

Next to the main image a page of text in a similar two-column, four sections structure delves into the personifications of problems the system can solve under the exact same header as the previous text-heavy page consisting of the bold “IBM SYSTEM/360” title followed by the “Now one computer fills all your data processing needs” subtitle. Each header follows the structure of “solves X problems,” with X being commercial, scientific/engineering, control, or communication. The text wrapped around the outline of the cut-out images of personifications (fig. 3.4).

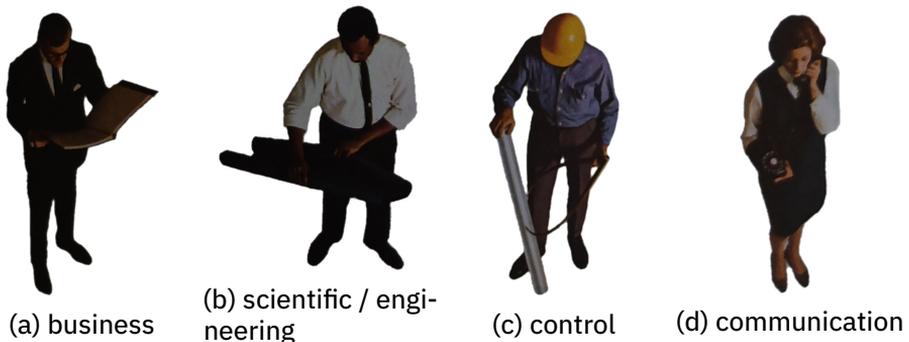


Figure 3.4: Leaflet, “IBM System/360,” 7th April 1964, New Product Line papers.

Commercial Users

In the first business section however, the text starts with “you can tailor SYSTEM/360,” rather than leading with “SYSTEM/360” as in all other sections. Furthermore, IBM wanted to reach the entire business market, therefore mentioning how their product was meant for small, medium,

and big companies. Elaborating on the potential commercial applications, numerous examples included “inventory management simulation, operations research,” and “market forecasting.” Besides mentioning technical advances in memory and the common business-oriented language (COBOL) compiler, the text ends on what can only be described as a dream for employers and a nightmare for employees. “It moves from job to job without operator intervention and thus speeds work flow.” Effectively the advertisement is promising to replace human labour with machines, a recurring but often misleading claim made in advertisements for new technology.

Scientific and Engineering applications

The next section moves on to scientific and engineering applications mentioning “linear programming, automated design engineering, statistical analysis of experimental data,” and last but not least “floating point arithmetic.” Similar to the previous section the text then continues with technical advances such as sharing core memory, creating a back up and again an improved compiler, called the mathematical formula translating system (FORTRAN). Finally, several superlatives underscore the solutions a larger memory provides in handling bigger problems and complexity, as well as processing them more quickly.

The S/360 strive for control

The third section on *control* problems begins with the S/360’s ability to handle large volumes of data in real-time. Specific control applications include “product testing, process control, process analysis.” Interestingly, this also includes “medical data collection” as a further indication of the broad audience IBM wanted to reach. Furthermore, the advertisement emphasises data protection, as well as error detection and prevention. Control here is understood as staying informed about the business through “analysis, decision and action” based on up-to-date forecasts.

The Female Communication Department

The final section on communication is the only application represented by a woman. As in all other sections however, the focus is not so much on the user, but rather on the computer and its capabilities. Contrary to the scientific/engineering section, the text suggests a gradual adoption of the system and twice repeats to start small. Occupations related to communication were often female dominated. Recently, scholars have demonstrated that once an occupation became female dominated, the status of that field was diminished, leading to lowered wages and less recognition of their contributions.³¹ The only nouns in this section of the text related to communication are “messages,” “inquiries,” and “network,” but there is no reference to telephone calls as the image of a woman holding a telephone might suggest. Instead, terminals accepted input, output was printed or displayed on a screen, and information could be disseminated to other locations. Communications should thus be understood in the context of information and communication technology (ICT), a term that came into use a decade later to include the role of telecommunications in Information Technology (IT).

The announcement of the S/360 in revolutionary discourse referred to the computer as a stand-in for the human labour of data entry and machine operation. The only labourers mentioned in the folder were IBM’s own circuit manufacturers. Throughout the advertisement, marketers continued to focus on technical features rather than the user experience. The sales division of the company clearly intended to reach executives who were responsible for purchasing equipment rather than using the S/360. User personifications of computer applications displayed stereotypes through artifacts and clothes. All people pictured in the advertisement were white, ignoring people of colour as potential users. The only female user was linked to communication. Clothing also signaled class differences between male-stereotyped occupations of businessmen, engineers, and a construction project manager.

Despite the advertisement’s claim that the S/360 covered all appli-

31. Hicks, *Programmed Inequality*, 16, 102.

cations, Ceruzzi mentioned Seymour Cray's supercomputer and the low-end programmed data processor (PDP) minicomputer developed by the Digital Equipment Company (DEC) (see chapter 4) as counter examples.³² Both scientific computer applications and the use of computing equipment in business applications highlighted continuity rather than a revolution. The advertisement's discourse does emphasize the increased managerial control computers offered over workers, the production process, and the business. After focusing on the promotion of the S/360 to executives, the next section moves to the life cycle stage of the purchase and installation of the smallest model 20 in offices.

3.2 Rebuilding the Office around the Mainframe

Originally, a mainframe only defined the CPU and primary memory of a computer, whereas now a mainframe constitutes a *pars pro toto* describing any large or general-purpose computer, specifically supporting numerous peripherals or subordinate computers.³³ The IBM S/360 corresponds with several essential characteristics of a mainframe in terms of sheer size and collection of peripherals that can be connected to any CPU in the system family. Due to the size of both the individual components and the entire system, the design and layout of the office often needed to accommodate for the machine. In order to understand the experience of being in a designated computer room, several museums reconstructed at least some of the structure of a computer room. The most complete reconstruction can be found at the LCM+L in Seattle where they installed air conditioning for the entire room, and for one specific mainframe. The entrance to the room is up a little ramp, because of the raised floor that can support the weight of the computer and hides the very thick cables.

32. Ceruzzi, *A History of Modern Computing*, 154-162.

33. *mainframe*, n., accessed March 27, 2019, <http://www.oed.com.proxy.bn1.lu/view/Entry/233318>.

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The manager of the Software Preservation lab, Dr. Moya, describes the room as very loud, cold, and with a distinctive smell that resembles “machine oil and hot dust on plastic wires.” Entering the computer room is “a very physical, visceral experience.”³⁴

Purchasing and installing an IBM S/360 required careful planning in terms of physical requirements and site selection, taking into account environmental, electrical, and signal factors. In order to facilitate the installation, IBM’s Systems Reference Library provided several installation manuals for physical planning. Based on the Model 20 on display at the DM, I will discuss the planning process, as well as the spatial, environmental and electrical prerequisites.

In the *Installation Manual-Physical Planning* for the Model 20, IBM first and foremost requires customers to provide a suitable environment for the installation.³⁵ Besides the system and associated personnel, other furniture including storage cabinets, work tables, chairs, and desks should also be taken into consideration.³⁶ Furthermore, the length of the cables connecting the machines limited the distance between the system components.³⁷ Since the Model 20 was the smallest mainframe in the S/360 family, fortunately the weight does not “exceed the floor loading capacity of most buildings.”³⁸ The schedule proposed by IBM encourages customers to order six months before delivery and finalising the layout two months later to allow for building alterations and time to process the cable order.³⁹

The workflow and working conditions in relation to IBM S/360 Model 20 are nicely illustrated in a German programming course booklet. On the one hand, the materiality of the device dictated the workflow and working

34. Moya, (Collections Manager, Living Computers: Museum + Labs), interview by Sytze Van Herck.

35. International Business Machines Corporation, *IBM System/360 Model 20 Installation Manual-Physical Planning*, 11th ed., Systems Reference Library, S360 (Mod 20)-15 (Atlanta, GA: International Business Machines Corporation, September 1975), 1.

36. Corporation, *IBM S/360-20 Installation and Planning*, 1.

37. Corporation, *IBM S/360-20 Installation and Planning*, 1.

38. Corporation, *IBM S/360-20 Installation and Planning*, 1.

39. Corporation, *IBM S/360-20 Installation and Planning*, 1.

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conditions. On the other hand, existing processes and customer requirements determined the design of the computer in the first place.

Before any interaction with the IBM S/360 model 20, programmers used paper forms and a pencil to write their instructions. Next, the instructions and input data were punched and assembled by keypunchers and transferred to the computer (room). Operators then entered the punch cards into the card reader. Once data and instructions were read, the CPU processed the information and the results were either printed on paper or punched onto new cards.

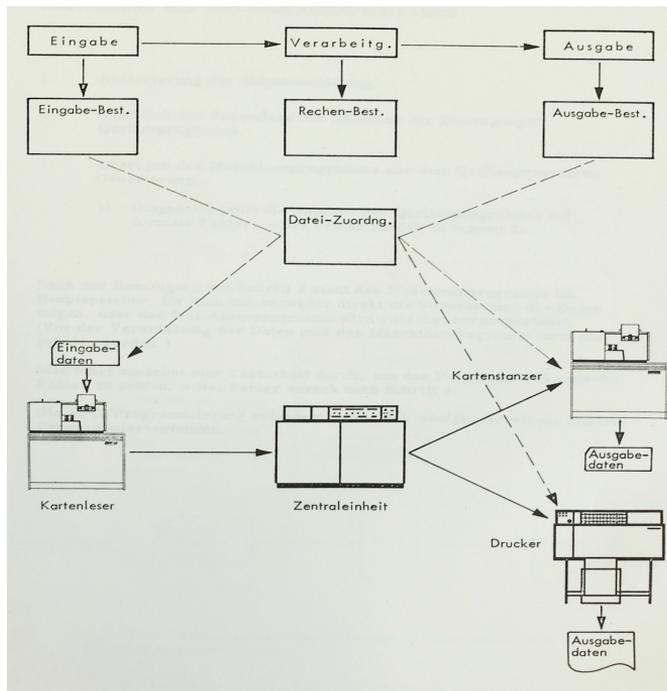


Figure 3.5: Dr. Thomas, “IBM System/360 Model 20 Workflow,” *Programmieren mit dem IBM/360-RPG Arbeitsmittel: Fernseh- und computerunterstützter Gruppenunterricht* (Sindelfingen: IBM Schule für Datenverarbeitung), Folder 06, IBM Firmenschriften.

3.3 German Healthcare Applications

3.3.1 Access to Computers

IBM's CALL/360 time sharing system offered users direct access to a mainframe through remote data stations or terminals connected via the public dial-up network of the *Deutschen Bundespost*.⁴⁰ Multiple users simultaneously accessed the speed, storage capacity, and programs of the connected S/360. Users could run a small program written in beginners' all-purpose symbolic instruction code (BASIC) to solve a unique problem, test the syntax and logic of larger programs, or use standard programs from an extensive software library. Although the introductory document inside the CALL/360 booklet emphasised programming as a key skill for users, the text assured readers that the system was user friendly (*benutzerfreundlich*). "Es ist nicht nur für EDV-Experten konzipiert." IBM does acknowledge the *Elektronischen Daten Verarbeitung Expert* or electronic data processing expert as the main intended user, but appeals in particular to visitors of a congress for medics. They were invited to test the system in the congress hall next to the auditorium. Programs for isodose calculation (in radiation therapy), patient management in the laboratory, and an x-ray diagnostic program highlight the audience's occupational background in healthcare.⁴¹

The CALL/360 system booklet mentioned other potential users such as "Betriebswirte, Kostenrechner, Ingenieure un Techniker, Wissenschaftler, Marktanalytiker, und viele andere Berufsgruppen" including "Programmierteams." Computer users thus worked in business, as scientists, or as engineers, technicians and programmers. Even for users without any experience with computers, a short introduction into the system and programs for their application domains would suffice according to the booklet. The CALL/360 mainframe stored data and programs on large disks which was inexpensive for time sharing customers. The price was de-

40. *Call/360 Datenfernverarbeitung*.

41. *Call/360 Datenfernverarbeitung*.

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terminated by the lease or purchase of a data station or terminal; the processing time, the connection time, and the disk storage usage making up the CALL-service; and the network cost consisting of a model (110 DM/month) and the connection time for close areas (24 DM/hour) or remote areas (42 DM/hour) for the Datex network. Depending on the data station model, users of the time sharing system could enter paper tape, punched cards, or magnetic cards (storing 5,000 characters). The installation of one data station required up to three power outlets: one for the terminal, modem, and perhaps a card punch. Inside the IBM computer centre CALL/360 customers connected to a S/360 model 50 with disk storage, a control unit, card reader, card punch, printer, and tape units.⁴²

One particular healthcare application becomes apparent in a program description for frequency analysis, and in particular to support *Statistischen Qualitätskontrolle im Klinisch-Chemischen Laboratorium*.⁴³ Section 3.3.2 will discuss the need for quality control in the clinical chemistry laboratory. The introduction of the program booklet does describe possible computer installations for large and small laboratories.

Einige Zentrallaboratorien sind heute bereits mit einer EDV-Anlage ausgerüstet und damit in der Lage, u.a. die Qualitätskontrolle mit einem fast beliebigen Formelaufwand halb- oder vollautomatisch durchzuführen [...]. Als Alternative dazu bietet sich für zahlreiche kleine und mittlere Laboratorien der Anschluß an ein Datenfernverarbeitungsnetz an, wie es durch das IBM-Teilnehmersystem CALL gegeben ist. Es stellt einen wirtschaftlich sehr günstigen Kompromiß dar zwischen einem teuren eigenen Computer und einem billigeren, aber wenig leistungsfähigen Teschrechner.⁴⁴

While some central laboratories had already installed a computer system to check the quality of tests either partially or fully automatic, smaller

42. *Call/360 Datenfernverarbeitung*.

43. Hägele, *CALL/360 Häufigkeitsanalyse*.

44. Hägele, *CALL/360 Häufigkeitsanalyse*.

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laboratories could not afford an expensive mainframe installation. Instead, the IBM CALL/360 time sharing system offered them a cheaper alternative, more powerful than a calculator.

3.3.2 Managing the Clinical Chemistry Laboratory

Between 1950 and 1969, the clinical chemistry laboratory gained importance with the development of new test methods. Lab results also increasingly supported the diagnosis of patients, placing more responsibility on the laboratory for accuracy of results. The number of lab studies doubles almost every five years, leading laboratories to hire more personnel and introduce computers. Although computers could handle the increased quantity of tests, their introduction did not necessarily improve the quality of results. As an example, Dr. E. Blatt mentions an error rate of 3-4% in the communication of lab results and 10% of results that were simply lost at the hospital of Tübingen.⁴⁵

Dr. Blatt also describes how the introduction of technology altered the work of (female) medical-technical assistants (*Assistentin*). A manual analysis required 90% of her time in the lab, meaning she only used 10% of her time to write, calculate, correct, and communicate test results. For a partially automatic procedure the time spent on analysis dropped to 70%, or 40% for a fully automated procedure. As a result, the assistant's job became dominated by paperwork instead of analysis as automation increased. Errors occurred more often due to the increased number of organisational steps required to calculate, write, and transfer data.⁴⁶

In 1970 the Bundesrepublik Deutschland or West Germany introduced the *Eichgesetz* or calibrating law mandating clinical chemistry laboratories to perform quality control. The extent of quality control required by law depended on the number of different analytical procedures, rather than the frequency of sampling. Technical personnel could no longer manage the extensive calculations on a routine basis without the help

45. Blatt, *Datenverarbeitung im Klinisch-Chemischen Laboratorium*, 1, Folder 05, IBM Firmenschriften.

46. Blatt, *Datenverarbeitung im Klinisch-Chemischen Laboratorium*, 1-2.

of tools. A statistical evaluation of test results meant the patient would receive accurate results and quality control benefited clinical chemists due to their heavy workload and high cost of running control analyses.⁴⁷

According to Dr. Blatt, a data processing system would take over several tasks such as recording laboratory test requirements, creating labels for test tubes, creating work lists, identifying samples, recording measured values, checking the functioning of laboratory instruments, correcting errors and calibrating results, performing quality control, printing reports, running statistics, and entering laboratory services into a patient record for billing.⁴⁸

The workflow as shown in figure 3.6 starts with a standardised form on which a nurse indicated the lab tests requested by the doctor and stamped on the personal data of the patient to be machine readable (1). In the central computer room, the form was transferred onto punch cards and read by the machine for storage on tape (2). The data served to print a label for the sample tube and prepare the information for lab analysis (3). When the nurse had taken the sample and attached the label (4), it was sent to the lab for analysis (5) where values were entered manually, off-line or on-line (6). Dr. Blatt believed manual entry offered an intermediary solution for evaluating and reporting results. Values entered off-line were recorded by the system, coded, and then punched on cards or tape, whereas online systems connected laboratory equipment directly to the computer (7). The connection of analog laboratory equipment to a digital computer required an interface.⁴⁹

In order for the computer to connect the values of tests to the correct patients, the (female) lab technician (*Laboratin*) received a work list she needed to adhere to. In hospitals this system posed a problem when emergency analysis received priority and interfered with the order of the working list. As a result, the identifying information and lab results needed to remain together and were often attached to the sample itself. An iden-

47. Hägele, *CALL/360 Häufigkeitsanalyse*.

48. Blatt, *Datenverarbeitung im Klinisch-Chemischen Laboratorium*, 2.

49. Blatt, *Datenverarbeitung im Klinisch-Chemischen Laboratorium*, 3-5.

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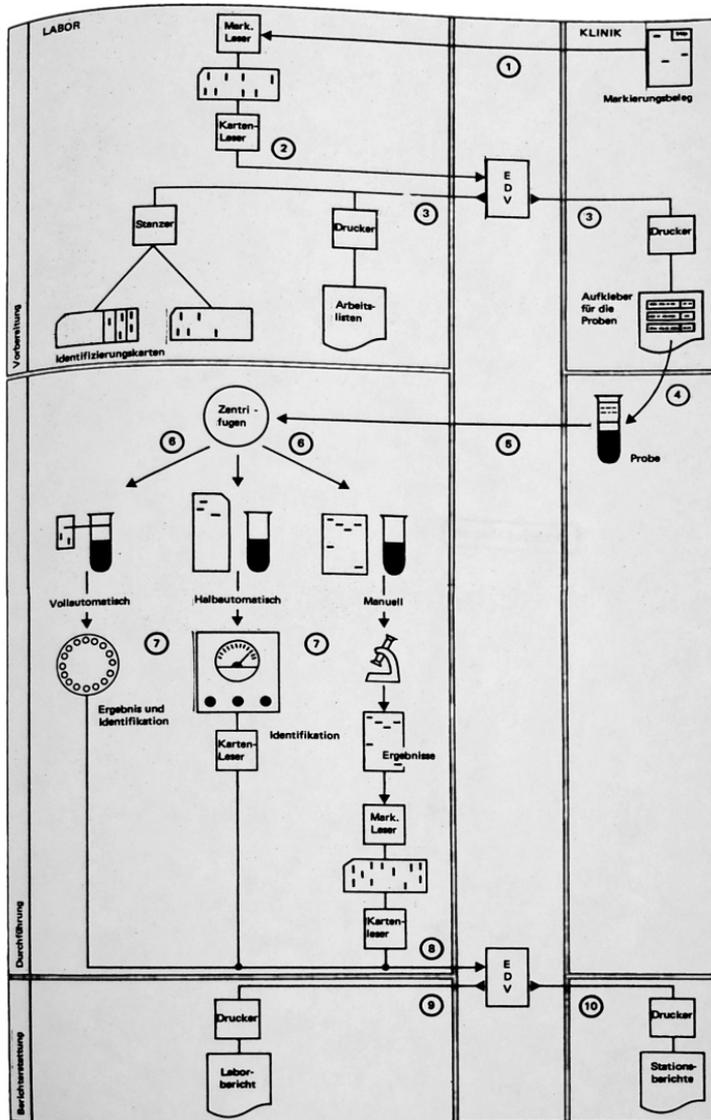


Figure 3.6: Dr. Blatt, "Laboratory Workflow," *Datenverarbeitung im Klinisch-Chemischen Laboratorium* (IBM, 1969), 28.

tification device attached to laboratory equipment would read and transfer the patient's admission number and their results (8). Other personal information was stored in a patient master record file and later added to the evaluation and reporting of test results. A short twelve-column card was manually taped to the tube so if the nurse attached the wrong identifier, the error could not be corrected. All of the proposed procedures required the cooperation of the lab technician. Since the technology could not entirely replace the worker, Dr. Blatt called this workflow an emergency solution. The lab technician's work was reduced to the insertion of test tubes and entry of patient identification because the computer stored and transferred the results.⁵⁰

The use of computers in the clinical-chemical lab however meant more time could be spent on the analysis of a larger volume of tests and the accuracy of results would improve with automated quality control. The (male) laboratory physician (*Laborarzt*) would check a daily list of all tests printed by the computer for deviations and mark them with a star (9). When he released the results, they were communicated to the patient and the healthcare facility (10). Since lab results could be stored for a longer time, all test results could be bundled when patients were discharged from the hospital. A report was printed for ambulant patients with the address of the requesting general practitioner or hospital printed so that letters could immediately be posted. Dr. Blatt listed the following advantages of the system: writing and associated mistakes as well as calculation errors were eliminated; no data was lost; values are more accurate because of "automatische Drift- und Interaction-Korrekture, sowie durch Qualitätskontrollen"; since lab personnel could focus on test analysis, equipment was used more efficiently; results were communicated automatically and stored for further scientific research.⁵¹

By 1974 IBM published a program modelled according to the procedure Dr. Blatt proposed, with six segments: patient admission, creation of work lists, entry of lab results, reports, invoicing, and closure. Pa-

50. Blatt, *Datenverarbeitung im Klinisch-Chemischen Laboratorium*, 5-7.

51. Blatt, *Datenverarbeitung im Klinisch-Chemischen Laboratorium*, 8-12.

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tient data was stored locally on magnetic cards in the data station and contained personal and billing information, statements about the sample, and the requested lab analysis. Work lists were produced per laboratory and in patient order, leaving space to insert results manually. If certain results were missing, the program allowed the laboratory to insert a code for an analysis the lab could not perform (*Befund erfolgt*), or for failing equipment or errors. The filled out work list was printed for a final inspection when the test results were stored. The computer prepared the patient report based on patient, doctor, and analysis information, as well as values entered. Once the analysis was completed and the report sent, the invoice was prepared either for health insurance, as a collective invoice for a hospital, or for a private person. The daily closure program segment retained information needed the next day and erased all other data stored locally. One support program stored information about general practitioners and hospital doctors which was only retrieved to compose reports and invoices. Another support program contained the name of the analysis, measuring unit, *Gebührenordnung für Ärzte* or GOÄ-number and associated doctor's fee for insertion in work lists, reports and invoices.⁵²

3.4 The S/360's modular Building Blocks

With the S/360 IBM “provided everything: hardware, peripherals, systems and applications software, and service.”⁵³ The main response to “customer's needs for general-purpose processors,” was to develop “a single compatible family extending from the smallest” to the largest pro-

52. Hansjörgen Hägele, *CALL/360 Programmpaket Laborverwaltung* (Bonn: IBM Deutschland GmbH, March 1974), 1-13, Folder 06, IBM Firmenschriften.

53. Ceruzzi, *A History of Modern Computing*, 143. Historians have attributed IBM's success to their bundling of “processors, peripherals, software, and services.” Martin Campbell-Kelly and Daniel D. Garcia-Swartz, *From Mainframes to Smartphones* (Cambridge, MA: Harvard University Press, 2015), 40, <https://books.google.be/books?id=Lc3eCQAAQBAJ>. Cited in Cortada, *IBM*, 198.

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cessors.⁵⁴ Despite the initial recommendation of five processors, eventually six models were announced simultaneously differing in “size, speed, and cost” to accommodate new applications and data rates.⁵⁵ IBM’s experience in large commercial systems, large scientific and engineering installations, real-time processing, and data processing for small companies in combination with existing product lines provided the necessary insights that informed the S/360.⁵⁶

At the basis of the system family was Solid Logic Technology (SLT) which improved reliability and speed, lowered costs, micro-miniaturized components and circuits, and reduced overall size. Rather than assembling computer components from other manufacturers and offering services to business, IBM became an integrated circuits manufacturer, producing roughly 150 million circuits yearly. The performance of the S/360 models differed based on the speed of storage and circuits, size of the data being processed, and the number of tasks running simultaneously. However, the appearance of the system to the programmer and operator remained the same for each model.⁵⁷

Programs would run on all processors “with the same or smaller I/O and memory configuration”; therefore an applied programming plan could “be written for only three configurations of the compatible family.”⁵⁸ Program compatibility increased the productivity of programmers and eased migration to processors with a higher performance. Based on an inven-

54. J.W. Haanstra et al., “Processor Products: Final Report of the SPREAD Task Group, December 28, 1961,” *Annals of the History of Computing* 5, no. 1 (March 1983): 6-7, <https://doi.org/10.1109/MAHC.1983.10007>.

55. Haanstra et al., “SPREAD Task Group,” 10. The final six models were model 30, 40, 50, 60, 62, and 70. See *IBM System/360: System Summary* (Poughkeepsie, NY: International Business Machines Corporation, 1964), Box 43, 191697, Living Computers Museum+Labs, Seattle.

56. Market segments defined by Steven Usselman, “IBM and its Imitators: Organizational Capabilities and the Emergence of the International Computer Industry,” *Business and Economic History* 22, no. 2 (1993): 13. Referenced by Cortada, *IBM*, 199.

57. Programs dependent on internal timings might not be compatible. *IBM S/360: System Summary*, 5-6.

58. Haanstra et al., “SPREAD Task Group,” 7.

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tion from an earlier machine (the IBM 7030 Stretch), peripherals now shared a standard interface and could be attached to any processor from the product family, leading to fewer models being produced in higher volumes. Before the introduction of the S/360, “user migration from one architecture to another was usually difficult - if possible at all.”⁵⁹ Changing to a more powerful system “required rewriting software,” as well as “retraining or hiring new staff.”⁶⁰ Migration to a larger model of the S/360 no longer required rewriting programs and smaller models could serve as a back up for larger models.⁶¹

Main memory would grow exponentially and perhaps most influential: “an 8-bit character called the ‘byte’ was selected for the basic alphanumeric structure.”⁶² The main core storage of the system models ranged from 8,192 to 524,288 bytes.⁶³ Additionally, the S/360 could address up to 16,777,216 bytes, or roughly 16 MB of additional storage.⁶⁴ These input/output (I/O) devices, called peripherals by the trade press, had a standard interface.⁶⁵

With a standard interface, IBM could offer a single line of tape, card, and printing equipment that worked across the whole line of machines - a powerful selling point whose advantages easily offset whatever compromises had to be made to provide compatibility.⁶⁶

Eventually, the word length of the S/360 was 32 bits, which simplified the design.⁶⁷ Finally, the S/360 introduced a new character structure in-

59. Evans, “Introduction to SPREAD,” 4.

60. Cortada, *IBM*, 207.

61. *IBM S/360: System Summary*, 6.

62. Evans, “Introduction to SPREAD,” 5.

63. For reference, the largest model can store 0.5 MB in main memory which roughly equals the size of *Harry Potter and the Chamber of Secrets*. *IBM S/360: System Summary*, 6.

64. *IBM S/360: System Summary*, 7.

65. *IBM S/360: System Summary*, 8, 11; Ceruzzi, *A History of Modern Computing*, 153.

66. Ceruzzi, *A History of Modern Computing*, 153.

67. Ceruzzi, *A History of Modern Computing*, 151.

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cluding “uppercase and lowercase alphabets, special symbols, and subscripts and superscripts.”⁶⁸

Data channels directed “the flow of information between main storage and those input-output devices,” thus speeding data processing by relieving the CPU from input-output operation. The multiplexor channel separated high-speed operations from operations on lower-speed devices such as printers, card punches, readers, and terminals. High-speed devices including tape units and different storage peripherals operated in *burst* mode, meaning a single I/O device would occupy the multiplexor channel until the operation was finished.⁶⁹

The variations in system models, core storage capacity, optional features, and I/O configuration provide a flexibility that permits the system to be tailored to suit the individual user’s exact requirements, with the added advantage of system growth without reprogramming.⁷⁰

Finally, the system panel interface provided direct control over the processing unit and contained three sections: “operator control, operator intervention, and Customer Engineering maintenance.” Controls included “stop, start and selection of the unit for initial program loading.”⁷¹

The *System Summary* contained a list of peripherals split into eleven types of devices and their control units.⁷² For clarity, I have grouped these I/O types into four categories. First and foremost, operators interacted with the system directly through both visual and manual interfaces. Second, storage devices handled different mediums such as tape, files and punch-cards. Third, the main output of the S/360 was printed on either continuous or separate pages. Fourth, the remaining I/O devices for specific applications include magnetic ink and optical character readers used

68. Evans, “Introduction to SPREAD,” 4.

69. *IBM S/360: System Summary*, 8-10.

70. *IBM S/360: System Summary*, 11.

71. *IBM S/360: System Summary*, 12.

72. *IBM S/360: System Summary*, 16.

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in banking transactions and cash accounting, as well as communication systems.

3.4.1 Interfaces

Operators directly interacted with the CPU through either visual or manual interfaces. The S/360 included two visual display unit models, as well as two models of an inquiry display terminal.⁷³ All visual and inquiry displays consisted of a monitor attached to a cabinet with an integrated desk surface and fixed keyboard, the main difference being the size of the screen.⁷⁴ In terms of manual controls, the S/360 provided the printer-keyboard for “such operator-to-program or program-to-operator communication as program checking, program correction, and job logging.”⁷⁵

The visual display units showed tables, graphs, charts, “alphameric [sic]” letters, and figures on “a 21-inch cathode ray tube” (see figure 3.7). Whereas the first model of the visual display unit could only be used as a single console, the second model facilitated multiple displays with a maximum of eight displays at a maximum distance of 2,000 feet or around 600 meters from the control unit. The 12” square area displayed fifty-two lines of seventy-four characters each. Optional features included a light pen, programmed function keyboard and alphanumeric keyboard. A light pen was “a hand-held, pen-like device used by the operator to identify to the program a particular point or character on the display screen.” The programmed function keyboard could contain functions assigned “by application-oriented interpretation programs,” and defined by “illuminated and interchangeable overlays.” Finally, the alphanumeric keyboard corresponded to a traditional typewriter keyboard including letters, numbers, and symbols, as well as controls for “the screen location of a movable

73. IBM 2250 Display Unit Model 1 and 2, with 2840 Display Control. IBM 1015 Inquiry Display Terminal Model 1 and 2 controlled by the 1016 Control Unit. *IBM S/360: System Summary*, 16.

74. *IBM S/360: System Summary*, 18-19.

75. IBM 1052 Printer-Keyboards Model 1 controlled by the 1051 Control Unit. *IBM S/360: System Summary*, 20.

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electronic marker,” or the cursor as it is now called. The inquiry display terminal allowed operators to consult records in storage on demand. One control unit could connect ten model 1 inquiry display terminals, which in turn could attach five model 2 inquiry display terminals. The terminal could be located at a maximum distance of 2,500 feet or roughly 760 meters from the control unit. The much smaller screen displayed thirty lines of forty characters each.⁷⁶

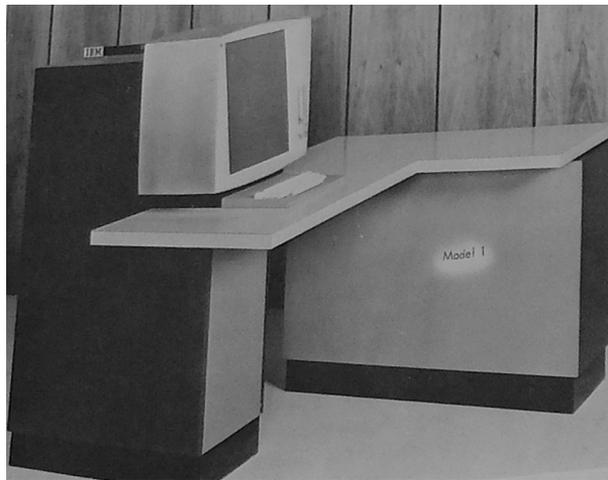


Figure 3.7: IBM 2250 Display Unit. *IBM S/360: System Summary*, 18.

The manual control looked similar to the traditional typewriter (see figure 3.8), but “the keyboard and the printing are electrically and mechanically independent of each other.” Each part of the printer-keyboard had a separate function, since the keyboard accepted system input, and the printer showed computer output. The device was placed on top of a desk which housed the control unit in a cabinet below. The printing speed was 14.8 characters per second, and the printing head could be replaced.⁷⁷

76. *IBM S/360: System Summary*, 17.

77. *IBM S/360: System Summary*, 20.

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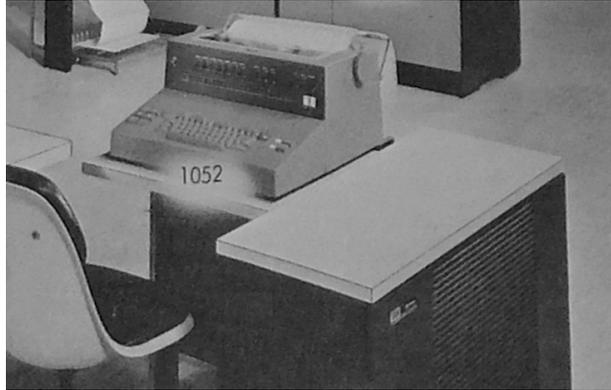


Figure 3.8: IBM 1052 Printer-Keyboard, *IBM S/360: System Summary*, 19.

3.4.2 Storage Devices

Additional data storage attached to the CPU could take many forms. The S/360 used magnetic and paper tapes, disk and drum storage, as well as traditional punched cards. The magnetic tape units were newly developed by IBM and could be used for input and output.⁷⁸ The paper tape reader was “especially designed for data communications, source recording, for use in scientific data processing, and for data acquisition.”⁷⁹ IBM also resorted to disk and drum storage, which could “record and retrieve data either at random or sequentially.”⁸⁰ For on-line random access storage, the S/360 offered a data cell drive that stored files on strips of magnetic tape.⁸¹ In order to attach most disk drives, data cell drives and

78. The IBM 2400 Series Magnetic Tape Units consisted of four tape units and controls: 2401, 2402, 2403, and 2404. Furthermore, two stand-alone tape control units were included: the 2803, and 2804 (simultaneous) unit. The IBM 7340 Hypertape Drive Model 3 was controlled by the 2802.

79. IBM 2671 Paper Tape Reader.

80. IBM 1302 Disk Storage model 1 and 2, and 2311 Disk Storage drive. IBM 7320 and 2301 Drum Storage.

81. IBM 2321 Data Cell Drive model 1.

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drum storage, a storage control unit and adapters interpreted and executed system orders and checked “the validity of the data transferred to and from the storage devices.”⁸² Finally, IBM held on to the storage medium of punch cards in which they had a large market share built up over the past fifty years by including two card read punches.⁸³

The newly developed magnetic tape units could read or write 800 bytes per inch of tape on nine tracks simultaneously. A standard feature of the magnetic tape units was error correction on a “reread of a record containing one or more errors in a single track.” Mounting and loading tape reels became easier since tape automatically entered the columns, and the tape was read backward to speed “tape sorting by eliminating certain rewind operations.” The high performance magnetic tape drive also came in a cartridge to eliminate “tape contamination or damage” caused by manual handling.⁸⁴ A maximum of sixteen high performance magnetic tape drives could be connected to the S/360. The paper tape reader on the other hand photo-electrically read “strips of 5-, 6-, 7-, or 8-channel paper tape at a rate of up to 1,000 characters per second,” and therefore worked slower and offered less memory than magnetic tape, but remained in use for certain applications mentioned earlier.⁸⁵

Disk storage permitted random access to files, and was available since 1956 when IBM announced the random access method of accounting and control (RAMAC).⁸⁶ Disks were described as “thin, magnetically-coated metal disks that spin at about 1,800 revolutions per minute,” on which “data and control information are recorded as magnetized spots on a track.” The Disk Storage Drive resembled a record player on top of a cabinet hiding circuits and cables, and was covered by a metal and glass lid showing

82. IBM 2841 Storage Control Unit.

83. IBM 1402 Card Read Punch model 1, and 1442 Card Read Punch model 1. *IBM S/360: System Summary*, 22-29.

84. IBM 7340 Hypertape Drive Model 3.

85. *IBM S/360: System Summary*, 22-24.

86. Louis D. Stevens, John J. Lynott, International Business Machines Corporation, Data Storage Machine, US Patent 3,143,097, December 24, 1954, and issued May 19, 1964; This patent was continued by William A. Goddard, Direct Access Magnetic Disc Storage Device, US Patent 3,503,060, filed September 16, 1968, and issued March 24, 1970.

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the spinning disks, shown in figure 3.9.⁸⁷



Figure 3.9: IBM 2311 Disk Storage, *IBM S/360: System Summary*, 22.

A single disk pack could store up to 7.25 MB of information, and each control unit could attach eight disk storage drives or up to 58 MB of storage. The main selling point for disk drives was the alleged ease of use and unlimited storage capacity, since “the disk pack in each drive can be easily removed and replaced with another in less than 1 minute.”⁸⁸ A disk pack held six disks with a diameter of 14" inches or about 35 cm spaced evenly on top of each other. With the exception of the two outer disk surfaces protecting the pack, information was read or written on ten disk surfaces through “magnetic read/write heads, mounted in pairs between each two disks on a movable comb-like access mechanism.” Drum storage as seen in figure 3.10 was still in use and could either provide on-line random access storage of 0.83 MB or up to 4 MB per drum, amounting to a maximum of 16 MB per control unit.⁸⁹ Finally, file storage was even

87. IBM 2311 Disk Storage Drive.

88. *IBM S/360: System Summary*, 22.

89. IBM 7320 Drum Storage. IBM 2301 Drum Storage controlled by 2820.

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more efficient with the Data Cell Drive which extended “on-line random access storage capabilities,” and offered up to 400 MB at a data rate of 55,000 bytes per second. Data cells contained 200 strips of magnetic tapes, of which each individual cell could be accessed via a rotary positioning system.⁹⁰

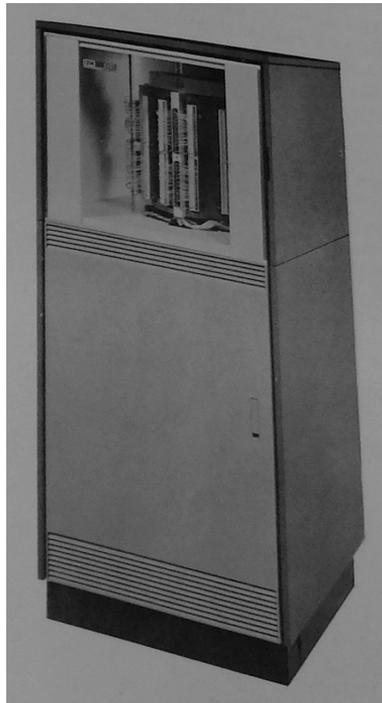


Figure 3.10: IBM 2301 Drum Storage, *IBM S/360: System Summary*, 27.

The Card Read Punches both combined reading and punching cards, with one main difference. The first model separated the read and punch sections, to read and punch simultaneously, whereas the second model used “a single common card path for reading and punching.”⁹¹ To ensure

90. *IBM S/360: System Summary*, 24-28.

91. IBM 1402 and 1442 Card Punches.

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compatibility with shorter 51-column cards such as “postal money-order forms, installment payments,” and “inventory cards,” the first model provided an optional “interchangeable read feed.” Because the second model serially fed cards “past a read and then a punch station,” the program could read a card first, then at the next column punch the results onto the same card. The Card Read Punch hopper could hold 1,200 cards for input and inserted the output in two stackers of the same size. The first model read cards twice as fast as the second at 800 cards per minute, but punched cards much slower, at 250 cards per minute or 4 cards per second versus 160 cards per second.⁹²

3.4.3 Output Devices

Results were still printed on either separate or continuous pages or even punch cards as main output. The S/360 therefore offered many printer models.⁹³ Besides using different paper formats, three features set printers apart: the type of printer carriage, the rate of lines per minute, and the size of the character set. Printer carriages either consisted of a chain of linked characters, or trains of characters that were not linked. As an optional feature the carriage could also be interchangeable, meaning users could change the type font of the printer. One specific printer model could also print in magnetic ink, specifically for “American Banking Association approved type font E-13B characters.”⁹⁴

Two printers included in the S/360 were developed in 1959 for an older IBM computer.⁹⁵ The first printer held a stack of continuous paper in a metal wire basket underneath. Printed pages were visible at the top and came out in a metal wire basket at the back of the printer. Operators thus needed access to both the front and the back of the ma-

92. *IBM S/360: System Summary*, 29.

93. The IBM 1403 Printer model 2 and 3, IBM 1404 model 2, and 2201 model 3 were controlled by the 2821 Control Unit which came in four models. IBM 1443 and 1445 Printer model 1 had their own control units and storage buffers.

94. IBM 1445 Printer model 1. *IBM S/360: System Summary*, 30-32.

95. IBM 1403 Printer model 2 and 3, IBM 1404 Printer model 2.

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chine and were required to work standing. The first model used a chain of linked characters for printing, whereas the second model operated a train of characters that were not linked.⁹⁶ Both models included an optional tape listing feature that could substitute continuous paper for paper sheet forms. Another difference between the models was the auxiliary polyester ribbon “for sharper impressions” that came with the first model, compared to the preferred character set which was only included in the second model. Although the second printer looked similar, on the front of the metal box, two punch card holder accepted 51- and 80-column cards (see figure 3.11).⁹⁷ The printer also printed on continuous paper.⁹⁸



Figure 3.11: IBM 1404 Printer, *IBM S/360: System Summary*, 30.

The new line of printers developed especially for the S/360 combined “the proved performance of the [first printer] with the latest circuitry and packaging techniques,” resulting in a tall metal cabinet with only paper in- and output being visible. Finally, the last two printers were very similar

96. IBM 1403 Printer model 2 and 3.

97. IBM 1404 Printer model 2.

98. *IBM S/360: System Summary*, 30-31.

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using “a single type-bar that moves back and forth horizontally across the paper.”⁹⁹ Furthermore, a tape-controlled carriage advanced paper, thus providing adjustable vertical line spacing. The difference between the last two printers was the use of magnetic ink specifically for banking applications.¹⁰⁰

3.4.4 Application I/O Devices

Although IBM claimed that the S/360 was a general-purpose computer, some applications still required specialised input/output devices. Magnetic ink was often used in finance, and the Magnetic Character Readers were developed specifically for “magnetically inscribed information on checks and other banking transactions.”¹⁰¹ Other optical readers that eliminated “transcribing source data for entry into the system” could read either numeric, alphameric, or even pen and pencil marks. The optical character reader was used in cash accounting, whereas the optical mark page reader had many more accounting applications in “payroll, order entry, accounts payable, inventory control, sales analysis, general ledger work,” etc.¹⁰² Furthermore, the S/360 offered a range of peripherals to support data collection, data communication, process communication, and audio communications.

The magnetic character reader was an optional component for the 1410 data processing system developed in 1960.¹⁰³ Developed specifically for check-handling, documents read by the machine could differ in “size and thickness.”¹⁰⁴ The character reader also printed “the bank’s endorsement on the back of documents as they pass through the machine.” The (Alphameric) Optical Readers as shown in figure 3.12 read

99. IBM 1443 and 1445 Printers.

100. *IBM S/360: System Summary*, 31-32.

101. IBM 1412 and IBM 1419 Magnetic Character Readers.

102. IBM 1418 Optical Character Reader model 1, 2, and 3, IBM 1428 Alphameric Optical Reader model 1, 2, and 3, and IBM 1231 Optical Mark Page Reader Model N1.

103. *IBM Archives: 1410 Data Processing System*, January 2003, //www.ibm.com/ibm/history/exhibits/mainframe/mainframe_PP1410.html.

104. IBM 1412 Optical Character Reader Model 1, 2 and 3.

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the data from card or paper documents into core storage.¹⁰⁵ The number of stackers for sorted cards and the document-handling capabilities differed depending on the model. The first model sorted “according to class or general category” into three stackers, whereas the second model could sort documents numerically into thirteen stackers. The third model was specifically adapted to “cash-accounting applications in which a small stub is customarily returned with a payment.” Finally, the Optical Mark Page Reader could read pencil marks for “electronic test scoring” from letter-size paper and served a myriad of applications in “business, government and institutions.”¹⁰⁶

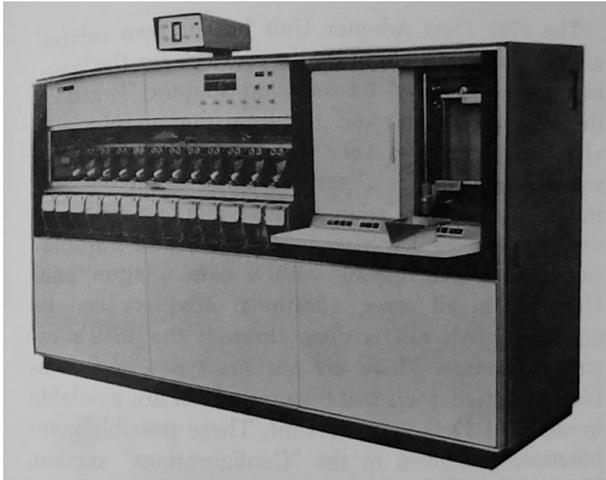


Figure 3.12: IBM 1418 Optical Character Reader, *IBM S/360: System Summary*, 33.

All communication systems attach to the S/360 via one of two control units.¹⁰⁷ The data adapter unit can connect between one and four lines

105. IBM 1418 Optical Character Reader model 1, 2 and 3, IBM 1428 Alphameric Optical Reader Model 1, 2 and 3.

106. IBM 1231 Optical Mark Page Reader Model N1. *IBM S/360: System Summary*, 33-34.

107. IBM 2701 Data Adapter Unit or IBM 2702 Transmission Control

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for “data communications, control, and data acquisition,” whereas the transmission control “is a multi-line data communications device.”¹⁰⁸ In combination with input stations and printers at “locations remote from the computer area,” the system is used for consulting the processing unit in another plant or within the same plant.¹⁰⁹ The input would be pre-punched cards and badges, as well as numeric data from either a twelve-column manual entry unit or data cartridge.¹¹⁰

The S/360 included two tele-processing data communication systems, one office-oriented and the other focused on customer service that connected to the Model 30 processor.¹¹¹ The office-oriented data communication system as shown in figure 3.13 required a control unit which “contains the power supply, code translator, data channels, and control circuitry.”¹¹² This communication system connected to remote terminals on-line, yet simultaneously prepared and recorded data off-line.

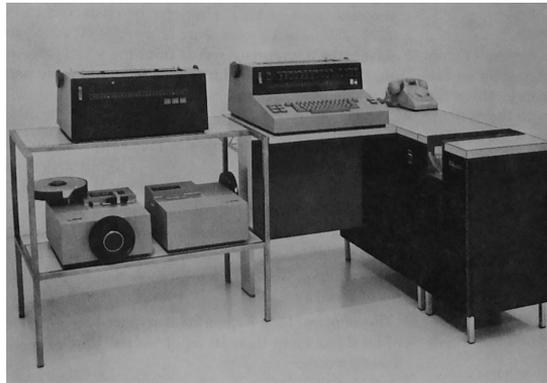


Figure 3.13: IBM 1050 Data Communication System, *IBM S/360: System Summary*, 41.

108. *1410 Data Processing System*, 34.

109. IBM 1031 Input Station and IBM 1033 Printer.

110. *IBM S/360: System Summary*, 40.

111. IBM 1050 and 1060 Data Communication System.

112. IBM 1051 Control Unit.

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The customer service data communication system was used in institutions such as “savings banks, savings and loan associations, and commercial banks.”¹¹³ The Teller Terminal connected to the processing unit from a branch office or within the main office and transmitted transaction data through “communication-company facility or IBM line adapter.” In the main office, “the record of the account is updated by the computer, and the status of the account is transmitted back.” In the branch office or separate department of the main office, the data are kept on “terminal-record tape and on the customer’s account document (passbook),” and the teller balance is updated. For teller terminals that could go off-line, the keyboard could also function as an adding machine.¹¹⁴ One other tele-processing terminal included in the S/360 was the Process Communication System which facilitated “control of natural gas and petroleum pipe lines, utility distribution systems, and the collection of process data in petroleum refineries, chemical plants, paper mills, iron and steel works, batch processes in manufacturing, and many other applications.”¹¹⁵

Finally, the last communication system suggested for the S/360 were Audio Response Units.¹¹⁶ These units answer inquiries consisting of a series of digits from either “telephone type terminals” or “similar terminals.” The unit first processes the digits and composes the reply message through addresses to select the words from the vocabulary, which is pre-recorded in a male, optionally female, voice. Both the storage medium for the pre-recorded vocabulary and the size of this vocabulary differ. The first model uses a limited analog vocabulary on a magnetic drum composing between four and sixteen, and maximum 48 lines. Whereas the second model stores an unlimited vocabulary “digitally coded voice on an external disk file” for only two to eight lines.¹¹⁷

113. IBM 1060 Data Communication System.

114. *IBM S/360: System Summary*, 40-41.

115. IBM 1070 Process Communication System. *IBM S/360: System Summary*, 42.

116. IBM 7770 Audio Response Unit model 3, and IBM 7772 Audio Response Unit model 3.

117. *IBM S/360: System Summary*, 43-44.

3.5 Big (blue) isn't always better

IBM was sometimes referred to as Big Blue because of its large main-frame machines in an iconic shade of blue, and perhaps due to its position as the computer company with the largest share in United States computing in the 1960s.¹¹⁸ Not all of IBM's systems or applications were geared towards large mainframes or big businesses. This section focuses on the smallest model in the product family, the S/360 model 20. Despite its modest size and relatively low price, or rather because of its size and price, the model 20 was sold in the largest quantity, especially to small businesses. Furthermore, IBM had evolved from a domestic United States company with a World Trade subsidiary developing its own computers, to an international company marketing, engineering and manufacturing the S/360.¹¹⁹ Consequentially, the model 20 was not developed in one of the laboratories in the United States, but in the German IBM laboratory in Böblingen. The laboratory's mission centered on "the design of electronic processors for small systems primarily oriented toward applications at the lower end of a rapidly growing commercial market."¹²⁰

The laboratory in Böblingen competed with other IBM Development laboratories in San Jose, California, and Endicott, New York, however IBM required that information between laboratories was exchanged openly. "The principle of free information flow within IBM's research and development (R&D) resources resulted in a powerful, fast worldwide knowledge transfer." One of the findings of an ongoing debate between Böblingen, San Jose, and the New York laboratories (Poughkeepsie, Endicott, and Yorktime Heights) at the start of the 1960s on "data flow, structure, and processor speed requirements" resulted in a surprising find. As the first

118. The System/360 also came in other colours, including burnt orange as seen in the advertisement discussed in section 3.1. Mentioned in Pratt, John. 2008. "The IBM System/360." *Youtube*. <https://www.youtube.com/watch?v=10dRHImbPug>.

119. Wise, "IBM's \$5,000,000,000 Gamble."

120. Karl E. Ganzhorn, "IBM Boeblingen laboratory: product development," *IEEE Annals of the History of Computing* 26, no. 3 (2004): 20, <https://doi.org/10.1109/MAHC.2004.11>.

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director of the IBM Böblingen laboratory, Karl E. Ganzhorn, recalls that “-for economic reasons- low-end systems needed high-end components to enable serial processing.”¹²¹

Despite international knowledge transfer, the internal competition further manifested in conflicting demands placed on the German laboratory once the CEO decided to combine San Jose and Böblingen’s forces.¹²² “Systems responsibility for the next accounting system was given to Böblingen, to give this laboratory another chance to grow into full product development capability..”¹²³ John Haanstra from the General Products Division in Endicott wanted the accounting system to be compatible with the earlier 1401 and 1410 systems, whereas the Data Systems Division in Poughkeepsie was pushing for the NPL, later the S/360.¹²⁴ The solution the German laboratory came up with was based on the earlier breakthrough Cortada describes as “the possibility of adding special microcode to the control stores of computers to improve their performance *when simulating earlier IBM computers.*”¹²⁵ The microprograms were stored in fast read-only memory and allowed the system architecture of the S/360 and the 1401-compatible system architecture to be interchangeable.¹²⁶ In other words, the older accounting system’s architecture could be emulated on the new S/360 model 20 by changing the microcode.¹²⁷ In early 1964 however, the dilemma of choosing between a backward compatible emulator and the new system architecture was no longer relevant since “IBM decided to launch the NPL exclusively as the System/360.”¹²⁸

The team at the IBM laboratory in Böblingen was strengthened by an American systems manager and engineers from San Jose in order to fulfill all requirements of full product development including “announce-

121. Ganzhorn, “IBM Boeblingen laboratory,” 20-21.

122. Ganzhorn, “IBM Boeblingen laboratory,” 24.

123. Ganzhorn, “IBM Boeblingen laboratory,” 24.

124. Ganzhorn, “IBM Boeblingen laboratory,” 25.

125. Cortada, *IBM*, 212. He cites Pugh, *Building IBM*, 274.

126. Ganzhorn, “IBM Boeblingen laboratory,” 25.

127. Cortada, *IBM*, 212.

128. Ganzhorn, “IBM Boeblingen laboratory,” 25.

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ment, release to manufacturing, and shipment of the new system.”¹²⁹ Each system component was developed by a different group, and other departments were responsible for customer engineering, documentation or writing operating manuals, product testing, marketing, estimating costs and pricing the system, engineering control and eventually the release to manufacturing after the announcement of the S/360 model 20 in November 1964. The eventual production of the components was distributed over “five IBM plants: Sindelfingen, Endicott, Toronto, Vimercate (Italy), and Fujisawa (Japan).”¹³⁰

“The primary objective of the Model 20 design was to have a low-cost system for the System/360 line, allowing the unit record or punched card accounting business to be linked with IBM’s new computer line.” In order to keep costs down however, compatibility was compromised and several components were designed specifically for this machine.¹³¹ The IBM laboratory in Böblingen started developing the core memory for the CPU and a new bar printer in 1963, whereas the multi-function card unit (MFCU) was developed in San Jose.

3.5.1 System components

When the IBM S/360 Model 20 was announced in November 1964, the basic configuration consisted of a CPU, a MFCU, and a new line printer, as illustrated in figure 3.14.¹³² Furthermore, Ganzhorn mentions “seven existing and new card handling machines and three different line printers,” however, the announcement folder only mentions two line printers.¹³³ Additional tape units, disk storage, a magnetic character reader, and a communication link were added later on as shown in figure 3.1.¹³⁴

129. Ganzhorn, “IBM Boeblingen laboratory,” 24.

130. Ganzhorn, “IBM Boeblingen laboratory,” 25.

131. Ganzhorn, “IBM Boeblingen laboratory,” 25.

132. IBM 2020 CPU, IBM 2560 MFCU, and IBM 2203 line printer.

133. Ganzhorn, “IBM Boeblingen laboratory,” 25-26; Leaflet, “IBM S/360 Modell 20,” November 1964, Folder 06, IBM Firmenschriften.

