BRITISH COMPUTER SOCIETY
MONOGRAPHS IN INFORMATICS
Editor: P. A. Samet

# MICROCOMPUTER-BASED AIDS FOR THE DISABLED

Julia M. Schofield

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# MICROCOMPUTER-BASED AIDS FOR THE DISABLED

JULIA M. SCHOFIELD

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# CONTENTS

# LIST OF FIGURES

# FOREWORD

It has long been recognized that programming is an activity in which physical disability need not be a handicap to success. Equally, computers have for long been used successfully to control complex machinery. The recent development of inexpensive microprocessor technology has brought computer-controlled equipment into the lives of all of us, in the form of digital watches, pocket calculators, space invader games and the like. Fun but rarely essential.

For the severely disabled, however, the new technology offers the possibility of doing some of the basic things most of us do effortlessly and without a second thought. The construction and evaluation of such aids is the theme of Julia Schofield's fascinating text, which is both stimulating and exciting to read. Being herself blind Julia brings an understanding to the overcoming of the problems and frustrations of physical handicap that few people can match.

I am proud to welcome this volume to the BCS Monographs in Informatics series. I hope that some, at least, of its readers will be encouraged to take up work in this field.

July 1981

P. A. Samet
Series Editor
BCS Monographs in Informatics

# PREFACE

The material in this book was originally written as a PhD thesis at the Hatfield Polytechnic, the research being carried out at the National Physical Laboratory under the guidance of the late Dr Chris Evans, author of 'The Mighty Micro' and expert in the human factors associated with man–computer interaction. Chris's unique way of thinking and experimental approach to research are very apparent throughout the chapters discussing the research work. During the last two years there has been much interest in the subject of microcomputers and the disabled and it seems useful to publish the thesis material, along with other useful information, as a book.

The aims of this book are twofold:

(1) To make a study of existing problems and their possible solutions for specific groups of disabled people, this being the first piece of work of this kind that studies and discusses the problems of both the sensory and the physically handicapped together.
(2) To discuss current aspects of state-of-the-art microelectronics and computer technology with the specific aim of seeing where these can be built into a general aid for the disabled which can be maintained and purchased economically.

It is hoped that the material in this book will be of use to those already doing similar work, those interested in purchasing aids and those working with or constantly in touch with the severely disabled.

# ACKNOWLEDGEMENTS

Many people have offered invaluable help and assistance throughout my research, but nobody gave more enthusiasm and encouragement than the late Dr Chris Evans, who unfortunately died in late 1979 before the work in which he had played such an important part was written up. Chris's unique work on human factors at the National Physical Laboratory offered the ideal environment for research of this kind. I would also like to thank Dr David Schofield who took over the supervision of the work after Chris's death and ensured that it was written up. Others who deserve particular thanks are the NPL workshop for building and designing equipment; the Department of Human Sciences at Loughborough University of Technology for the team work on MAVIS; BP Ltd, Banstead Place, Dr Tony Hicklin and the Dawsons for taking part in the evaluation of MAVIS; and many others who provided equipment or expertise. I should also like to thank Dr John Lewis of Hatfield Polytechnic for his overall supervision of the work.

I should like to thank the following, who have granted me permission to reproduce copyright material: BP Ltd (Fig 2.12), the BBC (Fig. 2.13), C. K. Bliss–Blissymbolics (Fig. 3.5), Telesensory Systems Inc. (Figs. 2.1, 2.2, 2.3, 2.4, 2.9 and 3.3), Tools for Living (Fig. 2.10) and B. Wilby (Fig 2.11). Figures 2.5, 2.7, 2.8, 3.4, 4.2, 4.4, 4.6, 4.7, 4.8, 4.9, 4.10, 5.1 and 5.2 are Crown copyright and are reproduced by permission of the National Physical Laboratory.

J. M. Schofield

## Chapter 1

# AN OVERALL VIEW

## 1.1 GENERAL INTRODUCTION

My work in this area really started in the Computer Science Department of Hatfield Polytechnic where a small group of lecturers were very interested in how the computer could be used to bridge the communication gap between Braille and print. One lecturer in particular, Mark Jenkin, deserves special mention. His hours of work on building a Braille translation system using the central DEC System 10 machine and his ideas and thoughts guided me towards this topic. Other contributing factors at this stage were two severely disabled students in my year studying Computer Science. One of these was a paraplegic, confined to a wheelchair all the time, and the other was a spastic, unable to write; both had very different problems from my own visual handicap.

I have always been painfully aware of the cost of equipment that a disabled person requires and this is particularly true for a severely motor impaired individual. Although microprocessor technology is beginning to be used in the most recent aids for the disabled, most equipment currently is built of discrete components. The electromechanical nature of this equipment not only makes it expensive to buy, owing to its specialized nature, but also a disaster to maintain. One of the outstanding motivations for my own work has been to try to create a general approach to aiding the disabled and to use a technology that is becoming cheaper. However, this will by no means solve the problem of purchasing necessary equipment: aids may do more and be more reliable but the cost to a parent, or person out of work, will still be astronomic.

So, with a background of having carried out research into Braille translation, especially of technical material, I started, in the middle of 1975, to study ways in which computers might be used to assist disabled people. A seminar had been held in 1974, arranged jointly by Hatfield Polytechnic and the Royal National Institute for the Blind (RNIB), to discuss the role of the computer in the lives of the blind. Comments from this formed the basis for my own work. The subject of using microelectronics for assisting the disabled was already of great interest to many individuals and university departments throughout the world, but nobody seemed to be trying to generalize it across the disability groupings. This book tries to introduce this generalized point of view, as well as surveying some relevant existing aids.

## 1.2 INCLUSIONS AND EXCLUSIONS

A very full study of disabilities and current aids available, with their history, would run into volumes and would not necessarily produce definite background information and proposals on how computer technology can be used in future aids for the handicapped. Disabilities are here grouped broadly into the following.

(1) The Sensory Handicapped (visual disabilities, hearing impairment and speech difficulties).
(2) Motor Impairment (often called physical handicap in Britain).
(3) Mental Handicap.

While these groups may be discussed separately, it is important that later generalizations can be gradually built up using individual problems. This approach illustrates where problems for a particular disability have to be dealt with separately and where the general approach would offer great improvements. However, there is an increasing number of multiply handicapped people and these are posing more problems for the aid builders. The problems of the multiply handicapped are particularly relevant to the later chapters, especially where MAVIS and the off-the-shelf machines are discussed. It is in the area of multiple disability that the microcomputer has the largest part to play.

Specific clinical details of particular diseases are generally not included, although the effects are frequently discussed. In the later chapters, where handicaps are discussed, an educational and rehabilitational approach has been taken rather than a clinical one. Much of my own work has been based on the sensory and motor impaired, although MAVIS design (Chapter 4) and evaluation (Chapter 5) relate mainly to the multiply disabled, including those with brain damage.

Chapter 2 of the book briefly describes some of the more advanced aids currently available. This chapter should be treated mainly as background to the current work — it is not intended as a full survey of aids. Aids included have been carefully selected to provide contrast and background to the work discussed in Chapters 4 and 5.

Much of the work described here is experimental and was carried out at the National Physical Laboratory (NPL), Teddington. The philosophy of the man–computer interaction group at NPL has always been to try out simple ideas, which often seemed ridiculously obvious, and to build systems round the results if these were favourable. This 'building block' approach was taken here, with the initial experiments being described in Chapter 3 and work with MAVIS in Chapters 4 and 5. Any results from the initial experiments are given in Chapter 3 but trials with off-the-shelf computer systems and with MAVIS are rather more long term. These are discussed in general terms in the final chapter. Very few quantitative results have been given, as the aim of the experiments was to establish people's feelings towards certain configurations of equipment and to proceed depending on whether they were liked or disliked. As few quantitative results have been included, some reports from independent observers and users have been inserted as a balance.

The following topics are outside the scope of this book. In most cases they have not been ignored but, for a variety of reasons, inclusion is not appropriate to the work described here.

(1) Mobility problems, including control of cars, wheelchairs, robots etc.
(2) General health problems and social difficulties.
(3) Clinical details of different types of disabilities.
(4) Work specifically aimed at severe mental disorders when not associated with physical difficulties.

## 1.3 INTRODUCING SOME GENERAL PROBLEM AREAS

This short section talks very briefly about some of the areas that are to be covered later. Already a very broad classification of disabilities has been introduced and this is used throughout. It will be seen in the later chapters that different aspects of these problems can either be coped with using a generalized aid that is tailored to the person's needs (Chapter 4) or solved individually (examples in Chapter 2). In some cases there is nothing yet available that can help.

One example of a problem that affects a wide variety of different disabilities is that of communication. Visually impaired people can communicate by speech, but they either use Braille for writing or have to type all material. A severely motor-impaired person does not possess the dexterity to write normally and, owing to lack of movement and the right kind of equipment, often cannot type or correct written material easily. These two groups of disabled people appear to have different problems but on investigation it can be seen that it is the same writing difficulty showing itself differently. A possible solution is to produce a typewriter with easy editing and with some sound keys to assist those with a visual disability.

The above problem serves as an illustration of the different approach that has been taken in this book. The problem of communication is not discussed in full here and nor is the solution. In fact, communication problems affect all groups of severely disabled people in different ways, as will be seen later. One of the problems that also affects many handicapped people is that of mobility. This has not been included in this study although, where relevant, it is mentioned. It is not denied that a similar study should be carried out in the mobility area.

## 1.4 TWO BASIC APPROACHES TO AIDING THE DISABLED

So far this introduction has been concerned with approaches to the research programme, and introducing disability with some of its problems. In this section two basic approaches to actually designing and building an aid are briefly introduced. There are, of course, many other ways of aiding the disabled but the more 'social' of these are not discussed. Much of the work that follows is concerned with the development of future aids for the handicapped using recent developments in microelectronics as a basis for the equipment.

Until very recently, the general trend in aids for the handicapped has been to develop equipment specifically to assist one particular aspect of disability. This approach has evolved and in most cases the necessary technology has not been available for any generalizations. This book does not argue that the specific approach should stop (it is obvious that someone without sight does not want a wheelchair even if it does talk), but suggests that a wider view of disability might now be appropriate as well. This possible change in direction can be directly attributed to the new microelectronics technologies.

The recent trends in microelectronics do not only affect the more general approach to building aids developed throughout this book. Already there are miniaturized circuits and microprocessors being used in some specific aids. For example, in 1970 the world's first print-reading machine for the visually handicapped (the OPTACON, Section 2.2) was produced. This probably marks the start of a general change in direction. The change was much needed, especially in the area of reliability.

In summary, the two approaches to building aids for the disabled are:

(1) the specific approach (solving one particular problem for a group of disabled people; see Chapter 2), and
(2) the system or group approach (doing a human factors study of one particular problem across the disability groupings and developing suitable equipment; see MAVIS, Chapter 4).

The systems approach requires much research in the areas of human factors contributing to the building of an aid, and into the assessment and training required for a generalized piece of equipment. It is also necessary to take an entirely different look at the equipment so that it can have a general body with *cheap* bolt-on extras for tailoring. This monograph describes four years work in this area.

## 1.5 THE ROLE OF THE MICROPROCESSOR

Already in this chapter microelectronics have been mentioned and their effects briefly discussed. Most of the changes in direction in designing aids for the handicapped can be attributed directly to the microprocessor and its associated miniaturized circuits. The great advantage of using a microprocessor with associated memory etc. (a microcomputer) as the heart of an aid for the handicapped is the great flexibility it offers. Other advantages come down to straight economics and maintenance. In the past, many projects for building equipment for the disabled have had to be shelved purely because the technology was not available, at the right price, for a small market. Until now, it has been very difficult to alter a mass-produced article for the disabled, and in many cases where adaptation is currently possible it is so costly that the equipment loses many customers; for example, the POSSUM adaptations to typewriters (Section 2.5). Using 'off-the-shelf' chips, modules and even systems, the approach to providing, adapting and building aids is rapidly changing.

The microprocessor can be used in aids for the disabled in three distinctly different ways:

(1) as a built-in component along with all the other circuitry (for example a talking calculator, Section 2.3),
(2) as a specially built microprocessor-driven personal computer designed specifically for use by the handicapped (see Chapter 4), or
(3) as an 'off-the-shelf' personal computer system adapted by the user or just used as it is (see Chapter 6).

The first use of a processor is really just a miniaturization of circuitry and is invisible to the user; this will not be considered again as one of the definite approaches to using microprocessors in aids for the disabled, although it is very valuable. The second and third uses of built-in microprocessor systems are discussed in this book and are of major importance to current work.

## 1.6 MAINTENANCE, TRAINING AND ECONOMICS

The three topics of maintenance, training and economics will be discussed further where they are relevant, in later chapters. As all three are crucial to the success or failure of an aid, some introductory comments are given here.

Many of the existing aids that offer a very useful service to an individual have been received unfavourably because of poor maintenance by the supplier. A disabled person very quickly develops a psychological dependence on an aid and will feel very lost when it is not working, even if the fault appears at a time when the aid would not have been used anyway. It is now becoming common for systems to offer a self-debugging routine for fault finding which can be used without an engineer. On the way out, hopefully, are the vast electromechanical aids that need so much maintenance, and in their place is coming equipment that can be maintained by exchanging circuit boards. However, as aids become more complex the need for them to work continuously increases and the cost of offering fast maintenance, therefore, also goes up.

Training can also be a costly process, more necessary for some aids than for others. Some of the new aids offer 'teach yourself' systems that could be handled by many, but not all, users. For some equipment, for example the Optacon (Section 2.2), very specialized training is required with highly skilled teachers. At present there are no centres that run training for a number of different aids under one roof; this would be ideal but very difficult to set up and justify. Linked with training is the initial assessment of the suitability of a user for a particular aid. This is a subject that is currently changing rapidly as equipment based on microprocessors becomes more widely used.

In the previous two paragraphs the economics of more generalized aids have already been introduced. Many of these do require special training but such aids tend to be more reliable, solving perhaps more than one problem and making a severely disabled person employable for possibly the first time. The aids at present are costly for their initial purchase and the costs that are saved through use are frequently hidden. If employment is achieved then there can be a great saving to the state. If a child can be educated locally and can do schoolwork independently there is a noticeable saving. For many, however, the savings are slight but the mere need for something to do is great. Certainly, the new aids will provide more independence, recreational facilities for perhaps the first time, less direct attendance by helpers and more reliable contact with the outside world through automated telephones and alarms; but for support from an official agency, improvement in the quality of life is frequently difficult to justify in these days of expenditure cuts.

## 1.7 STRUCTURE OF THE BOOK

The following is the structure of the remainder of the book. Chapter 2 gives a brief review of some currently available aids for the handicapped. Chapter 3 describes experimental work carried out by the author and others on man–computer interactions relevant to aids.

Chapters 4 and 5 discuss MAVIS, a microprocessor-based generalized aid for the disabled developed and tested during the research at NPL. Chapter 4 describes MAVIS and its uses, and Chapter 5 describes the field trial made of MAVIS, with the cooperation of the Department of Health and Social Security (DHSS). An Appendix gives more technical details of the hardware and software of MAVIS. Chapter 6 compares two approaches to aids — specifically developed computer-based aids such as MAVIS and the use of standard, off-the-shelf microcomputer equipment.

Chapter 7 reviews the topic of microprocessor-based aids in general, with some pointers to the future.

A list of useful addresses and other information is included in the Appendices and References at the end of the book.

Chapter 2

# SOME CURRENTLY AVAILABLE AIDS

This chapter introduces and discusses some of the currently available aids. Volumes could be written on this subject so the equipment selected has been chosen either because of its historical importance or because it uses modern technology. The chapter concentrates on the newer aids as many of these are not well known. Where there are competing aids that are very similar the author has selected one, but those choosing an aid should always look carefully at the whole situation before settling for a particular piece of equipment. General information on equipment can be obtained from the Disabled Living Foundation and from the manufacturers. Very little technical information has been included here as this can also be obtained from manufacturers. A list of useful addresses for obtaining further information has been included at the back of the book. Aids have been grouped according to disability, with comments as to where they can be used more widely.

## 2.1 AIDS AND THEIR USES

Before looking at some specific aids, it is necessary to briefly discuss the use of aids by disabled people. This is particularly relevant to those in research, as correct human factors are of critical importance. Much of the research for the MAVIS system (Chapter 4), which represents a fundamentally different approach to designing and building an aid, was based on work on human factors.

Even if an aid has been designed to offer the maximum assistance, those involved in making it will soon find that it is used in a rather different way than that which they had anticipated, although functionally it will be providing the same service. For example, a talking typewriter may have been designed to enable a blind person to check their work but it might also assist a person who has bad speech to talk over the phone. A designer not in a wheelchair may not be quite able to appreciate the limited reach that many physically disabled people have, or realize that a larger power-on button might make the unit accessible to someone with little manual dexterity. Disabled people are, on the whole, far better at adapting to their disabilities than designers imagine and must be given enough freedom to experiment. What does it matter if a keyboard is used upside down by someone who is bedridden, so long as the keys do not fall off and success is achieved?

Many aids have limited use because insufficient thought and imagination have been put into their design. Often, very simple things are missing which would have been easy to design differently. Ensure that an assumption is correct before building it into an aid. The designer must also take into account that the person who will use the aid is human and likes to be proud of the equipment. Unsightly wires and huge boxes should not be necessary in this day and age. One must ensure that portable aids really are portable and easy to pick up if someone has limited movement. All too often designers are very highly technically qualified but lack imagination and are too keen to try and start being helpful before they understand the problem. When one has had all one's preconceived ideas dashed to the ground because that is just not how a disabled person works it is often difficult to throw them all away and start trying to make something useful.

Until recently, aids were built to assist with one particular aspect of disability, for example, an adapted typewriter for someone unable to use their hands to write, or a reading machine for the blind. In some cases, particularly that of the blind, this approach to building an aid still has to continue but, with programmable microelectronics becoming cheaply available, problems of different groups of handicapped people can be considered together. Many aids are now becoming more complex, more specialized and frequently more expensive, while government expenditure is being cut. An aid that can be used by a larger group of people is therefore desirable. This topic will be discussed in more detail later.

## 2.2 SOME AIDS FOR THE VISUALLY HANDICAPPED

Research for the blind has been very advanced for some years, resulting in many good services and much reliable equipment. The aids discussed in this section and in that on synthetic speech aids are those that have been revolutionary in their effect and which use microelectronics. For those generally interested in aids for the blind the RNIB offers a wide selection, and they are very willing to discuss the problems of visually handicapped people.

It is often said that blindness is more of a nuisance than a disability. For many blind people the problems are not those of access to buildings or changes to the home, they are fundamental annoyances throughout the day such as not being able to read the train indicator at a station, or going into the wrong shop. In daily work and school life the main problems are associated with reading and writing.

Braille, that well known system of raised dots, has been used by the blind for over a century for reading and writing. A variety of machines is available to enable a blind user to punch the Braille patterns on to paper and many of these are in everyday use. The problem with using Braille is that literature has to be translated, as do school work, university essays, letters etc. For books, the RNIB and others produce many volumes a year in Braille. These range from literature to items for a single student at university. However, when it comes to employment it is for the blind persons themselves to manage as best they can with readers, secretaries and their own typing skills.

Technology is making the problems of communication using Braille far easier. For some years a transcription system has been running at Warwick University for personal reading requirements, bank statements, knitting patterns, machine instructions etc. Reading machines are also now available, changing the lives of many blind people. Word processing is allowing blind people to create well-written, well-formatted material and there are special systems which can be operated in Braille and then be connected to a printer for normal printed copies.

All is changing dramatically and those who are at the moment lucky enough to be able to use the new equipment find it of great importance in their lives. New systems with written and spoken output are at last going to solve the reading problems. However, as problems are solved, others predominate. No one has solved the problem of teaching blind people to spell. They miss the many signs and words around in the world and go through life finding spelling one of their main handicaps.

### 2.2.1 The Optacon reading machine

The Optacon was first marketed in 1970 and was the first direct print-reading machine for the severely visually handicapped. Research on the machine started in the early sixties when Professor John Linvill of Stanford University wanted to produce equipment to enable his blind daughter, Candy, to read her school books without the need for them to be translated into Braille: a long and tedious process. John Linvill was joined by Dr Jim Bliss and Dr Steve Brugler who developed the machine to the current design. There are, to date, over 8000 Optacon reading machines throughout the world, the equipment still being unique. Telesensory Systems Inc. (TSI), with President Jim Bliss, produce the Optacon and are responsible for the training programmes that have been developed for the equipment.

The Optacon is an OPtical to TActile CONverter. It produces the shape of the print letters appearing under its camera on an array of vibrating pins (See Fig. 2.1). The small lens and camera unit is held in one hand and freely moved across the printed page. The other hand is placed with the index finger in a groove under which are the vibrating pins (see Fig. 2.2). The standard lens module has a zoom lens for use with all normal sizes of print; other modules can be attached for reading computer visual displays (Fig. 3.3), for accurate typing, and for very small material. Clear print is obviously easier to recognize than blurred or bad copying but, depending on the user's skill, most types of print can be read, with the exception of cursive handwriting.

Unlike for most aids on the market, the new Optacon user requires a training

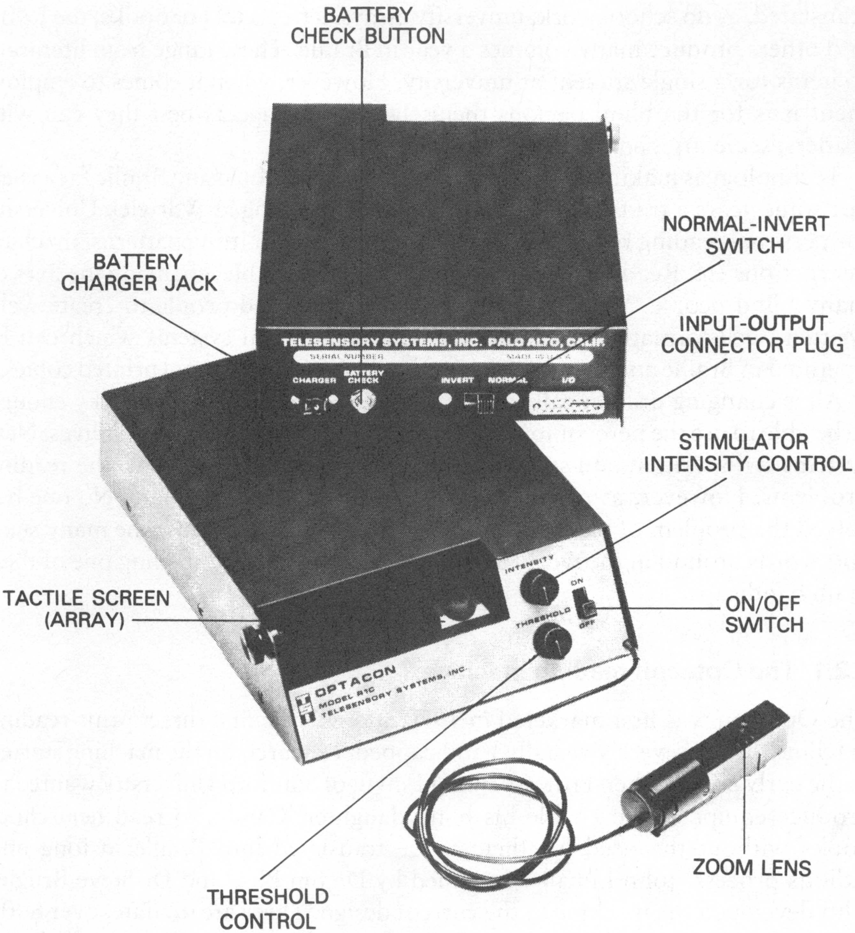



**Figure 2.1: The Optacon.** The Optacon print-reading machine for the blind. This is the only system which allows normal printed material to be read by touch.

course. This course normally consists of two weeks of intensive individual tuition with some follow-up lessons if difficulties are encountered or if the operator has more specialized requirements, such as reading music. The course teaches users to recognize different types of print and layout, how to operate and look after the machine and how to use the attachments as necessary. Although some users have taught themselves to operate the equipment, this has normally resulted in bad tracking which can be very difficult to correct. TSI has produced a set of training manuals and aids. Figure 2.3 shows a typical training environment with an Optacon visual display, tracking aid and one of the manuals.

Although the Optacon is a major breakthrough, enabling those unable to read print to do so independently and without transcription, not everyone is able to

**Figure 2.2: Reading with an Optacon.** The Optacon shown in use. A small camera is held in the right hand and is moved across the printed material; images of symbols appearing under the camera can be felt on the index finger of the left hand. Images are the actual shape of the printed character, in dot matrix form on an array of vibrating pins, six across and 24 down.

use the equipment. Research has been carried out to find a test that can be given to each user to see how they will read with the Optacon (see Fig. 2.4). This is used to show how well a potential user will be able to track, test recognition skills and assess language confidence. A good score on this test will normally show a potentially able user, although the most critical factor is motivation to read, which cannot easily be tested.

To develop a useful reading speed takes hours of hard work which is initially very tiring and boring. TSI's work in the area of assessing Optacon users, and particularly their training manuals, were studied in detail as part of the MAVIS research as they were particularly relevant to similar problems to be encountered with that system (see Chapter 5).

TSI has been developing a talking attachment for the Optacon. This attachment plugs into the standard unit (see Fig. 2.1) and produces a spoken word output as the camera is moved across the page. This new accessory should

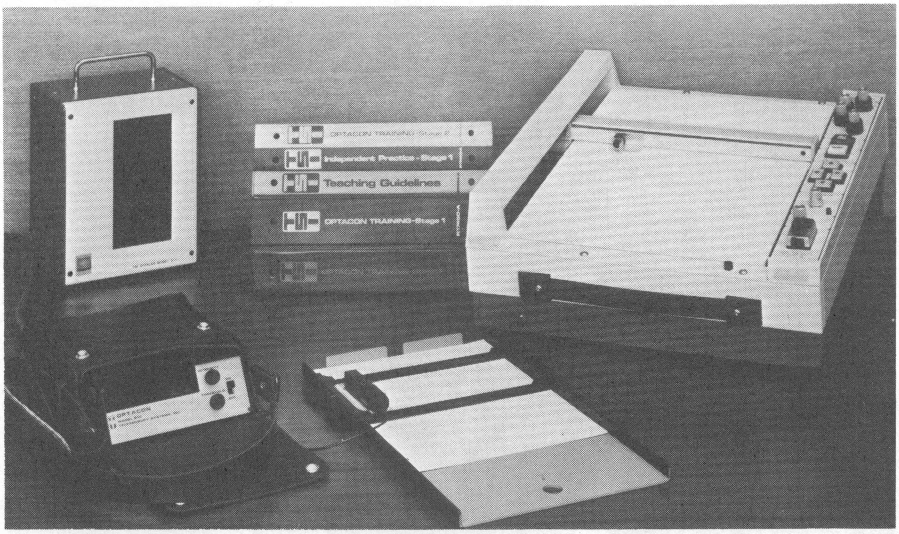



**Figure 2.3: A typical Optacon training station.** This shows the Optacon (bottom left), the tactile array visual display (top left), a tracking aid (bottom middle) and the automatic page scanner for teaching smooth and non-hesitant scanning (right).

enable users to read much faster and should also enable some who find great difficulty with the existing equipment to read print directly. Field evaluation of this unit started in the USA in 1981.

