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THE DEVELOPMENT OF AN INTERACTIVE VIDEODISC SYSTEM

by  
Ian Bruce Jones

Thesis submitted for the  
Degree of Master of Science at the  
University of Glasgow, October 1988.

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## ABSTRACT

The thesis traces the development of interactive videodisc from origins based on early automatic machines through large-scale computer assisted learning (CAL) to microcomputer-based multi-media CAL.

A comprehensive discussion of the interactive videodisc medium is provided, in terms of its features, advantages, problems, authoring and production processes, and educational applications.

The requirements for interactive systems, and essential elements of video and videodisc technology are described.

A relatively low-cost demonstration interactive videodisc system is developed in three phases, based on a BBC 'B' microcomputer and a Pioneer LD1100 videodisc player.

In the first phase, software interfacing routines are developed in assembly language to control the player from the versatile interface adaptor (VIA) of the BBC micro. The signal control codes are based on a pulse code modulated format with uni-directional synchronous transmission. The interfacing routines are linked to, and driven by, a Basic program which provides full manual control of all player functions using the microcomputer keyboard.

In the second phase, the interfacing routines are further extended to provide control linkage for interactive video application programs. Using a pilot videodisc, these Basic programs demonstrate interactive video techniques, including still frame access and the presentation of video sequences and sub-sequences.

In the third phase, the application programs are converted to the authoring language, Microtext. The assembly language interfacing routines are developed into a corresponding Microtext extension command module. A mixer/genlock unit is used to provide graphics overlay of video still frames.

An evaluation of the demonstration system is provided, in terms of developmental difficulties, its hardware and software features and capabilities, and its potential as a base for further suggested research work.

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#### REFERENCES

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## 1. INTRODUCTION

Teaching has always been, and perhaps always will be, a potentially inefficient process. Skinner(1961) has asserted that 'holding students together for instructional purposes in a class is probably the greatest source of inefficiency in education'. In trying to teach more than one student at a time, both fast and slow learners can be harmed.

Several early researchers developed teaching machines which, by assuming the role of 'teacher', allowed students to learn at their own pace. The first teaching machine is credited to Sidney Pressey, who developed a typewriter-based device which presented multiple-choice questions to the student [Pressey(1926)]. Pressey's concept of automatic individualised learning and immediate feedback was further extended by Skinner(1958). Skinner's contribution to interactive technology included the development of mechanical teaching machines which were 'unusually efficient because (1) the student is frequently and immediately reinforced, (2) he is free to move at his natural rate, and (3) he follows a coherent sequence' [Skinner(1961)]. These machines used 'programmed instruction', which involved the presentation of discrete units of information to the student, followed by 'fill-in-the-blank' questions. Crowder(1960) combined Skinner's and Pressey's work to create branched programmed tests, using the technique of 'automatic tutoring by intrinsic programming'. Crowder's work was the forerunner of computer assisted instruction (CAI).

The first CAI system is accredited to Rath, Uttal and Anderson [Rath et al(1959), Uttal(1962)], which linked an IBM computer to an electronic typewriter to provide a system for the teaching of basic binary mathematics. The language developed in writing the programs provided the basis for the first authoring language, Coursewriter [Atkinson and Wilson(1969), Bunderson(1970)]. Some very comprehensive and successful CAI projects were developed in the United States during the 1960's and 1970's. These include the Programmed Logic for Automatic Teaching Operations (PLATO) [Bitzer et al(1961),(1974), Bitzer(1976) ], the SOCRATES system [Stolurow

and Davis(1965)], the CLASS system [Coulson(1962)], and the Time-shared, Interactive, Computer-controlled Information Television (TICCIT) project [Stetten(1972)]. In the U.K., the most noteworthy initiative was the National Development Programme in Computer Assisted Learning (NDPCAL), which involved 35 projects and produced computer-based packages in a diverse range of educational areas [Hooper(1974), (1975), (1977)].

Computer assisted learning developments up until the mid-1970's were confined to mainframe or minicomputer systems, and were mostly designed for time-sharing use. The general availability of microcomputers from the late 1970's onwards has allowed the development of relatively low cost multi-media computer assisted learning (CAL) using a range of audio-visual and other devices e.g. tape recorders, slide projectors, switches, special keyboards etc. Examples of projects are provided by Kenny and Davis(1979), Bryce and Stewart(1981), Barker(1982a,1982b), and Howlett et al(1981). Major developments include the porting of PLATO and TICCIT to microcomputer-based hardware, as MicroPLATO and MicroTICCIT. Barker and Yeates(1985) provide an overview and comparison of these systems.

In recent years, the interfacing of videotape and/or videodisc players with a computer, to provide automatic operation of the player under program control, provides the concept of 'Interactive Video'. Early projects on interactive videotape in the U.K. are described by Bryce and Stewart(1982) and Copeland(1983a,1983b). The development of videodisc technology and players which incorporate significant features such as rapid access to any video frame and unlimited still frame capability, offers a new dimension in interactive video.

There are several descriptions of the ways videodiscs can be used in education and training [Branson and Foster(1979), Clark(1984), Cohen(1984), Priestman(1984)]. These may be summarised by Allen's (1982) classification of videodisc educational applications.

Allen's classification is as follows :

1. Straight-through playback. The videodisc is used as a device for developing theatrical and instructional video and film without computer remediation.
2. Tutorial. Individualised instruction in which the computer adapts the sequence selection based on student responses.
3. Simulation. The videodisc system is interfaced with other devices (for example, a mock-up of a control panel), through which the student may practice complex psychomotor and cognitive skills.
4. Image retrieval. The computer accesses the video storage system to display specific sequences, such as blueprints, parts diagrams, microscopic slides.

A notable contribution from the University of Nebraska Videodisc Design/Production Group has been a formal classification of videodisc delivery systems in respect of levels of interactive capacity [Christie and Nugent(1981)]. The classification levels are described below.

#### Nebraska Levels of Interactivity

Level 1 This level relates to 'Domestic players' with little or no processing power, which respond to hand-set control only. These players have no programmable memory, but are capable of manual interaction with the user. Chapterisation, automatic picture stops, frame search and the normal optical videodisc features (fast and slow motion, freeze frame, dual channel audio and so on) are available at this level. The players return no information to the outside world apart from the video image.

Level 2 This level is based on 'Educational/Industrial players' with built-in programmable memory. These players can be programmed by down-loading control instructions from the audio track of the disc. Branching based on user input makes it possible to achieve a higher level of interactivity.

Level 3 At this level the player is interfaced with an auxiliary computer. In this case the videodisc functions primarily as a peripheral device, while the computer provides most of the interaction for the user. Very complex branching strategies, and scorekeeping, are possible. At this level the player functions with two-way communications control with the computer.

Much of the early work on interactive videodisc was conducted in the United States, and involved the development of hardware and software interfaces for computer connection of prototype models of commercially - produced industrial/institutional videodisc players. Merrill and Bennion (1979) provide a comprehensive review of these early developments and the associated educational and training applications. Kearsley (1981) reviews a range of applications in the areas of industrial training, military training, medical education, higher education, and elementary and special education, covering Levels 1 - 3 of interactivity based on the Nebraska scale.

We now review some noteworthy videodisc development projects in the field of education, prior to this project which commenced in early 1984.

The U.S. National Science Foundation (NSF) has supported the development of several instructional videodiscs. One of these, a videodisc entitled 'The Development of Living Things' by WICAT Inc. and McGraw-Hill, is considered to be the first interactive videodisc, developed for individualised learning [Merrill and Bennion(1979) ; Bunderson(1979)]. The videodisc was designed to teach Biology at high school or college level, with subject matter covering about one-third of a college course on cell development and genetic mechanisms. The player could be switched automatically from normal 'play' mode to the still-frame mode, by the use of special stop-codes on the disc. A sense of continuity could be maintained in the programme by including such still-frame items as tables of contents, graphs and charts, and instructions, together with normal colour motion picture sequences. The disc was developed in three

phases - firstly as a manually-controlled disc, secondly as a computer-controlled disc, and thirdly as a redesigned 'intelligent' disc utilising a theoretical framework developed specially for interaction using a manually-controlled consumer player.

The Nebraska Videodisc Design/Production Group has developed videodisc courseware on the physics of structures [Christie & Nugent(1981), Kearsley(1981)]. Actual film of the collapse of the Tacoma Narrows Bridge is used to allow the student to explore the basic principles underlying the collapse. Nebraska Levels 2 and 3 of interactivity are used and the courseware design caters for three student ability levels. The first level offers qualitative explanations and requires similar performance from the student. The second level expects the student to perform numerical calculations. The third level involves algebraic reasoning and the derivation of functional relationships between variables, by the student.