134. IBM 2415 Tape Unit, IBM 2311 Disk Storage, IBM 1419 Magnetic Character Reader. Ganzhorn, “IBM Boeblingen laboratory,” 26.

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Figure 3.14: Leaflet, “IBM System/360 Modell 20,” November 1964, IBM Firmenschriften.

The disk storage drive is already shown in figure 3.9 and the magnetic character reader as well as communication link are discussed in section 3.4, however the tape unit is of particular importance. “Specifically, customers frequently used one configuration with tape units attached as an offline tape-to-print system in large System/360 installations.”¹³⁵ This section therefore also includes a description of the tape unit that was later added to the IBM S/360 Model 20.

Central Processing Unit

The Model 20 came in “a variety of memory sizes from 4 Kbytes to 16 Kbytes” of main storage.¹³⁶ Main storage held the data that was being processed, as well as the instructions or program that controlled the operation. The system stored data in eight-bit bytes, each byte had its own address and could contain different data formats. A byte or pair of bytes

135. Ganzhorn, “IBM Boeblingen laboratory,” 26.

136. Ganzhorn, “IBM Boeblingen laboratory,” 25.

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was referred to as halfwords and could hold binary or decimal numbers, as well as logical data.¹³⁷ The S/360 Model 20 had an instruction set of thirty-seven instructions, which is only a fraction of the one-hundred and forty-three instructions included in other models.¹³⁸ The standard instruction set performed both binary and decimal arithmetic, as well as logical, branch, and input-output control.¹³⁹

The CPU had an internal bus structure with four ports that directly attached to peripherals through small micro programmed I/O processors, instead of through external channel controllers. One engineer compared this bus structure to *drivers* in PCs, which in turn could be understood as the location of for instance USB-ports when accessed on modern computers.¹⁴⁰ The processor architecture was stored in transformer read-only storage (TROS), which meant that by exchanging the micro program of the TROS architecture developers could switch from 1401 to S/360 compatibility.¹⁴¹

Multi-Function Card Unit

The MFCU was developed by the IBM laboratory in San Jose, California to handle card input and output.¹⁴² For the first time, one machine combined “almost all punched card operations” such as reading, punching, merging, collating, and sorting, as well as reproducing, gang- and sum-

137. *IBM System/360 Model 20 Functional Characteristics*, Systems Reference Library (White Plains, NY: International Business Machines Corporation, April 1967), 2, http://bitsavers.trailing-edge.com/pdf/ibm/360/funcChar/A26-5847-3_360-20_funChar_Apr67.pdf.

138. Pugh, *Building IBM*, 384. Ganzhorn mentions 47 instructions, however, the System/360-20 Reference Card contains 37 instructions in its standard instruction set in accordance with Pugh's statement; Ganzhorn, “IBM Boeblingen laboratory,” 26; *IBM System/360 Reference Card: System/360 Model 20* (White Plains, NY: International Business Machines Corporation), Box 1, 190157, Living Computers Museum+Labs, Seattle.

139. *IBM S/360-20 Functional Characteristics*, iii.

140. Ganzhorn, “IBM Boeblingen laboratory,” 26.

141. Ganzhorn, “IBM Boeblingen laboratory,” 26.

142. Ganzhorn, “IBM Boeblingen laboratory,” 26.

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mary punching, and decollating in a single pass.¹⁴³ Figure 3.15 shows the path of a card through the MFCU. The cards were read serially from two hoppers.¹⁴⁴

As each card moves through the read station, light passes through the punched holes in each column and is converted to electrical energy by an array of solar cells, one cell for each column position. [...] After a card is read it advances to the prepunch station in the same card path. From this point it advances through the punch station upon command of the CPU.¹⁴⁵

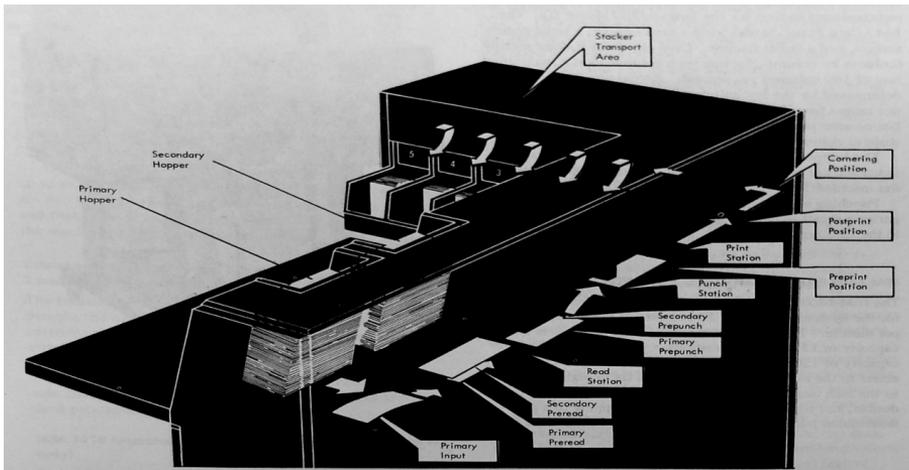


Figure 3.15: IBM 2560 Multi-Function Card Unit, *IBM System/360-20 System Summary*, 17.

The optional print station could print up to sixty-four characters on

143. *IBM System/360 Model 20 System Summary*, 5th ed., Systems Reference Library (Boeblingen: International Business Machines Corporation, May 1970), 16, Box 1, 190135, Living Computers Museum+Labs, Seattle; Ganzhorn, "IBM Boeblingen laboratory," 26.

144. Ganzhorn, "IBM Boeblingen laboratory," 26.

145. *IBM S/360-20 System Summary*, 16.

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any of the twenty-five lines of a card.¹⁴⁶ Once the operation was finished, the cards were placed in any of the five stackers.¹⁴⁷

Line Printer

Printers posed an issue in early computer design due to the “speed discrepancy of millisecond processes in mechanical devices and the microsecond range of electronics” slowing down the entire throughput. Eventually, I/O controllers were separated from the CPU. The new bar printer used an electronic control for mechanics “printing on the fly with continuously moving print elements.”¹⁴⁸

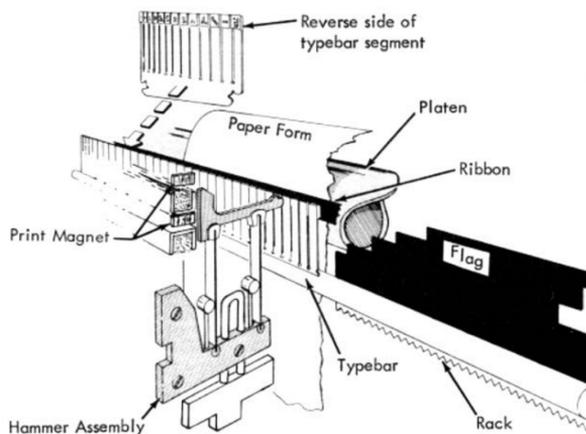


Figure 3.16: Bar printing unit of the 2203 printer, Ganzhorn, “IBM Boeblingen laboratory,” 28.

As illustrated by figure 3.16 the printer functions as follows:

A bar [...] [carried] print elements, and moved horizontally back

146. *IBM System/360 Model 20 Functional Characteristics*, 10th ed., Systems Reference Library (Boeblingen: International Business Machines Corporation, March 1974), 38.

147. *IBM S/360-20 System Summary*, 16.

148. IBM 2203 Printer, Models A1 and A2. Ganzhorn, “IBM Boeblingen laboratory,” 27

and forth in front of an ink ribbon and the paper. Hammers under electronic timing control hit the individual type elements on the fly as the bar moved across the print line.¹⁴⁹

Front printing, where character print elements “hit the paper via an ink tape like in a typewriter” produced better (carbon) copies in comparison to the back-printing technology used in previous printer models.¹⁵⁰ Despite printing at ever increasing speed, the cost was kept down because of the carrier for type elements which evolved from chain, to bar, and later a rotating steel band. Furthermore, “interchangeable typebars allow the operator to select a type style and character set for a specific printing job.”¹⁵¹

The stored program in the CPU “controlled the sequence and arrangement of data printed” according to the order of the data assembled in core storage.¹⁵² An optional dual-feed carriage could simultaneously print two separate forms.¹⁵³ The printer was produced at IBM plants in Sindelfingen, Essonnes in France, and Endicott. Eventually 1300 printers were produced.¹⁵⁴

3.5.2 Software

Problems of software development in the 1960s and early 1970s included the “cost and technical constraints on hardware - slow processors and I/O, expensive primary and secondary storage, and multiple hardware features.”¹⁵⁵ “Although the software was supplied free to customers when they ordered the appropriate hardware, the software had to meet high

149. Ganzhorn, “IBM Boeblingen laboratory,” 28.

150. Ganzhorn, “IBM Boeblingen laboratory,” 26.

151. *IBM S/360-20 System Summary*, 14.

152. *IBM S/360-20 System Summary*, 14.

153. *IBM S/360-20 System Summary*, 15.

154. Ganzhorn, “IBM Boeblingen laboratory,” 28.

155. Albert Endres, “IBM Boeblingen’s Early Software Contributions,” *IEEE Annals of the History of Computing* 26, no. 3 (2004): 31, <https://doi.org/10.1109/MAHC.2004.12>.

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quality and efficiency standards.”¹⁵⁶ The IBM laboratory in Böblingen started developing software in 1962 and were assigned to provide programming support for the S/360 Model 20 starting in 1964 with a team of about thirty people. The software support for the smallest model in the computer family was unique because “customers differed from those for larger systems,” the peripherals described in section 3.5.1 were developed specifically for model 20, and because the “architecture differed from the standard System/360 architecture.” In short, model 20 used a subset of the standard instructions, had only eight registers, and peripherals were directly attached to the CPU.¹⁵⁷

Between 1965 and 1968 the laboratory released three software packages: card, tape, and disk support. The first two software packages were based on either “punched card and tabulator functions,” or on “previous high-end systems.” The disk support was the only program new to the S/360.¹⁵⁸

The Card Programming System was available from December 1965 and ran Punched Card Utility programs and assembly as well as Report Program Generator languages on installations “consisting of a CPU (including a manual operator interface with lights, buttons, and switches), a card reader/punch, and a printer” with optional console typewriter. In keeping with punch card machine functions, utility programs could punch cards, collate, merge, tabulate, accumulate, and print cards. The MFCU supported most functions including reading cards, but did not collate, tabulate, or accumulate cards. One hopper held existing cards making up a file, while the other hopper held cards with instructions for additions, deletions, and changes. The first stacker contained the new file, while other stackers contained old versions of changed cards, deleted cards, and (non)matching delete requests. By repeatedly merging sequential cards, files could be sorted.¹⁵⁹

In August 1967 the Model 20 also included a Tape Programming Sys-

156. Endres, “IBM Boeblingen’s Early Software Contributions,” 31.

157. Endres, “IBM Boeblingen’s Early Software Contributions,” 31, 33.

158. Endres, “IBM Boeblingen’s Early Software Contributions,” 31.

159. Endres, “IBM Boeblingen’s Early Software Contributions,” 32.

tem which was usually loaded from a single tape drive, while other drives only stored data. This software supported (de)blocking and label processing, as well as sorting or merging tapes. “A Model 20 tape drive system frequently served as a peripheral printer for larger systems.”¹⁶⁰ Exactly one year later, in August 1968, Boeblingen finished the Disk Programming System offering random access to data stored on disks.¹⁶¹

Specially trained technical writers produced all customer documentation in English only. As an industry first, DPS documentation included, besides manuals for each component [...], a system guide. This publication described the software system as a whole, taking a task-oriented view to explain installation, operation and maintenance..¹⁶²

New functions and a different file organization laid the foundation for “long-term online data storage, such as databases.” Before the introduction of cathode-ray tube (CRT) monitors, users interacted with computers through a console typewriter. When the Disk Programming System was introduced, users could interrupt a program to retrieve and print records from a disk, supporting multi programming for the first time.¹⁶³

3.5.3 Marketing and Sales

The Model 20 was marketed in particular towards *kleinere und mittlere Unternehmen* or small and medium-size enterprises. In order not to scare off new potential customers, the front cover of folder for the smallest IBM S/360 computer (fig. 3.17) did not show a chip or machine, but rather a paper folded in a circular fan to emphasize the 360 degrees which symbolized the wide range of applications the System supported. The first page of the product folder did show an image of the computer installation (fig. 3.14). A woman wearing stilettos and looking at the output of

160. Endres, “IBM Boeblingen’s Early Software Contributions,” 32.

161. Endres, “IBM Boeblingen’s Early Software Contributions,” 32.

162. Endres, “IBM Boeblingen’s Early Software Contributions,” 33.

163. Endres, “IBM Boeblingen’s Early Software Contributions,” 32-33.

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a printer on the left side of the installation wore a fashionable business dress and sported the popular 1960s bob haircut. The Model 20 still occupied the centre of the image and she did not look towards the camera but was shown at work, standing in front of the machine. Perhaps her presence also served to illustrate the size of the installation.



Figure 3.17: Leaflet, “IBM System/360 Modell 20,” November 1964, IBM Firmenschriften.

Above figure 3.14, the advertisement poses the question “Can your company afford a data processing system?” On the right-hand page, the advertisement answers “Wann ist ein Unternehmen groß genug für die elektronische Datenverarbeitung?” in the first column, recognizing that before the advent of the Model 20, electronic data processing simply was not feasible or economic for small and middle-sized companies. The second column then lists the advantages of the smallest S/360 model under the header “Klein- und Mittelbetriebe können jetzt die Vorteile der Elektronik voll nutzen.” The text tries to convince these companies with adjectives such as low-cost, safe, high-speed (*preisgünstige, sichere, mit*

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hoher Geschwindigkeit) and addressing possible prejudice or fears with words like simple, easy, and low requirements (*einfache Programmierung, leichte Bedienung und geringen Raumbedarf*). Instead of airconditioned large computer rooms, the Model 20 occupied little space by comparison and did not require additional modifications of the office. Since small and middle sized companies often used punch card equipment in administration, programs read from cards and stored on magnetic core memory were partially familiar. Finally, the S/360 was praised for its high processing speed and large memory capacity, economy and adaptability.

The next two pages of the product folder start with a column on possible business applications like invoicing, sales analysis, payroll accounting, statistical tasks, market research, and investment and production planning. The intended audience of executives and managers becomes apparent in the following sentence:

Damit wird das IBM System/360 Modell 20 ein wirkungsvolles Instrument der Unternehmensführung - es hilft nicht nur, bestimmte Arbeiten zu rationalisieren, es weist und erschließt neue Wege zur wirtschaftlichen Führung des gesamten Betriebes.

The management discourse of electronic data processing as an effective instrument of business management leading to the rationalization of work through new ways of economic management fit the control discourse of the United States S/360 announcement folder (see section 3.1). Aside from a description of SLT and an image of a chip next to a pencil to showcase its small size, the first column on the next page assured executives that programming the system was easy. "Auch Mitarbeiter ohne spezielle Maschinenkenntnisse [können] in kurzer Zeit ein entsprechendes Programm erstellen." Employees did not have to learn machine language but could use free translators or *Übersetzungsprogrammes* offered as programming systems.

The next column detailed the operation and technical features of the CPU. The following pages of the folder discuss most of the technical characteristics of peripherals (see section 3.4 and 3.5.1) such as the MFCU, several reading and card punches, card readers, and printers. The final

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page ends with a scheme of six possible S/360 Model 20 configurations depending on the use of a card reader, reading punch, or the MFCU as input, and the addition of a card punch to the CPU. Compatibility was also stressed in the German folder as “die Möglichkeit zur Leistungserhöhung bei steigenden Anforderungen.” The smallest IBM S/360 performed slower and wasn’t entirely compatible with the other processor units in the system family. However, the model 20 was the cheapest and sold most in terms of numbers with up to 7,400 computers installed in the United States alone by 1970.¹⁶⁴

164. Emerson W. Pugh, *IBM's 360 and Early 370 Systems*, History of Computing (Cambridge, MA: MIT Press, 1991), 639.

Chapter 4

Minicomputers Opening the Skies: PDP-11s at NASA and Boeing

Once computing became more affordable and performance increased in the 1960s, computers moved from government applications to industry “making banking more accessible through automated tellers, making airline reservations more convenient over a telephone network, and monitoring freight trains more efficiently via automated databases.”¹ Key characteristics of minicomputers as defined in the *Encyclopedia Britannica*’s computer lemma were the small size and relatively low price, their use in single departments for one particular task or shared by small groups, with limited power but great compatibility with other devices in laboratories and industry.² Historian Paul Ceruzzi credits the Apollo mission at the National Aeronautics and Space Administration (NASA) for the change from batch operation in mainframes like the International Business Machines

1. Jamie Parker Pearson, *Digital at Work: Snapshots from the First Thirtyfive Years*, X2740.2004, Gift of Gordon Bell (Burlington, MA: Digital Press, 1992), 46, https://archive.computerhistory.org/resources/text/DEC/dec.digital_at_work.1992.102630350.pdf.

2. Paul A. Freiberger et al., *Computer - Minicomputer*, December 2008, <https://www.britannica.com/technology/computer>.

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(IBM) System/360 (S/360) discussed in the previous chapter to the minicomputer which allowed more personal interaction.³ As stated in the introduction (see 1.1.2), the minicomputer allowed engineers, scientists and other to interact directly with computers for the first time.⁴

With the space age in full swing by the end of the 1960s when astronauts first set foot on the moon and commercial airlines offering an ever increasing number of passengers the opportunity to fly by the start of the 1970s, an intimate link between computers and the aerospace industry becomes apparent. On the one hand, computers supported developments in aeronautics for instance by providing engineers with direct access to minicomputers for designing new aircraft. On the other hand, contracts from government institutions to win the space race and the Cold War in turn spurred developments in computing. This chapter will illustrate parallels between the history of the minicomputer and aviation history in the context of the Cold War. The life cycle of design, manufacturing and sales at the Digital Equipment Company (DEC) in section 4.3 from the perspective of the computer manufacturer's personnel is followed by a detailed explanation of the components and functioning of the programmed data processor (PDP) minicomputer in section 4.4 and ends with an advertisement analysis in section 4.5 to assess the configured or envisioned user. Usually, the life cycle then continues with the application and use of minicomputers. Instead, this chapter first evokes the historical context of the 1970s with the application and use of minicomputers at NASA and Boeing to represent spaceflight research as a governmental use of minicomputers, and the design of commercial aircraft as an application with even greater impact on people's lives in the 1970s.

Aviation in the 1960s and 1970s had a light and a dark side, similar to any other technology. Military aviation and especially the use of aircraft in the Vietnam war fed a growing antiwar sentiment in the United States and abroad. The Military Airlift Command established in 1966 from an earlier

3. Ceruzzi, *A History of Modern Computing*, 124.

4. Ceruzzi, *A History of Modern Computing*, 24.

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institution sent high-priority military cargo and troops to Vietnam and facilitated medical evacuation from combat. The loss of fighter planes in combat also led to high expenses for American tax payers. Furthermore, bombs dropped by airplanes left craters which filled with water where malarial mosquitoes bred and the large scale use of defoliants caused enormous ecological damage. The war in Vietnam created a controversial image of American military aviation, yet aviation made president Nixon's negotiations for peace possible with his journeys to China and Russia in 1972.⁵ The advent of jumbo jets stimulated domestic and foreign travel as well as air cargo operations. However, conflicts in the Middle-East caused a momentary contraction at the beginning of the 1970s for commercial aviation due to the increasing price of fuel. By 1975 however, commercial aircraft manufacturers soon rebounded with revenues rising to \$3.8 billion.⁶ Finally, space exploration inspired optimism while at the same time stemming from Cold War competition with the Soviet Union. After the peak of the Apollo 11 lunar mission on 16 July 1969, by December 1972 manned mission to the moon came to an end with the Apollo 17 mission. NASA's continued space exploration contributed significantly to the analysis of the earth and the environment, with increased knowledge of "the ocean, weather and climate, pollution, and natural resources" through photography.⁷

The origins of the DEC (also known as DIGITAL) illustrate the company's connection to aerospace from its inception to the eventual use of minicomputers at NASA and Boeing. DEC started in a rented mill in Maynard, Massachusetts. The mill was located in a town just outside of Boston where the three founders had previously worked for the Lincoln Labs at the Massachusetts Institute of Technology (MIT). Brothers Ken and Stan Olson together with Harland Andersen started with \$70,000 venture capital and sold logic modules in 1957.⁸ At MIT's Lincoln Lab

5. Roger E. Bilstein, *Flight in America: From the Wrights to the Astronauts*, 3rd ed. (Baltimore: Johns Hopkins University Press, 2001), 249-256.

6. Bilstein, *Flight in America*, 257.

7. Bilstein, *Flight in America*, 278, 281.

8. *Digital Equipment Corporation: Nineteen Fifty-Seven to the Present* (Maynard, MA:

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Ken Olsen first built a Memory Test Computer to test core memory for the Whirlwind computer, a large-scale, real-time control system for air defense. He then worked on the TX-0 which used a cathode-ray tube (CRT) monitor and a light pen for interaction with light bulbs indicating the status of a flip flop. Aside from his degree in electrical engineering and experience building computers at MIT he also gained practical skills from working in a tool shop while studying machine shop practice. During his stay at MIT he also controlled the quality of the Semi-Automatic Ground Environment (SAGE) computers and observed production and organization techniques while in residence at IBM. Cofounder Harland E. Anderson studied (engineering) physics and joined MIT in 1952 where he took on administration for eight engineers. He also helped plan associated SAGE systems before starting the DEC in 1957.⁹

After selling only modules, DEC introduced the PDP-1 in 1959 which established DIGITAL's design goals "of interactivity, low cost, simplicity and reliability" for a number of follow-up PDP's.¹⁰ George Doriot's suggestion to avoid *computer* vocabulary in the business proposal stemmed from a fierce competition in the 1950s where few computer companies were successful.¹¹ This also explains why the line of minicomputers were called programmed data processor rather than minicomputers.¹²

Over five years after the introduction of the PDP-1 DEC launched its first successful minicomputer. The PDP-8 sold around 50 000 systems.¹³ It was designed for specific tasks and expanded applications beyond process control and laboratory applications to "chemical plants, newspapers, laboratories, refineries, oceanographic studies, and schools."¹⁴ By

DEC Press, 1978), 2, <http://gordonbell.azurewebsites.net/digital/dec%201957%20to%20present%201978.pdf>.

9. Parker Pearson, *Digital at Work*, 4, 7, 10-11.

10. Parker Pearson, *Digital at Work*, 18.

11. General George Doriot headed the venture capital firm American Research and Development (AR&D) who provided Ken Olson with a \$70,000 loan to start the Digital Equipment Corporation (DEC) in 1957. Parker Pearson, *Digital at Work*, 8.

12. Parker Pearson, *Digital at Work*, 10.

13. Parker Pearson, *Digital at Work*, 45.

14. Parker Pearson, *Digital at Work*, 50.

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spring 1970 the PDP-11 was available at a lower price of around \$20,000 as a family of compatible machines. Around one million machines were sold over the next two decades with over half a million PDP-11s still in use at the start of the 1990s.¹⁵

Similar to IBM's S/360, DEC offered a system rather than a single device. In particular the PDP-11 was intended as a "modular system for real-time data acquisition, analysis and control." The minicomputer handbook stresses compatibility as another selling point comparable to the S/360, with input/output (I/O) devices to complement the PDP-11.¹⁶ Although a minicomputer the size of a drawer rather than room-size computers from previous decades seems to suggest that the PDP-11 was a miniature computer by comparison, an entire PDP-11 system could still take up an entire room. As hardware prices dropped, software and training became more expensive, thus hardware compatibility saved time and money since applications were easily transferred to larger or smaller machines. Compatibility also meant customers could reuse peripherals and software could be migrated to prevent users from having to retrain.¹⁷

Before diving into the research questions, the next section 4.1 delves deeper into the source collections that support the analysis and the type of user that emerges from them. The sources have shaped the selection of the case study on the use of minicomputers in aerospace applications. Therefore, the discussion of sources also includes a motivation for the selection of certain images over others. Although aerospace and commercial applications influenced many employees and travelers, the sources also highlight entirely different industries which were not included in this research.

15. Parker Pearson, *Digital at Work*, 58,61.

16. *PDP-11 Handbook* (Maynard, MA: Digital Equipment Corporation, 1969), 1, box 1765, 103622, Living Computers Museum+Labs, Seattle.

17. Parker Pearson, *Digital at Work*, 60.

4.1 Users and Personnel in the Picture

In contrast to the predominance of textual sources in previous chapters, the collection of visual sources such as slides and prints presents its own opportunities and challenges. Users of the PDP-11 minicomputer and DEC personnel who developed the device get a face and are depicted while actually using the minicomputer. Interpreting the actions of those users however needs to rely on secondary literature and other textual sources, since the image alone cannot provide the full context of use. Sensory experiences such as the sound, smell, sense of touch, and working experiences in general require extensive analysis of the image and where possible additional sources, including working museum objects on display or available for hands-on experience. Furthermore, visual discourse is constructed from the point of view of “the object and the subject - the seen and the seer.”¹⁸ Understanding the assignment and perspective of the photographer commissioned by the computer manufacturer matters. The composition of the image influences the interpretation and provides information on the intended audience.¹⁹ The user that emerges from the images floats between the configured user when the composition of images betrays their intended use in advertisements, and the expert user when understood from the perspective of the subject in action.²⁰

The Digital Equipment Corporation records collection of the Computer History Museum (CHM) in Mountain View, California includes a series of photographs. This large collection was donated to the museum by Hewlett-Packard (HP) in 2004 which had acquired Compaq in 2002, a company that had previously purchased the remainder of the DEC in 1998.²¹ As Sara Lott, Senior Archives Manager recalls in her blog post describing the

18. Hooper-Greenhill, *Museums and the Interpretation of Visual Culture*, 108.

19. Rose, *Visual Methodologies*, 24-26.

20. Fickers, “Experimentelle Medienarchäologie,” 70-71.

21. Bo Doub, Kim Hayden, and Sara Chabino Lott, *Guide to the Digital Equipment Corporation records | 102733963 | Computer History Museum*, 2017, 4, <https://www.computerhistory.org/collections/catalog/102733963>.

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process, the processing of such a large collection was only made possible thanks to a grant of \$274,500 from the Andrew W. Mellon Foundation.²²

The inclusion of the Digital Equipment Corporation records into the collection of the CHM flows from the fact that the museum actually grew out of the DIGITAL Computer Museum established in 1979 inside DEC's Marlborough office in Massachusetts. After a move to Boston in 1984 and a move of the collection to Mountain View, California, in 1996 the Computer Museum in Boston closed its doors in 1999 and moved part of the exhibit to the Boston Museum of Science and what remained of the collection to the CHM Center in Mountain View, California, where a building in the heart of Silicon Valley was purchased in 2002 to house the museum.²³

The most important part of the DEC records spanning from 1947 to 2002 for this chapter are the still images of the DEC Photo Library and Archive.

The photo library holds tens of thousands of original slides, transparencies, prints, negatives, and proof sheets spanning the company's active years from 1957 to 1998. These images depict client applications of DEC products, brochures and promotional material, portraits of DEC pioneers, and historical files of images documenting the company's early history and achievement milestones, along with histories of Maynard, Massachusetts and the "Maynard Mill" (DEC's headquarters).²⁴

4.1.1 Client Applications in the Aerospace Industry

The client applications part of the collection and in particular for aerospace contain mostly slides, whereas images of DEC personnel were grouped

22. Sara Lott, *What the DEC?!?*, Medium, December 2017, <https://thechm.medium.com/what-the-dec-6d9f92d172bf>.

23. *Museum History | Computer History Museum*, accessed February 8, 2021, <https://www.computerhistory.org/chmhistory/>.

24. Doub, Hayden, and Lott, *DEC Finding Aid*, 5.

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on sheets with images developed from negatives. The subseries of client application slides were produced between 1972 and 1988 “showing DEC systems installed and in use at a number of client companies and institutions worldwide.”²⁵ The finding aid provides a good overview of different applications shown in the slides including at “hospitals, airports, government agencies, universities, large corporations, and laboratories.”²⁶ For the PDP-11 in particular, client application slides included several banks (Farm Credit Bank, Wachovia Bank, and Community National Banks), a medical setting (Massachusetts General Hospital), and original equipment manufacturers (OEMs) such as the Converse Rubber Company and Toronto Iron Works, as well as the New York Telephone Company, Typeset, Boston Globe and others. Despite the myriad of applications, I have decided to focus on the use of PDP-11 systems in aerospace, and in particular at NASA and Boeing.

Since the previous chapter 3 already focuses on the use of computers in healthcare during the 1960s, the use of minicomputers in hospitals adds little to the diverse overview of computing applications featured throughout the thesis. Client applications at universities represent a very limited number of highly expert users which does not illustrate the key characteristic of minicomputers as more accessible compared to previous models. In addition, the use of minicomputers in universities had little influence on the image of computing that emerged from advertising or added to the popular image of computing in the United States during the 1970s.

Applications in aerospace then includes four different client applications visible in the collection: airports, government agencies, large corporations, and laboratories. An increasing number of passengers indirectly encountered computers in airports through ticket reservations, baggage handling, and the organisation of ground operations. Government agencies such as NASA were very visible to Americans in general and certainly influenced the vision on technology in the 1960s and 1970s, also feed-

25. Doub, Hayden, and Lott, *DEC Finding Aid*, 51.

26. Doub, Hayden, and Lott, *DEC Finding Aid*, 51.

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ing into popular culture where motion pictures for instance constitute the imagined user. Military use of minicomputers in aviation also fits into government agency applications. Records from military uses are however far less accessible. In addition, the growing antiwar sentiment fed by military aviation was not explicitly geared towards the use of computing in military aviation. Commercial aircraft manufacturers such as Boeing and commercial airlines such as Pan Am purchasing and operating the airplanes clearly fit into applications of minicomputers at large corporations. Finally, both the Boeing Test Centre and some client applications at NASA show the use of the PDP-11 minicomputer in laboratory settings. The client application slides thus feature most of the aerospace community members Ceruzzi lists in *Beyond the limits: flight enters the computer age* which “included university faculty and students, civil and military government agencies, airframe manufacturers, and commercial airlines.”²⁷

Aerospace presents a diverse field where minicomputers aided users in different occupations. Travel by air became increasingly available to the masses, much like computing became more accessible with the introduction of minicomputers. In comparison to the micro- and personal computers of the 1980s however, interaction and access was still rather limited. A parallel can be observed in commercial aviation where budget airlines only started operating after deregulation in 1978.

4.1.2 Occupations at DIGITAL

Unlike previous case studies where corporate executives of the computer manufacturer feature prominently in secondary literature but employees are less visible, the collection of prints from DEC also provide insight into the occupational segregation and working conditions of the teams who influenced the design, production and sales of the PDP-11 minicomputer. Supplemented with accounts from employees based on interviews in the publication *Digital at Work: snapshots from the first thirty-five years* writ-

27. Paul E. Ceruzzi, *Beyond the Limits: Flight Enters the Computer Age* (Cambridge, MA: MIT Press, 1989), 15, <http://archive.org/details/beyondlimitsflig00ceru>.

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ten by (former) DEC employees, the prints and first-hand accounts combine the experience of remembered and expert designers, assembly line workers, marketeers, and sales personnel.²⁸ The images of DEC personnel are part of the subseries of archival proofs that were used by clients “to determine which transparencies or prints to duplicate for use.”²⁹ These sources answer research questions such as: How was the PDP-11 designed and produced and who was responsible for the design and production? What initiated the need for this particular design or provided the incentive and what were the working conditions of personnel at the DEC?

4.1.3 A Library of Handbooks

The installation and operation of the PDP-11 is best understood from handbooks. The two main handbooks for section 4.4 originate from the Living Computers Museum+Labs (LCM+L) archive in Seattle, Washington, which grew out of the personal collection of Paul Allen, co-founder of Microsoft.³⁰ Allen’s original goal was to be able to run the original paper tape Microsoft software as an important historical artefact of the company and his personal history. Since Microsoft was first developed on a Teletype connected to a DIGITAL system, he collected many machines as well as documentation from DEC. The LCM+L was established in 2013 and was open until the beginning of the COVID-19 pandemic and following lockdown which forced the museum to close its doors and take its collection offline in 2020.³¹

The first *PDP-11 Handbook* from 1969 was my main source for writing

28. Parker Pearson, *Digital at Work*.

29. Doub, Hayden, and Lott, *DEC Finding Aid*, 53.

30. *PDP-11 Handbook* (Maynard, MA: Digital Equipment Corporation, 1969), box 1765, 103622, Living Computers Museum+Labs, Seattle; *PDP-11 Peripherals Handbook: programming, interfacing* (Maynard, MA: Digital Equipment Corporation, 1973), box 1766, 103640, Living Computers Museum+Labs, Seattle.

31. Moya, (Collections Manager, Living Computers: Museum + Labs), interview by Sytze Van Herck; *About LCM+L: Our History*, accessed May 31, 2021, <http://livingcomputers.org>.

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a general introduction to the system.³² The overview of components that made up a PDP-11 system illustrate how the minicomputer functioned, but also explain the interface users interacted with and provides insight into the working conditions of the engineers and lab technicians at Boeing and NASA. Handbooks reference the configured user and answer research question such as: How did the interface influence the workflow? What did input and output data look like? How did software transform the data and who developed software? How was the minicomputer installed and operated? Environmental requirements of the manufacturer also indicate some characteristics of the working environment for users.

Since the PDP-11/20 model only came to market in June 1970, the handbook predates the system by at least half a year. DIGITAL handbooks were printed as paperbacks and served as an educational and promotional tool.³³ They were probably distributed to existing and potential future customers at trade shows or by sales people. In addition, the handbook was probably helpful to engineers developing the system further and other product lines building new devices for the PDP-11 system. The handbook provided information concerning addressing modes, programming of peripherals, and how to interface to the Unibus. Other employees benefiting from the handbook were software engineers developing applications for different markets since the handbook also discussed the paper tape software system and operator's console, and field service engineers sent to customers to resolve problems who found not only an overview of configuration and installation planning which was again useful to sales people, but also useful instruction and addressing summaries in appendix.³⁴

The second *PDP-11 Peripherals Handbook for Programming and Interfacing* was dated 1973. By then many more PDP-11 processors and other products were introduced to the market and DEC's approach to peripherals had changed. Whereas previously peripherals were purchased and

32. *PDP-11 Handbook*.

33. Parker Pearson, *Digital at Work*, 143.

34. *PDP-11 Handbook*.

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rebranded from other manufacturers, DIGITAL started to develop and produce its own peripherals by purchasing existing manufacturers and expanding to other facilities.³⁵ The *Peripherals Handbook* explained how to program peripherals, which types of peripherals were available, how to connect peripherals to the central processing unit (CPU) via Unibus connections, and planning sites as well as configuring the system. On the one hand, the handbook was geared towards customers programming peripherals. On the other hand, sales people as well as field service engineers found instructions for planning, configuring and installing or repairing peripherals in the manual. With production scattered over two and later three continents, the handbook also provided an overview of products that were being manufactured by DIGITAL.³⁶

The composition of the computing workforce at DEC and its customers reflects the gendered discourse in the *Occupational Outlook Handbook* published by the Bureau of Labor Statistics that offered graduates a guideline on existing occupation.³⁷ This source paints the picture of occupational segregation based on gender, nationality, ethnicity, and class in the computer industry and provides an insight into the intersectional experience of minicomputer users.

4.1.4 Product Leaflets Displaying Users

Whereas the client application slides featured customer's personnel at work using the PDP-11, the collection of slides and prints also contained staged photographs of equipment with or without users intended for advertising. Some of these photographs were included in the collection of Marketing Brochures of the Computer History Museum (CHM).³⁸ The

35. Parker Pearson, *Digital at Work*, 115.

36. *PDP-11 Peripherals Handbook*.

37. *Occupational Outlook Handbook, 1976-77 Edition* (Washington, DC: Bureau of Labor Statistics, 1976), <https://eric.ed.gov/?q=Occupational+Outlook+Handbook&ft=on&pg=4&id=ED126289>.

38. Sarah Wilson, *Guide to the Company Collection of Computing Manuals and Marketing Materials | 102634420 | Computer History Museum, 2007*, <https://www.computerhi>

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CHM's collection of digitized marketing brochures however included only two PDP-11 brochures, whereas I found a full folder of PDP-11 marketing at the Centre for Computing History (CCH) in Cambridge.³⁹ The folder was addressed to Mr. Lemaistre from Micro Consultant in Surrey in the United Kingdom. A digital representative provided some marketing materials and price lists with a particular emphasis on an OEM Discount Agreement dated 3 November 1972.⁴⁰

Product leaflets contain both visual and textual discourse on the mini-computer itself and the envisioned, intended or configured user according to the computer manufacturer's marketing team. Print remained the preferred medium for DEC in the 1970s. This particular folder of product leaflets was sent to an existing customer by a DIGITAL representative which suggests that customers were already loyal to or at least familiar with the brand and renewed or expanded their existing systems.

Since I did not encounter advertisements geared towards aircraft manufacturers or government agencies such as NASA, I decided to compare DEC's rather technical product leaflet to a study of the evolving image of stewardesses in advertisements to promote domestic and international commercial airlines. Vantoch's research on *The Jet Sex* highlights female stereotypes in advertisements aimed at a general audience and differed substantially from the intended expert audience for PDP minicomputers.⁴¹ At the same time, the juxtaposition of the image of stewardesses and

story.org/collections/catalog/102634420.

39. *PDP-11 Resource Timesharing System RSTS-11*, 1970, Company Collection of Computing Manuals and Marketing Materials, Lot X3067.2005, Catalog 102646128, Computer History Museum, Mountain View (hereafter cited as Company Collection of Computing Manuals and Marketing Materials), <https://www.computerhistory.org/collections/catalog/102646128>; *PDP-11 Variations on a Theme*, 1977, Company Collection of Computing Manuals and Marketing Materials, Catalog 102646131, <https://www.computerhistory.org/collections/catalog/102646131>; The PDP-11 Family - Brochures, box FB1, CH42250, Centre for Computing History, Cambridge (hereafter cited as The PDP-11 Family - Brochures).

40. Brian Fifield to D. LeMaistre, 3rd November 1972, PDP-11 Family - Brochures.

41. Victoria Vantoch, *The Jet Sex: Airline Stewardesses and the Making of an American Icon* (Philadelphia: University of Pennsylvania Press, 2013).

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users featured in the product leaflets illustrates radically different stereotypes of women in 1970s advertising.

4.2 Computers in the Space Age and Jumbo Jet Decade

Throughout the 1970s photographers travelled to DEC's customers to document different PDP-11 applications. One of the most frequently photographed industries featured several applications in aerospace. Both NASA and Boeing were able to purchase and install computers in the 1960s and 1970s. NASA received sufficient government funding to purchase central mainframes, minicomputers, and to develop dedicated computer systems in collaboration with computer industry contractors. Similarly, the military and commercial aircraft manufacturer Boeing had the means necessary to purchase computers to design, produce, and operate aircraft.

In *A Social History of the United States* Laurie Mercier describes the technological dreams of the 1970s in the context of *The Economy, Work, and Society*.⁴² After the last Apollo mission to the moon in 1972 enthusiasm for astronaut space flight wavered due to high expenses in a time of “the Vietnam War that siphoned funds away from NASA, and the geopolitical achievement of U.S. technical superiority over the Soviets.”⁴³ Instead NASA launched robot explorers to discover space and study planetary composition collecting photos and making important discoveries. “Yet these discoveries did not capture the public imagination as much as did the first Apollo moonwalk in 1969, and the decade lacked the optimism

42. Laurie Mercier, “The Economy, Work, and Society: Crises and New Directions,” in *Social History of the United States: The 1970s*. Ed. Daniel J. Walkowitz and Daniel E. Bender, vol. 8, *Social History of the United States* (Santa Barbara, CA: ABC-CLIO, 2008), 265–336, <https://books.google.be/books?id=xypn4djsxVD4C&pg=RA7-PA316&lpg=RA7-PA316&dq=PDP+computers+at+NASA+1970s>.

43. Mercier, “The Economy, Work, and Society,” 312.

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that accompanies 1960s space travel.”⁴⁴ As funding declined, NASA began to focus more on commercial projects benefiting “the aerospace industry, and improved satellite technology [to] advance weather forecasting and telecommunications.”⁴⁵

Faced with a declining economy and rising unemployment as well as the 1973 oil and environmental crisis, Americans started to question the notion of progress.⁴⁶ Although space exploration had origins in the Cold War, it evolved to “a symbol of international cooperation” in the 1970s, but cooperation failed to lower costs.⁴⁷ Furthermore, NASA did not incorporate the change propagated by social movements until the late 1970s when women and African Americans were finally admitted to the astronaut corps.⁴⁸

Despite the decline of popular and federal support for NASA, “fantasies about space travel, life and battles continued to capture the popular imagination.” With reruns of the *Star Trek* television series, and the release of the first *Star Wars* movie, as well as classics such as *Planet of the Apes* and *Alien*, science-fiction continued to capture attention.⁴⁹ As one of the first computer games written for the PDP-1 called *Space War!* helped popularize gaming as a leisure activity, and with DEC’s success in laboratory settings, it is hardly surprising that uses of PDP-11s at NASA figure in the client application slides of the Digital Equipment Corporation records.⁵⁰

Different applications required different computer configurations, and only employees in certain occupations could gain access or interact directly with computers. The following sections outline applications and the accompanying occupations and users who had access to computers

44. Mercier, “The Economy, Work, and Society,” 313.

45. Mercier, “The Economy, Work, and Society,” 313-314.

46. Mercier, “The Economy, Work, and Society,” 314-315.

47. Mercier, “The Economy, Work, and Society,” 316.

48. Mercier, “The Economy, Work, and Society,” 316.

49. Mercier, “The Economy, Work, and Society,” 314.

50. *Spacewar!*, December 2020, <https://en.wikipedia.org/w/index.php?title=Spacewar!&oldid=996247926>. Doub, Hayden, and Lott, *DEC Finding Aid*.

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in the aerospace industry. The client application slides can answer research questions relating to occupational segregation and working conditions such as: Who had access? Under which circumstances did employees use computers? How did the interface influence the workflow?

4.2.1 Spaceflight Research at NASA

The role of NASA in propelling the computer industry and innovations forward had been the object of several studies. NASA itself contracted a study by James E. Tomayko in 1988 to supplement its encyclopedia with a volume dedicated entirely to *Computers in Spaceflight: The NASA Experience*. The report discusses several computer developments with a focus on NASA missions between the 1960s and 1970s but leaves out the use of computers in administration and research.

When the National Aeronautics and Space Administration was founded in 1958, “the stereotypical computer was the ‘UNIVAC,’ a collection of spinning tape drives, noisy printers, and featureless boxes, filling a house-sized room.” A decade later, giant mainframes were replaced “by clusters of medium-sized computers in spaceflight operations,” mirroring commercial developments. Computers were used “on the ground and in manned and unmanned spacecraft.”⁵¹

Computers on manned spacecrafts were generally developed from other computers (Apollo from Polaris; 4Pi from the System 360). Computers in ground operations were adapted from commercial machines. However, computers on unmanned spacecraft were custom designed.⁵²

Mission control was manned by flight controllers who assured a smooth flight and collected scientific data, performed navigation calculations, and sent commands to both manned and unmanned spacecrafts. Computers

51. James E. Tomayko, *Computers in Spaceflight: The NASA Experience*, ed. Allen Kent and James G. Williams, March 1988, 2, <https://ntrs.nasa.gov/citations/19880069935>.

52. Tomayko, *Computers in Spaceflight*, 136.

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in mission control processed massive amounts of data in real-time since control tasks were beyond human abilities. Computer sites for mission control were located near Washington, DC, since 1961 and Houston since 1964 for manned missions, with the site in Washington, DC, and another location in Pasadena, California, responsible for unmanned missions. Computers and software for manned mission control were developed in close cooperation between IBM and NASA.⁵³

Mission control of unmanned spacecrafts differed substantially from manned spacecraft due to the long duration of unmanned flights with few original engineers still associated with the mission by the end and simultaneous responsibility for multiple missions. Thus operations were planned for the long term and detailed documentation was critical.⁵⁴ The Goddard Space Flight Center near Washington, DC, used “dedicated small computers for specific missions, thus eliminating the complexity of handling multiple missions on a single mainframe” controlling “the plethora of scientific, navigational, communications, mapping, and weather satellites.”⁵⁵ Although minicomputers similar to DEC’s PDPs were used at the control center and ground stations, the first mention of a concrete processor used at NASA was the PDP-1. This PDP-1 served as a near real-time data processor for spacecraft telemetry with data displayed on teletypes at the Jet Propulsion Laboratory in Pasadena, California, which handled control for deep space exploration.⁵⁶

James E. Tomayko concluded that NASA had the greatest impact on developments in real-time systems and achieved reliability through redundancy, with emphasis on back-ups. However, NASA avoided innovations in hardware, instead purchasing existing and reliable equipment.⁵⁷ At NASA in Washington, DC, a PDP-11/34 as photographed from different angles showed people sitting at and around the system.⁵⁸

53. Tomayko, *Computers in Spaceflight*, 242-243.

54. Tomayko, *Computers in Spaceflight*, 258.

55. Tomayko, *Computers in Spaceflight*, 259.

56. Tomayko, *Computers in Spaceflight*, 261.

57. Tomayko, *Computers in Spaceflight*, 300-301.

58. Photographs, “PDP-11/34 and VAX-11/780 at NASA, Washington, D.C.,” 1978-

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Figure 4.1: Photographs, "PDP-11/34 and VAX-11/780 at NASA, Washington, D.C.," 1978-1979, Client application slides.

The first slide in the top-left corner of figure 4.1 portrays an office setting in which a man is sitting in front of an alphanumeric display terminal taking notes while engaged in a telephone conversation. The setting and his attire suggest an administrative use of the terminal, similar to the uses of punch cards in accounting (chapter 2) or the S/360 mainframe for business and communication (chapter 3). Two central slides in figure 4.1

1979, Still images, Client application slides, 1972-1988, Digital Equipment Corporation records, Lot X2675.2004, Box 634, Folder 30, Catalog 102753921, Computer History Museum, Mountain View (hereafter cited as Client application slides).

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show two female employees in a lab coat seated at an alphanumeric display terminal typing instructions and looking at the screen. The lab coats point more towards the use of minicomputers for research and testing rather than administration. In these three images, users were accessing the computer remotely. Their working environment was located outside of the computer room in an adjoining office, where noise and heat generated by machines was less disturbing. The orientation of desks could indicate that users had a separate office, or that offices were shared with few other colleagues.⁵⁹

The computer room was separated by a glass wall from an office. Inside the computer room, a person was turned with their back to the camera and bent over a peripheral. Two men sat in the office in front of the computer room, where they were discussing design drawings of an aircraft on a monitor as shown in figure 4.2. In the 1970s, computer-aided design (CAD) allowed engineers to update and document design changes and to record and keep track of the structural analysis. According to Paul Ceruzzi, a central mainframe was used for structural analysis, whereas a minicomputer handled detailed computations for smaller teams. The visual display units (VDU) did not merely display graphics, but CAD could also manipulate and store pictures with associated numeric information.⁶⁰ In contrast with previous terminals at NASA which were located in separate offices, this small team of engineers could see what was going on inside the computer room through panes of glass while still being separated from the cabinets of minicomputers and peripherals to keep noise down. The separated computer room also allowed to keep costs down since air conditioning, raised floors, and designated electrical circuits were limited to one space.

At the same site, three slides in figure 4.1 (two slides in the top right corner and one slide on the left in the middle row) show rows of men seated at terminals in the control room. The location in Washington seems

59. Photographs, "PDP-11/34 and VAX-11/780 at NASA, Washington, D.C.," 1978-1979, Client application slides.

60. Ceruzzi, *Beyond the Limits*, 115-119.

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Figure 4.2: Engineers at work with the PDP-11/34 computer room in the background. Photograph, "PDP-11/34 and VAX-11/780 at NASA, Washington, D.C.," 1978-1979, Client application slides.

to indicate that this control room was located at the Goddard Space Flight Center. Most men in the control room wore light blue dress shirts, some with a navy vest, pencil behind their ear, binders on top of the terminal and interacting with push button indicator lights, looking at the monitor in front of them or at the wall-size display at the front of the control room. Some were in conversation with their neighbouring colleagues or taking notes, few if any were typing.⁶¹

The control room setting points towards a real-time application such as flight control or rocket guidance.⁶² In such high-pressure environments, individual terminals and monitors offered users direct and real-time ac-

61. Photograph, "PDP-11/34 and VAX-11/780 at NASA, Washington, D.C.," 1978-1979, Client application slides.

62. Ceruzzi, *Beyond the Limits*, 114.

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cess to the computer, while the overview was still visible on the display at the front of the room. Rows of terminals were organised in a theatre-like setting to ensure that the display at the front was visible to all and employees could quickly turn to adjoining colleagues for deliberation. While I have no direct experience of such a control room environment and cannot judge the noise, sound, or smell, these three slides display an abundance of visual cues such as indicator lights and screens, as well as some paperwork that requires trained personnel to track flights, rockets, or perhaps satellite launches.



Figure 4.3: Mission Control at NASA. Photograph, "PDP-11/34 and VAX-11/780 at NASA, Washington, D.C.," 1978-1979, Client application slides.

A careful observation based on the client application images at NASA in figure 4.1 is that the few female computer users that were shown had their hands on the keyboard and were actively interacting with the PDP-11/34 using the terminal. Most male computer users were seated in front

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of terminals but not directly interacting. A similar observation has been made for a later decade by Aristotle Tympas and others for Greek computer users.⁶³

The client application slides of the PDP-11/34 and VAX system at NASA illustrate different uses of DEC minicomputers, as well as broader uses of computer systems in the aerospace industry. The terminals in offices for administrative and research applications are similar in application to previous case studies (see section 2.2 and 3.1), but employees at NASA had more direct access to minicomputers. Visual displays rather than printouts allowed for an increasingly interactive computing experience. Two further applications at NASA return in commercial aviation with engineers increasingly able to draw and alter designs on computers rather than paper, and real-time applications in mission and air traffic control requiring intricate interconnected systems to support employees in tracking aircraft and making immediate, informed decision.

4.2.2 Commercial Aircraft by Boeing

One aircraft manufacturer featured in the client application slides of the DEC records was Boeing. Boeing developed the first commercial jet plane towards the end of the 1950s, referred to as the dawn of the jet age in aviation history. The Cold War had funded the necessary research for military aircraft which could then be applied to commercial airplanes. Aside from the swept-back wing design for bombers which increased speed and made commercial jets faster and more attractive to passengers, the Boeing 707 or first commercial passenger jet was based on a jet tanker refueling bombers in flight. Using cheaper kerosene for more reliable engines that produced less vibration, Pan Am ordered and operated Boeing's first

63. Aristotle Tympas et al., "Constructing Gender and Technology in Advertising Images: Feminine and Masculine Computer Parts," in *Gender Codes: Why Women Are Leaving Computing*, ed. Thomas J. Misa (Hoboken, NJ: John Wiley & Sons, 2010), 187–209, <https://doi.org/10.1002/9780470619926.ch9>.

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commercial jet by 1958.⁶⁴

Similarly, the Boeing 747 was based on a proposal for an oversized military cargo plane which eventually went to a competitor.⁶⁵ Again, Pan Am was the first to order the Boeing 747 seating between 360 and 450 passengers depending on the configuration and effectively doubling capacity compared to previous jet aircraft.⁶⁶ After constructing a new assembly building, the first Boeing 747s rolled out in autumn of 1968 and after extensive testing and approval, deliveries started in December 1969.⁶⁷ The wide-body Boeing 747 entered commercial service for Pan Am on January 22, 1970.⁶⁸ Their wide-bodied jet or jumbo jet characterized air travel in the 1970s.⁶⁹

With two aisles and rows of ten seats space became increasingly restricted, and staff could not devote as much personal attention to travelers in economy class. Passenger overload in airports caused delays and strikes.⁷⁰ The experience of first class travelers better resembled advertisements which promoted “comfortable, quiet, and luxuriously-appointed cabins reminiscent of large living rooms with spacious lounges and cocktail bars.”⁷¹

By the 1970s airlines witnessed a reduction in first-class travelers with a steep incline of leisure travelers or people visiting friends and relatives. Flying was no longer an unusual experience travelers dressed up

64. *History of Aviation - First Flights*, accessed May 25, 2021, <https://www.avjobs.com/history/index.asp>.

65. Bilstein, *Flight in America*, 262.

66. R. E. G. Davies, *Airlines of the Jet Age: A History* (Washington, DC: Smithsonian Institution Scholarly Press, August 2016), Chapter 15.

67. Bilstein, *Flight in America*, 262.

68. Tim Brady, *The American Aviation Experience: A History* (Carbondale, IL: SIU Press, 2000), 222.

69. Davies, *Airlines of the Jet Age*, Chapter 15.

70. Nina Hadaway, *The Golden Age of Air Travel* (Oxford: Shire Publications, 2013), The Boom in Air Travel; Jenifer Van Vleck, *Empire of the Air* (Cambridge, MA: Harvard University Press, November 2013), 272.

71. Charles Schuler, *Widebody: The Launch of the Jumbojets in the Early 1970s*, September 2019, <https://www.flysfo.com/media/press-releases/widebody-launch-jumbojets-early-1970s>.

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for. Students were now able to fly to college thanks to fare discounts, and the younger generations introduced T-shirts and jeans in flight. As many historians state “air travel for the masses had arrived.”⁷² By 1977, 63 per cent of the American adult population had flown and about 273 million travellers had passed through airport gates in 1978 alone with around 700 flights crossing the skies every hour.⁷³

Although passengers rarely encountered computers directly while going through the airport and boarding the aircraft, computer systems fulfilled several essential roles in commercial aeronautics. Aircraft manufacturers like Boeing relied on computers during the design stage, the testing phase, in manufacturing and for training pilots in flight simulators.⁷⁴ Passengers unknowingly used computer systems to make an airline reservation. At airports their baggage was handled by computers. Ground operations as well as air traffic control was managed by computer systems.⁷⁵

Unlike figure 4.2 which illustrates the use of the PDP-11/34 in the design stage at NASA, client application slides for Boeing do not include minicomputers used by engineers while drawing. Presumably, the 6,000 engineers who produced over 75,000 engineering drawings for the Boeing 747 also relied on computers during the design stage.⁷⁶ The client application slides from Boeing do include other examples of the PDP-11/40 minicomputer used at the test centre in Washington. Although the finding aid does not include an exact reference to the location of the test centre, the sheer size of the Boeing 747 meant testing most likely happened at the newly constructed assembly plant next to the military base at Paine Field near Everett close to Seattle, Washington.⁷⁷

72. Davies, *Airlines of the Jet Age*, Chapter 20; Martin W. Bowman, *Boeing 747 A History: Delivering the Dream* (South Yorkshire: Pen / Sword, June 2014), Introduction; Hadaway, *The Golden Age of Air Travel*, Epilogue; Van Vleck, *Empire of the Air*, 288.