### 2.2.2 The SPEECH+

In 1976 TSI launched another aid for the visually handicapped that had a great impact. The Speech+ calculator is a hand-held unit with synthetic voice and visual display output. The calculator has two other interesting ergonomic features; firstly, a keyboard arranged like that of the touch-tone telephone, a key pad commonly used by visually handicapped people; and secondly, optional voice output on key depression. The Speech + is still the most portable, simplest calculator available for the blind and is widely used. Figure 2.5 shows the Speech+ calculator being used by a multiply handicapped student who is backward in simple mathematics. In this application the calculator has been found to be extremely useful, even when the disabled person has no visual handicap at all.

The need for more general talking instrumentation, for example telephone switchboards, encouraged TSI to develop speech boards like the one used in the calculator and the talking Optacon for other applications. Numerous other companies offer a wide range of speech chips, boards and full voice systems. These companies include Votrax, Texas Instruments and National Semiconductor.

TRACKING TEST. A grid of four lines is presented for the user to track, freehand. (The diagrams are reproduced two-thirds actual size.)

| Scored Examples | | Trial 1 | Trial 2 |
|---|---|---|---|
| 1. | C J O S C | ____ | ____ |
| 2. | H X H D U | ____ | ____ |
| 3. | B V B N R | ____ | ____ |
| 4. | M M A I W | ____ | ____ |
| 5. | i o s v i | ____ | ____ |
| 6. | n y h n z | ____ | ____ |
| 7. | a e m a f | ____ | ____ |
| 8. | d k g b d | ____ | ____ |
| 9. | 7 4 8 2 7 | ____ | ____ |
| 10. | 1 9 1 5 4 | ____ | ____ |
| 11. | 3 3 9 7 8 | ____ | ____ |
| 12. | 6 0 6 8 5 | ____ | ____ |

PATTERN RECOGNITION TEST. The aim is to spot which letters are the same. Warm-up examples are given before the test itself.

O O O O C C C C I I I I T T T T H H H H

E E E E S S S S A A A A M M M M

Criterion Test:

T H C S O E I A M

Number correct ____________/9

Incorrect responses

| ___ | ___ | ___ | ___ | ___ | ___ | ___ | ___ | ___ |
|---|---|---|---|---|---|---|---|---|
| T | H | C | S | O | E | I | A | M |

Reading Test:

TOM IS A CAT. HE EATS MICE. THE MICE HATE TOM.

LEARNING POTENTIAL. If seven or more of the letters are recognized, the sentence is also presented.

**Figure 2.4: Optacon assessment tests.** Details are needed from the potential user as background to the test — motivation both for reading at home and at work, the age of onset of visual disability, Braille reading speed (if appropriate), print letter knowledge etc. The equipment is introduced to the user and three tests are administered. These do not give a definite answer as to whether a user will read with an Optacon, but together with the background information the likely usefulness of the machine can be assessed. The tests are timed.

**Figure 2.5 : The Speech+ talking calculator.** Shown in use at a school for the multiply handicapped, being used to develop numeracy.

### 2.2.3 The VERSABRAILLE

The VersaBraille is, again, a TSI product, introduced in 1979/1980. In effect it is a portable information processor for the blind, acting as a notebook, Brailler and filing system. The VersaBraille is designed to handle all information in Braille with the exception that it can be used as a variable speed audio cassette recorder also.

The Braille is written using the special keyboard shown in Fig. 2.6. The keyboard, situated at the front of the unit, is the same as that normally used for writing Braille where chords of keys are pressed to build up the Braille character (see Fig. 3.2 for examples of Braille). The VersaBraille offers searching, editing, storage (using cassettes) and computer terminal facilities. The unit is portable and battery-operated.

**Figure 2.6: The VersaBraille system.** Shows the Braille keyboard (six keys and a space bar), a 20-character Braille display, word processing control keys and Braille/audio selection furthest from the operator. At the right is the cassette unit.

The importance of the equipment is its size, capacity and organization. Normally, Braille is written with a rather large machine (the Perkins Brailler). Braille is also very large to store; one fairly small printed book often runs to volumes of Braille, which are heavy to carry as well as bulky to keep. The cassette on the VersaBraille holds about two volumes of Braille per side. Such facilities as being able to edit material, Braille normally being punched on to paper, and find material quickly using a computer searching mechanism are new for most Braille users. For students at college the machine will be especially valuable as, at last, Braille notes can be written in lectures silently and then accessed easily.

## 2.3 COMMUNICATION AIDS

In everyday life, a communication problem is normally taken to mean difficulties with speech. Here it is given a rather wider meaning in that it is linked with the reading and writing difficulties associated with severe lack of movement. In fact, most of the aids discussed in this chapter are communication aids, but those described in this section are normally used by those with severe movement problems. For many people in a wheelchair their main problems are associated with access and mobility, but when someone has very little movement at all their communication skills can be severely limited. In reading what follows it must be remembered that many severely disabled people have multiple disabilities and poor speech is not rare.

For those with very little manual dexterity there is a wide range of controls on the market varying from a breath tube, a method of blowing and sucking to control attached switches, to systems where waving a hand interrupts a light beam and activates a switch. Some people with little movement communicate by eye pointing, and there are several projects trying to develop a device to follow the direction of gaze. This has often been done in laboratory experiments but not with the sort of equipment that could be worn as is, for example, a hearing aid. The Disabled Living Foundation can offer general information about controls and adapted keyboards that are available for those with little or no limb movement. For anyone in a wheelchair, reaching paper or switches is a problem, so that furniture, power sockets and day-to-day material have to be carefully arranged to enable them to be independent.

### 2.3.1 The Possum typewriter and environmental controller

Before the 1960s it was next to impossible for severely physically disabled people to write. In cases where communication has to be carried out by writing and motor skills are severely impaired, this problem is at its worst. An engineer, Reg Maling, when visiting a road traffic accident case in Stoke Mandeville Hospital hit on the idea of building a breath tube that would pneumatically control switches which could then be used to control a typewriter or other equipment.

The breath-controlled typewriter, which can also be controlled by other switching mechanisms, such as a foot switch, is very widely used and is marketed by a number of different companies throughout the world. Figure 2.7 shows a model made by Possum Controls, the original manufacturer. Letters are selected from a matrix situated above the typewriter. A user blows until the light moves into the correct column and then sucks until vertical selection is achieved. Blowing again then actuates the typewriter for the currently selected item. The method was a major breakthrough in its day and is still the means by which many disabled people do their work. The system should not be underrated in the light of technology today.

This type of typewriter has many drawbacks, which users have learned to live with; using microprocessor technology these can be removed. It is difficult for a user to see the paper as it is being produced since typing takes place very near to the head and there can only be a limited amount of stationery visible at any one time. The typing selection matrix is fixed, although some commonly used words have been added to later models. Even with the latest models of the equipment, which do allow some limited correction of material, it is difficult to produce a tidy, well-formatted copy. Using the old typewriter, which many people have, it

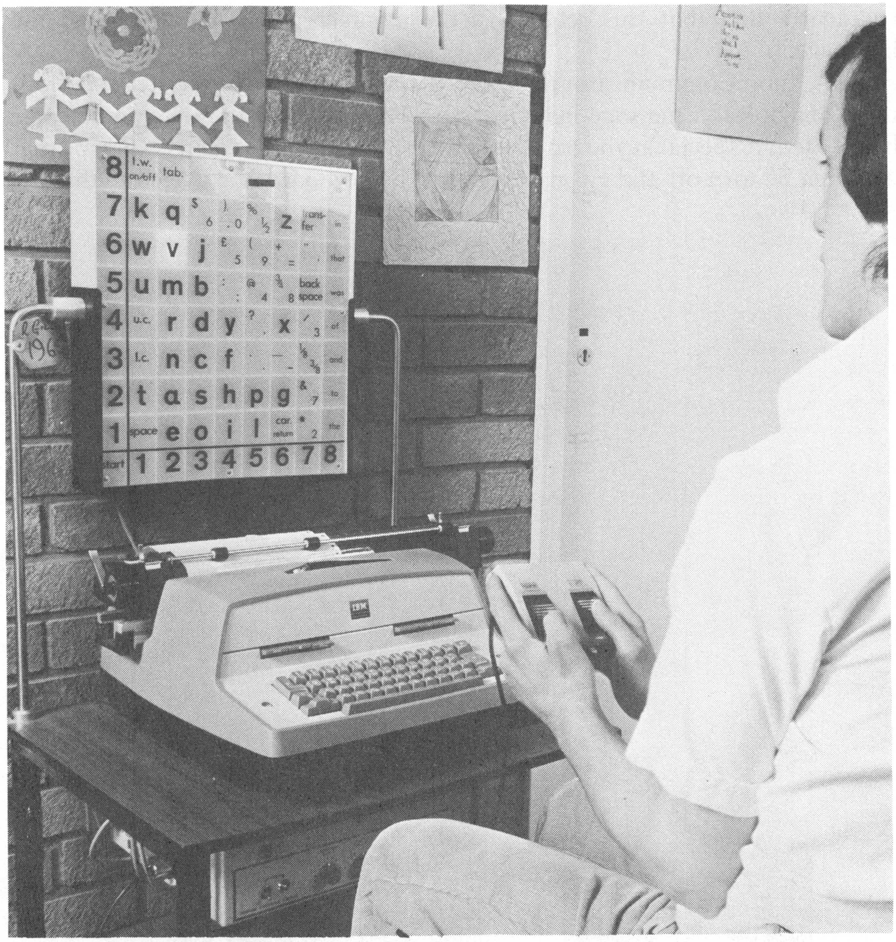



**Figure 2.7: Possum typewriter**. Shown here with the letter 'v' selected on the matrix. A two-button input with large buttons is being used.

is impossible to edit text at all. Finally, the equipment is large and electromechanical, so that it is conspicuous in a room and requires considerable maintenance and adjustment.

The matrix selection method with a simple switch controller has also been used for other equipment. A matrix is commonly used for controlling the environment, switching lights on and off, pulling curtains, controlling the television, opening the door etc.

## 2.3.2 The Canon Communicator

For those with severe speech difficulties, few aids have been produced that are portable, battery-operated and provide a record of a message. Finger spelling is frequently used but this requires actual contact and a knowledge of the language.

The Canon Communicator represented a change for the better in the development of a portable message-making device. Figure 2.8 shows the communicator being used. A special keyboard is used to produce messages on reels of tape that can then be torn off and given to people. The keyboard is arranged so that the

**Figure 2.8: The Canon Communicator.** Here one of the few portable communication devices is shown being used in conversation. The keyboard has been organized on frequency of use of letters, and sentences are produced on a thin paper tape. The Canon Communicator is battery-driven, and is used widely by those with severe speech impairment.

most frequently used letters are grouped together, as are the vowels. The Canon is battery-operated, lasting for about eight hours before needing recharging, and can easily be carried around in a large pocket or bag. The front panel of the equipment can be overlaid so that the keys are located through holes; this is useful for those who do not have the dexterity to press small keys.

### 2.3.3 The AUTOCOM

The Autocom is now manufactured by TSI and was launched in 1980. The initial research, development and field trials of the equipment were carried out at the Trace Centre of the University of Wisconsin. So far it is reported that the system has been received very favourably by those with severe speech and/or motor difficulties.

The Autocom can best be described as an electronic communication board that is normally mounted on a wheelchair table. It measures about 20 by 24 inches and it can be battery-driven for up to eight hours. Selection of items from a grid is normally by pointing with a special hand control or headset. The normal display is a 32-character LED array which can be orientated so that

**Figure 2.9: The Autocom.** This has been designed for the very severely disabled and is housed as a wheelchair tray. The system does not have a fixed vocabulary, words can be entered into any grid position on the tray, each grid position can contain a small vocabulary in its own right. This multilevel, programmable grid arrangement means that those with very limited reach can use the part of the tray that is easiest. A facing display is present for two-way communication.

someone facing the wheelchair can see it. This is an important human factor, enabling a disabled person to carry on a face-to-face conversation. The Autocom has been attached to other devices for control of the environment, display on a converted television set, or as a computer peripheral. The system is based on a microcomputer and can therefore be easily changed to a picture-and-symbol system and the vocabulary is fully expandable.

### 2.3.4 SPLINK

Inability to communicate in the normal way, by talking, causes many frustrations. Those who suffer head injury or have a stroke later in life have particular difficulties, having lost something they are already used to using. SPLINK was developed by a general practitioner in working to assist his patients who had communication problems resulting from a stroke. The firm Medelec Ltd now produces and markets SPLINK.

SPLINK is a large, touch-sensitive keyboard that is connected to a normal television. All interfaces are ultrasonic so that wires are not trailing between the user and television. Symbols on the keyboard represent common words and phrases, thus allowing sentences to be quickly built up on the television screen.

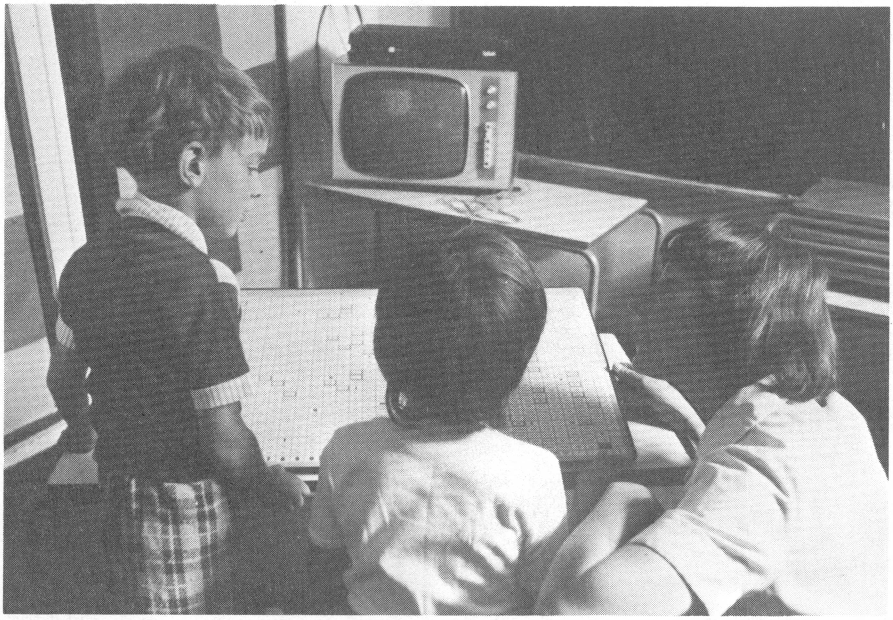


**Figure 2.10: SPLINK.** SPLINK is a large, wire-free keyboard containing common phrases and words used in everyday communication. It has been specifically designed for the adult stroke patient but has been found to be useful for many disabled children who cannot speak. The output appears on a normal television screen.

SPLINK has had a full field evaluation with children and adults and production started in 1980. For those with good manual dexterity when using a large keyboard it is very successful. The company do plan further development for other groups of disabled people and have spoken about adding synthetic speech.

### 2.3.5 The MATE terminal

This has been developed by Essex University with assistance from a severely disabled programmer, Geoff Busby. Geoff is employed by Marconi as a computer programmer but finds typing with his nose, the most useful movement he has for keyboard work, tedious without some wordstore facilities and a keyboard that does not require him to depress more than one key at a time. Computer programming is one of the few professions that academically bright, severely disabled people can enter so the development of aids around this work is very important.

The original MATE was a limited wordstore built into a Teletype terminal

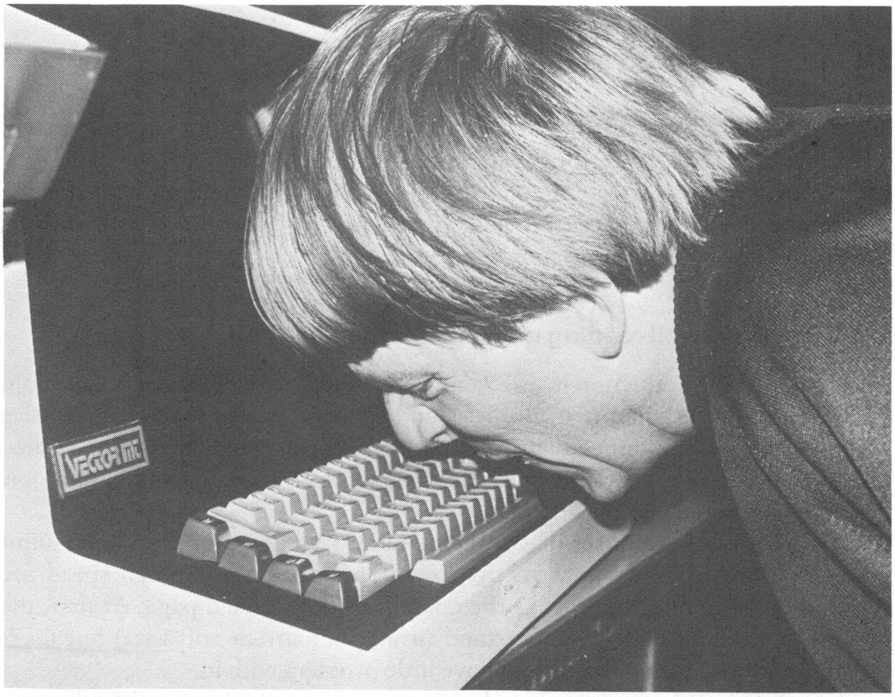


**Figure 2.11: The MATE terminal.** Geoff Busby, a severely spastic computer programmer, is shown using the MATE terminal at work. The keyboard of the MATE has a modification so that control keys and shift do not have to be held down together with another key. Geoff has a large word store on the MATE which enables him to type faster. Typing with his nose is the most convenient movement for him to use.

with a modification to the keyboard and control keys. This was a great success, but more words and greater flexibility were required so a second version has been built. The development programme was possible through the kindness of Computer Weekly who raised the money. The new MATE runs as a software package on a Vector Graphics microcomputer and offers full word processing for the disabled user as well as offering word selection. Again, small modifications have been made to the keyboard, but this MATE works on a screen, a far easier way for disabled people to see what they are doing as there is no paper to move out of reach.

### 2.3.6 Other communication aids

There are a number of other projects in this area, both products and research items. Both communication and environmental control are sometimes dealt with together. Examples are the Carba range of equipment, the Electraid and the Phonic Mirror Handivoice (a 'talking' communicator).

## 2.4 AIDS USING SYNTHETIC SPEECH

There is no doubt at all that, as speech technology becomes cheaper, it will appear in all kinds of aids for the disabled. Already mentioned are the Speech+ calculator and plans to add a voice to SPLINK. Two reading machines for the blind have also appeared recently and the technology is moving swiftly towards the production of a portable communication aid.

### 2.4.1 The Kurzweil reading machine for the blind

This started full production in 1979 and is currently priced as $31 000. Its main market for the disabled is in libraries and schools, where such an expensive machine can be economically justified. The machine is made up of three units, the hand-held keyboard, the camera unit and the speech and computer unit. It is normally mounted in a trolley.

To read a book, the user places the material face down on the camera unit platform and positions it correctly. Keys for reading and speech speed are selected and the machine speaks the content of the selected page. At first, the voice is a little difficult to understand (using the current software) but users normally soon get used to this and have little problem with it.

The machine has been developed for use mainly by the blind although it has been used by severely physically disabled people who are bedridden. Its fully automatic approach has advantages and disadvantages. It is an advantage, especially in the multi-user situations like libraries, for users to need very little instruction in its use. However, the automatic nature of the scanning can cause problems with more complex formats and layouts that are non-linear, for example mathematics and diagrams. The machine does diagnose some faults, for example it says if the material is upside down on the camera unit, but the user has no tactile check on the material and why the machine will not read it. In the UK, trials with the Kurzweil have been carried out at St Dunstans and a report on this evaluation work is available from St Dunstans or from the RNIB who jointly funded the trial.

### 2.4.2 Talking Optacon

TSI is also experimenting with a voice accessory for the Optacon (Section 2.2.1). Although an automatic scanner has been designed, the main difference between the two machines at present is that the TSI approach offers hand-scanning of printed material. This has two main advantages. A user who can hand-scan can select material more easily and can also use tactile methods to read text that is difficult for the talking accessory, for example mathematics. An automatic scanning camera unit is large and mechanical. Using a hand scanning approach based on the normal Optacon could make the unit less expensive as many users already have an Optacon.

To use the talking Optacon, material is selected and set up as for normal Optacon reading. As scanning takes place, the voice speaks the text. This is easier if one can already use an Optacon. It will also be useful to the many people who cannot use the Optacon because of poor tactile ability. The system is visualized as a much more individual reading machine than the Kurzweil product.

Both reading machines were first attempts to produce a reading system with optical recognition and speech output. The Optacon is rather easier to understand than the Kurzweil but it is not yet in production (a new voice could easily be added to the Kurzweil). It will be some time before these types of machines replace the talking books that are commonly used by non-Braille readers at present, but for professional people and educational establishments they are a major breakthrough.

### 2.4.3 The IBM Talking Typewriter

In 1979, IBM produced a talking typewriter to be attached to their standard word processing units. Earlier talking typewriters have been rejected because their human factors were not well developed. For example, Spellex spoke words letter by letter and had no memory facility. The IBM speech attachment is very easily understood and used. Three levels of speech output are offered, spoken word output, spelled speech output and spelled output using the international communication alphabet. Typing can be corrected before it is entered into the memory. IBM claims that for security work the talking typewriter is a must as it can be used without hard copy; all typing is immediately committed to memory.

## 2.5 AIDS FOR THE DEAF

Deafness is one of the disabilities that require very special understanding. It is often associated with poor speech so that other sections of this chapter will be relevant. Deafness and poor speech are the most socially inhibiting of the disability groups, often leading to very poor treatment of the individual by the general public. One of the most difficult situations is a group conversation in which the deaf person may lipread the main speaker but know nothing of other interruptions. Obviously many of the aids for deaf people are associated with hearing aids and amplification systems. These are not discussed here, although new technology has provided very valuable miniaturization.

German measles and other conditions have caused deafness and blindness together. People with both disabilities need very specialized provision and understanding. Aids like the Optacon have been used successfully by deafblind people and it is in this area that technology still has a large part to play.

### 2.5.1 Transcription

In mid-1980 there was considerable coverage of the introduction of a special Palantype translation system for Jack Ashley in the House of Commons. Mr Ashley is a profoundly deaf member of the British Parliament. Palantype, like Stenotype in the USA, is a machine shorthand keyed in using a special machine. Operators are highly trained and can work at over two hundred words per minute. The system has been in use for many years for making records of the proceedings of Parliament, and of major Law Courts.

The Palantype machine is used by pressing groups of keys simultaneously to generate a series of symbols on a roll of paper which represent the words in syllabic form. It is an equally skilled job, and very time-consuming, to convert the output into readable text. In the 1960s work was done at NPL on automating this transcription, and further work at Southampton University has led to the unit used by Mr Ashley. This produces text on a visual display as the operator keys in, so that Mr Ashley can take part in a meeting with full facility. The text is not perfect but is understandable.

The problem with using Palantype much more widely for the deaf is the need for highly skilled operators. Experiments have been carried out at the Open University Summer Schools using a typist with a normal keyboard and a visual display for deaf students. A stilted, but understandable, text can be produced in this way but it is slower than the Palantype method. More work in this area is being carried out with new equipment becoming available in the future. Systems for assisting deaf people with the telephone and with text translations of spoken conversations are in the experimental stage. Deafness requires very specialized assistance because it appears in so many forms that almost every deaf person is different in both degree of deafness, the tone and pitch differences they can detect and the amount they can lipread, talk and use sign language. Those

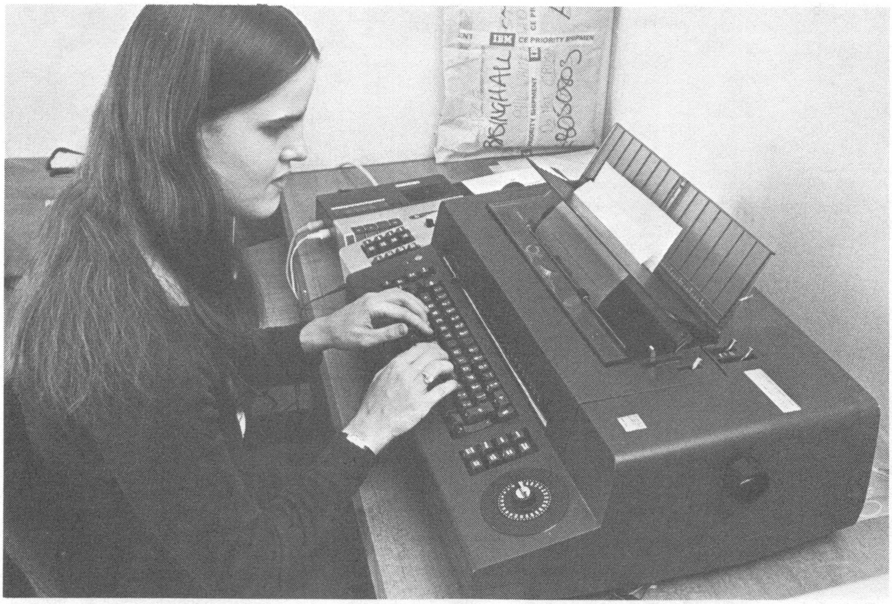



**Figure 2.12: IBM talking typewriter.** Leslie is a visually handicapped secretary at British Petroleum Ltd head office in London. She uses the IBM talking typewriter to produce her work, thereby competing fully with the other secretarial staff using word processor systems and providing management information. Leslie is also perhaps the most reliable person for doing top secret work as she can do all her work just using the sound with no paper in the machine.

working on aids for the deaf need to work on two levels: improving hearing and providing aids to fill the gaps in information that the deaf person encounters in everyday life.

## 2.5.2 Teletext

Subtitles for the 'hard of hearing' are now a common sight on BBC news and for those with a Teletext set subtitles are provided for many programmes on British television. Teletext in itself is an aid to many different disabled people but it is not yet exploited to its full potential.

Teletext is the public information system offered by both the BBC (Ceefax) and IBA (Oracle). A television with a special receiver is required for this 'newspaper' of the air. The service is very economical, requiring no extra licence and adding about one pound a month on to the rent on a colour television set. The service gives three channels of information, including up-to-date news, weather, travel information, prices, stories, jokes, recipes and other items of public interest. For the housebound it is a very economical newspaper available through their television set.

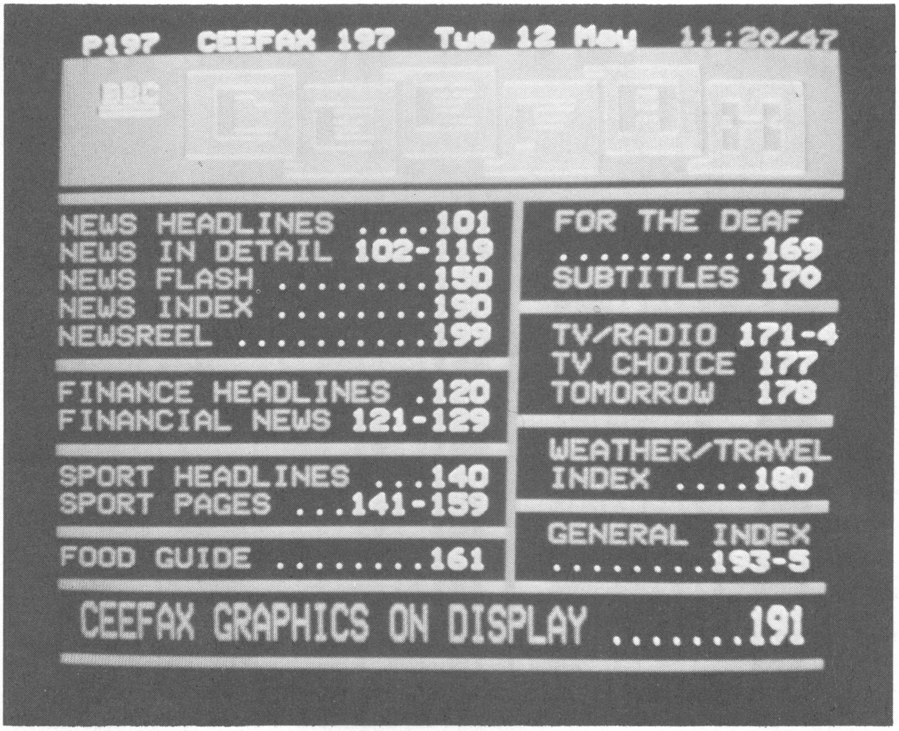



**Figure 2.13: Example of Teletext.** Shown is the main index page of BBC-1 CEEFAX. Material can be text or pictorial and is in full colour. The Teletext service is very like a constantly updated newspaper that can be received on all three UK TV channels. It is controlled from a remote, small, hand-held key pad.