The Minnesota Educational Computing Consortium (MECC) has produced 'Introduction to Economics', which is a Level 3 project designed for college use, and covers the concepts of economic resources, wants and needs, scarcity, allocation, values, and goals [Glenn & Kehrberg(1981)]. This system is based on a Pioneer VP-1000 videodisc player, and the popular Apple II microcomputer.

A project based at the University of South Florida has been funded by the NSF, to develop interactive courseware for engineering and science students, and to identify those subject areas which are best suited to the usage of computer aided instruction and colour graphics [Hiraki & Garcia(1981)]. This application is of interest, since it is based on the multi-user access of videodisc facilities connected to a Prime 750 minicomputer to which is connected 20 Apple II Plus computers, each of which is provided 'intelligent terminal' use of courseware. The role of the Prime minicomputer is to act as a course and data-base manager, keeping track of the courseware and student access.

Sustik(1980a) describes information retrieval applications in Urology and Art History at the University of Iowa, using a prototype production model Thomson-CSF NTSC videodisc player

linked to an Apple II via an IEEE 488 interface board. In a later paper, (1983), Sustik and Brooks discuss the requirements for such retrieval systems, and use the Art History project to illustrate five main operations required in any such implementation.

An advanced and innovative project, funded by the U.S. Defense Advanced Research Projects Agency, at Massachusetts Institute of Technology, is described by Merrill and Bennion (1979). This project involves a study by the Architecture Machine Group at M.I.T., of an experimental spatial Management Data System. The subject sits in a chair with two joysticks and two-inch square touch sensitive pads on each arm, in a room containing a wall-sized display screen, two touch-sensitive TV monitors, and eight loudspeakers. The spatial world of this information system is called 'Dataland', and is supported by computer and videodisc resources. An aerial view of Dataland is continuously visible, and smaller subsections are simultaneously magnified and displayed on the large screen. The user navigates around Dataland using the joysticks and a touch screen monitor. One joystick provides horizontal and vertical movement and the other provides a 'zoom' facility. Fox(1982) describes an interactive programme which enables a subject to guide himself through a 'virtual' town. Thus, an environment is created "... wherein the user is directly engaged with data bodied forth in vision, sound and touch - data inhabiting a spatially definite 'virtual' world that can be interactively explored and navigated" [Bolt(1979), in Merrill and Bennion].

Several projects have developed in the field of medical and paramedical education. One of the earliest and most extensively-used medical applications was the cardiopulmonary resuscitation (CPR) training system developed by the American Heart Association [Hon (1982),(1983)]. Hon provides a comprehensive description of the system, which involves a Sony industrial videodisc player, two video monitors, a random-access audio tape player and a life-size manikin, all under control by an Apple microcomputer. One monitor presents motion or still frames from the videodisc and the other is used for the presentation of computer-generated text and graphics.

Detailed coaching and feedback is provided during the learning of psychomotor skills - the manikin has a large number of in-built sensors, and the system can detect aspects such as correct hand placement, depth and rhythm.

Andriessen and Kroon(1980) developed an early Level 3 application, based on a prototype Philips player and Philips P857 minicomputer, and a videodisc entitled 'The Work of the Heart'. The system was evaluated using a group of medical students and the system flexibility was found to be lacking due to the design, which had all still text pictures fixed on the disc, rather than based within the computer program.

Kearsley describes a videodisc project based on the topic of duodenal ulcers, and developed by Smith, Kline and French Pharmaceuticals (S.K. & F.) for use by gastro-enterologists. Three different patient case histories may be presented in any of three different modes - simulation, guided simulation or discussion. Parsloe (1983a,1983b) describes the development for S.K. & F. of Britain's first educational interactive videodisc entitled 'Mary Wetherton - A Case Simulation'. This commercially-produced disc provides a case study of a patient from her first visit to her doctor, through diagnosis and treatment. British clinical practices are reflected in the design, and users are faced with the same options and decisions which a general practitioner would have. The system uses a Pioneer PR-7820 NTSC videodisc player imported from the U.S., and is based on a Level 2 design using the on-board microprocessor.

The use of interactive videodisc for the simulation of patient-management problems (PMP) is described by Leveridge(1983), who notes that : 'As a close simulation of actual patient encounters, the PMP requires clinical reasoning, and thereby provides intellectual stimuli and a higher level of training than a tutorial format can supply'. Leveridge points out that the design of such a simulation demands acquired skills and special effort, compared with a tutorial design, but that it offers 'a more interesting challenge to both authors and users'.

Kearsley notes other projects - one by the University of Nebraska-Lincoln, on dentistry training in areas of oral

surgery and diagnosis ; the second by the University of Nebraska Videodisc Group, on the concepts and treatments associated with pulmonary illness. This latter project is a level 3 design and provides overlay of computer-generated text and video on a single screen.

One of the earliest educational applications in the U.K. was developed at the Open University [Williams(1984)], and is based on the subject of Materials Science. This Level 3 project covers elements of topics which contributed to the resolution of a civil court case centred around the fracture of plastic teddy bear eyes, hence the title of the disc 'The Teddy Bear Disc'. The student acts as technical adviser to the teddy bear manufacturer. After an interactive revision tutorial on the structure, behaviour and properties of plastics, the student progresses through 'experimental' and 'deductive' modes of interaction. Finally he has to provide conclusions which apply to the failure of the plastic eyes. Early evaluation indicated that some problems were encountered. These problems included design difficulty in anticipating 'unpredicted' responses, random breakdowns in the communication within the system elements, and the need for an improved index to allow a student to start or restart at any point. The system was based on a Philips VP705 player, Apple II microcomputer and teletext TV receiver and appropriate interfaces, and the software was written in UCSD Pascal.

A limiting factor in relation to interactive video research developments in this country was the non-availability of European broadcast standard (PAL) videodisc players. Clark(1983b) notes the introduction of PAL players into the U.K. in January 1983. American standard (NTSC) players were available in limited quantities in Britain. However these were very expensive and had inherent compatibility problems with U.K. standard microcomputers, notably in relation to video signal generation. The non-availability of PAL players had inhibited to some extent, educational research developments in the U.K. in relation to interactive videodisc. This was evidenced by the apparent lack of published research work in this country by 1984, although some commercial organisations had initiated industrial training or marketing projects which

were based on expensive NTSC players and U.S. microcomputers [Parsloe(1983a)].

It was evident that an opportunity existed to develop a relatively low-cost interactive videodisc delivery system for educational applications, based on a U.K. standard player and microcomputer.

Apart from a personal interest in such a development, the author was also motivated by other factors in commencing this part-time M.Sc. project. The Queen's College, Glasgow, has an academic policy which seeks to extend the amount of student-centred learning and methodology in its courses. These courses include degrees in paramedical disciplines, for example in Physiotherapy and in Dietetics. A significant number of audio-visual programmes on tape/slide and videotape media have been produced by the College to support subject teaching. Recently a library of microcomputer-assisted learning packages has also been established for student use, and is steadily growing. Production of multi-media teaching materials using linked audio-visual and microcomputer technology appeared to be a logical step. In particular, development of an interactive videodisc delivery system with the potential to further enhance student learning experience was regarded as an exciting prospect. It was perceived at the outset, however, that the high cost of original production and mastering of interactive video courseware would be a major constraint. Accordingly it was decided that the delivery system would be developed and demonstrated using a suitable commercially-available videodisc. All interfacing software and demonstration application programs could be developed and validated using such a videodisc. The demonstration programs would be used solely to illustrate interactive control of all player functions, since it was recognised that there might be some difficulty in obtaining a videodisc with appropriate content for a serious or complex pedagogical application.

The foregoing describes the rationale behind the main technical phase of this project submission. The development of a demonstration interactive videodisc system commenced in February 1984.

The prime objectives of the project are detailed next.

## Project objectives

The prime objectives of the project were,

- 1) to configure a relatively low-cost interactive videodisc delivery system, suitable for Nebraska level 3 applications, using commercially-available hardware components,
- 2) to develop and test appropriate interfacing routines which would provide full manual control of the videodisc player, using the microcomputer keyboard,
- 3) to develop demonstration application programs in a high level or authoring language, to illustrate full interactive control of the player, and
- 4) to evaluate the delivery system.

The chapters of the thesis are presented as follows.