73. Bilstein, *Flight in America*, 286.

74. Ceruzzi, *Beyond the Limits*, 2, 16.

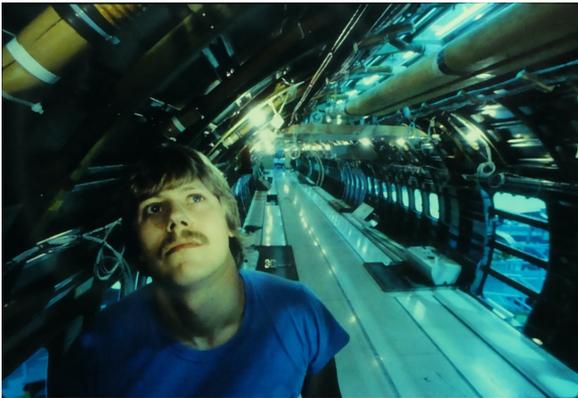
75. Ceruzzi, *Beyond the Limits*, 226.

76. Bowman, *Boeing 747*, Chapter 1 and 2.

77. Bowman, *Boeing 747*, Chapter 2.

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Aviation author Martin W. Bowman mentioned that numerical controlled machines were used for assembly at Boeing.⁷⁸ Paul Ceruzzi also explains how CADs were translated to computer-aided manufacturing (CAM), which in turn could support the numerical controlled machines that Bowman mentioned. A person entered information from engineering drawings into the computer which printed commands on punch tape. Milling machines then read the tape and selected tools for cutting metal automatically.⁷⁹ The client application slides included one image of a man in a blue T-shirt looking up at the ceiling of an aircraft under construction (see figure 4.4 (a)), but I cannot ascertain that he in fact works in manufacturing.⁸⁰



(a) Manufacturing



(b) Testing

Figure 4.4: Photograph, "PDP-11/40 at the Boeing Test Center," 1976, Client application slides; S. Spelman, photograph, "PDP-11/34 and laboratory peripheral system at Boeing," July 1980, Client application slides.

In a second set of client application slides, the PDP-11/34 was connected to laboratory peripherals at Boeing. One man was taking notes

78. Bowman, *Boeing 747*, Chapter 2.

79. Ceruzzi, *Beyond the Limits*, 132-133.

80. Photograph, "PDP-11/40 at the Boeing Test Center," 1976, Client application slides, Box 633, Folder 13, Catalog 102749324.

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while observing a machine. Figure 4.4 (b) of a man turning a switch on laboratory peripherals connected to a DECwriter, also includes heavier machinery in the background of the image that was either used for testing components or perhaps illustrates the use of numerical controlled machines in CAM described in the previous paragraph.⁸¹ Another image showed a man holding a microscope while adjusting an oscillator.⁸² Bowman does confirm that the Boeing 747 underwent 15,000 hours of wind-tunnel testing, and minicomputers similar to the PDP-11 were installed on board of test flights in a cabinet structure.⁸³

The clearest example of the use of a PDP-11/40 system at the Boeing Test Centre is illustrated by two people in a flight simulator, one dressed in a pilot uniform one hand on the engine handle, the other in a checkered shirt talking to an intercom. As at NASA, the PDP-11/40 in the Boeing Test Centre was located in a separate room behind a wall of glass as seen in figure 4.5. The pilots were seated in a cabin supported by hydraulics which simulated movement based on input from the PDP-11 system.⁸⁴



Figure 4.5: Flight Simulator. Photographs, "PDP-11/40 at the Boeing Test Center," 1976, Client application slides.

The final use of minicomputers by Boeing was in the cockpit. Until the

81. Steve Spelman, photograph, "PDP-11/34 and laboratory peripheral system at Boeing," July 1980, Client application slides, Box 634, Folder 40, Catalog 102753934.

82. Photograph, "PDP-11/40 at the Boeing Test Center," 1976, Client application slides.

83. Bowman, *Boeing 747*, Chapter 1 and 3.

84. Photographs, "PDP-11/40 at the Boeing Test Center," 1976, Client application slides; Ceruzzi, *A History of Modern Computing*, 158.

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mid-1970s the cockpit was full of analogue instruments as shown in the flight simulator. Pilots required the assistance of flight engineers to interpret all of the instruments. One innovation of the Boeing 747 was its inertial navigation system (INS) which eliminated the need for ground-based navigation aids, inspired by the Apollo mission. The automatic flight control system furthermore combined autopilot with a flight director system (AP/FD) and used three Sperry (later Honeywell) minicomputers.⁸⁵ Only in 1985 did Boeing catch up to its competitors by including a “full digital, two crew flight deck with cathode ray tube (CRT) displays.”

The client application series also included several images of the PDP-11's use at airports. Airline reservation systems however were not pictured, but often mentioned in literature. “Reserving airline seats is clearly a complicated task, well-suited to computerization. Agents all over the country can now check flight availability and reserve seats from their work stations [...]”⁸⁶ In fact, Ceruzzi attributes the Semi-automated Business Research Environment (SABRE) reservation system for American Airlines in part to IBM's experience with SAGE, a defence system to intercept missiles during the Cold War. The reservation system “gave the ticket agent direct and rapid access to information” on available seats and planes.⁸⁷

American Airlines in New York did send DEC photographs of a second computer application at airports, in particular baggage handling at the Logan Airport (see figure 4.6). Dr. Frey's dissertation on *Models and Methods for Optimizing Baggage Handling at Airports* includes a brief historical review which makes up for its lack in references with a general overview of baggage handling in the 1970s. The introduction of the Boeing 747 and other airplanes of similar size meant baggage logistics changed completely from passengers carrying their suitcases until they embarked while baggage handlers loaded baggage one by one, to the check-in process at counters in the terminal building still in use today.⁸⁸ Some images show

85. Bowman, *Boeing 747*, Chapter 1.

86. *Computer-Based National Information Systems: Technology and Public Policy Issues* (Congress of the U.S., Office of Technology Assessment, 1981), 40.

87. Ceruzzi, *Beyond the Limits*, 76.

88. Markus Matthäus Frey, “Models and Methods for Optimizing Baggage Handling at

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Figure 4.6: D. Coady, photographs, "Baggage handling at American Airlines," 1973, Client application slides.

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a male employee of colour loading passenger's luggage onto a conveyor belt, others show passengers waiting for their luggage after arrival.⁸⁹ Figure 4.6 shows luggage handling on the tarmac and behind the scenes at the airport.⁹⁰ In fact, figure 4.6 includes "shots of an American Airlines terminal, airplanes on the runway, and handlers loading DEC equipment (not visible in the images because they were already packed in crates) to be sent to Australia."⁹¹ Minicomputers were not only used in airports, DEC was also a customer of American Airlines for shipping the equipment to Australia.

The increase of passengers and sheer size of the jumbo jet meant airports needed to adapt their runway and taxi areas, hangarage space, food and fuel replenishment service, baggage capacity, as well as their stock of spares adding to the cost of introducing the wide-bodied aircraft.⁹² The next series of slides shows the PDP-11/70 used at Logan Airport and illustrates that the introduction of the wide-bodied jet also required "major adaptations or extensions of ground-handling facilities at airports."⁹³ The scene displayed in slide 4.7 might be an example of a ground-handling operations room. A man is shown making a phone call in front of a series of equipment including a collection of paper slips, two keyboards, and four panels of indicator lights.⁹⁴

In an essay on *Centres of Coordination* Lucy Suchman describes the setting of airport ground operation rooms in the context of an ethnographic study which took place at a metropolitan airport on the west coast of the United States between 1989 and 1991. Although most technology

89. Photographs, "American Airlines - Logan Airport," 1972, Client application slides, Box 633, Folder 3, Catalog 102749314.

90. Dennis Coady, photographs, "Baggage handling at American Airlines," 1973, Client application slides, Box 633, Folder 4, Catalog 102749315.

91. Doub, Hayden, and Lott, *DEC Finding Aid*, 51.

92. Bowman, *Boeing 747*, Chapter 1.

93. Sigmar Stadlmeier, *International Commercial Aviation: From Foreign Policy to Trade in Services*, ed. Marietta Benkö and Willem de Graaff, vol. 5, *From for Air and Space Law* (Paris: Editions Frontières, 1998), 234.

94. Susan Lang, photograph, "PDP-11 at Logan Airport," 1977, Client application slides, Box 634, folder 20, Catalog 102753911.

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Figure 4.7: Ground Operations. S. Lang, photograph, "PDP-11 at Logan Airport," 1977, Client application slides.

and some procedures have probably changed between 1977 (the date of the slide from Logan Airport) and 1989 (when the ethnographic study started), the description of working conditions and the environment from the essay evokes the experience displayed in figure 4.7. Unlike the slides depicting the air traffic control tower in figure 4.8, the man in the operations room was seated in the dark with no view of the runway and taxi areas. Therefore, the scene probably represents ground operations, which coordinated the servicing of arriving and departing planes. Servicing included "loading and unloading passengers and baggage, ensuring that connecting baggage from an incoming plane [was] moved to the appropriate outgoing plane, [and] replenishing the plane's store of food and fuel." Personnel in the ground operations room needed to communicate with co-workers in other locations, for instance via telephone (see figure

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4.7).⁹⁵

The man in figure 4.7 might be a flight tracker who kept track of arriving and departing flights by mapping the gate to a flight number. The paper slips on his desk are then likely records of scheduled arrivals and departures with associated flight numbers. Flight Trackers communicated “with pilots on the ground via a radio, and clear[ed] their arrival at designated gates.” Work in ground operations involves multiple technologies such as forms, computer terminals, telephones, and so on. Computer terminals in ground operations provided “access to a network of databases shared among the distributed sites of the airline’s operation.”⁹⁶

Since the team in the operation room - and in the air traffic control tower for that matter - needed to collaborate to ensure smooth arrival and departure from the gates according to schedule, while at the same time focusing on their own tasks, they needed to differentiate their attention. Depending on whether information was relevant to them or not, personnel would “disattend sights, sounds, and events that [drew] the attention of their co-workers” while still picking up relevant information from the *sonic soup*.⁹⁷

Another set of client application slides showed the air traffic control tower at Logan airport as seen in figure 4.8.

The higher speeds of jet airliners, coupled with their higher frequency of airport arrivals and departures, unquestionably increased the volume of air travel, and consequently, the burden on air traffic controllers. [...] en route air traffic continued to be handled by an increasingly cumbersome radar system that had to be updated manually during the progress of any given flight. A controller’s radar screen might show several

95. Lucy Suchman, “Centers of Coordination: A Case and Some Themes,” in *Discourse, Tools and Reasoning: Essays on Situated Cognition*, ed. Lauren B. Resnick et al., NATO ASI Series (Berlin: Springer, 1997), 41–62, https://doi.org/10.1007/978-3-662-03362-3_3.

96. Suchman, “Centers of Coordination.”

97. Suchman, “Centers of Coordination.”

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moving “blips,” each signifying a plane in flight.⁹⁸

Air traffic control became necessary when “the skies were getting too crowded” and aircraft collided in 1956, which led to the creation of the Federal Aviation Agency in 1958, later the Federal Aviation Administration under the Department of Transportation in 1967. The agency set up “a broad airtraffic control system, to maintain safe separation of all commercial aircraft through all phases of flight.”⁹⁹



Figure 4.8: Control Tower. S. Lang, photographs, “PDP-11 at Logan Airport,” 1977, Client application slides.

98. Bilstein, *Flight in America*, 286.

99. *History of Aviation - First Flights*.

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In the top-left slide of figure 4.8 three men were standing behind tables filled with paper slips and control instruments in front of the windows overlooking the runway. The first man in pale blue sweater was holding a pen, looking down to slips of paper. The next man in yellow pullover was gazing down at the desk and in the back a man in maroon vest was in conversation via telephone. Behind the space where these three men were standing was another circle of tables filled with equipment. Binoculars were within reach for people in the outer and inner circle on top of the inner desk. One man in checkered dress shirt sat inside the semi-circle desk and gazed towards the CRT monitors hanging suspended from the ceiling in front of the windows. He was wearing a headset but did not seem to be conversing in this particular moment. Two men were standing with their back towards the camera in the inner circle, looking at a video monitor or outside.

In the next slide at the top-right of figure 4.8 the air traffic control tower was photographed from a slightly elevated angle to show the view outside from the air traffic control tower. The man in salmon-coloured dress shirt was not visible in the previous slide and was gazing outside. The man in maroon vest was adjusting paper slips on the console in front of him, and the man in checkered dress shirt had moved from the inner circle to a desk chair in the outer circle and was holding two paper slips as well.

The bottom-left slide in figure 4.8 shows little change from the previous slide. The photographer had moved to the inner circle, showing that the man in pale blue sweater from the top-right slide had moved to a printer-terminal inside the semi-circular inner desk, where he was engaged in a telephone conversation. The positions of the other three men remained almost exactly the same, but the man in maroon vest was gazing down at the microphone for radio communication his colleague was holding and the man in checkered dress shirt was looking up at a CRT monitor. In the final bottom-right slide of figure 4.8 the man wearing a blue sweater had moved his chair slightly to the right in front of a printer-terminal where he was typing on a keyboard and producing a printout. His colleague in maroon vest was roughly in the same spot talking into

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a headset and looking at gauges on the desk. The men in salmon and checkered dress shirts had barely moved.¹⁰⁰

Desks in the air traffic control tower were not assigned to a single person. The job required colleagues to switch positions regularly to use different equipment depending on the task at hand. The altered direction of their gaze from one slide to the next also suggests that people in the control tower needed to monitor both the situation outside and the CRT monitors, while simultaneously ordering paper slips of flight information. With several men wearing headsets or holding telephones, the air traffic control room must have been buzzing with people talking.

The recession caused by the oil crisis in 1973 meant airlines carried fewer passengers. Combined with fixed fares, high debts from purchasing expensive wide-bodied jets, and the threat of hijackings by passengers who wanted to travel to Cuba, airlines plummeted into ever greater debt.¹⁰¹ Some of the larger aircraft was sold second-hand or converted into cargo aircraft.¹⁰² Another Boeing 747 airplane was purchased second-hand by NASA and converted to carry the Space Shuttle.¹⁰³ Before 1978, the Civil Aeronautics Board determined routes and fixed fares.¹⁰⁴ Fares were based on distance instead of market demands and meals, seating widths, and separations were almost standardised.¹⁰⁵ After the Airline Deregulation Act in 1978, airlines were suddenly free to compete.¹⁰⁶ The deregulation led to bargain fares and with another increase in fuel costs by the end of the 1970s, passenger traffic and aircraft sales declined once more.¹⁰⁷ In the peak year of 1979 with 317 million passengers and 5.9 billion freight ton-miles of cargo, revenues amounted to \$27.2 billion, but by 1981 airlines led a net operating loss of \$421 million.¹⁰⁸

100. S. Lang, photograph, "PDP-11/70 at Logan Airport," 1977, Client application slides.

101. Van Vleck, *Empire of the Air*, 273-276.

102. Bowman, *Boeing 747*, Chapter 10.

103. Bowman, *Boeing 747*, Chapter 11.

104. Brady, *The American Aviation Experience*, 223; Van Vleck, *Empire of the Air*, 283.

105. Davies, *Airlines of the Jet Age*, Chapter 20.

106. Brady, *The American Aviation Experience*, 223.

107. Bilstein, *Flight in America*, 285.

108. Bilstein, *Flight in America*, 286.

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In short, computers such as DEC's PDP-11 were used in the commercial aeronautics industry for designing and testing aircraft, and training pilots. At the airport, the PDP-11 was used inside the ground-operations control room and the air traffic control tower. Employees who gained more direct access to minicomputers through terminals were still separated from the cabinets of minicomputers in the computer room. Despite increased accessibility, users pictured in the client application slides of Boeing and at airlines were highly educated engineers and pilots or worked in testing and control rooms. Whereas at least two female NASA employees were shown for the spaceflight applications, not a single female employee was visible in Boeing's application slides or in airport applications pictured. Occupational segregation and working conditions also differed for personnel in the computer industry. The next section discusses the composition of four occupations at the PDP-11 manufacturer's site.

4.3 The People Behind the Minicomputer

In previous chapters very little information about the personnel within the computer manufacturer's company was available. For the Digital Equipment Company however, the gender composition of occupations within the company becomes clear from images of several departments. Images are available for the development teams of the PDP-11/35 and the PDP-11/70. Furthermore, the group composition and working environment of the manufacturing and marketing departments were also photographed.

4.3.1 The Digital Equipment Corporation

When the first PDP models became increasingly popular, DEC restructured in 1964 creating product lines. A product line grouped Engineering, Programming, Marketing and Production departments.¹⁰⁹ The prod-

109. *Digital Equipment Corporation: Nineteen Fifty-Seven to the Present*, 6.

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uct line manager was responsible for development and in charge of a marketing group and an engineering group. Each product line had a budget, a plan, and a marketing plan. In addition to product lines, other departments were in charge of specific customer applications such as laboratory data processing, manufacturing and distribution, academic computing, etc. Software was often an afterthought and customers developed and shared their own programs via the Digital Equipment Computer Users Society (DECUS) program library. Only by the mid-1970s did software development become a serious and profitable part of the computer industry.¹¹⁰

With internal competition reaching new heights between the PDP-8, PDP-10, and PDP-11 product lines and redundant elements that could have been shared, the product line structure was no longer feasible. In February 1974, Gordon Bell advocated to create one Central Engineering Department. Product lines shifted focus towards customer applications and central engineering developed common lines of terminals, printers, disks and other peripherals for each system increasing performance, output, revenue and production space. Central Engineering established procedures, developed product plans and was held accountable. Projects were also reviewed before resources were spent on developments, product announcements, and manufacturing.¹¹¹

4.3.2 Design and Development

Whereas the inventor's legendary narrative for the IBM S/360 centered around the original requirements from a management team, the invention myth of DEC's PDP-11 focuses on building the minicomputer in a short time frame with a small team. Steve Teicher remembered the process of developing a low-end PDP-11 to compete with Data General's Nova at the request of Gordon Bell, head of engineering.¹¹² Based on

110. Parker Pearson, *Digital at Work*, 84-86, 172.

111. Parker Pearson, *Digital at Work*, 89-90.

112. Stephen Norman Teicher (28 March 1944 - 5 July 2014) obtained a B.S. Degree in electrical engineering from MIT in 1966 and started his career at DEC in 1969 where

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the user manual for the PDP-11 and the microprogramming technique a paper mock up of the PDP-11/05 was designed and announced before it was even built, a technique IBM also used for the S/360. Two months later the PDP-11/05 needed to be displayed at a trade show. After struggling with the printed circuit board they came across someone who sold programmable read-only memory and received components one week before the conference. Since electrical power was under maintenance at Maynard Mill over the weekend, the engineers got to work using a long extension cord. After someone unfortunately switched off the computer in the middle of the process, it all came down to the night before. The performance test took fifteen seconds and then the machine was shipped to Las Vegas. By some miracle the machine functioned the entire week. Manufacturing for the PDP-11/05 was moved to Puerto Rico but with only a midnight prototype, the entire engineering crew was sent to the plant to set up production within 90 days.¹¹³

From the historical overview created on the occasion of the company's twentieth anniversary, a sense of nostalgia and corporate culture led to a comparison of "New England's traditional values: the work ethics, Yankee ingenuity, care in craftsmanship and pride in good work" which DEC sought to keep up and extend with "innovative and dynamic approaches to the computer field."¹¹⁴ Corporate culture and values expressed by executives but shared by DEC employees can be understood as *sociotechnical imaginaries*, a term coined by Sheila Jasanoff to denominate "collectively imagined forms of social life and social order reflected in the design and fulfillment of specific scientific and/or technological projects." To some extent, imaginaries can express a shared understanding of good and evil which is reflected in the company's mantras.¹¹⁵ As a company

he held leadership roles until 1990. *Obituary for Stephen N. Teicher*, July 2014, <http://www.deconnection.org/obits/Stephen%20N%20Teicher%20obituary%20070514.pdf>

113. Parker Pearson, *Digital at Work*, 75-76.

114. *Digital Equipment Corporation: Nineteen Fifty-Seven to the Present*, vii.

115. Sheila Jasanoff, "Future Imperfect: Science, Technology, and the Imaginations of Modernity," in *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication*

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of mainly engineers the core values of DIGITAL were “do the right thing” credited to Ken Olson and “he who proposes, does” a mantra of Gordon Bell. Rather than a top-bottom hierarchy similar to IBM, DEC encouraged ideas to move bottom-up into products. Engineers thus held responsibility and the freedom to propose and develop as well as manage projects. The atmosphere was open and supportive to allow for a free exchange of information and the freedom to propose, criticize, and review ideas. “Everyone was on a first name basis, there were no time clocks and dress was informal and casual,” said Gordon Bell.¹¹⁶

DIGITAL managed to attract engineers from government labs and institutions such as the Xerox Palo-Alto Research Center (Xerox PARC) because they offered engineers the chance to actually bring products into the market. The motivation and drive for engineers came from seeing the results of their projects at customer sites, gaining respect from other engineers, and receiving new projects. Aside from dinners, plaques, and the occasional stock option, DEC engineers were not rewarded with a window office or financial bonus. The ethic of doing the right thing resulted in high-quality products and a focus on customers. At the start of the 1970s systems were configured for the individual customer and engineers often visited customers to discuss requirements and design solutions. Newly hired engineers were sent to customers, trade shows or DECUS meetings to get in touch with users. Being in direct contact with customers encouraged engineers to create realistic solutions to user requirements.¹¹⁷

The group responsible for designing and developing the PDP-11/35 consisted of around eighteen people, mostly white with the exception of one man of colour as seen in figure 4.9. Only three female employees worked on the design and development team. The team proudly posed around the PDP they worked on. The computer took center stage in the image and the photographer stood slightly higher looking down upon the group placed left and right of the PDP-11/35. In the background empty

of Power, ed. Sheila Jasanoff and Sang-Hyun Kim (Chicago: University of Chicago Press, 2015), 4, <https://doi.org/10.7208/chicago/9780226276663.003.0001>.

116. Parker Pearson, *Digital at Work*, 76-77.

117. Parker Pearson, *Digital at Work*, 77-79, 107.

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Figure 4.9: Photograph, "PDP-11/35 group shots," 1975, Archival proofs.

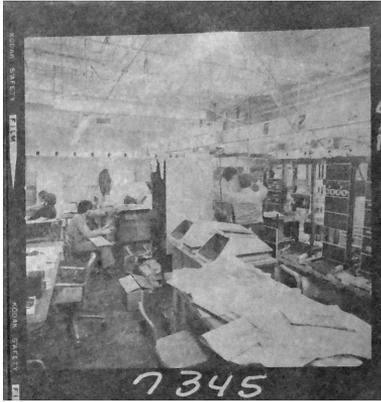
DEC cabinets are visible through a large opening inside the factory wall with desks placed facing the wall either side of the opening.¹¹⁸

The team that developed the PDP-11/70 was photographed in action. Some photographs show two men in shirt and tie discussing in front of equipment, while another man in a striped T-shirt was connecting cables in the back of a PDP-11 cabinet. Another man was typing instructions on a teletype. Several images show a man seated at a table drawing with pencil on paper. Another scene portrays the team in a classroom setting, one man instructing in front of a blackboard while others were taking notes. Of the fourteen people in the room, only one employee of colour is visible, but the quality of the image is too low to determine the gender composition. Other photographs show male employees fidgeting with machinery, mostly by themselves.¹¹⁹

118. Photograph, "PDP-11/35 group shots," 1975, Still images, Archival proofs, 1963-1975, Digital Equipment Corporation records, Lot X2675.2004, Box 743, Folder 209, Catalog 102773342, Computer History Museum, Mountain View (hereafter cited as Archival proofs).

119. Photograph, "PDP-11/70 development team," 1974, Archival proofs, Box 743,

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(a) office overview



(b) group portrait

Figure 4.10: Photograph, "PDP-11/70 development team," 1974, Archival proofs.

The rare office overview photograph as seen on the left of figure 4.10 shows that the team shared a large open office with desks placed next to peripherals and PDP-11 cabinets alongside the back wall. Some colleagues sat behind the desk while others discussed next to the computer cabinets. In a group shot of the PDP-11/70 development team six white men are proudly posing next to the machine. In another picture shown on the right of figure 4.10, nine other team members including one white woman and one woman of colour who look like they are in their twenties were sitting or standing next to the computer cabinet. In an image of a meeting we see two other female employees, one Asian and one white man discussing the paperwork in front of them. Three other white men were engaged in conversation next to a pulled-out drawer from the computer cabinet. The final sheet of images of this team includes several photographs of a man attaching cables, two men individually bent over papers at their desk, two men in conversation and two women smiling at

Folder 88, Catalog 102771208.

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the camera from behind their desk.¹²⁰

As images of product groups show, not all engineers were male. In fact, Barbera Stephenson was one of the first female engineers at DEC and wrote the first logic handbook in the 1960s which served as an important promotional tool and textbook.¹²¹ Based on a rough count, the PDP-11/70 team of about twenty-five people consisted of nineteen men of which one looked Asian and six women of which one woman of colour. In terms of gender composition the development teams consisted of between 6 and 24% female employees and very few employees of colour. Another observation based on the images is that female employees all looked relatively young whereas the age of male employees varied more. Finally, in older PDP-11 team group shots of 1969 twelve white male employees are shown wearing white dress shirts, black trousers and a tie.¹²² Either this particular image was taken on a very formal occasion, or attire styles changed between the end of the 1960s and the beginning of the 1970s from business suits to more casual outfits as mentioned by Gordon Bell earlier. Furthermore, the first PDP-11 team did not include a single woman or person of colour. As later images show, the lack of diversity in the first PDP-11 team did not necessarily reflect a corporate policy since DEC prided itself on its diversity as enthusiast historian and Maynard resident David Mark discusses in his blog post on diversity at DIGITAL. The company took action in the 1970s both by moving to locations where minorities made up the majority and by hiring a manager of affirmative action and equal employment opportunity in 1974.¹²³

120. Photograph, "PDP-11/70 development team," 1974, Archival proofs.

121. Barbera Stephenson worked at Digital between 1960 and 1966 as an Analog/Digital Engineer. Parker Pearson, *Digital at Work*, 81, 198. For an image of Barbera Stephenson, see *Barbera Stephenson - CHM Revolution*, accessed February 8, 2021, <https://www.computerhistory.org/revolution/minicomputers/11/335/1901>. Parker Pearson, *Digital at Work*, 80

122. Photograph, "PDP-11 team group shots and portraits," 1969, Archival proofs, Box 715, Folder 29, Catalog 102771208.

123. David Mark, *Digital Equipment Corporation - Diversity*, March 2020, <http://www.maynardlifeoutdoors.com/2020/03/digital-equipment-corporation-diversity.html>.

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4.3.3 Manufacturing

In the middle of the 1960s, manufacturing still happened at the Maynard Mill. Lu Klotz remembers that machines were built by a single person and the process took around one week.¹²⁴ From metal frame and power supply, to memory modules which were tested using paper tape and processor modules and options ordered by the customer, all components were inserted, soldered and tested manually. During nights and weekends machines (and lasagna) were placed inside a wooden heat chamber followed by diagnostic and mechanical tests. So long as machines survived slapping and didn't start smoking, they passed the test. When machines were faulty as they often were, they needed to be debugged, sometimes literally since the mill was full of spiders.¹²⁵

Gloria Porrazzo started working in assembly in 1957 and soon became Modules Assembly Group Manager. Jack Smith recalls that at first mostly male engineers and technicians worked in assembly but missed the dexterity.¹²⁶ Soon manufacturing introduced women to the job, with Gloria leading 300 female production workers.¹²⁷

Porrazzo set company policies before such things as job descriptions existed. She taught the company how to develop work classifications, chose team leaders on the strength of their ability to deal with people, hired minority workers, and championed maternity leave by letting her people stay on the payroll when they left to have babies.¹²⁸

Gloria's Girls as they were called, hand drilled holes in the printed circuit boards, bent wires of components attaching them to the board and

124. Lu Klotz joined DIGITAL in 1966 and became Senior Manufacturing Engineering Manager. Parker Pearson, *Digital at Work*, 196.

125. Parker Pearson, *Digital at Work*, 109, 111.

126. Jack Smith joined DIGITAL in 1958 and became Senior Vice President of Operations. Parker Pearson, *Digital at Work*, 198.

127. Parker Pearson, *Digital at Work*, 113.

128. Parker Pearson, *Digital at Work*, 113.

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passed them over molted solder.¹²⁹

Since the beginning of the 1960s manufacturing was split into two groups, the Volume Manufacturing group producing modules and the Systems Manufacturing group, later called Final Assembly and Test (FA&T) to put everything together. Peripherals Manufacturing was added in the early 1970s. Based on Stan Olsen's visit to a meat-packing plant, machines hung from hooks overhead and moved through stations in assembly and testing. Other processes were also automated as a result of the high production volumes of the successful PDP-8 in the mid-1960s.¹³⁰

Despite automation in manufacturing bringing down costs and ramping up production, by 1970 the Mill could not expand any further so within five years eighteen new facilities were added. A decade later in 1980 30,000 people worked in manufacturing, spread over twenty-six plants. DIGITAL preferred small blue-collar American towns and establishing a people-oriented culture by choosing a local personnel manager and plant manager. Production plants were embedded into small towns to fit in with existing communities and DIGITAL transferred its expertise, culture and values by starting from existing teams.¹³¹

FA&T first moved to Westminster and then to Westfield, both close by in Massachusetts. When European demand for the PDP-8 and PDP-11 rose, the production plant in Galway, Ireland also focused on FA&T. By 1973 Aguadilla in Puerto Rico and Kanata in Canada were also manufacturing PDP-11s. Puerto Rico was chosen for its "large and competent labor pool, a compatible local culture with a strong work ethic, and significant tax benefits for manufacturing investments."¹³² To improve communication without long telephones and frequent travels to meetings, product and process documentation was distributed, although a subtle lan-

129. For an image of the production line see *DEC production line - CHM Revolution*, accessed February 8, 2021, <https://www.computerhistory.org/revolution/minicomputers/11/335/1902>, and Lott, *What the DEC?*. Parker Pearson, *Digital at Work*, 113.

130. Parker Pearson, *Digital at Work*, 115.

131. Parker Pearson, *Digital at Work*, 112, 119.

132. Parker Pearson, *Digital at Work*, 119.

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guage barrier still caused issues, with most employees speaking Spanish.¹³³

Before the introduction of the PDP-11 DIGITAL purchased core memory modules because of the labor intensive process. However, by the 1970s DIGITAL decided to produce memory internally. After purchasing the memory business and headquarters of the Radio Company of America (RCA) in Marlboro, Massachusetts, DEC acquired the necessary technical expertise. They also took over the RCA Taiwan facility employing 400 female employees of between 15 and 25 years old with very good eyesight, stringing cores. DIGITAL offered employees a higher wage and housing in free dormitories with a cafeteria. A perceivable cultural difference was the commitment and quality Far Eastern facilities such as Taiwan and Hong Kong delivered, outpacing Volume Manufacturing in the United States. When semiconductor technology became cheaper to buy than make in 1978, the Hong Kong facility moved to module manufacturing and Taiwan, renowned for television production retained all personnel to produce video monitors. By 1980 Manufacturing was split into six operating groups (systems, chips, memories, terminals and printers, storage systems, and Far East operations).¹³⁴

Although the images of manufacturing do not provide an overview of the workplace, the first few images show a man at work using an oscilloscope to check the wiring of a machine sitting next to an exposed computer cabinet. From another angle a set of three images shows the same scene and setup with another man testing a circuit board using an oscilloscope as shown in figure 4.11 on the left.¹³⁵ A final set of photographs show a small room from birds perspective with a man seated at a Teletype placed in front of an oscilloscope that was switched off adjusting a switch on the PDP-11 computer cabinet on his left, then turning to read the manual on top of a table to his right (fig. 4.11 on the right).¹³⁶

133. Parker Pearson, *Digital at Work*, 119-120.

134. Parker Pearson, *Digital at Work*, 127-130, 132.

135. Photograph, "PDP-11 manufacturing," 1970, Archival proofs, Box 717, Folder 19, Catalog 102771234.

136. Photograph, "PDP-11 manufacturing," 1970, Archival proofs.

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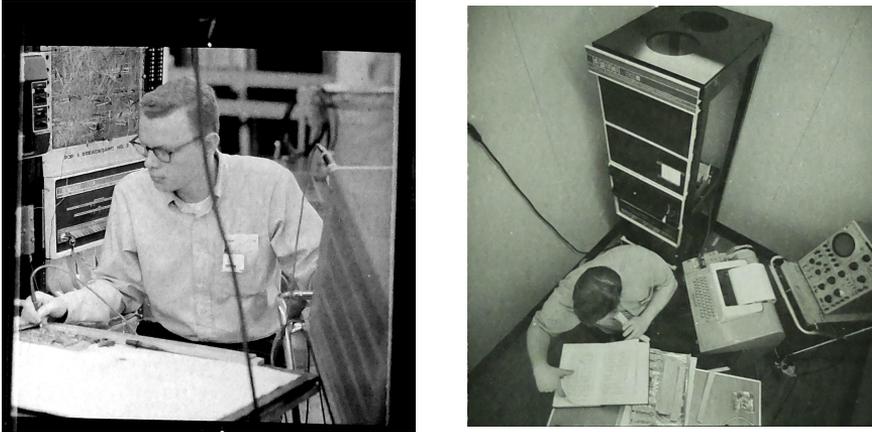


Figure 4.11: Photograph, "PDP-11 manufacturing," 1970, Archival proofs.

The scenes in figure 4.11 illustrate very different working environments. On the one hand men were seated next to PDP-11s under construction on a factory shop floor testing connections on circuit boards before inserting them into minicomputer cabinets. On the other hand, a fully finished PDP-11 was displayed inside a separate room in a seemingly staged set-up where a man was following the procedure in a manual, perhaps for a final round of testing. The second working environment in a carpeted and sectioned off room was likely quieter, better lit, air conditioned, and cleaner than the shop floor where noise was not absorbed by carpet but bounced off walls and ceilings, dust spread further and where temperatures were more difficult to regulate. However, the factory environment did not show assembly lines where machines hung from hooks overhead. The size of the minicomputer cabinets in the photographs instead suggests that people moved around and machines remained in a fixed spot until they were fully assembled.

4.3.4 Marketing, Sales and Service

When DEC just started, the main challenge was finding customers who knew how to use, program and maintain computers. Thus sales, service, and training were interrelated. Physicists were early adopters of lab modules and training equipment. Sales engineers developed custom solutions for customers and focused on products rather than sales techniques. A key element of DEC's sales technique was Barbera Stephenson's handbook to educate consumers and soon led to other paperback handbooks to reach the engineering market. Scientists and engineers required less service support and were considered "self-sufficient, challenging, and influential customers."¹³⁷

Since designers visited customers to assess their needs, customers remained loyal to DEC in the long term. Customers chose the level of field service and paid accordingly for field service engineers experienced in installation, training, and repair. DEC valued support and feedback from customers, learning about future needs and discovering common user requirements for new products. The DECUS became an important marketing and communication tool for the company as Bill Lennon from the Lawrence Livermore Laboratory and an early customer stated.¹³⁸ By 1964 around twenty sales persons were responsible for selling a number of products but with the success of the PDP-8 minicomputer, sales became a service to each product line and field service was considered both a product line and a service.¹³⁹ Sales offices were set up across countries and all sales and marketing was informed of developments in products, markets, and product line policies via biweekly newsletters.¹⁴⁰ Much like IBM's extension beyond the borders of the United States, DEC had offices beyond the 36 sales and service locations in the United States, and 5 locations in Canada. DEC had an office in Japan and four offices in Australia.

137. Parker Pearson, *Digital at Work*, 141-144.

138. Bill Lennon became DECUS president between 1977 and 1979. Parker Pearson, *Digital at Work*, 196.

139. Parker Pearson, *Digital at Work*, 145-146, 148.

140. Parker Pearson, *Digital at Work*, 150.

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Europe's headquarters were located in Switzerland with sales and service points in Germany (2), England(3), and one office per country for France, Benelux, Sweden and Italy.¹⁴¹ Unlike IBM's sales force who were motivated by commissions, DEC's salespeople mostly received a fair wage and career opportunities. By avoiding commission, DEC ensured that salespeople had customer's best interests at heart without personal motives. "In both Sales and Service, customer satisfaction surveys were a key metric in determining performance and compensation."¹⁴²

In July 1973 DEC overhauled its corporate marketing policy and instead of focusing on product groups, marketing was now aimed at different customer markets. Furthermore, software was no longer included in the price for hardware, instead DEC followed the industry trend of software licensing. Licensing meant a better return on investment.¹⁴³ IBM had been the first computer manufacturer to unbundle software and hardware in response to an anti-trust lawsuit, and many other manufacturers had soon followed suit.¹⁴⁴ Barry W. Boehm had predicted how the cost of software compared to hardware would escalate in 1973 and by 1976 had added the cost of software maintenance as shown in figure 4.12.¹⁴⁵

A *PDP-11 Software Price List* from 1972 included prices for system software programs, diagnostic programs and software packages before DEC started licencing software. While software packages cost between \$100 and \$440, customers received a disk operating system (DOS) (at a price of \$3,000) and mathematical formula translating system (FORTRAN) packages (at a price of \$2,000) for free when they purchased the required hardware. Other system software could cost as much as \$5,000 (e.g. the Resource Time Sharing System (RSTS)) which translates to a quarter of the price of a basic PDP-11 installation at around \$20,000. Diagnostic programs were much cheaper with prices between \$5 and \$50

141. *PDP-11 Handbook*.

142. Parker Pearson, *Digital at Work*, 150-151.

143. *Digital Equipment Corporation: Nineteen Fifty-Seven to the Present*, 36.

144. Yost, *Making IT work*, 144.

145. Barry W. Boehm, "Software Engineering," *IEEE Transactions on Computers* C-25, no. 12 (1976): 1227, <https://doi.org/10.1109/TC.1976.1674590>.

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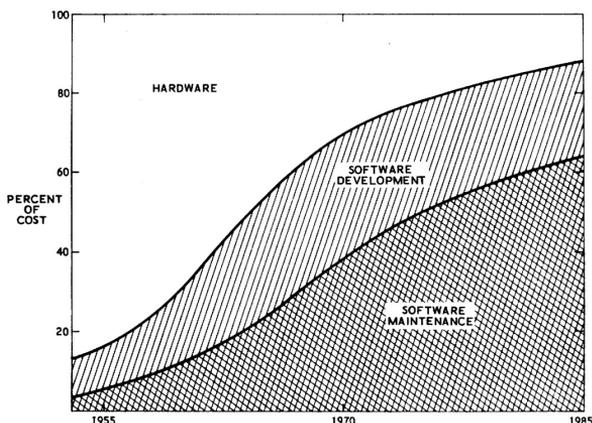


Figure 4.12: Hardware-software cost trends. Figure 1 from B.W. Boehm, 'Software Engineering,' 1228.

a piece, or \$154 for a DECTape diagnostic package. The price of documentation such as manuals was negligible at around \$2 for single handbooks.¹⁴⁶ The *PDP-11 System Software Components Catalogue* from the United Kingdom dated 1977 covered 151 pages as compared to only 61 pages for 1972, and had incorporated an alphabetic coding system for prices which were added in a separate letter to make price changes easier to communicate. However, by then many packages were licensed software products which required customers to first purchase the necessary system software and sign a license agreement before being able to order individual software.¹⁴⁷

With the success of the PDP-11 sales restructured itself based on market or industry rather than product.¹⁴⁸ In line with the changed marketing strategy, customers were encouraged to purchase complete systems

146. *PDP-11 Software Price List* (Maynard, MA: Digital Equipment Corporation, 1972), box 1441, 102751, Living Computers Museum+Labs, Seattle.

147. *PDP-11 System Software Components Catalogue* (Maynard, MA: Digital Equipment Corporation, 1977), Centre for Computing History, Cambridge.

148. Parker Pearson, *Digital at Work*, 152.

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rather than a selection of components. These standard systems were complete, ready-to-run and considered advantageous because optimal configuration, of a faster delivery and a general better value for money. For instance, by March 1974 a second standard system built around the PDP-11/40 for labs was shipped for \$37,500 or 20% cheaper than similar configurations before.¹⁴⁹ From a one-person sales force, Ted Johnson eventually led a sales force of around ten thousand men and women.¹⁵⁰



Figure 4.13: Photograph, "Candid of PDP-11 marketing personnel," 1972, Archival proofs.

Images from the marketing department at DEC portray personnel during a meeting or at their desk. The team of nine counted only one woman, but she looked slightly older than the twenty-somethings from other teams. She leaned back, smiling, with her arms and legs crossed while other colleagues leaned forward with their hands on the table as seen in figure 4.13.¹⁵¹ Her posture reflects defensiveness whereas leaning forward in-

149. *Digital Equipment Corporation: Nineteen Fifty-Seven to the Present*, 41-43.

150. Ted Johnson was Vice-President of Sales between 1958 and 1983. Parker Pearson, *Digital at Work*, 139, 155.

151. Photograph, "Candid of PDP-11 marketing personnel," 1972, Archival proofs, Box

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dicates a more dominant stance. Most people at the meeting had papers and a cup of coffee in front of them and one image shows an ashtray on the table. Two images show men seated at their desk while talking on the phone and in one image another person was photographed from behind holding a piece of paper and standing in front of a desk talking to a colleague.¹⁵² Several men wore wedding bands, which I have not seen on the hand of some of the few female employees.

The contrast with development and manufacturing is clear from the clean office environment of the marketing department compared to the messy open space cluttered with machine components in between desks. Furthermore, the gender balance on the marketing team could be a scene from the television show *Mad Men*. The television drama which ran from 2007 to 2015 is set in a fictional advertising agency in New York in the 1960s and depicts “the golden age for advertising before the turmoil of Vietnam, civil rights, student protests, and feminism.” Both the advertisements and the inner workings of the agency have been analysed for its depiction of gender, race, ethnicity, sexuality, and class. What jumps out from the series aside from obvious and less explicit barriers to women in advertising, is the domination of “the white, heterosexual, male, Anglo-Saxon Protestant,” with his claim to authority and status.¹⁵³

Since engineers interacted often with customers, they were attuned to user’s needs before developing a product line. However, by 1974 DEC restructured to create a Central Engineering department to focus on hardware compatible across product lines. Product lines in turn then focused on customer applications. In the design and development stage, engineers worked in small teams and announced the design before the prototype was built. The bottom up culture promoted free exchange of ideas in an informal setting, but the introduction of central engineering did add

732, Folder 33, Catalog 102772487.

152. Photograph, “Candids of PDP-11 marketing personnel,” 1972, Archival proofs, Box 732, Folder 33, Catalog 102772487.

153. William M. O’Barr, “Mad Men: Gender, Race, Ethnicity, Sexuality, and Class,” *Advertising & Society Review* 11, no. 4 (2011), <https://doi.org/10.1353/asr.2011.0004>.

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a level of management to prevent duplicating efforts. The development teams worked in the factory hall where desks were scattered between equipment in a noisy open space. In some scenes engineers were drawing with pen and paper or moved to a classroom setting, perhaps to pitch ideas or discuss the design. In a final stage they worked hands-on to build prototypes. Engineers were certainly not all male, but the proportion of female engineers amounted to maximum one quarter of the workforce and very few people of colour were visible in the group photographs. Manufacturing changed from a single person responsible for developing a machine from scratch to assembly lines. Furthermore, whereas male engineers and technicians were predominant in manufacturing at the start, women were soon employed for manufacturing small components. New plants were built in blue collar communities both inside and outside of the United States. However, the images of DEC personnel only showed men in manufacturing. Marketing also changed in July 1973 when shifting from promoting products to appealing to customer markets and selling complete systems. As discussed, marketing in the 1970s was still dominated by white men.

In the next section, the PDP-11 interface, software, and peripherals are discussed in more detail to better understand the experience of users. Furthermore, descriptions of computer occupations from the *Occupational Outlook Handbook* in 1976 link certain parts of the system to users, their educational background, and remuneration, combined with the composition of the workforce.¹⁵⁴

4.4 What the Programmable Data Processor looked like

In 1969 the PDP-11 came in two models, both with the same processor. However, the 11/10 combined 1,024 words read-only memory with 256 words of read-write memory, whereas the 11/20 had 4,096 words

154. *Occupational Outlook Handbook*.

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of read-write memory, all 16-bit. The PDP-11/20 also included a programmer's console, and an ASR-11 Teletype which served as a user interface. Further expanding on the notion of a system with compatible I/O devices the PDP-11's modular building blocks allowed customers to configure and expand their computer installations. Systems were composed of basic building blocks, called System Units, which were completely independent subsystems connected only by pluggable Unibus and power connections.¹⁵⁵ Much like IBM's S/360, the PDP-11 sought to keep customers tied to the company not just for servicing and training, but most of all to continue selling equipment to further expand existing computer installations.

The fairly common yet currently highly questionable computer terminology of *master-slave relation* explained how a single device - called the master - controlled the Unibus at any given time.¹⁵⁶ The other device connected to the Unibus in turn was called a slave. Another key concept that returned frequently in relation to computing during the 1960s and 1970s is the notion of *control*. As Unibus connections were bidirectional, data could be transferred from master to slave (out) or from slave to master (in).¹⁵⁷

Ron Eglash's essay examined the *Broken Metaphor* of the master-slave analogy tracing the earliest usage of the terminology in computing back to the Dartmouth Timesharing system of 1964 where the metaphor was "inspired by an innovative control relationship between two autonomous devices." Although the terminology resonates with enslaved Africans of the nineteenth century which caused controversy at the beginning of the millennium, the terms appeared much later in patents and Eglash argues convincingly that patent holders were not inspired by this particular type of slavery. However, the terminology is often inaccurate because there is no control relationship but rather an order (first-second) between what is incorrectly called the master and the slave. An interesting suggestion

155. *PDP-11 Handbook*, 1-2.

156. *PDP-11 Handbook*, 59.

157. *PDP-11 Handbook*, 62.

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Eglash makes with regards to the introduction of master-slave terminology for computing in the 1960s are changes in management that “allowed a greater split between skilled and unskilled labor.” Regardless of accuracy, the metaphor to this day risks alienating minorities in computing, and remains problematic especially when it is inaccurate.¹⁵⁸

A PDP-11/20 provided space for user-designated options. Options included a combination of 8,192 words of additional core memory, a Teletype control, and a High-Speed Paper Tape Control, or 4,096 words of core memory and six Teletype interfaces.¹⁵⁹ DEC thus envisioned installations for customers where only one person interacted with the computer yet in need of more memory, or customers who preferred six people able to interact while sacrificing core memory space.

In reality a combination of PDP-11 processors and other peripherals looks like a tall chest of drawers where each drawer contains *building blocks* that are connected in the back.¹⁶⁰ The PDP-11 came in either a tabletop or rack-mounted configuration in a DEC or customer cabinet (figure 4.14).¹⁶¹ Both configurations had a 8¾" or 22 cm high front panel but the table top version was slightly deeper and wider in comparison to the rack-mounted PDP-11 at 25½" x 22" (65 cm x 51 cm) compared to 23" x 19" (58 cm x 48 cm) for the rack drawer.¹⁶²

Both the tabletop and the rack-mounted PDP-11 could be extended with an additional mounting box.¹⁶³ Mounting boxes were built from zinc-plated steel to resist corrosion and used fans to cool the machines. The insulated top cover kept dust at bay and the foam-lined bottom cover minimized vibrations and insured further cooling.¹⁶⁴ DEC also offered a cabi-

158. Ron Eglash, “Broken Metaphor: The Master-Slave Analogy in Technical Literature,” *Technology and Culture* 48, no. 2 (2007): 360–369, <http://www.jstor.org/stable/40061475>.

159. *PDP-11 Handbook*, 77.

160. *PDP-11 Handbook*, 2.

161. *PDP-11/20/15/R20 Handbook* (Maynard, MA: Digital Equipment Corporation, 1971), 127, 129, box 1766, 102180, Living Computers Museum+Labs, Seattle.

162. *PDP-11 Handbook*, 78-79.

163. *PDP-11 Handbook*, 80.

164. *PDP-11 Peripherals Handbook*, 4-19.

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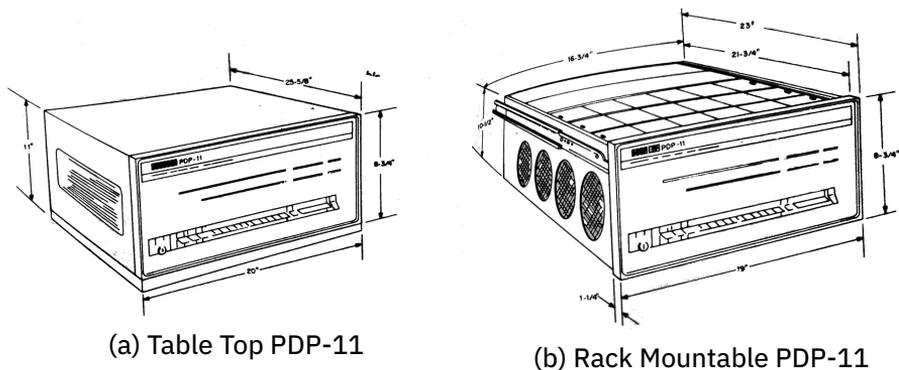


Figure 4.14: PDP-11 Dimensions, *PDP-11/20/15/R/20 Handbook*, 1971, 127, 129.

net that could fit up to six PDP drawers.¹⁶⁵ The standard PDP-11 cabinet measured 72" x 21" x 30" (182 cm x 53 cm x 51 cm). All equipment inside the cabinet was connected to cabinet outlets and a power switch meaning all equipment could be turned on or off simultaneously. Power supplies and sliding drawer(s) were not included, and the weight of the equipment varied between 120 lb. (54 kg) and 470 lb. (213 kg).¹⁶⁶

Whereas IBM's S/360 processors were often located either below or next to the desk with a keyboard or other user interface built in, the programmer's desk for the PDP-11 was an optional feature. This programmer's table fit into the furniture vocabulary and could be attached to the cabinet directly below the programmer's console. Much like some of the IBM S/360 installations, this resulted in a desk attached to the minicomputer. The Teletype needed to be placed within 8 feet (2.43 meter) from the computer due to its cable length and was about 22½" (57 cm) wide and 18½" (47 cm) deep.¹⁶⁷

The *Occupational Outlook Handbook* distinguished between three cat-

165. *PDP-11 Handbook*, 80.

166. *PDP-11 Peripherals Handbook*, 4-186.

167. *PDP-11 Handbook*, 81.

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egories of occupations related to computers: operators, programmers, and system analysts. While all relied on technical knowledge and skills, as well as the ability to concentrate on detailed work, operators needed manual dexterity and mechanical aptitude, whereas programmers and analysts were expected to solve problems by thinking logically. The handbook thus already opposed manual and intellectual labor, which is relevant when compared to the gender composition of each occupation. Unlike the descriptions of occupations in air transportation, the handbook explicitly states the gender composition for each computer occupation and the accompanying educational requirements and remuneration.¹⁶⁸

As with the IBM S/360, the PDP-11 only functioned properly under specific environmental requirements. The PDP-11 could cope with temperatures between 10°C and 50°C and a relative humidity of from 20% to 95% (without condensation).¹⁶⁹ Despite the fact that the PDP-11 functioned in fairly high temperatures on paper, several complaints arrived from Japan stating that the machine did not cope with temperatures there.¹⁷⁰ DEC personnel installed the machines for customers and offered “instruction courses on computer operation, programming, and maintenance” for customer’s personnel. Courses took place in Maynard, Massachusetts, Palo Alto, California, and Reading, England.¹⁷¹

4.4.1 The User Interface

For customers using the Paper Tape Software system source programs could be typed on the teleprinter and edited by reading, printing, and punching out parts of the program on paper tape, as well as searching, deleting, or adding text to the program. Furthermore, a user could de-

168. *Occupational Outlook Handbook*, 104.

169. *PDP-11 Handbook*, 82.

170. Steve Teicher, memorandum, “Problems with 11/05s in Japan,” 6th February 1974, Executive’s papers, Ken Olson papers, Product design and production, 1967-1979, Digital Equipment Corporation records, Lot X2675.2004, Box 14, Folder 27, Catalog 102737447, Computer History Museum, Mountain View.

171. *PDP-11 Handbook*, 83.

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bug “his binary programs at the console by running them in specific segments and checking for expected results at various points.”¹⁷² Although the reference manual rarely uses gender-specific pronouns, the programmers default to male in this particular case.¹⁷³ In 1974 the Bureau of Labor Statistics counted about 200,000 programmers, with around 75% of them male.¹⁷⁴

Operators could also interact with the system using the front panel console through switches and keys to manually insert or modify both programs and information shown through indicator lights.¹⁷⁵ The *Occupational Outlook Handbook* distinguishes between operators based on their interaction with either the minicomputer itself, or peripherals. The people inserting programs and setting up the console to run them were called console operators.¹⁷⁶

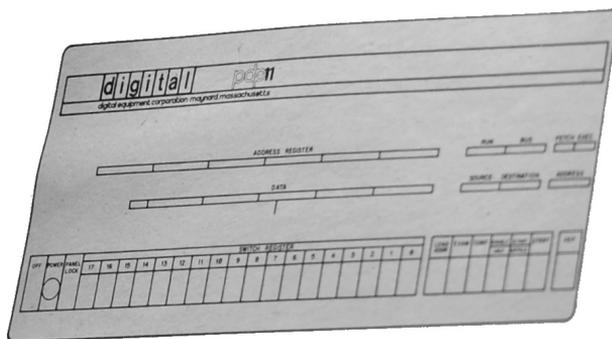


Figure 4.15: PDP-11 Console, *PDP-11 Handbook*, 1969, 87.

Lights indicated specific machine functions, operations, or states such as fetching or executing an instruction. Furthermore, indicators display whether the processor is running, obtaining source or destination data

172. *PDP-11 Handbook*, 85.

173. *PDP-11 Handbook*, 87.

174. .

175. *PDP-11 Handbook*, 87.

176. *Occupational Outlook Handbook*, 104-106.

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and the matching address of the central processor. Register displays show an 18-bit address or the location, and 16-bit of data. Switches of the switch register can reference byte addresses with up equalling 1 and down referencing 0. Operators could thus form an address using eighteen switches to load it into memory using the correct control switch.¹⁷⁷

Aside from transferring the contents of the 18-bit switch register or depositing the low 16 bits into the bus address register, the PDP-11 could display the content of the bus address. Other controls could enable, halt, continue or start programs. An operator could correct data in the data register and programmers could start a program by setting the correct address in the switch register.¹⁷⁸

Console operators examined programmer's instructions, loaded cards or tape with data and programs, started the computer and watched while it was running to detect any errors. Console operators could advance to supervisory positions or become programmers and the introduction of terminals meant more job openings for console operators. They earned slightly more than average with salaries of between \$140 and \$160 for beginners and up to \$250 per week for lead console operators. They worked in air conditioned computer rooms in a noisy environment and were expected to work evening and night shifts because many computer installations ran for 24 hours per day.¹⁷⁹

4.4.2 Software

The DECUS fulfilled an important need starting in 1961 with a program library of programs written by users, openly exchanging information between the users and the manufacturer.¹⁸⁰ Besides the Paper Tape Software system other operating system software supported "small stand-alone configurations, disk based real-time and program development systems, and large scale multiprogramming and time-sharing system." In

177. *PDP-11 Handbook*, 87-88.

178. *PDP-11 Handbook*, 88-90.