Teletext was originally thought of as a way of providing subtitles for the deaf, and up-to-date information which others hear on the radio. Certain 'frames' of teletext are used to hold subtitles which a deaf viewer can superimpose on the normal television picture. Only a minority of programmes have subtitles at present, because of cost, and live programmes leave no time for subtitling. The Palantype technique described above has also been developed for this use, at Leicester Polytechnic, and the BBC used it for the first time on a live broadcast for the inauguration address of President Reagan in January 1981. Again the text, though not perfect, was understandable, and this technique holds great promise for the future.

For other disabled users very little is currently appearing in the way of extended control units and other useful modifications, but one knows that this is only a matter of time once the disabled realize what a useful service this is. The same is true of Viewdata, an extension of Teletext which uses the telephone to transmit information and allows the user to interact and send choices back into the system. However, this is not a free system.

### 2.5.3 Other work for the deaf

The transcription techniques described have all required participation by an interpreter. Current work on computer-recognition of speech is too primitive to replace this in the short term, but it is being applied to develop an aid to lipreading. Only 25% of spoken syllables can be determined by the shape of the lips alone, but work is being done (AUTOCUE) to use the sound to provide the necessary supplementary information. A lot of work is also being done in speech training using computer analysis of sound to provide feedback to the deaf speaker. This is particularly important in teaching children who have been born deaf to speak.

## 2.6 AIDS OF THE FUTURE

Cheap, reliable technology is providing a basis for many new aids to be developed. In the last five years we have seen the introduction and rapid expansion of talking aids which will continue, perhaps offering a voice for those without speech in the not-too-distant future. The television and personal computer are also beginning to make disabled people at home less isolated, with development of conversation through the television set and electronic mail just around the corner. These kinds of developments for the disabled may make the difference between someone working or not working, between being in touch with others or being isolated, even between them being at home or being in hospital. There can be no assessment of the improvement to life that the new aids can bring nor to the improvement to general motivation to continue a full life in spite of severe disability.

One of the most fundamental technologies that has still to appear is speech recognition by computer. Already some experiments have been carried out using cheap speech input boards to personal computers. These can recognize a few distinct individual noises or words and phrases. For those with poor spoken word communication and very severe lack of movement, voice activation will make a great deal of difference. Imagine being able to shout at everything to make it go on and off or to make noises at the television, attached to a phone, and comprehensible synthetic speech to come out. All this is now possible and will be appearing in the next few years.

A great deal of other work is now in progress to develop personal computers as aids, to provide even more modifications to cars, to provide small robots that can fetch and carry for someone immobile. There is just no end to what is round the corner.

Although aids are becoming more and more powerful in the assistance offered, at present many of the computer-based aids are very expensive and could not easily be purchased by most disabled individuals. This situation is causing problems and is likely to become worse before it improves. For example, in the employment area an aids to employment scheme is offered to disabled people who are registered and have a job. Many of the aids discussed here could aid people in finding work but they cannot usually be obtained with state assistance without a job. The present economic situation is not helping the aids provision programme. This is one problem that must be solved in the future. Reference is made to this again in the final chapter.

Chapter 3

# SOME EXPERIMENTAL WORK

While MAVIS (Chapter 4) was being planned and designed, some simpler experimental work was being carried out. The experiments were performed either to assist with one particular problem area, for example, the Braille printer attachment (Section 3.2), or the results were required to determine the specific design for a particular feature of MAVIS. Five of the relevant experiments are described here. They are:

(1) a Morse, tone and limited speech generator (Sparky),
(2) a Braille printer attachment,
(3) uses of computerized information systems by the disabled,
(4) understanding synthetic speech (Mimic), and
(5) a Bliss-to-speech experiment.

All the work was carried out at NPL with the exception of trials of some of the systems. This chapter has been included as an example of the kind of work needed to establish the correct human factors in the design of aids.

## 3.1 A MORSE, TONE AND LIMITED SPEECH GENERATOR (SPARKY)

The aim of the Sparky experiments was to try to establish the usefulness of specific auditory information to those with either a visual handicap or difficulty in directing their vision towards a screen. Three simple experiments were carried out:

(1) Morse code for every character on the screen,
(2) a discrete tone for every character on the screen, and
(3) spoken numbers.

When these experiments were complete some further work was carried out on providing auditory systems information only.

### 3.1.1 Hardware

Alan Davies of NPL built a unit with the three components present: Morse, a 64-tone generator and a synthetic speech board. This unit was switchable both externally and by software. Known as Sparky, the box was connected in parallel with a terminal attached to the NPL network, via a microprocessor (the Intel 8008).

### 3.1.2 Software

Initially, software was written so that each character displayed on the screen could also be heard in Morse code as a discrete tone or (if it was a number) as a spoken word. Later, software was added so that certain system messages could be distinguished as tunes and only these heard. All software was written in 8008 assembler.

### 3.1.3 Conclusions

It was found that Morse, although sometimes useful for system messages that must be understood, was rather too slow to be useful. There was also a problem of learning and gaining enough experience to use the code efficiently.

Work with the tones was interesting. Many people who tried the system could soon pick out the general information on the screen, i.e. whether a table, diagram, program or text was displayed. System messages could also be recognized very easily. However, the tones slowed down the output and were tedious to use over a long period of time. Users soon became motivated to write musical programs and text. Some of the results from this experiment were eventually added to MAVIS (Chapter 4). They were:

(1) a multi-tone sequence at the end of a line instead of a single 'bell' (MAVIS uses an ascending scale of five notes, for the last five characters of the line),
(2) a tone sequence for commands or special characters (MAVIS has a special tune for cursor-home and escape keys, for example), and
(3) the ability to write programs or just simple tunes was highly motivating to new users, unfamiliar with computers.

The speech board was added later (June 1976). At this time the only cheap, easily interfaced board was capable of numbers only. This in fact limited its usefulness, but for finding frame numbers or files it was found to be helpful. This also led to the work described in Sections 3.4 and 3.5.

## 3.2 THE NPL BRAILLE PRINTER ATTACHMENT

For some years, Braille has been produced using computers. Both hardware and software have been produced for most needs varying from the requirements of book production to equipment needed by blind computer programmers. However, with the increased use of computer-based information systems, particularly by blind university students, there is a growing need for high quality Braille to be produced in small quantities without the purchase of expensive special-purpose equipment. It was decided to try to build a piece of equipment that would bolt on to the normal line printer and produce, using a small software driver, high quality Braille quickly from the normal print queue.

Braille is frequently produced on a line printer using the full stop and a rubber backing sheet behind the stationery. This works reasonably for a well-adjusted printer but, because normal computer paper has to be used, the output cannot be kept for any length of time. Braille produced in this way is also slower to read, an important fact for the blind student.

### 3.2.1 Hardware

This was designed in conjunction with the NPL workshops and is the subject of a patent application [Barnes and Howlett 1979]. The general arrangement is shown in Fig. 3.1. The attachment, containing the pins for producing dots, was bolted on to an MDS chain printer attached to the NPL network. This required that the chain be removed and, so that Braille lines were printed at the correct spacing, the printer was switched to print at eight lines to the inch. A further adjustment was made to the eight-line gear so that the printer actually printed at ten lines to the inch. Heavy quality printer paper also had to be inserted before the printer was switched back online.

### 3.2.2 Software

The Braille printer attachment is capable of producing a line of correctly spaced dots which are approximately the correct height and diameter. Figure 3.2 gives the technical specifications for normal Braille. A Braille cell needs three such lines of dots and these need to be built into the correct Braille shapes. This was done by writing Braille printing routines that could be activated from the SCRAPBOOK system, an information system available within NPL [Robinson and Yates 1973]. The coding of the routine and the Braille print command software was carried out by Michael Stevens, one of the software team associated with Scrapbook.

The Braille software carried out the following tasks.

(1) Text was received by the routine and the correct Braille equivalent was selected.
(2) The Braille character was then broken up into its three lines and these were assembled ready for printing with the attachment. Note that each Braille character was stored in its reversed form as printing took place from the back and through the form.
(3) When the three lines were printed out, two blank lines were printed to space the lines of Braille correctly.

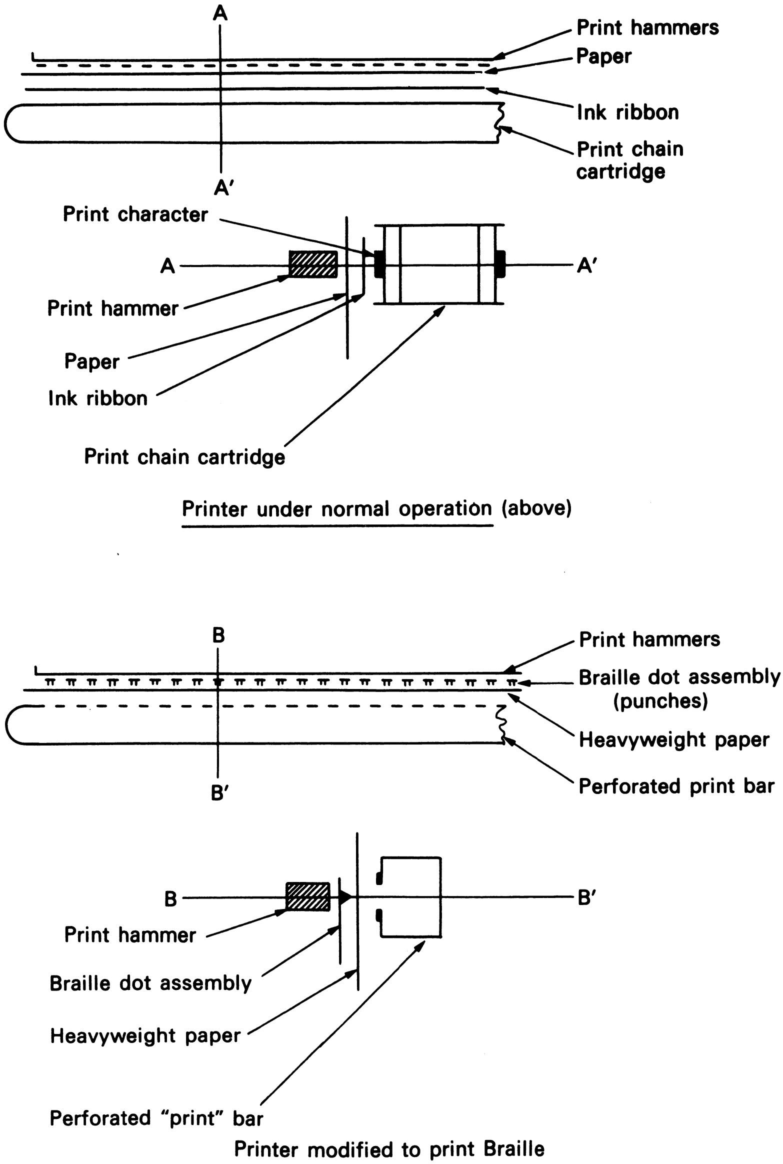



**Figure 3.1: Braille printer attachment.**

Lines of Braille were only 54 characters in width so the routines also had to break the lines of input in the correct place. Some simple formatting was also done by the routines and, at a later stage, some of the grade II abbreviations were added (see Fig. 3.2).

Finally a BRAILLE command was added to the Scrapbook system. This worked in exactly the same way as the normal PRINT command except options for printing Braille were requested instead of such items as double spacing, page length etc. Braille options included requests for Grade I or Grade II Braille, formatting etc. The routine formed a Braille queue with the prepared text and alerted one of the listed people to the fact that, at a convenient moment, some Braille needed printing. If no person could be found logged on to Scrapbook who could operate the attachment then the message was sent to the person requesting the Braille, leaving them responsible for finding an operator.

### 3.2.3 Conclusions

One such attachment was successfully used at NPL for some time. The Braille produced was found to be very acceptable compared to that normally produced from a lineprinter. It was found that five minutes of an operator's time was normally required to switch the printer for Braille and, with the queueing system implemented, this operation could always be carried out at a slack time. Although there was some additional wear to the printer hammers this did not appear to damage the normal print output, although it might if the printer were to be used for hours each day for printing Braille.

A further attachment was built at Hatfield Polytechnic with the agreement of NPL. This is to be used for a blind student already at the college; no results have been received from this equipment as yet.

## 3.3 USE OF COMPUTERIZED INFORMATION SYSTEMS BY THE DISABLED

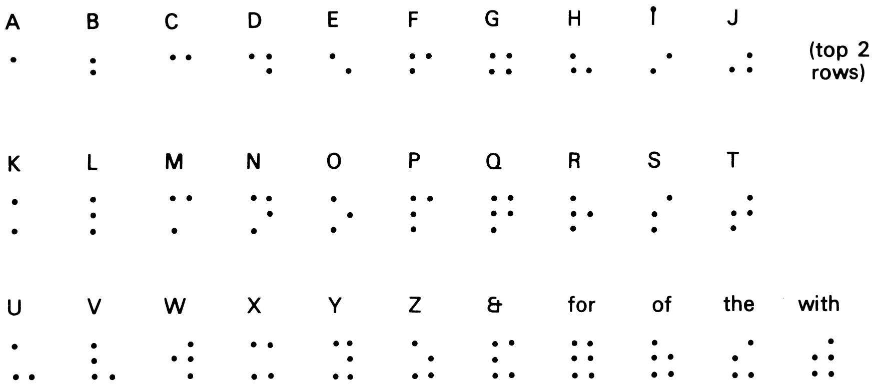
Writing well-presented, correct documents is a problem for many disabled people. Access to printed material may also cause difficulty. Further problems are encountered by disabled people when preparing and displaying presentation material for lectures, talks and seminars. In all these cases, using a computer-based information system solves many of their difficulties. Two areas of use of information systems were explored for their usefulness to certain groups of disabled people. These were:

(1) comparing conventional methods of 'typing' for the severely motor-impaired with using a computer-based system, and
(2) the use of a computer-based information system by the blind.

There is much common ground between these two areas of interest; for

EXAMPLE 1

Punctuation is not shown. The original French scheme omitted W.




EXAMPLE 2

COMING = (COM) (ING)

COMFORTABLE = (COM) (FOR) TA (BLE)

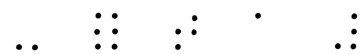


**Figure 3.2: Braille facts**. Note: drawings of Braille cells are not to scale. The Braille cell is a two by three dot matrix. The horizontal and vertical spacing between dots in the Braille cell is 0.1 in. The following table gives Braille dot, line and cell dimensions.

| | Size (in) |
|---|---|
| Interdot gap (within cell) | 0.1 |
| Intercell gap | 0.15 |
| Interline gap | 0.2 |
| Circular dot base diam. | 0.055 |
| Height above paper | 0.018 |
| Paper thickness between | 0.015 and 0.008 |

Grade I Braille

Grade I Braille is comprised of the letters, numbers, punctuation and usually five simple word signs AND, FOR, OF, THE and WITH. Braille symbols for the letters and the five word signs are given above as EXAMPLE 1.

Grade II Braille

Grade II Braille is similar to shorthand and, as well as the symbols of Grade I, Grade II has a set of 200 words, signs and abbreviations. EXAMPLE 2 shows some words with abbreviations. There are also abbreviations which use two Braille cells.

example, both groups have difficulty in preparing tidy material, though the reasons for the difficulties are completely different.

### 3.3.1 Information systems used in experimental work

Here, information system is taken to mean any computer-based system which can be used, relatively easily, to prepare and store text. Most of the systems used had been specifically designed for non-numeric information handling and easy retrieval, but some had not. Systems used were those listed below.

(1) Scrapbook [Robinson and Yates 1973] and EDIT [Hillman and Schofield 1977]. Both of these had been designed by information systems research teams, and were available as services within NPL.
(2) The DEC System 10 document production systems and editors. These systems were designed specifically for the computer professional and were not, therefore, always easy to learn by the inexperienced.
(3) IBM Administrative Terminal System (ATS). Designed for use by typists using hard copy.
(4) RAIR Black Box microcomputer system. A boxed microcomputer (see Chapter 6) packaged with limited text handling but easily used for information storage and retrieval.

These systems were chosen because they were easily available. They do not represent all aspects of this topic.

### 3.3.2 Hardware adaptations

All visually handicapped people are taught to touch-type so that input does not pose a problem. For those with severe motor disabilities, input can be difficult. Many are able to use a conventional keyboard, often with a light touch, pressing keys with a nose, tongue, a head stick, the feet etc. However, computer systems often require users to hold two keys down at once; CONTROL C, for example, is vital on all DEC systems. This often necessitates a small modification to the keyboard so that keys can be depressed separately, the first holding automatically until the second is depressed. A special keyboard incorporating this feature, and a limited word store to speed up the typing process, was developed at Essex University (MATE [Wilby 1978]).

Other severely motor-disabled users are not able to use a keyboard at all and require a special input. This modification usually needs special software written to drive the switches and there may also be an interfacing problem (see Chapter 6). However, once a motor-disabled person has access to a system, output does not usually pose any problem unless it is hardcopy only, for which the paper needs careful organization and support. Paper, even when it is balanced so that it can be seen from a wheelchair, quickly moves out of sight, especially at the rate that computer systems can generate copy.

Although automatic editing and access to documents is very useful for the visually handicapped, actually using a system can cause problems. These occur both with visual displays and with large volumes of output. In the future, speech synthesis will be a breakthrough, but such systems will not be widely available for some time.

### 3.3.3 A horizontal screen

A simple experiment was carried out to try to make it easier to read a screen using an Optacon. When reading with an Optacon the arm moving across the screen (Fig. 3.3) tends to get very tired, especially when information is displayed at the bottom, and keys on the keyboard are also easily hit accidentally. To try to overcome this problem a monitor was mounted horizontally in a trolley. For this a high-quality monitor had to be chosen so that its resolution was as good as possible for reading with the Optacon, and the chosen equipment had to operate on its back. The monitor ran in parallel with the screen and had the advantage that a blind user had a private display if the VDU was used in a group. This approach was rather expensive, but successful. Further work was carried out on the feasibility of linking the Optacon directly in parallel with the VDU. This was not simple because the scanning movement of the letters across the pin display had to be built in, as did a variable reading speed and the ability to move the Optacon one-character display around the current page. A system was designed using a microcomputer as a buffer between Optacon and screen. The VDU and the Optacon plugged into this. The experiment was not completed owing to difficulties in having all the necessary hardware built.

### 3.3.4 Conclusions

Basically, all people who were introduced to using computer-based information systems for the preparation of everyday information found them extremely useful. Some blind people found the silent nature of VDU terminals a great problem but they did not require auditory information at all times. It was decided to develop a system of tone messages for MAVIS (Chapter 4) to assist those with poor sight.

Most users found it easier to use Scrapbook than the other systems studied, with the exception of those already used to computer-based systems. This was not carried out as a quantitative survey, but those associated with the work were asked to comment when they came to NPL. This meant that people did not have much time to learn complex systems like Edit. However, it was decided to base the MAVIS system on the page-based, fixed format system used in Scrapbook.

## 3.4 SOME WORK WITH SYNTHETIC SPEECH UNDERSTANDING

As synthetic speech is to play a large part in aids for the disabled in the future (Section 2.4), a simple experiment was carried out in late 1977 on reactions to the typical computer voice. A talking version of a questionnaire system like those already in use for medical interviewing [Somerville *et al.* 1979] was set up. Visitors were asked to listen to the questionnaire and respond using a button box indicating YES, NO, DON'T KNOW.

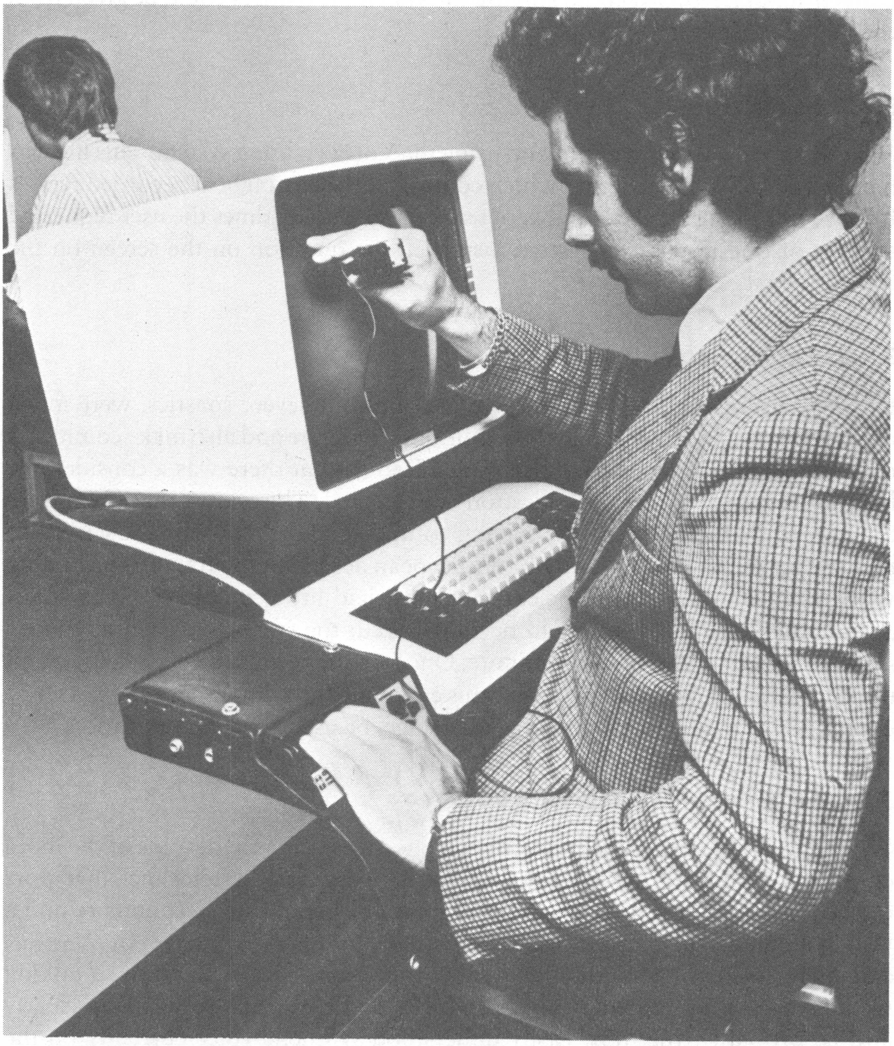


**Figure 3.3: Reading a screen using the Optacon.** The special CRT attachment replaces the normal camera unit and is tracked normally across the screen. Not all screens can be read in this way.

### 3.4.1 Hardware

The Votrax ML1, programmable voice synthesizer was used working in parallel with a normal visual display terminal. Questionnaire and voice software was run on a small DEC PDP11, as this system had already been programmed for speech string editing. Users spoke their answers on to a tape recorder and then pressed the appropriate button: white to continue and red to repeat the question. The tape recorder configuration was used so that visitors unable to use a conventional keyboard could still use the system; responses could be given from the keyboard if desired.

### 3.4.2 Software

A file of speech strings was built up using the Votrax editing system. This file was handled by a BASIC program which controlled the button box, recorded replies from the keyboard if used, and kept track of how many times the user requested repeats of questions. The system displayed the question on the screen on the fourth repeat.

### 3.4.3 Conclusions

Disabled users, especially the three blind and four severe spastics, were much more motivated to sit through the whole questionnaire and also make comments on the voice. The system had been organized so that there was a considerable lead-in of speech before any questions were asked. This meant that users were familiar with the voice before having to understand every word. Users commented on the system's slightly East European accent and that words beginning with Js and Gs were very unclear, but most had little trouble with the voice. Some users felt that they would become bored; the system was running fairly slowly at about 150 words per minute. One Swedish visitor wanted a female and not a male voice. Work started after this experiment on designing a spoken word output for MAVIS that might, at a later stage, be used for communication.

### 3.4.4 Other work on aids with voices

While the simple experiment described above was being tried, some of the more complex reading aids were being displayed. Telesensory Systems Inc., inventors of the Optacon (Section 2.2), showed great interest in the questionnaire and a visit was made to their talking reading machine in Palo Alto, USA. Various exchanges were made on human factors for voice systems. Recently, a talking word processor module has been produced by IBM which speaks very clearly and is, probably, the most easily understood synthetic voice currently on the market for use by the disabled. Kurzweil Computer Products [Kurzweil] also make a talking reading aid for the blind which, like TSI's talking Optacon, incorporates optical character recognition and scanning so that direct output from the printed page may be obtained. These items have been discussed in Section 2.4.

## 3.5 A BLISS-TO-SPEECH EXPERIMENT

Following on from the talking questionnaire, and after contact with TSI regarding speech chips, it was suggested by Nigel Ring of Chailey Heritage Hospital School for the Disabled that an experiment might be run using talking Bliss symbols. Bliss is a symbol language used by many disabled people who, for one reason or another, are unable to speak (see under Bliss in the address list, Appendix 3).

Bliss is used by pointing to a symbol on a board; some boards are electric, and the symbol then lights up. The Bliss language has 500 symbols and it was originally developed by Dr C. K. Bliss as an international language for communication. The idea did not catch on, but it is very valuable to the disabled. Various Bliss boards are in use (see Fig. 3.4); these offer from 100 to 500 symbols.

Bliss, being a language with its own syntax (Fig. 3.5 — a Bliss poem written by a child at Chailey), is not straightforward to translate. For example, there is an action symbol which, in context, can mean WHAT, WHERE, WHEN etc. and is

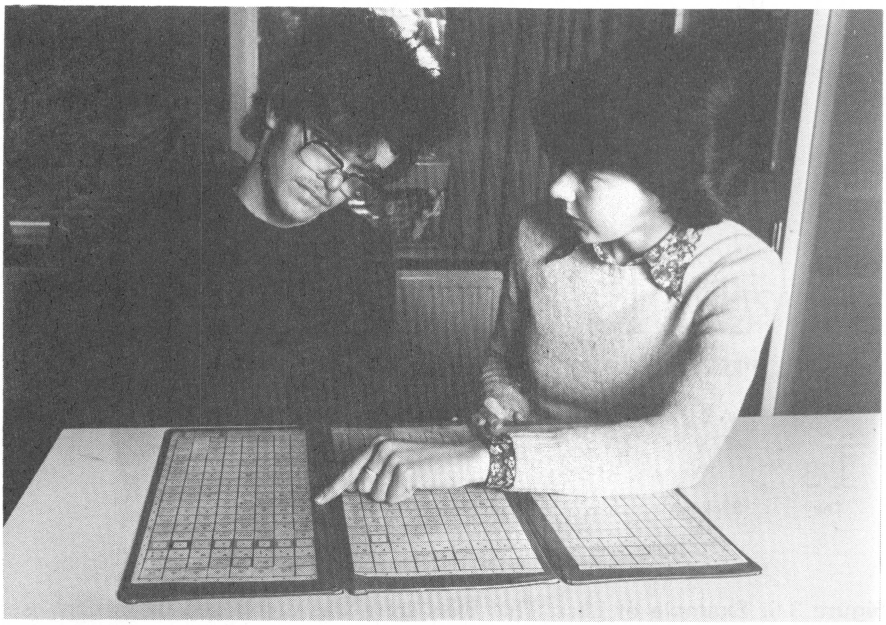


**Figure 3.4: Bliss board in use.** This is the most commonly used form of portable Bliss board. Electronic boards are also available.