Chapter 2 provides a brief history of computer assisted learning, from automatic machines to significant developments in mainframe and minicomputer-based CAL. The features of microcomputer-based CAL are discussed, together with advantages in relation to multi-media interactivity.

Chapter 3 provides a discussion of the interactive videodisc, and outlines the advantages and problems associated with the videodisc medium. A comparison of videotape and videodisc is made, in terms of interactive features and limitations. Factors involved in videodisc authoring and production are noted.

Chapter 4 describes the development of the demonstration interactive videodisc system. The objectives and timetable of activities are defined. The hardware requirements for an interactive videodisc delivery system are detailed. The selection of the hardware components, and their essential features are described. The development of assembly language

programs for videodisc player control is described. These programs, using the Versatile Interface Adaptor (VIA) of the BBC microcomputer, generate command signals encoded in the format required by the Pioneer LD1100 videodisc player.

Chapter 5 describes the development of demonstration application programs to illustrate full interactive control of the player. The programs were written initially in BBC Basic, then in the authoring language Microtext. A Microtext extension command module in assembly language was developed to control the player.

Chapter 6 provides a discussion of the work carried out, and offers suggestions for further work and investigation.

## 2. A BRIEF HISTORY OF COMPUTER ASSISTED LEARNING (CAL)

This chapter provides a basic review of CAL, tracing its origins from automatic teaching machines, to significant mainframe computer-based developments of the 1960's and 1970's. The interactive features of more recent examples of microcomputer-based multi-media CAL are discussed.

### 2.1 Early Work on Automatic Machines

Modern computer assisted learning owes its origins primarily to the work of B.F. Skinner, a research psychologist at Harvard University in the 1950's. Skinner was stimulated by earlier work on automated teaching machines by Pressey (1926). Pressey had developed mechanical devices for presenting multiple-choice questions to a student, accepting responses, and maintaining a record of the student's score. Pressey's work had illustrated the basic concepts of modern-day CAL. These concepts include the facility to allow the student to progress at his or her own pace, the provision of immediate feedback to the student based on the response to questions, and the design to permit the student to play an active role in the teaching and learning process. Skinner (1958) recognised the limitations of the Pressey machines as being inherently testing devices which could only be used after a prior learning process. Certainly the provision of immediate feedback to student responses did provide a teaching mechanism, but this was intrinsically a by-product of the design. Again, the 'multiple-choice' format provided only 'recognition responding', rather than allowing the student to construct his own response. Machines and devices based on Skinnerian principles were programmed 'to evoke specific forms of behaviour and, to bring them under control of specific stimuli'. This was achieved using prompting and coaching cues in the programming technique, to elicit the correct response from the student.

The concept of automated private tuition was reinforced by

various features. These were,

- a) a constant interchange between program and student which provides sustained student activity,
- b) a student only moves on if a given point has been thoroughly understood,
- c) the material is presented to the student only when he is ready i.e. when prerequisite subject matter has been presented and understood,
- d) the correct response is coaxed from the student by orderly construction of the program, and in-built cues and suggestions, and
- e) correct responses result in immediate feedback to reinforce the learning and provide stimulation for the student.

Skinner's machines exhibited, however, the drawback of inflexibility. They were programmed in a linear fashion, so that an able student was required to cover precisely the same material as a weaker student, albeit at his own pace.

Increased motivation and improved learning could result through a more individualised course of instruction, in which the next problem or question presented to the student is governed by the previous pattern of responses. This concept was put forward by Crowder (1960) as the technique of 'automatic tutoring by intrinsic programming'. The student is given the material in small logical units, and is then tested on each unit immediately, using a multiple-choice test format. The test result is used automatically to conduct the material that the student sees next. A correct result will ensure that new material is presented to the student, and an incorrect result is followed first by the presentation of remedial material, then by the original test.

The techniques of Skinner and Crowder are collectively known as programmed instruction (PI). Both techniques propose that the best way of tackling a learning task is to break it down into a series of smaller sub-tasks, which are then tackled in turn. Learning is reinforced by rewarding a student in an appropriate way when he demonstrates mastery of a sub-task. When a sub-task has been successfully completed, the student will be presented with the next. If difficulties are

encountered, the learner's progress is restrained until the required level of attainment has been achieved, normally by means of presenting additional material for remediation.

The concept of intrinsic programming originated in 1955 and it was not envisaged at that time that it would be implemented on a computer. However, computer systems are ideal for such an application, with their inherent facility for automatic routing and branching under program control.

## 2.2 The Development of Computer Assisted Instruction (CAI)

The term 'computer assisted instruction' describes the process whereby a student is guided by a computer through a prescribed course of learning and testing, with the computer assuming the role of teacher, asking questions and assessing the student's responses. In essence, it is the computer-based embodiment of those techniques originally developed by Skinner and Crowder.

The earliest CAI system was developed at an IBM Research Centre and was called the IBM Teaching Project [Rath et al(1959)]. This was based on a vacuum tube IBM 650 RAMAC computer, and the project was concerned with basic psychological research into memory and learning. Binary arithmetic was selected as the subject matter to be taught.

This original feasibility study was followed by further CAI curriculum developments in the areas of stenotypy, psychological statistics and German reading [Uttal(1962)]. In the statistics course, for example, the body of the student lesson material was incorporated in a loose-leaf textbook, and a standard IBM 838 inquiry terminal was used for student response input. The interaction included testing of the student, and direction to new or remedial text material. Essentially this system, like many computer-based educational applications of the early 1960's, was based on Crowderian programmed instruction techniques.

The University of Illinois established the PLATO Project in 1961, after a committee considered the possibility of using computers to teach elements of psychology, education and engineering. The committee's report was evaluated by D. Bitzer,

who recommended that the computer could be used initially for storing and tracking students' educational performance. [Bitzer et al(1961)]. The main goal of PLATO was to 'develop an automatic teaching system sufficiently flexible to permit experimental evaluation of a large variety of ideas on automatic instruction'. The original PLATO project was based on the University of Illinois' centralised, general purpose digital ILLIAC computer, and was designed for multiple student use, via several input stations. Compared with previous teaching machines which had been purpose-built, PLATO offered the advantages of the centralised availability of the teaching resource to a number of students, the flexibility and ease of teaching program modification, and the centralised storage and subsequent analysis of student performance records.

Other noteworthy projects in the early 1960's include the SOCRATES and CLASS systems. Interaction with the SOCRATES system took account of the student's progress through the material, including previous responses and past history [Stolurow and Davis(1965)]. The CLASS system provided not only individualised instruction, but also guidance and administrative capabilities [Coulson(1962)].

The first system to employ integrated multi-media techniques was the IBM 1500 Instructional System [Atkinson and Wilson(1969)]. This was also the first system designed exclusively for CAI applications and derived from a joint project between IBM and Stanford University. Based on an IBM 1131 CPU, a total of 32 student terminal workstations were serviced, each comprising a CRT display, a keyboard, a lightpen, a slide image projector, and an audio unit with earphones and a microphone. Slides, and audio messages from a bank of audio-tape devices, could be randomly accessed under centralised computer control, for presentation to the student. This system was also noted as being the first to employ a specialised language, COURSEWRITER, for the coding of instructional programs.

It is estimated that about 100 CAI projects were in progress in the U.S.A. in the late 1960's. [Pressman(1970)].

Various terms and acronyms have been coined in the past in relation to the role of the computer as an aid to learning.

## 2.3 Terminology and Roles of CAL

Different names which have been used to describe aspects of techniques of learning using computers include 'computer based learning' (CBL), 'computer based training' (CBT), and 'computer assisted instruction' (CAI). The currently preferred name, CAL, recognises that the computer can be an effective adjunct to learning, if used with other methodologies and materials.

In 1973, the National Development Programme in Computer Assisted Learning (NDPCAL) was established in the United Kingdom, and identified five roles of the computer as a learning resource [Hooper(1974)] :

### 1) The computer as manager

This role includes information retrieval applications, the routing of students through individualised learning materials stored outside the computer, student records processing and student assessment. Commonly, this role is known as computer managed learning (CML).

### 2) The computer as tutor

This role involves teaching a range of skills, concepts, and facts using different teaching strategies. The term 'computer assisted instruction' (CAI) relates to this role.

### 3) The computer as exerciser

In this role the student is provided with regular practice in skills, concepts, and facts using different strategies.

### 4) The computer as laboratory

This role includes simulation, gaming and modelling, inquiry, problem-solving and student-controlled exploration.