179. *Occupational Outlook Handbook*, 104-106.

180. Parker Pearson, *Digital at Work*, 20.

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parallel to the different hardware configurations aimed at different types of users, the software possibilities thus further differentiated between PDP-11s. Some installations were meant for specific single use, other minicomputers were used to develop programs and aimed at customers who employed programmers, or systems meant for real-time interaction by several users. Programmers at computer manufacturing firms such as DEC were called systems programmers and they generally earned more than other types of programmers. When customers employed programmers to develop dedicated software for their PDP-11 installation, a program analyst might first examine the problem at hand, whereas the applications programmer then writes detailed instructions in a programming language before debugging the program and writing an instruction sheet for the console operator. Programmers generally earned twice the average salary compared to non-supervisory workers in the private sector beginning at salaries of between \$170 and \$240 a week, or up to \$360 a week for lead programmers.¹⁸¹

For instance, the Cassette Programming System could be used on a monitor.¹⁸² Together with the Real Time Single User System which came in both DECTape or DECpack disks, the Cassette Programming System also supported the BASIC program language. The next two disk-based software systems on the other hand supported FORTRAN IV. The Disk Based Batch Operating System featured interactive or BATCH mode of operation, file handling and protection, and a powerful and flexible command language. In addition to the contents of previous software systems, the DOS contained a librarian and file utility program. The advanced Real Time Operating System could execute multiple real-time tasks using a task builder. Finally, the RSTS/E implemented “BASIC-PLUS” and allowed up to thirty-two users to simultaneously use interactive terminals offering complete file security.¹⁸³

“The Interactive Application System (IAS) provides users multi func-

181. *Occupational Outlook Handbook*, 106-108.

182. *PDP-11 Peripherals Handbook*, 1-3, 1-4.

183. *PDP-11 Peripherals Handbook*, 1-4.

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tion (time-sharing/batch/real-time) and multi-language (FORTRAN/BASIC/COBOL/MACRO) capabilities. The system emphasizes protection and ease of use for the non-technical user.”¹⁸⁴ Moreover, several software packages were developed for different PDP-11 applications such as communications, laboratories and industrial applications.¹⁸⁵ Other packages aimed at education or publishing.¹⁸⁶ Programmers were usually employed by large firms that could afford extensive computer systems.¹⁸⁷

System analysts on the other hand specialized in either business, scientific, or engineering applications and discuss data processing problems with managers and specialists to determine the data that needs to be recorded, which equipment can be used for processing, and develop procedures for extracting information. In 1974 the Bureau of Labor Statistics counted around 115,000 system analysts, but only “10 percent of them women.” System analysts and programmers in the North and West of the United States were better paid than in the South. Overall, system analysts earned more than computer operators and programmers beginning at \$230 a week, up to \$360 per week for lead system analysts.¹⁸⁸

4.4.3 Peripherals

The PDP-11 system offered several peripherals which were grouped into input and output equipment based on the medium used. Operating personnel often specialised in certain peripherals. Keypunch operators only produced paper cards or tape, whereas the occupation of data typists emerged because of the introduction of mediums such as magnetic tapes and disks for computers. Some operators were responsible for converting information from one medium to another. Card-to-tape converters for instance would wire plugboards to connect circuits, load the machines

184. *Digital Equipment Corporation: Nineteen Fifty-Seven to the Present*, 52.

185. *Digital Equipment Corporation: Nineteen Fifty-Seven to the Present*, 24.

186. *Digital Equipment Corporation: Nineteen Fifty-Seven to the Present*, 25-26.

187. *Occupational Outlook Handbook*, 107.

188. *Occupational Outlook Handbook*, 104, 109.

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with cards and tapes, and notice and resolve any malfunctions.¹⁸⁹ The Teletype and High Speed Reader-Punch used paper tape both for input and output. Punch cards only served as an input medium for the card reader, whereas three models of printers provided output. Three devices used magnetic tape for both input and output. Finally, two CRT terminals were classified as output.¹⁹⁰

Strangely, the peripherals handbook treated different types of memory as a category of peripherals although it was an “electrically integral part of the computer system.”¹⁹¹ Semiconductor memory was only available for the PDP-11/45 but other core and read-only memory (ROM) was available for all PDP-11 computers. Next, the handbook listed characteristics and applications for each category of peripherals. DEC considered terminals the most convenient human interface to the computer using a typewriter-like keyboard for data entry and showing output either via a printer or display. Terminals could be attached to the machine but also functioned remotely.¹⁹²

Both paper tape and cards received praise for being readable by a person. Although few people nowadays would be able to read punch cards or tape unless characters were printed as well as punched, paper tape could hold individual programs of variable length on separate tapes. Cards were considered the ideal medium for individual records and could easily be added, deleted, or rearranged. Hard copies from printers were useful for keeping a permanent record or making copies, but some could also produce plots.¹⁹³ Magnetic tape was ideal for unlimited off-line storage and could be removed easily. Disks on the other hand provided fast access to online storage allowing programmers to swap programs. Depending on the type of head disk storage either offered fast access (fixed head) or a cheaper and higher storage capacity (moving head). As with tape, disk packs could be removed for unlimited off-line storage. Displays

189. *Occupational Outlook Handbook*, 104.

190. *PDP-11 Peripherals Handbook*, 3-1.

191. *PDP-11 Peripherals Handbook*, 3-1.

192. *PDP-11 Peripherals Handbook*, 3-2, 3-3.

193. *PDP-11 Peripherals Handbook*, 3-3.

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only began to gain serious popularity with the introduction of micro- and personal computers, however DEC also listed several advantages for this type of peripheral. Displays were a “pleasing human interface” that could represent both alphanumeric and graphic information quickly.¹⁹⁴

Punched Cards and Paper Tape

In 1974 the Bureau of Labor Statistics counted around 500,000 computer operators. However, “women held more than 90 percent of the keypunching jobs and nearly 45 percent of the console and auxiliary equipment jobs.” Keypunchers needed a high school degree and employers often preferred applicants with a college degree, who had trained as typists. Keypunchers and data typists had to pass aptitude tests to check their speed and accuracy. This repetitive task was often performed under close supervision and the opportunities for advancement were limited, their wage was also slightly less than average at between \$105 and \$120 per week. Furthermore, the introduction of terminals and other storage media meant keypunch occupations would disappear within a decade.¹⁹⁵ The keyboard with its rattling noise and the reader sounding like inflating and deflating lungs meant keypunch operators worked in a noisy environment. Furthermore, the repetitive task in a fixed seated position was strenuous.

The peripherals handbook briefly described four machines using punched cards or paper tape. The High Speed Punched Card Reader processed up to 1,200 cards per minute using the Electronic Industries Alliance (EIA) standard 80-column card. Cards moved through the reader by a combination of vacuum pickers and raffle air. During reading, each column was loaded into memory as either a word or a byte.¹⁹⁶ Two other card readers functioned similarly to the previous machine but at different speeds. The Card Reader read 300 cards per minute and the Mark Sense Card Reader

194. *PDP-11 Peripherals Handbook*, 3-4.

195. *Occupational Outlook Handbook*, 104-105.

196. *PDP-11 Peripherals Handbook*, 4-24.

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handled 285 cards per minute.¹⁹⁷ The readers measured 11" x 19" x 14" (28 cm x 48 cm x 36 cm), and weighed 60 lb. or 27 kg.¹⁹⁸

The High Speed Paper Tape Reader/Punch in figure 4.16 could read eight-hole uncoiled perforated paper tape at 300 characters per second, and punched tape at fifty characters per second.¹⁹⁹ Paper tape could be inserted into the machine by lifting the cover, inserting tape into the right-hand bin with the beginning of the tape toward the rear of the bin. After running the blank tape through the reader several times, the tape needed to be placed over the reader head with feed holes placed over the teeth of the sprocket wheel. After closing the cover again, the reader feed would place the leader tape over the reader head.²⁰⁰

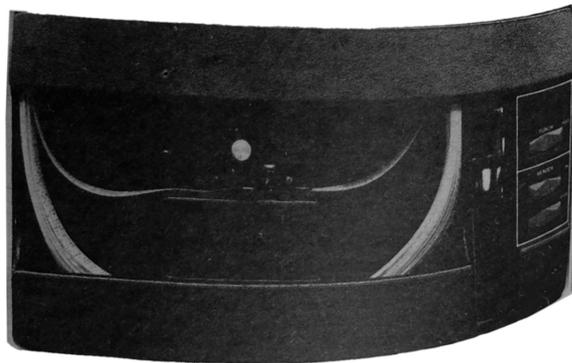


Figure 4.16: High Speed Paper Tape Reader/Punch, *PDP-11 Peripherals Handbook*, 1973, 4-252.

Terminals

In most cases the PDP-11 was connected to one or several Teletype Terminals which symbolizes the continuing link with the punch era as shown

197. *PDP-11 Peripherals Handbook*, 4-37.

198. *PDP-11 Peripherals Handbook*, 4-44.

199. *PDP-11 Peripherals Handbook*, 4-252.

200. *PDP-11 Peripherals Handbook*, 4-253.

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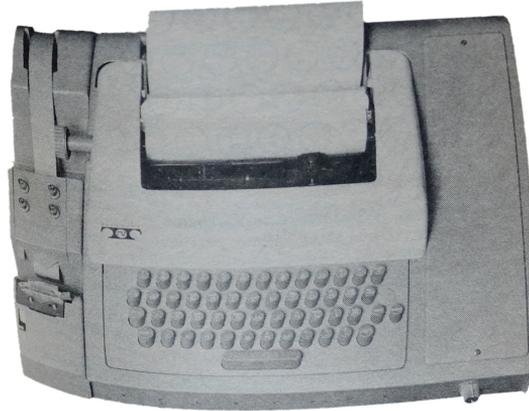


Figure 4.17: ASR-33 Teletype Console, *PDP-11 Peripherals Handbook*, 1973, 4-233.

in figure 4.17. This multi functional I/O device consisted of a printer, keyboard, paper tape reader, and paper tape punch. Information was printed, punched or read at a speed of ten characters per second.²⁰¹ The Teletype keyboard is similar to a typewriter keyboard with a few additional control keys. To insert paper tape into the reader, the control needed to be set to free after lifting the cover and the tape was positioned over the read pens similar to the previously mentioned paper tape reader. After closing the cover the tape was read by pressing START.²⁰²

Another terminal that connected to the PDP-11 was the fast, reliable, and low cost DECwriter. Printing at thirty characters per second data was entered on a keyboard and produced an original and a copy on a standard continuous form. Explicitly tailoring the terminal to an office environment, the handbook emphasised that the terminal generated less noise than an electric typewriter. Furthermore, the low price made the terminal particularly appropriate for systems requiring large numbers of

201. *PDP-11 Peripherals Handbook*, 4-233.

202. *PDP-11 Peripherals Handbook*, 4-234, 4-235.

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highly reliable printer/terminals.²⁰³

Printers

The peripherals handbook from 1973 listed three types of printers which came in different models and were operated by high-speed printer operators.²⁰⁴ The first on the list is a High-Speed Line Printer in figure 4.18 Up to six copies could be printed simultaneously and fan-fold paper varied between 4" and 19" (10 cm - 48 cm) width.²⁰⁵ When the printer was offline - and thus disconnected from the PDP-11 - the operator could roll up the form to the top of the next page or move the paper by a single line. On-line evidently does not refer to an internet connection but rather to the connection between the printer and the computer.²⁰⁶ Printing speed varied between 170 and 1200 lines per minute.²⁰⁷ Sizes ranged between 46" x 24" x 22" (117 cm x 61 cm x 56 cm) and 48" x 49" x 36" (122 cm x 125 cm x 91 cm) and weighed between 200 lb. and 800 lb. respectively (91 kg - 363 kg).²⁰⁸

The second type of printer, the Electrostatic Printer/Plotter, printed at 500 lines per minute or 122,880 dots per second for plots. Aside from fan-fold paper, this printer also accepted roll paper for continuous plots and printouts. Rather than moving to the next form or line, a control switch allowed the operator to press paper advance as long as needed to move the paper further.²⁰⁹ If there was no more paper left, a low paper light turned on. The contrast could also be adjusted by turning the button as far clockwise as necessary for a high contrast.²¹⁰ The printer/plotter was smaller than the line printer at 38" x 19" x 18" (97 cm x 48 cm x 46

203. *PDP-11 Peripherals Handbook*, 4-201.

204. *Occupational Outlook Handbook*, 104.

205. *PDP-11 Peripherals Handbook*, 4-208, 4-209.

206. *PDP-11 Peripherals Handbook*, 4-210.

207. *PDP-11 Peripherals Handbook*, 4-213.

208. *PDP-11 Peripherals Handbook*, 4-214.

209. *PDP-11 Peripherals Handbook*, 4-241.

210. *PDP-11 Peripherals Handbook*, 4-242.

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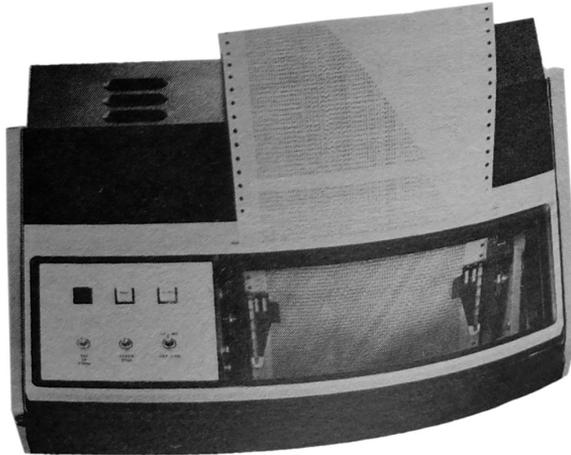


Figure 4.18: High-Speed Line Printer, *PDP-11 Peripherals Handbook*, 1973, 4-241.

cm) and lighter at 160 lb. (73 kg).²¹¹

Finally, two Line Printer models were “designed to print clear reports, statements, and listings as required by most users.” This inexpensive, medium-speed printer produced 165 characters per second or up to 60 lines per minute.²¹² Forms could only be 14 $\frac{7}{8}$ ” wide (38 cm) or smaller. The operator could complete the form being printed before changing paper. As for the second Printer/Plotter, the Line Printer also indicated paper-handling malfunctions using the paper out indicator light.²¹³ The Line Printer measured 12” x 28” x 20” (31 cm x 71 cm x 51 cm) and weighed 155 lb. (70 kg).²¹⁴

211. *PDP-11 Peripherals Handbook*, 4-244.

212. *PDP-11 Peripherals Handbook*, 4-227.

213. *PDP-11 Peripherals Handbook*, 4-228.

214. *PDP-11 Peripherals Handbook*, 4-232.

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Memory

Although memory does not easily fit into the peripherals category since memory can also be built into the computer, memory was a part of the larger I/O group of devices. Aside from memory, information could also be stored on tape or disks. The peripherals handbook mentions three memory types: core memory, read-only memory (ROM) and semi-conductor memory.

Core memory “is a read-write, random access, coincident current memory,” and was available in basic increments of 8,192 words (8K). The magnetic core memory could be mounted within a CPU or a separate unit.²¹⁵

ROM was much more limited than core memory and came in increments of 32 words with a total of 256 words of ROM as the maximum. ROMs could be programmed by the user, or were pre-programmed for peripheral devices. Diodes in a 32 x 16 diode matrix could be selectively cut out to form the desired data pattern where the presence of a diode represents 1 and absence represents 0. ROM was used for “non-erasable recovery routines, or lowered program execution times for often-used loops or subroutines.” ROMs were available for paper tape readers, a card reader, disk or DECTape and cassette peripherals, as well as mass storage.²¹⁶

Finally the semiconductor memory was only available for the PDP-11/45. Bipolar and metal-oxide semiconductor (MOS) memories allowed “faster computer processing, and [were] especially useful in storing often used data and instructions.” Bipolar memory was faster, but MOS memory was smaller.²¹⁷

Tape storage

The PDP-11 processors could attach to three types of tape storage: magnetic tape, tape cassettes, and DECTape. Given the large amounts of

215. *PDP-11 Peripherals Handbook*, 4-245.

216. *PDP-11 Peripherals Handbook*, 4-22.

217. *PDP-11 Peripherals Handbook*, 4-249.

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magnetic tape that were stored away when not in use, the *Occupational Outlook Handbook* mentions a specialised function of tape librarian who classified and catalogued the program development records and computer operating instructions.²¹⁸ Magnetic tape was praised by the peripherals manual as a high-performance, low cost system capable of writing, reading, and storing large volumes of data and programs. Unlike IBM, DEC proudly mentioned that the tape used an industry-compatible format, meaning tape could also be used with other computers. Depending on the number of tracks, a single tape reel could hold between 180 million (9-track) and 140 million (7-track) bits. Tape could move forward or reverse, but it could only be read or written while moving forward.²¹⁹ After inserting tape into the system, the load switch drew tape into the buffer columns using a vacuum motor. As with any cassette player, the tape could be forwarded, rewound or reversed.²²⁰

The Tape Cassette System, unlike the magnetic tape used proprietary Digital Equipment Corporation Philips-Type cassettes designed to replace paper tape. One tape cassette held a minimum of 92,000 bytes.²²¹ The final tape system used DECTape in a Dual-Unit, Bidirectional Magnetic-Tape Transport System for Auxiliary Data Storage. The read-write head recorded and read information on five channels of tape. However, unlike the previous tape, the system stored information at fixed positions on magnetic tape similar to magnetic disk or drum storage. The 10-track read/write head scanned a timing track, a mark track, and three data tracks either side with the second five tracks recording redundant characters to increase reliability. The mark track recorded the data format.²²² For programmers to locate programs in the fixed address system they could search for a specific address, meaning they needed to remember where a program was stored.²²³ If an operator or programmer needed to

218. *Occupational Outlook Handbook*, 104.

219. *PDP-11 Peripherals Handbook*, 4-322.

220. *PDP-11 Peripherals Handbook*, 4-324, 4-325.

221. *PDP-11 Peripherals Handbook*, 4-304, 4-305.

222. *PDP-11 Peripherals Handbook*, 4-309.

223. *PDP-11 Peripherals Handbook*, 4-310, 4-311.

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search for an address, they could select the desired address on a zero to seven thumb-wheel switch.²²⁴ A single tape reel could hold 147,968 words (144K).²²⁵

Disk storage

The final storage medium available for the PDP-11 were disks. DEC offered four options: a DECDisk, a fixed head disk, the DECPack Disk Cartridge and a Disk Pack system. A DECDisk stored 65,536 16-bit words for a low-cost, random access, bulk storage system.²²⁶

The Fixed Head Disk system stored up to 262,144 17-bit words (16 data bits and 1 parity bit) and whereas the DECDisk control could run up to four disks, the Fixed Head Disk Control handled up to eight disks. A total of 128 fixed read/write heads could address each single word meaning that unlike most disks, there were no limits of fixed blocks or sectors for reading or writing.²²⁷

Storing even more data, the DECPack Disk Cartridge could hold over 1.2 million words and the system expanded up to 9.6 million words per Control (8 disks).²²⁸ This large volume, random-access data storage was particularly useful if a large volume of programs and data were developed and maintained for one or more users. The protective case surrounding the disks opened automatically inside the disk drive thus protecting the disks from dust when taken out.²²⁹

Displays

Aside from terminals, DEC already provided some displays for the PDP-11. The point plot display, storage display, alphanumeric terminal and graphic display system slowly introduced computer users to the interface

224. *PDP-11 Peripherals Handbook*, 4-312, 4-313.

225. *PDP-11 Peripherals Handbook*, 4-320.

226. *PDP-11 Peripherals Handbook*, 4-260, 4-261.

227. *PDP-11 Peripherals Handbook*, 4-272.

228. *PDP-11 Peripherals Handbook*, 4-282.

229. *PDP-11 Peripherals Handbook*, 4-283, 4-284.

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that became ubiquitous in later decades: the screen. The Point Plot Display used a 6¾" x 9" (17 cm x 23 cm) CRT display in a compact 19" (48 cm) package. The display used X and Y coordinates to generate point plots.²³⁰ The Storage Display suggested by DEC was the Tektronix Model 611 Direct View Storage Tube with a resolution expressed in line pairs (400 vertical and 300 horizontal).²³¹



Figure 4.19: VT-05 Display, *PDP-11 Peripherals Handbook*, 1973, 4-348.

The Alphanumeric Display Terminal included a CRT display and self-contained keyboard (figure 4.19). This terminal measured 12" x 19" x 30" (31 cm x 48 cm x 76 cm).²³² The novelty of the display terminal was emphasised by the following comparison to a teletypewriter in the peripherals handbook. “[...] [Users could] compose, edit, and forward messages to the computer; retrieve and update alphanumeric data contained in the computer files; receive instructions and data from the processor; and perform on-line debugging.”²³³ Compared to typewriters, a display terminal was faster, quieter, more compact, easier to maintain and more reliable. To further reinforce its novelty, the handbook emphasised the design of the display stating that “the distinctive flowing lines of the VT05 blend

230. *PDP-11 Peripherals Handbook*, 4-344.

231. *PDP-11 Peripherals Handbook*, 4-346.

232. *PDP-11 Peripherals Handbook*, 4-347, 4-351.

233. *PDP-11 Peripherals Handbook*, 4-347.

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well with any decor.”²³⁴ The handbook non-ironically explains how a cursor works. “The cursor is a blinking underline showing where the next character will be displayed on the CRT. With direct cursor addressing, the cursor may be placed at any position on the screen by a computer instruction.”²³⁵ Furthermore, the display could also show a video recorded by a connected camera and data from the computer simultaneously. Perhaps inspired by the mother of all demos by Douglas Engelbert on 9 December 1968 to demonstrate the computer mouse, the possibility of displaying videos was considered useful in training, teaching, and testing applications as well as factory, warehouse and process control.²³⁶

The final display available for the PDP-11 was a Graphic Display System using a powerful general-purpose computer. It could display “either alphanumeric information or graphic information such as drawings, diagrams, or patterns.” Furthermore this display also connected to a light pen. The system was aimed especially at designers who were “free to concentrate on layout while the system handles computation.”²³⁷ As a stand-alone system, this Graphic Display System consisted of a central processor, display processor, light pen, keyboard, communications interface, memory, and bootstrap read-only memory. The computer could also connect to other PDP-11 peripherals. The CRT monitor was the same size as the *Point Plot Display*.²³⁸

Occupations related to computers were clearly segregated by gender, with over 90% female keypunchers and only 10% of women working as system analysts. Female dominated computer operating occupations offered less opportunities for advancement, a lower than average wage, and the repetitive job was highly supervised and considered as a form of manual labor. Programmers and system analysts were predominantly

234. *PDP-11 Peripherals Handbook*, 4-347.

235. *PDP-11 Peripherals Handbook*, 4-347.

236. Doug Engelbart Institute, 1968 “Mother of All Demos” with Doug Engelbart & Team (1/3), 2017, <https://www.youtube.com/watch?v=M5PgQS3ZBWA>. *PDP-11 Peripherals Handbook*, 3-348

237. *PDP-11 Peripherals Handbook*, 4-179.

238. *PDP-11 Peripherals Handbook*, 4-180, 4-181.

male, offered more independence, were better paid, and were considered intellectual labor that was further removed from the actual minicomputer interface in a more pleasant environment. The working conditions of computer operators become more explicit from DEC's requirements for installation in the next section.

4.4.4 Installation

Despite the deceiving name of minicomputer, customers needed to check the route the equipment would travel between delivery and installation:

Check the size of doors, passageways, ramps, etc. for height, width, and turning radius [...]. Take into account the size of the moving equipment and the shipping skid (wooden platform for moving) under the equipment cabinets. If an elevator is to be used, DIGITAL should be notified of any size or gross weight limitations.²³⁹

DEC customers needed to consider space, power, fire, and safety, the environment (air conditioning and/or humidifying equipment), and building requirements very similar to IBM's requirements. DIGITAL added three more site considerations: efficient work-flow and easy observation of I/O devices as well as sufficient storage space for supplies, and planning for future system expansion.²⁴⁰ To ensure data protection DEC advised customers to store duplicates in a fire-proof storage vault preferably away from the computer site.²⁴¹ Although standard PDP-11 systems were not too heavy for most offices and industrial plants, raised floors were still preferred for several reasons. By hiding cables underneath the floor, both cables and personnel were protected as they did not become tripping hazards. A raised floor would also lower the cost of future layout changes.²⁴²

239. *PDP-11 Peripherals Handbook*, 8-1.

240. *PDP-11 Peripherals Handbook*, 8-1, 8-2.

241. *PDP-11 Peripherals Handbook*, 8-2, 8-3.

242. *PDP-11 Peripherals Handbook*, 8-3.

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The handbook distinguishes between system reliability based on two applications that illustrate diverging configured users. In the first case mentioned, the airline reservation system provides a good example, while the second type of reliability is more important in the design stage of aircraft.

A computerized telephone switching center might allow a total of only two hours of complete inoperativeness in twenty years but might not consider computation errors or failure of parts of the system as serious errors. An on-line laboratory computer, on the other hand, may require complete error-free operation for several hours, but allow substantial amounts of scheduled down-time before and after the experiment.²⁴³

Paper and plastic media suffered from high humidity which caused moisture absorption and affected line printer paper, cards, paper tape, magnetic tape, etc; whereas dust could reduce the life span of tapes, cause excessive head wear and early data errors in all moving magnetic storage media such as drums and disks. Vibration impacted mechanical parts but in severe cases could result in data errors. Even radar installations or nearby broadcasting stations could result in hardware logic errors caused by high power radio frequency pulses.²⁴⁴

An interesting debate regarding the environmental impact of computing was similarly relevant in the 1970s with the oil crisis of 1973 resulting in a campaign to save energy. Perhaps as an indirect response or otherwise influenced by this crisis, DEC launched a Power Management System to reduce costs for customers with high energy consumption. The system was popular for “food processing, textiles, newspaper printing and electrical equipment manufacturing” industries.²⁴⁵

Ideally, an air distribution system provided cool, well-filtered, humidified air, with higher air pressure than surrounding areas to prevent dust

243. *PDP-11 Peripherals Handbook*, 8-3.

244. *PDP-11 Peripherals Handbook*, 8-3, 8-4.

245. *Digital Equipment Corporation: Nineteen Fifty-Seven to the Present*, 66.

infiltration. A computer room with tall ceiling was preferred to allow 30 inches or 76 cm of clearance above cabinets for air cooling. Sudden air temperature changes were detrimental to disks and drums but also for paper tape, thus air conditioning needed to remain at a stable temperature in the computer room. Obviously, DEC also warned customers to avoid spilling liquids on equipment.²⁴⁶ Certainly, any computer user nowadays tries to prevent spilling coffee over a keyboard. Imagine using even more expensive company equipment.

DEC urged customers to refrain from using carpet and metal flooring or to otherwise minimize static electricity. To reduce noise from peripherals such as line printers and magnetic tape transports the manual suggested an acoustically dampened ceiling.²⁴⁷ Furthermore, each cabinet or peripheral required an outlet.²⁴⁸ From these room requirements to increase reliability, we can imagine the space where PDP-11s were installed. Computer operators would still work in separate, air conditioned, noisy environments, much like users of the IBM S/360.

4.5 Advertising in the 1970s: From technical product leaflets to sexualized stewardesses

In *The Jet Sex*, Vantoch briefly explains the transition of gender stereotypes epitomized by the changing image of stewardesses between the 1950s and the 1970s. Stewardesses of the 1950s embodied the domestic ideal of a wife in training but soon evolved to jet-setting career girls by the late 1950s. The gender rebellion and sexual revolution in the late 1960s turned the stewardess into a sex symbol, fitting the advertising trend of using images of sexualized women's bodies to sell products.²⁴⁹

246. *PDP-11 Peripherals Handbook*, 8-4, 8-5.

247. *PDP-11 Peripherals Handbook*, 8-5, 8-6.

248. *PDP-11 Peripherals Handbook*, 8-10.

249. Vantoch, *The Jet Sex*, 3.

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During the 1960s, advertising in America had adopted the dominant youth culture in which “young people challenged the impersonality, emptiness, and overall conformity of middle-class consumer culture,” and instead advocated sexual liberalization.²⁵⁰ Ironically, large corporations adopted youth culture by producing increasingly sexualized advertising campaigns. The introduction of the wide-bodied jet had transformed air travel from an elite mode of travel to transportation for the masses. As airlines needed to fill seats and sell tickets to middle-income travelers such as women and young people, the iconic sexy stewardess epitomized youth and fashion and was presented as a consumer dream for middle-class women. A key change in uniform and advertising was the mini dress inspired by Mary Quant who also popularised the mini skirt.²⁵¹ Flight crew uniforms were updated in true 1970s style “with formfitting minidresses in vivid patterns, go-go boots, and plaid jackets in dazzling colors.”²⁵²

In *Advertising the American Dream* Roland Marchand concludes that advertisements matured in the 1920s and 1930s by shifting focus from the product to the consumer. The experience a product offered became more important in advertising than the characteristics of the product itself.²⁵³ Stewardesses in airline advertisements appealed to the masses as an icon of youth and fashion. Their lifestyle came to substitute the experience of travel or the mere airline ticket as a central focal point of advertisements. Computing advertisements did not yet reach this level of abstraction in the 1970s and the product leaflet for DEC’s PDP-11/45 remained thoroughly focused on the device and its characteristics.²⁵⁴ Two key differences between the commercial airline industry and the computer industry of the 1970s can explain why the product leaflet did not advertise a lifestyle or experience. First, computers only became a mass

250. Vantoch, *The Jet Sex*, 157-158.

251. Vantoch, *The Jet Sex*, 158-168, 177.

252. Schuler, *Widebody*.

253. Roland Marchand, *Advertising the American Dream: Making Way for Modernity, 1920-1940* (Berkeley: University of California Press, September 1985), xxi.

254. *PDP-11/45*, (Maynard, Massachusetts: Digital Equipment Corporation, 1972), The PDP-11 Family - Brochures.

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Figure 4.20: United Airlines, advertisement, "Improvements," 1968. Personal collection of Vantoch, *The Jet Sex*, 179.

consumer product on par with air travel a decade later in the 1980s. Second, airline advertisements targeted mass consumers, whereas the PDP-11 was much more expensive and meant for technical expert users. The sales and marketing teams at DIGITAL mainly consisted of engineers who promoted products and later applications to other engineers, whereas the airline industry spent large budgets on campaigns set up by advertising agencies.

In a folder addressed to Mr. Lemaistre from Micro Consultant in Surrey in the United Kingdom, a digital representative provided some mar-

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keting materials and price lists with a particular emphasis on an OEM Discount Agreement dated November 3, 1972.²⁵⁵ One of the first brochures printed on high quality paper promoted the PDP-11/45 which was announced in a newsletter from October 14, 1971, but became available around June 1972.²⁵⁶ The introduction of the brochure highlights the PDP *computer family* which illustrates that despite the name, a PDP was really a computer. Additionally, the family vocabulary matches with IBM's S/360 marketing strategy. Yet instead of focusing immediately on compatibility, DEC emphasized the choice of equipment tailored to every application. The next few paragraphs detail the sophisticated design and possibility to upgrade "without modifying programs or replacing peripherals." Next, the introduction shifts attention to the "largest and most powerful" processor's features and finally lists peripherals and software support.²⁵⁷



Figure 4.21: *PDP-11/45*, 1972, p.4-5, The PDP-11 Family - Brochures.

255. B. Fifield to D. LeMaistre, 3rd November 1972, PDP-11 Family - Brochures.

256. *PDP-11/45*, (Maynard, Massachusetts: Digital Equipment Corporation, 1972), The PDP-11 Family - Brochures.

257. *PDP-11/45*, 1972, p.1, The PDP-11 Family - Brochures.

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The next two pages are mostly taken up by a photograph of the system (fig. 4.21) in keeping with the red-white-black colour scheme of the brochure. The console is visible in the middle of the cabinet on the left with bright coloured switches in keeping with the preferred colours of the 1970s. The DECWriter stands in the left corner, so that a data typist or console operator could interact with the PDP-11/45 using the keyboard or switches on the main console. The installation pictured shows a closed and opened disk reader as the central focus point of the image. On the page titled *the PDP-11/45 at a glance* the product leaflet listed key selling points: power, speed, floating point precision, software, sophistication, flexibility, and reliability. This list of technical specifications is accompanied by an image of modules on a printed circuit board with the console interface of the PDP-11/45 and its indicator lights and row of switches in the background, further emphasising the inner workings of the device. The text on hardware and in particular the powerful instruction set and fast general registers was accompanied by keywords printed next to the paragraph for clarity.²⁵⁸ The explanation of three processor modes illustrates different levels of access: “The three modes allow user programs (user mode) to be separated from monitor functions (supervisor mode) which, in turn, are isolated from kernel mode functions which are global to all system monitors.”²⁵⁹ The distinction between user and supervisor mode reflects the occupational differences between data typists or programmers who were mainly concerned with entering the relevant data and programs, and console operators who accessed the system more directly and supervised its functioning.

The hardware section continues with paragraphs on hardware stacks for fast data handling and the fast, accurate floating point processor. In an accompanying image (see figure 4.22) pictured next to this section a male operator or programmer is typing and studying the VDU with the processor cabinet visible in the background. To preserve a gender balance, the photograph on the next page shows a side view of a woman

258. *PDP-11/45*, 1972, p. 2-7, The PDP-11 Family - Brochures.

259. *PDP-11/45*, 1972, p.6-7, The PDP-11 Family - Brochures.

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Figure 4.22: *PDP-11/45*, 1972, p.9, *The PDP-11 Family - Brochures*.

holding a pen and staring down at a piece of paper, with the video display terminal in focus where the text on the CRT monitor reads “VT05 interactive CRT terminal designed for use with all PDP computers from digital equipment.” The paragraph next to the image however is not related to video display terminals but rather discusses memory and the user is gendered male in the text. The access modes in combination with memory segmentation “give the user wide flexibility, yet assure that he cannot destroy other user programs or system monitors.”²⁶⁰

The flexible configurations advertised next accommodate both “the system designer and the systems programmer” allowing them to add “new peripherals and additional memory.” Two diagrams show a single or a dual processor configuration with schematic connections between system components and the Unibus, thus remaining product centered and technical. The illustration on the right shows teletype terminals lined up against the right wall with one person holding a piece of paper in the foreground seated next to a man looking down upon printed output and a

260. *PDP-11/45*, 1972, p.8-11, *The PDP-11 Family - Brochures*.

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younger woman typing on the middle teletype (fig. 4.23).



Figure 4.23: *PDP-11/45*, 1972, p.13, *The PDP-11 Family - Brochures*.

The hardware discussion continues on page fourteen with sections titled powerful hardware and software interrupt structure, and automatic power fail and restart. The tone of the text is rather technical and centers on the processor and its functioning rather than applications or the user perspective. Perhaps to appeal to the OEM customer, the photograph illustrating these two pages shows large manufacturing equipment inside an industrial looking complex with a big ventilation tube overhead.²⁶¹

The software section only starts on page sixteen of the brochure with a description of PDP-11 DOS for efficient program development and operation.²⁶² The file security procedure explained under section 4.4.2 is explained as follows: “By requiring the user to specify programmer and group number as well as the program name, access can be restricted to authorized personnel.”²⁶³ If users left their numbers laying around or

261. *PDP-11/45*, 1972, p.12-15, *The PDP-11 Family - Brochures*.

262. *PDP-11/45*, 1972, p.16-17, *The PDP-11 Family - Brochures*.

263. *PDP-11/45*, 1972, p.16-17, *The PDP-11 Family - Brochures*.

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could not remember the name of their program, file security diminished. The first software mentioned is Resource Time Sharing System (RSTS) - a 16-users basic-plus time-sharing system. With this system access is similar to current logins since “each user is issued a password which he uses in ‘logging onto’ the system.” Although earlier photographs illustrating the brochure were clearly well staged, the people photographed in figure 4.24 seemed to be posing less. This photograph showed two women in full length with the first woman seated at a terminal and another woman changing a tape drive in the background. Both were wearing miniskirts but with their faces turned away from the spectator and engaged in work, the image does not sexualize them as the airline advertisement in figure 4.20 does.²⁶⁴



Figure 4.24: *PDP-11/45*, 1972, p.16-18, *The PDP-11 Family - Brochures*.

The right-hand image in figure 4.24 was placed next to a list of fourteen different peripherals, showing the same setup as the left-hand image, but from a different angle. The woman who was previously changing tape was now seated at the DECwriter terminal and photographed from

264. *PDP-11/45*, 1972, p.16-17, *The PDP-11 Family - Brochures*.

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behind with the perspective zooming out and focusing the attention of the viewer on a disk drive in the front of the picture with the processor, small and large tape readers inside cabinets on the right, and a very large printer in the back. The white walls and grey carpeted floor do hint at a studio setting.²⁶⁵

Finally, the product leaflet ends by promoting field service which was made up of over 1,000 engineers who represented around 100 international sales offices. When issues arose, they could cover single or multiple shifts through a local office. Customers could also pay for resident service in which DEC engineers worked at the customer site, or save on repair bills by dropping equipment off at depot repair stations. Software specialists handled service calls or trained customers on-site. Some software and maintenance training was included with the purchase of the system for a limited number of employees. Finally, the leaflet promoted the DECUS with 10,000 users from forty countries who provided a free library of user-contributed programs. In 1972 software was still included for free since DEC only introduced software licensing a few years later. The image accompanying field service shows a man in front of a blackboard engaging in conversation with two other men only visible from behind, representing the scene of a training offered by DEC.²⁶⁶

DEC's product leaflet targeted companies that could afford to purchase minicomputer systems. Although customers were considered experts in computing judging from the technical tone and emphasis on hardware characteristics in the brochure, the service and training section suggests that customers employed minicomputer users rather than using the system personally. Only one male operator was pictured, which confirms the Bureau of Labor Statistics assertion that data entry remained a predominantly female occupation. The images did not overtly sexualize women's bodies, and while female users wore mini skirts according to 1970s fashion, their position and gaze is turned away from the viewer and suggests they were interacting with the system rather than the audience.

265. *PDP-11/45*, 1972, p.18, *The PDP-11 Family - Brochures*.

266. *PDP-11/45*, 1972, p.20-21, *The PDP-11 Family - Brochures*.

Summary

Despite minicomputer's lower price compared to expensive mainframes and their more accessible interface, only companies and employees in certain occupations used minicomputers extensively. A minicomputer also required peripherals and a system still occupied an air-conditioned, noisy, computer room with the exception of terminals that appeared in adjoining offices. The applications of computers in aerospace illustrate diverse occupations that turned to (mini)computers, influenced the experience of travelers, and increased public visibility of computer technology in space missions. While air travel became available to the masses, access to minicomputers was still reserved for experts.

The image collection of the Digital Equipment Corporation records at the CHM allowed me to reflect on the occupational segregation and working conditions of the personnel employed by the computer manufacturer. Small design teams consisted of predominantly white male engineers who worked at desks or prototype machines in an open space on the factory floor. Small computer components were produced by predominantly female blue-collar workers. With increasing internationalisation or even globalisation of production, DEC outsourced some of the manufacturing to countries where labor was cheaper.

Advertisements for minicomputers still targeted a wealthy, corporate audience that employed computer users. Advertising focused on the product or the device rather than the experience which stands in stark contrast to the life style promoted by stewardesses for airlines who wanted to appeal to the mass consumer market. As processors became even smaller, cheaper, and faster, the micro or personal computer made its way out of the office and into the home. Children were introduced to microcomputers in schools and persuaded parents to purchase one as well, or people who used computers at work could afford a personal computer for home use. Users no longer needed technical expertise or support to operate computers, and advertisements for personal computers promoted the life style and experience rather than the product.

Chapter 5

Microcomputers: BBC and Apple Educating the Nation

The minicomputer discussed in the previous chapter was followed by the microcomputer, a smaller computer using a “microprocessor as its central processing unit (CPU),” or in other words a computer “whose CPU is contained on a single integrated semiconductor chip.”¹ In later years the term *microcomputer* made way for the *personal computer* which emphasised the use rather than the computer architecture and was popularised by the International Business Machines (IBM)’s PC model.² Some smaller microcomputers integrated “all CPU, memory, and interface circuits” on a single chip, whereas others contained several “associated semiconductor chips.”³ These associated chips served as “main memory for storing program instructions and data” or to connect to peripherals such as input/output devices, namely keyboards, a video display, and printer, as well as additional storage units, notably floppy disk readers or tape read-

1. Robert Lewis, *Microcomputer*, October 2016, <https://www.britannica.com/technology/microcomputer>.

2. The terms are often used interchangeably and there is no clear consensus for a definition of either term.

3. Lewis, *Microcomputer*.

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ers.⁴

Although microcomputers were introduced from the mid-1970s onward and often as assembly kits, I will focus on two microcomputers from the 1980s when these machines became more user-friendly and spread to a much wider audience.⁵ After noticing a similar type of exhibition in three different computer museums, I decided to select two computers that were often used in (recreated) classrooms: the BBC Micro and the Apple *IIE*. Both The National Museum of Computing (TNMOC) in Bletchley Park, and the Centre for Computing History (CCH) in Cambridge have recreated a 1980s classroom full of BBC Micros representative of computing for education in the United Kingdom. Across the Atlantic ocean in the Living Computers Museum+Labs (LCM+L) in Seattle a special exhibition titled *Total 80s Rewind* recreated Middleton High School, a classroom filled with several Apple *IIE*'s. In the stock of BBC Microcomputers held by the CCH, I also found many markings of school names which further motivated me to select this computer model in particular.

The museum settings as well as manuals, software, and especially commercials demonstrate that the microcomputer found its way to schools and homes. Since computers in schools were used by many students, the 1980s marked the decade in which even those who could not yet afford a microcomputer of their own, could interact with the machine. By comparing an American example of the Apple *IIE* and the British BBC Micro, national differences in the adoption of computers and the approach to introducing computers in schools are laid bare. Although the IBM PC also sold in great quantities on the United States and international market, the PC was mostly introduced in businesses and chapter 3 already discussed an IBM mainframe. In the United Kingdom the Sinclair ZX was cheaper than a BBC Microcomputer, but none of the government schemes intended to introduce computers in schools included the ZX Spectrum.

After contextualising both computer models and their manufacturers, and discussing the features of each, this chapter focuses on the educa-

4. Lewis, *Microcomputer*.

5. See Chapter 7 in Ceruzzi, *A History of Modern Computing*, 207-241.

tional policies in the United States and the United Kingdom and the diffusion of microcomputers in primary and secondary schools in the first half of the 1980s. Advertising for each machine shows how companies targeted children, families, and schools (see section 5.1.1 and section 5.2.4). Finally, section 5.3 compares the introduction of computers in primary and secondary schools in the United Kingdom and the United States. Aside from the different approaches to funding schemes for the acquisition of microcomputers, this chapter describes how much time students could actually spend interacting with computers, how teachers were trained to work with them, and whether computers were used for drill and practice exercises or to teach computer literacy. Furthermore, software and the applications it was built for differed based on geography and preference for certain disciplines.

5.1 BBC Micro: The Computer Literacy Project

The British Broadcasting Company (BBC) became “a publicly funded yet quasi-autonomous organization” on 1 January 1927 established by royal charter with a board of governors appointed by the state. The state also granted the licence to broadcast and determined the cost of the licence fee for fixed periods. The BBC’s statutory obligations “to inform, to educate and to entertain,” as well as its constitution, remained stable for seventy-five years.⁶

The BBC’s responsibility to educate became closely related with external educational bodies through the first Controller of Educational Broadcasting appointed in 1963, John Scupham, who established many contacts outside the BBC.⁷ Educational broadcasting privileged higher and

6. Andrew Crisell, *An Introductory History of British Broadcasting*, 2nd Edition (London: Routledge, 2002), 28, <https://www.routledge.com/An-Introductory-History-of-British-Broadcasting/Crisell/p/book/9780415247924>.

7. Asa Briggs, *The History of Broadcasting in the United Kingdom: Volume V: Competition* (Oxford: Open University Press, March 1995), 468-469, https://archive.org/details/historyofbroadca0005brig_z0w9.

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adult education over schools and “Further Education moved into Television in 1963,” however a Department of Further Education (Television) was only set up by 1965 with Donald Grattan appointed as editor. He had defined adult education programs as series with clear educational aims “primarily addressed to members of specific professional or occupational groups” in terms of audience by 1964. He would become Controller of Educational Broadcasting in 1972. A producer from the same department, Sheila Innes, would take over his position in 1984.⁸ From five educational television programs per week in 1964 to 132 series for schools under production by 1974, educational broadcasting was firmly established long before the advent of the Computer Literacy Project.⁹

The Continuing Education Television department led by Sheila Innes within BBC Education initiated the *Computer Literacy Project* between 1979 and 1982.¹⁰ The project took inspiration from international research funded by the Manpower Services Commission sending David Allen and Robert Albury from the BBC Education team on a global fact-finding trip to America, France, Germany, Holland, Norway, Sweden and Japan resulting in three television documentaries, titled *The Silicon Factor*, and the Microelectronics report. The report argued “for educating children in computing, vocational training in Further Education, and Adult Education focused on the professions” to reach all levels of society.¹¹ This report was based on input from technology, industrial, union, and education specialists, and sent to all members of parliament. The BBC’s Continuing Education Department was inspired by the report and set up a “public awareness and education campaign, with a ‘hands-on’ philosophy: people should learn how to use and control computers not feel dominated by them.” The

8. Briggs, *The History of Broadcasting in the United Kingdom*, 479-484.

9. Briggs, *The History of Broadcasting in the United Kingdom*, 484,932.

10. Steve Lowry and David Allen, *The Computer Literacy Project (1980-1989)*, March 2020, <https://web.archive.org/web/20200326115623/https://clip.bbcrewind.co.uk/history>.

11. Tilly Blyth, *The Legacy of BBC Micro: Effecting change in the UK’s cultures of computing*, technical report (Nesta, May 2012), 9, <https://www.nesta.org.uk/report/the-legacy-of-bbc-micro/>.

education department relied on previous experience with the *Adult Literacy Project* which extended the television program with learning materials and courses in “schools, colleges, and adult education centres” organised and supported by a network of BBC education officers.¹² The goal of the Computer Literacy Project was “to offer a complete learning system,” “which included not only television programs, books and a linked course, but access to a microcomputer and appropriate software.”¹³

In the first phase between 1982 and 1983, the BBC aired four initial television series. *The Computer Programme* is discussed in detail in section 5.1.1. Other series included *Making the Most of the Micro*, *Computers in Control*, and *The Electronic Office*. All combined how-to-demonstrations with real-life and research examples.¹⁴ *The Computer Programme* focused on major aspects of computing and explained computer principles by analogy, demonstrating how computers worked and what they were used for.¹⁵ *Making the Most of the Micro* first aired on 10 January 1983 and went into “much more practical detail about how to use home computers” focusing on home applications for the microcomputer. This ten-episode television series was presented by Ian McNaught-Davis with help from John Coll and Ian Trackman.¹⁶ On 2 March 1984 *Computers in Control* first aired, examining robotics in particular and discussing how the computer could monitor and control things. Five episodes presented once more by Ian McNaught-Davis featured many examples from America and

12. Lowry and Allen, *The Computer Literacy Project (1980-1989)*.

13. John Radcliffe, memorandum, 'BBC Continuing Education Television. The BBC Microcomputer System. Some Questions Answered', 13 March 1981, folder R103/113/1, BBC Microcomputer Acorn Computers Ltd Part 1, BBC Written Archives Centre, Reading (hereafter cited as BBC Microcomputer); John Radcliffe, memorandum, 'BBC Microcomputer System. The Choice of Equipment', 22 April 1981, folder R103/113/1, BBC Microcomputer.

14. Lowry and Allen, *The Computer Literacy Project (1980-1989)*.

15. *The Computer Programme*, March 2020, <https://web.archive.org/web/20200326115617/https://clp.bbcrewind.co.uk/de37d97905d37f58038f2d7c8341ff4b>.

16. *Making the Most of the Micro*, March 2019, <https://web.archive.org/web/20200326115619/https://clp.bbcrewind.co.uk/f57ff3510ad952db6d45753d4f9a6c1a>.

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the program marketed a robot called the BBC 'buggy' for do-it-yourself enthusiasts.¹⁷ Finally, *The Electronics Office* first aired on 12 April 1984 explaining changes in the office and illustrating how technology altered peoples work.¹⁸

The television series were accompanied by books, courses, software, advice services, and of course the BBC Microcomputer System. This approach was first introduced with the establishment of the Open University. Since 1964 Prime Minister Harold Wilson had started to campaign for a "University of the Air" and he appointed Jennie Lee to the Department of Education and Science (DES) in March 1965 to set up what eventually became the Open University. With time and patience, she managed to establish a partnership with the BBC. In 1971 the Open University received its first students and by 1974, the BBC transmitted "1,500 hours of Open University programmes."¹⁹ Historian Asa Briggs argued that the Open University partnership between academics and broadcasters introduced the BBC to the practice of associating television programs with other teaching and learning materials, especially in a forerunner of *The Computer Literacy Project* called *National Adult Literacy Campaign* and illustrates the BBCs concern with further education rather than schools.²⁰

The Computer Book sold over 80.000 copies by 1983. By then over 160.000 people had taken the 30-hour BASIC course introducing the programming language used by the BBC Microcomputer. Two million BBC Microcomputers were sold and over 85% of primary schools and 65% of secondary schools had purchased at least one BBC Microcomputer by 1983.²¹

In the second phase between 1983 and 1989, the special two-hour

17. *Computers in Control*, March 2019, <https://web.archive.org/web/20200326115700/https://clp.bbcrewind.co.uk/4d70db67f1bb222cf3d2a515636c19be>.

18. *Electronic Office*, March 2019, <https://web.archive.org/web/20200326115657/https://clp.bbcrewind.co.uk/27bcf968d0c805c00ee69fbca89931b9>.

19. Briggs, *The History of Broadcasting in the United Kingdom*, 490-502,932.

20. Briggs, *The History of Broadcasting in the United Kingdom*, 934-935.

21. Lowry and Allen, *The Computer Literacy Project (1980-1989)*.

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feedback program *Making the Most of the Micro - Live* aired in October 1983, followed by a regular magazine program called *MicroLive* between October 1984 and 1987. Other series included *With a Little Help from the Chip* on disability and computing, *The Learning Machine*, *Micro File*, *Electric Avenue* and *Micro Mindstretchers* for schools television. Software developers could now also make use of the BBC's *Guidelines for Software Writers* to develop and produce their own computer programs.²²

At the start of the project, the idea was not necessarily to build a BBC Microcomputer, but rather to set a software standard and ask existing microcomputer manufacturers to adopt a particular programming language. Educational advisor John Coll from the Micro Users in Secondary Education (MUSE) helped develop the initial software standard called adopted BASIC for computer (ABC) which was presented to all British manufacturers. Due to the costs of developing new microchips which neither the manufacturers, nor the BBC or government was willing to pay, this option was soon abandoned.²³ Thus "the only way to ensure a machine would be available at the right time was either to build the system around an existing commercial machine or to licence a BBC machine."²⁴ After approaching the partially publicly-funded Newbury Laboratories to redesign an existing machine for the project without much success, the only remaining solution was to licence a BBC machine. John Coll and David Allen then developed a functional description sent to seven manufacturers.²⁵

When the British computing industry became aware of the project they voiced their concerns to the Department of Trade and Industry (DTI) stating unfair competition from a public service broadcaster. Since the BBC wanted to licence the computer to a British manufacturer rather than developing a "new design in direct competition with existing manufacturers," the DTI did not intervene.²⁶ In an article from *Electrical and Ra-*

22. Lowry and Allen, *The Computer Literacy Project (1980-1989)*.

23. Blyth, *The Legacy of the BBC Micro*, 10-11.

24. J. Radcliffe, memorandum, 'Some Questions Answered', 13 March 1981, BBC Microcomputer.

25. Blyth, *The Legacy of the BBC Micro*, 11.

26. Kenneth Baker to Christopher J. Curry, 14 January 1981, folder R103/113/11, BBC

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Radio Trading a similar argument stated that BBC Enterprises usually offered “licences to manufacturers to produce the equipment and make their own arrangements for marketing,” even though the *Radio, Electrical and Television Retailer’s Association* considered the associated television programs “as a related if indirect means of advertising the micro-computer.” Yet BBC Enterprises emphasised the “need for a series to introduce the layman to computers and take away something of the fear they often produce.”²⁷ The DTI also welcomed the Computer Literacy Project “as a significant step towards improving the technological literacy of the nation,” thus complementing the “microelectronics application (MAP) and information technology programmes.” In fact, the BBC had not yet decided on the manufacturer but only determined the “specification, price, and availability” requirements for the machine by the end of 1980.²⁸

Six machines from different manufacturers were taken into consideration by the BBC from companies such as “Acorn, Newbury, NASCOM, TANGERINE, Sinclair and TRANSAM.” The final decision was based on fourteen criteria regarding the company licensed to produce the micro-computer, the machine and its usability. The company needed the financial means to produce the necessary number of microcomputers as well as the capacity to increase production if demand exceeded expectation. The BBC also required a robust and reliable, powerful machine that could be expanded and was compatible with the ViewData format and could eventually support teletext. Furthermore, the microcomputer had to support different interfaces such as TV, cassette, video and disc, and should include a display. In terms of user-friendliness the selection criteria mentioned an existing handbook and software documentation. Finally, the BBC was looking to offer a computer at a reasonable price for both sale and lease.²⁹

Microcomputer.

27. Electrical & Radio Trading, magazine article, ‘... and challenge to the BBC’, 15 January 1981, folder R103/113/1, BBC Microcomputer.

28. K. Baker to C.J. Curry, 14 January 1981, BBC Microcomputer.

29. Shiela Innes to John Cain 5 February 1981, folder R103/113/1, BBC Microcom-

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Acorn won the bid in the end provided that they built “a special BBC version of their new generation machine” according to their specifications.³⁰ The BBC licensed the microcomputer to Acorn Computers Ltd. for a royalty of 10% which was reduced to 7% for schools purchasing through the Microelectronics in Education scheme discussed later.³¹ They also retained the right to write the User Guide and demanded a lease of ten computers to start developing software. Acorn was not allowed to use their company name “on any advertising, publicity, or promotional material whatsoever.” Nor could it feature the Computer Literacy Project or the BBC Micro in a “film, television or radio commercial” without “prior consultation” and “written consent” from the BBC.³² Section 5.1.2 discusses the timeline of events from launch to delivery with attention for how the relationship between Acorn and the BBC changed over time.

Initial complaints from the British computer industry focused on the BBC’s decision to forego open tender. The BBC defended their lack of transparency based on three arguments pointing out the “multifarious and unstable” computer industry, the external advice received from the DTI and others, and the unlikelihood of market dominance from the BBC Micro.³³ Prepared for accusations of unfair competition, the BBC minimized the advantage to Acorn by bargaining the price, avoiding links to Acorn in advertising and publishing hardware and software specifications for other companies to create compatible hardware and software, a practice later known as “open source,” thus supporting the British computing industry.³⁴ However, the first two arguments backfired in hindsight

puter; John Radcliffe, memorandum, ‘BBC Continuing Education Television. Computer Literacy Project’, 15 January 1981, folder R103/113/1, BBC Microcomputer.