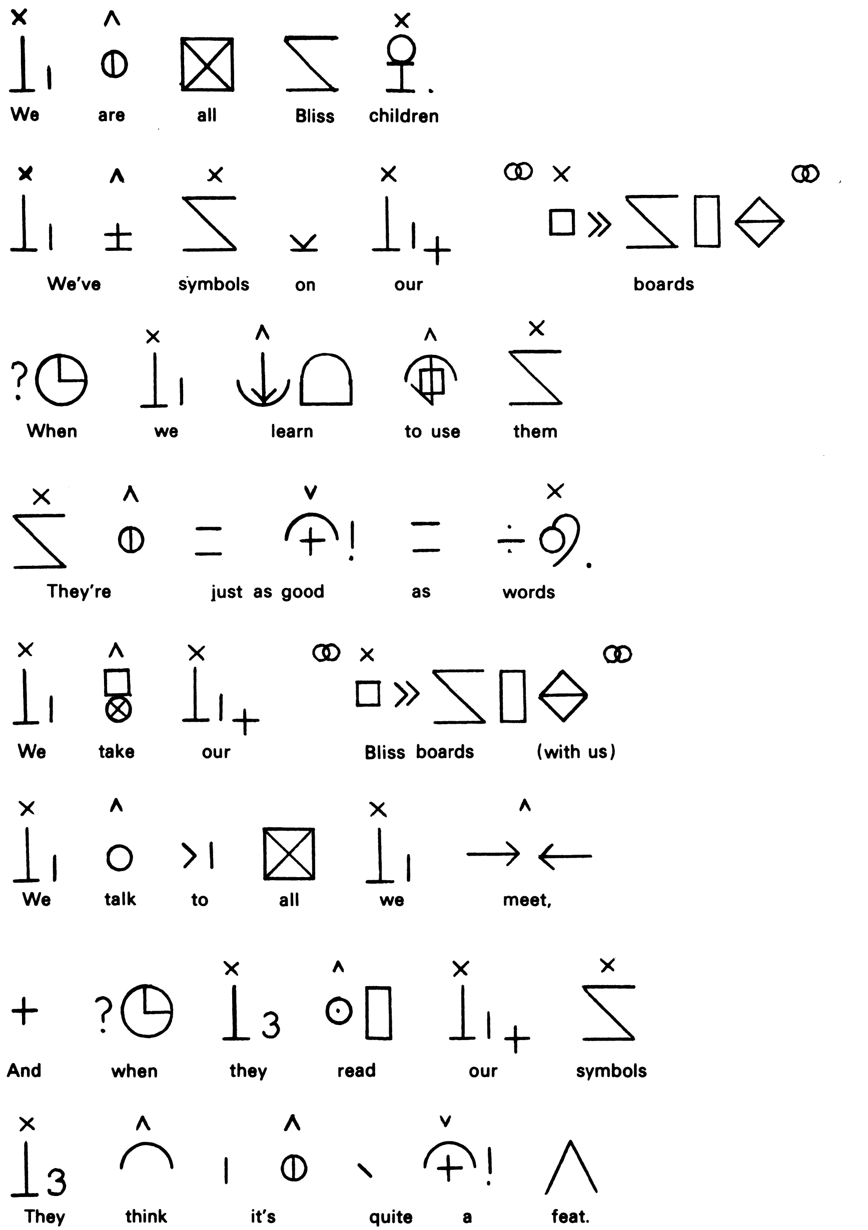





**Figure 3.5: Example of Bliss.** This Bliss song was composed by symbol-user Alistair Hunter, aged 15 years, and Elizabeth Dean, Speech Therapist, Westerlea School, Edinburgh. It is sung to the tune of 'All Things Bright and Beautiful' (Bliss users bang their boards in rhythm!). It was composed for, and first performed at, the end-of-term Concert and Prize-giving, June 1979, Westerlea School, Edinburgh.

known as the query symbol. A speech system would have to deal with these difficulties by scanning ahead. Ultimately Chailey wanted to build small units with the vocabulary permanently recorded but, owing to the difficulties involved in speaking the symbol vocabulary, a more versatile system was required for experimentation. There are about 4000 users of Bliss in this country alone who might benefit from a talking system.

### 3.5.1 Hardware

A Rair Black Box was chosen as a suitable processor for running the experiment. The system needed to be simple to operate and to have dual discs. Rair offers the facility of being able to load straight into a particular system, important in this application (no commands to initiate the computer are required). Two external interfaces were required, one for the Bliss board and a second for the speech synthesizer, which can be connected in parallel with a monitor terminal if necessary. The system was initially designed round the Votrax ML1 and a 100-symbol board, but this was found to be unsuitable so a 500-symbol board was substituted. The Bliss board is TTL-compatible, so that an interface board was needed to the V24 interface offered on the Black Box.

### 3.5.2 Software

Each time a Bliss symbol was selected, a row and column coordinate was passed to the machine. For most symbols this was translated directly by table lookup; however, some symbols generate an exception code so that output is held up until the next symbol is received. Three new command symbols were required:

(1) repeat symbol, i.e. speak the last symbol again,
(2) speak the whole sentence, and
(3) clear the sentence buffer.

When the system is set up for each user a personal disc is inserted. All interactions between the user and the system are recorded for each session. This information can be analysed later and will show whether a Bliss or spoken language syntax is being used; many Bliss users have no hearing loss.

### 3.5.3 Conclusions

Quite a lot of work was done on this project, including system design and the phonetic breakdown of the 100-word Bliss vocabulary, and valuable insights were gained into speech output. Work was done on establishing an initial target vocabulary, shown in Figs 3.6 and 3.7. The project was not completed because the extra hardware effort required was transferred to the MAVIS project, but the Bliss-to-speech work is likely to be taken up again at a future date.

SOCIAL RESPONSES:

1. Yes 2. No 3. Please 4. Thanks 5. Hello 6. Goodbye.

QUESTIONS:

7. Who 8. What 9. Where 10. When 11. Why 12. How 13. Which.

PEOPLE:

14. I/me/my
15. you/yours
16. woman
17. man
18. mummy
19. daddy
20. brother
21. sister
22. teacher
23. boy
24. girl
25. he
26. she.

NOUNS:

27. mouth
28. eye
29. legs
30. hand
31. ear
32. nose
33. head
34. name
35. food
36. drink
37. toilet
38. pan
39. clothing
40. car
41. chair
42. wheelchair
43. pen
44. paper
45. book
46. table
47. television
48. bed
49. news
50. word
51. light
52. game
53. friend
54. God
55. house/home
56. school
57. hospital
58. shop
59. room
60. street
61. animal
62. bird
63. water
64. sun
65. weather
66. day
67. night
68. weekend
69. birthday.

VERBS:

70. want
71. like
72. come
73. go/walk
74. give
75. make
76. help
77. think
78. know
79. wash
80. see
81. hear
82. eat
83. sleep.

ADJECTIVES:

84. happy
85. sad
86. angry
87. good
88. big
89. little
90. new
91. difficult
92. hot

**Figure 3.6: Basic vocabulary list for Bliss-to-speech experiment.**

ADDITIONAL VOCABULARY:

| DETERMINES: | VERBS: | ADDITIONAL NOUNS: | ADJECTIVES: |
|---|---|---|---|
| and | to be | seasons | in |
| the | know | rain | on |
| a | think | snow | up |
| to | to have | medicine | more |
| it | can | | sorry |
| | will | | |
| | get | | |
| | wish | | |
| | send | | |
| | need | | |
| | forget | | |
| | buy | | |
| | find | | |
| | sleep | | |
| | try | | |
| | play | | |
| | stop | | |
| | put | | |

Strategies:

1. Verb tenses: past, present, future.
2. Opposite Meanings : to extend vocabulary in areas like adjectives e.g. on/off, up/down.
3. Colours : primary colours.
4. Numbers : 0 – 10.
5. Plural :
6. Combine :
7. Like/similar to:

**Figure 3.7: Additional vocabulary for Bliss-to-speech experiment.**

## 3.6 OVERALL CONCLUSIONS

In this chapter, each section has been treated as a separate entity and therefore individually concluded. Here some general comments are made regarding the experimental work as a whole.

Many of the experiments were carried out with a view to including or excluding a specific man–computer interface feature on MAVIS. For example, MAVIS plays short series of notes when carrying out control functions; these were based on the experiments with tones. When the first prototypes of MAVIS were built tones were more desirable than speech output for economic reasons, although this was almost certain to change as speech chip technology improved. Allowance was made for the addition of speech and tones.

It was soon found that a visual display screen was a very useful aid to those with very poor sight, and therefore this should not be replaced by a specialized piece of equipment such as a Braille terminal unless this was unavoidable. The silence of a visual display, as opposed to the general clatter of the hardcopy, caused problems. If a noise for end-of-frame and end-of-line was inserted, a screen for input of material caused no problems unless the material was of a very technical nature. The printer attachment solved the problem of having to read large amounts of output and the set-up appeared ideal for those working with word processing, studying or requiring information from a computer system. Recently a Braille mini-information system has been produced by TSI (see Section 2.2) which, coupled with the attachment, would provide an ideal studying environment, especially if a suitable bulk dumping interface to the VersaBraille becomes available. The VersaBraille Braille display could also be coupled to MAVIS if this was required.

In all the experimental work personal attitudes played a large part. Such factors as motivation and desire to master a particular situation were important human factors. For example, those who were highly motivated to understand synthetic speech, perhaps because they saw its potential in their own lives, often managed to comprehend what sounded like gibberish to others. People's feelings towards the equipment being used also affected the results. Of course, results in such experiments, especially when trials need to run for years to produce a large sample, are very difficult to quantify and, therefore, in the present work quantitative results were not obtained and effort was concentrated on assessing people's feelings towards living with a particular piece of equipment.

Chapter 4

# THE MAVIS SYSTEM

MAVIS started as a plan, formed at Loughborough University of Technology (LUT), for a microprocessor-based aid for severely disabled children. The LUT team had been contracted by NPL who were already working on different aspects of computer aids for the disabled. In 1976 the two projects merged and the MAVIS team was formed as one of the microcomputer projects in the man–computer interaction group at NPL under the general guidance of Dr Christopher Evans. Sadly, Chris Evans died before the project was completed but MAVIS owes many of its unique features to him. Chris's enthusiasm also helped publicize the idea of a generalized computer aid for the disabled.

MAVIS, microprocessor-driven audio/visual information system, was the first attempt to build a general system offering many facilities for a range of widely differing disabilities [Howlett 1978, Folkard 1976, 1978]. Until this time, it had been impossible to economically justify building an aid that could be applied to the needs of many disabilities. The overall objective in the design of MAVIS was to have a general device that could be cheaply modified. So as to ensure that the resulting aid was portable, versatile and reliable, microcomputer technology has been used in MAVIS. This ensured easy modification and maintenance and employed hardware whose cost is falling dramatically.

## 4.1 EARLY RESEARCH AND BACKGROUND

Initial design was influenced by many visits made to disabled people and parents of handicapped children. The early work on the MAVIS project was carried out at a time when the usefulness of the computerized information system to the disabled had just been realized by those working in the field. A close study was made of the man–computer interface of such systems as Scrapbook [Robinson 1973] and Edit [Hillman 1977] at NPL, so that features could be included (see Section 3.3).

In early 1976, work started on looking at the problems of the severely disabled child with the aim of finding out how microprocessors might be configured to assist him. The particular problems of the severely physically disabled child had been discussed with the team by Reg Maling who, at the time, was working closely with the disabled and who had, some years before, invented the breath-controlled typewriter Possum (Section 2.3). Without Reg Maling's ideas and wide experience the resulting MAVIS equipment would not have been so versatile.

Until this time, many aids existed for the severely physically disabled, but these usually assisted only one area of difficulty and, where children were concerned, considerable adaptations had to be made, with the child frequently needing a lot of adult assistance. For example, to this day there is still no adequate page turner that can be used independently by either a child or an adult. As more and more existing aids for the disabled were studied and more, very cluttered houses were visited, it became very apparent that there was a need for a general purpose 'black box' that could be used for many tasks and by different age and disability groups.

During the first year of the MAVIS project, work was limited, almost entirely, to the problems of the severely physically disabled. However, difficulties faced by other disabled people, including those with multiple handicaps, were considered for inclusion later. On the first MAVIS system some special applications were developed for children, such as simple tune playing and a small remote controlled robot. One of these special applications for children, in the first prototype, can be seen in Fig. 4.1 where a simple maths teaching program is being demonstrated.

In September 1977, MAVIS Mark I was shown to a small audience of interested and informed people. The system and its fundamentally different approach were received favourably, in spite of various hitches which arose with the large and rapidly assembled prototype shown in Fig. 4.1.

A further year's work was carried out on MAVIS to extend its uses and to provide reliable, portable hardware. Figure 4.2 shows the production prototype model, built by Ferranti Instrumentation Ltd, being used by a severely disabled, non-communicating boy at Banstead Place. Here the system is being controlled by chin switches, the only movement that Andrew has.

When a fully tested system was completed in the summer of 1979 an evaluation project was planned. At least three systems were to be evaluated in widely different environments. The Department of Health and Social Security agreed to play watchdog to this stage of the work, and suggested medical consultants who might be interested in placing units. The evaluation would also provide valuable assessment, training and maintenance information as well as a full test of the design. The first site to be used, Banstead Place, is a rehabilitation and assessment centre for the severely disabled where the equipment has been received very well (see Chapter 5).


**Figure 4.1: The Mark I MAVIS system.** Here the original prototype is shown being used with a simple talking mathematics program for retarded children. This system was shown to a selected audience of those interested in aids in September 1977, when enough interest was shown for research on the Mark II system to be continued.

## 4.2 SUMMARY OF DIFFICULTIES ASSOCIATED WITH PHYSICAL DISABILITY

The particular difficulties of the physically disabled have been mentioned in previous chapters. The present brief summary is included for completeness and because these areas of difficulty are particularly applicable to MAVIS.

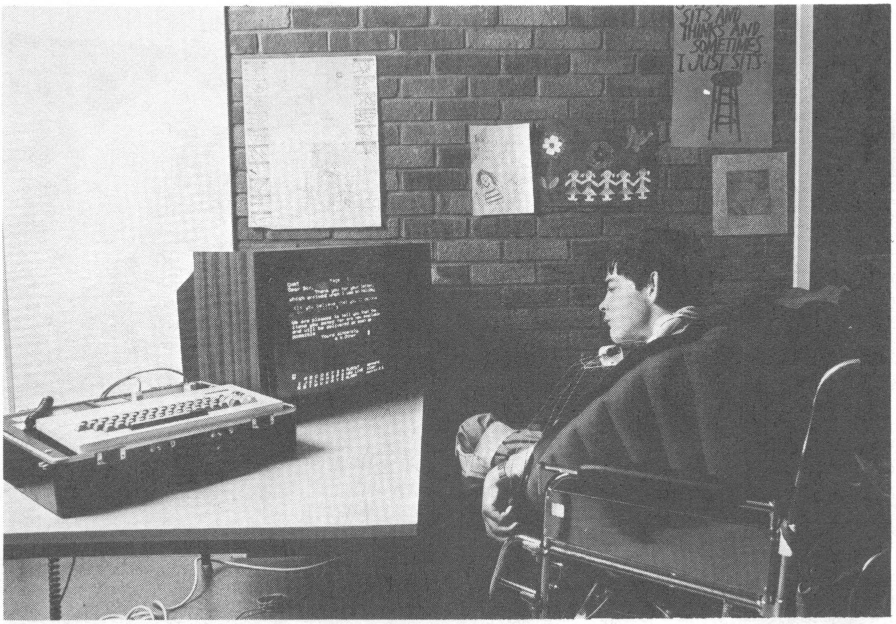



**Figure 4.2: Mark II MAVIS system.** One of the current MAVIS prototypes is shown being tried out for writing a letter. Andrew is operating the system with chin switches, selecting the items to be displayed on the screen from a matrix at the bottom of the screen. Hardware for the Mark II MAVIS has been built by Ferranti Instrumentation Ltd.

In the early research, first the problems of the severely physically disabled child were considered and then those of the adult. It was on the findings of this initial informal research (Chapter 3) that the first system design was based. Most of the severely disabled children visited in early 1976 were spastic, had spina bifida, or had severe motor neuron damage. Four spinal injury cases were included, as were two thalidomide cases. Adults seen varied tremendously, including spastics, severe multiple sclerosis cases, road traffic accident cases with both spinal and head injuries, muscular dystrophy cases, brittle bone disease cases, etc. Observation of these people showed the following areas of difficulty:

(1) recreational difficulties,
(2) problems with access to written material and writing,
(3) communication difficulties, and
(4) resistance to the change of equipment.

Obviously, not all of the people seen had all four areas of difficulty, but many did. The same areas of difficulty are also experienced by the severely sensory handicapped, but in different ways and for different reasons.

### 4.2.1 Recreational difficulties

These were experienced in different ways by both children and adults. Physical recreation was usually provided but frustration occurred with the lack of interesting leisure activities. Television was the commonest form of relaxation but even this could not always be controlled by the disabled person. A child who is either born severely physically disabled or who suffers spinal injury very early in life is faced with a very difficult and frustrating world. Parents of such children also suffer greatly, not only from feelings of guilt, but also because of the constant attention demanded by the disabled member of the family. Manipulation of toys, exploration of the environment and normal playing is totally denied the child, who requires compensation with other activities. Such children are often reading fluently by the time they are three.

### 4.2.2 Access to written material and writing

Creation of written material poses problems for both children and adults. The problem is twofold. Firstly it is often difficult to reach or find an item to be read and secondly flicking through pages can be difficult. Developing children have the additional frustration of not being able to scribble and draw. The existing adapted typewriters (Section 2.3) and page turners are far from ideal solutions. A breath-controlled typewriter provides no editing functions and the paper is frequently held in such a way that it is difficult to see what has just been written. Watching children and adults at school and at work shows a great need for a screen-based information system offering editing and drawing and having a large file store for easy access to stored material. The lack of an adequate reading and writing system is fundamentally handicapping the development of both educational and employment facilities for the severely physically disabled.

### 4.2.3 Communication

Many severely physically disabled children also have communication problems. Speech impairment coupled with lack of movement causes much frustration in small children and, even in adults, requires a highly developed personality in order to overcome the problem. Various symbol languages, Bliss being the most commonly used (Section 3.5), and pointer boards (see Fig. 3.4) exist with electronic versions, for example the Autocom, just coming on to the market. It is the use of synthetic speech that should have the most impact on these kind of problems (see Sections 2.4 and 3.4). A different kind of communication problem is also experienced by those who, in the course of their daily lives, use languages such as Braille, finger spelling and Bliss, which are not understood by non-specialists.

### 4.2.4 Alteration of equipment

For the growing child, or person with a progressive disabling condition, there is a frequent need to change equipment. This change is often a major job with much upheaval to the living or working environment. This, often noticeable, change frequently leads to a psychological rejection of aids, with people surviving without assistance and causing themselves much additional hardship.

## 4.3 MAVIS

MAVIS was built as an easily adapted, generalized black box. Two versions of the system have been built, Mark I and Mark II, shown in Figs 4.1 and 4.2, respectively. Details given here will refer to the Mark II version unless otherwise stated.

MAVIS consists of a small suitcase that attaches to a standard colour television and other equipment if desired. The case contains a microcomputer with a large memory and a mini-cassette unit. Normally, a removable keyboard is housed in the case. MAVIS has been specially designed to be used by people with little movement who normally control equipment by breath or simple switches. For use in different environments, allowance has been made for attachments to other equipment, for example, a printer. Possibilities are shown in Fig. 4.3.

MAVIS has been built for those who either do not have time or are not interested in adapting an 'off-the-shelf' system. All of the system's programs are held in a Read Only Memory that cannot be destroyed. This memory also holds some basic selection matrices for those using special switches, but facilities are available for these to be written by a user. This facility means that the system can be tailored to a person's needs with commonly used phrases or commands being easy to add to the matrices.

MAVIS can be used as a word processor. Many severely disabled people find great difficulty in manipulating paper and creating tidy documents. MAVIS has been designed to be like an electronic notebook with each page being one screen of text. The system offers many commands for creation and correction of text and also routines for printing and saving the material. As many disabled people have trouble with vision, either because of their sitting position or through actual eye damage, auditory cues have been added to the commands and matrices. The sound generator can also be used for playing simple tunes.

As part of the text handling system, a simple drawing package has been added. This allows for colour drawings and simple diagrams.

MAVIS also provides environmental control. Many severely disabled people lack the manual dexterity or mobility to switch on lights, operate televisions and radios, answer the door and telephone, etc. A box can be added to MAVIS enabling the user to easily control anything that is attached to it using normal commands to the system. MAVIS also offers an autodialler for the telephone.

Most of the MAVIS operations are controlled by programs (software). Those used every day are permanently resident in the indestructable memory section. Other programs can be obtained from the cassette. The built-in operations can

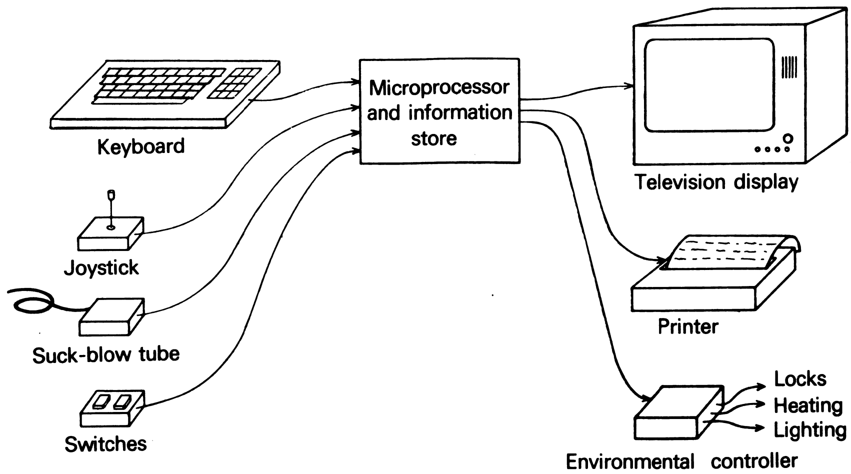



**Figure 4.3: MAVIS inputs and outputs.** This shows some typical input and output devices that can easily be connected to a MAVIS system.

easily be extended in this way. MAVIS uses a normal colour television set as its display, tuned to the MAVIS channel. Sets with remote control can normally be controlled from MAVIS either for viewing or for using MAVIS itself.

### 4.3.1 MAVIS unit construction

The rest of Section 4.3 gives more details of the construction of MAVIS and of the structure of the software. It can be skipped by those mainly interested in the applications.

MAVIS is a unit weighing twenty pounds, measuring five and a half inches deep, fifteen and a half inches from front to back and seventeen inches broad. The computer, storage, interfaces for handling the peripherals and cassette unit are all housed in a large briefcase. A keyboard can also be held in this unit. So as to ensure easy maintenance and change, MAVIS has been built on a number of exchangeable cards. Appendix 1 gives a more detailed breakdown of the hardware construction. The high-level hardware design for the unit was carried out jointly with Ferranti Instrumentation Ltd, who then developed it to form the existing Mark II unit.

The processor chosen for this application was the Zilog Z80. Initially, a Motorola 6800 was used, but it was found that the Z80 had better memory management facilities, an instruction set and interrupt system more suitable to the application and a wider range of compact associated chips. However, the system hardware and software has been built so that a change of processor could be made if required.

### 4.3.2 Storage configuration

MAVIS has been built with four levels of storage: programmable read-only memory (PROM), fast random access memory (RAM), bulk store, and a mini-cassette unit. This may seem unnecessarily complex until the application is considered. For many physically disabled people, manual dexterity is a problem, either because of weakness or general lack of movement. A balance must therefore be achieved between the amount of on-board memory, directly affecting the cost of the equipment, and the amount of exchanges or backing store required to perform a particular set of tasks.

The PROM is used for holding the essential systems software. It is on-board programmable so that system changes can be carried out by the user or an assistant. All control of peripherals, systems functions and some essential matrices (see Appendix) are held in PROM so as to minimize the possibility of a user being left without any functioning equipment. At present, 14 kbytes of PROM are being used.

Sixteen kbytes of fast RAM provide the immediate scratch memory. This is usually used for immediate operations in progress, text creation or temporary space for systems functions. Experiments so far have shown that 16 kbytes of fast memory is sufficient for normal use of MAVIS using the current configuration.

The idea of a bulk store between the immediate RAM memory and the cassette is an unusual feature in this type of system. Owing to the frequent lack of manual dexterity in MAVIS users, it was decided to provide a large, non-volatile bulk store. This storage can be used in the same way as a fixed disc and it is intended eventually to consist of bubble memory. However, the bubble memory chip manufacturers have had difficulty in producing cheap, large-capacity memories and the intended hardware was not obtainable. As a temporary measure, a large RAM board has been inserted in the current prototypes to simulate the bulk store, and the system has been built so that this can be changed as soon as the technology is available. Initially, this store is to be 128 kbytes in size, but this will be increased as the technology improves.

A cassette unit has been included to be used mainly for exchange of information between users and for changes in software. MAVIS uses a mini-cassette with each side of the tape holding 80 frames (screen-sized pages). The smallest unit retrievable from a cassette is one block, one frame, but normally a file is copied or a whole side read into the bulk store. A cassette unit has been used in this application in preference to a disc as it is far cheaper, bulk store being available anyway for random access, and it does not require a fan, thus making the unit silent when in operation. It is also smaller and transportable without risk of damage.

The four levels of memory, with the exception of the cassette which has to be addressed directly by the SAVE command, are invisible to the user. Obviously when the bulk store is full the user has to take care of clearing it and if software is to be written to PROM, special procedures must be followed.

### 4.3.3 Input/output interfaces

MAVIS has two parallel and two serial (RS232 compatible) device-handling interfaces. These are used to handle the wide range of peripherals that have to be attached for this application. Communication with the television normally used as the display uses standard Teletext code. At present, decoding is carried out within the MAVIS unit but, as the public information systems become more widely used, this board will not be required. Provision has also been made for the handling of Viewdata with an autodialler included.

### 4.3.4 Software

MAVIS software can be categorized as follows:

(1) debugging and systems packages,
(2) the Text Handler,
(3) PLUM, and
(4) applications packages.

At present, most of these are written in Z80 assembler and all of the systems packages, debug routine and text handler are held in PROM.

System debugging and low level interface handling are carried out by a set of routines always present within MAVIS; these form the kernel and are used by all the other software as required. The debugging function BEBUG allows various checks to be made of general system functions, for example, interrogation of tables and checks for memory malfunction. A level of hardware automatic fault detection is also built into the system. The kernel also handles the details of display and input.

Most of the text-handling system is always present when MAVIS is being used. All commands are received and decoded by this handler, including those which have no effect on the manipulation of text, for example, switching of environmental control. So as to make use of the system as simple as possible, all commands and information use a set screen layout (see Section 4.6). Full colour can be used if desired; a simple drawing facility is also offered, shown in Fig. 4.4.