### 5) The computer as producer

This role involves the production of visual materials in various media for use in non-computer-based teaching.

Combinations of these roles were evident in several major CAL systems of the early- and mid- 1970's :

- a) The PLATO IV Project [Bitzer et al(1974), Bitzer(1976)], which was used primarily for science teaching. This project incorporated new hardware and software features, for example, special 'plasma display' graphics terminals, and a high level author language called TUTOR.
- b) The TICCIT (Time-shared, Interactive, Computer-controlled Information Television) Project developed jointly by the MITRE Corporation and Brigham Young University [Stetten(1972)], was noteworthy for its approach of developing complete courses in areas such as mathematics and English, thereby displacing traditional teaching practices. The teacher's role was redefined as tutor/counsellor/ diagnostician/problem solver for individual students.
- c) The British NDPCAL [Hooper(1975),(1977)], which provided funding for 35 projects which collectively produced over 200 computer-based teaching packages in application areas as diverse as engineering sciences, clinical decision-making, geography, and remedial reading.

## 2.4 Microcomputers and CAL

Notwithstanding the relative success of the above and many other CAL systems based on the use of large time-shared minicomputer or mainframe computer systems, their efficacy can be limited by several factors. These include,

- a) the relatively high cost of the computer system,
- b) the exposure presented by hardware unreliability,
- c) the limited overall availability of the CAL system,
- d) a system performance which may be prone to degradation with increasing number of users, and
- e) the limited interaction environment which is normally available.

In contrast, microcomputers can offer the advantages of relatively low cost, high reliability and availability, constant performance level, and the basis for a much more complex interaction environment.

Barker (1982a) described the minimal requirements which

need to be satisfied if a microcomputer is to be useful for CAL applications. Hardware requirements include a large memory and backing store. Appropriate input/output ports should be available to support multi-media CAL by enabling the interfacing of slide projectors, tape recorders, voice synthesisers etc. Facilities should be available to provide easy connection to a mainframe via a telecommunications link to enable loading of material from remote computer systems. The screen and keyboard should be easy and comfortable for novices to use. Where possible, a variety of modes of user interaction should be available - via screen, special function keys and so on. Software requirements include the availability of a high-level language development system such as BASIC, COMAL or PASCAL, and if possible, an author language. The system must be programmable in assembler language or machine code when required. There must be adequate file-handling software if no database management system is available.

The transporting of CAL packages from large multi-user systems to microcomputer systems is a major activity. O'Shea and Self(1983,p 256) have noted that only highly-financed institutions, such as large universities or industrial organisations, can afford a large-scale computer network like PLATO IV. The response of the licensor, Control Data, has been to introduce MicroPLATO, a microcomputer-based version which can be linked to a mainframe PLATO system. Backen(1983) points out that TICCIT has now been ported to micro-based hardware. The system, known as MicroTICCIT, has been produced commercially and is a superset of previous TICCIT systems, with the maintenance of 'complete courseware compatibility'. The system is hosted on a Data General micro system, and uses IBM PCs, each with a colour display, linked via a local area network. An overview and comparison of MicroPLATO and MicroTICCIT is provided by Barker and Yeates(1985,pp 236-245).

In relation to micro-based CAL in the UK, Shaw(1981) provides a review of subject-based packages which are used at secondary school level. The packages were initially developed for timesharing mainframe use, and are mainly simulation or modelling in nature. Two projects, viz. the Chelsea Science Simulation Project and the Schools Council Project 'Computers

in the Curriculum', have produced between them 48 units of CAL material in five subject areas - biology, chemistry, economics, geography and physics. The units have been implemented on various microcomputer systems- Apple II, Research Machines and BBC. Shaw states that 'the greater organisational flexibility associated with easily transported microcomputers will alleviate many of the organisational constraints associated with CAL'. It is apparent that similar development efforts will be made generally to convert other quality large-scale CAL software onto microcomputers, with enhanced features.

However, one of the major differences between microcomputers and other types of interactive computing system is the relative ease with which it is possible to interface additional local peripheral devices. Apart from standard I/O devices such as printers, magnetic diskette drives etc., it is possible to attach special-purpose units such as a light pen, tracker ball, mouse or touch keypad. For example, Howlett et al(1981) have provided an overview of the MAVIS microcomputer-based system which was built to provide a highly flexible communication and learning aid for the physically and/or sensorily handicapped. The system uses a range of alternative devices such as suck-blow tubes, switches, pointer boards, braille keyboards, and environmental controllers.

The addition of audio-visual devices, for example tape recorders, slide projectors, videotape recorders etc. has provided opportunities for the development of a comprehensive multi-media CAL environment. Various researchers have been involved in specialist CAL work based on such audio-visual media linked to microcomputers. Kenny and Davis(1979) have described the interfacing technique for control of an audiotape-slide projector using a Commodore microcomputer. The system has been used for anaesthetic teaching, on an individual CAL basis and also for controlled delivery of tape-slide lectures. Computer control of a random-access slide projector has been developed by Barker(1982b), who describes the capability of the system with examples chosen from CAL, automated display systems and information retrieval applications. Barker asserts that any evaluation of the capability of such a system as a teaching aid, requires the

estimation of two major criteria - acceptability and effectiveness.

Copeland(1983a,1983b) has described a comprehensive microcomputer-based system, CAVIS, which uses a linked VHS videocassette recorder. The system includes an authoring facility to generate the course structure comprising text, graphics, video and audio. A management and analysis facility maintains student records, student performance analysis, question analysis, group performance and course evaluation. Copeland has developed a theoretical model which suggests that two principal ways of improving the efficiency of learning are - to use a presentation (media) mix and to provide interaction.

Other authors have adopted a pragmatic approach to multi-media CAL which is supportive of Copeland's view. Bryce and Stewart(1981,1982) assert that the quality of the learning experience is improved by using media appropriate to the learning task, and by using a range of presentational modes and treatments to accommodate a variety of learner characteristics. This view is based on experience in the development of interfaces and CAL software for a variety of microcomputer systems individually linked to a random-access microfiche viewer and a random-access videocassette unit.

The videodisc is one of the most recent and rapidly developing fields of microelectronics and communications technology. This new audio-visual medium, linked to a microcomputer system as 'Interactive Videodisc' is likely to be of major significance for multi-media CAL in the future.

Videodisc technology has already been spawning offshoots, in the form of Compact Disc-Read Only Memory (CD-ROM), Compact Disc-Video (CD-V), and Compact Disc-Interactive (CD-I). These developments are based on a 12 cm disc and provide for optical storage of combinations of digital audio, computer data, analogue video and digital video still images [Bayard-White(1987b)]. Currently, only videodisc and CD-ROM are commercially available.

A basic technical overview of videodisc is provided in Appendix A.

The features and capabilities of interactive videodisc are described in the next chapter.

### 3. INTERACTIVE VIDEODISC

This chapter provides a discussion of the interactive videodisc. Advantages and problems associated with the videodisc medium are outlined. Videotape and videodisc are compared in terms of interactive features and limitations. Factors involved in the courseware authoring and production of videodiscs are noted.

#### 3.1 Introduction

A videodisc is a record-like disc which is 'played' by a device which has some similarities to a record player. However, both pictures and sound are produced by connecting the player to a standard television set. The ability to interface videodisc players with microcomputers and computer systems is a major feature of interest, allowing an interactive presentation of video and sound information to a user, under program control. Most industrial/educational players have internal microprocessors, and several others may also be interfaced with external computers.

Four different videodisc formats were in existence in the early 1980's - the optical transmissive, the optical reflective, the capacitance grooveless and the capacitance grooved. Optical discs are read by a player with a low-power laser, and capacitance discs by a player with a contact stylus which tracks across the disc surface. Since 1985, there have only been two systems available commercially in the U.K. - the optical reflective and the capacitance grooveless. The former system is the 'Laservision' system developed and produced by Philips, and the latter system is the Video High Density (VHD) system developed in Japan by JVC. Technical descriptions of the Laservision and VHD formats are provided in Appendix A, which also reviews basic elements of video technology, including video broadcast standards.

Much of the early work in design, production and experimentation with videodiscs was developed in the U.S. in the field of education and training [Andriessen and Kroon (1980); Eastwood(1978); Ferrier(1982); Glenn and

Kehrberg(1981); Hofmeister and Thorkildsen(1981); Kearsley(1981); Sustik(1980a)]. The largest proportion of such work in education involves interactive videodisc, or 'intelligent videodisc', requiring the development of interactive computer/video programmes. An interactive video programme is one in which the sequence and selection of messages is determined by the user's response to the material [Floyd et al(1982)].