30. John Radcliffe, minutes, ‘BBC Microcomputer’, 18 February 1981, folder R103/113/1, BBC Microcomputer.

31. BBC Enterprises Limited and Acorn Computers Limited, agreement, 29 April 1981, folder R103/113/1, BBC Microcomputer; Bryon Parking to John Radcliffe, ‘BBC Microcomputer System’, 1 April 1981, folder R103/113/1, BBC Microcomputer.

32. BBC and Acorn, agreement, 29 April 1981, BBC Microcomputer.

33. John Radcliffe to Donald Grattan, ‘BBC Micro’, 5 March 1981, folder R103/133/1, BBC Microcomputer.

34. An example of publishing specifications is provided in John Radcliffe, memorandum,

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since “suggestions that the directors of the firm will become billionaires” were not as far-fetched as the BBC proclaimed and the clause preventing Acorn from advertising their company in relation to the BBC Micro was not always respected.³⁵ This contract clause also created other difficulties since the BBC were held accountable by customers for delays and malfunctions originating from Acorn.³⁶

Despite initial trouble with production and delivery, the BBC Microcomputer System did become a success and section 5.1.3 details the life cycle of the computer itself. Expanding on the conception phase of the *Computer Literacy Project*, this section delves further into what initiated the need, and what was the incentive to develop the BBC Microcomputer. Following the vision of the BBC *Computer Literacy Project* team and Acorn’s prototype in the design phase, the next stage of purchase and installation illustrates the intended or configured user apparent in supporting materials in comparison to the demographic of people who had the means to purchase the BBC Micro. The final stage of the life cycle looks into the actual use and applications based on the user manual as well as reviews which in addition to the television series demonstrate how the BBC Microcomputer System functioned and in what context.

The intended or configured user of the BBC Microcomputer is explicitly described in a press release dated 17 February 1981 announcing the *Computer Literacy Project* which would launch in 1982.³⁷

The project should appeal to teachers and students, hobbyists, engineers and technicians from other disciplines, businessmen needing to keep up, parents of teenagers, a wide

’Response to Simon Dally of Harrap’, 15 October 1981, folder R103/113/1, BBC Microcomputer.

35. J. Radcliffe, memorandum, ‘Some Questions Answered’, 13 March 1981, BBC Microcomputer. Examples of Acorn not respecting the advertising contract clause in: John Radcliffe to John Coll, 15 May 1981, folder R103/113/1, BBC Microcomputer; Bryon Parkington to Donald Grattan, 7 September 1981, folder R103/113/1, BBC Microcomputer; John Harrison to Chis J. Curry, 15 July 1981, folder R103/113/1, BBC Microcomputer.

36. BBC and Acorn, agreement, 29 April 1981, BBC Microcomputer.

37. Press release, ‘BBC to Launch Series on Computer Literacy’, 17 February 1981, folder R103/113/1, BBC Microcomputer.

range of people - office workers, bank managers, and so forth - who are encountering keyboards, Visual Display Units, bar-coding, etc., and more widely those for whom this could quite simply be an engrossing, challenging and intellectually satisfying new hobby.³⁸

A key component for distributing software and generating public interest for the Computer Literacy Project was the teletext receiver. Compatible with the BBC Micro, the receiver connected to CEEFAX which distributed telesoftware. The programs could be “down-loaded [sic] direct from teletext transmissions into the memory of a computer.”³⁹ Other software plans of the BBC in collaboration with an advisor from the DTI Research department ranged “from games (crosswords, chess, space-invaders) to serious application programs for business (stock control, VAT, etc.) including programs for learning (spelling, typewriting), hobbyists (astronomy, music, etc.), home management (income tax, health, diary, etc.).”⁴⁰

Almost simultaneously with the announcement of the Computer Literacy Project, the Controller of Educational Broadcasting became aware of an interesting government scheme called the *Microelectronics Education Programme (MEP)* being discussed during the advisory board meeting of the Council for Educational Technology (CET).⁴¹ The goal of the proposal was to put “a microcomputer in every secondary school inside two years.”⁴² By 6 April 1981 a press release confirmed that the BBC Microcomputer would be included in the MEP as presented by Prime Minister Margaret Thatcher at a press conference. Section 5.1.4 discusses

38. Press release, 'Computer Literacy', 17 February 1981, BBC Microcomputer.

39. J. Radcliffe, memorandum, 'Some Questions Answered', 13 March 1981, BBC Microcomputer.

40. J. Radcliffe, memorandum, 'Some Questions Answered', 13 March 1981, BBC Microcomputer.

41. Council for Education Technology, report, 'Microelectronics Education Programme', 19 February 1981, folder R103/113/1, BBC Microcomputer; Donald Grattan, letter, 'Microelectronics Education Programme', 13 March 1981, folder R103/113/1, BBC Microcomputer.

42. CET, report, 'MEP', 19 February 1981, BBC Microcomputer.

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the British schemes introducing microcomputers to both secondary and primary schools in detail. Local Education Authorities approved by the DTI would receive financial help to purchase BBC Micro's for their schools starting in autumn. The television series aired in January 1982 to support "adults as well as colleges and schools" using the BBC Micro.⁴³

5.1.1 The Computer Programme

Since *The Computer Programme* indirectly promoted the BBC Microcomputer and the associated educational *Computer Literacy Project*, the following section discusses the television series in more detail. The research questions answered here are similar to previous case studies discussing other forms of advertising. First and foremost, I provide some background information on when and where the television show aired as well as the structure of an episode and the topics discussed. Furthermore, the program provides a unique insight into not only the audience the documentary makers envisioned, but also the type of computer users it catered for. Finally, the first section introduces how the BBC Microcomputer was featured during the episodes.

The television series

The decision to create a series of ten episodes taken in November 1979 originated from previous documentaries such as the March 1978 documentary *Now the Chips are Down* as part of the Horizon series, and three episodes of *The Silicon Factor* on the social impact of the microchip. Whereas *The Silicon Factor* "focused on the impact of the microprocessor as a new social force to which people would need to adjust," the BBC Continuing Education Television Department noticed a shift away from computing as an external force towards the computer as a useful tool. This shift of perspective paired with the fact that microcomputers had become cheap

43. Press release, 'BBC Microcomputer to be included in government scheme', 3 April 1981, folder R103/116/1, BBC Microcomputer.

enough to enter the home led to the creation of what was eventually called *The Computer Programme* as part of the *Computer Literacy Project*.⁴⁴

The production team collaborated with BBC's Broadcasting Research Department to conduct two studies into audience needs and determine the type of audience and the sort of content that would appeal to them. The first street survey researched the interest of either the motivated or casual viewers, with or without previous knowledge of computers, and their attitude and willingness to learn more about computing. The survey results presented in April 1981 revealed a generally positive attitude towards computing and an interest into how computers worked as well as existing and future applications. However, people feared a depersonalisation of technology and were concerned about the storing of personal details on computers. Older people were more anxious about being able to come to grips with computer literacy. Although producers expected the interest to be "strongest among men, among middle class or skilled working class viewers, among the better educated, and among people under 50," who were more technically-minded and would want a serious approach, the research revealed an unexpectedly strong potential interest in the subject from a more general audience. Thus rather than focusing on a specific demographic in terms of gender, age, and class, the team decided to appeal to a wider audience with a desire to learn. The television format as a mass-medium lends itself well to capturing the interest of the general audience, demystifying the technology, and providing practical examples. A pilot program was then tested with four groups of thirty people to find the right balance in terms of content between theory and example, filmed cases and studio demonstrations, the level of technical explanation, teaching or arousing interest, and between didactic and explanatory or chatty and exploratory presentation styles.⁴⁵

44. John Radcliffe and Roberts Salkeld, eds., *Towards Computer Literacy: The BBC Computer Literacy Project 1979-1983*, BBC Continuing Education INSIGHT (London: British Broadcasting Corporation, December 1983), 5-6, <https://web.archive.org/web/20200919203041/https://clp.bbcrewind.co.uk/media/Towards%20Computer%20Literacy.pdf>.

45. Radcliffe and Salkeld, *Towards Computer Literacy*, 9-11.

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The timing of the television broadcast of the program reflected the intended audience. Airing on Monday afternoon at 15:05 on BBC Two, the show would reach schools and colleges either in real time or for recording a copy to be shown in classes afterwards. The general audience would be reached on BBC One either late at night at 23:20 on Monday, or with repeats on Sunday morning. The first episode of the Computer Literacy Project titled *The Computer Programme* aired on BBC Two on Mondays between 11 January and 15 March 1982 and was repeated on BBC One starting on Monday 22 March 1982.⁴⁶ In the first episode, presenter Chris Serle explicitly stated *the information technology year* of 1982 declared by the British government and its ensuing introduction of a new ministerial post as the motivation for the television series. The program was meant for “non-computer experts” who wished to understand why computers were important and what a non-expert needed to know.⁴⁷

The program featured a “combination of studio demonstration on micros, explanation of principles by analogy, and illustration on film of real-life examples of practical applications.” The recording of demonstrations on the BBC Microcomputer in the television studio was a real challenge because the hot, crowded environment full of disturbing electrical fields meant that the computer often broke down. Producer Paul Kriwaczek also applied the technique of a dialogue between layman Chris Serle and expert Ian McNaught-Davis to further “dispel the idea that computing was an obscure specialist subject, which could only be grasped by people with a knowledge of maths or a scientific training.” The third and only fe-

46. Radcliffe and Salkeld, *Towards Computer Literacy*, 9. Listings for *The Computer Programme* episodes can be found on <https://genome.ch.bbc.co.uk>. Episode 1, 'It's Happening Now', aired 11th January 1982, on BBC Two. <https://genome.ch.bbc.co.uk/58120aff2c0741cc8982dd353632691f>; Episode 10, 'Things To Come', aired 15th March 1982, on BBC Two. <https://genome.ch.bbc.co.uk/f6f497efa00d4762a6f60af19c29acdf>; Episode 1, 'It's Happening Now', aired 22nd March 1982, on BBC One. <https://genome.ch.bbc.co.uk/68f5996d29ec4d788303a5f4be1d3ee5>.

47. *The Computer Programme*, episode 1, 'It's Happening Now', directed by Matt Boney and Frank Ash, aired 11th January 1982, on BBC Two. https://archive.org/details/the_computer_programme_ep01.

male presenter on the show was experienced science correspondent Gill Nevill, she presented most of the film stories that were proposed by researcher Catherine Robins.⁴⁸ Examples of incredibly skilled young users were actively avoided to prevent scaring off older viewers.⁴⁹



Figure 5.1: Still from Ash and Boney, *The Computer Programme*, episode 1 (01:06), 'It's Happening Now', aired 11th January 1982, on BBC Two.

At the start of each episode, Chris introduced the topic before the title sequence. The title sequence centred around a cartoon owl, similar to *The Computer Literacy Project* logo which referenced the owl as the ancient Greek goddess Athena who symbolised wisdom and knowl-

48. Radcliffe and Salkeld, *Towards Computer Literacy*, 26-27, 29.

49. Radcliffe and Salkeld, *Towards Computer Literacy*, 12.

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edge.⁵⁰ Flying over the rooftops with its chimneys and television antennas at night, the owl flies into one of the houses in front of the television set and landing inside the screen on top of the program title (figure 5.1).

Then Ian McNaught-Davis also known to friends as Mac went on a field trip to trace a computer concept back in time. When Mac and Chris came together in the studio, Chris as the impersonation of the non-expert computer user asked Mac the expert questions to better understand the computer concept of the episode. Mac in turn tried to answer his questions using various examples. Next, reporter Gill Nevill was sent on a mission to demonstrate real-life situations linked to the computer concept and to interview computer users. Only in the final ten minutes of an episode would Chris and Mac sit down in front of the BBC Microcomputer where Mac would teach Chris how to use the machine running various short programs from cassette or floppy disk. The episode sometimes ended with an assessment of author and journalist Rex Malik discussing the future of computing.

All of the episodes of *The Computer Programme* are available in a dedicated collection on the Internet Archive.⁵¹ Below is a quick overview of the title and topic of each episode:

1. It's happening now (introduction to computing)
2. Just one thing after another (basic processing concepts)
3. Talking to a machine (programming languages)
4. It's on the computer (data storage and retrieval)
5. The new media (communications and media)
6. Moving pictures (graphics and animation)

50. *The Computer Programme - It's Happening Now*, March 2019, <https://web.archive.org/web/20200326191850/https://clip.bbcwind.co.uk/cd0b39000ec7f484b89a3ff545b99d4>.

51. *The Computer Programme*, directed by Matt Boney and Frank Ash, aired 1982 on BBC One and BBC Two. <https://archive.org/details/computer-programme>.

7. Let's pretend (computer modelling and simulations)
8. The thinking machine (artificial intelligence)
9. In control (computers controlling other equipment)
10. Things to come (the future of computing)

The first episode explicitly introduced the goal of the television series, its intended audience, and the type of computer user targeted. Based on magazine advertisements, Chris showed the variety of microcomputer models available and who was targeted as a computer user from the businessman to the family. As advertising for computers in the 1980s became increasingly focused on television commercials, the presenter moved from magazines to an example of a commercial. Eventually he walked past several different models on display in the studio explaining how people could no longer avoid computers as shops popped up in high streets and pubs all had game computers.

Chris then voiced his concern as a non-expert user as follows:

I sometimes get the feeling that the only people who will get any use out of [computers] - apart from Space Invaders - are a few highly qualified boffins and some home enthusiasts who until ten years ago would have been making their own television sets.⁵²

This narrative illustrates the key change between mainframes and mini-computers compared to microcomputers which isn't so much the technology itself, but rather the user. From expert users and specialists needing an education and gaining access to expensive equipment in closed spaces to hobbyists who still needed specialist knowledge but could purchase more affordable components, the 1980s became known as the era of personal computers that amateur users could afford and use without special training. In the 1980s the computer was introduced to primary

52. *The Computer Programme*, episode 1.

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and secondary school children and found its way into the home. The goal of *The Computer Programme* was to demonstrate that the computer was within the reach of anybody, including Chris Serle, helped by Ian McNaught-Davis, who took on the role of the expert.

In the final episode, Chris repeated the goal of the television series: to demonstrate how computers would change everyday life. He then wondered whether this change should be considered a threat or an opportunity. After the closing credits, producer Paul Kriwaczek concluded as follows: “In this series we have tried to show you something of what computers are and how they can be used. Whether they should be used and if so how and to what purpose are questions we haven’t had time for.”⁵³

Although the television show does not avoid featuring other brands of mainly British microcomputers, computer concepts were demonstrated using the BBC Microcomputer. Any programs written for the series or lines of code entered by Chris catered specifically to the BBC Microcomputer. At the end of the first episode several other products were advertised. The BBC explicitly promoted *The Computer Book* publication written for the television program, together with the BBC Microcomputer System and an associated correspondence course from the National Extension College (NEC) in the beginners’ all-purpose symbolic instruction code (BASIC) programming language that could be ordered via mail. So although the television show aired on a publicly funded national television network that was not supposed to capitalize on commercial ventures, the series directly promoted the BBC Microcomputer benefiting the BBC and Acorn, as well as a book published by BBC Publications and a course offered by the NEC. The final episode also advertised associated software, local computer clubs, and local courses.

The Computer Programme appeared on British television and was frequently repeated. Episodes introduced computer concepts, discussed the history of computers, showed users at work, and touched upon the

53. *The Computer Programme*, episode 10, ‘Things To Come’, directed by Matt Boney and Frank Ash, aired 15th March 1982, on BBC Two. https://archive.org/details/the_computer_programme_ep10.

future of computing. Aside from an introduction and reflection of the future of computing in the first and last episode, other topics included: processing, programming, data, communications, graphics, simulations, artificial intelligence, and how computers controlled other machines. The goal of the show was to introduce computing to non-experts or amateur users and to illustrate the role of computers in everyday life. The television show featured the BBC Microcomputer during the episodes, but advertised the system and associated products directly at the end of the show.

Applications and Users Featured

The television series format is also suitable for an analysis of different computer applications and shows users at work. Reporter Gill Nevill interviewed actual computer users about their perception and use of the machine, or demonstrated everyday situations in which computers played a role. Therefore the television series showed the purchase, installation and operation of microcomputers in different occupational contexts and described the workflow. Other applications in which computers were used behind the scenes demonstrated the influence of technology in everyday life during the 1980s.

Real and Stereotypical Users The personal or microcomputer was most popular for small business users. In the first episode, Gill illustrated one of the smallest businesses applying computers, by interviewing a nice grey-haired sweets shopkeeper who used the microcomputer for accounting and stock keeping as seen in figure 5.2. The lady explained she wasn't apprehensive about the computer because it looked like a typewriter which she operated before. The main advantage of the computer for her small business was that it saved time.

Interestingly she spotted a business opportunity in owning the computer as Gill explained.

Because she found it so useful, Phyllis thought that a computer might help other people with small businesses. So a

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Figure 5.2: Still from Ash and Boney, *The Computer Programme*, episode 1 (12:39), 'It's Happening Now', aired 11th January 1982, on BBC Two.

year ago she started up a computer service to take over their paperwork allowing them to get on with their jobs.⁵⁴

Given how the chocolate sweets business was becoming less profitable the shopkeeper said she wouldn't mind focusing solely on her computer business because she found it more exciting.

In a slightly larger business, episode five sees Gill reporting how British Aerospace's new Airbus 146 was programmed from home using terminals.⁵⁵ She explained that "once the telephone link has been established

54. *The Computer Programme*, episode 1.

55. For more information on computers in the aerospace industry, see chapter 4.2.

and the programmer has logged on by giving her password, programs can be run automatically.” Thus the programmers Gill discussed here working from home for an aerospace client through their software company employer were female, as seen in figure 5.3.



Figure 5.3: Still from Ash and Boney, *The Computer Programme*, episode 5 (11:34), 'The New Media', aired 8th February 1982, on BBC Two.

The male operator shown replacing disk packs on site in the main-frame computer room did have to come in to the office. “It was the flexibility of the work that appealed to Leslie Smith. She could work from home in her own time and still fetch the children from school or go shopping without being tied to an office or office hours..”⁵⁶ Her work was

56. *The Computer Programme*, episode 5, 'The New Media', directed by Frank Ash and

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printed out and checked by the airplane designers, before the wiring specifications were sent to the factory, where another man was assembling the wires.



(a) Episode 5 (16:01)



(b) Episode 5 (17:10)

Figure 5.4: Stills from Ash and Boney, *The Computer Programme*, episode 5, 'The New Media', aired 8th February 1982, on BBC Two.

Chris and Mac continued the subject discussing what an office would look like in the future as seen in figure 5.4, which tasks would be replaced by computers and how the job of office workers would change. As Chris stated “for those of us who work in offices - and that, believe it or not is about 40% of the working population - these new electronic systems could mean very big changes.” Walking between an old largely paper based office and the office of the future reconstructed on set, Chris stated which digital alternatives would replace some of the elements in the office. Filing cabinets, invoices, and bills would be sent through computers, typewriters would be replaced by word processors. Mac added “so a secretary’s job will really be enhanced as she is able to help her boss in understanding the sort of speed at which his business is changing.” From female programmers to female secretaries and male bosses, the television show clearly gender typed certain occupations. Despite the decreasing

Matt Boney, aired 8th February 1982, on BBC Two. https://archive.org/details/the_computer_programme_ep05.

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price of telecommunications and the increasing cost of paper mail in the 1980s, Mac believed that although the use of paper in the office would be greatly reduced, people still preferred to read from paper rather than the screen. In the office of the future the desk would consist of a computer terminal, a View Data terminal, a Word Processor and a connected printer.



Figure 5.5: Still from Ash and Boney, *The Computer Programme*, episode 10 (07:34), 'Things To Come', aired 15th March 1982, on BBC Two.

In the final episode two occupations illustrate opposite ends of the spectrum regarding the influence of computers on the labour market. Gill assured the viewer that some skilled jobs would continue to require the human touch. For instance in dairy farming the computer could provide

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the farmer with detailed information about individual animals and the herd concerning their yield, feed, date of calving, and veterinary inspection as shown in figure 5.5. However, after the farmer decided to get rid of an unproductive cow, Gill added the following: “Though the computer supplies the farmer with information about his animals, it may be he no longer knows them as individuals. This could also be a problem in professions involving people and computers..”⁵⁷ In essence, the animals or employees were reduced to numbers and underlying issues might be ignored.

At the other end of the spectrum, Rex Malik explained the process of transferring money after Chris walked into a high street bank to pay for his electricity bill (figure 5.6), a process taking three days.

Rex Malik started by stating that “the paper trace we are following is probably one of the world’s most complex, routine, large volume, paper handling operations.” First, the payment slip went to the bank’s clearing centre unlike cheques which were handled by computers. Once payment slips were sorted manually by the recipient’s bank, all slips destined for that bank were added to determine the total amount the bank owed every other bank. Before lunch on the second day, all the paper went to a central clearing point to exchange with other banks and the paper was destined for the recipient bank’s clearing centre. Finally, the paper was sent to the specific branch of the receiver’s account in the evening.

The recipient bank’s clearing centre shown in *The Computer Programme* was a large open office where women were seated at desks, going through papers and making calculations. The clear occupational segregation of a woman at the reception of the high street bank, men transporting paper, and women processing paper is important when reading Rex’s analysis of the women’s job at the clearing centre. He first wondered “surely there must be another way for people to spend their lives?” Next he predicted that “jobs like this in which people are just used as a convenient interface between machines, will probably disappear (...) during the eighties.” I will continue this discussion on the characteristics of jobs that were likely

57. *The Computer Programme*, episode 10.



Figure 5.6: Still from Ash and Boney, *The Computer Programme*, episode 10 (11:18), 'Things To Come', aired 15th March 1982, on BBC Two.

to disappear as a result of the introduction of microcomputers in at the end of this section on the future of computing and occupational segregation.

Finally, another computer application made the bridge to everyday uses of computers through a commercial airline application. Chris stated in episode seven that “some airline pilots around the world are converting from one type of jet to another without once stepping foot in an expensive real plane” with the help of realistic simulators. He got a lesson in a Boeing 727 flight simulator at Crawley Industrial Estate (see figure 5.8). This application ties in nicely with the case study on commercial airlines from

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Figure 5.7: Still from Ash and Boney, *The Computer Programme*, episode 10 (14:40), 'Things To Come', aired 15th March 1982, on BBC Two.

the previous chapter showing how not only the traffic control tower and luggage handling were computerised, but how pilots were trained on the ground.⁵⁸

After showing the movement created by hydraulics underneath the simulator, Chris took a look at the computer controlling the movement

58. *The Computer Programme*, episode 7, 'Let's Pretend', directed by Frank Ash and Matt Boney, aired 22nd February 1982, on BBC Two. https://archive.org/details/the_computer_programme_ep07.

58. *The Computer Programme*, episode 7, 'Let's Pretend', directed by Frank Ash and Matt Boney, aired 22nd February 1982, on BBC Two. https://archive.org/details/the_computer_programme_ep07.



(a) Episode 7 (02:19)



(b) Episode 7 (02:57)

Figure 5.8: Stills from Ash and Boney, *The Computer Programme*, episode 7, 'Let's Pretend', aired 22nd February 1982, on BBC Two.

based on the input of the simulator dashboard, and generating the graphics inside the simulator.

Everyday Situations influenced by Computers After these examples of real or archetypal users and computer applications in which people were directly using computers, the following examples illustrate situations in which people's everyday lives were indirectly influenced by computers during the 1980s.

The first episode ended with Chris booking an airline ticket to Paris using the BBC Microcomputer connected to the Prestel database through a telephone line. He then arrived at the airport counter to pay for his reservation and receive his ticket (figure 5.9).

Thus passengers too depended on computers directly or indirectly to make a reservation. Before his plane took off, Chris explained how computers made commercial flights cheaper by ensuring full planes.

Another example of how computers impacted daily life was Gill's report during the second episode of the central control of London's traffic lights from New Scotland Yard. Traffic was monitored via cameras and traffic light settings were changed for morning rush and off peak 24 hours

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Figure 5.9: Still from Ash and Boney, *The Computer Programme*, episode 1 (20:41), 'It's Happening Now', aired 11th January 1982, on BBC Two.

per day.⁵⁹ Operators also manually adapted settings at the console to speed the flow of traffic (see figure 5.10).⁶⁰

Next, Gill continued with another use for computers related to cars in episode seven with the job of a car accident investigator such as Tom

59. For an example of another CCTV installation monitoring traffic, see Jeffrey Gnehm, Jonas Hochberg, and Gökçe Kaya, *Freie Fahrt dank CCTV*, 2021, <https://dronetv.lu/en>. The Dronetv.lu digital exhibition curated by postdoctoral researcher Anne-Katrin Weber researched uses of televisions outside the home.

60. *The Computer Programme*, episode 2, 'Just One Thing After Another', directed by Frank Ash and Matt Boney, aired 18th January 1982, on BBC Two. https://archive.org/details/the_computer_programme_ep02.



Figure 5.10: Still from Ash and Boney, *The Computer Programme*, episode 2 (15:47), 'Just One Thing After Another', aired 18th January 1982, on BBC Two.

Rivensdale to model the situation of a car accident in reverse in order to determine the speed of each car during a collision. The reporter moved from the scene of a hypothetical accident to the office of the investigator where the statics of each car were displayed on the computer screen. After inserting measurements from the scene of the accident, it appeared that the surviving driver lied about his speed and the speed of the other car and did indeed cause the accident.

Mac also introduced a car example, showing a self-driving BMW in episode nine to explain the function of computer chips in cars. The board

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computer used sensors to indicate when an oil change or service was needed, or prevented wheels from locking in case of an emergency break. Chips in cars thus provided information, controlled safety, and could help save petrol by monitoring fuel consumption.⁶¹

Continuing the topic of computers running behind the scenes of people's everyday lives, in the fifth episode Gill shows how the timetable of British Rail at Waterloo station was automatically compared to real time information, announcing delays to commuters. The project of designing a bus map given to design student Magda from the Royal College of Arts was Gill's computer user example for episode six. Together with programmer Brown Smith her goal was to draw parallel lines on a map for busses travelling the same parts of a route. Figure 5.11 shows Magda and Brown at work.⁶²

First, the roads had to be digitised and then Brown's program would draw parallel lines on the computer. However, "the simplest looking problems take the longest time" and the project took two months rather than one day as Brown estimated. In the end, Gill showed the bus map of the West of Scotland which Magda designed.

Part of the interview with Brown Smith was added after the closing credits where he reflected on other types of computer uses for artists. Aside from using the computer as a tool to draw pictures on a screen, it also helped artists deal with concepts. In other words, the computer made artists reflect on their decision-making process by forcing them to break down their work process into ever smaller steps and sets of computer instructions.

As Mac introduced the topic of data retrieval in episode four, he was seated in the science section of the British library to discuss the mass of information stored in seven buildings and containing 85 000 books.

61. *The Computer Programme*, episode 9, 'In Control', directed by Matt Boney and Frank Ash, aired 8th March 1982, on BBC Two. https://archive.org/details/the_computer_programme_ep09.

62. *The Computer Programme*, episode 6, 'Moving Pictures', directed by Frank Ash and Matt Boney, aired 15th February 1982, on BBC Two. https://archive.org/details/the_computer_programme_ep06.



Figure 5.11: Still from Ash and Boney, *The Computer Programme*, episode 6 (09:53), 'Moving Pictures', aired 15th February 1982, on BBC Two.

Such large amounts of paper did not only pose storage problems, but also caused retrieval issues. With the help of a librarian, Mac then consulted the computer index of the British library as shown in figure 5.12. Firstly, the library terminal connected to the database by dialing the correct number on a rotary-dial telephone. The librarian then typed keywords and checked how many references resulted from the index. Only after pairing down the search to a manageable number of titles were the results printed out, followed by detailed information of a single item in the collection.⁶³

63. *The Computer Programme*, episode 4, 'It's On The Computer', directed by Frank

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Figure 5.12: Still from Ash and Boney, *The Computer Programme*, episode 4 (08:59), 'It's On The Computer', aired 1st February 1982, on BBC Two.

In episode four, Gill illustrated the use of data sets in hospitals. Before the system was operational, food needed to be ordered from the menu 24 hours in advance, resulting in up to 20% of food going to waste because some patients were already sent home the following day. By computerizing the process, Gill could order on the same day leading to less food waste. An optical card reader read the menu cards to transfer the information to a microcomputer. The computer was shared between staff members in the office and could generate shopping lists and prices

Ash and Matt Boney, aired 1st February 1982, on BBC Two. https://archive.org/details/the_computer_programme_ep04.

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(a) Episode 4 (14:56)



(b) Episode 4 (16:07)

Figure 5.13: Stills from Ash and Boney, *The Computer Programme*, episode 4, 'It's On The Computer', aired 1st February 1982, on BBC Two.

as well as invoices for patients and staff as demonstrated in the images of figure 5.13. Food was cooked in batches per ward as Gill showed inside the kitchen, meaning it arrived fresh at precise times during the day. This system was introduced at the Queen Alexandra hospital in Portsmouth in 1979 and provided a great return on investment.

Another example of computer applications in the health sector was the medical expert system shown in episode eight and tested at the Saint-James hospital in Leeds where a patient was interviewed about symptoms and medical history by a research assistant, or in other cases by a doctor, nurse, or medical student. She collected patient information and entered the data into the microcomputer. The program then compared symptoms with other patient data and predicted a diagnosis which was printed out for the doctor to check. Although the man designing the system was aware of people who believed “the computer should be made to try and think like a doctor,” he considered the doctor as the focal point of the program because only he had the full picture and could make the final decision. The designer repeatedly gendered the doctor as male, and the nursing sister as female.⁶⁴

64. *The Computer Programme*, episode 8, 'The Thinking Machine', directed by Matt

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One of Gill's final examples of computers used in daily life lead her to visit a sewage plant where Portsmouth polytechnic engineers were experimenting to optimize the environment for microorganisms playing a key role in the purification process. The difficulty was converting analog signals for a motor controlling a floppy pipe managing the flow of sewage to digital signals using expensive interface units, whereas the computer itself was cheap (see figure 5.14). The Total Organic Carbon Analyser to measure the efficiency of microorganisms was also expensive. "Researchers in Portsmouth hope for huge financial savings if they can process more sewage faster, without a drop in the quality of the end product." As Chris concluded the segment he remarked "a personal computer providing a real public convenience."

Many examples of computers impacting daily lives focused on transport, health, or utilities. These were application domains in which computers played a role long before the introduction of the microcomputer. What the television program does convincingly convey though is that although we may not directly use the computer, they still influenced situations in daily life profoundly even during the 1980s. Presumably, these examples were less threatening to the envisioned casual viewer.

1980s perspectives on the past, present, and future of computing

Finally, *The Computer Programme* lends itself to both a textual and visual discourse analysis concerning the history of technology, the way in which both presenters and users anthropomorphise the computer, the future of computers and their influence on existing occupations as envisioned during the 1980s. Although the historical examples of computers featured throughout the television series are neither accurate nor in and of itself valuable to my particular research, they illustrate trends in the history of technology and provide a perspective on the role of computers common to the 1980s.

Boney and Frank Ash, aired 1st March 1982, on BBC Two. https://archive.org/details/the_computer_programme_ep08.

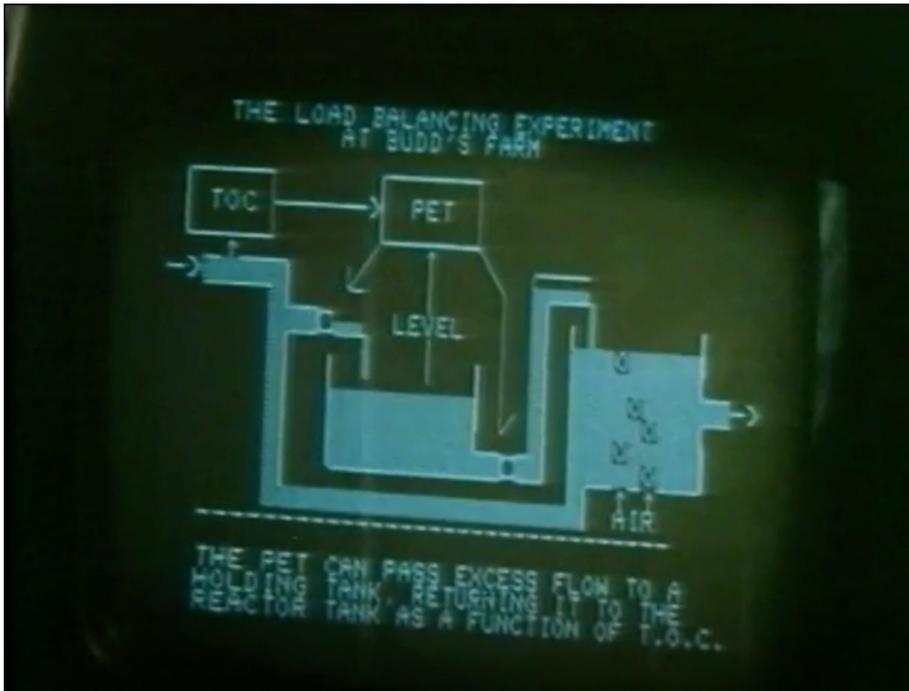


Figure 5.14: Still from Ash and Boney, *The Computer Programme*, episode 9 (10:51), 'In Control', aired 8th March 1982, on BBC Two.

Evolution or revolution? The Computer Programme's historical discourse.

Fitting into the national discourse and continuous history of technology debate, Chris ended the introduction of the first episode with “don't expect the computer revolution to happen tomorrow, it's happening now.” In 1988 historian of computing Michael Mahoney critically examined the analogy of “the microcomputer as an object of mass consumption” and “software systems as objects of mass production.” Both analogies stress the notion of a computer “revolution as profound as that triggered by the automobile,” and Ford's Model T in particular. The historical concept of revolution however warrants precaution since the new emerges from

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the old and remains “embedded in the worlds of science, technology, industry, and business which structured computing.”⁶⁵ In the final episode Chris reflected on the computer revolution as he walked down a city road in the following monologue:

Doesn't really look as if there's a revolution going on, does there? In fact, everything seems perfectly normal, as if the world has always been like this, but it hasn't. The world our grandparents were born into was a very different place and yet it's amazing how quickly people can adapt to change.⁶⁶

The generational gap between potential computer users and their perceived competence in computer literacy was obvious from the assumptions made by Aubrey Singer, Managing Director of BBC Television in the introduction of *Towards Computer Literacy*. In August 1983 he believed there was “a generation gap. The young are ahead of the old. The world of computers is rapidly becoming the province of the schoolchild and the young adult.”⁶⁷ The results of the broadcasting research study however did not indicate a lack of interest from an older audience. In fact people aged 45 years and older made up 48% of viewers.⁶⁸ Thus although Chris emphasised the notion of revolution through a generational comparison, the older generation was not necessarily behind on the times so to speak. The juxtaposition of normal and change yet again invoked a sense of revolution. However, Chris did not question the human ability to adapt to change.

The historical examples counteract the discourse of change somewhat by focusing on principles that remained stable throughout history. After the title sequence, the first episode of *The Computer Programme* began with sunrise at Stonehenge tracing back the origin of computers to pre-

65. M. S. Mahoney, “The History of Computing in the History of Technology,” *Annals of the History of Computing* 10, no. 2 (April 1988): 14, <https://doi.org/10.1109/MAHC.1988.10011>.

66. *The Computer Programme*, episode 10.

67. Radcliffe and Salkeld, *Towards Computer Literacy*, 4.

68. Radcliffe and Salkeld, *Towards Computer Literacy*, 47.

historic times. Mac explained the reasoning behind such a far-fetched connection between microcomputers and a large prehistoric stone structure.

For many centuries man has searched for tools to help him with complex calculations. [...] Recently a theory has emerged that [Stonehenge] was built 5000 years ago as a complex astronomical computer to calculate the movements of the sun and the moon.⁶⁹

The theory was published first by astronomer Gerard Hawkins in *Nature* in 1963. Thus the visual reference to Stonehenge that struck me in the announcement of IBM's System/360 fitted with the popular and at the time recent research of professor Hawkins, which was furthermore calculated using an IBM 704. Archaeologists even at that time have questioned his findings, thus to state that Stonehenge was an astronomical computer in the introduction of a 1981 television series without questioning the theory relies more on popular opinion rather than continued scientific debate.⁷⁰

Although Mac recognized how far-fetched such a comparison to 1950s large scale computers seemed, he mentioned several similarities: "very few people understood how they worked," both systems became redundant, and one application of computers bears a similar function to Stonehenge, instead of predicting the seasons, computers were still used to predict the weather.

Several computer exhibitions at museums have traced the history of computing back at least 2000 years. The first example is *Revolution: The First 2000 Years of Computing* at the Computer History Museum (CHM) developed in 2011.⁷¹ The exhibition at the Heinz-Nixdorf museumsForum

69. *The Computer Programme*, episode 1.

70. Mike Pitts, "Gerald Hawkins: Astronomer who claimed Stonehenge was a Computer," *The Guardian*, July 2003, chap. Higher Education, <http://www.theguardian.com/news/2003/jul/24/guardianobituaries.highereducation>.

71. *Revolution: The First 2000 Years of Computing*, accessed April 22, 2021, <https://computerhistory.org/exhibits/revolution/>.

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(HNF) opened in 1996 similarly traced computer concepts back to antiquity.⁷² At the Deutsches Museum (DM) the *Informatik* exhibition dating back to 1986 started from analog calculators.⁷³

The key error of historic interpretation in labeling Stonehenge as an astronomical computer and then comparing it to 1950s computers results from a teleological interpretation of events that anachronistically places the origin of technology in a context of time and place in which no such concept or tool existed. Lucien Febvre labels anachronistic interpretation as the capital sin of any historian.⁷⁴ According to Lorenz' classification of anachronisms, Mac's Stonehenge example commits the capital crime of factual anachronism in combination with an anachronism of language in which people "use contemporary vocabulary in order to describe and understand past phenomena."⁷⁵

Several other historical examples cited throughout *The Computer Programme* trace the history of computing back to the use of punch cards in different contexts. In the second episode, Mac moved from a mechanical violin or *violano-virtuoso* which played when you inserted a nickle and was driven by a roll of paper to punch cards and eventually the jacquard loom (figure 5.15). Mac then explained the principle of the jacquard loom that is often linked to computing. Information was stored on punched cards where holes would result in threads being lifted, generating a different weaving pattern for each card which corresponds to the binary system used by computers.

In the third episode, another musical instrument driven by punch cards was introduced by Mac at a reenactment fair for steam engines: the steam

72. *Vorgeschichte des HNF*, accessed April 22, 2021, <https://www.hnf.de/das-hnf/vorgeschichte.html>.

73. *Mathematische Instrumente und analoges Rechnen*, accessed April 22, 2021, <https://www.deutsches-museum.de/ausstellungen/kommunikation/informatik/analoges-rechnen/>.

74. For a more extensive review of the concept of anachronism in historiography, see Georgi Verbeeck, "Anachronism and the Rewriting of History: the South Africa case," *The Journal for Transdisciplinary Research in Southern Africa* 2, no. 1 (April 2006): 181-185, <https://doi.org/10.4102/td.v2i1.314>.

75. Verbeeck, "Anachronism and the Rewriting of History," 184-185.

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(a) Episode 2 (09:23)



(b) Episode 2 (09:51)

Figure 5.15: Stills from Ash and Boney, *The Computer Programme*, episode 2, 'Just One Thing After Another', aired 18th January 1982, on BBC Two.

organ. Next, Chris and Mac were exploring the British Science Museum's annex and listening to computer music from a Ferranti computer. When Chris asked Mac about the similarities between the steam organ and the Ferranti computer, Mac explained that instructions on punch cards were simply replaced by ferrite cores on boards.⁷⁶ Actual punch card machines were only introduced in episode four with a 40-column card sorter from Powers-Samas. Mac explained how it functioned using the example of an age analysis for the United States census.

In episode five on new media, Mac took viewers on a visit of a reconstructed Western village dressed up like a cowboy where he listed changes in communication. From mail by mule train taking fifty-three days, to stage coach introduced in 1858 taking only twenty-three days between San Francisco and St. Louis, followed by a pony express service for urgent messages taking six and a half days for 3,000 miles, he ended the list with the telegraph. The telegraph "revolutionised commu-

⁷⁶ *The Computer Programme*, episode 3, 'Talking To A Machine', directed by Matt Boney and Frank Ash, aired 25th January 1982, on BBC Two. https://archive.org/details/the_computer_programme_ep03.

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nications” and its principles had “hardly changed over the last 150 years.” Again Mac emphasised continuity rather than change.

Science Fiction and Anthropomorphising the Computer Aside from the notion of the computer revolution and the discourse of a deterministic history of technology, a third theme emerging from the television series is illustrated by a monologue from Chris in the third episode on programming languages.

I suppose the most daunting thing about computers is this business of communicating with them. There’s the machine, and I’m supposed to talk to it. I say talk but it’s more a matter of writing it little notes, you type little memos into it.⁷⁷

He identified interacting with the computer as daunting for non-experts like himself and alternated between communication discourse of talking with and writing to the machine. It almost seems as though the computer is another actor in the social interaction on equal footing with the human user, two entities engaged in a conversation. In the same decade sociologists introduced Actor-Network Theory which considers artefacts as “active social actants endowed with a history and a collective career (...).”⁷⁸ In a network actants, whether human or artefact are independent mediators of events which are “neither completely a cause nor a consequence.”⁷⁹ Continuing this discourse, Chris explained the concept of languages as computer experts call them, but immediately adds that “they don’t seem much like any language we humans speak,” thus the user never forgets they are “talking to a machine.”

77. *The Computer Programme*, episode 3.

78. Bruno Latour, “Social Theory and the Study of Computerized Work Sites,” in *Information Technology and Changes in Organizational Work: Proceedings of the IFIP WG8.2 working conference on information technology and changes in organizational work, December 1995*, ed. Wanda J. Orlikowski et al., IFIP Advances in Information and Communication Technology (Boston, MA: Springer US, 1996), 301, doi:10.1007/978-0-387-34872-8_18, https://doi.org/10.1007/978-0-387-34872-8_18.

79. Latour, “Social Theory,” 304.

As Mac explained the concept of programs, the attribution of a human-like conscious to the machine is illustrated through both a visual and textual discourse. First, to illustrate that a program is always checking keyboard activity, the camera was positioned inside of the computer filming both presenters staring into the lens through the computer screen (figure 5.16). Chris then rephrased Mac's explanation in his own words as "so deep down in this machine's subconscious, implanted there is the message 'Make A on the screen.'" The word subconscious thus implies that Chris attributes humanoid characteristics to the machine.

Donna Haraway's *Cyborg Manifesto* references science fiction's "hybrid of machine and organism, a creature of social reality as well as a creature of fiction" in the context of socialist-feminist culture and theory.⁸⁰ The concept of cyborg rooted in science fiction helps explain the crucial boundary breakdowns between animal-human (organism) and machine noticeable in the television series discourse. According to Haraway, machines - and in this case microcomputers - blur "the difference between natural and artificial, mind and body, self-developing and externally designed (...). Our machines are disturbingly lively, and we ourselves frighteningly inert."⁸¹

The link between computers and science fiction was never far away, since at the end of episode four on data retrieval, Rex Malik expressed his concern that soon an "electronic big brother" from administration would be able to access data fast, easy, and cheap. He suggested the creation of laws, customs, and procedures to prevent data from falling in the wrong hands or being misused. "What worries me is not that Big Brother will get it right, but that he will get it wrong," Rex said, explaining a twenty year old principle of "garbage in, garbage out."

Gill Nevill's interview with Brown Smith in episode six made the discourse of the anthropomorphic computer most explicit. He explained

80. Donna Haraway, "A Cyborg Manifesto. Science, Technology, and Socialist-Feminism in the Late Twentieth Century," in *Sex / machine: readings in culture, gender, and technology*, ed. Patrick D. Hopkins, The Indiana Series in the Philosophy of Technology (Bloomington: Indiana university press, 1998), 434.

81. Haraway, "A Cyborg Manifesto," 437.

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Figure 5.16: Still from Ash and Boney, *The Computer Programme*, episode 3 (07:21), 'Talking To A Machine', aired 25th January 1982, on BBC Two.

that the program would “suddenly zoom off to the side and have its lunch and come back again.” As a result, some of the programmers felt the urge to “thump it if it wasn’t going to work right.” I believe many people still recognize the feeling of wanting to throw their computer out of the window or smash it when it seems to taunt us. However, as Brown understood, the mistake in the program was his responsibility. The computer merely executed his instructions. Despite his self-reflexive reaction of realising how he anthropomorphised the computer, he still considered the computer to be his pupil. “As it made each mistake we learned how to make it do better, and in essence taught it what of course we were doing,

[which] is teaching ourselves.”

At the start of episode eight as Chris was trying to solve a Rubik’s cube, he reflected on the ideal computer which would be able to solve a problem by itself. Or with another reference to popular computer discourse, the type of computer “they write about in science fiction stories: the thinking machine.” In the same episode Chris and Mac discuss a naughts and crosses game where the computer learned from experience. Mac believed that the advantage computers had over humans in this learning process, was that the computer had “a capacity of never forgetting anything once it’s been told.” The notion of forgetting implies a human error of the brain, a form of memory loss or simply human nature. Learning by being told also invokes a classic classroom setting of a teacher speaking and a pupil listening. Again the constant comparison between computers and humans continued.

As Chris analysed the goal of computer scientists “to create machines which think like people do,” I wondered: Do people anthropomorphise machines because they project themselves onto machines, or because computer specialists purposely design computers to reflect human intelligence? According to professor Roger Shank from the university of Yale the latter answer is correct. During the interview he explained that the first goal was for computers to “mimic human being,” and eventually build computers that surpassed human intellect. Interestingly, the opposite reasoning arose from his research as his respect for human capabilities grew while trying to equal human intelligence.

In *A (Very) Brief History of Artificial Intelligence* professor emeritus Bruce C. Buchanan explains the relation between artificial intelligence (AI) and “philosophy, fiction, and imagination.” While intelligent machines from a philosophical perspective serve “as a literary device to help us define what it means to be human,” science fiction writers create “the fantasy of intelligent non humans” and allow readers to reflect on their own human characteristics. Computers are used in AI as experimental devices to understand intelligent thought with the famous Turing test evaluating

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whether a program behaves intelligently or not.⁸²

A postgraduate student of professor Shank explained the difficulty of interpreting text for a computer. Chris read out the quiz questions posed to the program to see “that the machine has in some way understood what’s been fed into it.” Although these programs were “capable of understanding within limited domains,” as professor Shank discussed, they could not “talk about everything” or “have opinions on life.” The philosophical or all-knowing computer did not exist in the 1980s, but the idea of developing intelligent machines had been around for almost half a century. Vannevar Bush’s essay *As We May Think* suggested modeling a hypothetical machine called a Memex in parallel to the functioning of the human mind, through association.⁸³

When Gill asked Mr. Tim Dedomble whether he considered his expert program predicting the medical diagnosis of patient to be artificial intelligence, he made the most direct reference to science fiction yet. He did not consider his program to be artificial intelligence, based on a comparison to two science fiction characters he did consider to have artificial intelligence (Big Brother from the book *1984* by George Orwell - whom Rex Malik also referenced earlier, and Hal from the science fiction book and movie *2001: A Space Odyssey* which came out in 1968). Instead, he compared his program to R2D2 in *Star Wars* “whose function was simply to carry information to the right point at the right time and enable the people concerned to make a winning decision.”

The Future of Computing and Occupational Segregation Finally, *The Computer Programme* clearly tried to address people’s concern regarding the effect of computers on existing occupations. At the end of episode five Chris predicted that computers would change our everyday life resulting in people working from home, shopping and banking via the terminal. Rex Malik did not expect computers to supplant what came before.

82. Bruce G. Buchanan, “A (Very) Brief History of Artificial Intelligence,” *AI Magazine* 26, no. 4 (December 2005): 53-56, <https://doi.org/10.1609/aimag.v26i4.1848>.

83. Vannevar Bush, “As We May Think,” *The Atlantic*, July 1945, <https://www.theatlantic.com/magazine/archive/1945/07/as-we-may-think/303881/>.

Books and paper would not disappear, but their role would change. He believed the peopleless office to be an illusion saying that offices were needed “to fight, to argue, to discuss, to compete.”

Mac in turn used the agricultural revolution as a historical example of a technical revolution in the final episode. From oxen to horses ploughing the field under human direction to machines directed by few men cultivating vast amounts of land, the next step in the process would be for machines to work the land without human direction. He deduced that as a general rule in the productive industry the “introduction of automation reduces the workforce but allows for greater flexibility of manufacture.” In other words, Chris concluded the following: “Wherever there is a repetitive job to be done, even one involving considerable skill, somebody will devise a machine to do it better, cheaper, and faster.”⁸⁴

Contrary to Gill’s assertion that some skilled jobs such as dairy farming would continue to require the human touch, Chris listed the advantages of a microcomputer over human labour based on its lower cost, higher reliability (“it never forgets”), long working hours, and low power consumption (less than a 60 watt light bulb), whereas humans needed light and heating while working. He ended the monologue with computer vocabulary I encountered in the previous chapter as well: “In other words, it’s the perfect slave.” The difference with the reference to master-slave relations in the Digital Equipment Company (DEC) manual is that Chris is not discussing the relationship between computer components, but rather the computer as a slave of the employer, and by extension the employee as replaceable by the computer. If I were to extend this argument further, the underlying idea is that an employee merely serves an employer in a master-slave relationship. The question is, does computer jargon reflect human relationships, or has it started to shape them?

Rex criticised the job of women sorting payment slips in the clearing centre and was glad to see this particular type of job disappear since he considered people “too precious a resource to waste on mechanical work” and believed other jobs to be more fulfilling for the employee and

84. *The Computer Programme*, episode 10.

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“of greater worth to society.” Information handling was thus not fulfilling nor very useful to society according to Rex. In fact he went as far as to quote Norbert Wiener and thus answering my previous question. “Any labour that accepts comparison with slave labour, accepts the conditions of slave labour and is essentially slave labour.”⁸⁵ Computer specialists thus considered certain types of labour, and in this case an occupation that was particularly gendered female, as slave labour which should be replaced by computers.

Charles Lekt, chairman of the Advanced Computer Techniques Corporation in New York thought tasks done by office workers were better done by machines and believed this type of work to be “dehumanizing their daily existence by asking them to do things, to be at a place they don’t want to be, at a time they don’t want to be there, to do what they don’t want to do.” But if tasks could be done by a computer, then people could create. “Man’s future will be enormously dignified by the employment of tools to improve his productivity and to decrease cost.” Thus Charles considered tasks that could be passed to computers dehumanizing when done by people, thus reversing the perspective of people who anthropomorphized the computer to the computer tasks as dehumanizing to humans. He believed offices and office hours were preventing office workers from creating. In his view very few jobs would survive, but the jobs that would survive were more creative.

The Computer Programme’s discourse regarding the computer revolution invoked the sense of urgency reflected by government initiatives and *The Computer Literacy Project* as a whole. Historical examples and references to science fiction, as well as the anthropomorphizing of computers fitted into the popular discourse of the 1980s. What concerned me most was the discourse regarding the negative consequences of computers on occupations which the presenters emphasized especially for female-dominated occupations. In reality, it would take quite some time before people could receive their BBC Micro. Furthermore, the computer itself found its way into schools rather than business.

85. *The Computer Programme*, episode 10.

5.1.2 From launch to delivery and eventually success

Launch

In February 1981 Acorn won the bid and started the development and production of the BBC Microcomputer System. The BBC anticipated a minimum demand of 12,000 microcomputers during the three initial transmissions of *The Computer Programme*. In fact, the first transmission needed to be postponed from November 1981 to January 1982 “to ensure that the machines would be ready by the launch of the television series.” The programming language BASIC was only finalized in September and the first users within the BBC were eagerly awaiting the computer. The television production team needed to plan demonstrations for studio recordings by November, and the project editor needed a BBC Microcomputer to produce the user guide and develop the software demonstration. By November 1981 the microcomputer was “demonstrated at various exhibitions, and extensively reviewed in the technical press,” leading to many inquiries for the Broadcasting Support Services (BSS). In addition, late night transmissions of the television show aimed at a more general audience were postponed by another five weeks to alleviate an unexpectedly high number of orders from favourable early reviews, the high specification, and the DTI Micros in Schools scheme which provided first secondary, then primary schools with BBC Micro model A computers at a reduction of 50%. Other educational users were given priority through the Microelectronics in Schools program since “many schools and colleges had planned the television series into their timetables.” By Christmas 1981 12,000 BBC Microcomputers were ordered through cash post before the television program even aired. In January 1982 50 journalists were invited to the launch of the project where sixteen microcomputers displayed the Welcome Package demonstrating software.⁸⁶

Unfortunately only a few months after the launch of the BBC Microcomputer Acorn and BBC Enterprises needed to announce a price increase.

⁸⁶. Radcliffe and Salkeld, *Towards Computer Literacy*, 16-17, 30-31. More information about both government schemes is provided in section 5.1.4.

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Due to “the need for particularly rigorous test procedures and various increases in component costs” the price for a basic model (A) increased to £299 from February 1982 onward and to £399 for the enhanced BBC Micro (model B), a price increase of £64.⁸⁷ Although the Acorn spokesman attributed the price increase to improvements made, the original price of two hundred pound sterling before taxes was far below market value.⁸⁸

Delivery Issues

By Christmas 1981 the first 69 BBC Micro’s model A were delivered to schools through the DTI, whereas 535 were originally scheduled for 23 November. Furthermore, 1000 microcomputers were meant to be distributed on 30 November for the BBC priority list but by February 1982 they still hadn’t arrived. As a result education courses were postponed. The particular component that caused delays was “the uncommitted logic array-chips supplied by Ferranti” which failed quality control in larger tests.⁸⁹ “Production would only reach 1000 per week by the end of January 1982. Furthermore, the 12,000 outstanding orders placed as early as the beginning of November could only be cleared by the end of March 1982.”⁹⁰

Beebug magazine’s first editorial in April 1982 explained the dire situation as follows:

Far too many would-be users suffer the frustrating experience of having waited up to 7 months for a machine, only to discover when it finally arrives that it doesn’t actually work. This

87. Press release, ‘BBC Microcomputer to cost more’, 27 January 1982, folder R103/113/1, BBC Microcomputer Acorn Computers Ltd Part 1, BBC Written Archives Centre, Reading (hereafter cited as BBC Microcomputer); John Radcliffe, memorandum, ‘BBC Continuing Education Television. The BBC Microcomputer System. Some Further Questions Answered’, 24 February 1982, folder R103/113/1, BBC Microcomputer.