MAVIS, when in text mode, operates as a word processor offering a full set of text-handling commands. All commands are based on simple English words and can be abbreviated. A fully comprehensive text handler is important to the disabled user as correction and creation of text is difficult using other, paper-based aids available. For details on the actual commands, see the Appendix.

PLUM is an acronym for Programming Language for Users of Mavis. PLUM is a simple, high-level language written for MAVIS. It was written as an experiment combining a simple syntax, like that of BASIC, with some structure so that good programming practice and techniques can be used. A subset of PLUM also forms a simple BASIC so that a user can use both languages. Although the language has been used by members of the team for writing applications, it has not yet been tried with users because the bubble memory versions of MAVIS are

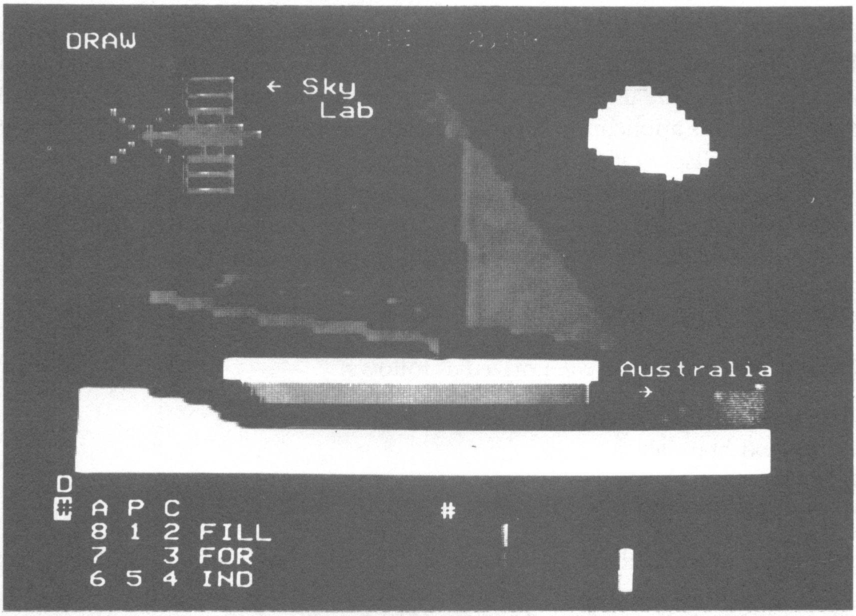



**Figure 4.4: Drawing on MAVIS.** Here a typical MAVIS picture is shown. The original is in colour. Drawing has been found to be particularly useful for children at school, although there are other applications as well. Drawings have been used for communication(see Chapter 5), to show large print, for diagrams in meetings, and in games such as Hangman. Items in matrices can also be pictorial.

not yet available. An example of PLUM is shown in Appendix 1. When PLUM was designed there were very few small BASIC interpreters available. It might now be desirable to offer BASIC as a language in its own right for MAVIS.

## 4.4 APPLICATIONS PACKAGES

As well as its function as an electronic notebook for reading, writing and storing information, MAVIS has a wide range of uses varying from game playing (currently impossible for many severely disabled people) to work-orientated packages. For the evaluation trials some packages were written and, as trials progress, others will be provided. Z80 assembler and PLUM have been used. A selection of the current applications packages is briefly described below to illustrate some of the uses of MAVIS.

### 4.4.1 Games

For the severely disabled person, game playing is particularly difficult. MAVIS has various games available, some of which are purely recreational, for example

Simon, a game where the user must imitate patterns produced by the machine; others are designed with an element of teaching or assesssment in mind, for example the spelling and word recognition game, Hangman. Games are also used as the initial introduction to MAVIS for new users. All games can be controlled from the special inputs (Fig. 5.1).

### 4.4.2 Music

The ability to play simple tunes was initially used as a demonstration of the equipment, although it was thought that the package might have some other application. The evaluation has shown that most users of the system find tune playing highly amusing and use it extensively for entertainment. Various versions of the software are available, from one which codes the length and times of notes very simply as letters (Fig. 4.10), to a more elaborate version which displays notes on a stave as they are played. This software is also used to give auditory cues for typing and alarms, for example, an ascending scale of five notes is heard at the end of each line when inserting text.

### 4.4.3 User response system

At Banstead Place, MAVIS has been used extensively for assessment tests. This is an important application in that environment because there is often no other way in which the user can respond to a written questionnaire. A package is provided so that the text can be set up with expected, but unseen, responses. Branching will occur, based on the users' replies. A Teach program for users of MAVIS has also been written in this way.

### 4.4.4 Environmental control and page turning

MAVIS can be used as an environmental control system. A special hardware box with isolation has been developed for this purpose, and mains-powered items are normally plugged into it. Users can control such items as lights, fires, television, telephone and other devices by typing commands to the MAVIS system. These commands are of the same form as all other MAVIS commands, thus simplifying use. The software is kept permanently in PROM so that it has maximum reliability.

## 4.5 MODES OF OPERATION

MAVIS can be operated in basically two ways:

(1) keyboard input, or
(2) special switch input.

Although the two input modes are often used separately there are instances where both are used together.

### 4.5.1 The MAVIS keyboard

MAVIS has to have a detachable keyboard that can be easily operated from a wheelchair. The keyboard must be light enough so that it can easily be angled for use by those with very little movement, for example typing with a nose, but heavy enough so as not to move around too readily. Special protections also need to be included, for example the keyboard must be waterproof as food spillage is very likely. At present MAVIS offers a single, normal-sized keyboard which has only slight adjustment for pressure of operation. The evaluation has shown that at least three keyboards are needed, one very small, one normal sized and one very large one. Such keyboards are already available for use in other environments. It should be noted at this point that if a user can, whatever the problem, use a keyboard, he will (almost without exception) wish to have this rather than any other device.

The keyboard layout currently being used for MAVIS resulted from many arguments and much work. Various human factors had to be considered, as follows.

(a) Touch-typing was frequently used by disabled people or by those preparing material for them. This made it undesirable to use some of the standard computer keyboards.
(b) Keys had to be grouped so that no long stretches occurred; no movements up, down, left or right of more than one key.
(c) Colour keys, special characters and cursor movements had to be logically placed.
(d) Key tops had to be considered for maximum contrast, for those with poor sight.
(e) Special, important action keys, for example, RETURN and ESCAPE, needed to be clearly differentiated from other keys.

The keyboard layout, shown in Fig. 4.5, was the best compromise that could be achieved at the time of prototype production. No texturing of special keys was carried out for the initial systems but it was decided that on production models, if the system was marketed, some larger, slightly rough faces might be included for ESCAPE and NEWLINE. A further modification that might be made to the existing keyboard layout is to add some keys with differently coloured tops, say on the vowels, to enable those typing with their nose to find characters faster.

### 4.5.2 Special input controls

One of the most unusual features of the MAVIS system is the ability to operate it by using a wide range of single and multiple switch devices (Fig. 5.1 shows operation with the feet). MAVIS has a set screen layout (see Section 4.6), with one feature being a matrix that appears at the bottom of the frame (Fig. 4.7 and succeeding figures). The matrix area of the screen allows four lines of items to be displayed; it can never be overwritten by the user, but he can, by selecting the

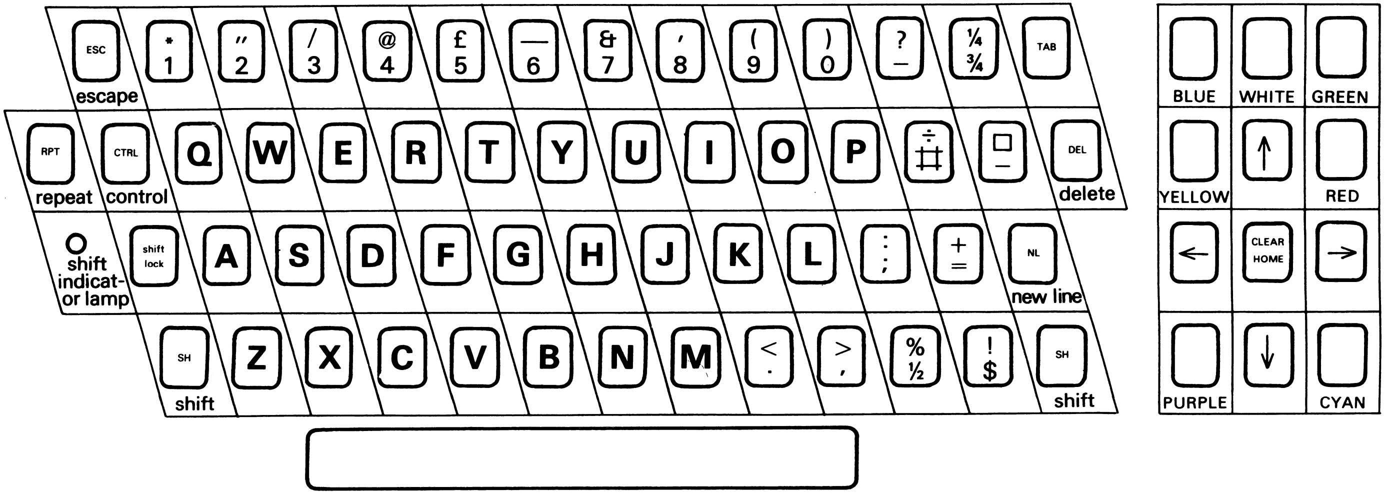



**Figure 4.5: The MAVIS keyboard.** This shows the keyboard layout being used at the moment; the keyboard is programmable so that other arrangements can be used if they are found to be superior. The colour buttons are associated with the use of graphics. The system uses the Teletext character set and the keyboard provides a full editing capability for Teletext.

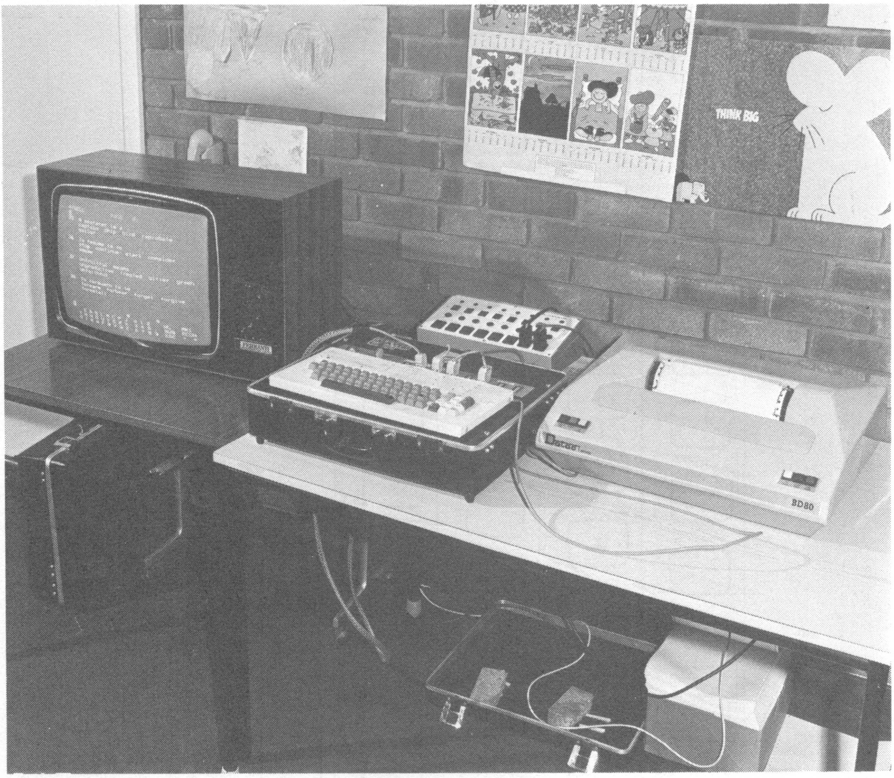



**Figure 4.6: Mark II MAVIS equipment.** A typical MAVIS set-up showing a normal colour television (left), a MAVIS unit (middle bottom), an environmental controller (top middle) and a printer (right).

appropriate item, cause a new 'menu' of choices to be displayed. The four lines can contain system commands, alpha characters and digits, words or sentences for communication, environmental control commands etc. The matrix area of the screen has its own special cursor which, when a button is pressed, moves across the items in the matrix. When the correct column has been located, a second button is pressed to move the cursor downwards. On finding the correct item, the first button is operated again and selection is achieved. The 'buttons' can be any actuators which the user can operate.

The matrix method of selection is widely used for environmental control systems currently on the market, and also for the Possum typewriter. On most of the existing systems the matrix is hardwired so that it cannot be changed or extended. The MAVIS method, which allows choice between a range of matrices, is much more flexible and powerful. MAVIS also contains software to allow the user to change the rate of scanning of the cursor; experienced users can become very quick. An alternative selection method is available where selection can be

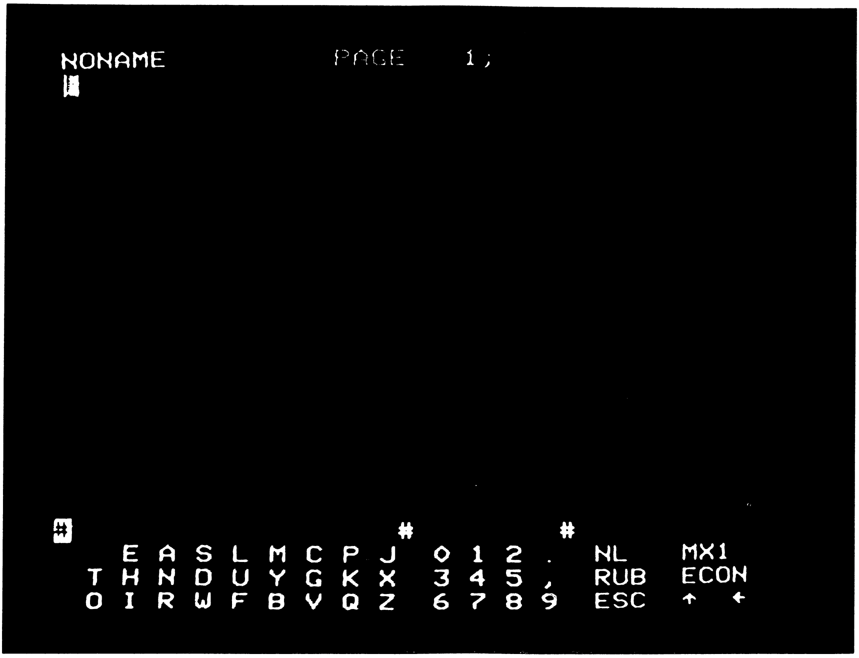



**Figure 4.7: Layout of a frame (screen) on MAVIS.** This shows the first frame that the user sees when the machine is switched on. The MAVIS frame is divided into four areas: (1) the top line always contains the name of the file currently being displayed (in this case NONAME). Normally the frame number within the file is also shown along with an optional frame title. (2) The next 18 lines of the screen are the user typing area where text or drawings are created and displayed. (3) The fifth line from the bottom of the screen is the command and error message line. This line is entered whenever the ESCAPE key is selected and is used for systems' commands and error messages. (4) At the bottom of the screen, the last four lines contain the current matrix. Here a typing matrix is shown, with the letters arranged in frequency order. The items ECON and MX1 are names of other matrices which can be accessed from this matrix by selecting them. A user can himself create matrices for different applications.

achieved in just two steps; when the second button is released, the item pointed at is selected automatically. The ability to make simple changes like this so easily is perhaps one of the system's strongest points.

## 4.6 USING MAVIS

Figure 4.6 shows a typical MAVIS configuration: the MAVIS system itself, a printer and a standard television set. For those very disabled users in their own homes, an environmental control system would be added. However, provision

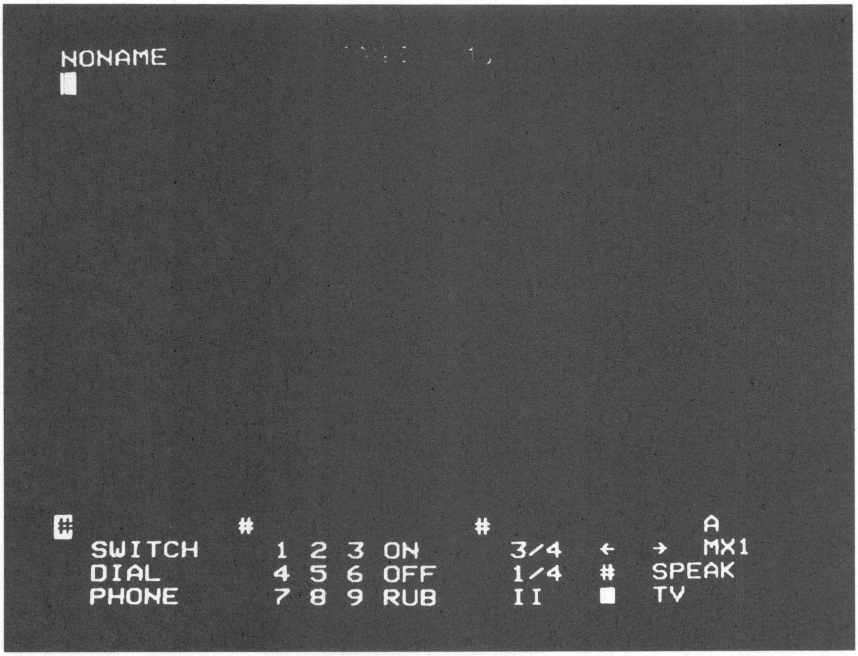



**Figure 4.8: Environmental control.** This matrix can be used to control switches and equipment from MAVIS, for example, to switch lights on and off, unlock the door, use the phone or change channels on the television.

has been made for MAVIS to be reconfigured very easily so that different input and output peripherals can also be attached.

When MAVIS is switched on, the first page of memory is shown. This appears in the normal MAVIS format, which is used throughout with the exception of 18-line matrix frames described below. Figure 4.7 shows the screen layout in more detail; there are four distinct parts.

(a) The title line at the top of the screen. This line is divided into two areas. The first identifies the current file. The second identifies the frame currently being shown, by giving its title and its number in the file. Titles for frames are optional (the user has a TITLE command) but the number is always shown.
(b) The user area: 18 lines of a frame are reserved for use by the user. When a new frame is shown, the cursor is always in the HOME position at the top left corner of the screen. This 18-line area is used for text creation, drawing, game playing etc.
(c) The command line. The 20th line of the screen is reserved for MAVIS commands. This line cannot be used until ESCAPE is pressed; this puts the cursor in the command area and MAVIS expects some instruction from the user (terminated by NEWLINE).

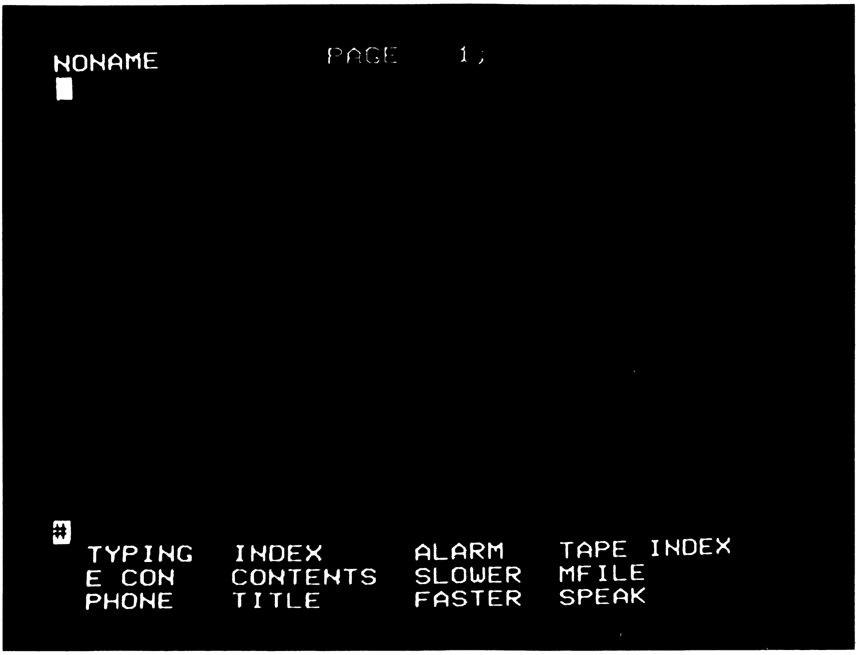



**Figure 4.9: The control matrix.** This is another of the four basic matrices held in Read Only Memory and therefore which cannot be destroyed, being always present in the system. Other matrices TYPING, E CON and SPEAK can be accessed directly from this matrix. FASTER and SLOWER control the selection speed. INDEX and TAPE INDEX list the files present in the system and on the cassette. For many users the ALARM is present on a matrix so that help can easily be summoned.

(d) The matrix area. Four lines are normally reserved at the bottom of the screen for matrix items. This area can only be used with a special input such as a button box or breath tube. Items present in the area can be characters or words to be copied into the user area, or mnemonics for commands or other actions.

Users very quickly become familiar with the set MAVIS layout. On entering the system a file NONAME is always shown; from this point, the user can select any file or carry out other operations by using the commands available. These commands are given in summary in Appendix 1.

When using MAVIS for environmental control it is useful to be able to display a larger choice of items than will fit on the four lines of the matrix area, and therefore 18-line matrices can also be used if necessary. An example is their use by the program which can make phone calls by taking information from a directory generated by the user.

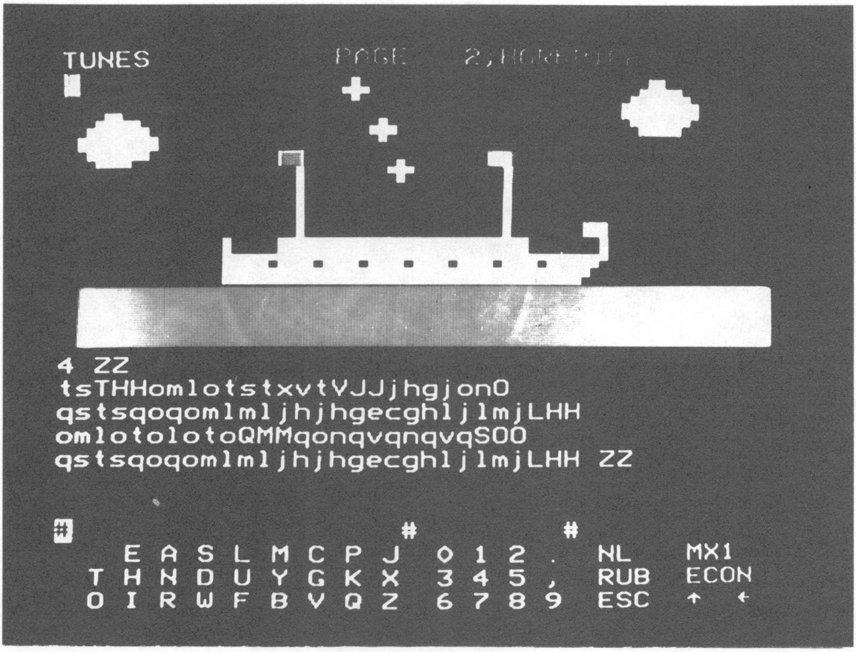



**Figure 4.10: Tunes on MAVIS.** On this frame, text has been prepared on the screen in the user typing area. To those unfamiliar with the system it looks like rubbish, but in fact it is the notes for the tune of a Hornpipe. Letters of the alphabet each have a tone associated with them, capitals being twice the length of lower case. The tune is played by using a PLAY command.

New matrices can be added to MAVIS by the user, or on his behalf. No knowledge of programming is required. Matrix elements can be pictorial as well as being letters or words.

This chapter has described the operation of MAVIS and its functions. What happened when it was used is described in the next chapter.

Chapter 5

# THE MAVIS EVALUATION

This chapter discusses the first user trials of MAVIS. These trials were carried out to test the feasibility of such a system, its general usefulness and to find faults and improvements on the existing equipment. Trials were carried out over six months from the middle of October 1979 to the end of April 1980. On the whole, the prototype equipment performed reasonably well and the trials have been very useful for ironing out faults.

Here the evaluation work and material used is described, together with some desirable improvements revealed by the work. Comments from those involved with the evaluation are reproduced in full where relevant. The last chapter will discuss the general conclusions from the research.

During the evaluation, technical support and overall planning and design was the duty of the author; most of the field work with users was performed by Miss Julia Charles, a research student associated with the project.

## 5.1 EVALUATION SITES

For an evaluation, the Department of Health and Social Security nominated three medical consultants to suggest sites and oversee the work carried out. This led to a plan to site three systems in Surrey, Essex and Manchester. Evaluation with a system in Surrey proceeded according to the original plan but siting of the other two systems had to be changed because of the limited support available.

In January 1980, a revised plan for the evaluation trial was produced and accepted by all concerned. So that the trial could be completed in a satisfactory manner, BP Ltd offered financial support. It was decided to site one MAVIS near BP in central London so that those interested could see the system in use. Facilities were not by this time available for the support of three systems so the decision was made to continue with the Surrey site and to start the further trial in central London. The third system was to be used for the preparation of material and short term trials, if possible. At a later stage an environmental control evaluation was planned with this system. Therefore, trials were to take place as follows.

(1) Work to be continued at Banstead Place (the Surrey site).
(2) A system to be installed with an individual at a school near BP (Richard Cloudesley School). The time available would only allow the second site to be started and monitored.
(3) The third MAVIS would be sited with some less severely disabled people for comments and used for preparing material for the other two sites.

## 5.2 BANSTEAD PLACE

It was decided to start the evaluation trial of MAVIS at Banstead Place, the site selected by Dr J. A. Hicklin. Dr Hicklin is responsible for the prescription and selection of aids for severely disabled people in this area and is also involved with many other activities with the handicapped. His enthusiasm and encouragement gave a great boost to those working with the system.

Banstead Place Assessment Centre, Banstead, Surrey is a residential centre for the assessment and further education of physically handicapped young people of school leaving age, run by the Queen Elizabeth Foundation. Its facilities are designed to help those whose future presents problems. Students are sponsored by their Local Education Authorities or other responsible bodies for a period of assessment, the length of which is determined by the needs of the specific individual.

### 5.2.1 Assessment

Banstead Place provides total assessment of the individual — educational, personal, vocational and social assessment. During the assessment, plans are formulated for the student's future with the help of specialists in many fields, and in full consultation with the student, the student's parents and the authorities responsible for carrying them out. Banstead Place works closely with the Departments of Education and Science, Employment, and Health and Social Security.

All young people with severe physical handicaps may be accepted, and 32 students are accommodated at any one time. An initial assessment is arranged, usually during the student's last year at school, but it is the main assessment period, after leaving school, which provides the detailed information that will form a positive recommendation for the student's future; whether it is to be at home, in further education or training, in open or sheltered employment, or in a residential home. A plan is then agreed with the student, his family and the local authorities, and the remaining time at Banstead is spent helping the student to prepare for the demands that he is likely to face in the future.

### 5.2.2 Curriculum

An individual timetable is arranged for each student on arrival at Banstead, based on the need for him to accept increasing responsibility for himself and to understand the demands of normal everyday life. The programme includes further or remedial education, training in independence or mobility, vocational assessment, work experience, social activities, the use of leisure, and, where possible, learning the skills of driving and use of public transport. The individual's programme is regularly reviewed with the student, and much of it is carried out away from Banstead Place with the help of local facilities of every kind.

The period of assessment depends on the needs of the individual. On average, a student will stay for about a year and admission and departure may take place at any time of the year. When the student is ready to leave, a final report is written by the members of staff and circulated to any individual or authority for whom it may be relevant.