Interactive programmes of a certain level of complexity require a computer, and a distinction may be made between the computer program and the interactive video programme. The former is the set of computer instructions in a high and/or low level programming language or in an authoring language, which controls the overall process of interaction with a user. This includes the logical sequencing of presentation of computer-generated graphics and the associated videodisc picture and sound material, based on the user's responses. The interactive video programme, however, incorporates both lesson control material (provided by the computer program) and lesson audiovisual material. Interactive video programmes are also commonly known as courseware.

### 3.2 Advantages of Videodisc

A significant advantage of videodiscs is convenience - the player can be loaded as easily as a record player, can be used with a standard television and remote control, and the discs are light and inexpensive to transport. Each side of an optical videodisc contains 54000 frames read by a low-power helium laser beam, and provides a normal speed motion-picture sequence running time of thirty minutes. The radial surface of the disc allows random access to any frame on the disc, without going through intermediate frames in a linear fashion. Each frame of visual material is preceded by a unique digital frame number code which can be read by the player and displayed on the screen. Thus the user may access any frame by typing in a code on a handheld remote control or keypad. Normally the keypad has the following standard features - variable forward and reverse speeds, slow motion, freeze-frame, a memory, and the facility to step forward or backward one frame at a time.

A range of other features are available [Kemph(1981)]. Parallel soundtracks enable the use of such techniques as two languages, two different levels of commentary, or the use of one soundtrack to store an interactive video computer program in digital form. Extremely rapid frame access (maximum of 3 to 5 seconds) and fast-forward and fast-reverse are available, as is the ability to stop precisely on an individual frame. Synchronisation of sound and picture is a standard feature. Frames may be easily edited by the programmed deletion or skipping of frames during playback.

A major advantage is the availability of programmable players, whereby all of the foregoing features and functions may be computer-controlled.

Grills(1981) asserts that a device which has the above capabilities for the access of slide, film, video and sound material is likely to bring radical changes in teaching, researching and learning methods.

Kearsley(1981) has summarised the favourable factors for the choice of videodisc in an instructional situation. The situation is potentially suitable when it involves a lot of multi-media materials, serves a large number of students (over time and place), is relatively stable, and involves the teaching of processes, procedures, problem-solving or decision-making.

### 3.3 Problems with Videodisc

Some aspects of the technology are currently less than perfect. These include the high expense due to the costs of development [Clark(1985)], and the availability of audio at normal playback speed only. The inability to erase, insert or amend material on a commercially-pressed disc can also cause difficulty. However, the development of 'pilot' discs may now be assisted by the recent availability of Recordable Laser Videodiscs (RLV) in the U.K. [Bayard-White(1987a)]. This provides real-time cutting of an individual Laservision disc, with the capability of adding further information at a later stage.

Butler(1981) describes potential problems when using videodiscs as a training tool. These include fixed content and format, difficulties in software development, hidden operational costs, limited software, lack of production control, and high costs of replacement equipment.

Again, although discs are inexpensive to reproduce in large quantities, initial production costs can be extremely high for a one-hour disc : \$100000 in 1981 [Butler], £50000 in 1983 [Duke(1983)], and £10000-£100000 [Clark(1985)]. The high costs are related to the labour involved in the production of original courseware material, and are unlikely to decrease significantly.

Price and Marsh(1983) argue, however, that there is a need in education to shift from a labour-intensive to a capital-intensive instructional system, and that this can happen because of the rapidly decreasing costs of microcomputers and related hardware. Thus 'Interactive video can dramatically bring down the costs of education'.

Schneider and Bennion(1981) list some unfavourable factors in the selection of videodisc as a medium. These include situations where the content will require to be revised frequently, consists of large blocks of text, or must be available for distribution in less than eight weeks. Other unfavourable situations include those where the images require higher resolution than video or computer graphics can provide, and those in which large groups are involved for simultaneous viewing. Essentially, videodisc is not a good medium for trial and error implementation.

### 3.4 Videodisc versus Videotape

Significant work on interactive video based on videotape has been carried out. Hallgren(1980) describes the development of a system for medical education, based on a Sony Betamax recorder and TRS-80 and Apple II microcomputers. Schwartz(1980) provides details of the availability of interfaces to connect Apple II microcomputers to a range of low-cost videotape units. A feasibility study of the interactive videotape medium is provided by Laurillard(1982), while Copeland(1983a) describes an interactive videocassette

teaching system which was designed to meet certain training needs within BP International. Bryce and Stewart(1982) describe the implementation of learning packages on DNA replication, and the interfacing of a variety of computer systems with audio-visual hardware, including a microfiche viewer and a Sony U-matic video recorder. In a later paper, Stewart and Bryce(1984) describe the success of computer-controlled videotape in meeting the primary aims of the teaching package, by giving access to a considerable amount of high-resolution and high quality video material and providing effective learner-interactivity. However, it was noted that the access times for videotape were sluggish, and that there were considerable problems in achieving good still pictures.

Videotape has a relatively slow response (20-30 seconds can be typical) and lack of accuracy in locating video programme selections. Videodiscs, however, provide rapid access time (1-5 seconds) and frame accuracy. Again, the quality of the image, especially on freeze frame, is significantly better with videodisc. The videodisc image has twice the saturation and is noticeably superior to the videotape image [Clark(1984)]. This is because videotape scans only one of the two fields that are used to create the image while videodisc uses both fields. Optical videodisc as a medium also offers the advantage of indefinite life, in contrast to videotape which has significantly reduced life, when still-frame access is used.

Floyd(1982) lists separately the advantages of videodisc and videotape. For videodisc, these are,

- 1) rapid access to any frame,
- 2) unlimited still frame capability, with no wear on the disc,
- 3) precise frame accuracy in accessing any frame,
- 4) scanning of material at 100 times playback,
- 5) advance frame-by-frame or 1/5 playback speed,
- 6) extremely low duplication cost for large numbers of copies,
- 7) internal programmable microprocessor for basic interactive programs, and
- 8) greater storage density.

For videotape, the advantages are,

- 1) record capability,
- 2) duplication locally - no four to six week delays waiting for a disc master,
- 3) no mastering charge, and
- 4) often appropriate video equipment already exists in an organisation.

Because videodisc is generally available only as a replay medium, original material has to be recorded on high band videotape or film before the disc can be mastered commercially [Clark(1983a)].

Interactive video based on low-band videotape can be limited by frame accuracy, poor still-frame quality, and problems of access time. However, the production and development costs and time can be less than videodisc, and an effective interactive videotape programme can be developed by judicious design and tape editing.

### 3.5 Authoring and Production Considerations

There are several decision/task areas in the authoring and production of videodiscs. These are - the delivery system, the composition of the authoring team, instructional development, author mock-up and simulation prior to premastering, premastering, mastering and replication, and evaluation.

The choice of delivery system is primarily among three types, categorised by Nebraska Levels 1, 2 and 3. The first is based on a manually-controlled videodisc player, the second on a player with built-in microprocessor control, and the third on a computer-controlled player [Christie and Nugent(1981)].

The development of interactive courseware of any significant degree of complexity requires the establishment of an authoring team [Schwarz(1982), Daynes(1982)].

Instructional development requires the establishment of learning objectives [Bunderson(1981)]. These objectives may be met by appropriate instructional strategies and techniques in courseware design [Daynes(1982)].

Author mock-up and simulation provides for the review and testing of the components of an interactive programme, prior to the production of a premaster. Authoring languages and authoring systems can offer improved efficiency in lesson creation. Examples are provided by Bevan and Watson(1983a, 1983b), Copeland(1983b) and Ixer(1984).

Premastering involves the final transfer of appropriate video material onto either film or videotape prior to mastering [Griffiths(1984), Maxwell-Hyslop(1981a), Clark(1983a)].

Mastering and replication involve the production of videodiscs from a master film or videotape, and require the services of a commercial mastering plant.

Evaluation is concerned with measuring the results achieved by the courseware [Romiszowski(1986)].

Appendix B offers a more expanded view of videodisc authoring and production.

## 4. THE DEVELOPMENT OF A DEMONSTRATION INTERACTIVE VIDEODISC SYSTEM

The development of the demonstration interactive videodisc system is described in this chapter. The objectives are stated, and the timetable of activities is laid out. The hardware requirements for an interactive videodisc delivery system are detailed. The selection of the hardware components, and their essential features are described. The development of assembly language programs for videodisc player control is described. These programs use the Versatile Interface Adaptor of a BBC microcomputer to generate command signals to drive a Pioneer LD1100 videodisc player.