88. David Graham and Sheridan Williams, “Editorial,” *Beebug* 1, no. 1 (April 1982): 3.

89. Donald Grattan to McNichol, ‘BBC Micro-computer’, 2 February 1982, folder R103/113/1, BBC Microcomputer.

90. Press release, ‘BBC Microcomputer to cost more’, 27 January 1982, BBC Microcomputer.

has happened to a number of our members, whose general experience was that faulty machines were not replaced with any great haste⁹¹

As the delivery delays were harmful to the reputation of the BBC despite the fact that Acorn and its suppliers were held responsible, two temporary staff members were hired by the BBC to handle complaints and restore their reputation.⁹² Furthermore, the use of the BBC name by a marketing house appointed by Acorn was questioned by some of the customers as a way to “hide behind the name of the BBC” while providing a dissatisfying service. Whereas the contract clause preventing Acorn from using their own name in advertising was meant “to prevent them exploiting this BBC connection to gain broader, gratuitous benefit.”⁹³

By May 1982, the delay for BBC Micro model B computers had risen to twenty-one and a half weeks with 12,585 outstanding orders. The backlog of Model B computers could have far reaching consequences to the BBC: “the bad P.R. would continue, the D.O.I. scheme may not include the BBC Micro in primary schools, a user base of 53,000 machines would be inadequate to support the publication of a range of software, the dealer network might suffer and the use of BBC Basic looked vulnerable.”⁹⁴ By the end of May 1982, Acorn had finally found a third manufacturer in the United Kingdom and was negotiating the final contract. Furthermore, this manufacturer would deal with orders from educational customers for a small number of model computers including disk and network interfaces.⁹⁵

91. Graham and Williams, “Editorial,” 3.].

92. John Harrison to Sheila Innes, ‘Late Delivery of the microcomputer’, 8 March 1982, folder R103/113/1, BBC Microcomputer.

93. Michael Harrison to G.G. Del Medico, ‘BBC Microcomputer System’, 22 March 1982, folder R103/113/1, BBC Microcomputer.

94. Jean Nunn, minutes, ‘Informal Notes of the Special Meeting convened by C.E.B to discuss the BBC Microcomputer’, 1 June 1982, folder R103/113/1, BBC Microcomputer.

95. Minutes, ‘Notes of a Meeting with Acorn Computers Ltd. in London on Friday 28th May 1982 to Discuss Progress of the BBC Microcomputer’, 1 June 1982, folder R103/113/1, BBC Microcomputer.

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Customer relations were handled by three different companies. The Broadcasting Support Services (BSS) of the BBC were responsible for providing information about the Computer Literacy project, sending “out a range of literature, including a brochure and order form for the computer.”⁹⁶ The BBC Micro was accompanied by a welcome cassette and more software from BBC Publication would follow in June 1982 starting at £10 each.⁹⁷ BL Marketing would receive the orders and answer “enquiries regarding delivery dates,” whereas Acorn was supposed to handle “requests for additional information about the computer.”⁹⁸ However, Acorn could not handle the unexpected amount of correspondence and phone calls.

By 12 May 1982 the BBC was worried about the future of the project for several reasons. Not only did the BBC Micro show “an unwelcome rate of failure,” but “the Acorn follow-up service appears unreliable.” Given the BBC’s involvement with a new television series underway and the software under development at BBC Publications as well as future income for Enterprises, an urgent meeting was scheduled to decide on “substantial remedial action.”⁹⁹ Regaining the trust of customers required “good hardware and software for some years.” Despite all Acorn’s “faults, they are a brilliant design team,” so the BBC wanted to establish trust again and plan for the future.¹⁰⁰

By the end of May 1982 the weekly orders from the BBC Micro had dropped from 1,000 to 800 a week, “a reduction undoubtedly due to adverse publicity, and the fact that we have not been able to authorise Acorn to advertise while the backlog is so large.” The delivery of Model B’s was

96. Tom Wymer to Donald Grattan, ‘BBC Micro: Customer Relations’, 6 May 1982, folder R103/113/1, BBC Microcomputer.

97. John Harrison, memorandum, ‘BBC Microcomputer’, 11 May 1982, folder R103/113/1, BBC Microcomputer.

98. Tom Wymer to Donald Grattan, ‘Customer Relations’, 6 May 1982, BBC Microcomputer.

99. Donald Grattan to Bryon Parkin, ‘BBC Micro-computer: BBC Software: BBC Computer Literacy’, 12 May 1982, folder R103/113/1, BBC Microcomputer.

100. David Allen, memorandum, ‘BBC Microcomputer’, 7 May 1982, folder R103/113/1, BBC Microcomputer.

most impacted by the backlog, resulting in a delay of 18 weeks. Legally, the BBC was allowed to end the collaboration with Acorn and find another manufacturer. In practice, the corporation did “not own the design of the microcomputer, nor [did they] contribute substantially to its development.” Thus, by combining “diplomacy and pressure,” the enterprise hoped to convince Acorn to accept the plan suggested by the BBC and a consultancy firm.¹⁰¹

By the second half of June 1982 the BBC analysed several consultancy reports and suggested action points to improve the relationship with Acorn. Given the “serious weaknesses” in Acorn’s production of the BBC Micro, the BBC proposed to appoint two engineers “to inspect the operations of the factories, to maintain quality control including component quality and test facilities, and monitor production against forecast.” Furthermore, BBC Enterprises wanted to be involved in negotiations with sub-contractors and to include “penalty clauses and time-schedules” in these contracts. In terms of development, an “updated specification for the Microcomputer, and full design specifications of the add-on units” were urgently needed in combination with “detailed planning charts.”¹⁰² Acorn had “no objection the BBC being involved and party to general information about the developments and financial matters” in relation to the BBC Microcomputer but rejected a full financial analysis. As for installing a Project Controller, Acorn was already in the process of hiring someone, albeit with even more responsibility and “access to financial information.”¹⁰³

The matter of replying to technical inquiries was still a point of debate but Acorn did accept the regular detailed progress information. In fact, Acorn felt that given the high number of technical enquiries which

101. David Allen, John Radcliffe and Roy Williams, memorandum, ‘BBC Computer Literacy Project. Relations with Acorn Computers Ltd’, 20 May 1982, folder R103/113/1, BBC Microcomputer.

102. John Radcliffe, memorandum, ‘BBC Microcomputer System. Development, Production and Distribution’, 20 July 1982, folder R103/113/1, BBC Microcomputer.

103. Donald Grattan, minutes, ‘Microcomputers: Discussions with Acorn’, 17 August 1982, folder R103/113/1, BBC Microcomputer.

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were time consuming to respond to and the BBC's further advertisement to the micro and its peripherals in the second TV-series of the Computer Literacy project, the BBC should take responsibility for the majority of enquiries.¹⁰⁴ Enterprises finally did allow advertising of the BBC Microcomputer in the United Kingdom starting from the middle of September onward. However, by the time Acorn was catching up with the development of peripherals such as the teletext receiver deemed of key importance to distribute software the roles were reversed. BBC's Designs Department wanted Acorn to stall production so that the BBC could "produce the tele-software."¹⁰⁵

In another consultancy report from Deloitte, BBC Enterprises examined its own role in the project. A draft of the report mentioned that the BBC failed to adequately assess market potential. A mistake which could have been prevented with "a detailed market research survey." In hindsight the original estimate of 12,000 microcomputers rose spectacularly to a demand of around 100,000 microcomputers. Furthermore, despite working with third parties, the report points out that "in the eyes of the public, [BBC Enterprises] is responsible for all projects with which it is associated."¹⁰⁶

Enterprises continued to worry about "Acorn's financial status" since the company owed the BBC £300,000 and had asked the BBC "to guarantee the cost" of advertisement in Radio Times worth £19,000, which Enterprise refused.¹⁰⁷ BBC Publications went as far as to refuse "any further supplies of either the User Guide or the Welcome Pack until settlement of outstanding invoices" was completed.¹⁰⁸ Acorn owed Pub-

104. Donald Grattan to John Radcliffe, 'BBC Microcomputer: Technical and Other Queries', 19 August 1982, folder R103/113/1, BBC Microcomputer.

105. F. Gordon Parker to Bryon Parkin, 'BBC Microcomputer System', 6 October 1982, folder R103/113/1, BBC Microcomputer.

106. Deloitte, report, 'The BBC Microcomputer Project Draft', n.d., folder R103/113/1, BBC Microcomputer.

107. Jon Holmes to Donald Grattan, 'Acorn', 11 October 1982, folder R103/113/1, BBC Microcomputer.

108. R.C.S. Chown to Jim Merriman, 12 October 1982, folder R103/113/1, BBC Microcomputer.

lications “£246,821.75 of which £235,051.75 is overdue” for material supplied between June and September 1982. In order to avoid further delays BBC Publications agreed to continue supply, but was unwilling to retroactively lower its prices and only willing to discuss future prices.¹⁰⁹ On 16 May 1983 BBC Publications reached an agreement with Acorn concerning the licensing of the Welcome Pack and the User Guide for the BBC Microcomputer for 40p a piece. The BBC still retained the right to “request editorial changes” and quality control, as well as the right to continue printing and selling the User Guide and Welcome Pack itself.¹¹⁰

Success

By June 1983, roughly two and a half years after the launch of the BBC Micro, Acorn had “manufactured and sold over 100,000 machines.” Aside from the royalty of the BBC Micro, Enterprises generated additional income through sales of the *Computer Book* and were bound to generate more money “providing applications software packages” and publishing Telesoftware through BBC Publishing.¹¹¹

BBC profit from the sale of the machine amounts to £2 ½ m at present. Worldwide sales of the two television series are expected to generate a further £200,000 by the end of 1983. Sales of books and software in the financial year ending in March 1982 have produced a profit of £250,000 for BBC Publications.¹¹²

Interestingly, the future policy did not stress the need for additional or improved hardware but rather considered that “the greatest incentive

109. John Holmes to D.F., ‘Acorn Computers Ltd.’, 15 November 1982, folder R103/113/1, BBC Microcomputer.

110. John Holmes to Hermann Hauser, ‘Welcome Pack and User Guide for the BBC Microcomputer’, 16 May 1983, folder R103/113/1, BBC Microcomputer.

111. Memorandum, ‘Future Policy for Microcomputer Hardware and Software Developments’, 9 May 1983, folder R103/113/1, BBC Microcomputer.

112. Memorandum, ‘Future Policy’, 9 May 1983, BBC Microcomputer.

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to sustain and extend the sale and use of the hardware at home and overseas is a good software library.” Software had “concentrated on the ‘home’ market,” however “60% of secondary and 80% of primary schools” bought the BBC Micro through the MEP. Since the BBC had received funding to develop educational software, this became a priority in particular to “support and extend educational broadcasts.”¹¹³ By September 1983 the BBC had “published 9 software packs” which ought to generate “a net sales revenue of £1,213,000” with eleven additional packages underway “with a projected revenue of £580,000.” Furthermore, the BBC planned to develop fifteen software packages for schools.¹¹⁴

Funding from the DTI and the DES had contributed to “research and evaluation of programmes, consultancy, software development (both for Publications and Telesoftware), the Computer Referral Service, Publicity and Information, and Education Officer and Telesoftware posts.” Still, funding only “represented less than 10% of the £2.9 million profit made by BBC Enterprises.”¹¹⁵ Two years after the first deliveries of the BBC Microcomputer more than 200,000 had been dispatched by 6 November 1983.¹¹⁶ By January 1986 the 500,000th BBC Microcomputer would be presented at a BBC Microcomputer System Exhibition.¹¹⁷

5.1.3 The Beeb

The BBC Microcomputer System was also known informally as the Beeb. Although I initially assumed that the nickname referred to the noise the microcomputer makes when it switches on, the etymology of the word

113. Memorandum, ‘Future Policy’, 9 May 1983, BBC Microcomputer.

114. John Holmes, memorandum, ‘Future Policy for the Microcomputer: Software’, 26 August 1983, folder R103/113/1, BBC Microcomputer.

115. Donald Grattan to Bryon Parkin, ‘The Future of the BBC Microcomputer: BBC Software and Telesoftware’, 7 June 1983, folder R103/113/1, BBC Microcomputer.

116. John Radcliffe to Donald Grattan, ‘BBC Microcomputer System’, 28 November 1983, folder R103/113/1, BBC Microcomputer.

117. Bob Coates to John Harrison, 10 October 1985, folder R103/101/1, Acorn Computers BBC Master Series Micro - Exhibition and Launch, BBC Written Archives Centre, Reading.

mentioned by Merriam-Webster traces the first use of the noun Beeb back to 1967 before the microcomputer even existed. Beeb was first used as an informal shorthand for the BBC.¹¹⁸ The nickname Beeb as used for this section is clear from the title and first editorial of the *Beebug* magazine in April 1982, where Beeb refers not to the BBC as such, but to the BBC Microcomputer System in particular.¹¹⁹

This section centres around the microcomputer itself, from its inception as part of the *Computer Literacy Project*, to the prototype and leaflet announcing the computer. The first part (5.1.3) is all about the design phase and the two companies that collaborated to produce the microcomputer.¹²⁰ Since much attention has gone to the BBC's role in the project already, this section will look into Acorn's history answering how it amassed the capital, personnel, and resources to design and produce the computer based on interviews with founders and Acorn's BBC Micro design team.

The second part (5.1.3) moves to the purchase, installation and use phase of the life cycle, discussing configured user types based on supporting materials, as well as the demographics of the people who bought the BBC Microcomputer System initially. After a review from *Beebug* magazine which illustrates the struggles and positive experience of early adopters, the technical descriptions provide a quick insight into the system components.¹²¹

Finally, the user guide details the process of setting up the computer and shows the difficult balancing act between reassuring novices while at

118. *Beeb*, accessed April 18, 2021, <https://www.merriam-webster.com/dictionary/Beeb>.

119. Graham and Williams, "Editorial."

120. *BBC Microcomputer System*, September 1981, <https://web.archive.org/web/20200919202928/https://clp.bbcrewind.co.uk/media/bbc-microcomputer-system.pdf>.

121. David Graham and Sheridan Williams, "Brief review of the BBC Microcomputer," *Beebug* 1, no. 1 (April 1982): 5–7; *BBC Microcomputer System Technical Specification*, Issue 3, ed. R.T. Russell (BBC, September 1981), pp. 30–31, folder R103/113/1, BBC Microcomputer; *BBC Microcomputer System. Technical Description*, (BBC, September 1982), folder R103/113/1, BBC Microcomputer.

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the same time keeping expert users interested in section 5.1.3. Finally, some of the pedagogical techniques and examples from *The Computer Programme* discussed earlier (section 5.1.1) found their way into the user guide.¹²² This section thus delves into research questions such as: How was the BBC Microcomputer designed and who was it targeting? Who could afford the microcomputer and how was it set up? How did the computer function and what was it used for?

The Miracle of a Working Prototype

In the development phase of the *Computer Literacy Project*, the team realised the potential of microcomputers for their cheap price which meant that the audience could explore computer principles demonstrated in the studio on their own machine. They recognized the use of microcomputers in various applications in education, for practical use and entertainment at home, and as a cheap tool for data processing in small businesses. Existing microcomputers did not meet the requirements of the project, so the team set a list of requirements in terms of hardware and software aimed at educational use in particular. The ideal computer for the project would need to be affordable, user friendly and a good learning instrument, with a memory capable of supporting practical programs, with attractive graphics and sound, and the potential to expand.¹²³ Most microcomputers had installed BASIC as a popular programming language for beginners. The language thus fit with the new demographic microcomputers appealed to.¹²⁴

Although the *Computer Literacy Project* team agreed on BASIC in principle, they criticised the lack of a software standard and wanted a well-designed and structured version of the language to present in the televi-

122. John Coll, *BBC Microcomputer System User Guide*, ed. David Allen (Cambridge: Acorn Computers Ltd., October 1984), <https://web.archive.org/web/20200919202949/https://clip.bbcrewind.co.uk/media/BBCUserGuide-1.00.pdf>.

123. Radcliffe and Salkeld, *Towards Computer Literacy*, 13.

124. *The Computer Programme*, episode 3, 'Talking to A Machine', directed by Matt Boney and Frank Ash, aired 25th January 1982, on BBC Two. https://archive.org/details/the_computer_programme_ep03.

sion show, books, courses, and to install on the microcomputer linked to the project. In the end, BASIC expert Richard Russell collaborated with senior engineer David Kitson from the BBC Engineering Designs Department to define the language specification for BBC BASIC. The language needed to be approachable to the layman and structured so as “to encourage good practice in programming, but (...) powerful enough to be developed in the future.”¹²⁵ Because no existing machine met requirements, BBC Enterprises made the “radical step of having a machine specially developed for the project” with advice from the engineering department.¹²⁶

Acorn was included as one of the potential BBC Microcomputer System manufacturers.

[...] [They had a] proven track record of building rack-based machines for research laboratories and a reputation for producing reliable single-board machines. It had experience of manufacturing large numbers (having sold around 10,000 units of their Atom) and it was well known to be working on a successor machine, known as the Proton.¹²⁷

The Archives of IT organisation in the United Kingdom has interviewed Acorn’s co-founders, Hermann Hauser in 2018 and Chris Curry in 2016. Hauser grew up near Tyrol in Austria and first visited Cambridge to learn English at summer school. He obtained a degree in physics from the university of Vienna and returned to Cambridge first to work on his PhD in the Cavendish laboratory, and then as a research fellow in 1976.¹²⁸ Chris Curry was two years older and born in Cambridge taking “A’levels in Maths, Physics and Further Maths,” but choosing a Diploma of Technology rather than a university education to start working sooner. He even-

125. Blyth, *The Legacy of the BBC Micro*, 12.

126. Radcliffe and Salkeld, *Towards Computer Literacy*, 14.

127. Blyth, *The Legacy of the BBC Micro*, 12.

128. Hermann Hauser, interview by Richard Sharpe, April 26, 2018, transcript, Archives of IT, Offices of the Amadeus Capital, <https://archivesit.org.uk/interviews/dr-hermann-hauser/>.

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tually started working at Sinclair Radionics in 1966 as an engineer. He explained he would put Clive Sinclair's ideas into practice and "lay the printed circuit board out, test the components, put it all together in a kit suitable for selling mail order," and Sinclair would advertise the product. Eventually Curry left Sinclair's company to set up a consultancy called the Cambridge Processor Unit Ltd. (CPU Ltd.) in 1977 together with Hauser whom he met in bars, building products to order for the industrial market, starting with processors for a gaming machine.¹²⁹ Without any official business plan, their vision was to participate in the microprocessor industry.¹³⁰

Hermann Hauser was introduced to computers by the Cambridge University Microprocessor Group (CUMG) and became interested in the microprocessor industry.

Computers until then [...] had to live in an air-conditioned room and were only accessible to PhD students or professors, and you had to have special permission to use a computer. [In the Cambridge University Microprocessor Group] you could build one yourself and use it yourself. [...] Ordinary people with an interest in computing, could buy a microprocessor and build a sort of home brew kit, and compute.¹³¹

Hauser understood computing because of his basis in mathematics, but his main role in the CPU Ltd. and later Acorn was to find passionate, gifted people who were able to produce products and software, and keeping them motivated.¹³² He found many people either volunteering time in exchange for computer parts or actually employed by the company through the CUMG and the Cambridge Computer Lab. Acorn was formed in 1978 to cater to the consumer market with the Atom single board com-

129. Christopher Curry, interview by Alan Cane, April 26, 2016, transcript, Archives of IT, WCIT Hall, <https://archivesit.org.uk/interviews/christopher-curry/>.

130. Hauser, interview by Richard Sharpe.

131. Hauser, interview by Richard Sharpe.

132. Hauser, interview by Richard Sharpe.

puter.¹³³ Stephen (Steve) Furber had occasionally worked for Acorn and had already developed designs for the next Acorn machine called the Proton which formed the basis for the BBC Microcomputer prototype.¹³⁴

Christopher Curry had set up a meeting with the BBC to show a prototype of what became the BBC Microcomputer despite the fact that Steve Furber was not convinced they could possibly develop a prototype within a week. Hauser motivated Sophie Wilson by stating that Steve thought it was possible, to which she eventually replied “if Stephen is in, I am in,” and vice versa.¹³⁵ Sophie Wilson transitioned in 1990 and still went by the name Roger Wilson when she started working for CPU Ltd. and later Acorn as one of the first official employees. She had met Hauser at CUMG while she was studying mathematics at Cambridge University. Because she failed her second year, she switched to a one year computer course while working for Hauser because of her experience in building machines and designing her own circuitry for her personal home computer.¹³⁶ Steve Furber had studied mathematics at Cambridge University and had finished a PhD and a research fellowship at Emanuel College before officially joining Acorn in September 1981 to develop the BBC Microcomputer further. When he agreed to work on the prototype he was still employed as a research fellow, but was already involved with CPU Ltd. and Acorn during his PhD after meeting Hauser at CUMG.¹³⁷

Steve Furber had started sketching the Proton with a dual processor, the 6502 circuit for front end input/output (I/O) processing, and a second processor to improve computing capabilities. Only the first processor was originally included in Acorn’s proposal to the BBC with the op-

133. Curry, interview by Alan Cane.

134. Hauser, interview by Richard Sharpe.

135. Hauser, interview by Richard Sharpe.

136. Sophie Wilson, interview by Dough Fairbairn, January 31, 2012, transcript, CHM Oral History Collection IMLS Grant, Computer History Museum, <https://www.computerhistory.org/collections/catalog/102746190>.

137. Steve Furber, interview by Thomas Lean, 2012, *An Oral History of British Science*, The British Library, University of Manchester, <https://www.bl.uk/voices-of-science/interviewees/steve-furber>.

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tion to expand the computer at a later stage.¹³⁸ According to Wilson the two processor design came about because Curry and Hauser wanted the Proton to serve the hobbyist and home computer market, whereas Andy Hopper preferred a workstation. Prototyping for the BBC started on Monday morning, with Furber mostly “drawing out the schematic of the BBC machine.” Simultaneously the team was obtaining all parts including the only four high-performance Hitachi direct random-access memory (RAM) 48/6 chips in the country which served both the processor and the display controller. By Wednesday the “nightmare of building the thing, hundred-chip machine” was underway and Hauser had asked Ramanuj Banerjee, an expert from the Cambridge Computer Lab, to wire wrap the prototype which took until Thursday night. Wilson remembers that the prototype still wasn’t working on Thursday evening, but she went home at two in the morning to get some sleep. When she came back at eight am on Friday, Hauser had suggested to cut an umbilical cable to the emulator which somehow resolved the issue an hour earlier. Wilson found the team sleeping on the floor, but the BBC Microcomputer prototype was working. She then had only three hours before the BBC team arrived to adapt the “Acorn operating system to run on this new hardware, bootstrap BBC Basic, get a basic interpreter running on it,” and program the cathode-ray tube (CRT) controller to display a random line on the screen.¹³⁹

Acorn convinced the BBC team with a prototype developed in under a week by a team including Hermann Hauser, Christopher Curry, Steve Furber, Sophie Wilson, and Chris Turner who “worked three days and two nights non-stop to put a working prototype together.”¹⁴⁰ When the BBC arrived, “BASIC was running, with real programs, and by the afternoon some graphics were working too.”¹⁴¹ Steve Furber added that the box to hold the prototype was also designed by Friday which allowed the visi-

138. Furber, interview by Thomas Lean.

139. Wilson, interview by Dough Fairbarn.

140. Blyth, *The Legacy of the BBC Micro*, 13.

141. Blyth, *The Legacy of the BBC Micro*, 13.

tors to get a better impression of the finished product.¹⁴² Chris Curry believes it was Andy Hopper's Econet design which worked on Acorn's Atom computer that convinced the BBC in particular, because it would allow teachers to take over a pupil's machine and write on their computer.¹⁴³ Steve Furber's comment puts this claim into perspective, since very few schools could afford a classroom full of BBC Microcomputers. When they did upgrade from one computer to several computers, the network and file servers did become more important.¹⁴⁴ Aside from the impressive prototype, the BBC appreciated Acorn's "can do" attitude and got along well with the team even going for drinks afterwards.¹⁴⁵

Steve Furber recognized that having the BBC name attached to an Acorn computer greatly improved their previous reputation as a small Cambridge start-up creating interesting machines for hobbyists. However, their start-up identity was reflected in their "unique culture that allowed the transfer of ideas into and out of the company." In fact, many people such as Furber were loosely associated with Acorn before being employed by the company.¹⁴⁶

The Learning System

In September 1981 a short leaflet describing the BBC Microcomputer system was released. The system plan illustrated the differences between Model A and Model B as well as options for expansion. The computer itself consisted of a built-in keyboard, power supply, and speaker connected to the input/output processor. Users could connect to their domestic television or a video monitor, and use an audio cassette recorder to load or store programs and data.¹⁴⁷ Some options were only available for model B including analogue inputs connecting laboratory equipment

142. Furber, interview by Thomas Lean.

143. Curry, interview by Alan Cane.

144. Furber, interview by Thomas Lean.

145. Blyth, *The Legacy of the BBC Micro*, 13.

146. Blyth, *The Legacy of the BBC Micro*, 19.

147. *BBC Microcomputer System*, 2.

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as well as “games-paddles or joysticks.” Other peripherals such as R/G/B/Sync colour monitors and printers could also be connected to Model B computers without soldering in additional components. At any time the BBC Microcomputer Model A could be expanded to a Model B.¹⁴⁸

Other internal expansions available at purchase or afterwards by a dealer were the floppy disk interface, the Econet network interface, circuits for voice synthesis, and an interface to attach read-only memory (ROM) for high-level languages or for computer-aided design (CAD) and Word Processing software. Aside from paddles, a cassette recorder, and monitors and televisions, two types of disk drives and printers, and a Teletext or Prestel acquisition unit could also be plugged directly into a BBC Microcomputer provided that the correct interfaces were installed. Finally, two types of external second processors could add 60 K of RAM. In the software description, the leaflet further emphasised the BBC *Computer Literacy Project's* desire to set a standard for BASIC by suggesting that this version would be “very close to the Microsoft standard” with extensions. Applications under development were very diverse ranging from educational (Computer Assisted Learning, Engineering Training, and Primary School), to entertaining (Games, Musical compositions), and from practical business applications (Financial modelling, Income Tax, VAT) to scientific applications (Astronomical predictions).¹⁴⁹ The Econet network was intended for schools and colleges to share printers and a disk file server which were expensive. The network could also be useful in offices and businesses and could connect up to 254 computers through telephone cables over a maximum distance of one kilometre. Furthermore, network users could exchange messages, view the screen of others or be prevented from interacting.¹⁵⁰

The success of supporting materials for the BBC Microcomputer System illustrates the configured user the BBC aimed to reach through the *Computer Literacy Project*. An important organisation contributing to the

148. *BBC Microcomputer System*, 5.

149. *BBC Microcomputer System*, 6-7.

150. *BBC Microcomputer System*, 8.

high demand for the BBC Microcomputer System was the NEC. This Cambridge based correspondence college coincided their *30-hour BASIC* course with the transmission of the television series. The NEC sold 100 000 copies of the handbook in the first nine months, and included around 2000 schools and colleges supporting the course. The User Guide written by John Coll from Acorn and edited and published by David Allen from the BBC in consultation with the BBC Continuing Education Advisory Council was aimed at the computer novice and attempted to provide “a systematic instruction on how to use the machine.” To appease and interest the more experienced users, the guide explained BASIC enhancements and extensions. *The Computer Book* was used extensively in schools and colleges and mostly useful for beginners. Finally, *The Computer Programme* was aimed primarily at adults, but “it was used in many schools, both to introduce younger pupils to computers and as revision material for pupils taking General Certificate of Education Computer Studies at Ordinary Level and Advanced Level.”¹⁵¹ In short, supporting materials were geared towards different users, but three configured users jump out. First and foremost, the entire project was geared towards education, and targeted students from secondary schools and at college level. The BBC also distinguished between two other types of users based on their level of experience: novices and experienced users, or students at different levels of education.

Initially, the BBC Microcomputer System was targeted at the home-user rather than schools. “In 1982, the main user of the machine tended to be middle-class men, who were under 45, and had some previous experience of using computers.”¹⁵² The postal survey from a systematically selected sample of BBC Microcomputer owners furthermore discovered most users bought the computer to learn how it worked, but also “for entertainment purposes and as a hobby.” This preference was also reflected in the most popular applications software programs (games, drawing and word processing).¹⁵³ The Micros in Schools scheme launched

151. Radcliffe and Salkeld, *Towards Computer Literacy*, 19-20, 32-34.

152. Blyth, *The Legacy of the BBC Micro*, 20.

153. Vivian Harles, memorandum, 'The Computer Literacy Project: An Evaluation',

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by the DTI did increase the school market for the BBC Micro and by October 1983, 25% of BBC Microcomputers were purchased by schools compared to 35% for home use and 40% going to business users.¹⁵⁴ When defining the future policy, the BBC noticed that the main market for software were not only home users, but school users in particular.¹⁵⁵

The hardware specification written by R.T. Russell from BBC's Engineering Designs Department was published around the same time the first leaflet appeared and listed requirements for Acorn as well as underlining the intended or configured user. The case needed to be 40 cm wide and deep and 6 cm tall using injection moulded thermoplastic, a technique and material still in use today. Since the BBC Microcomputer was sent to customers by mail, the case needed "to withstand rough handling in transit." The technical specification also kept in mind the demonstrations in the studio of the television series by demanding that ventilation allowed for continuous use at 35°C. As mentioned earlier, the BBC *Computer Literacy Project* and Microcomputer System were aimed at home users. The BBC engineer thus demanded that the case was fitted with non-slip, non-scratch feet for "use in a domestic environment (on polished furniture etc.)." Unlike many computers today, BBC Micro owners were encouraged to look inside so any internal parts connected to the mains needed to be inaccessible and sharp edges were avoided.¹⁵⁶

November 1982, folder R103/140/2, BBC Microcomputer Acorn Computers Ltd. Part 3, BBC Written Archives Centre, Reading (hereafter cited as BBC Microcomputers).

154. Blyth, *The Legacy of the BBC Micro*, 20-21. See also John Radcliffe, report, 'Future Policy for the BBC Microcomputer: Report of the Technical Study Group - October 3rd 1983', 4 October 1983, folder T62/233/1, Computer Literacy Project, BBC Written Archives Centre, Reading.

155. J. Holmes, memorandum, 'Future Policy: Software', 26 August 1983, BBC Microcomputer.

156. *Technical Specification*, pp. 30-31, BBC Microcomputer.

157. Sytze Van Herck, *BBC Microcomputer System Model B*, Centre for Computing History, CH182, May 16, 2018.



Figure 5.17: BBC Microcomputer System Model B at the Centre for Computing History in Cambridge.¹⁵⁷

A Hands-On Approach

In a user experiment conducted by the researcher in 2018 and 2019 testing the BBC Micro and Apple *IIfx* computers still running and accessible in the CCH and the Media Archaeology Lab (MAL), some noted a sense of nostalgia towards the noisier, haptic experience of the keyboard. The hardware specification explicitly states that the BBC Microcomputer detected when keys were pressed at 2,5 mm, but total key travel was up to 5 mm which is almost double the distance of key travel on laptop key-

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boards today.¹⁵⁸ Combined with the ideal angle where the top rows were slightly higher than the bottom rows (see figure 5.17), the minimum requirement according to BBC Engineering was that the keyboard needed to be “acceptable to a professional typist.” The final recommendation bearing in mind the user once more, was to make the keyboard “resistant to liquid spills and cigarette ash.”¹⁵⁹ With smoking at home and in the office still acceptable during the 1980s, this recommendation provides another glimpse into the user’s habits.

The first review in *Beebug* magazine mentioned that the BBC Micro’s “exterior looks good; the keyboard feels good,” and noting “no noticeable keybounce.”¹⁶⁰ The look and feel would probably be judged differently in comparison with current computer design (see figure 5.17). Fortunately the messy printed circuit boards had improved, however the power supply connections with tape preventing shorts were crude and the supply could become quite hot.¹⁶¹ Furthermore, Acorn originally stored the temporary operating system on erasable programmable read-only memory (EPROM) which they offered to replace for free with a factory programmed permanent ROM. However, *Beebug* magazine suggested their readers to wait for version 1.0 of the operating system which was supposedly two times faster than version 0.1 but did increase the heat of the power supply unit. Another practical issue was the placement of the phono socket to connect the TV which was “too low for the hole,” making the plug difficult to insert. Sometimes keys would also hit the keyboard surround and finally, *Beebug* suggested adding a lid to the hole for program cartridges to prevent accidentally dropping things in the machine.¹⁶²

158. For a full discussion of what defines the feel of a keyboard, see <https://www.popularmechanics.com/technology/design/a18550/the-science-of-making-a-great-keyboard/>.

159. *Technical Specification*, pp. 31-32, BBC Microcomputer.

160. Graham and Williams, “Brief review of the BBC Microcomputer,” 6.

161. I also experienced this during my visit to the Centre for Computing History and the user test there.

162. One of the guides in the Centre for Computing History in Cambridge explained that schools were particularly worried about children poking their fingers inside and getting stuck or hurting themselves. Graham and Williams, “Brief review of the BBC Microcom-

Despite a lack of proper structure for the 16k BASIC programming language installed on the machine, *Beebug* magazine was rather pleased with the overall “set of reserved words.” Programming must have been rather repetitive because bulk editing or loading program sections in sequence from tape was impossible. In terms of graphics the BBC Micro could only display seven different colours, but users could define graphics themselves although they could not select the graphics and text size independently from the list of graphics modes. The reviewer was impressed by the sound and the possibility of the software controlling the pitch and amplitude, but the audio was very noisy and many users complained. Saving and loading cassettes was easy and fast at 1200 bits per second data transfer rate (baud), but the motor control was inconvenient for rewinding the cassette. Overall the review concluded that Acorn and BBC had “done a good job.”¹⁶³

An updated technical description of the BBC from September 1982, described the firmware consisting of the “BASIC language interpreter” which lists all commands as well as the hardware description of all components and keyboard layout including key codes.¹⁶⁴ The BBC Micro eventually measured 41.2 cm x 35 cm x 7 cm high in a “cream coloured case with black coloured keyboard.” Openings allow a user to connect various peripherals and allow for ventilation. A printer could only be used for a BBC Micro model B when the cassette recorder was disconnected. The “teletext receiver/datagrabber” too could only connect to model B. The computer supported 8 visual display unit (VDU) screen formats.¹⁶⁵

When the BBC Microcomputer System first shipped, it included a provisional manual which didn’t impress most users. In fact, many suggested to split the user guide into a machine guide and a programming manual. Users did appreciate the lay-out and tone of the provisional user guide, but requested that the introduction, functions, and facilities were expanded to include more details. Setting the system up also required

puter,” 6-7.

163. Graham and Williams, “Brief review of the BBC Microcomputer.”

164. *Technical Description*, BBC Microcomputer.

165. *Technical Description*, pp.30-36, BBC Microcomputer.

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more information and guidance from the manual. For the programming manual users wanted full explanations, flow charts, examples, and application ideas.¹⁶⁶ Although the user guide was not split into two manuals by 1984, the section on setting the system up seemed extensive and some program examples were certainly included.

By October 1984 Acorn had taken over from the BBC in amending, correcting, and printing the user guide. The user guide began with a list of warnings concerning the setup and ideal environment for the BBC Microcomputer. Aside from warning users to earth the computer, the guide recommended keeping the microcomputer away from direct sunlight or moisture. The user guide explained how to set up the system with a cassette recorder and run the WELCOME programs. The section on “Giving the computer instructions” consisted of two parts. The first part aimed at beginners and the second part followed a similar structure for the more experienced user. The reference section occupied most of the *User Guide* with 170 pages listing BASIC keywords in alphabetical order in a very similar layout to the DEC manual discussed in chapter 4. For expert programmers, the section included chapters on the Operating System and assembly language.¹⁶⁷

The BBC Microcomputer System came with a *User Guide*, WELCOME package, and guarantee registration card. One cable for connecting the microcomputer to the television was included, but the user needed to purchase a separate the cable to connect the microcomputer to an ordinary cassette recorder.¹⁶⁸ If the user had a high quality monitor available, they would need another cable as well.¹⁶⁹ The *User Guide* centered around programs in the WELCOME pack or listed exemplary programs, but referred users to other software “linked to hobbies and games, and programs for use in the home, in business, and in education.”¹⁷⁰

166. V. Harles, memorandum, 'The Computer Literacy Project: An Evaluation', November 1982, p.6, BBC Microcomputer.

167. Coll, *BBC Micro User Guide*.

168. Coll, *BBC Micro User Guide*, 1.

169. Coll, *BBC Micro User Guide*, 3.

170. Coll, *BBC Micro User Guide*, 2.

Once users had plugged in the necessary cables to power and connect the BBC Microcomputer and monitor, the computer could be switched on at the back. Immediate user feedback was provided in the form of “a short ‘beep’ and the red light marked caps lock.”¹⁷¹ Once the computer was switched on, the television could be turned on to warm up and a spare channel needed to be tuned to the computer on channel 36.¹⁷² Once set up, the manual encouraged users to press all buttons, adding “you can’t do it any harm at all.” Usually the error message “mistake” would appear which meant that “the computer does not understand your commands. It’s fault - not yours!”¹⁷³ These instructions were clearly meant to encourage experimentation and minimize fear for first-time computer users. Furthermore, the computer was depicted as robust yet stupid, and responsible for misunderstanding the user. After free experimentation, the *User Guide* gave clearer instructions on how to clear the screen and test out some commands for drawing lines and testing the sound. Again, users were reassured “don’t worry if you make a mistake - it really doesn’t matter!”¹⁷⁴

Next, users could connect the cassette recorder to load programs from the WELCOME pack cassette. First, the correct cable needed to be plugged into the microcomputer and cassette recorder. Second, much like tuning the television set, the volume needed to be set correctly.¹⁷⁵ Some recorders played the tapes on loudspeaker resulting in screeching noise. The proposed solution was to somehow disable the speaker.¹⁷⁶

Novice users were not expected to have experience with computer keyboards, but the writer did suppose that those who had used a typewriter before would recognize most of the keyboard layout on the BBC Microcomputer. Absolute novices were reassured as well because they didn’t need “to be a touch typist to work with the computer” and a pro-

171. Coll, *BBC Micro User Guide*, 3.

172. Coll, *BBC Micro User Guide*, 3-5.

173. Coll, *BBC Micro User Guide*, 5.

174. Coll, *BBC Micro User Guide*, 5-6.

175. Coll, *BBC Micro User Guide*, 7.

176. Coll, *BBC Micro User Guide*, 10.

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gram for practicing was available on the WELCOME cassette.¹⁷⁷ A confusing feature on the BBC Microcomputer caused some symbols to be displayed differently from those on the keyboard since screen mode 7 used the Teletext standard rather than ASCII to display characters.¹⁷⁸

The *User Guide* explained the difference between commands which were executed immediately and series of numbered instructions or statements forming a program that could be stored and run.¹⁷⁹ Sample programs in the *User Guide* needed to be typed in accurately and were meant for users to become familiar with the keyboard and build up a library of programs if stored on cassette afterwards.¹⁸⁰

The graphics of the BBC Microcomputer were by no means comparable to the graphical user interfaces we have gotten used to over the past three decades. The screen modes were defined by the number of colours available (two colours for modes 0 and 4, four colours in modes 1, 2, and 5), the resolution (high for modes 0, 1, and 4 or medium in mode 2 and 5), whether they permitted graphics or text-only (modes 3 and 6), and the amount of memory required for the screen mode (16K for modes 0 to 3, 8K for modes 4 to 7).¹⁸¹ Graphics for drawing lines and triangles used X and Y coordinates to determine the position of a point on the screen.¹⁸² In text-only modes no graphics windows could be included, but in mode 5 for instance, part of the screen could be assigned to text or graphics using windows.¹⁸³

The BBC Microcomputer could “produce notes spanning five full octaves,” and controlled the sound by setting amplitude, pitch, and duration.¹⁸⁴ Analogue input was useful for game controls such as four paddles or two joysticks. Paddles looked like the volume control of a record

177. Coll, *BBC Micro User Guide*, 11.

178. Coll, *BBC Micro User Guide*, 14.

179. Coll, *BBC Micro User Guide*, 15.

180. Coll, *BBC Micro User Guide*, 30.

181. Coll, *BBC Micro User Guide*, 137.

182. Coll, *BBC Micro User Guide*, 46.

183. Coll, *BBC Micro User Guide*, 47.

184. Coll, *BBC Micro User Guide*, 155.

player and moved objects on the screen in two directions, whereas joysticks could move from left to right, and up or down. The second and more serious use of analogue input measured voltages from transducers to monitor “temperature, light intensity, smoke density, water pressure, gas concentration, etc.”¹⁸⁵

Much like *The Computer Programme* which was aimed at adults in the first place, the manual reassured the adult novice that “learning to use the computer is a little like learning to drive a car.” Although the sample programs might be “bewildering at first,” with experience “the various pieces of the jigsaw puzzle should begin to fall into place.”¹⁸⁶

The chapter on print formatting clearly distinguished between what Andreas Fickers has called expert and amateur users by adding a section “for the more technically minded.”¹⁸⁷ The manual also commented on a specific feature for users with previous experience stating that the ability to superimpose characters resulting in bold text, was “not normally available on ‘personal’ computers.”¹⁸⁸ In another chapter a paragraph “for the slightly more advanced” explained best practices for programmers.¹⁸⁹ Thus, an advanced user was considered a good programmer. The *User Guide* praised the integration of procedures in BASIC. “These powerful features enable the user to structure his or her programs easily and in addition provide a real introduction to other computer languages like PASCAL.”¹⁹⁰ Not only does this statement emphasise the ease of use, but it suggests that BASIC provides an ideal learning opportunity for the novice user to move to other programming languages. The discourse further illustrates that the manual did not assign a particular gendered pronoun to the user or programmer whereas other manuals for previous case studies often specified the gender of certain users such as programmers or operators.

185. Coll, *BBC Micro User Guide*, 459.

186. Coll, *BBC Micro User Guide*, 30.

187. Coll, *BBC Micro User Guide*, 60.

188. Coll, *BBC Micro User Guide*, 64.

189. Coll, *BBC Micro User Guide*, 85.

190. Coll, *BBC Micro User Guide*, 87.

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The GOTO statement provided the writer with another opportunity to distinguish between beginners who “find it easy to use,” and experts who believed this practice led to “spaghetti” programming. Experts write more structured programs avoiding such statements unless for handling error conditions.¹⁹¹ In this case, the distinction encouraged beginners to follow what experts considered good practice. In fact, an entire chapter on good practice in programming centered around the trade-off between execution speed and program size. Saving precious memory space by reducing the program size often reduced readability.¹⁹²

The distinction between novice and expert continued in the reference guide’s list of BASIC keywords. The structure of keyword descriptions contained parts “intended for the novice user and others for the person who is familiar with BASIC.” Next to the actual keyword the derivation was briefly explained, followed by “a plain-English description” of its purpose for the beginner. After an example, the actual description used “normal computer jargon.”

Finally, one chapter was meant for programmers using “more advanced facilities such as definition of graphics and text windows” or writing “other high level languages or machine code programs.”¹⁹³ The distinction between amateur and expert according to the user manual depended more on experience and practice, rather than education or occupation.

Several sample programs illustrated mathematical applications such as solving equations, calculating the square root, drawing polygons, and plotting a sine wave. One plot of a block diagram illustrated a business use to show changing prices over a twelve-month period. Not all example programs were for serious applications. In later chapters, users were taught how to program a game called hangman or a lunar landing game with the goal of “landing a ship on the moon.”¹⁹⁴

The discourse analysis reveals the configured user both literally and through descriptions of potential uses. For example, the use of variable

191. Coll, *BBC Micro User Guide*, 99.

192. Coll, *BBC Micro User Guide*, 168.

193. Coll, *BBC Micro User Guide*, 347.

194. Coll, *BBC Micro User Guide*, 116, 151.

was explained through the hypothetical task of calculating all wages in the company and storing each individuals' wage to determine the total wage bill.¹⁹⁵ The same example was expanded to explain the concept of a program for working “out the number of £1, £5 and £10 notes that you will need to pay the wages at the end of the week (...).”¹⁹⁶ The example of calculating “wages for a group of people” was used again to explain arrays and associated names.¹⁹⁷ The configured or envisioned user thus worked in a small business and was responsible for payroll accounting.

Some rare sections of the user guide provide a glimpse of the domestication of technology. For instance, users were encouraged to “wander off and have a cup of coffee” while the BBC Microcomputer was executing a program.¹⁹⁸ Perhaps less obvious, yet still illustrating a very practical concern was remembering where on the cassette a program was stored. The manual suggested keeping an index by using the tape counter and leaving gaps between programs to avoid overlap.¹⁹⁹ Another option was reading the entire tape and displaying a catalogue on the BBC Micro.²⁰⁰

The attribution of human characteristics to computers also occurred in the *User Guide*, similar to the anthropomorphisation of computers in *The Computer Programme* while discussing the use of the “panic button” or ESCAPE. “If the computer seems to be ignoring you because it’s too busy running a program. You can nearly always get its attention by pressing the ESCAPE key.”²⁰¹ This description depicts the computer as a concentrated person busy at work who needs to be interrupted to gain their attention.

Similar to comments made in *The Computer Programme*, the manual stated that “computers are fundamentally pretty stupid things,” with their

195. Coll, *BBC Micro User Guide*, 18.

196. Coll, *BBC Micro User Guide*, 20.

197. Coll, *BBC Micro User Guide*, 102.

198. Coll, *BBC Micro User Guide*, 20.

199. Coll, *BBC Micro User Guide*, 26.

200. Coll, *BBC Micro User Guide*, 28.

201. Coll, *BBC Micro User Guide*, 21.

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strength being repetition.²⁰² However, IF...THEN statements enabled “the computer to make a choice,” a concept explored in detail during the *Thinking Machine* episode of *The Computer Programme* and the main reason some users assigned a conscience to the computer resulting in anthropomorphizing the machine.²⁰³ The TRUE or FALSE statements led the writer to anthropomorphise the computer saying this method was useful “to fathom out what on earth the computer thinks it is doing!”²⁰⁴ By assuming that a computer has a self-awareness and can reflect on its own actions, the writer assigns it one quality that distinguishes human beings from others.

5.1.4 Micros in Schools

Since microcomputers played an important role in education starting in the 1980s, this section looks into the role of the British government in funding computers and determining a strategy to introduce students to this technology. Aside from the MEP and the Micros in Schools scheme, the role of the BBC liaison network and its Computer Referral Service are briefly discussed. Although many other government initiatives were started in later years, these were less directly linked to the BBC Microcomputer and thus fall outside the scope of this research. Finally, a survey by dr. Tilly Blyth from the Science Museum provides an insight into the experience of remembered users who used microcomputers in the 1980s. The research questions answered in this section centre around the accessibility of computers in schools in particular, and the training of teachers, as well as those in charge of developing educational software.

The British DES started the MEP in 1980 with an initial funding of £9 million pounds sterling.²⁰⁵ The program aimed “to help schools to pre-

202. Coll, *BBC Micro User Guide*, 74.

203. Coll, *BBC Micro User Guide*, 84.

204. Coll, *BBC Micro User Guide*, 86.

205. Tibor Vasko and Darina Dicheva, “Educational Policies: An International Overview,” *International Institute for Applied Systems Analysis*, September 1986, 6, <https://web.archive.org/web/20120531051641/http://www.iiasa.ac.at/Admin/PUB/>

pare children for life in a society in which devices and systems based on microelectronics are commonplace and pervasive.” Initial priority was given to students in further education between sixteen to nineteen years old. The MEP investigated how to use “the computer as an aid to teaching and learning, as a guide to the individual children, as a learning aid for small groups of children, or as a system involving the whole class.” The programme preferred the development of certain software applications such as mathematics, science, geography, and business, over others. Furthermore, the program also researched which topics to add to existing courses, and which disciplines to introduce to the curriculum.²⁰⁶ For instance, the MEP funded the existing national project started by the Schools Council called *Computers in the Curriculum*.²⁰⁷ At a regional level, fourteen regional centres coordinated MEP initiatives through Local Education Authorities (LEAs) with colleges and schools.²⁰⁸ Aside from curriculum development, the strategy outlined plans for teacher training.

In addition to short courses of between one and three days to create awareness and familiarise teachers with computers, the MEP suggested specialist courses of one week regarding new topics and three-month courses for teachers in particular disciplines such as science or craft and design or teachers wishing to develop computer-based learning materials. Furthermore, the program provided funds for training the trainers and supplied the equipment to regional centres. The MEP also advised other institutions regarding longer degree or diploma courses, such as an Open University course, or the BBC’s collaboration with the NEC to develop the 30-hour BASIC course.²⁰⁹ The NEC developed an adult distance-learning course based on the *30-hour BASIC* book to intro-

Documents/WP-86-052.pdf.

206. Richard Fothergill, *The Microelectronics Education Programme Strategy*, technical report (April 1981), <http://www.naec.org.uk/organisations/the-microelectronics-education-programme/the-microelectronics-education-programme-strategy>.

207. Fothergill, *MEP Strategy*.

208. Blyth, *The Legacy of the BBC Micro*, 25.

209. Fothergill, *MEP Strategy*.

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duce programming, even providing access to machines at local colleges for students.²¹⁰ The course appealed to employers who asked tutors to train groups of students at work. Although the distance learning course attracted a limited number of students, it served as the basis for courses at local colleges. The book sold between 150,000 and 250,000 copies by the summer of 1983.²¹¹

The final element of the MEP Strategy looked into the provision of microcomputers for schools, but decided against funding the “acquisition of equipment for general use in individual schools.”²¹² Instead, the DTI started the “Micros in Schools” project “to persuade every secondary school to buy a computer,” offering a 50 percent subsidy for “one of two British made microcomputers.”²¹³ In July 1982 the same scheme was expanded to primary schools for an estimated nine million pounds sterling. In addition, each microcomputer came with a free “self-instructional package for teachers, and about thirty software packages.”²¹⁴ On 13 December 1984, the Secretary of State for Trade and Industry was asked in parliament how many computers the *Micros in Schools* scheme funded and how much was spent. Overall, the scheme had cost £13.4 million so far funding 6,511 computers in secondary schools and around 26,000 applications from primary schools. The scheme did not only fund microcomputers, but also “monitors and printers and a range of peripheral equipment.” However, schools had also purchased additional microcomputers themselves averaging around ten microcomputers per secondary school, and around 1.8 microcomputers per primary school.²¹⁵ The timeline of the National Archive of Educational Computing suggests that eventually 27,295 primary schools received partial funding for a microcomputer, and that 4000 secondary schools were able to purchase additional equipment including memory upgrades, disk drives, an electronics box

210. Blyth, *The Legacy of the BBC Micro*, 26.

211. Blyth, *The Legacy of the BBC Micro*, 27.

212. Fothergill, *MEP Strategy*.

213. Vasko and Dicheva, “Educational Policies: An International Overview,” 8-9.

214. Vasko and Dicheva, “Educational Policies: An International Overview,” 9.

215. Parl. Deb. H.C. (6th ser.) (1984) cols. 553-4.

and a robot kit for the BBC Microcomputer.²¹⁶

The BBC also collaborated with the DTI's Micros in Schools scheme through their liaison network. BBC Education Officers built a network of educational agencies such as "colleges, adult centres, clubs, information services, and other organisations" which could help viewers with computer literacy. The BBC's Education Officer Robert Salkeld from Leeds introduced the project at regional meetings in March and April of 1981 receiving feedback from the educational sector concerning the TV series, software plans, and "the practicalities of providing local 'hands-on' experience." The key challenge was providing information and local contacts. BSS would answer postal enquiries and gathered a list of over 1000 local agencies "from adult centres to universities and computer clubs as referral points."²¹⁷

BSS created the Computer Referral Service using a database containing ten categories of who to turn to for information: "informal advice, beginner's courses, advanced courses, computer clubs, [British Computer Society (BCS)] branches, Acorn dealers, British Broadcasting Corporation Microcomputer user-groups, business consultancy services, courses for small business users, and in-service courses for teachers."²¹⁸ They also informed viewers of the BBC Microcomputer and associated software, books, and correspondence courses. In November 1981 regional directors of the MEP were fully informed about the *Computer Literacy Project*, familiarised with the BBC Microcomputer System, and planned seminars for staff in Regional Information Centres.²¹⁹

As the DTI was looking into possible suppliers for the "Micros in Primary Schools" scheme, they shared similar concerns about the "adequate production levels, timeliness of delivery, customer information provision and after sales service" Acorn could provide before including the BBC Mi-

216. *Timeline of significant events in the history of educational computing*, accessed April 22, 2021, <http://www.naec.org.uk/events>.

217. Radcliffe and Salkeld, *Towards Computer Literacy*, 22-23.

218. Blyth, *The Legacy of the BBC Micro*, 26; Radcliffe and Salkeld, *Towards Computer Literacy*, 25

219. Radcliffe and Salkeld, *Towards Computer Literacy*, 25.

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cro in the scheme. The DTI continued “to receive adverse feedback from Local Authorities, education advisers and individual schools.”²²⁰ As a result, the DTI encouraged the BBC the “strengthen Acorn’s management ability” by seeking “expert advise on a major appraisal of the company’s managerial structure.” The DTI felt “it would be difficult (...) to recommend the machine to our Ministers” unless the BBC could provide “evidence of a genuine attempt to improve Acorn’s performance.”²²¹

By 16 June 1982 faith in the BBC Micro had been partially restored for the DTI’s *Micro’s in Primary Schools* scheme. The main priority of the scheme was “to provide schools with a package which is complete, ready to plug in and use.” Focusing on what we now refer to as usability, a colour monitor was preferred for primary schools in particular.²²² Nevertheless, the DTI still needed Acorn’s assurance that by October 1982, when schools could apply for the scheme, delays in delivery would not exceed four weeks. In addition, the DTI imposed further safety standards in particular for the removal of the “ashtray” or opening on the back of the BBC Micro computer from the case and any other element of the design “to prevent potential damage via open sockets.”²²³

Recollections of Beeb Users

A survey by dr. Tilly Blyth into the *Legacy of the Computer Literacy Project* conducted between March and April 2012 with 292 completed questionnaires from entrepreneurs in digital or creative industries and people interested in the BBC Microcomputer provides some interesting insights.²²⁴ These results reflect the perception of remembered users 30 years after

220. Eric B. Bates to Chris J. Curry, 20 May 1982, folder R103/113/1, BBC Microcomputer.

221. Eric B Bates to John Radcliffe, 20 May 1982, folder R103/113/1, BBC Microcomputer.

222. Janet Morgan to Chris J. Curry, 16 June 1982, folder R103/113/1, BBC Microcomputer.

223. Bob Salkeld to Donald Grattan, 'Leeds, LEA, Acorn and the BBC', 18 June 1982, folder R103/113/1, BBC Microcomputer.

224. Blyth, *The Legacy of the BBC Micro*, 32.

using the BBC Microcomputer. For many respondents owning or having access to a BBC Micro in the 1980s positively influenced their future careers in software or app development.²²⁵ When asked what first interested them about computers, five themes emerged: from “a parent’s (usually the father’s) enthusiasm,” science fiction for showing the possibilities computing offered or simply highlighting the novelty of computers, to a sense of control and empowerment computers offered, and of course computer games.²²⁶ Most respondents used a computer for the first time in the 1980s (73,5%) either at home (53,8%) or at school (30,8%). However, access to computers was often limited at school. BBC Microcomputers were mostly used for programming (82,4%) and playing games (79,6%).²²⁷ Almost 90% had learnt to program, mostly in BASIC.²²⁸

A significant number of respondents were self-taught, relying mainly on magazines and instruction books. These resources were used whether they were learning at home or at school. When it was with other people, these tended to be friends, a parent or other close family member.²²⁹

Even those who had learned programming in school or at university, had still gained most experience by themselves.²³⁰ Programming at school was often difficult due to the lack of sufficient computers and protective teachers who often know less about programming than students.²³¹ Despite limited access to the BBC Microcomputer in schools and their high price, computers became accessible even outside of professional contexts. However, the BBC Microcomputer in particular became a symbol of status as a result of its high price. Furthermore, one respondent remembered having only three computers available for 1500 students. As

225. Blyth, *The Legacy of the BBC Micro*, 34.

226. Blyth, *The Legacy of the BBC Micro*, 36-37.

227. Blyth, *The Legacy of the BBC Micro*, 37.

228. Blyth, *The Legacy of the BBC Micro*, 41.

229. Blyth, *The Legacy of the BBC Micro*, 42.

230. Blyth, *The Legacy of the BBC Micro*, 42.

231. Blyth, *The Legacy of the BBC Micro*, 43.

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a result, the BBC Microcomputer was only used in maths and physics departments.²³² “Schools were at times unwilling or unable to invest money in a large number of BBC Micros,” meaning pupils had limited time to access the computer and were often only playing games. Protective teachers prevented computer enthusiasts from experimenting or practicing on the computer.²³³

As for the experience of teachers in the 1980s, a paper on the *Early Uses of Computers in Schools* by a user and later researcher of computer usage in an educational context points out that with the introduction of microcomputers in schools, teachers needed to book access to a school—rather than a classroom-based resource for the first time.²³⁴ Aside from the lack of availability and accessibility of hardware, teachers often lacked confidence to try out software and could only plan and anticipate learning by frequently experimenting with software themselves.²³⁵ In primary schools similar issues arose since teachers who did not use microcomputers lacked confidence and competence.²³⁶ Only when schools had more computers available by the end of the 1980s could attention turn to using computers across the curriculum rather than as a separate subject or part of specific subjects mentioned earlier.²³⁷

The *Computer Literacy Project* illustrated the British approach to introducing computers in homes and schools. The BBC prepared an entire

232. Blyth, *The Legacy of the BBC Micro*, 46.

233. Blyth, *The Legacy of the BBC Micro*, 47.

234. Don Passey, “Early Uses of Computers in Schools in the United Kingdom: Shaping Factors and Influencing Directions,” in *Reflections on the History of Computers in Education: Early Use of Computers and Teaching about Computing in Schools*, ed. Arthur Tatnall and Bill Davey (Springer, 2014), 133, https://doi.org/10.1007/978-3-642-55119-2_9.