### 5.2.3 Staff

The staff are a multidisciplinary team, all members of which contribute to the total assessment. A medical officer directs the work of the physiotherapists, occupational therapists and speech therapist, and their programme is co-ordinated by a senior therapist. The assessment team includes a social worker, a psychologist and a technical officer, and the work of the teaching staff is supplemented by the local facilities for education.

### 5.2.4 The use of MAVIS at Banstead

During the initial six-month evaluation period at Banstead the primary role of MAVIS has been in education. Its potential as an environmental controller has not been tested at all, but it has been used as a communicator in a limited sense.

### 5.2.5 Education

The most obvious role MAVIS can play at Banstead is that it enables even the most severely disabled individual to read independently of others. Once text is on cassette, the student needs only to be able to grasp the simple principles of turning the 'page' forwards and backwards to be totally independent of staff help. There are no satisfactory page turners available for severely handicapped people that will cope with various sizes and types of books, and there are no devices that enable them to turn back or forward a specific number of pages. MAVIS enabled users to continue with set lessons and reading, independently of staff help, purely by allowing them to refer back to areas of text so that they could check information.

An obvious drawback is the time that is required to get material on to cassette for the students. This process needs time rather than secretarial skills, and it was found that, even with the limited amount of skilled help that was available at Banstead, a library of cassettes soon accumulated. The editing facilities enabled members of the staff who did not possess typing skills to put text and lessons on to cassettes, and many of the students who have had some secretarial skills, or were learning to type, were enthusiastic about practising on MAVIS. At present, the range of material that is being entered is very wide, with contributions from various departments. The further education staff have used the system most initially. The physiotherapists are entering material related to the riding and swimming tests that the students take, and highway code questions have been put on for those students who are learning to drive. The nursing staff have plans for entering files about personal care and hygiene and the social worker has entered details of Post Office allowances and benefits.

In this kind of teaching, repetition is a vital and integral part of learning. Information at a very basic level may need to be repeated, which can be tiring and frustrating for staff. If this basic information can be put on MAVIS, so that students can pursue it at their leisure whenever they want, a lot of staff time and patience may be saved.

### 5.2.6 Assessment testing

A second area where MAVIS has important potential was in the area of assessment testing, which each student has to undergo during his stay at Banstead. The tests are those normally used in schools to estimate reading ability, numeracy and other aspects of intellectual ability, such as Vernon's test of arithmetic ability and Atwell's test of reading skill.

The problem of the application of such tests to a handicapped individual is already well documented. The methods of response available to the individual are often limited so someone else may need to be involved, which may bias the result in several ways. The effort involved for a handicapped person to communicate his answers is often considerable, and physical exhaustion may cause him to give up before his actual intellectual capacity is reached. Similarly the motivation to do well in the test must be considered and the tests are often tedious and boring to complete. Their purpose is not always clear to the individual. All these factors and many others contribute to the tests being a restrictive, and probably unrealistic way of estimating ability.

Having criticized the use of this type of test it is accepted that, despite their limitations, they will continue to be used for some time, purely because at present there are no alternatives.

Using MAVIS, the tests are far easier for the disabled person to complete. The conventional breath- or switch-controlled typewriter is tedious, and makes editing of material next to impossible. MAVIS allows the user to:

fill in answers anywhere on the screen;
edit, change and look back through already completed material; and
pause during a test and resume later.

Carrying out the tests on MAVIS also seems to provide a motivation in itself.

From the staff angle too, the use of MAVIS for assessment tests has several advantages. Firstly, the student is independent while he is doing the test and so staff may be with some other student. Secondly, the teacher may keep a record of the test, both in the form of a print-out, and on a particular cassette for the student. As these tests may be repeated at a later stage of assessment, it is interesting if a record of earlier attempts can be kept, and cassettes are the ideal way in which to store these attempts.

### 5.2.7 Written work

MAVIS enables students to produce all types of written work, essays, letters etc. at a standard that is higher than is possible on other devices. The editing facilities allow text to be corrected and amended, which relieves much frustration.

### 5.2.8 Games

The games package played a very important part in the evaluation trials. Three games were provided, Hangman, Target (a game where a score is accumulated by hitting a target with a moving spot on the screen) and Patience (a number matching game). The games were used in three ways; as a recreational facility, as an introduction to using MAVIS and as educational toys for helping with spelling and numeracy.

Most students at Banstead watched television as their main recreation. Games on MAVIS provided a second possibility which could be used independently. Many students who could not manage other facilities on the system used the games as recreation. These games proved so successful that a fourth was soon added — Simon, a colour and pattern matching game.

### 5.2.9 MAVIS users at Banstead

In theory all the students at Banstead could benefit from MAVIS in some way, but during the trials it was decided to concentrate on training a few individuals in its use. This decision was taken mainly on the basis of time, for with only one system it was impossible to cope with the teaching of all the students and it was felt that a fairer opinion of the uses and limitations of the system would be gained if attention was concentrated on selected individuals. During the initial period it was obviously necessary to train certain members of the staff in the use of the equipment, so that they could continue to use it when supervision was removed. In time the staff will select and teach students who are to use the system, but they agreed that a concentrated effort with fewer students would be preferable to attempts to try all the students at once. The initial users were selected on the advice of the senior tutor at Banstead, and aimed to cover a fairly wide field of disability types, both physically and intellectually. Subsequently other individuals have tried the system, being introduced to it by the further education staff.

**Figure 5.1: Use of MAVIS at Banstead Place.** Two or three of the students at Banstead Place operated MAVIS using foot switches. Selection was carried out either from the wide range of four-line matrices displayed at the bottom of the screen or from a whole-page menu. The ability to be able to create new matrices as required means that word and sentence stores can easily be provided, thus increasing the speed of the operator and cutting down the error rate. The picture shows one of the students playing Hangman.

## 5.3 SENIOR TUTOR'S REPORT ON MAVIS AT BANSTEAD

PRELIMINARY REPORT ON THE USE OF MAVIS IN FURTHER EDUCATION DEPARTMENT OF BANSTEAD PLACE,
Miss H. Elphick

MAVIS is being used with teenagers who have a variety of severe congenital handicaps such as Spina Bifida, Celebral Palsy, heart disease, epilepsy, the totally and partially deaf, and those who have had road traffic accidents. It was decided that the initial assessment would be with a small group of studens, two of whom are totally non-communicative, whilst the other four have some speech, but of a kind that is barely intelligible. In the last few weeks, a new student who is a non-communicant, totally deaf and partially sighted, has been introduced to the system and is already benefitting from it.

### 5.3.1 Situation

MAVIS is situated in a teaching room which is mainly used for assessment purposes. This is not ideal as its placement has been governed by two factors:

(a) location of a suitable power point, and
(b) the advisability of keeping MAVIS under lock and key when it is not being used.

The assessment I.Q. falls roughly into three categories:

(1) ESN (Educationally Sub Normal) Remedial,
(2) ESN(M) (ESN Medium), with an I.Q. of 70 to 90, and
(3) ESN(S) I.Q. of 60 and below.

### 5.3.2 Usefulness

Although MAVIS has been used at Banstead Place mainly for educational and communication purposes it is already obvious that it has implications for a much wider application. Staff from disciplines outside Further Education (Occupational Therapy, Physiotherapy, Nursing Staff, Social Worker etc.) are able to use the system for information processing in their own Departments and also for educating students in such things as personal care, theory for riding examinations, the highway code and road safety.

Much time is wasted in unnecessary editing if knowledge of the keyboard does not already exist, therefore I have found it useful to give students some practical experience of keyboarding before they use MAVIS, if there is sufficient dexterity in all or several fingers.

### 5.3.3 Assessment

It has been possible to use MAVIS for the more formal tests required by the Foundation and it is very helpful to be able to use the page-turning facilities in this respect, as many of our students are unable to turn a page by themselves. An added benefit is the storage facility to work either on the memory of the system or on a cassette. If a very severely disabled non-communicant student is being assessed, the process takes some time, and there is always the possibility of loss of interest, or physical tiredness at the effort required to make the correct response. We have seen that with MAVIS interest is being sustained for longer periods and there has been an additional stimulative effect. It is also possible to put silent reading tests (for non-communicants) on file.

The print-out is a necessity for educational as well as social purposes. Obviously it is important to have a record of the student's work, not only to assess vocabulary, arithmetic and comprehension ages, but also intelligence quotient calculations, as well as continuing comparison and assessment. The students who have used the system so far are introduced to it by means of familiarization with the games, jingles (tunes) and drawing facilities.

TESSA is a non-communicant and confined to a wheelchair, with spastic movements. Although she operates at middle primary level she grasped the principles of using MAVIS fairly rapidly and, with practice, she will be able to use it without supervision. She uses the button box and would benefit from the addition of environmental control facilities.

DARYL is a non-communicant severe spastic confined to a wheelchair, with a fairly low I.Q. He learned to perform simple tasks with MAVIS (he has now left Banstead Place) but it is unlikely that he would ever be able to utilize it for anything more than TV games, short messages and social letters, nor could he be left to use it unsupervized, as his low I.Q. militated against any further progress. Daryl used the foot board and would benefit from the addition of environmental control facilities.

RACHEL is a non-communicant with Bulbar Palsy, confined to a wheelchair with some spasticity. She is not very strong and although initially she was able to operate the on/off button and the cassette changing unit she is no longer able to do this without assistance. She grasped the principles of operating very quickly and once she has been given work to do she is able to complete it without supervision. She is able to recall a file from memory, to make a file, to save it, and to turn pages. If she has the opportunity for further progress I would anticipate that she can only add to her knowledge of the machine. Rachel has had such difficulty in communication that her mental capacity has never been truly assessed,

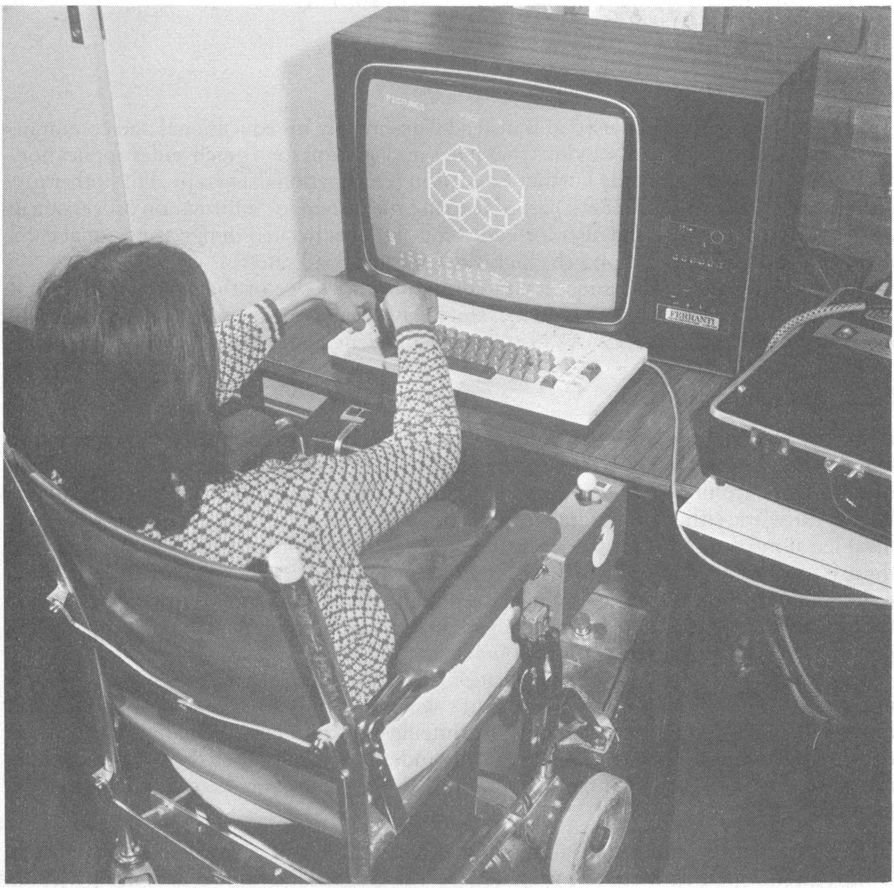



**Figure 5.2: One-finger typing.** Rachel, who is very weak and cannot speak, is operating MAVIS using the keyboard and one finger. She very quickly became a competent user of the equipment and used it for communication and all other class work, including preparing material for other users.

as indeed is the case with most non-communicants. We have realized since she has been using MAVIS that her intelligence is greater than was thought when she was first admitted to Banstead Place. Rachel operates MAVIS with a button box, although initially she used the full keyboard. She would also benefit from the addition of environmental control facilities.

ROBERT suffered brain damage and some paralysis as a result of a road traffic accident and what little speech he has is extremely difficult for him to produce, and is almost unintelligible. His movements are gross and very athetoid, therefore his accuracy in operation is minimal, although he understands the reasoning involved. Although he has had considerable brain damage his thought processes are still working, albeit at a lower level than before the accident. He has to work with a wooden support just in front of the MAVIS keyboard and this helps to a certain extent, but his real need is for an expanded keyboard similar to the PEK manufactured by Possum, but with the addition of the keys necessary to operate MAVIS. Obviously this problem will be met time and time again with road accident cases (which are on the increase) as well as some severe forms of Cerebral Palsy.

LEE is a severely spastic young man confined to a wheelchair with barely intelligible speech. He operates MAVIS with a foot board. Lee quickly learned the operating principles of MAVIS and is able to locate a file, save it, and use the page turning device. As in the case of Rachel, it has not been possible to assess Lee's intelligence with a precise degree of accuracy and since using MAVIS it is clear that his potential is greater than has been thought. Again one would expect further progress with more practice. He would benefit from an environmental control facility.

CLIFFORD has only recently joined us at Banstead Place. He is totally deaf, partially sighted and non-communicant and uses a wheelchair. In the past, communication with him has been extremely difficult. This has made him frustrated and his continued isolation meant that he lacked the motivation to do anything. He possesses a portable electric typewriter with 'Jumbo' size typeface, but since beginning work on MAVIS he is no longer interested in using his typewriter. At first I did not think it would be possible to communicate to Clifford the method of using MAVIS but I persisted with signs and finger spelling, and he very quickly learned the procedure and retained the knowledge. He recalled a file after being shown how to do so only once. The system has been a boon to Clifford and to the staff in the Further Education Department as assessment of this boy has been so difficult. Obviously MAVIS has not solved all our problems but it has stimulated him into some form of motivation. He is happier and comes to sessions without prompting, and is actually using MAVIS not only for assessment, but for communication purposes. I cannot stress too much the benefit MAVIS has been to us and to Clifford. Although he is partially sighted, and I did not think at first he would be able to see the screen properly, he sits very near it and does not seem to have too many problems. His vocabulary is very limited and one hopes that, through the system, his knowledge of words will be increased.

### 5.3.4 Disadvantages

I would stress that some of these disadvantages only apply to the situation in which we would find ourselves at Banstead, and probably would not apply elsewhere. One member of the staff is kept fully occupied in supervision of students' work and also to make new files. It is emphasized that our staff/student ratio and the frequent interruptions militate against any continuity in work. The matrix files are difficult to retrieve and sometimes there has been corruption of materials on the files. There has also been a loss of information from cassettes, making them unreliable, therefore they need to be constantly checked.

### 5.3.5 Advantages

The machine is flexible, and can be used by the partially sighted, the non-communicant, the deaf and partially deaf and the motor impaired. It is possible to recall students' work and to monitor progress. It makes use of a page turner obsolete. It provides mental stimulus and therefore increases motivation.

### 5.3.6 Recommendations

I would suggest that wherever the system is installed the maximum number of staff be trained to use it properly, but one person be allocated to be in charge of it full time, and also to take responsibility for checking and making new files and for indexing them and maintaining the students' work. Ideally the system should be installed in a room specially allocated for it, in order that students can be taught on a one-to-one basis after being withdrawn from the usual sessions either daily, or a minimum of three times a week. Constant supervision is needed with the handicapped, especially those with mental retardation, and time is needed to ensure that new files are made and that the existing ones are checked and kept up to date. Some students are able to work on their own once they have grasped the principles of retrieving files, saving information and turning pages, but all severely handicapped persons need help to set the machine up, switch it on and insert and change cassettes. (The on–off button is far too stiff for anyone with motor impairment.) The cassette cover is too far from students with weak muscles: possibly its situation could be changed.

As far as students who are less able mentally are concerned, constant help is needed as they forget from day to day how to perform the simplest tasks. If the system is to be used by persons who are severely handicapped it is vital that a number of inputs be produced to suit various disabilities, otherwise the system will not be used properly, or will not be used at all by some people for whom it was originally intended. There are already on the market at least a dozen different adaptations which the manufacturers of this system could supply, in order to make it a more viable prospect for those who wish to use it.

It is recommended that the instruction booklet be completely rewritten as it is not suitable for the severely handicapped to use on their own, or indeed for many lay persons who might be confused by it and, as a result, become disinterested. There is no index and the language used takes no account of the fact that severely handicapped persons are sometimes mentally retarded or even that their language is institutionalized, therefore the vocabulary that they normally use is of a simple and repetitive nature. For example, different words would have to be found for 'cursor' and 'matrix'; 'Press' would be better than 'Depress' and so on. Also, certain processes have been left out of the booklet altogether, for example, there is no mention of when to use upper case or lower case, and more guidance would need to be given following the responses such as 'file already exists' and other error messages in order to help the operator to remember what the next stage should be.

### 5.3.7 Software

I have found it necessary to make my own cassette to suit our students as they follow individual timetables and have different levels of aptitude, but it may be that if the system was used in a normal classroom situation the need for software could be met by manufacturers and would cut down the necessity for the teacher to produce them when she has limited time.

If the system is to be used by disabled people on their own (and presumably this is the case if environmental facilities are to be built in), perhaps a separate instruction booklet could be produced.

(*Note*: Miss Elphick uses 'software' to include both exchangeable programs from cassettes and textual information.)

## 5.4 MAVIS AT CLOUDESLEY

The Richard Cloudesley School, Moorgate, is an ILEA school for physically handicapped children from the districts of Hackney, Islington, Westminster and Victoria.

There are about 100 pupils at the school, ages ranging from three to 16 years, all of whom attend as day pupils. A wide range of physical handicaps occur among the pupils, such as spina bifida and spasticity, but all should be able to benefit from a normal educational curriculum. The teacher/pupil ratio is approximately 1 : 8 together with some additional helpers.

It was decided that MAVIS should be allocated to an individual in the school and that the child's family was also to be involved in the trial. At the recommendation of the headmistress and staff, Joanne was selected as a suitable individual.

In spring 1980 Joanne was just five years old; she is a very severe athetoid, wheelchair bound, totally dependent and has no speech. Trials with Joanne therefore require a long-term approach. She has attended Cloudesley since she was two-and-a-half, and in the previous year had been learning to communicate using Bliss symbols. She could then use a 30–40 word vocabulary on a Bliss board and was both eager and able to increase this vocabulary further. She indicates the symbols she wants to communicate by eye pointing, a method of pointedly directing vision at an object.

Initially Joanne was in the nursery section of the school. This functions basically as an assessment unit and formal teaching methods are not employed. It is an open plan section, marvellously equipped with a wide range of toys and games, and playing is actively encouraged by the teacher and her assistant. Children are extracted from the group for individual sessions by physiotherapists, speech therapists and other specialist staff, but otherwise they remain in the nursery. There are usually about eight children in the nursery and visitors are impressed by the atmosphere of the unit, as well as by the staff and equipment.

Later in 1980 Joanne moved into the infant school. Her general attitude and disposition had indicated that she was ready to begin formal learning, despite still being in the nursery group, and so she had already been introduced to the Possum. She has three or four private 20-minute sessions each week and uses a two-button input device. She is being taught by the 'look and say' method, where pictures are matched with words and then copied. Jo is now being taught to read and to construct phrases herself.

Joanne was introduced to MAVIS by playing games and looking at pictures with her family at home. At school she has started reading and writing work with the aids teacher, carried out in relatively short personal sessions. During sessions she learns how to use her input device and how to select from a matrix, and she will gradually build up a larger vocabulary.

It would be impractical for Joanne to attempt to use MAVIS in the classroom until she has mastered selection from matrices and has a basic vocabulary. When this has been achieved she will be able to use MAVIS in class for general work, which will be guided by her form teacher.

Two important preliminary factors which must be considered before successful use of an aid are seating position and the input device. With Joanne there have been problems in both these areas. The problem of seating now seems to have been solved in that Joanne has a new chair which improves her seating position. Prior to this, the lack of support for her head meant she had great difficulty in looking at the display of the Possum.

The second area, that of a suitable input device, is still being worked upon. Joanne's general weakness causes the operation of a standard button box to need a major effort. The possibility of touch-sensitive and heat-sensitive switches was investigated. Heat-sensitive switches caused problems because the amount of surface area that Jo places on the switch is often insufficient to activate it. The most successful input so far is one, constructed as part of the evaluation, consisting of a board with microswitches on light levers looking rather like two windscreen wipers. They are actuated by very light pressure through sideways movement of the arm. A colourful appearance greatly increased the acceptability of the device.

The importance of selecting a suitable input device cannot be overemphasized for the success of any user–aid interaction. It is not always best to use the movement over which the individual has most control for this may not be a movement that can develop or may not be socially acceptable. The success of an input device therefore needs to be constantly monitored and alternative inputs considered.

### 5.4.1 MAVIS at home

The idea behind the evaluation was to introduce MAVIS into all areas of Joanne's life and so the co-operation and support of her family were essential.

At an early stage of the trial Joanne's family was contacted and gave its wholehearted support to the scheme. Her parents and brother received instruction in the use of the system and were encouraged to use it, both with Jo and on their own, playing games, drawing etc.

MAVIS has been transferred between the school and Jo's home where it can be plugged into the family television set.

At present it is sufficient for Jo's family merely to become familiar with the system and they will use it very little with Jo. At a later stage, when Jo is more competent at selecting from a matrix and is able to use her input device independently, she will be able to use MAVIS at home with her family. Her parents will be able to reinforce the learning she is acquiring at school, and join in recreational activities. This will also help them to feel more involved in her progress.

Joanne is obviously an intelligent child and is very frustrated by her inability

**Figure 5.3: Use of MAVIS in the home.** Joanne cannot make any sounds and is therefore unable to communicate verbally. Controlled movement is also impossible, although Jo is able to use her right hand in a sideways movement. Here MAVIS is shown being used at home by Joanne for games and communication. She has just started word construction at school and is using MAVIS to display and save her work.

to communicate and participate. Considering the severity of her handicap, her general progress so far has been considerable and her obvious determination suggests that this will continue. It will be extremely interesting to observe how Jo progresses with MAVIS for she seems to represent an ideal candidate for a system of this kind.

## 5.5 MATERIAL USED IN THE EVALUATION TRIAL

As well as the built-in software and games, and material generated by the user himself, MAVIS can access material already prepared on cassette. Most application areas will need to build up useful libraries to get full benefit from MAVIS. A great deal of time was spent during the evaluation trial preparing different types of information for MAVIS users. Where pictorial information has to be inserted into text the preparation is lengthy and exacting. We now have a better understanding of the kind of material needed for this application, and how to set about preparing it.

Initially a selection of useful material was prepared by those setting up the trials. Some weekly magazines were typed, such as parts of the Radio and TV Times, and also a couple of stories. (If this were to be done regularly the copyright position would need looking into.) Even parts of the Highway Code were put in. All this material was well used.

At Banstead, the staff developed quite a lot of their existing material for use on MAVIS, and staff and students typed it on to cassettes. Tests of reading age and simple sums were included, as well as exercises in comprehension and spelling. As the trial progressed the site became self-supporting.

Further work was done on MAVIS itself. The games had proved so useful that a further one was written. Some of the MAVIS User Guide was typed on to a cassette so that reference to this could be more easily carried out by disabled users. The early stages of using MAVIS were covered by a teach-yourself system on MAVIS, but a full self-instruction system has not been fully developed as yet. The evaluation showed that the original user manual, prepared by technical writers, was virtually useless to users in the field.

For the Richard Cloudesley School some communication pictures were prepared as were some frames matching words and numbers with pictures. During the first part of 1981 Joanne has been learning sequencing in reading and writing. She has been able to use MAVIS with word store matrices built up from the words in her books. This is teaching us a lot about the organization of material on a matrix.

## 5.6 SYSTEM IMPROVEMENTS AND ALTERATIONS

A number of suggestions for change were made as a result of the evaluation, and some of these were carried out as the trial proceeded. Items included ergonomic features such as the position and design of switches, aspects of software such as minor inconsistencies in the commands, and hardware aspects such as the effects of construction on portability and reliability. As already mentioned, a lot was discovered about the teaching manuals and other documentation required and training needed for a general-purpose aid. All this information is being applied to improve MAVIS and its supporting material.

## 5.7 REPORT BY THE MEDICAL CONSULTANT NOMINATED BY DHSS

We conclude this chapter with comments on the evaluation from Dr J. A. Hicklin, Consultant advisor in environmental control equipment, South West Thames Regional Health Authority, and Consultant in rehabilitation to Queen

Elizabeth Foundation for the Disabled (Banstead Place) and to the South West Thames Regional Health Authority.

Disabled people have three problems to solve. Problems of communication, problems of control of the environment and problems of work/leisure pastimes. These are fundamentally the same problems as are met by the able-bodied — the desires and needs of the disabled are fundamentally the same as those of any other human being, but a wide variety of disabilities requires a wide variety of solutions in the form of aids and control systems.

At the present time, aids provided by the Health Service are divided into two groups. The first group is provided centrally by the Department of Health and Social Security, is funded centrally and is provided after assessment of the patient by one of the consultant regional assessors. The environmental controls provided under this heading are the PSU1, a mechanically activated electro servo system based on valve style technology, and the PSU3, a more advanced machine based on semiconductor technology. The PSU1 allows one of a number of functions to be selected and activated through a wide variety of inputs. The PSU3 allows the selection of a variety of functions and allows these functions to be modified by sub-headings on the graticule, for example, the television can be not only on or off but loud or soft and channel can be changed with a compatible machine. Both these machines are rather bulky and only the PSU3 can be triggered remotely by ultrasound. Communication problems are dealt with by the IA5 remotely controlled typewriter and by later variants. These again are bulky, slow and, although they produce hard copy, cannot be corrected except by usual typing techniques and are not easily adapted to 'shorthand' requests. The expanded keyboard Possum is used by people having difficulty in fine hand control as well as having no speech. They tend to be children with athetoid Cerebral Palsy.

The second group contains a wide variety of other aids and these can be purchased on a 'one-off' basis through Area Health Authority funds and through Social Services. Many of them are simpler than or more sophisticated than the devices available through central purchasing but the main characteristic of these devices so far is that they solve only one problem: they are an environmental control aid or a communication device or a specially adapted telephone, etc.

MAVIS presents a fundamentally different approach to these three broad headings of difficulties which disabled people experience in organizing their own lives. The difference arises from the new technology and it is the complexity of what can be achieved by MAVIS which has led some people to the view that it is excessively complex. It is more correct to regard MAVIS as a system which combines in one piece of apparatus the solution of problems of communication, problems of environmental control and problems of work and/or leisure. It can provide, for a price which is entirely comparable to other pieces of apparatus solving fewer problems, a system which is as simple or as complex as the user requires. It has been possible to show, at Banstead Place, that people whose I.Q.s are traditionally regarded as being towards the lower limit of that compatible with open employment are capable of understanding and using MAVIS.