### 4.1 Objectives and Timetable of Activities

#### 4.1.1 Objectives

This part of the project, the development of a demonstration interactive videodisc system, had several main objectives. These were,

##### Objective 1

To configure a relatively low-cost interactive delivery system, using commercially-available hardware components.

##### Objective 2

To select a commercially-available videodisc, and use it to develop and test appropriate interfacing routines. These routines were to provide full manual control of the videodisc player, using the microcomputer keyboard.

##### Objective 3

To develop demonstration application programs in a suitable high-level or authoring language, to illustrate full interactive control of the videodisc player.

##### Objective 4

To evaluate the delivery system.

The means by which the stated objectives were obtained are described in the following sections.

Objective 1 - Sections 4.2, 4.3, and 4.4

Objective 2 - Section 4.5

Objective 3 - Sections 5.1 and 5.2

Objective 4 - Chapter 6

In particular, Objective 3 resulted in the development of BBC Basic demonstration programs, and the corresponding programs were further developed using the authoring language Microtext. The latter programs provided the facility for computer-generated teletext graphics overlay, using a single TV/monitor.

#### 4.1.2 Timetable of Activities

The schedule of activities in the development of the demonstration interactive system was,

February 1984	Purchase of Pioneer LD1100 Videodisc Player
March 1984	Purchase of ULAVC Demonstration Videodisc
March - Aug. 1984	Software Development Phase 1
Sept. - Nov. 1984	Software Development Phase 2
November 1984	Purchase of Microtext Plus 3.3
December 1984	Purchase of Beeblock BL.2K Unit
December 1984 - February 1985	Software Development Phase 3

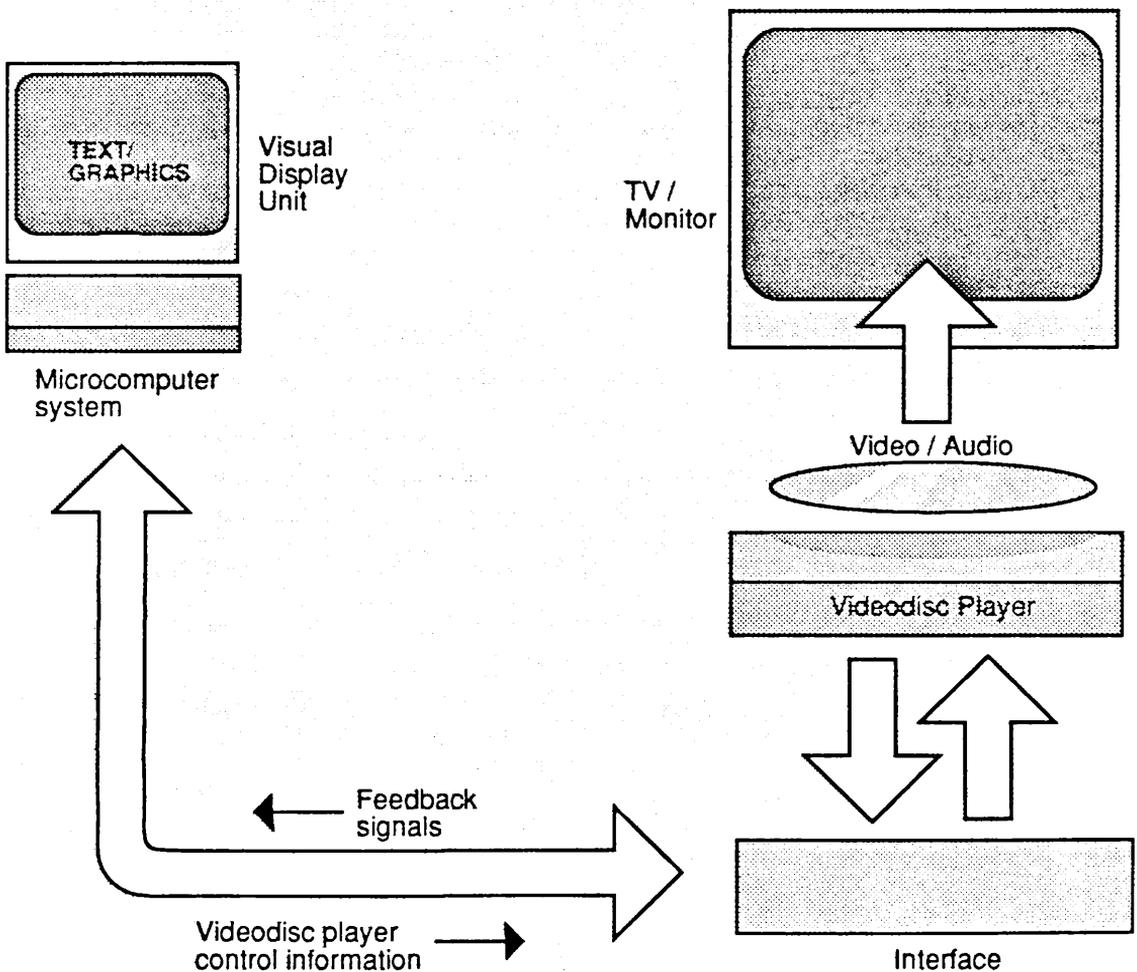
## 4.2 Interactive System Requirements

We consider here the general requirements for the hardware components of an interactive delivery system.

The three main levels of interactive delivery systems are classified as described in Chapter 1, according to Christie and Nugent(1981).

In particular, we review the requirements for a Level 3 interactive videodisc system, i.e. one in which the videodisc player operates as a peripheral device to an external computer.

Figure 1.



A modern interactive system has four principal hardware components (Figure 1).

### 1. Videodisc Player

In the U.K., this will normally be of either Laservision or VHD format.

### 2. Microcomputer System

The microcomputer system will include microprocessor and associated random access memory (RAM), a keyboard for user input responses, magnetic disk drives for storage of computer programs and associated courseware files, and other input/output devices which might include - printer, keypad, joystick, light pen etc.

The visual display unit is used for the presentation of computer-generated text and graphics. Alternatively, dependent upon the microcomputer output signal, a TV/monitor or RGB monitor may be used as the visual display.

### 3. TV/Monitor

This could be a video monitor or adapted television receiver, which would accept either unmodulated, high quality, low frequency signals, or modulated UHF line output signals from the videodisc player, and present the associated video and audio material.

### 4. Interface

The interface unit integrates the functioning of the microcomputer and the videodisc player.

Control information from the microcomputer is transmitted via the interface to the player, to initiate player operations such as play, still/step forward, slow reverse, etc.

Depending upon the type of player and interface, feedback signals from the player may be sent to the microcomputer, to indicate physical completion of the individual operations by the player.

An interface also requires special software, sometimes called interfacing routines, which provide a software linkage between the interactive application control program and the

interface hardware. Thus an interface package consists of both hardware and software elements.

Hardware interface units have been developed for different types of microcomputers and players, and some are available commercially. Ciarcia(1982) describes the construction of such a unit, and notes that interfacing may be accomplished either mainly by software, or mainly by hardware. In the latter case, more customised logic and control circuitry has to be developed.

Ideally, communication between the computer and the player should be bi-directional and asynchronous.