235. L. Gibbons, “Escape or Run?” *Journal of Computer Assisted Learning* 2, no. 1 (1986): 27, <https://doi.org/10.1111/j.1365-2729.1986.tb00060.x>. Cited in Passey, “Early Uses of Computers in Schools,” 143.

236. G. Heywood and P. Norman, “Problems of Educational Innovation: the Primary Teacher’s Response to Using the Microcomputer,” *Journal of Computer Assisted Learning* 4, no. 1 (1988): 34–43, <https://doi.org/10.1111/j.1365-2729.1988.tb00091.x>. Cited in Passey, “Early Uses of Computers in Schools,” 136.

237. Passey, “Early Uses of Computers in Schools,” 144.

learning system with input from the government for the 1982 Information Year, centred around the BBC Microcomputer. The project aimed at educating all levels in society offering television series, learning materials such as books and software, in combination with courses. In 1982 the first television series *The Computer Programme* intended to capture the interest of a general audience, to demystify technology and to give practical examples. The television series mostly demonstrated business applications but also highlighted everyday situations in which people encountered computing indirectly from transportation and healthcare to utilities. Through discourse analysis a tension between the past and the future, between continuity of computer principles from historical examples, the revolutionary present and utopian or dystopian future expressed in science fiction emerged the idea that computers would eliminate repetitive jobs and reduce the workforce, but also allow more flexibility to shop, work and bank from home. The BBC Microcomputer featured in *The Computer Programme* to demonstrate programs but when the television show aired, the designer and manufacturer of the computer system licensed by the BBC, Acorn, was running behind on deliveries. By mid-1983 the issues were resolved and Acorn had sold around 100.000 microcomputers while BBC Enterprises made a profit of around £2.9 million from its 10% royalty and the sales of learning materials. Acorn quickly evolved past the Cambridge start-up built around people who mostly met at the CUMG in part thanks to their connection to the BBC.

The BBC Microcomputer nicknamed the Beeb included a built-in keyboard, power supply and speaker but could connect to any television set or video monitor and cassette recorder. Optional hardware such as a disc drive, printer, external second processor, could also be connected. In 1982 the main customers for the BBC Micro were middle-class men under forty-five with previous experience. By October 1983, partially because the government funding schemes, 25% were sold to schools, 35% purchased a BBC Micro for home use, and 40% of small businesses bought the system for data processing.

The manual distinguished between beginners and experts based on experience and practice rather than education or occupation and encour-

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aged novices to experiment. BBC's particular BASIC programming language was said to provide a good basis for learning other programming languages. Yet many examples in the manual were limited to mathematical applications. The Microelectronics in Schools government scheme also mentioned mathematics as well as science, geography and business as key disciplines for teaching computer literacy. In the UK schools received a 50% subsidy to purchase microcomputers and the BBC Microcomputer was included in the scheme for secondary and later primary schools. A survey among 1980s computer users thirty years on however revealed that access to computers at school was limited due to the low number of available machines and protective teachers. Teachers often had limited experience and lacked confidence to make good use of this school-based resource. The situation improved by the end of the 1980s when computers were used across the curriculum.

The paternalistic style of the BBC and government to educate the nation in computer literacy and offer a limited selection of UK manufactured microcomputers differed in several ways from the entrepreneurial approach of another late-1970s start-up in the United States.

5.2 Apple IIe: Personal Computing in the USA

In Silicon Valley the legend of a computer born in a garage attributes the personal computer to two inventors with help from members of a hobbyist club.²³⁸ Wozniak worked as an engineer for Hewlett-Packard (HP) after Stephen (Steve) Wozniak had tried out his ideas at the *Homebrew Computer Club* meetings at Stanford campus. Both he and Steve Jobs had written computer games for Atari.²³⁹ In 1977 the Apple II became

238. Ceruzzi, *A History of Modern Computing*, 264.

239. Ceruzzi, *A History of Modern Computing*, 264. Michael Friedewald, *Der Computer als Werkzeug und Medium: die geistigen und technischen Wurzeln des Personal Computers* (Verlag für Geschichte der Naturwiss. und der Technik, 1999), 373.

one of the first microcomputers for the consumer market, encased in plastic rather than industrial looking metal. Similar to the BBC Microcomputers, customers could connect the Apple II to their own television. Apple Computers Inc. became a profitable enterprise when managed by Amas Clifford (Mike) Markkula as chairman of the board of directors who had experience in marketing from Intel and Fairchild, and when Mike Scott was appointed president. From selling 2500 computers in 1977 to 150.000 computers in 1980, the company was valued at \$1.7 million when it entered the stock market in 1980. Employing 1.500 people at production plants in Cupertino, San Jose, Los Angeles, and Dallas, Apple had evolved from hobbyists in a garage to a profitable multi million enterprise within three years.²⁴⁰

Joy Lisi Rankin deconstructs the Silicon Valley myth in *A People's History of Computing in the United States*.

[...] once upon a time, modern computers were big (and maybe even bad) mainframes. [IBM] dominated the era when computers were the remote and room-sized machines for the military-industrial complex. Then, around 1975, along came the California hobbyists who created personal computers and liberated us from the monolithic mainframes. They were young men in the greater San Francisco Bay Area, and they tinkered in their garages²⁴¹

Rankin criticizes the myth for attributing technology to “hackers, geniuses, and geeks” as Walter Isaacsson illustrates in *The Innovators*. The myth removes computer technology from everyday life into the hands of engineers, experts, and innovators until it is sold to the user.²⁴² Paul Ceruzzi believes that the Apple II was the first computer to be “embraced by the people as a friendly, nonthreatening piece of technology that could enrich

240. Friedewald, *Der Computer als Werkzeug und Medium*, 374-376.

241. Joy Lisi Rankin, *A People's History of Computing in the United States* (Cambridge, MA: Harvard University Press, September 2018), 2.[.

242. Rankin, *A People's History of Computing in the United States*, 2-5.

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their personal lives.”²⁴³ Yet he also cautions against revolutionary claims about the personal computer’s political or cultural meaning since “computers came ‘to the people,’ but for a price: corporate control.” Rankin identifies a “shift from personal computing to personal computers” when people needed to purchase computers and software and earlier developments in a freely shared BASIC were adopted by hobbyists for home computers and marketed as a consumer product.²⁴⁴

One television episode and a documentary with interviews of Steve Wozniak discussed in section 5.2.1 illustrate Silicon Valley’s technology discourse of the 1980s with an emphasis on entrepreneurs and the creation of hacker culture. Comparing the social and cultural values of the entrepreneurs in the United States with the British approach to *Computer Literacy* reveals important similarities and differences between the introduction of personal computers in both nations. A retrospective interview with Steve Jobs exposes the incentive to design the Apple II and his motivation to target school children in particular. In contrast to the Micros in Schools government scheme in the United Kingdom, computers were introduced to schools in the United States either through state-wide tax incentives or school discounts offered by the company (section 5.2.2). Next, section 5.2.3 discusses the installation and operation of the Apple IIe, an extended version of the Apple II, based on a manual. The images in the manual illustrate the user envisioned by Apple and in combination with instructions for care suggest settings in which the computer could be used. The chapter ends with an analysis of stereotypes in advertising both in print and in television commercials (section 5.2.4) promoting different Apple II models to schools, students, and parents.

243. Ceruzzi, *A History of Modern Computing*, 264.

244. Rankin, *A People’s History of Computing in the United States*, 229, 236-238.

5.2.1 Silicon Valley: Birthplace of the Personal Computer and Hacker Culture

Television series and documentaries from the first half of the 1980s illustrate the American discourse on personal and microcomputers and its different approach compared to the BBC's *The Computer Programme*. In an episode of *The Computer Chronicles* presenters interviewed entrepreneurs such as Apple's Steve Wozniak rather than focusing on users, but the educational purpose of the show mirrored the British approach by broadcasting an extended version of the episode as a telecourse. Rather than aiming to teach computer literacy to a general audience, *The Computer Chronicles Telecourse* seemed to target Silicon Valley's next generation of entrepreneurs. The television documentary depicts the 1980s cultural phenomenon of *Hackers* which influenced gender stereotypes attached to personal computers. A discourse analysis of these two television productions thus illustrates not only Steve Wozniak's personal vision on the design of the Apple II, the place and culture in which this personal computer originated, and the narrative of other hackers who considered themselves as invisible yet equally important contributors to the development of personal computers. Steve Jobs further explained the incentive for designing the Apple II and the intended user in a retrospective interview with the Smithsonian concluding this section.

Computer Entrepreneurs

The episode titled *Computer Entrepreneurs of The Computer Chronicles* aired on 10 May 1984 and included additional segments titled "Computer Principles" and "Chronicles' Summary" presented by Herb Lechner. This particular recording was part of *The Computer Chronicles Telecourse*.²⁴⁵ The episode was also included in the original show as episode 22 of the

245. *People in Computing*, 1984, accessed February 15, 2021, <http://www.imdb.com/title/tt6029906/alternateversions>.

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first season titled “People in Computing” which aired in March 1984.²⁴⁶

The Telecourse was sponsored by Micro Focus, “creators of visual tools for software development.” Television courses for the Open University or programmes on computer literacy offered by the BBC on the other hand were funded by public institutions rather than privately owned companies and retained a closer link to educational institutions in the United Kingdom. Similar to the historic examples Ian MacNaught-Davies mentioned in *The Computer Programme* (section 5.1.1), the introduction theme of the *Chronicles* illustrated the history of computers from ancient calculators to 1980s computer chips supported by period-inspired music composed mostly on synthesizers. The television set was rather formal with two presenters sitting at a desk in front of a light box with the title of the TV series and two fake windows overlooking the Golden Gate Bridge in San Francisco at sunset (see fig. 5.18).

After a short welcome by Stewart Cheifet and Gary Kindall, Stewart introduced the subject of the episode referring to the local area: “Silicon Valley is in fact as famous for its young entrepreneurs as it is for its products.” Gary explained from personal experience as founder of Digital Research how the computer business had become very competitive, more professional with higher stakes, yet also more fun over the past decade. Stewart then mentioned the guests that would appear on the show, but first the episode would focus on “other people who played a key role in the evolution of computer business,” in particular Steve Wozniak, co-founder of Apple Computer Co.²⁴⁸

As the TV-series moved to the interview with Steve Wozniak, a clip showed him in his home setting holding his daughter and riding a motor cycle on the lawn followed by his dogs. For the interview he sat on a chair underneath a tree in the garden wearing a sporty blue and yellow

246. Peter Nichols, Ronald K. Lakis, and Patrick Moyroud, *People in Computing*, October 1984, https://www.imdb.com/title/tt6029906/?ref_=ttep_ep2.

247. Peter Nichols, Ronald Lakis, and Patrick Moyroud, dirs., “Computer Entrepreneurs,” *The Computer Chronicles Telecourse*, aired 5th October 1984 on KCSM-TV, https://archive.org/details/Computer1984_5.

248. Nichols, Lakis, and Moyroud, “Computer Entrepreneurs.”



Figure 5.18: Still from *The Computer Chronicles Telecourse* (00:53).²⁴⁷

sweater over a T-shirt with a rainbow Apple logo on jeans and sporting a full beard, as if to emphasize a style polar opposite from the three-piece business suit the managers in his company wore. He started by recounting his experience with microcomputers in 1974 and 1975 and the sense of excitement he and Steve Jobs had thinking they “were doing things for the first time they’ve ever been done.” In hindsight he recognized that the only difference with minicomputers and larger systems was how cheap microcomputers could be built thanks to large-scale integration (LSI) technology.²⁴⁹ Wozniak remembered “putting out a little table and showing off a little card that could play music on a computer or make color [as] the most exciting thing in the world and we thought we were

249. Nichols, Lakis, and Moyroud, “Computer Entrepreneurs.”

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way ahead of the world.”²⁵⁰ The idea that the product would become so successful or that Apple would grow out to such a large company did not cross his mind. Wozniak explains “I had been working my whole life to build a certain type of computer for myself and I just built the best one that was doable in that day with the particular components available.”²⁵¹

He went on to explain that his design was made possible because of the freedom from not being tied to a company where managers determined product requirements. His obvious dislike from business culture and the ensuing lack of technically creative microcomputers becomes clear from his description of meetings where “they are all sitting there in three-piece suits, it’s a large business, there is a lot of dollars involved.” When asked whether a business success like Apple was still feasible for others in the small computer business a decade later, Wozniak stated that manufacturing hardware on a small budget, marketing the product in hobbyist magazines and selling hardware had become impossible for small entrepreneurs. Much like DEC’s shifting focus towards software, Wozniak believed small entrepreneurs were better off pitching good software.²⁵²

The scene then alternates between the garden interview and footage of Wozniak walking into his house followed by the dogs. His office with a large corner desk contained several Apple computers and the audience could look over his shoulder while he was working on an Apple II (fig. 5.19). In another scene he walks around the garden carrying his daughter around followed again by the dogs. In the final part of the interview he explains he now understands how he and Steve Jobs must have been perceived in the very beginning by looking down on others driving around trade shows in mobile homes ten years after they did the same thing. He realised that their success was “a quirk of fate.”²⁵⁴ While Wozniak underscores Apple’s hobbyist origins and attributes part of his success as

250. Nichols, Lakis, and Moyroud, “Computer Entrepreneurs.”

251. Nichols, Lakis, and Moyroud, “Computer Entrepreneurs.”

252. Nichols, Lakis, and Moyroud, “Computer Entrepreneurs.”

253. Nichols, Lakis, and Moyroud, “Computer Entrepreneurs”

254. Nichols, Lakis, and Moyroud, “Computer Entrepreneurs.”



Figure 5.19: Still from *The Computer Chronicles Telecourse* (04:34).²⁵³

Apple's hardware designer to the technology of others, he still claims full credit for the design as inventor of the Apple II. Steve Jobs on the other hand fulfilled the role of visionary, while corporate management was left to marketing expert Mike Makkula and financial expert Mike Scott.²⁵⁵

Herb Lechner's *Chronicles Summary* nicely explained the changed computer industry from entrepreneurs with a strong technical background and "vision and insight into the new technology and the perseverance to see their ideas through" to a different kind of entrepreneurialism, evolving from technical startups into more mature business.²⁵⁶ "Once the ideas are formulated, the investment capital is secured, the assembly lines are

255. Friedewald, *Der Computer als Werkzeug und Medium*, 375.

256. Nichols, Lakis, and Moyroud, "Computer Entrepreneurs."

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rolling, the product must be sold and serviced and continuing return realised on the investment.”²⁵⁷ Marketing and financial profiles became more important in the computer industry. Like any other business, computer companies had “design, manufacturing, marketing, sales, public relations, [and] advertising” departments.²⁵⁸ Lechners explains the evolution of microcomputers to personal computers as the development of a hobbyist product brought to the consumer market. From ideologies of bringing computing to the people to profit centred corporations, Wozniak’s opposition to corporate culture as one of the company’s founders led to his identification with hacker culture.

Hackers

Steve Wozniak was also interviewed for the 30-minute documentary called *Hackers: Wizards of the Electronic Age* produced by Fabrice Florin in 1985, one year after the first *Hackers* conference for his role as designer of the Apple II.²⁶⁰ After the introductory clip, we see three bearded, scruffy-looking men and two slightly more presentable women looking at a computer screen hidden from the camera (fig. 5.20). Hackers are defined by narrator Tony Russomanno as “the computer wizards who in just a decade created both a multi-billion dollar industry and a cultural phenomenon.” Steve Wozniak is considered “one of the nerds of the personal computer revolution.” The documentary states that personal computers changed lives at work, at schools, and at home. Ordinary users, says the narrators, do not realise that hardware and software was “hacked away for nights on end by brilliant and fanatic designers.” Consumers or end users enter only after the technology is sold, while hackers distinguish themselves from mere ordinary users designers of hardware and

257. Nichols, Lakis, and Moyroud, “Computer Entrepreneurs.”

258. Nichols, Lakis, and Moyroud, “Computer Entrepreneurs.”

259. Fabrice Florin, *Hackers: Wizards of the Electronic Age* (1985), https://archive.org/details/Hackers_201808

260. *Hackers: Wizards of the Electronic Age*, accessed February 15, 2021, <http://www.imdb.com/title/tt1191116/plotsummary>.



Figure 5.20: Still from Florin, *Hackers* (00:24).²⁵⁹

software. Images of the young Steves (Jobs and Wozniak) illustrate the “happy few that became overnight millionaires,” whereas hackers consider themselves as the unsung heroes. Stewart Brand, editor of the Whole Earth software catalogs and organizer of the exclusive *Hackers* conference describes them as “shy, sweet, incredibly brilliant.”²⁶¹

He invited one hundred computer designers to a campsite, providing enough computers, soda and candy for all-night hackers, with the goal to discover “the unique set of values that made the computer revolution possible and brainstorm about its future.” The invitees were asked to define a hacker, a term that has an entirely different and often malicious connotation today. The 1980s hacker “hacked away on the computer keyboard until a program works,” whereas crackers sought to break into existing code (a person that we would call a hacker today). *Wired* journalist Steven

²⁶¹ Florin, *Hackers: Wizards of the Electronic Age*.

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Levy who authored the book *Hackers: Heroes of the Computer Revolution* - which inspired the conference in the first place - said that hackers never finished a program, always adding more features and only stepping away from the computer when they collapsed at the keyboard. Steve Wozniak mentioned how hackers are not distracted by friends or other social activities, nor do they have girlfriends. They are only attached to the computer. He also compared hackers to our inner child, always discovering, exploring, and creating something new.²⁶²

After a segment of the documentary discussing the origins of hacker culture and contemporary programs, Steve Wozniak is interviewed in the context of a second wave of hackers and hobbyists in the 1970s Silicon Valley “triggered by the introduction of low cost microprocessors.” He describes his urge to build a computer while still at school with posters of computers on his bedroom wall. The documentary shows photos of him as a teenager and the narrator calls him one of the first members of the *Home Brew Computer Club*. Wozniak explains that he learned how to build a computer from minicomputer handbooks, and chip manuals. He shared his chip design with other Home Brew members and helped them build their own computer. The documentary moves through a slideshow of Apple computers claiming Wozniak earned over 50 million dollars. The success of the Apple II computer - ironic though it may sound now - is attributed by the narrator to “its open architecture, allowing users to tinker with the machine and improve on it,” as is show in figure 5.21. When hardware became readily available, the third wave of hackers earned a lot of money quickly by developing software, and games in particular.²⁶³

Another interesting remark as a follow up to the open architecture of the Apple II is the hacker ethic that “information and tools should be free or at least available to serious seekers and they openly share their work with others.” Although some do not agree that source code should be shared, Steve Wozniak argued such code should be shared at least with

262. Florin, *Hackers: Wizzards of the Electronic Age*.

263. Florin, *Hackers: Wizzards of the Electronic Age*.

264. Florin, *Hackers: Wizzards of the Electronic Age*.

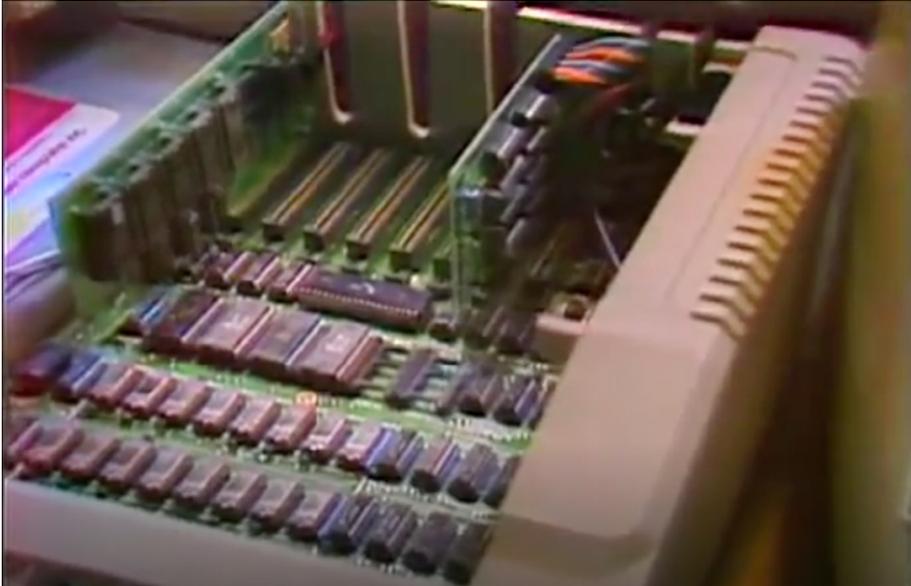


Figure 5.21: Still from Florin, *Hackers* (13:04).²⁶⁴

other hackers “not for sale, not to copy, but to learn from.”²⁶⁵

A Visionary’s Retrospective

In an interview of Steve Jobs by the Smithsonian on 20 April 1995, he remembered how his father showed him how to build things and other engineers in his Silicon Valley neighborhood taught him more about electronics. When asked about his own experience in education and the importance of education, Jobs explained his belief in equal opportunity which mostly meant a great education. “If I hadn’t encountered two or three individuals that spent extra time with me, I would have absolutely ended up in jail.” He was adamant that computers were by no means the solu-

²⁶⁵ Florin, *Hackers: Wizards of the Electronic Age*.

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tion, only people could incite and feed curiosity.²⁶⁶

A computer design is the result of people's decision, whether this is an individual (as Steve Wozniak claims for the first Apple computer), or a company (as Steve Jobs emphasised his role as people manager at Apple). People's decision are driven by a myriad of factors, but certainly by their own background and personal preferences. Thus the following quote from the interview with Steve Jobs about the demographic at Apple is indicative of some shared traits of Apple employees in the 1980s. "We were all pretty young. The average age in the company was mid-to-late twenties. Hardly anybody had families at the beginning and we all worked like maniacs."²⁶⁷

The interviewer then turned his attention to Apple users and customers which Jobs divided into two groups. For non-educational consumers Apple computers were all about lifestyle, his goal for educational customers was that "if there was just one computer in every school, some of the kids would find it. It will change their life."²⁶⁸

Because bureaucracy was slow, Jobs said they "realized that a whole generation of kids was going to go through the school before they even got their first computer so we thought the *Kids Can't Wait*." A national law provided a tax reduction for donating computers to a university for education and research which Jobs tried to amend to include elementary, middle and high schools with only an educational requirement. Unfortunately the law didn't pass the Senate, so Apple's plan to donate 100.000 computers which would cost Apple 10 million dollars fell through. The State of California decided to approve a similar bill called the Computer Equipment Contribution Act (AB3194) and 10.000 computers were donated to schools in California. "We got a whole bunch of software companies to give away software. We trained teachers for free and monitored this thing over the next few years. It was phenomenal."²⁶⁹

266. Steve Jobs, *Smithsonian Oral and Video Histories: Steve Jobs*, April 1995, <https://americanhistory.si.edu/comphist/sj1.html>.

267. Jobs, *Steve Jobs Interview*.

268. Jobs, *Steve Jobs Interview*.

269. Jobs, *Steve Jobs Interview*.

5.2.2 Tax Exemptions and School Discounts

Unlike the Micros in Education government scheme which provided the incentive for schools to purchase microcomputers at half the price in the United Kingdom, the United States did not approve a federal subsidy. Instead, only the State of California motivated companies rather than schools to donate computers to elementary, middle, and high schools at a tax reduction. Apple's *Kids Can't Wait (KCW)* program illustrates how schools in the United States obtained computers, and how teachers were trained, as well as who developed the learning material and educational software on offer.

Audrey Watters, freelance writer and owner of the blog *Hack Education* traced the history of Apple II computers in the classroom slightly further, mentioning Apple's 1978 contract to provide 500 computers to schools in Minnesota for the Minnesota Education Computing Consortium (MECC) which offered "a sizable catalog of educational software (including the iconic Oregon Trail)" to schools for free.²⁷⁰ While MECC offered programs subsidized by the state freely on its network, it gradually shifted to selling software.²⁷¹ When the Computer Equipment Contribution Act was voted in California "proponents of this bill [felt] that computer literacy for children is becoming a necessity in today's world."²⁷² Creative Computing covered the story in 1983.

Apple is offering a free Apple *IIfx* system to every eligible elementary and secondary school in California. The package includes a 64K Apple *IIfx* computer, a display monitor, one floppy disk drive, and a copy of Apple Logo, a computer language designed for students. The current suggested retail value of the package is \$2364. The KCW package also contains coupons for free and discounted educational software from more than

270. Audrey Watters, *How Steve Jobs Brought the Apple II to the Classroom*, February 2015, <http://hackeducation.com/2015/02/25/kids-cant-wait-apple>.

271. Rankin, *A People's History of Computing in the United States*, 238.

272. Watters, *How Steve Jobs Brought the Apple II to the Classroom*.

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25 educational software publishers.²⁷³

Since the legislation requested training for at least on teacher of a school that received a computer, Apple dealers provided training. Unfortunately this training was often very limited.²⁷⁴

Apple's *KCW* package also promoted the use of a particular programming language in classrooms. Logo is announced as "Child's Play" in the computer manual with vocabulary such as intuitive, simple, and natural. The recommended age for teachers to introduce this programming language was 8 years. The short description explains a lesson on how to draw geometric shapes and create pictures from a combination of shapes. In a clearly defined learning goal, the handbook explains that children are taught that bugs are not wrong answers, but normal in programming. "Logo is designed to convey programming concepts in a natural problem-solving manner."²⁷⁵

Whereas the British government offered funding for schools to purchase microcomputers, schools in the United States benefited from a key principle of the free market: competition. Computer manufacturers either offered "large educational discounts" or donated computers under the condition of a "tax exemption" from the local state government. Apple devised two types of discount for schools, either a discount on larger orders, or a three year repayment scheme.²⁷⁶ Between 1981 and 1985 "the number of computers in US schools has steadily increased" from 33.000 to around 700.000. In 1985 nearly ninety percent of schools had at least one microcomputer.²⁷⁷

273. Ken Uston, "9,250 Apples for the Teacher," *Creative Computing* 9, no. 10 (October 1983): 178, https://www.atarimagazines.com/creative/v9n10/178_9250_Apples_for_the_teac.php.

274. Watters, *How Steve Jobs Brought the Apple II to the Classroom*.

275. Joe Meyers, *Apple IIe Owner's Manual* (Cupertino, CA: Apple Computer, Inc., 1982), 90.

276. D'Ignazio 1986 in Vasko and Dicheva, "Educational Policies: An International Overview," 6.

277. Hebenstreit 1986 in Vasko and Dicheva, "Educational Policies: An International Overview," 6.

5.2.3 Key Design Features of the Apple IIe

When a user purchased the Apple *IIe*, the manual first and foremost explained how to assemble the system and its components connecting cards and a monitor or television set. After detailing how to care for the computer and how to start or boot the computer, users were acquainted with the keyboard. The manual then discussed how hardware, software, and disks worked, followed by chapters on the operating system, applications and programming. Finally, the handbook listed how to add peripherals to the Apple *IIe* and where to look for help in case of issues.²⁷⁸ The manual thus answers research questions regarding the installation and operation of the Apple *IIe*. More importantly, an analysis of the visual and textual discourse reveals the configured user Apple intended to target with the extended version of the first consumer oriented personal computer.

The Configured Users

Interestingly, the author did not expect every user to read the full manual, instead pointing to specific chapters for configured users. For the person setting up the system (1 & 7), the business person (2, 5 & 8), and the programmer (2, 4, 6 & 8) the author expected them to read less than half of the manual. Whereas a first-time user looking for ready-made programs (2, 3, 4, 5 & 6) needed or perhaps preferred more information.²⁷⁹

The photographs at the start of each chapter also show users at work. Chapter 1 on assembling the system is illustrated by a oenologist standing next to his window-side desk smelling wine with shelves full of chemistry equipment above the desk and wooden wine vessels in front.²⁸⁰ Chapter 2 on getting acquainted shows two businesswomen at work (fig. 5.22). A middle-aged white woman in a black suit and blue dress shirt wearing jewelry was touching her chin thoughtfully while looking at the monitor with one hand on the keyboard. A younger African-American

278. Meyers, *Apple IIe Owner's Manual*, 2-5.

279. Meyers, *Apple IIe Owner's Manual*, 7.

280. Meyers, *Apple IIe Owner's Manual*, 11.

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woman wearing a pin-striped navy dress and white vest with a pearl necklace and earrings was taking notes standing next to the other woman at the desk holding the phone to her shoulder to keep a caller waiting.²⁸¹



Figure 5.22: Illustration *Apple IIe Owner's Manual* Chapter 2²⁸²

Chapter 3 for beginners and experts on “How It Works” shows a very staged family setting of a father, son, and daughter in their pyjamas in bed on Sunday morning with an Apple *IIe* next to them on the bed (fig. 5.23). The daughter in ponytail is typing and looking at the keyboard, the son is holding a geography book open and watching the computer monitor as is the smiling father with his hand on his daughter’s back and holding a

281. Meyers, *Apple IIe Owner's Manual*, 26.

282. Meyers, *Apple IIe Owner's Manual*, 26

glass of orange juice.²⁸³



Figure 5.23: Illustration *Apple IIe Owner's Manual* Chapter 3²⁸⁴

The vocabulary of chapter 3 is certainly adapted to beginners. In fact, the text shows that Apple considered first-time users not just as someone who bought an Apple computer for the first time, but as someone who has never used a computer before. The handbook tries to reassure beginners with phrases like “don’t worry” and “be patient with yourself.”²⁸⁵ Similar

283. Meyers, *Apple IIe Owner's Manual*, 44.

284. Meyers, *Apple IIe Owner's Manual*, 44

285. Meyers, *Apple IIe Owner's Manual*, 45.

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vocabulary was also used in the BBC Microcomputer manual (see section 5.1.3) to reduce fear for novices. The introduction to the chapter even compares understanding computer concepts and using the computer to engines and cars.

You don't need to know exactly how an internal combustion engine works to drive a car. Likewise, you don't need to understand exactly what is going on inside the Apple *IIf* computer to be able to put it to work for you.²⁸⁶

Chapter four aimed at the programmer as well as first-time users and experts is illustrated by a middle-aged man entering product information on the computer reading from the label of a kit in his other hand standing at the desk of a car garage.²⁸⁷ Chapter five for experience business users about application programs shows a female scientist looking through a microscope in a laboratory setting with the Apple *IIf* in the background.²⁸⁸ In contrast to chapter three for beginners, chapter five is clearly written for experts with the first sentence setting the tone. "The Apple *IIf* computer demonstrates its true power and value when you put it to work on your own real-world problems." Examples of application programs were: electronic worksheets, word processors, data base management programs, telecommunications, and graphics programs. As expert users were experienced computer and Apple users, the handbook emphasised differences with programs run on previous models, frequent mistakes and how to solve or avoid them as well as how programs made "parts of the system work together."²⁸⁹

For chapter six titled "Programming: the Ultimate Computer Skill" the illustrative image fits into the educational customer Apple tried to reach with a class of four boys and four girls listening to the female teacher

286. Meyers, *Apple IIf Owner's Manual*, 45.

287. Meyers, *Apple IIf Owner's Manual*, 56.

288. Meyers, *Apple IIf Owner's Manual*, 72.

289. Meyers, *Apple IIf Owner's Manual*, 73.

290. Meyers, *Apple IIf Owner's Manual*, 86



Figure 5.24: Illustration *Apple IIe Owner's Manual* Chapter 6²⁹⁰

standing around the computer desk (fig. 5.24).²⁹¹ Despite the illustration of a classroom setting, the chapter on programming is certainly not adapted to children in terms of vocabulary and remains rather technical. Chapter seven on additional equipment is illustrated by a middle-aged woman seated in a cubicle with an Apple *IIe* on her desk with a meeting room behind where three men were discussing an architectural model around the table.²⁹² The Help chapter eight meant for programmers or businessmen is illustrated by a retired man overlooking the sunset from his sailing yacht, the newspaper on his lap sitting next to his Apple *IIe*

291. Meyers, *Apple IIe Owner's Manual*, 86.

292. Meyers, *Apple IIe Owner's Manual*, 95.

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computer.²⁹³ No other illustrations or images inside the manual's chapters show users in a working or lifestyle setting. Plenty of photographs illustrate computer components, sometimes with a hand demonstrating an action or pointing towards a part of the board. Other illustrations support the text throughout the manual, and in chapter three in particular.

How to care for an Apple IIe Computer

With the introduction of microcomputers which found their way into homes and offices, environmental requirements such as dedicated airconditioned rooms with raised floors were a thing of the past. Still, Apple recommended customers to find “a place away from direct sunlight or sources of intense heat (radiator, fireplace) or cold.” The Apple *IIe* manual took DEC's recommendation not to spill any drinks on a computer one step further by suggesting computers should not stand in rain or snow. Funnily enough, the image of a computer on a yacht or a father checking out the Christmas gift by the fireplace in the second TV commercial discussed in the next section ignore the first two recommendations. Energy consumption of the computer led the author to suggest using a grounded three-wire outlet on a circuit that does not have an iron or electric heater or other large appliance attached. Ventilation should not be blocked and in keeping with the period, Apple's final recommendation concerned avoiding “excessive dust, dirt or cigarette ash” around the computer.²⁹⁴

As for floppy disks or in official terminology, flexible disks, users had to avoid touching the disk itself, instead holding it by the jacket and label. Only a felt pen was gentle enough for writing on the attached label. Sunlight, extreme temperatures, or moisture were equally damaging to disks. Perhaps another familiar advice for computer storage predating SSD technology was to “keep disks away from magnets or electrical devices, especially telephones, television sets, and large motors.”²⁹⁵

293. Meyers, *Apple IIe Owner's Manual*, 105.

294. Meyers, *Apple IIe Owner's Manual*, 29.

295. Meyers, *Apple IIe Owner's Manual*, 29.

Where is the power button?

As I discovered myself together with user test participants at the MAL, starting the computer is not straightforward and requires a certain order of successive actions. The first floppy disk drive needed to contain a startup disk. Then the monitor or TV set should be switched on to warm up. Finding the power switch without instructions was tricky for modern day first time users without a manual in the reenactment, but the manual clearly mentions “reach behind the left rear corner of the computer case and find the power switch with your fingers.” The sounds of turning on the computer are difficult to explain, but the handbook’s description is quite good.²⁹⁶ After the first beep, the power light on the keyboard and on the disk drive lit up “and the disk drive will make some whirring and clicking sounds.” Once the program was loaded from the disk, the sounds stopped and the light on the disk drive turned off. The opening page of the program then appeared on the monitor.²⁹⁷

I will not discuss the keyboard layout in great detail, but some keys or layouts stood in stark contrast with current keyboards as the user experiment demonstrated.



Figure 5.25: Apple IIe Keyboard²⁹⁸

296. In a video of the user experiment you can hear it for yourself.

297. Meyers, *Apple IIe Owner's Manual*, 32.

298. Meyers, *Apple IIe Owner's Manual*, 33

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The handbook mentions three control keys none of which are still included on current Apple computers: the open apple, the solid apple, and a reset button (see fig. 5.25). The reset button in combination with other keys could restart the computer, stop a program, or start a self-test. The open and solid apple are comparable to the command and option buttons on current macbooks and invoke special functions. Also note the arrow key layout which is counter intuitive to modern-day computer users.²⁹⁹

Apple IIe Components

The handbook explains the relationship of main memory and the processor inside the computer with peripheral devices such as the keyboard, printer, disk drive and monitor through interfaces. The circuits connecting a peripheral to processor and memory make up the interface.³⁰⁰ Software fell into three categories: firmware, system software and applications programs. Firmware is installed on ROM in the factory and cannot be changed. Other system software can be loaded from a disk and generally moves information to make the system easy to use. Finally, application software can “organise information, do calculations, connect the computer with a distant source of information, and so on.”³⁰¹

The processor’s functioning is explained in simple terms which boils down to “all it does, really, is find, move, compare and combine numbers” and moving to the next instruction or another location in main memory. In another interesting comparison, the handbook explains “main memory is like a grid of thousands of pigeonholes or post office boxes, each identified by a number called its address.” The content of a post office box or memory location can be a program instruction, memory address or character typed on the keyboard. To avoid confusion, areas for programs are separate from areas containing information and some memory locations are reserved for specific I/O devices such as the keyboard. Turning off

299. Meyers, *Apple IIe Owner’s Manual*, 40-41.

300. Meyers, *Apple IIe Owner’s Manual*, 46.

301. Meyers, *Apple IIe Owner’s Manual*, 47.

the computer before saving work meant that the information was lost.³⁰²

The descriptions of application programs include references to potential users. One of the most successful software products for the Apple II in the 1980s was VisiCalc, an example of a spreadsheet software. The manual recommended this type of software for real estate agents to evaluate properties, for managers “to do financial modeling, create forecasts, and develop pricing strategies,” and for the financial sector.³⁰³ Data Base Management applications included business and personal examples such as organizing business cards or “a collection of magazines and professional journals” to find articles based on the title, but also an address book or stamp collection.³⁰⁴ Examples of telecommunications seem particularly useful to academics or students. Accessing a library catalog from home, accessing a university computer centre, or even more general services such as sending messages, posting on a bulletin board, or accessing the news were all available on networked Apple computers.³⁰⁵ Two applications were built specifically for accessing the latest Dow Jones news or keeping track of a stock portfolio again aimed at the financial sector.

Finally, the list ends with other examples of users ranging from “scientists, lab technicians, handicapped people, educators, oil rig operators, librarians,” to other professionals.³⁰⁶ Librarians were certainly early computer adopters with examples of punch card systems being used for library loans and as a card catalog in public libraries in the 1930s. As for computers helping the disabled, the BBC Micro also included software for this particular use. Other software for the Apple computers was catalogued by type of user into business, games, and education. A dedicated educational software directory was also available for teachers and students.³⁰⁷

302. Meyers, *Apple IIe Owner's Manual*, 49.

303. Meyers, *Apple IIe Owner's Manual*, 80.

304. Meyers, *Apple IIe Owner's Manual*, 81.

305. Meyers, *Apple IIe Owner's Manual*, 82.

306. Meyers, *Apple IIe Owner's Manual*, 83.

307. Meyers, *Apple IIe Owner's Manual*, 111.

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In terms of peripherals the handbook mentions five types of printers, several hand controls such as game paddles or a joystick for gaming, a cassette tape recorder and other specific peripherals. The Apple *Iie* connected to both parallel and serial printers but the interface card differed for each. The difference is that a parallel printer “receives information one character (letter, number, etc.) at a time through eight wires,” whereas a serial printer connected with the computer through a single wire “one bit at a time.” Three printing methods were available: thermal, dot-matrix impact, and letter-quality printers. A thermal printer required heat-sensitive paper for drafts or charts but cannot print sharply on ordinary paper. The key selling features of a thermal printer were the low decibels, and price, as well as reliability.³⁰⁸ A dot matrix impact printed balanced price and quality by striking needles with a tiny hammer to print text and graphs. Finally a letter quality printer used letters instead of dots in the form of a daisy-shaped wheel, thimble or golf-ball to print at the highest quality and was more expensive.³⁰⁹ Cassette recorders could be used to load programs or save programs but when cassettes were used to read and write programs the two cables were required instead of just one. Programs were saved via a cable connecting to the microphone jack of the recorder.³¹⁰

5.2.4 Marketing a Personal Computer for Kids

From the myriad of users, beginners and experts, with different occupational backgrounds mentioned in the manual, Apple clearly marketed to children and their parents in both printed advertisements and television commercials. An analysis of the discourse in Apple’s advertisements answers research questions on stereotypes associated with represented users, the setting in which computers were used as envisioned by marketers and the emphasis on technical features, the user experience, or status linked to the machine.

308. Meyers, *Apple Iie Owner’s Manual*, 96.

309. Meyers, *Apple Iie Owner’s Manual*, 97.

310. Meyers, *Apple Iie Owner’s Manual*, 99.

Print Advertising

A two-page advertisement from 1984 titled *Why every kid should have an Apple after school* specifically targeted parents of children finishing their secondary school education. The feature image of a student's desk takes up two-thirds of the page spread over two pages. Although the advertisement makes no explicit reference to the gender of the targeted "kid," some of the many objects on the desk hint at a son. The more explicitly gendered references in figure 5.26 are a baseball cup, baseball and glove, a sticker of the hard rock band Mötley Crüe, as well as a motor cycle helmet and a motor cycle Polaroid picture. Other objects such as an (empty) fishbowl and hamster running in a wheel inside its cage, as well as a telephone hardly hint at a particular gender stereotype.³¹¹

Another interesting detail is the time indicated by the clock at 4.35 p.m. which is when kids were likely back from school and started working on their homework with cookies and milk. Finally, some of the subjects on both the book covers and of the software packages hint at a rather specific target user. Aside from a geology book and math software package, the software package titled *Mastering the SAT* points to a student finishing secondary school and applying at universities. Other books focus more on computer applications such as *Data Sources* and the *Apple II Basic Handbook*. Finally the Flight Simulator software package again supports the argument that this advertisement implicitly targeted male senior students and their parents.³¹³

Although Apple dominated the United States computer market for schools, the company regretted that there were "still more kids in schools than Apples." Appealing to parents worried that their children would not gain enough computer experience and describing the limited access to computers at school the advertisement continues: "So innocent youngsters

311. 'Why every kid should have an Apple after school', *Apple Computer Inc.*, 1984. <http://www.macmotherhip.com/gallery/MiscAds/IIcspread.jpg>.

312. 'Why every kid should have an Apple after school', *Apple Computer Inc.*, 1984. <http://www.macmotherhip.com/gallery/MiscAds/IIcspread.jpg>.

313. 'Why every kid should have an Apple after school', *Apple Computer Inc.*, 1984. <http://www.macmotherhip.com/gallery/MiscAds/IIcspread.jpg>.

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Why every kid should have an Apple after school.

Today, there are more Apples in schools than any other computer. Unfortunately, there are still more kids in schools than Apples.

No innocent youngsters (like your own) may have to fend off packs of bully nerds to get some time on a computer. Which is why it makes good sense to buy them an Apple IIc Personal Computer of their very own.

The IIc is just like the leading computer in education, the Apple IIe. Only smaller, about the size of a three-ring notebook, to be exact.

Even the price of the IIc is small—under \$1000*.

Of course, since the IIc is the legitimate offspring of the IIe, it can access the world's largest library of educational software. Everything from Siskiyewer Slaps™ programs in all. More than a few of which you might be interested in yourself.

For example, 3-in-1 integrated business software: Home accounting and tax programs in all. More than a few of which you might be interested in yourself.

And built-in electronics for adding, accessing like a printer, a modem, an AppleMouse or an extra disk drive when the time comes.

So while your child's shoe sizes and appetites continue to grow at an alarming rate, there's one thing you know can keep up with them: Their Apple IIc.

To learn more about it, visit any authorized Apple dealer or talk to your own computer experts. As soon as they get home from school.

*The IIc is commercial street price. It is sold in a suggested Street Price. You can pay more. If you really want to. © 1984 Apple Computer, Inc. Apple and the Apple logo are registered trademarks of Apple Computer, Inc. registered in the U.S. and other countries. Apple IIc is a trademark of Apple Computer, Inc. An authorized Apple dealer nearest you call (800) 538-9696. In Canada call (800) 268-7796 or (800) 268-7631.

Figure 5.26: Why every kid should have an Apple after school.³¹²

(like your own) may have to fend off packs of bully nerds to get some time on a computer.” The solution? Acquiring a personal computer at home. Not just any computer of course, but the Apple IIc which is simply a smaller version of “the leading computer in education, the Apple IIe (...) the size of a three-ring notebook,” for the small price of one thousand one hundred dollar. In keeping with the family discourse the IIc is called the “legitimate offspring of the IIe” and thus has access to “the world’s largest library of educational software” for all ages. In total there were over ten thousand programs available for the IIc.³¹⁴

The advertisement then turns its attention to software that could ap-

314. 'Why every kid should have an Apple after school', *Apple Computer Inc.*, 1984. <http://www.macmotherhip.com/gallery/MiscAds/IIcspread.jpg>.

peal to the parents and actual purchasers of the machine with *3-in-1 integrated business software*, as well as “home accounting and tax programs,” and “diet and fitness programs.” Aside from two family programs such as “Genetic Mapping,” the advertisement lists what is included in the box “to start computing,” including an instructional computer course on four diskettes. Since the monitor often wasn’t included, the computer came with a modulator to attach almost any TV. Furthermore, the advertisement mentions the internal memory (128K) at “twice the power of the average office computer,” “a built-in disk drive” and the possibility to attach “accessories like a printer, a modem, and AppleMouse, or an extra disk drive.”³¹⁵

Although Apple claims that one thousand one hundred dollars is a small price earlier in the text, it goes on to justify such a price by claiming that customers get value for money with more power than other computers and features such as the disk drive which “would drive up the price of a less-senior machine.” Furthermore, the emphasis on built-in features reflects Apple’s philosophy until this day. Apple prefers to keep software closed-source and to use proprietary hardware, creating products that are well-integrated into the family and that work well together.³¹⁶

The discourse of the advertisement also flipped the script from the computer teaching the kids to the kids teaching the parents but eventually getting tired of their questions. The advertisement even suggested that parents talk to their own computer experts - “as soon as they get home from school” - instead of authorized Apple dealers. Finally according to the advertisement, only their Apple *IIC* would keep up with the “children’s shoe sizes and appetite [growing] at an alarming rate.”³¹⁷

315. ‘Why every kid should have an Apple after school’, *Apple Computer Inc.*, 1984. <http://www.macmotherhip.com/gallery/MiscAds/IICspread.jpg>.

316. ‘Why every kid should have an Apple after school’, *Apple Computer Inc.*, 1984. <http://www.macmotherhip.com/gallery/MiscAds/IICspread.jpg>.

317. ‘Why every kid should have an Apple after school’, *Apple Computer Inc.*, 1984. <http://www.macmotherhip.com/gallery/MiscAds/IICspread.jpg>.

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TV Commercials

The earliest Apple II commercial I found on the Internet Archive was released on 28 February 1985. Opening with calm piano music in the background and a female teacher closing a large classroom window wearing a checkered dress and cardigan, she walks towards the blackboard and rolls up a map of the United States. She stows away her Apple II inside a computer bag but leaves the monitor on her desk. As she is putting on her coat, she spots a young girl holding a lunch box and her school bag peering into the classroom door. The teacher nods her head encouraging the girl to come inside. The narrator says “even though teaching tools have changed over the years, two things about teachers haven’t. They still care about kids, their day still doesn’t end at three o’clock.” The little girl enters the classroom, and the camera zooms in on the faces of the teacher and the student sitting next to each other in front of the computer (fig. 5.27). While the teacher is typing, the camera changes perspective to show the girl’s surprised and delighted expression smiling at the teacher. Next we see the scene from the back of the classroom revealing that the two front school desks each hold an Apple II computer. The teacher and students are studying a map on the monitor together. While the camera slowly backs out of the classroom, the commercial ends with the narrator saying “The Apple II. There’s no telling how far it can take,” followed by the rainbow Apple logo on a black screen.³¹⁸

Given the lack of any vendor information or metadata, this commercial might have reached a national audience in the United States. Appealing more to secondary and primary schools, the message of the commercial fits with Apple’s strategy of promoting the Apple II range mostly to schools and later to parents and children at home.³²⁰

On 1 December 1985 Bright Ideas released a TV commercial titled *a Christmas Miracle* promoting the Apple IIc. This advertisement was spon-

318. *Apple II commercial (USA, 1985)*, aired February 28, 1985, http://archive.org/details/appleII_2-28-85.

319. *Apple II commercial (USA, 1985)*

320. *Apple II commercial (USA, 1985)*.



Figure 5.27: Still from *Apple II commercial* (00:17).³¹⁹

sored by an Apple vendor called Bright Ideas located in Guilford, New Haven County, Connecticut.³²¹

With Christmas carols on piano in the background we see a white middle-class man wearing a wedding ring seated on the floor of his living room beside a Christmas tree in front of a crackling fireplace (fig. 5.28). The box of the Apple IIc is still on the sofa but he is plugging a wire into the computer with the manual in front of him on top of the monitor. The Apple IIc is described by the narrator as “the perfect computer to give your kids, because Apples are the leading computers used in schools.” The camera then moves to a range of floppy disks one of which dad inserts

321. *Apple IIc commercial* (USA, 1985), aired December 1, 1985, http://archive.org/details/AppleII_1985-12-01.

322. *Apple IIc commercial* (USA, 1985)

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(a) 00:05



(b) 00:11

Figure 5.28: Stills from *Apple IIc commercial*.³²²

into the disk drive, followed by a shot of a boy and a girl in their pyjamas looking down upon the scene from the decorated stairs (fig. 5.28). The boy whispers: “This should be good,” and the girl, clutching a teddy bear, replies “yeah” with a big smile on her face. The perspective changes back to the father wearing shirt and tie while the narrator mentions business and home finance programs and praises the easy set-up. Moving between close ups of the keyboard, the father’s pleased expression, and the screen showing a lion cartoon, the video ends with the young boy on the stairs wide-eyed stating “another Christmas miracle.” The advertisement ends with a view of the living room from the children’s perspective with their father toggling on the computer.³²³

Even if Apple lost money by giving away computers to schools in California, introducing children to Apple computers in school meant indirectly targeting parents and urging them to buy a computer for their children. The previous two commercials were still aimed at younger children in primary school, but the next TV commercial shifts demographics to teenage boys. This particular commercial also fits the hacker and geek computer boy stereotype that Steve Wozniak remembered in the *Hackers* documentary.

323. *Apple IIc commercial (USA, 1985)*.

324. *Apple II commercial (USA, 1986)*, aired March 28, 1986, <http://archive.org/>



Figure 5.29: Still from *Apple II commercial* (00:25).³²⁴

When the Christmas holidays and sales period was well and truly over, another 30-second commercial aired on 28 March 1986. The commercial starts with a father walking into the study where his teenage son is working on the Apple II and purposefully eyeing his watch. The narrator explains “using an Apple II is very easy, the only hard part is getting your kid away from it.” The camera zooms in on the boys hands stroking the keyboard and his glasses reflecting the screen while he rolls his eyes at his fathers presence. The father then walks away and comes back with a skateboard, then a basketball, and dangling keys in front of his sons eyes but without any success. As the narrator explains from the father’s perspective “you see Apples are the leading computers in schools. So even

details/Apple_II_commercial_USA_1986

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though you bought it to help you work at home, your kid will want to use it for his own homework.” The narrator then suggests a final solution: purchasing an Apple for the kid. The father proudly walks into the study one last time holding a box with a brand new Apple II, turning his sons head to look at his gift (fig. 5.29).³²⁵

Some similarities between the first three TV commercials were the voice of the narrator and the use of soft piano music in the background. The standard length of a commercial was 30 seconds. Each commercial centered around children as computer users. Finally, all commercials ended with the name of the computer model in white letters on a black background, followed by the rainbow Apple logo. The last commercial I found on the Internet Archive differs slightly from the previous three but still emphasizes the goal and audience of Apple’s marketing strategy even more.

Two years later, another Apple commercial aired on 13 November 1988 starting with a black-and-white scene of father and son launching a home made rocket in the back yard of a white picket fence house with a dog house and washing hanging outside emulating 1950s family living. Next, another father and son team in checkered pyjamas were lying on the living room floor watching a toy crane under the Christmas tree with a vintage television in the back. The third scene shows a boy and girl sitting at the kitchen table watching ants move inside a glass display filled with sand with their mother standing in the back wearing an apron and smiling down upon her children (fig. 5.30). Then we see a boy and girl studying an anatomy model in their bedroom with books in front of them, the girl turning away with a disgusted look. The fifth scene shows a little boy and his father studying chemistry in the garage. The narrator explains the nostalgic black-and-white scenes. “Remember how determined your parents were to give you the gift of knowledge. No matter how many gifts it took?” Colour finally returns and the camera zooms in on an Apple II GS in a children’s room with a toy truck and skateboard beside the computer (fig. 5.30).

325. *Apple II commercial (USA, 1986)*.

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(a) 00:07



(b) 00:14

Figure 5.30: Stills from *Apple IIGS*.³²⁶

The screen shows the movements of the moon around the earth while the narrator continues “today you have a big advantage with the Apple II GS.” The set up changes to a computer surrounded by a piglet and an elephant toy with a fish moving on the screen, a rocket launch on the next screen where the Apple computer is surrounded by a guitar and dinosaur toys, and back to the original rocket launch scene in black-and-white. The narrator ends by alluring to the parent’s need to do what’s best for their children saying “your parents gave you the world, you can give your kids the universe.” This inter-generational commercial appeals to the 1980s parent with a sense of nostalgia and a call to action for modern parents to do better than their own parents. An interesting details at the end is the addition of the catchphrase “the power to be your best,” underneath the Apple logo.³²⁷

One thing that strikes me in these commercials is the lack of women and girls as active computer users with the exception of first the teacher’s advertisement.³²⁸ The last commercial showed a sister looking at what her brother was doing with disgust and the Christmas commercial had the

326. *Apple IIGS (USA, 1988)*, aired November 13, 1988, http://archive.org/details/Apple_IIGS_USA_1988

327. *Apple IIGS (USA, 1988)*.