The Senior Tutor's report from Banstead Place (Section 5.3) deals with the educational and communication advantages of MAVIS. I would not wish to repeat Miss Elphick's views but merely to emphasize that MAVIS allowed people with a severe physical handicap and some mental retardation to communicate where they had not previously communicated, to learn in ways which had previously be denied them, to take part in testing procedures and to find new enthusiasm. In other cases it enabled people of good intelligence to demonstrate and use the intelligence which had previously only been guessed at.

Lack of equipment has prevented proper assessment of the environmental control performance of MAVIS. An almost totally handicapped company director who has used

Possum equipment since it was first devised is available and keen to take part in a trial of MAVIS as an environmental control/business communications device. What follows, therefore, is a view based on several years experience with existing equipment and a comparison of the function of this equipment with the advantages of MAVIS. MAVIS can be triggered through all the usual environmental control inputs — microswitches, wobble sticks, suck/blow, and presumably radar, infrared and so on — and the problems of the patient–apparatus interface have been well researched. It is the varying levels of environmental control that MAVIS can achieve which is the major advance. The basic, four-programme MAVIS system contains an environmental control which is as complex as PSU3; it will do all the necessary opening and closing of doors, switching on and off of intercommunication devices, switching on and off of lights, television sets and radio sets that can be achieved by the PSU3. Because it functions through a television set it has what may be an advantage of being both a control device and the device controlled. In addition to this type of environmental control, MAVIS can be a shorthand communication device listing common requests which the disabled have to make many times a day and which it is tedious to have to spell out in full, such as 'I am thirsty' or 'I am uncomfortable'. The PSU3 telephone dialling system contains two retained numbers. It is possible for the MAVIS user to build up a large personal telephone directory, any of whose numbers can be dialled by MAVIS and this has obvious advantages for the person either with a large circle of friends or trying to work through MAVIS.

The text composing and editing functions of MAVIS have been mentioned in other parts of this report but it is worth emphasizing that the disabled find it just as boring to have to type every line of every letter as an able-bodied person would if he were not allowed to have headed notepaper, and the ability to retain parts of letters and to re-use them is a major advance.

The way forward for MAVIS seems to lie in a fairly simple modification of what already exists. It is my understanding that it would be possible to greatly reduce the cost of the present MAVIS by removing some of the circuit boards and the cassette memory, providing a simple, four-programme MAVIS containing the present unerasable part of the memory. The 'Type I' MAVIS would solve both communication and environmental control problems, as well as entertainment problems and would provide, for a cost lower than that of presently available equipment, a system which would solve problems which at present require at least two devices. It would then be possible to offer the cassette deck and additional circuit boards as optional extras either to be purchased privately or prescribed to a limited number of people requiring to use the full potential of MAVIS.

MAVIS presents a particular difficulty for the administrator in that it bridges and blurs the distinctions between health provision, education provision and employment provision in a way that no piece of environmental equipment has done so far. It would be tragic if the enormous opportunities for the severely disabled which this device presents were to be lost because MAVIS is too good and too potent, particularly in circumstances where it is no more, and possibly less, expensive than the cumbersome and outdated equipment which we are using at present.

Chapter 6

# OFF-THE-SHELF MICROCOMPUTER SYSTEMS AS AIDS

There are already many disabled people, both in this country and abroad, who are using microprocessor systems as aids. Most of these machines are used in employment, although there are increasing instances of children using personal microcomputers for schoolwork [Goldenberg 1979]. Some of the special schools for the severely disabled offer fairly extensive computing facilities to be used both as educational aids and as an encouragement to students to consider computing as a career.

The wide range of off-the-shelf, boxed microcomputer systems available makes the choice of the equipment difficult for those not familiar with the computer industry. Lack of information on systems and their facilities is causing difficulties for some of the government departments involved in providing aids for the disabled. However, the fact that the microcomputer will make a great difference to the general standard of life for the disabled is now well known.

In this chapter, the uses of the boxed microcomputer system are considered. Included are details on adaptations of equipment and where such systems can be particularly useful to a disabled person. The chapter serves as a contrast to the MAVIS system which is described in the preceding two chapters. Any reader who wants further information on microcomputer systems currently available is referred to the increasing number of journals available on general sale. Some of the best of these are Personal Computer World, Byte and Practical Computing.

## 6.1 THE BOXED MICROCOMPUTER AND ITS DISABLED USER

The boxed, off-the-shelf microcomputer system is most easily used by those disabled people who can use a conventional keyboard and have some experience either themselves or close at hand. Although it is always dangerous to generalize, personal computers are still basically produced for the person who either has plenty of time to sit and play and find out how it works, or for the person who has worked with computers before. The disabled user is no exception and perhaps if at home all the time is ideally placed for sitting and sorting out a computer.

The disabled person buys a system either for recreation or as an aid. Many of the small, cheap machines provide plenty of games and fun things to do, and also provide an easy way of writing the odd letter. For those who want the system as an aid as well as a toy, very careful selection of equipment is necessary, especially if a keyboard substitution is required.

Off-the-shelf microcomputers are currently in use by a number of different disabled people with a variety of disabilities. A boxed system can conveniently be used by a blind person as a filing system, intelligent typewriter and multiple copy device. The computer with a visual display can also assist a blind lecturer in preparation of material for a lecture and as a blackboard. When considering systems for blind people the specialized equipment already available must be considered as it could be more useful, for example, the VersaBraille. There are also severely physically disabled people using off-the-shelf systems for their day-to-day work, again as a convenient filing system and as an intelligent typewriter. For those who can use the system as it is and do not have to move it the application is ideal, but it can be expensive if all the optional extras are required. Use of a screen is always easier for a non-mobile person than dealing with paper, unless there is a sight problem. People with partial sight often find the screen-based equipment far easier than the large print typewriters that are available.

So, there are many disabled people who would benefit from the computer systems that are around at the present time. But don't just rush out and buy the cheapest or most readily available system; have a good look round and consider the differences that a microcomputer system might make compared with the specialized equipment that is also appearing. Remember that the microcomputer industry is booming and moving very quickly. Systems are becoming out of date faster than are the specialized aids. This is particularly true for the very cheap microcomputers where the market depends on up-to-date technology. Take advice, look at the available magazines and then sit back and enjoy the results, making sure there is enough experience around to make the machine useful. If a disabled person is to depend on a computer, ensure that a fast maintenance service is available and that the company involved understands that the user is disabled.

## 6.2 ADAPTING AN OFF-THE-SHELF MICROCOMPUTER SYSTEM

There is a lot of research going on now into ways in which the off-the-shelf systems can be adapted for use by different disabled people. The MATE terminal discussed in Chapter 2 is one of these research programmes which has now resulted in an available package. This, in effect, assists a slow typist to prepare material more quickly by offering word store. For those who can only just use a conventional keyboard, programs can easily be written to asist slow typing by providing words and phrases in common use at one keystroke. Software adaptations are, on the whole, reasonably easy to implement and can easily be developed to tailor aids for different users.

Modifications to the hardware, the actual equipment, are rather more difficult. There are people around who are using their microcomputers from switch inputs very successfully but, on the whole, this requires a degree of skill, especially if it is to be used away from home where safety regulations for equipment will apply. So as to enable a person who is unable to use a keyboard to have access to the computer, both a special software package is needed and a suitable switching device needs to be attached to the machine. To bolt on new equipment requires a certain understanding of the interfaces offered by the computer and how it 'talks' to its attached devices. Care must also be taken to ensure that the disabled person can use the equipment independently once the modifications have been made; for example, that there is enough backing store available and that exchangeable backing store can be operated.

Simpler adaptations may also be necessary, which may only need a good look at equipment available on the market so that part of the equipment can be bought from one company and part from another. It is often the case that the basic machine is suitable but its attached devices are not. For example, a visual display may be too small for someone to see easily, or the keyboard may be positioned in such a way that typing with a headstick or nose is impossible. If this is the case, looking around will almost certainly solve the problem.

## 6.3 TWO APPROACHES TO COMPUTER-BASED AIDS

Traditionally, aids have been built to assist with one particular difficulty for one group of disabled people. Although there have always been economic arguments for more generally useful aids, technology of the time has not offered a cost-effective solution. Microelectronics now makes it possible to build both aids that are useful to large groups of disabled people and more versatile and powerful specialized aids (see Chapters 2 and 4).

Aids based on microcomputers can be broadly classified into two groups:

(1) special-purpose equipment, and
(2) aids based on boxed microcomputers.

Some special-purpose aids based on microelectronics have already been considered in Chapter 2; see also Chapter 4 for more information on MAVIS. In the rest of this chapter, MAVIS — which was designed specifically to suit the needs of the disabled — is compared with a boxed microcomputer system. This comparison acts as a brief discussion of both types of system while also illustrating factors that have to be considered when choosing or designing aids.

## 6.4 THE ECONOMIC ARGUMENT

When comparing the cost of a MAVIS system with that of one of the cheaper boxed microcomputer systems, say a PET or APPLE, the former on face value looks the more expensive buy. For those who just wish to write the occasional letter and play a game or two the off-the-shelf system is almost certainly what is required. However, before deciding on the cheaper systems there are other considerations to be examined.

Many of the off-the-shelf systems, particularly the cheaper ones, have not been designed for extended use over a long period of time. The makers do not expect them to be moved regularly. Maintenance may be costly if a fast service is required. One also needs to look very carefully at what comes with the basic system and which modules are optional extras, some of which may be quite expensive. Easy-to-use instructions and manuals are also an essential part of a system if it is to be used as an aid, especially where the user may have poor communication skills and need assistance with the equipment. Many systems are geared to those people who either have or are wishing to gain some computer experience, with much computer jargon used in the instructions and within the system command language.

## 6.5 HARDWARE

The design of the hardware, or equipment components and boxes, plays a very large part in the assessment of the suitability of a particular aid. The aid may always be used in one place or may be transported between work and home. The equipment may also have to be operated in a certain way with special switches or an expanded keyboard; both need attaching to the computer. It is difficult to generalize, but some of the points to be considered are listed below.

MAVIS uses a normal television for its display. Colour is normally used, but a black-and-white set is perfectly adequate for many applications. The character size on a domestic television is normally sufficient, to some distance. Some boxed computer systems have a very small screen built into them which can be awkward to use from a distance. Other ergonomic features must also be considered, for example, easy-to-operate switches for power and system resetting.

Many disabled people, especially schoolchildren or students, use an aid for information handling during class and in a library environment. MAVIS can easily be carried, being mounted in one unit. Even more important, it operates silently.

Storage of a large amount of text is always a problem, especially when using a very small computer system. Many of the available microcomputer systems have a small amount of memory on their standard systems and offer a normal cassette as a bulk medium. Obviously, the memory capacity can be extended but this can be expensive if a large amount of store is required.

The cassette unit can cause reliability problems, and using an exchangeable medium requires a certain amount of manual dexterity on the part of the user. MAVIS has been purpose-built round this problem. A large store is offered on the system so that up to about 80 pages of text can be held at any one time. The cassette has been used purely for overnight storage or for exchange of material. This gives a severely disabled person a maximum amount of independence. MAVIS also holds all its essential programs and word processing system in a special protected memory so that the system is operational as soon as the power is switched on; no loading from cassette is required. On some of the more expensive off-the-shelf systems mini-floppy discs are used. These are very successful for someone who does not need to move a machine very often, but the disc drives are easily damaged in transit and require fan cooling, which can be noisy. Systems with a dual disc memory are rather more expensive and larger than MAVIS.

Finally, there is the question of operation, i.e. what keyboards are available or what switching devices can easily be attached. The computer industry uses a different standard for keyboard layout from that on the typewriter. For those people using a typewriter and a computer keyboard (especially if touch-typing) this can be confusing. The MAVIS keyboard has been specially designed so that it is compatible with a typewriter. It can easily be operated by those who use a head stick or nose; for such users, facilities have been incorporated so that the shift lock etc. can be operated by holding down only one key at a time. For switching devices such as a blow tube a wide range of interfaces has to be offered by the system so that they can be easily attached. Most systems require extra circuitry for this. MAVIS has these interfaces built in.

## 6.6 SOFTWARE

The most important part of any computer is the provision of reliable and useful software, or manufacturer-produced programs to drive the basic functions of the machine. Perhaps the most important part of the programs is their user interface, so that simple commands and instructions can be issued to the computer for performing tasks. For a disabled user who might find it difficult to constantly refer to manuals, an easy-to-learn command set is essential. As many boxed computers are built as toys for engineers or those technically qualified, there are many examples of poor design of a command language; these users are used to this fault in their day-to-day work. MAVIS has benefitted from research that has been carried out for many years at the NPL on the man–computer interface and has been designed so that its command language is simple, being based on words in the English language.

Care has also been taken with MAVIS to ensure that the main user facilities and programs cannot be lost or destroyed. The system is activated when the power is switched on and is then ready to use. Many of the off-the-shelf systems have their software stored on cassette or mini-floppy disc requiring a complex loading sequence before use.

One of the greatest disadvantages of the MAVIS system as compared with the marketed microcomputer systems is the lack of a high level language like BASIC. Although the system has been written so that new matrices and question-answering systems can be entered very easily using the existing structure, for use in education a BASIC system would be essential. MAVIS does have a high level language, PLUM, which was designed to be easy for children and teachers to use but this has not yet been tested by users. It is actually planned to put BASIC on to MAVIS at a later stage.

## 6.7 OVERALL CONSIDERATIONS

The following is a brief list of questions that should be asked about a machine which is to be purchased as an aid for a severely disabled person. Some brief comments have been inserted where appropriate.

### Is the need urgent or could development work on the aid be carried out by someone in the family?

In some cases where boxed computers have been purchased to aid a disabled person, there has been someone around who understands the workings of a machine and can write the necessary software or build interface hardware. If the time for doing alterations is quoted, always double this and expect bugs to occur and people to become bored.

### Is there a need for the system to be moved from work to home or to school or college?

Some systems are very difficult to carry or are packaged in more than one box. Care should be taken that if options are taken up on extra memory or a disc for storage that this does not come in an unexpected extra box.

### Is the aid to be used mainly as an information system and word processor?

Good specialized software is needed for these facilities; the provision of just a computer editor does not provide full word processing.

### Are Teletext and Prestel required?

Some of the public information systems provide a disabled person with a service which can normally only be found in newspapers.

Receivers for Teletext and Prestel are not normally attached to a boxed microcomputer. MAVIS uses Teletext already and can be easily fitted with Prestel (provision was made in the original specification).

### Is the system for a child?

Special care must be taken where a young child is to use the system as facilities such as tune generation and colour pictures are essential for motivation. A simple command language is also necessary.

AUTHOR'S NOTE: See Appendix 2: a short glossary of computer jargon which appears in the micro field.

Chapter 7

# COMPUTERS AS AIDS — PRESENT AND FUTURE

This book has discussed many aspects of computer-based aids, trying to act as an introduction to the subject from all angles. Pointers have been given to where information can be obtained and a list of useful addresses is included at the end of the book. As an introduction to the subject, it includes very little technical information, although some further details of the MAVIS system have been added in the Appendix; this is done as an example of the sort of components used in this type of system. This chapter tries to deal with the topic of computer-based aids more generally, introducing the subject of software control, getting an aid into production in this country, aids provision and some ideas on the future.

## 7.1 COMPUTERS AS AIDS

In Chapter 6 various comparisons were made between the 'off-the-shelf' computer system and those specially built, such as MAVIS. These show that three main areas must be studied if a computer is to be used as an aid:

(1) the hardware (actual equipment) must be conveniently packaged for the application,
(2) maintenance and training must be sufficient for the application, and
(3) the software must be carefully organized and built.

The first two of these have always had to be considered by aid builders, but the third is the most important and new as a concept.

### 7.1.1 Hardware packaging

Equipment built using microelectronics changes very rapidly. The size and portability of an aid will certainly be taken care of by natural developments during the next few years. However, the fast-changing technology causes problems to those making decisions about the provision of aids. Will a further piece of equipment have to be purchased in a very short period of time because the hardware is out of date?

The answer to this problem is NO. Like most people, the disabled, if satisfied with a piece of equipment, will not want change just so as to keep up with the latest packing and technology. However, some changes will certainly be welcomed by individuals. For example, if a person is dependent on an aid at work and at home and the equipment is not portable, technological change making that piece of equipment usable in two environments would make life a great deal easier. Many aid manufacturers, for example TSI (Chapter 2) with their Versa-Braille, are recognizing this problem and are using very advanced technology for their current products but, of course, this provides for the needs while causing the current cost to go up.

### 7.1.2 Maintenance and training

Maintenance and training have, again, always caused problems, with many people not using equipment because of the poor maintenance service. Again, this will be taken care of by developments in equipment technology, but using microelectronics immediately gets away from the electromechanical machines that are currently in use.

There are particular problems with maintaining equipment for the disabled. A person who has no job and spends most of his or her time using aids for recreation will be more demanding on servicing than the average person. Some problems might be simply that a switch has not been actuated or a socket not connected properly and a call will be made to an engineer unnecessarily. These problems can be partly solved by software and self-checking packages but reliable maintenance is still essential.

Obviously, aids of the future will be maintained using the board-exchange system. Once a reasonable system is set up and the cost of equipping it has been met, the problems could be solved for equipment based on microelectronics in a way that it has never been solved on a general basis, because microelectronics systems are intrinsically more reliable than electromechanical systems. At present, some companies offer excellent maintenance but others cannot. A proper service organization is bound to result from the increased use of computer technology in aids.

Training and assessment for computer-based and more general aids are currently being studied in more detail. Already with MAVIS a teach-yourself program has been developed and tried with success. These types of programs are also becoming available for other home computer systems as producing large manuals is very expensive; these, in the future, could well cost more than the equipment itself. So, many disabled people will be able, with possibly a short introduction, to teach themselves how to use the aid, although a follow-up service is frequently required so that exchange of uses and ideas can be achieved. In this way the disabled can use the powerful aids that are currently under development to their full potential. Follow-up training could be achieved in many ways; probably the most cost-effective would be through user groups and the existing voluntary organizations.

### 7.1.3 Software

Equipment that is driven by software or programs is a totally new concept for the disabled. On the software hangs the success or failure of a particular aid. At present, many individuals and organizations are producing programs for the disabled on home computers, but no list of these is being kept, no standards are set and, frequently, no maintenance is offered.

Although the hardware has to be reliable and the training sufficient, it is the software that dictates the whole design of a particular system. Programs can be moved from machine to machine with increasing ease and can be written in ways that are easy or difficult to change and maintain. Software cannot be effectively patented and can be easily stolen.

The MAVIS software is a good example to look at in more depth. During the trials many small faults in the code have been found and corrected by an expert. The programs could be moved to another machine which would then perform in the same way as MAVIS but would look different, but, as these programs have been written in the assembler for the processor that MAVIS uses, they are difficult to change and add to. When MAVIS was built there were such restraints on storage that there was no choice but to write the programs in assembler, and still there is no suitable high level language but, in the near future, these programs will have to be written in a more usable way so that developments in hardware and use can be more easily incorporated. A start has been made on this.

The mass of software, self-checking programs and teaching programs, as well as the applications programs, means that software maintenance and standards will have to be considered in the near future. This is a problem that has not been tackled by the aids providers in the past and, at present, its severity is not recognized by those in the aids field who have little experience of computers. In 1980 the Council for Educational Technology started looking at these problems for software used in schools and special education. Their proposals will be directly relevant to aids and will go a long way towards eliminating this problem.

## 7.2 GETTING AN AID PRODUCED

Experience with MAVIS has shown up some of the general problems associated with getting equipment for the disabled produced in this country. The computer-based aid has given another twist to this problem. Because people automatically assume that a computer is very complex, many aspects of aids are now being considered very seriously which were treated more casually before. For example, all equipment needs maintenance, but until now it was sufficient for a company just to offer maintenance of its products without stating how long it would take, what would be involved and without making allowance for all the problems that can occur. Maintenance, in many cases, has not been satisfactory so, for the new aids, a great deal of attention is being given to maintenance aspects. This leads to a new type of supplier who can not only provide a product but offer an effective service in the field.

In this country, money is available from many sources for research into aids. This leads to many projects in the universities being set up, and good 'one-off' equipment being developed as a result. At this stage, either the PhD student has completed the necessary work for a thesis or the project moves into a development stage which can be very far from pure research. Money for development and for evaluation trials is hard to find, as are the right kind of benevolent manufacturers who can support getting the development of an aid off the ground. Although the development stage of the work can be rather duller than the research, it is probably the most important stage, making the difference between a widely useful aid and one that is difficult to use, to obtain and to keep working. However, where computer-based equipment is concerned evaluation can cause problems if it takes too long to set up or to complete. Equipment needs to be used while the components are available and while a development engineering team is available to change both hardware and software components. Many useful substitutions of microchips can be made during a short and directed evaluation resulting in far better products. A three-year evaluation may be necessary for very specialized equipment, but for most aids a well funded, six-month trial, well documented, will bring out 99% of the problems and provide more than enough information for production.

In the UK we can learn a lesson from the USA here. American companies are very good at launching equipment before it is completely developed. Often they do this rather too early but it does mean that money is coming in from orders while the finer points of the equipment are being sorted out. The American method of launching products can be taken too far, but so can very lengthy, drawn out trials, especially where computers are concerned as this is a highly competitive area.

So what incentives are there for British companies to assist the disabled by producing aids? Looking at the subject coldly there are very few. The market is comparatively small, the development costs, education costs and maintenance costs are high and often there is no experience within the company about disability and its problems, thus making it very difficult to judge whether a particular aid is good or bad. On the other hand, Britain is a world leader in getting human factors associated with using machines right; it has many firsts, for example Teletext, that have not been fully exploited, and there is much equipment around that would have been highly suitable for the disabled given a little more thought when it was designed.

For the production and marketing of an aid a company needs to examine its motives and its approaches. The *right* company could really become a world leader, but poor marketing and rather too commercial attitudes can lead to early failure where patience would have brought rewards. The last two years have brought about a very informal but effective education programme in the government departments as regards computer-based aids, with the time being right for Britain, with its hard-pressed cash problems, to take its world lead again.

The *right* company could get a good aid out into a purchase trial situation very quickly. The key, in my opinion, to the whole area is imaginative marketing, with companies buying in experience in the area and looking carefully at every possible application for the product. With a little imagination a piece of specialized equipment can be used more widely or normal equipment can be made specialized. The disabled and the able have been separated by an unnecessary gap for too long. Why don't we use our human factors lead rather than let others bodge it?

Another convention that should possibly be eroded in the area of producing aids is that of 'one company, one aid'. Aids offer very good publicity for a company, worth money. Why not have various companies involved in the parts of an aid they are good at, share the small profits (or at least make it pay over the long term) and have all the names on the front of the box? This, again, perhaps does not bring much money to the companies involved but offers a very valuable service to the disabled. A conscience is not enough; a group approach, practicality and imagination might just do it.

## 7.3 AIDS PROVISION

At present, aids are either bought by individuals or provided by government or local authority funding. The move towards microcomputers as aids is causing headaches to cost-conscious departments. For these departments there is the problem of not knowing what the equipment is, and yet knowing that technology is changing very quickly. Up to the present time, equipment for individuals was mainly purpose-built, but now varied and often unadapted equipment is being requested. Home computer equipment comes at a wide range of prices, and those not familiar with the technology find it difficult to understand the differences between specially built equipment (like MAVIS) and off-the-shelf equipment. No performance figures are available for computer systems used as aids — a rather different application from the most common consumer use of microprocessors, as professional toys.

Aids are, at present, normally purchased for one particular reason, for example, as an aid to employment for a person who is working. Many of the computer systems, particularly MAVIS, could be used at work or at home for totally different applications. This means that the aid often falls within the purchasing power of two or more departments, causing more difficulties. Several departments have been involved as watchdogs in the MAVIS evaluation work and these problems have arisen in discussions with them.

Difficulties are not limited to lack of knowledge of the equipment. Usually the computer system is more expensive than other, single-purpose, aids. Users will not be quite sure what can be done with the system until they receive it. Savings are therefore difficult to estimate, especially where they take the form of a reduction in the time of care staff who might be paid by a department different from that purchasing the aid.

From the point of view of the users a whole new set of aids is emerging, which they think they would like, and for many a great benefit would certainly be obtained. However, the system of supply is not set up to deal with the changing technology and it will be some years before the necessary changes take place, especially with the UK economy in its present state.

State aids provision varies widely throughout the world and it is not necessarily dependent on the wealth of the country but on its attitude. Countries like Sweden have very good aids provision services, whereas in the USA much of the provision varies from state to state. In Britain it is a subject that is now under review but is currently patchy.

Aids for health are handled by the Health Service. This sounds as though most aids would be provided this way but there are very stringent rules meaning that, with the exception of glasses and hearing aids, few aids are provided through this source. Basically, aids other than direct health equipment are provided if they enable someone to manage at home when otherwise they would need to be in hospital or health care. This is not a simple ruling but tends to be provision of environmental control equipment and some typewriters to those who cannot move, cannot work and, for a typewriter, cannot communicate. The provision is slightly broader than this but the Department of Health is not the main provider of aids as it has very little purchasing power.

Where a disabled person is employed, then the Department of Employment meets the requirements of both aids and alterations to buildings. This is probably the largest state provision programme and covers a wide range of equipment from simple devices to computer assistance. The scheme also offers some assistance for blind people needing readers, and travel to work. However, to qualify for an aid under this scheme a disabled person has to be employed and here there is often a problem. As aids become more widely useful many disabled people might well find that they can either take on full-time or part-time employment given a particular piece of equipment. Usually, it is not possible to provide equipment unless the person is in full-time employment, so no practice or assessment with the aid is possible. Aids under this scheme are only given for work use and may well be withdrawn if a person stops work for any reason. This fact can be a problem, particularly for women who leave work to start a family, returning when the domestic situation is controlled.

Schoolchildren often have use of school aids; these are provided through various sources, a few through the Department of Education and Science. It is for severely disabled children that the computer-based aid is most useful as it allows easy change and offers more and more facilities as the child progresses. Often, voluntary organizations and charitable donations are used for providing personal aids for disabled children, otherwise it is another expense for the parents.

There is some provision of aids through the local authorities. This varies greatly throughout the country depending on how the social services department of the local government office is allowed to operate. Much of this provision is for small items and phones but many aids have been purchased through the local authority. This service helps to bridge the gap where the other departments cannot provide equipment.

## 7.4 MAVIS—THE NEXT INSTALMENT OF THE STORY

After all the discussions on MAVIS in Chapters 4 and 5 and the general points that the work has raised, somehow it seems that the story has not been completed. MAVIS is still in use by both sites, who put up with cassette trouble frustration and try to extend their work. The cassette unit has been the one part of the equipment that has functioned very poorly, causing much frustration and annoyance.

When working with children as severely disabled as Joanne, one is always trying to increase the motivation of the child to do things that are often very difficult and tiring. Joanne is now gaining confidence with her MAVIS system but has had many problems. Those involved in running the project have spent more time in making suitable input switches for Joanne than providing her with school material. When building inputs for children, motivation is the key problem. One is looking for things that appeal to the child and make the difficult development of movement fun. Colour appealed to Joanne so coloured fablon was used to cover the board of her aid, while soft, coloured pads were put at the end of the wiper-like switches. Getting the switch strength and angle of movements right is another problem. Her current input is shown in Fig. 7.1, giving an idea of what has to be done before a child can be expected to use a system regularly. Joanne has now had five inputs built and it is something that will have to be kept under review. For Joanne, some work on controlling toys through the environmental control is about to start. Again, this is really a motivational exercise but also works to improve her quality of life by giving her control over movement.

Banstead Place still has its unit available and the staff are currently proposing further classroom work and, perhaps, some environmental control testing. As staff leave and new people take over, there is a need to keep in touch with the sites and occasionally offer further training in using the equipment.