This means that the sequence of events is,

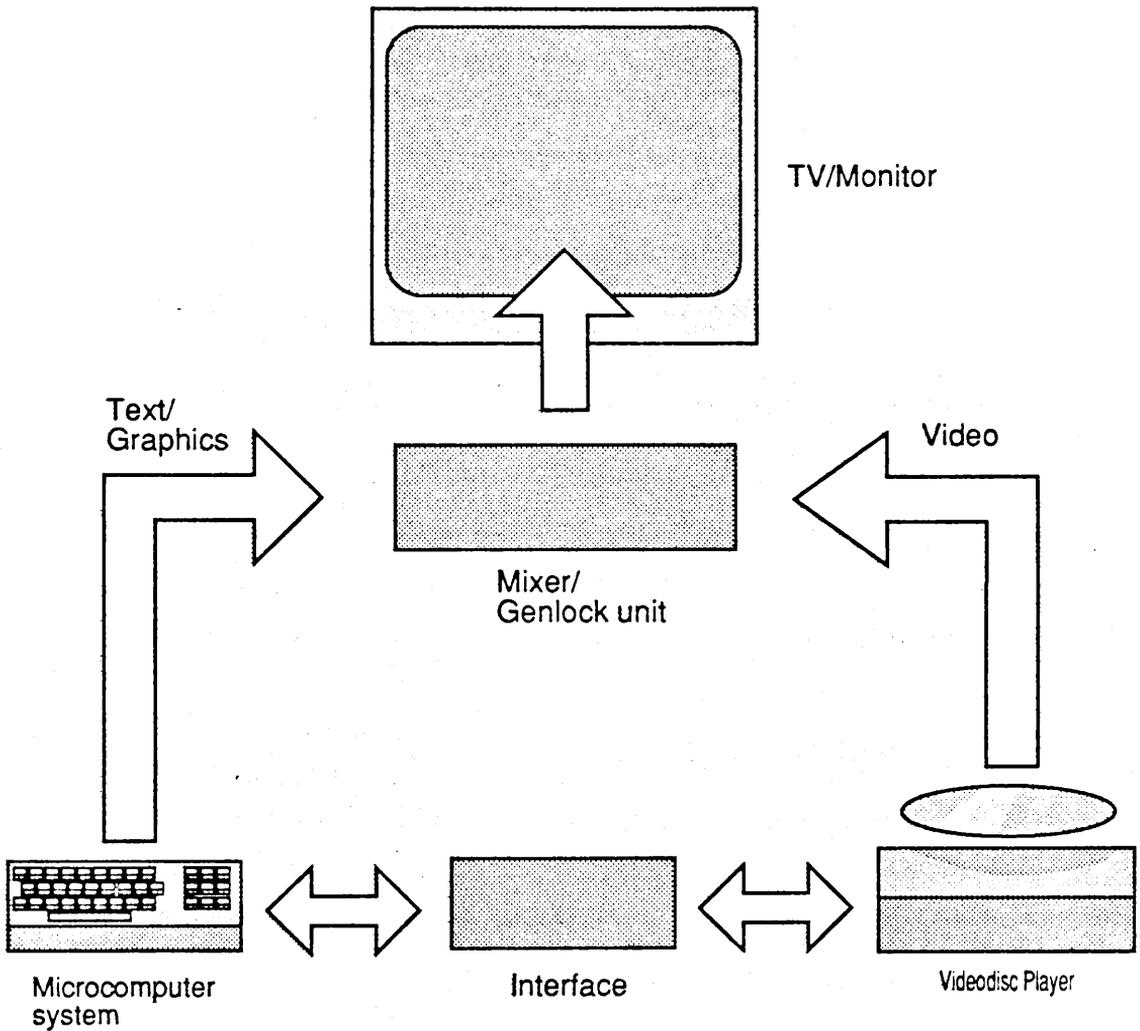
- 1) Computer sends control information via interface, which transmits corresponding instruction to player,
- 2) Player performs the required operation,
- 3) On completion, player sends appropriate feedback signal to computer, via interface, to indicate completion,
- 4) Computer recognises the feedback or 'acknowledgment' and continues processing.

Many industrial standard videodisc players provide asynchronous communications facilities, and an increasing number of these are based on the standard RS-232 computer interface. In general, any two devices with RS-232 ports (e.g. microcomputer and videodisc player) simply plug together without any interconnecting hardware other than cables.

However, most domestic players do not have such a facility, and only synchronous communications are possible. In this case, there is no two-way dialogue, as the player cannot send back an acknowledgment at the completion of its operation. This requires a more complex program design, in which an estimate of the time for each operation is required, to ensure that an appropriate delay is built-in.

An alternative basic interactive videodisc system is shown in Figure 2.

Figure 2.



This system uses a single screen to combine both video- and computer-generated signals, and provide superposition of graphics and text over the video picture. This facility is made possible by an additional hardware unit, called a mixer/genlock unit.

## 5. Mixer/Genlock Unit

This hardware device reconciles the output signal transmission differences between the computer and the videodisc player, to provide a composite video transmission.

Such a composite transmission requires that the individual video and computer signals are synchronised, when they are mixed. In practice, synchronisation is effected by using either the computer signal or the video signal as a 'locking' signal. For example, if the video signal is sufficiently stable and uninterrupted, it may be used by the unit. In this case, for full genlock, the unit will ensure that the output of the micro is both line- and field-phased to the incoming video signal, and that the colour subcarrier phase is also synchronised.

## 4.3 Hardware Components

We describe here the hardware components selected for the demonstration delivery system. The basic features of each component are described, together with the rationale for its selection.

### 4.3.1 Initial Hardware Configuration

The first photograph overleaf illustrates the initial hardware, and may be compared with Figure 1 of Section 4.2.

This configuration was used in Software Development Phases 1 and 2 (Sections 4.5 and 5.1).

#### 1. Videodisc Player

At the time of hardware selection (January 1984), there was a limited selection of commercially-available videodisc players from which to choose, and these were all of the Laservision format. The Pioneer LD1100 and the Philips VP700 were available. These were 'Domestic' players (Nebraska Level 1) which responded to handset control only. There were no PAL versions of 'Industrial' players (Nebraska Level 2) with on-board memory and computer control. NTSC versions which could be purchased were the Discovision DVA-7820 and the Sony LDP1000. The only true Level 3 player was the Philips VP705

which was an industrial player with an RS-232C computer port and an inbuilt teletext decoder. Under control of an external computer, it could provide video overlay of teletext characters and graphics. However, the high cost of the VP705 (£1200) precluded its selection. Dubreuil(1983) had also indicated that the RS-232 protocol of the VP705 was non-standard. Similarly, the high cost and potential compatibility problems of the NTSC players, removed them from consideration.

Of the remaining players, the Pioneer LD1100, although a domestic machine, did offer the prospect of synchronous communications with an external computer (Ref. Section 4.2). This could be effected by means of a remote control interface socket which could be used instead of the standard hand-held infra-red remote control unit (Model CU1100) which was provided with the player.

The LD1100 player, which cost £400, and the control unit CU1100 are shown on the left hand side of the first photograph. The second photograph also shows the player, and the close-up in the third photograph illustrates the front panel which has LED display indicators and control keys. These keys may be used as an alternative to the control unit for some manual operations.

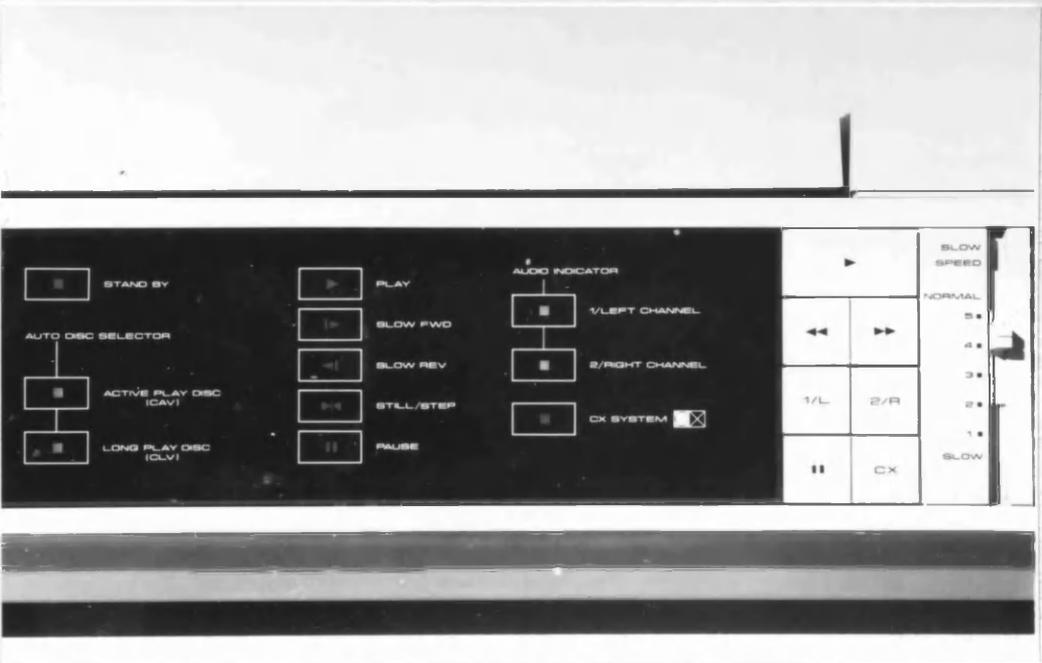
Photo 1



Photo 2



Photo 3



Functions available for CAV discs with this player and control unit are,

- PLAY - Start the player
- SEARCH - To specific frames or chapters
- CHAPTER - Display/erase chapter numbers on the screen
- FRAME - Display/erase frame numbers on the screen
- AUDIO LEFT - Off/On for left audio channel
- AUDIO RIGHT - Off/on for right audio channel
- STILL/STEP FORWARD- Frame by frame forward play
- STILL/STEP REVERSE- Frame by frame reverse play
- SCAN FORWARD - Fast forward scan of the video
- SCAN REVERSE - Fast reverse scan of the video
- FAST FORWARD - Triple-speed forward play
- FAST REVERSE - Triple-speed reverse play
- SLOW FORWARD - Slow-motion forward play  
(down to 1 frame/second)
- SLOW REVERSE - Slow-motion reverse play  
(down to 1 frame/second)
- PAUSE - Temporarily halt videodisc operation
- REJECT - Stop the player
- 0 TO 9 - Digits to select frame or chapter numbers,  
for the SEARCH mode.