328. *Apple II commercial (USA, 1985)*.

sister simply confirming what her brother was saying.³²⁹ Fathers seemed to be responsible for introducing their children to the computer, if they hadn't already been introduced to Apple computers at school of course. The only mother-figure in the nostalgic part of the final commercial was simply smiling at her children and standing in the kitchen.³³⁰ These toxic gender stereotypes of women as non-users or girls as passive observers in commercials was less present before the hackers stereotype became mainstream in the second half of the 1980s.

5.3 The American and British Approach to Personal Computers

The personal computer revolution of the late 1970s and early 1980s did not revolutionize technology itself, but rather the miniaturization and decreasing price of components meant personal computers were more affordable which in turn changed the human-computer interaction. Whether personal computers democratized technology however, remains at the centre of the debate. Joy Lisi Rankin distinguishes between the computing citizens using time-sharing systems in the 1960s and 1970s and the users of personal computers as mere consumers or end-users. Personal computing gave computing citizens access to computers in communal institutions such as universities and colleges via terminals and unlike users of personal computers allowed them to actively participate and write their own programs whereas end users and consumers purchased personal computers and software. Personal computers turned users into consumers, and expert users such as the computing citizens described by Rankin must have perceived the personal computer as a consumer product for which as Ceruzzi stated the price to be paid was corporate - or in the United Kingdom government - control. Nevertheless, novice or amateur end-users did gain access to a technology few people previ-

329. *Apple IIc commercial (USA, 1985); Apple IIGS (USA, 1988)*

330. *Apple IIGS (USA, 1988)*.

ously understood and with commercialization came increased usability for people outside of certain occupations and research institutions. The introduction of personal computers however, also highlighted national differences within the relatively small Anglosphere.

The Computer Literacy Project in the United Kingdom represented an effort from a national broadcaster in collaboration with the government to educate the nation. The centralised approach of combining diverse learning materials such as handbooks, television series, courses organised by the NEC and Open University, and a support service providing information on different initiatives within the project was coordinated by the BBC. Funding schemes for schools purchasing equipment, adapting the curriculum and training the teachers was organised by the government and often included the BBC Microcomputer. In the United States the development of the personal computer for the consumer market was left to entrepreneurs and established companies. While some states encouraged manufacturers to donate or discount personal computers for schools, the introduction of the personal computer in the United States is characterised by decentralisation.

Did Apple and Acorn differ as fundamentally as the nations in which they operated? Apple's founding myth traces the origin of design ideas for the Apple II to Steve Wozniak's membership of the *Homebrew Computer Club*, a similar hobbyist environment brought many employees and loosely associated people at Acorn in contact at the CUMG. Both associations were located near or within universities with *Homebrew* meetings taking place on the Stanford campus. Apple's Steve Jobs and Acorn's Hermann Hauser have emphasized their ability to find the right people. While Apple soon evolved to a multi-billion profitable company steered by marketers and managers, Acorn's management was often criticized by the BBC and the company was eventually taken over by Olivetti. Apple's first product, the Apple I, was still sold as a hobbyist assembly kit, whereas Acorn first sold components for industrial applications. The legendary prototyping week as told by Acorn employees to win the licence and develop the BBC Microcomputer system carries a striking resemblance to Wozniak's brilliant designer narrative. The hacker culture Wozniak iden-

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tified with and the Apple II's role within this culture however was a decisively American phenomenon fitting into individualism, and anti-establishment sentiment against corporate control. The BBC Micro was licensed by a national broadcaster and tied to government initiatives far removed from hacker culture. The BBC even actively avoided featuring brilliant young users to prevent scaring adults.

Steve Wozniak's goal was to build a machine for himself and share his machine with others, while Steve Jobs's vision together with Apple's managers was to turn the Apple II into a consumer product attractively encased and sold almost fully assembled appealing to a home user rather than a hobbyist market. The BBC Microcomputer fit into a project to educate the nation and was primarily aimed at adults and home users before being adopted by schools. The key difference between the introduction of microcomputers in schools in the United States as compared to the United Kingdom lies in the governmental structure for education. In the decentralised educational system in the United States, the responsibility for education lies with state governments and "there is no general plan for the introduction of computers into schools all over the country."³³¹ Some states such as Tennessee "provide funding, support and expertise," through the "first statewide mandated computer literacy program "Computer Skills Next"" which distributed 14,000 Apple computers to local schools between 1984 and 1986.³³² Other states place the responsibility on schools themselves.³³³ In California tax incentives encouraged computer manufacturers to donate "13,000 microcomputers to schools in 1983."³³⁴ The United Kingdom combined a centralised program from the DTI to introduce *Micros in Schools*, while still retaining a certain level of autonomy for the LEAs who are in charge of education.³³⁵

From the perspective of school children and teachers however, whether or not schools owned a computer was less important than how often and

331. Vasko and Dicheva, "Educational Policies: An International Overview," 4.

332. Vasko and Dicheva, "Educational Policies: An International Overview," 4,6.

333. Vasko and Dicheva, "Educational Policies: An International Overview," 6.

334. Vasko and Dicheva, "Educational Policies: An International Overview," 6.

335. Vasko and Dicheva, "Educational Policies: An International Overview," 9.

for how long students were allowed to interact with the computer. In the United States primary schools made use of the computer for about eleven hours per week compared to thirteen hours for secondary schools.³³⁶ In 1985, there were thirty four students per microcomputer and an estimated twenty students per microcomputer by the end of 1987.³³⁷ Access to microcomputers for individual students in the United States differed substantially between primary and secondary schools.

At the elementary school level the trend is to give many students access to computers, unlike the secondary level where the trend is to give longer access time to only some of the students. The median number of minutes of computer time per week per student user in elementary schools is 23 and in secondary schools it is 45. Typically in secondary schools 64 percent of the students who use a micro get more than 30 minutes of computer time each week in comparison to only 24 percent of the student users in elementary schools.³³⁸

In the United States in 1983 the majority of schools owning microcomputers had fewer than five computers and only ten percent of secondary schools linked their computers into a network. Whereas by 1985 in the United Kingdom, secondary schools typically owned nine or ten computers and they were often linked by a network.³³⁹ There is no information regarding the amount of time students were given access to computers in the United Kingdom in the 1980s.

At a time when teachers were not necessarily very familiar with computers, they too needed training. In the United States such education was sometimes provided by the computer manufacturer. The MEP in the United Kingdom on the other hand also included teacher training through

336. Vasko and Dicheva, "Educational Policies: An International Overview," 6.

337. Hebenstreit 1986, in Vasko and Dicheva, "Educational Policies: An International Overview," 6

338. Vasko and Dicheva, "Educational Policies: An International Overview," 6.

339. Vasko and Dicheva, "Educational Policies: An International Overview," 6.

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regional centers. Teachers were required to attend the training as a condition of the government funding for purchasing microcomputers in schools. Another possibility for teacher instruction were courses offered by the Open University, the BBC and the NEC. The regional centers also developed and disseminated software and accompanying materials and were “equipped with a library containing software packages and other relevant teaching materials as well as computers that teachers can make use of.”³⁴⁰ In the United States however some 750 private companies produced educational software.³⁴¹

In the United States in 1985 “commercially available educational software” mainly focused on mathematics (28%), and closely followed by language (21%), science (11%), social studies (6%), and reading (5%). Most educational software was compatible with the Apple.³⁴² In the United Kingdom in 1983 around sixty publishers sold courseware at an average cost of £10 per program offering about 250 packages for children aged six to fourteen.³⁴³ However in 1986 there was “still a shortage of well designed educational software for primary and secondary schools” despite the efforts from the MEP.³⁴⁴ Aside from the topics covered by educational software, there were two broadly defined types of exercises: drill-and-practice and computer literacy. In the United States that difference manifested itself based on the educational level.

Typically in elementary schools, about 40 percent of the time microcomputers are used for drill-and-practice mainly in basic mathematical and language arts skills. In secondary schools about 70 percent of computer time is used for teaching computer literacy, and only 18 percent is used for drill-and-practice.³⁴⁵

340. Vasko and Dicheva, “Educational Policies: An International Overview,” 9.

341. Vasko and Dicheva, “Educational Policies: An International Overview,” 6.

342. Williams & Williams 1985 in Vasko and Dicheva, “Educational Policies: An International Overview,” 6.

343. Vasko and Dicheva, “Educational Policies: An International Overview,” 9.

344. Vasko and Dicheva, “Educational Policies: An International Overview,” 9.

345. Vasko and Dicheva, “Educational Policies: An International Overview,” 7.

The focus on drill-and practice declined “as schools gain greater experience in using microcomputers” and instead made way for “teaching programming both in secondary and elementary schools.”³⁴⁶ In a third stage the trend shifted from computer literacy to “integrating computer education into the curriculum.”³⁴⁷ Similar to the second stage in the United States, in the United Kingdom the emphasis was “on teaching the subject Computer Studies” in secondary schools, dealing “with the principles and applications of computers.”³⁴⁸

Apple II sales have benefited from successful software on numerous occasions. Financial software like VisiCalc for spreadsheets and Apple Writer for word processing appealed to business users.³⁴⁹ Offering the Apple II to the MECC led to the development of educational software. Without applications teachers could not make good use of microcomputers and MECCs software library had a good reputation. MECCs software library written for Apple computers “gave Apple a strong foundation in selling to students, their parents, and educators in the early 1980s.”³⁵⁰ The use of Apple II computers in schools was then capitalized on through advertisements appealing to children and their parents to start using the same computer at home. The BBC Microcomputer was not advertised as much in television commercials or print, but relied on indirect promotion through television programmes for *The Computer Literacy Project*. People mainly purchased the BBC Microcomputer to experiment at home and the introduction in schools through government schemes came one year later. Rare advertisements for the BBC Microcomputer focused on technical specifications, whereas Apple emphasized the use and experience and elicited an emotional response from parents.

346. Second national survey mentioned in Vasko and Dicheva, “Educational Policies: An International Overview,” 7.

347. Vasko and Dicheva, “Educational Policies: An International Overview,” 7.

348. Vasko and Dicheva, “Educational Policies: An International Overview,” 10.

349. Ceruzzi, *A History of Modern Computing*, 267-268.

350. Rankin, *A People's History of Computing in the United States*, 240.

Chapter 6

Conclusion

On a dark and dreary Saturday evening in November 2021, I revised this conclusion and reflected upon technology past and present. My desk is scattered with several computing devices (phone, tablet, laptop). The manuscript is visible in the online editor in its raw and compiled version, and as a PDF on the tablet. Like notes taken on paper, I formulate my thoughts by moving the stylus across the tablet. An application allows me to open the notes on my laptop. As an additional revision, after a sip of coffee, I then type my notes paired with editorial commands as raw text in the editor, only to compile the next version of the dissertation. Soon I will download the final manuscript as a PDF filled with cross references and external links, save the file on the cloud, and send my jury a link to the document via e-mail.

Technology has become intertwined with our lives and work, but we rarely actively reflect on our own use of computing devices. In this conclusion I aim to reflect upon the position we have as a researcher, and the influence of the present on the questions I ask regarding the past. The conclusion begins by addressing the research questions, followed by a methodological reflection.

While case studies offer an in-depth look into the computer models used for specific applications by a variety of users in a clearly delineated

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period of time and local context, a comparative perspective answers key questions of continuity or discontinuity, similarities and differences. Are there parallels between case studies spanning the decades between the 1940s and the 1980s during the design, production, sale, installation, application, and use stages? Sections 6.1 and 6.2 address this question based on the content of the five case studies presented in the previous four chapters.

Section 6.3 discusses changes in workforce composition, working conditions, and gender stereotypes in advertising. In addition, the section also discusses the lack of gender in the research, as well as sources and methodologies for research about gender in computing from the 1990s until now. Next, section 6.4 discusses the influence of user perspectives and the accompanying types of sources on the analysis and interpretation. The research comes full circle in section 6.5, assessing the life cycle methodology and focusing in particular on the decommission and reuse phase of objects. Finally, section 6.6 reflects on the limitations and possibilities of the methodology and sources, and suggests possibilities for further research.

6.1 The Birth of the Machine

Life cycle studies emphasise the process behind the object from production over distribution to consumption. This perspective also includes the role of human actors who design, build, market, sell, buy, and use computers. Rather than focusing on the object in one particular moment in time and space, the life cycle framework spans multiple contexts. When computers become increasingly invisible through notions of the cloud, or vocabulary such as *smartphone*, and the materiality of technology is lost, then it is easy to forget those who conceive of, and build these devices. The following paragraphs compare the designers and the design process across all case studies.

At the end of the nineteenth and the beginning of the twentieth century, punch card machines were attributed to single inventors like Her-

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man Hollerith or James Legrand Powers. Soon, their businesses expanded and merged into International Business Machines (IBM), or Remington Rand and Powers-Samas. From the 1960s System/360 (S/360) mainframe to the 1980s Apple IIe, the computers discussed in case studies were always designed by teams. At IBM a team of managers set out the new product line (NPL) strategy, only for R&D teams to design CPUs and peripherals for the S/360. DIGITAL on the other hand relied on informal teams of engineers to design the next programmed data processor (PDP) of the family. Both the Acorn and the Apple teams consisted of people who met through computer clubs linked to a university area: the Cambridge University Microprocessor Group (CUMG) in Cambridge and the Homebrew Computer Club at Stanford. The Digital Equipment Company (DEC) founders met in a similar setting at the Massachusetts Institute of Technology (MIT) Lincoln Labs and both worked on an IBM project (SAGE). However, DEC and IBM were already established companies when they developed the PDP-11 and the S/360, whereas Acorn and Apple were only in their start-up phase when the BBC Micro and Apple IIe came out.

The design of computing devices has often been attributed to a single person, whereas my research has emphasized the team effort. These teams in turn reflect the corporate culture and social context of the time and place. While Henry Glassie's master contexts of objects start from creation, Karin Dannehl's life cycle study model begins with production.¹ I argue that the life cycle of computing devices or objects more broadly, ought to include the design phase as well. The design phase expands beyond object biographies and shares similarities across exemplary case studies. Karen Harvey's steps for material culture research include an object description, historical and socio-cultural context.² I agree that designs are not conceived of in a vacuum. On the one hand and to a small extent designs are inspired by existing devices. On the other hand, devices are constructed in a socio-cultural context. The economic context however should also be taken into account, since few computers were

1. Glassie, *Material Culture*; Dannehl, "Object Biographies."

2. Harvey, *History and Material Culture*.

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designed without any economic incentive.

James Legrand Powers built the mechanical equivalent of Hollerith's electrical punch card machines for the United States Census. Remington Rand and Powers-Samas continued to add to Powers's original line of punch card equipment. The S/360 design was based on a shared set of ideas developed by the Systems, Programming, Research, Engineering and Development (SPREAD) team, resulting in a family of compatible CPUs which connected to either new peripherals, or to peripherals adapted from earlier designs. DEC also developed a family of PDP mini-computers that through its UNIBUS could connect to a number of peripherals. There are two similarities between the PDP-11, BBC Micro and Apple IIe. First, all designs expanded on existing devices (previous PDPs, the Acorn Atom, and the Apple II). Second, each design myth mentions a prototype developed against a tight deadline. A key difference between DEC's PDP-11, the BBC Micro, and the Apple IIe lies in the origin of components. DEC had started as a manufacturer of logic modules, and had even purchased a section from the Radio Company of America (RCA) to string cores and later produce video monitors in-house, much like IBM's Solid Logic Technology (SLT) modules. Acorn incorporated components from other manufacturers such as Ferranti, and later developed chips itself. In fact, the Acorn subsidiary ARM is the only part of the former corporation still around today. According to Steve Wozniak, Apple grew because of cheaply available silicon computer chips.³

In the 1960s and 1970s computing devices were designed as families of products, at a time when family life was often idealized. Design myths of quickly developed prototypes in the 1970s and 1980s reflect the fast pace and incentive for designers to innovate. At first larger organisations and businesses needed computing devices, but from the 1970s onward, users and then consumers became important customers. Thus collectives made way for an increasingly individualised Western society and computers became consumer products. While more people continued in higher education, and students were encouraged to become en-

3. Florin, *Hackers: Wizards of the Electronic Age*.

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trepreneurs, ownership of computers like access to education, became a symbol of status. Others who actually built components and assembled computers were considered lower class, and manual labour in production was often overlooked in sources, but also in companies.

One of the most difficult life cycle stages to reconstruct was the production phase. Production is often poorly documented, unless issues caused significant delays (BBC Micro), or if a company history (DEC) also included testimonies and information about production facilities. I imagine punch card equipment was assembled in a machine shop setting, resembling an open factory floor, scattered with tools and equipment similar to a car maintenance garage. From IBM's *Bildkatalog* I gather that each facility specialised in a particular peripheral or system. Components were made on assembly lines where machines also performed tasks. DEC's case mentions largely female, blue-collar workers (*Gloria's Girls*) making the smallest components, as well as a facility taken over from RCA in Taiwan with a predominantly young female workforce. The company also greatly expanded production outside of the United States. Acorn on the contrary, fully outsourced production to national original equipment manufacturers (OEMs) in the United Kingdom. Consumers nowadays pay more attention to the provenance of raw materials and the environmental impact of the production and distribution of computing devices, as well as the working conditions in mines and factories, even when production is outsourced. The environmental impact of the production of technology, especially from the 1970s onward when computers were produced in much larger quantities, certainly presents an opportunity for further research.

Glassie's second master context of communication leans towards advertising as a sales strategy, whereas Dannehl's notion of distribution is more closely related to the installation phase of the life cycle framework for my research. Sales strategies varied for each case study. Promotion for punch card equipment from Remington Rand relied on testimonials from customers such as Helena Rubinstein in printed leaflets, attaching their brand to other successful businesses. They also sent existing customers leaflets of new equipment featuring operating instructions and

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examples. IBM boldly announced the new system in 1964, three years before the first S/360s were shipped, generating a lot of media attention. Since IBM often leased equipment, salesmen tried to convince existing customers to upgrade to a newer system. DEC's sales team mainly consisted of engineers who were encouraged to visit customers regularly in order to understand user concerns and demands. Their strong user base shared software via the Digital Equipment Computer Users Society (DECUS) and DEC printed cheap paperback user manuals to share as promotional material at conferences. For all aforementioned established businesses, retaining customers was as important as, if not more important than, convincing new potential users. Although IBM certainly took part in government funded projects (e.g. SAGE), only the 1980s case studies advocated for government funding (BBC Micro), or tax discounts (Apple IIe) for microcomputers in education. This discount or funding in combination with either direct (Apple commercials), or indirect (BBC's *The Computer Programme*) promotion via television boosted sales for younger computer companies.

A key moment in the transition from communication and distribution to consumption is the installation. As computing devices changed over time, installation became less cumbersome, but users were also increasingly responsible for installing their purchase. While Powers-Samas installed the equipment, Miss Summerell, new head of the Powers room at Helena Rubinstein in London, was responsible for designing and ordering the punch cards and other office supplies. She also needed to hire and most likely train new personnel. The IBM S/360, and larger installations in particular, required some customers to consult architects or engineers to build a room with reinforced foundations, adhering to additional electrical and fire safety regulations, a raised floor to run cables, and bespoke air conditioning inside this *cold room*. The smaller S/360 model 20 did not require a reinforced floor or air conditioning, but did often sit on a raised floor to hide cables. The peripherals and storage mediums also occupied space inside offices. Despite the name minicomputer, PDP's were often placed inside cabinets and kept in a separate computer room. Occasionally, terminals connected to the PDP were placed in adjacent of-

fices. DEC's customers were responsible for ensuring that the material could get to its intended place, but DEC engineers installed the equipment. Only with the introduction of personal or micro-computers did customers install the device themselves. While IBM and DEC published separate installation manuals, Acorn and Apple simply provided basic instructions on how to connect the cables in a much more condensed user manual.

Both Glassie and Dannehl's life cycle ends with consumption, whereas I prefer to split this phase into installation, followed by application and use because these phases imply a more active involvement of people during an objects' life cycle. Structuring case studies according to my expanded notion of the life cycle from material culture, and considering the social construction of technology from science, technology and society studies allowed me to focus on human actors for all phases of the design. As a historian these frameworks inspired me to reflect upon the provenance of material objects as I would for other sources.

6.2 Computers at Work

The application and use phase was central to the research, with attention for occupational segregation and working conditions of computer users. In accounting at Helena Rubinstein, a small team of women worked in the Powers-Samas room between 1955 and 1963. Afterwards, the team moved to another facility with International Computers and Tabulators Ltd. (I.C.T.) punch card equipment, until accounting was outsourced in 1972, making staff redundant. Women working as keypunchers or tabulators followed strict procedures and reported to both female and male managers. The predominantly female workforce of keypunchers and later data typists offered few chances of upward mobility with repetitive tasks in a noisy environment. Nearly all types of computing devices until the end of the 1970s required data typists to enter information on punch cards, tapes, or disks. Only when the technology became obsolete, did these jobs start to disappear.

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The introduction of terminals to access minicomputers on the other hand changed working conditions both for on-site employees and programmers working from home; Engineers at NASA for instance shared an open office adjacent to the computer room, but were separated from the noisy, air conditioned and pertinent smell of dust on wires by a glass window. Despite minicomputers' decreased size and the relatively lower cost of hardware, the increased accessibility through terminals gave users the impression of direct access while simultaneously keeping the computer room locked tight for most users.

Personal computers supposedly revolutionised computing in the 1970s and 1980s, but while a microcomputer became more affordable for middle-class families and was increasingly introduced in homes and schools, the interface effectively black boxed computers. Commercial software as well as educational software developed by the government, mediated the user interaction with personal computers. Software thus evolved from rudimentary programs distributed by the manufacturer with the purchased hardware such as IBM's S/360 and supplemented with programs developed by users, to user societies such as DECUS where users shared the programs they wrote for free, eventually resulting in a software industry that outpaced profits from hardware sales. By the 1980s software started selling personal computers with programs like VisiCalc.

As Michael S. Mahoney's work suggests, computing constitutes such a diverse field that we should speak of histories rather than the history of computing.⁴ The case studies throughout the thesis have only scratched the surface of computer applications from accounting, to the medical laboratory, aircraft design and computers in aerospace, and computers in education. The applications do display an evolution from computers which impacted people other than users indirectly for instance through invoices, medical results, and air travel, to a democratisation of computers allowing direct interaction for microcomputer users.

Occupational segregation remained rather constant, and female dominated repetitive jobs offered little upward mobility, payed less, and were

4. Mahoney, "The History of Computing in the History of Technology."

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often overlooked, especially in the United Kingdom and the United States. Inequality in access to occupations related to computer applications thus persisted, and the framework of intersectionality pushed me as a researcher to consider who was left out. The advertisements and images of people working for computer manufacturers or in user applications show very little diversity - gender or otherwise. The only exception to this lack of particularly racial and ethnic diversity can be found in DIGITAL's outsourced manufacturing plants in blue-collar areas in Puerto Rico or employing young women in Taiwan to produce components. Yet the blue-collar workers are mentioned as a collective and were not pictured in the company's advertisements or collection of still images. Microcomputer companies simply purchased ever cheaper components and assembled the hardware in the United Kingdom or United States rendering the workers of component manufacturers increasingly invisible.

6.3 Depictions of Technology

Advertisements for each case study illustrate an evolution from a clear focus on the product emphasising technical features and efficiency gains for executives or managers purchasing Remington Rand's punch card equipment, to the personification of applications in IBM's S/360 announcement where communication was gendered female while engineering, business, and control applications were gendered male. The equipment remained the central focus in product leaflets from DEC's PDP-11 minicomputer, however the images also show many (female) users at work. Women actively used the minicomputer but did not actively engage with the audience. Although women worked predominantly in data entry and almost half of the programmers were female, their presence in advertisements was sometimes meant to make the technology look easy to use despite their expertise. As Andreas Fickers has illustrated for radio advertisements and interfaces, several technologies have evolved from boy's (or rather men's) toys for experts and hobbyists to black boxes with user in-

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terfaces meant to make technology accessible for women.⁵

Advertisements pictured white users by default and only the images in Apple's manual included a woman and a girl of colour, neither seated at the computer.⁶ In fact, Apple proved to be rather exceptional even for its gender diversity in commercials and print advertising.⁷ Another intersectional imbalance especially observable in the United Kingdom, counteracted the genius entrepreneur and boys toys narrative of the United States by hiding youth as expert users in the Computer Literacy Project in an effort to interest and educate novice adult users. At the same time adults were motivated by an instilled fear of missing the computer revolution and losing jobs replaced by technology. Computer companies appealed to parent's sense of responsibility to offer their children better opportunities by providing them with computers at home and at school.

I started my research with a clear agenda of studying gender in an intersectional framework throughout the history of computing in terms of occupational segregation, working conditions, and stereotypes in advertising. This original intention diminished as research progressed, mainly because of source limitations. Attempting to uncover occupational segregation, especially in the past, is complicated, because few sources are available. Human Resources are rarely transparent, and privacy regulation makes personal records of employees inaccessible. While governments nowadays publish public reports about gender and diversity, and current technology giants like Meta (formerly Facebook), Alphabet (including Google), Microsoft, and others shared the gender balance of their employees pressured by media, little information concerning occupational segregation is available for the period of my study.⁸ The *Occupational*

5. Andreas Fickers, "Visibly Audible: The Radio Dial as Mediating Interface," *The Oxford Handbook of Sound Studies*, December 2011, 430, <https://doi.org/10.1093/oxfordhb/9780195388947.013.1001>.

6. Matthew Weinstein, "Computer Advertising and the Construction of Gender," in *Education/Technology/Power: Educational Computing as a Social Practice*, ed. Hank Bromley and Michael W. Apple (Albany, NY: SUNY Press, 1998), 87.

7. Weinstein, "Computer Advertising and the Construction of Gender," 99.

8. *Indicator: ICT specialists by sex | Gender Statistics Database*, 2004, https://eige.europa.eu/gender-statistics/dgs/indicator/ta_wrlab_lab_employ_

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Outlook handbook provided some insight into (gendered) occupations for the 1970s. Still, data was often aggregated in large occupational categories to a point where the actual role of employees became unclear.

When researching working conditions in the present, methods from UX design such as workplace observations paired with contextual enquiry, semi-structured interviews, and questionnaires can offer a good insight into the personal experience of computer users at work. Few publications captured the experience of a remembered user, making working conditions more explicit. DEC's company history of 1978 was based on testimonials of (former) employees, ethnographic observations between 1989 and 1991 captured the working conditions and environment in airport control rooms, and *The Legacy of the BBC Micro* report published in 2012 used a questionnaire to gauge the computer experience of former 1980s British students. Unless results from the aforementioned types of research are published or shared for the past, the best method for reconstructing working conditions is to gather different types of sources to assemble a scene of the working environment and the work process: product leaflets, installation and user manuals, images, video's, seeing the computer on display, or experiencing the device while it is running. Only visual cues and gendered discourse in text however, indicate how the working conditions might have differed based on gender.

6.4 Computer Users

The user typology proposed by Andreas Fickers in table 1.1 guided the interpretation of sources throughout the research.⁹ Both the typology and the sources merit closer inspection since theoretical frameworks shape the interpretation and influence my perspective as a researcher. The configured user as “defined by industry, manufacturer or marketing de-

selected_kwnd__isoc_sks_itsps/hbar; Miriam Quick and Stephanie Tomasevic, *Diversity in Tech*, 2014, <https://informationisbeautiful.net/visualizations/diversity-in-tech/>.

9. Fickers, “Experimentelle Medienarchäologie.”

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partment” featured prominently throughout case studies in large part because of the availability of user manuals and advertisements.

Comparing manuals from each decade offers insight into the changing target audience and purpose as well as the working conditions for users based on environmental requirements. Up until the 1980s expert users could refer to the manual for information on the system architecture, the inner and outer workings of components, and possible configurations. Programmers could find instructions in the manual and operators could find explanations of the interface. The purpose of handbooks differed and while IBM had published a library as part of their customer service for training employees, DEC had integrated manuals as part of sales. When microcomputers and personal computers entered the market however, the manuals - like the machines - targeted mostly novice or amateur users. Since manufacturers no longer installed the device, manuals now started with a new section on set-up instructing customers to attach other home technology. While teaching novices to type, manuals tried to remain relevant for experienced users through programming instructions or by focusing on expert applications as well. Ever since the 1980s however, user manuals have shrunk to a list of cautions and warranty statements presupposing that users are familiar with similar devices and that computers are so intuitive, explanation is no longer required.

The limitations of user manuals as a source are threefold. First, the mere existence of user manuals does not prove that users read the manual at all, nor how frequently users consulted the manual. Second, a handbook does not contain workaround or other forms of user appropriation. Since instructions were often written before any equipment was tested, manuals could include mistakes or fail to solve errors users encountered.¹⁰ Third, the configured user as envisioned by the manufacturer by no means corresponds to the real user. Few students in British schools of the 1980s lucky enough to get access experienced the fear the

10. Jasmin Meerhoff, *Read me! Eine Kultur- und Mediengeschichte der Bedienungsanleitung* (Bielefeld: transcript Verlag, 2011), 45, <https://doi.org/10.14361/transcript.9783839416259>.

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BBC presumed from adult novices for instance. Nor were expert programmers impressed by the long list of BASIC instructions as reviews and oral histories show. Yet without the understanding of how devices functioned and what manufacturers instructed, my reconstruction of computer use(rs) and working conditions might not be possible at all. So yes, our understanding of the past is mediated and limited by sources that itself rely on an imagined reality. The combination of multiply realities from several types of sources and user perspectives can still result in a founded reconstruction of the past.

Advertisements as a source present similar challenges because they depict the configured user as envisioned by manufacturers and marketers. This image does not necessarily correspond with the characteristics of people actually interacting with computers. However, the (visual) discourse in an advertisement can expose stereotypes in the first place from the team behind the advertisement, but also indirectly from existing or future customers and market segments as well as users. The evolution of the target audience from executives to parents and children is further highlighted by the changing advertising medium. From brochures distributed to (potential) customers by the manufacturer, to advertisements in for instance hobbyist magazines with a clear target audience, the final medium was television in the 1980s with commercials and product placement in programmes. The medium and distribution broadened to reach the general audience (or at least the white middle-class family). Additionally, the focus of advertising evolved between the 1940s and 1980s from technical features of the product to the user experience, opportunities and even status a personal computer granted the consumer.

Two unique sources did not fit into Ficker's user typology. The box of documents from the manager of the Powers-Samas room included a manual, but also offered a unique and more direct view into the installation, hiring of personnel, and responsibilities as well as work procedures at Helena Rubinstein in London. These sources move beyond the configured user into the experience of expert users. The extensive collection of stills from DEC teams and client applications slides show different working environments and contexts of use, as well as the gender and racial

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distribution in teams. Without a short description of the image and secondary literature for additional context however, the photographs themselves would add little to the research. Again the expert user beyond the configured user comes into view. Concrete actions with the device pictured are frozen in a single camera shot and rely heavily on interpretation. The working environment for users in a myriad of occupations are pictured rather than merely described leaving less room for interpretation and sparking the imagination to envision other sensory experiences of users.

Material objects on display at museums added another dimension to the analysis. Computers surrounded by glass display cases gave a sense of the dimensions, the interface, and in some cases showed marks of use. Worn out buttons indicated which buttons users pressed often. Minicomputers literally required a key to be inserted and turned ninety degrees to the left as if firing a car engine rather than turning on a PDP-11. Computers originating from schools were often tattooed or marked to assert ownership thus physically indicating where machines were used and by whom. At some museums volunteers devoted their time, energy, and expertise to restoring computers to working order so that visitors could actually interact with the device or see a demonstration of a large mainframe in operation. Although these computers are taken out of their original context of use, the noises of machines whirring, beeping, rattling, the visual cues such as small diodes lighting up or blinking and images on screens, the temperatures and smells around these ancient devices reenacted the sensory experience. Hands-on experience furthermore added the haptic sensation of turning switches and pressing keys. In *Why Hands On History Matters* John Ellis emphasizes that “written descriptions are not enough to develop a real understanding of the machine and its functioning.”¹¹ As a researcher the experience did not necessarily change my interpretation of sources, but rather redirected my attention.

11. John Ellis, “Why Hands on History Matters,” in *Hands on Media History*, ed. Nick Hall and John Ellis (London: Routledge, 2019), 10, <https://doi.org/10.4324/9781351247412>.

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Because of my hands-on experience, I delved deeper into environmental requirements mentioned in handbooks, and paid more attention to the ergonomics of a device to name just two examples.

Aside from personal hands-on experience, I set up user experiments to gain insight into the interactions of others. The reenacted user does not necessarily reflect the sense of novelty or the learning process of amateur users at the time. Instead the current perception of 1980s microcomputers and personal computers retroactively illustrates changes compared to current technology. For some participants who had used similar computers in the 1980s a remembered user perspective was prompted by the experiment, while younger participants expressed nostalgia, frustration or impatience. Struggles and errors indicated which elements of the interface were not intuitive to reenacted users. At the same time the issues encountered during the experiment pointed out how novices at the time might have experienced the often mentioned fear of breaking things in manuals.

The remembered user only appeared in the final two chapters through interviews and surveys conducted by other researchers or television show and documentary makers. The interviews often discussed the vision, impact, and perspective of inventors and designers of computers from the 1980s, privileging a heroic and individualistic narrative. A broader survey of people who remembered using microcomputers in the 1980s was still biased toward experts from the software industry rather than amateur users.

The user typology encouraged me to reflect upon which elements of the user experience sources allowed me to reconstruct, and especially the elements of experience we cannot reconstruct. The user perspectives emphasize the multiplicity of users, yet at the same time expose which users are not preserved in historical sources. For my case studies, the configured user featured most prominently, in combination with the expert user. I do at times question the distinction between the expert and amateur user perspective because defining expertise contains a certain judgement. If I stick with the artificial distinction between expert and amateur, the amateur user is only visible in the final chapter when access to

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computers expanded. The remembered user perspective is also limited to the most recent case studies. Oral history requires former users to be alive, available, and capable of remembering their experience, unless earlier interviews are publicly available. Finally, computing experiences can only be reenacted for functioning devices. Nearly all sources discussed in the framework of user perspectives however focus on the initial stages of the life cycle of computers of design, production, sales, and the use in different applications. The case studies have not mentioned when technology was decommissioned or perhaps re-used, an omission that the final section of the conclusion will rectify.

6.5 The Demise of a Device

Two phases of decline I refer to as end of life and re-use determine whether or not objects are preserved and the environment in which we now experience historic objects.

A first research question which arises at the end of life stage is what happened to the computer after use? In accounting at Helena Rubinstein for example the Powers-Samas punch card equipment was replaced in 1963 when the office moved from London to Molesey. By 1972 data processing had been outsourced.¹² The Powers-Samas equipment was first replaced with an International Computers and Tabulators Ltd. (I.C.T.) installation which mostly included newer models of the same, except for the tabulator which was replaced by a data processor.¹³ In fact, I.C.T. merged the British Tabulating Machine Company (BTM) which sold Hollerith equipment with Powers-Samas bringing together two rivals of the

12. "Powers-Samas and ICT Documentation," Box FB56, CH28274, Centre for Computing History, Cambridge (hereafter cited as Powers-Samas and ICT Documentation), <http://www.computinghistory.org.uk/det/28274/Powers-Samas-ICT-Documentation/>.

13. International Computers and Tabulators Limited, "Proposals and Specifications for the Installation of ICT Data Processing Equipment. Submitted to Helena Rubinstein Limited," 1 October 1963, Powers-Samas and ICT Documentation.

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early punch card industry.¹⁴ Only in the 1970s did data processing change to computers, in line with Martin Campbell-Kelly's observation that "many existing punched card machine installations remained in operation throughout the 1960s, but by the 1970s, the great majority of data processing departments had switched to computers."¹⁵

Two curators from museums in the United States and the United Kingdom pointed out a particular difficulty in finding IBM equipment from the 1950s and 1960s. Instead of selling computers, IBM often leased machines and reclaimed the equipment afterward. A volunteer in charge of the Large Systems gallery at The National Museum of Computing (TN-MOC) in Bletchley explained "IBM tended to rent equipment, rather than sell it. [...] The equipment went back to IBM at the end of the lease period and got scrapped or got reused."¹⁶ Similarly, Dr. Moya from the Living Computers Museum+Labs (LCM+L) in Seattle, Washington, observed "most IBM computers were leased in America, so when they were done with the lease they took it back and destroyed it or reintegrate it into something else [...]. It's hard to find IBM mainframe equipment in America anymore."¹⁷ At the end of life stage, the manufacturer rather than the user decided whether to scrap the computer or reuse parts for other installations for IBM computers. The Deutsches Museum (DM) in Munich provides another example from the end of life stage, in which a donation was turned down and sold for parts. "Alleine der Goldwert der Kontaktverbindungen wird heute mit ca. 5.000,- DM vergütet. Daher wurden alte Anlagen grundsätzlich demontiert."¹⁸

Further research questions surrounding the end of life of objects are:

14. Wikipedia's "International Computers and Tabulators" and "British Tabulating Machine Company" entries.

15. Campbell-Kelly, "Punched card machinery," 1491.

16. P. V., (Volunteer, The National Museum of Computing), interview by Sytze Van Herck, July 21, 2019, Bletchley.

17. Moya, (Collections Manager, Living Computers: Museum + Labs), interview by Sytze Van Herck.

18. Norbert Köthe to Deutsches Museum von Maisterwerker der Naturwissenschaft und Technik, "Angebot IBM-Anlage /360-20," 21 February 1986, Bestellnummer 7156, Verwaltungsarchiv, Deutsches Museum, München (hereafter cited as Verwaltungsarchiv).

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Who decided to scrap, replace, or remove the computer? Who did it go to next? Companies and later home users often replaced computers with newer models, with leased equipment returning to the manufacturer before being scrapped or re-used. Other computers were sold for parts or simply moved to the basement, attic, or other storage space to gather dust and eventually end up forgotten. Then again, when surviving machines were rediscovered, some were donated to museums or sold on the second hand market. Martin Campbell-Kelly for instance discovered “an active market for new and refurbished punched card machines to process old data and even to record current information such as payrolls.”¹⁹ So while many computers like other ordinary consumer products disappeared, in exceptional circumstances objects found a new home in museums or with private collectors.

If computers found a new owner, how did the owner acquire it? Few museum archives concerning acquisitions or donations are directly accessible. Correspondence from the Deutsches Museum’s *Verwaltungsarchiv* however nicely reconstructs the provenance of the IBM S/360 on display in the *Mathematische Instrumente und Rechenanlagen* gallery. The model 20 computer from 1967 or 1968 was donated to the museum in 1984 by the Erdinger Rechenzentrum, which repaired IBM equipment.

Sie haben dem Deutschen Museum [...] eine entwicklungs-
geschichtlich bedeutende Rechenanlage der Herstellerfirma
IBM überlassen, und zwar ein aus dem Jahr 1967/68 stam-
mendes System 360, Modell 20. [...] Die Rechenanlage wurde
zunächst in unser Studiendepot aufgenommen. [Sie bildet]
einen wertvollen Grundstock für unsere geplante Abteilung
“Mathematische Instrumente und Rechenanlagen.”²⁰

For two years the machine remained in the depot until the exhibition opened in 1986 where the computer is still located now. Not all objects

19. Campbell-Kelly, “Punched card machinery,” 1491.

20. Dr. Otto Mayer to Erdinger Rechenzentrum GmbH, “Datenverarbeitungsanlage IBM 360/20,” 3 December 1984, Bestellnummer 7151, Verwaltungsarchiv.

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end up in museums. In fact a blog from volunteers at TNMOC details their private initiative to acquire and restore an IBM S/360 model 20 from a dilapidated building in Nuremberg.²¹ Furthermore, museums also purchased objects emerging from storage. Dr. Moya for instance recalled the LCM+L museum's acquisition of an IBM 7090 originating from the Weapons Research Establishment (WRE) in Woomeera, Australia, which an employee had purchased after the machine was scrapped. "He put it in his pole barn with the intention of recommissioning it someday in a museum. [...] But he soon discovered it would be very expensive to get an IBM engineer, a raised floor, the air-conditioning, the power. It had some really heavy power requirements."²² Forty years later his widow eventually sold the machine to a museum. Like most objects in museums however, the device was still in storage waiting to be restored.

For those exceptional objects which do end up on display at a museum, three final research questions arise. How is the computer displayed? Who can access the machine now? Who can keep this equipment running? Out of seven computer museums I visited, at least four made the majority of computers on display available for visitors to interact with.²³ In all four museums the effort, knowledge, and expertise of enthusiastic volunteers, often retired engineers, meant machines were restored and kept in working order. When this older generation of engineers comes to pass, their tacit knowledge and expertise might be lost. Other objects are sometimes taken apart to assemble one fully operational device and restore a single mainframe, minicomputer, or microcomputer to working order. The availability of a large number of spare parts is eas-

21. Adam Bradley, Chris Blackburn, and Peter Vaughan, *IBM 360 Model 20 Rescue and Restoration – Documenting the recovery and restoration of an IBM System 360 Model 20 and potentially an IBM System 370 Model 125*, <https://ibms360.co.uk/>.

22. Moya, (Collections Manager, Living Computers: Museum + Labs), interview by Sytze Van Herck.

23. In the UK both the Centre for Computing History in Cambridge and The National Museum of Computing in Bletchley had some (micro)computers running games. The Media Archaeology Lab in Boulder, Colorado, and the Living Computer Museum+Labs in Seattle, Washington, both reflect the possibility to experiment with computers in their name, referring to the laboratory.

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ier for mass produced computers such as the Apple IIe or BBC Micro-computer. The collection organisation in the LCM+L reflects the goal of the museum to encourage interaction. In storage, some machines are taken apart by engineers and the storage is organised by component as an engineering shop to use scraps for restoration. The Centre for Computing History (CCH) in Cambridge for instance received so many BBC Microcomputers that they no longer register all donations and instead only officially entered a BBC Microcomputer System of each model in the original box. Sometimes new technology such as Raspberry Pi emulated the operating system and software to preserve software and keep electricity consumption down. The visitors thus do not necessarily interact with fully preserved original computers, but might unknowingly interact with a Frankenstein machine that nevertheless recreates or reenacts the experience of historic devices.

6.6 Do We Interpret Past by Present?

As a historian I was trained to respect the historical context and avoid anachronistic interpretations of the past. Research interests and questions however, are certainly shaped by both our personal experiences, and current debates in society. When I started my research a public history publication and feature film *Hidden Figures* restored the role of female African-American employees at NASA, and the scientific publication titled *Programmed Inequality*, illustrated how the topic of gender and the history of computing had permeated society and research. Gender studies, the framework of intersectionality, and the increased focus on user experience as computers entered the lives of more and more people, have all shaped my methodology. Only when I started to research the devices themselves in order to reconstruct past user experiences, did two methodological frameworks converge in my dissertation: the life cycle approach to material objects, and the user perspectives from media history.

The life cycle framework breaks away from a rigid periodisation of

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computing devices determined by either the date of announcement, or first delivery of a machine. Instead, I have adapted and extended the three stages of production, distribution, and consumption to suit computing devices with phases of design, production, sale, installation, application and use, and de-commission or re-use. The idea of a life cycle allows researchers to incorporate additional actors and periods when studying technology or other material objects. Computers as an artefact are shaped by humans and the human actors in the network are not limited to the developers, but also include the consumers and users who domesticate or appropriate technology. Some computers and especially software has been maintained for a long period, which other histories of computing rarely mention. The first iteration of the life cycle however shortened in time as research progressed, not because of an ever faster technological innovation, but rather due to changes in price, size, and owner. When businesses or government institutions purchased and installed large and expensive computing devices, the high monetary, time, personnel, and training investment, as well as major changes to the infrastructure, discouraged them from rapidly decommissioning computers. As computers became smaller, cheaper, and commercially available to individual consumers, consumer society and marketing encouraged owners to replace their computer with the latest and newest. Case studies add even more complexity emphasizing unique applications and uses. Researchers often forget about the time between the creation of a source and the moment in which they consult it. Including the phase of de-commission and re-use accounts for an additional context in which the artifact was used.

Methods from UX design are especially useful in the application and use stage of the life cycle and helped me to take the sensory experience into account. Museum visits and user experiments can reconstruct a past we cannot experience anymore, by reenacting user interaction. Some sensory experiences such as the haptic feedback, sound, and smell of certain computers are difficult to recreate and even harder to describe based on experiments. However, capturing sensory experiences purely based on images and textual sources is at times almost impossible. The

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added value of focusing on the perspective of the user rather than on the technology itself is that the technology is placed within the social, cultural, economic, and sometimes political historic context. The user perspectives linked to types of sources further shaped my reflection on the mediation of sources on what they can and cannot tell us about the experience of what I call the everyday user. Most readily available sources for instance focus on the configured and the expert user. One criticism of the user perspectives however is that an oversimplified categorization often diminishes real life complexity. A single everyday user could assume different user perspectives throughout their lives and in relation to different computers.

Finally, I hope to inspire others to appropriate my methodology, preserve sources, and research similar phenomena in current society. I invite archivists and curators to reconsider the types of sources that are preserved, and encourage (disappearing) computer companies to deposit their documents in well-established and stable institutions. With increasingly complex technology such as networks and software, archivists need to rapidly develop methods to preserve information and retain material artefacts of invisible technology. I encourage social scientists to continue research into working conditions and cultures, paired with gender biases. UX designers should value and publish user experiments even when they may not have led to new (iterations of) products. The preservation of a machine does not guarantee that the experience can be recreated. In order to reconstruct the user experience, historians rely on many different types of sources which each highlight a different user perspective. Throughout this research, case studies have been limited to particular computer applications. Other case studies of both computer models and applications certainly present an ideal opportunity for further research. Historians can give a voice to users as well in oral history archives such as *Archives of IT*. Additionally, by moving out of the archive from time to time, historians can also guard themselves from applying the I-methodology. If we ask others about their experience, we can include perspectives absent from sources. I hope governments continue to research demography and occupations, broadly conceived, and suggest framing statistics

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with detailed information about job categories in order to keep a close eye on occupational segregation and inequality. By addressing and diminishing overt and implicit barriers to occupations, I hope all people are encouraged to follow their passion.

Appendix

Curator Interviews

1. Which item in the [institutional] collection deserves better attention? Why?
2. When you think of this artefact can you tell me how/why this object was acquired?
3. If you could start over in developing the collection, what would you change?
4. How did you select/display/communicate the collection?
5. Who is the target visitor of the [institution]?
6. Visitor Journey Map
7. Which era/location/group would you like to include more (if you had budget, space) and why?
8. What haven't I asked you that you think would be valuable for me to know?

APPENDIX

Visitor Journey Map



Reenactment

5-Second Test

5-second test

1 Do you recognise this device? *(circle your reply)*

Yes No

2 My general impression of this device is ...
(circle your reply)

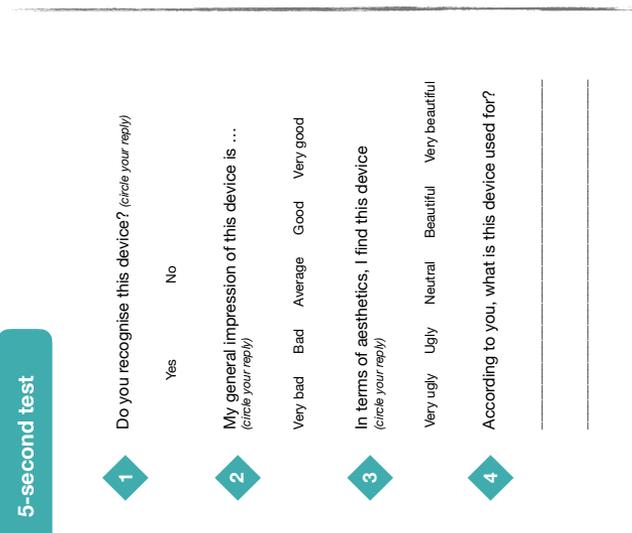
Very bad Bad Average Good Very good

3 In terms of aesthetics, I find this device
(circle your reply)

Very ugly Ugly Neutral Beautiful Very beautiful

4 According to you, what is this device used for?

5 Which elements of the device do you remember (text, logo, color, images, menu...)? Draw everything you remember from the device below, reproducing the interface.



Apple IIe - Maps and Globes

Instructions

1. Start the computer and insert the game into the disk drive. Enter your name when asked.
2. Select latitude and climate from the menu and follow the instructions.
3. When you get bored, go back to the main menu and select the world traveler simulation.
4. Once you finished the game, go back to the main menu. Turn off the computer and the screen before you take out the disk.

APPENDIX

Observation Sheet

Participant nr.: __ Observer: Sytze Van Herck Date: __/11/2018 Time: __:__

	Time	Notes	Pain points	Success / Fail
T1. Start computer, enter game, enter name.	Start ____ : ____ Finish ____ : ____			
T2. <i>Latitude & Climate</i>	Start ____ : ____ Finish ____ : ____			
T3. Back to menu	Start ____ : ____			
T3. Change disks				
T3. <i>World Traveler Simulation</i>	Finish ____ : ____			
T4. Shutting down computer.	Start ____ : ____ Finish ____ : ____			

Apple IIe - WordPerfect

Instructions

1. Start the computer and insert the Word Perfect disk into the disk drive. Follow the instructions on the screen.
2. Once you are done reading the introduction, exit the screen. You should save the readme document and then replace it.
3. Once you have an empty screen, please create this document:

1320 Grandview Avenue,
Boulder CO 80302
United States of America

Object: thank you!

Dear Mr or Ms,

I recently bought an **Apple IIe device** and I wanted to thank you for designing such a great word processor. As a teacher, this makes my life **WAY EASIER**. It is a surprisingly rich little package and I also appreciate the expansion tools. I am looking forward to more innovation in the upcoming years.

Yours faithfully,
Ms. Rose Morse

4. Save the file under "Thankyou"
5. Exit the document, you don't have to save it again. Turn off the computer and the screen before you take out the disk.

APPENDIX

Observation Sheet

Participant nr.: __ Observer: Sytze Van Herck Date: __/11/2018 Time: __:__

	Time	Notes	Pain points	Success / Fail
T1. Start computer, Insert WP, Insert Work.	Start ____ : ____ Finish ____ : ____			
T2. Read introduction, exit screen, save and replace.	Start ____ : ____ Finish ____ : ____			
T3. Create document. Bold. Underline.	Start ____ : ____ Finish ____ : ____			
T4. Save File	Start ____ : ____ Finish ____ : ____			
T5. Shutting down computer.	Start ____ : ____ Finish ____ : ____			

BBC Microcomputer - Mapventure

Instructions

1. Turn on the computer. Then insert Mapventure Part I into the disk drive. Press Shift + Break to start the game.
2. Select the startup menu and go to the beginning. Follow the instructions.
3. When you get bored, restart the game and select camping field from the startup menu.
4. For the adventure game you are allowed to take notes and use the reference material.
5. Once you finish the game or get sick of it, turn off the computer and the screen before you take out the disk.

APPENDIX

Observation Sheet

Participant nr.: __ Observer: Sytze Van Herck Date: __/07/2019 Time: __:__

	Time	Notes	Pain points	Success / Fail
T1. Start computer, Insert game, start game.	Start ____ : ____ Finish ____ : ____			
T2. <i>The Beginning</i>	Start ____ : ____ Finish ____ : ____			
T3. Back to menu	Start ____ : ____ Finish ____ : ____			
T3. <i>Camping Field</i>	Start ____ : ____ Finish ____ : ____			
T4. Change disks	Start ____ : ____ Finish ____ : ____			
T4. <i>Adventure Game</i>	Start ____ : ____ Finish ____ : ____			
T5. Turning off computer.	Start ____ : ____ Finish ____ : ____			

BBC Microcomputer - Wordwise

Instructions

1. Turn on the computer and start Wordwise Plus by typing *WORDWISE-PLUS. Go to edit mode and type the following letter, with the correct layout.

Rene Court
Coldhams Road
Cambridge CB1 3EW

Acorn Computers Limited
Fulbourn Road
Cherry Hinton
Cambridge CB1 4JN

Object: thank you!

Dear Sir or Madam,

I recently bought a **BBC Micro** and I wanted to thank you for designing such a great word processor. As a teacher, this makes my life **WAY EASIER**. It is a surprisingly rich little package and I also appreciate the expansion tools. I am looking forward to more innovation in the upcoming years.

Yours faithfully,

Ms. Rose Morse

2. Preview the text.
3. Insert the empty floppy disk and save your text as 'thankyou'

APPENDIX

Observation Sheet

Participant nr.: __ Observer: Sytze Van Herck Date: ___/07/2019 Time: ___:___

	Time	Notes	Pain points	Success / Fail
T1. Start computer, Start Wordwise Plus,	Start ____ : ____ Finish ____ : ____			
T2. Edit text Fully Indent Centre Double-strike Underline	Start ____ : ____ Finish ____ : ____			
T3. Preview File	Start ____ : ____ Finish ____ : ____			
T4. Insert empty floppy disk. Save text	Start ____ : ____ Finish ____ : ____			
T4. Turn off computer.	Start ____ : ____ Finish ____ : ____			

BBC Master - Domesday National Disk

Instructions

1. Press Ctrl + Q + Break to restart the disc and see the introduction video.
2. Once you are in the entry of the National Gallery, choose a gallery from the plan and navigate there. Click on the bottom left of one of the images on the wall and browse through a collection of interest.
3. Select a different gallery from the plan and navigate there. Find the text written on the wall and click on one of the topics that interest you. Use the index to find a page you like.
4. Navigate to the “Daily Life” gallery and walk through the right top window of the gallery, showing a driveway. Walk up the driveway, and enter through the front door. Look at the plan and choose a room you want to see. Walk to the room and zoom in on one item.
5. Walk back to the end of the driveway to get back to the gallery. Go back to main and use the “find” button and look for “Diana”. Choose the film from the list of results and let the researcher handle the disc.

APPENDIX

Observation Sheet

Participant nr.: __ Observer: Sytze Van Herck Date: __/07/2019 Time: __:__

	Time	Notes	Pain points	Success / Fail
T1. Restart disc and look at introduction video	Start ____ : ____ Finish ____ : ____			
T2. Navigate to gallery Browse through collection	Start ____ : ____ Finish ____ : ____			
T3. Back to gallery	Start ____ : ____ Finish ____ : ____			
T3. Navigate to different gallery. Wall text. Using index.	Start ____ : ____ Finish ____ : ____			
T4. Back to gallery	Start ____ : ____ Finish ____ : ____			
T4. Navigate to Daily Life gallery Find window. Walk driveway Choose room, navigate. Zoom in.	Start ____ : ____ Finish ____ : ____			

APPENDIX

Participant nr.: __ Observer: Sytze Van Herck Date: __/07/2019 Time: ____:____

	Time	Notes	Pain points	Success / Fail
T5. Back to gallery	Start ____ : ____ Finish ____ : ____			
T5. Go to find. Search "Diana".	Start ____ : ____ Finish ____ : ____			
T5. Researcher turns disc	Start ____ : ____ Finish ____ : ____			
T5. Watch film.	Start ____ : ____ Finish ____ : ____			

APPENDIX

Interviews

1. Describe the experience in 3 words.
2. What was the easiest / hardest part? And the most surprising?
3. How does it compare to new technology?
4. What was your impression of interacting with this computer?

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