Production of MAVIS has suffered many problems and is certainly affected by the general economic decline. The results from various efforts to get the equipment into production are invaluable, with production possibilities using a large British electronics company looking very possible. There is no better way than

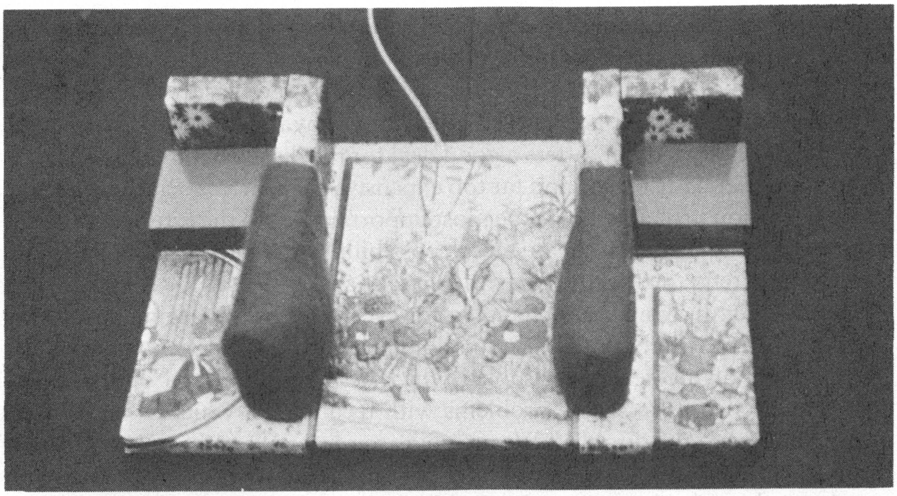


**Figure 7.1: Joanne's latest input.** Blue and yellow soft pads at the end of wooden 'wipers', and between them a picture of Peter Rabbit. Joanne puts her hand between the pads and is just able to control enough sideways movement to move them, activating microswitches and enabling her to use the matrix selection.

getting a number of systems purchased and into regular use to find faults and get them sorted out. Trials have basically proved the system to be very useful and sound, with the exception of the cassette system, which is being examined at present.

## 7.5 A BRIEF LOOK AT THE FUTURE

This book has tried to give an accurate picture of the infancy of microcomputer-based aids. It is intended to serve as an introduction to changing technology, changing attitudes, new ideas about aid-building and the new types of skills that disabled people of the future will need to acquire, preferably early in life. With technology that is changing very fast it is difficult to predict the future except to say that it is probably brighter than it has ever been, provided that the correct beginnings are made now. This really means a vast and factual information and education programme being carried out to ensure that decision makers are in full possession of the facts, and that disabled people and their parents know, and are realistic about, the techniques and skills that are needed; in fact that people generally become less in awe of computers.

The future of aids was briefly discussed at the end of Chapter 2. Certainly, technology is moving very quickly towards more integration, especially as companies making new products are made aware of human factors associated with the disabled. Looking round the High Street there are already computer shops and television rental shops. The home television is probably the best and most general aid which has not yet been fully exploited by the disabled. Many people with severe disabilities find television one of their few leisure activities, but services such as Teletext are not yet widely in use by the disabled. Prestel also, when it is fully sorted out, offers a good deal for the disabled, but at present it is far too commercially biased and far too expensive for general social benefit. The home television probably holds the most important key to the future in that this country is unique in its cheap rental possibilities and many companies are looking to extend the facilities over the three channels in use.

Trends in employment are changing for everyone. At the beginning of May 1981 the Manpower Services Commission published a discussion paper on the employment of the severely disabled which was very bleak in outlook. The able-bodied also have severe problems with technology, which at least offers improvements to the disabled. We are going to see a time in the not-too-distant future where leisure plays a far greater part in life than it has ever done, with people working far fewer hours, possibly from home. For the disabled person, working from home would be a great advantage, but it is now that leisure and the improvement of life need to be looked at carefully. It is no good having disabled people working if they are then totally cut off from the world outside and have nothing else to do.

Appendix 1

# TECHNICAL DETAILS OF THE MAVIS SYSTEM

## A.1 DESCRIPTION OF THE EQUIPMENT

MAVIS consists basically of five plug-in printed circuit boards, a power supply, a mini-cassette recorder, removeable typewriter-type keyboard and a small loudspeaker, all housed in a lightweight cardframe. The whole assembly is fitted inside a suitcase measuring 17 in × 16 in × 6 in, weighing approximately 20 lb when loaded. Peripheral equipment such as television, printers, suck-puff etc. are connected to MAVIS via plugs and sockets situated on an interconnection panel revealed when the suitcase lid is opened. The printed circuit cards are:

(1) microcomputer card,
(2) keyboard and cassette interface,
(3) Teletext and audio output,
(4) input/output isolation, and
(5) bulk memory.

Brief details of the cards are included here. Further specifications of cards 1 and 4 are given below.

### A.1.1 Microcomputer card

| | |
|---|---|
| CPU | Z80. |
| Clock | 2.308 MHz single phase, derived from an 18.464 MHz crystal. |
| Memory | 14K bytes of EPROM in 2K blocks, 4K or 16K bytes of dynamic RAM, } Expandable externally to 62K total.<br>64 × 4 bits of MNOS non-volatile read/write memory. |
| I/O | Four 8-bit programmable I/O ports,<br>Two programmable full duplex serial I/O ports,<br>Four programmable timer/counter channels, |

| | |
|---|---|
| | Memory mapped I/O can be added externally up to 512 total ports. |
| Interrupts | 1 non-maskable interrupt,<br>1 maskable interrupt, organized with a daisy-chain priority structure. |
| DMA | The address, data and control buses are tri-state, to allow a DMA facility and multi-processor operation. |

The Z80 has a repertoire of 158 instructions including all 78 of the 8080A instructions. These include memory to memory block transfer and search, bit manipulation, and 16-bit arithmetic. It has 22 internal registers, including two 16-bit index registers. Three modes of interrupt response are possible using the maskable interrupt input.

### A.1.2 Keyboard/cassette interface card

The keyboard/cassette board interfaces to the CPU via a PIO device and enables data to be entered from a keyboard or transferred to and from a digital cassette unit. The address decade, bus control and interrupt logic associated with the PIO is included on the board, allowing full use of the PIO's potential.

| | |
|---|---|
| Keyboard interface | The keyboard interface utilizes one of the ports of the PIO and has been designed to accept an 8-bit parallel input with handshake lines. The PIO is buffered from the keyboard, enabling input levels from +5 V to +18 V to be used. |
| Cassette interface | The remaining 8-bit port of the PIO is used to control the movement of the cassette and receive its status indications. Data is transferred to the cassette from the SIO on the CPU board. The data transmitted by this SIO is in NRZ format and is phase encoded by the logic on the keyboard/cassette board before being written on to the cassette. Data being read from the cassette in phase encoded form is converted by additional logic back into NRZ format before being presented to the SIO on the CPU board. A clock is provided with the outgoing data to ensure error-free data transfer. The data handling section of the board has been designed using CMOS integrated circuitry, with its inherent high noise immunity, so that any of the presently available 'phase encoded' digital cassette recorders may be used. |

### A.1.3 Teletext/audio output card

This card contains two independent circuits (ICs) one being a tone generator and audio amplifier, the other providing the interface between the microprocessor and the television. This interface consists basically of two integrated circuits from the Mullard teletex integrated circuit set plus a 1K × 8-bit static RAM. The television is capable of displaying a maximum number of 960 characters which are ranged into 40 rows × 24 columns, the 1K RAM providing a means of storing a screenful of information.

The two Teletext ICs are called 'TIC' and 'TROM'. TIC generates all the timing pulses necessary to produce a stable television picture, whilst TROM is a character generator producing red, green and blue video signals to drive the television display.

The interface between the CPU and RAM has been designed so that the microprocessor is capable of reading or writing to the simple graphics in any one of six colours.

The audio side of the card consists of a programmable square wave generator, which feeds an analogue switch IC. Output from the analogue switches feeds into a programmable volume control IC which drives the modulator.

### A.1.4 Input/output isolation card

This card has been designed to interface with the two PIO chips on the micro-computer card and provides 16 opto-isolated inputs and 16 opto-isolated outputs complete with handshake lines. Its purpose is to isolate peripheral equipment such as mains controllers and puff–suck-type inputs.

### A.1.5 Bulk memory card

This consists of 64K of Dynamic RAM, in two 32K blocks which are bank-switched by the CPU.

## A.2 SUMMARY OF THE MAVIS COMMANDS

This section provides an overview of the MAVIS software by giving details of the commands that can be used. A large part of the flexibility of MAVIS depends on the ability to add commands by writing programs which can be loaded from bulk store: some examples of these are given at the end of the section. These new commands can be introduced into matrices, and can be programmed without any need to know or use the Z80 assembly code.

If entered from the keyboard, all commands must be preceded by 'escape' and terminated with 'new line'. Below «n» and «m» represent numbers. Capital letters show the minimal abbreviations of the commands that are accepted by the system. Commands can also be activated by selecting the appropriate element from a matrix. A set of basic matrices is held by the system (in ROM); other matrices can be constructed, as text files, as required.

### A.2.1 Tape commands

| | |
|---|---|
| FORMat | prepares a new tape for reception of information. |
| TAPe index | displays a list of the files on the cassette currently in the system. |
| RECall «filename» | transfers the named file from tape into memory. If the file is other than text the type of file should be inserted after the filename, e.g. PLAY/C, GAMES/C. |
| SAve<br>SAve «filename» | records the current file on to tape so it can be recalled as necessary. If a filename is included in the instruction the designated file will be recorded despite not being currently displayed. |
| UNSave<br>UNSave «filename» | erases the current file from tape, providing a 'Y' for 'yes' is entered in response to the question 'are you sure?' If a filename is specified, the appropriate file will be erased. |

### A.2.2 File commands

| | |
|---|---|
| INDex | displays a list of the files in memory.<br>Against each file is an abbreviation of its type:<br>P private: the titles of these files are not displayed;<br>L locked: these files are available, but the information contained is locked and cannot be amended until the password is entered;<br>T text: otherwise specified;<br>C command: this is a program file. It cannot be displayed. It is used to add commands to the system. |
| EDit «filename» | displays the first page of the named file or creates a new file if the filename is not found in memory. |
| DELete «filename» | deletes the relevant file from memory. |
| Title «text» | heads the current page with the text specified. |
| CONtents | lists the pages of the current file, together with their titles if these have been given. |
| Page «n» | displays page «n» of the current file. If «n» is zero, page 1 will be displayed. |
| Forward «n» | moves forward «n» pages and displays this page. |
| Back «n» | moves back «n»pages. |

| | |
|---|---|
| Insert «n»Pages | inserts «n» pages after the current page and renumbers the following pages. The first inserted page is then displayed. |
| Erase «n» Pages | the current page and «n − 1» succeeding pages are erased. The remaining pages are renumbered and the new current page displayed. |
| Insert «n» Lines | inserts the specified number of lines at the current cursor position. |
| Erase «n» Lines | erases the specified number of lines including the one to the right of the cursor. The remaining text is moved up. |
| Insert «n» SPaces | inserts a specified number of spaces after the current cursor position. |
| Erase «n» Characters | erases a specified number of characters. These include the character the cursor is on and the appropriate ones to the right of it. |
| SEArch «text» | search the file from the current cursor position to the last page for a specified word or group of words. When the text is found the appropriate page is displayed with the cursor positioned immediately after the text. |
| Repeat | repeats the previous search. |
| SPLit | divides the displayed page in two at the current cursor position. The character the cursor is on and all following characters are placed in the same position on the succeeding page. |
| Join «n» | the text on the next page is joined beneath that on the displayed page and the next page is deleted. If «n» >1 then an attempt is made to join the text of «n» number of pages beneath that of the current page. |
| Add «n»–«m» «filename» | Add pages «n»–«m» of the specified file after the current page. The remaining pages will be renumbered and the last of the added pages displayed. |
| MFile «filename» | will change the matrix arrangement on the screen to the first arrangement in the file named. |
| MFile | will close the matrix file and the matrix arrangement on the screen will return to the default matrix. |
| LOCK «filename» | the file cannot be altered or deleted. |
| UNLOCK «filename» | allows the file to be edited again. |

### A.2.3 Drawing pictures

DRAW — causes the system to enter the drawing mode. A drawing or graphics cursor is now positioned in the centre of the screen. To move it across, diagonally or up and down the screen the following selections should be made.

- D — If D (Draw) is preselected, each subsequent move will leave a line on the screen.
- E — If E (Erase) is preselected the cursor will erase any lines passed through.
- M — Selections after M (Move) allow the cursor to be moved without drawing or erasing.
- F — (Fill). Any area within a previously drawn *closed* boundary can be filled. The cursor must be positioned within that boundary before F is selected. If the drawing cursor is not within a closed boundary the exterior region of the screen will be filled.
- S1–9 — This determines the size of the steps the cursor takes at each selection.
- Colours — These are selected on the graphics matrix or from the colour keys on the keyboard.

### A.2.4 Examples of commands loaded from files

PLAY — used for playing tunes. Providing the file PLAY/C has previously been loaded from tape this instruction will cause each subsequent character from the current cursor position to be output as a corresponding audio tone.

COPY — used to print output. Providing the file COPY/C has previously been loaded from tape and a printer is connected to the system, this instruction will cause a copy of the current contents of the screen to be produced.

DIAL «n» or DIAL<br>PHONE<br>BYE — these commands are associated with making, answering and clearing a telephone call. A directory of numbers can be made as a file, so the user can make calls without needing to dial the numbers. The file DIREC/C must have been loaded when using the phone commands.

Other examples are the various games (Hangman, Simon, Target, Patience) which have been packaged as a GAMES command.

### A.2.5 Use of larger matrices

Where a bigger choice is required, an 18-line matrix can be used, by switching the matrix and text areas on the screen. An example where this has been used is for making phone calls from a directory built up by the individual user. This way a call can be made by selecting the person to be called on a large matrix. The program DIREC/C has been developed to make setting up and using the directory as easy as possible, as mentioned above.

## A.3 THE PROGRAMMING LANGUAGE 'PLUM'

PLUM, Programming Language for Users of MAVIS, is a high-level language designed to take full advantage of the facilities provided by MAVIS. It incorporates the features normally found in an integer BASIC, and includes powerful string handling. Structured programming is encouraged by the provision of IF, FOR and WHILE loops and true subroutines with local variables.

PLUM programs are compiled to a compact intermediate code. This enables fast execution of comparatively large programs. Here is a simple program:

```
START: SHOW "TYPE 2 NUMBERS"
       INPUT B,C
       A=B+C; SHOW "TOTAL=",A !
       GOTO START
       END
```

SHOW is the routine to output to the screen. Output can also be to a file or to a printer, and corresponding input routines exist. There are facilities to assist in writing interactive screen-based programs, for example, to address particular positions on the screen, and to test whether input has been generated by the user.

More complicated programs can include user-defined FUNCTIONS used as subroutines. Labels, variables and functions have names. Names start with a letter optionally followed by between one and five further letters or numbers.

All arithmetic in PLUM is carried out on integers in the range −32768 to +32767. PLUM will not accept larger numbers or decimal points.

PLUM can use the full Teletext character set. This consists of:

(1) upper case letters A to Z,
(2) lower case letters a to z (only valid in strings and comments),
(3) digits 0 to 9,
(4) special characters, e.g. + − = " !;, and
(5) graphic control characters (only valid in strings and comments).

Strings can be held as constants, read into or printed out from variables, or manipulated within the program. String variables each contain between 0 and

40 characters. There is no limit to the length of string constants or expressions. There are two types of string expression. The + operator is used to add strings together, for example:

STR(7)+"more text"

The = operator is used to compare two strings and produces a relational expression used in the IF and WHILE statements, for example:

IF STR(7)="YES" DO FRED

Appendix 2

# GLOSSARY OF COMPUTING TERMS

This glossary gives the common meaning of some of the technical terms used in computing, based on enquiries that have been received from people buying microcomputer systems for use by the disabled. The list is not complete, but should help when reading the computing magazines.

| | |
|---|---|
| BACKING STORE | The memory of the computer itself will only hold programs and data required for immediate use. Backing store can be used to hold much more information which can be called on by the computer as required. It is usually disc or cassette. |
| BASIC | A very commonly used language for writing programs. BASIC is a fairly simple language to learn and use and is widely available. |
| BYTE | Normally one character-sized piece of memory (for example, each letter or digit of a piece of text will need one byte of memory to hold it). Characters are stored in eight BITs of memory where a BIT is a two-state item of memory. So a 64K byte memory means that the machine is capable of holding around 64 000 characters, including the system housekeeping programs. |
| CASSETTE and CARTRIDGE | These are very similar to the cassettes used for audio recording, and in some cases high-quality audio cassettes can be used, though special data cassettes are made. They provide a cheaper but slower alternative to a floppy disc. |
| COBOL | A commonly used programming language for commercial applications. It is less easy to learn than BASIC but offers easier manipulation of files and commercial records. |
| CP/M | This is the name of one of the commonest programs which does all the housekeeping, collecting text from terminals, storing it in free memory, |

filing on disc, removing unwanted material from memory etc. This type of program, which is always needed for a general-purpose computer system, is called an Operating System. Readers will find that much advertised software says 'CP/M compatible' which means that it can run on a machine which has CP/M as its operating system. If software is to be bought from a number of sources, make sure that it can run on the particular operating system offered or that a common package like CP/M can be bought and used.

CPU — Central Processing Unit. Usually a chip number such as 8085 or Z80 will be given if this term is associated with a microcomputer system. The number of the chip tells those with experience what computing power the system will have and what circuitry can be attached. Most boxed microcomputer systems are not used to their full processor capacity in the uses for the disabled, so the CPU chip is not too important unless many peripheral devices are to be attached and used together.

CURRENT LOOP INTERFACE — This permits the use of relatively long cables between equipment. It is usually an RS232 interface.

FLOPPY DISC — This is a slightly flexible disc either five or eight inches in diameter, used as backing store. Discs are loaded into disc drives for use, but can also easily be stored or sent through the post. However, exchange of information between users of different machines may not be possible because different formats and recording densities are used. A typical disc would hold from 125 000 to 512 000 bytes of information.

GRAPHICS — Picture-drawing facilities, either for lines or for shades of grey or colours.

HARD DISC — This is a kind of disc that is normally built into the machine and which is not exchangeable. It provides more store than a floppy disc and is faster in use, and therefore suitable for multi-user and other large systems. It tends to be expensive. Sometimes called a Winchester disc.

HARD AND SOFT SECTORED DISCS — Different discs are required for these two recording techniques and this is predetermined for any particular machine. Hard sectoring means that there are already fixed areas set out where the computer writes material, and soft sectoring means that the computer must first 'format' the disc before it can be used.

HARDWARE — The box, boards and physical equipment generally that make up a computer and its peripheral devices.

MEMORY — This is the internal storage of the system used for holding programs and their immediate data during execution. Remember when assessing memory size that the 'housekeeping' programs for the machine will take up space, so not all is available for the user's programs. Memory is measured in K, which in this application means 1000 or 1024 bytes.

OS, OPERATING SYSTEM — The housekeeping system present in all general-purpose microcomputer systems.

PARALLEL INTERFACE — A fast interface suitable for high speed devices (e.g. fast printers), which sends data along a number of wires at once. (Serial interfaces such as V24 or RS232 send the data bit by bit). Parallel interfaces are also easier to use with home-made or special equipment because the wiring is simpler.

PASCAL — A programming language that is becoming more available on microcomputer systems. This language is general-purpose but not so easy to learn and use as BASIC. It has not been designed with any particular application area in mind.

PROM — Programmable Read Only Memory. This is a form of ROM which, like all ROMS, has the advantage that the contents cannot be destroyed accidentally. However, the chip can be programmed or reprogrammed using special equipment. It is normally used by the manufacturer for smaller-scale production than ROM.

RAM — Random Access Memory. This memory can be read from or written into. RAM is usually volatile, i.e. all material stored in it will be lost when the power is switched off. RAM may be quoted in dynamic and static forms. For the average user this is irrelevant.

ROM — Read Only Memory. This memory is supplied by the manufacturer and usually holds system software, though not all systems software is in ROM. Its advantages are that information in it cannot be destroyed, and it is cheaper than RAM, provided the manufacturer orders in large enough quantities, therefore it is commonest in high volume products like pocket calculators. It cannot be used for users' own programs.

SOFTWARE — The programs that run on a particular computer.

UHF INTERFACE — This allows a computer to be directly connected to the aerial socket of a TV set, which is used as its terminal. Some of the cheaper computers offer this, which can be very sucessful.

V24 (or RS232) INTERFACE — This is a complex standard interface, widely used throughout the computer industry. It allows a system to be extended by plugging in devices such as a VDU. Nearly all manufacturers of equipment offer this interface so that a computer which has it can easily talk to equipment of other manufacturers.

VDU — Visual Display Unit, sometimes called a CRT (Cathode Ray Tube) by American manufacturers. This is a screen-based terminal, normally together with a keyboard. Some computer systems are mounted entirely within the VDU housing. VDUs come at a wide range of prices, with differing sizes and clarity.

Appendix 3

# USEFUL ADDRESSES

## AIDS

Bliss: Bliss and Blissymbolics are copyright C. K. Bliss and Blissymbolics Communication Institute, Toronto, Canada. Information in the UK can be obtained from:
Blissymbolics Communication Resource Centre, UK,
South Glamorgan Institute of Higher Education,
Western Avenue, Llandaff, Cardiff.

(Optacon, Speech+, Autocom)
TSI (Telesensory Systems Inc.),
3408 Hillview Avenue, PO Box 10099,
Palo Alto, California 94394, USA.
UK address: Mr John Tillisch,
Telesensory Systems Inc.,
PO Box 286, London W4 4EN.

(Canon Communicator)
Canon Business Machines,
Sunley House, Bedford Park, Croydon, Surrey.

(Reading machine for the blind)
Kurzweil Computer Products,
33 Cambridge Parkway,
Cambridge, Massachusetts 02142, USA.

(SPLINK)
Medelec Ltd,
Manor Way, Old Woking, Surrey GU22 9JU.

(MATE)
Mr B. Wilby, Computer Manager,
University of Essex, Wivenhoe Park,
nr Colchester, Essex.

## ORGANIZATIONS FOR THE BLIND

*International organizations*

World Council for the Welfare of the Blind,
58 Avenue Bosquet,
75007 Paris, France.

*Australia*

Australian National Council of and for the Blind,
PO Box 162,
Kew,
Victoria 3101.

*Canada*

Canadian National Institute for the Blind,
1929 Bayview Avenue,
Toronto,
Ontario M4G 3E8.

*France*

Fondation pour la Réadaptation des Déficients Visuels,
3 Rue Lyautey,
75016 Paris.

*Germany (Federal Republic)*

Deutsches Blindenstudienanstalt,
Am Schlag 8,
D-3550 Marburg.

*Ghana*

Ghana Society for the Blind,
PO Box 3065,
Accra.

*Hong Kong*

Hong Kong Society for the Blind,
33 Granville Road,
Kowloon.

*Indonesia*

Indonesian Federation for the Welfare of the Blind,
Kadipaten Wetan Kp 1/101,
Jogjakarta.

*Israel*

Centre for the Blind in Israel,
28 Bialik Street,
PO Box 4427,
Tel Aviv.

*Japan*

National Association for the Welfare of the Blind in Japan,
c/o National Tokyo Rehabilitation Centre for the Blind,
34–18, Umesato 2-chome,
Suginami-ku,
Tokyo 166.

*Kenya*

Kenya Society for the Blind,
PO Box 46656,
Nairobi.

*Malaysia*

Malaysian Association for the Blind,
PO Box 687,
Kuala Lumpur.

*Netherlands*

Vereniging het Nederlandse Blindenwezen,
Kipstraat 54,
3011 RT Rotterdam.

*New Zealand*

New Zealand Association of the Blind and Partially Blind, Inc.,
3 Lauriston Avenue,
Remeura,
Auckland 5.

Royal New Zealand Foundation for the Blind,
545 Parnell Road,
Private Bag,
Newmarket,
Auckland 1.

*Norway*

Norges Blindeforbund,
Sporveisgate 10,
Oslo 3.

*Saudi Arabia*

Middle Eastern Bureau for the Welfare of the Blind,
Imam Abdul Aziz bin Mohammed Street,
PO Box 3465,
Riyadh.

*Singapore*

Singapore Association for the Blind,
47 Tao Payoh Rise,
Singapore 11.

*South Africa*

South African National Council for the Blind,
1st Floor,
NOSA Building,
508 Proes Street,
Arcadia,
Pretoria 0007.

*Sweden*

Synskadades Riksforbund,
S-122 88 Enskede.

*United Kingdom*

Royal National Institute for the Blind,
224–226 Great Portland Street,
London W1N 6AA.

*United States of America*

American Foundation for the Blind,
15 West 16th Street,
New York,
NY 10011.

APPENDIX 3

## ORGANIZATIONS FOR THE DISABLED

*International organizations*

United Nations Secretariat,
Rehabilitation Unit for the Disabled,
New York,
NY 10017, USA.

*Australia*

Technical Aid to the Disabled,
PO Box 108,
Ryde,
New South Wales 2112.

*Canada*

Canadian Rehabilitation for the Disabled,
Suite 2110,
1 Yonge Street,
Toronto,
Ontario M5E 1E5.

*Sweden*

Handicappinstituten
(Swedish Institute for the Handicapped),
Fack,
S-161 25 Bromma.

*United Kingdom*

Banstead Place Assessment Centre,
Park Road,
Banstead,
Surrey.

Disabled Living Foundation,
346 Kensington High Street,
London W8.

Newcastle Aids Centre,
MEA House,
Ellison Place,
Newcastle upon Tyne.

Mary Marlborough Lodge (for deafness),
Nuffield Orthopaedic Centre,
Headington,
Oxford.

Royal National Institute for the Deaf,
105 Gower Street,
London WC1.

Royal Society for Disability and Rehabilitation (RADAR),
25 Mortimer Street,
London W1N 8AB.

Spastics Society,
12 Park Crescent,
London W1N 4EQ.

*United States of America*

Muscular Dystrophy Association,
810 Seventh Avenue,
New York,
NY 10019.

Rehabilitation International,
432 Park Avenue S.,
New York,
NY 10016.

University Center for International Rehabilitation,
D-201 West Fee Hall,
Michigan State University,
East Lansing,
MI 48824.

Veterans Administration
(has a programme supporting Rehabilitative Engineering Research and Development, and also publishes the *Bulletin of Prosthetics Research*),
Office of Technology Transfer,
Veterans Administration,
252 Seventh Avenue,
New York,
NY 10001.

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# INDEX

Julia M. Schofield

**MICROCOMPUTER-BASED AIDS FOR THE DISABLED is a unique book. Written by Julia Schofield, who has been blind since birth, this is one of the first books to explore the potentials of computer-controlled equipment for the disabled. Drawing upon the research done for her PhD thesis and her experience as a Microcomputer Consultant, specializing in adaptions for the handicapped, the author demonstrates that the new technology offers the severely disabled the possibility of doing the everyday tasks that the rest of us take for granted.**

**As well as examining experimental work in the field, Julia Schofield evaluates currently available aids, paying particular attention to MAVIS (Microprocessor-driven Audio/Visual Information System) which she helped to develop. Being disabled herself, she is able to bring a special understanding to the future recommendations she makes for computer aids aimed at a variety of physical handicaps.**

**As well as being of general interest, MICROCOMPUTER-BASED AIDS FOR THE DISABLED is aimed at those concerned with psychology, medicine and nursing; biomedical engineering; health and social sciences; teaching and special education; personnel management and computer science applications.**

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