## 2. Microcomputer System

The microcomputer selected was the BBC Microcomputer Model 'B' (32K), shown on the right hand side of the first photograph.

The BBC micro has an attached Cumana 40 track single sided single density magnetic diskette drive, and a Microvitec Model 1451 RGB monitor which was used as a computer visual display unit. Programs in assembly language and BBC Basic were stored on, and retrieved from, 5.25" floppy diskette. The Microvitec monitor was used for program development, as well as for interactive text messages.

An Epson LX80 dot matrix printer was also used for program development, to provide program listings.

The choice of the BBC micro was based on several factors. These were,

- a) The presence of many useful software features, e.g. an inbuilt assembly language, a structured Basic language, and high resolution colour graphics.
- b) The presence of an RS-232 serial port, and of a programmable Versatile Interface Adaptor (VIA), for use in peripheral interfacing applications.
- c) The relatively low cost (£350).
- d) The general high availability of the machine in schools, and further and higher education. In particular, all of the components of the micro system were made available by The Queen's College, Glasgow.
- e) The apparent lack of published work, at the time of microcomputer system selection, of interactive video based on the BBC micro.

### 3. TV/Monitor

Several TV/Monitors were used during software development. The model shown in the first photograph is a Sony 13" receiver/monitor Model CVM1350 which accepts video and audio line output signals from the LD1100 player.

### 4. Interface

At the time of system selection, Pioneer in Japan was developing a plug-in hardware interface unit to provide standard RS-232 computer communications using the LD1100 remote control interface socket. However, its future availability in Britain was questionable, and other types of commercially-produced units were not available for this player in this country.

It was evident that control of the player would require use of the BBC micro RS-232 serial port, or the VIA.

Due to the nature of the pulse code modulated signals required for LD1100 player control (Ref. Section 4.4), the use of the standard RS-232 interface was rejected on technical grounds.

Investigation of the properties of the VIA, and its associated timers which allowed pulse generation (Ref Appendix C), suggested that software interfacing routines might be developed to allow LD1100 player control from the BBC micro.

In practice, the hardware link between the units is made with a cable with appropriate plug terminations between the VIA and the remote control socket. The cable connects the ground pin (0V) and the data pin (PB7) of the VIA connector, to the ground and signal pins respectively of the remote control jack.

The VIA can provide signals of 5 volts, which is more than sufficient for the signal detection circuitry of the LD1100.

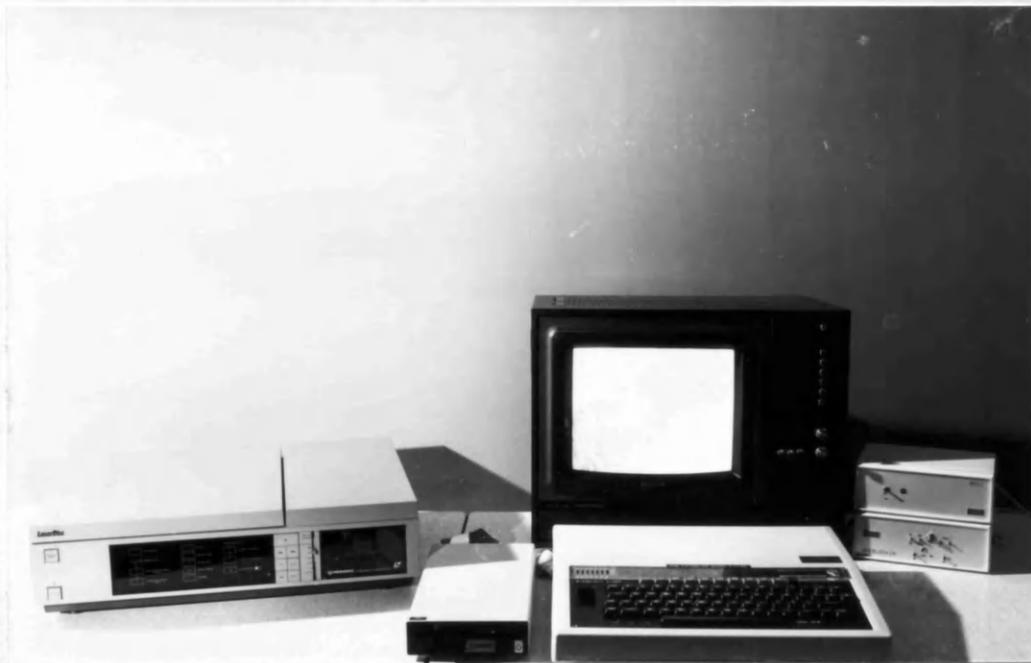
#### 4.3.2 Final Hardware Configuration

A mixer/genlock unit was purchased in December 1984, to allow superposition of video and computer text/graphics, using a single TV/monitor.

The photograph below illustrates the hardware and may be compared with Figure 2 of Section 4.2.

This configuration was used in Software Development Phase 3 (Section 5.1).

Photo 4



The mixer/genlock unit is a VEL Beeblock Model BL.2K, purchased from Video Electronics Ltd., Manchester, at a cost of £330. The unit is shown on the extreme right of the picture, and comprises two components, viz. a power supply, shown on the top, and the mixer/genlocker, shown underneath. The unit requires a synchronising reference signal, which must be a good quality, 625 line (PAL) composite colour video signal with a maximum amplitude of 1 volt and a nominal sync. amplitude of 0.3 volts. In practice, this signal is provided by the video output from the LD1100 player. The unit is fitted with a PAL colour encoder which encodes the three separate colour RGB signals from the BBC micro into a colour PAL output signal. This output signal and the incoming video signal are then mixed by a two channel vision mixer within the unit. The panel switches on the unit may be used to vary the picture 'mix' and thus alter the brightness of computer text/ graphics overlay on the video picture. The unit also offers left- and right-hand 'edge' facilities, which can be used to add a black edge to computer text, giving better separation from a light video background and a three dimensional relief effect [VEL(1984)].

#### 4.4 Pioneer LD1100 Control Signal Encoding

The hardware configuration having been established, it was necessary to consider the requirements for the development of software interfacing routines to drive the LD1100 player from the VIA of the BBC microcomputer.

Initially, this required an investigation of the control signal format used by the player.

The Pioneer LD1100 player may be controlled by signals transmitted via a remote control keyboard. The keyboard communicates with the main unit by coded signals sent through a cable, or, as in the unit under consideration, sent via a wireless infra-red light link.

These coded signals might be created by an external computer connected through the LD1100's remote control socket.

The signal control codes and transmission format is described by Ciarcia(1982), who provides a definitive analysis of the control codes which relate to the Pioneer VP-1000

player, which is the comparable USA-marketed model of the Pioneer LD1100 player.

The LD1100 control signal encoding provides for 26 different commands (listed in Table 1 overleaf) which can be recognised by the player.

Using Ciarcia's nomenclature, the bits, in order of serial transmission starting with the first, are referred to as K0, K1, K2, D0, D1, D2, D3, D4, D5, D6.

Of these, five are constant, viz.

$K0 = K1 = D5 = D6 = 0$  and  $K2 = 1$

Thus bits D0 - D4 form the command segment of the transmission.

For example, to command the player to 'Play', the remote control unit sends the 10-bit code 0011010000 in which bits D0 - D4 are 10100. This is one of the examples shown in Figure 3 overleaf.

The 10-bit commands are transmitted using a PCM ( pulse code modulated ) scheme, as illustrated in Figure 4. The commands consist of a series of bursts of 38 Khz square waves, with the bursts separated by a specified time duration which denotes either a '0' or a '1'.

Each pulse burst consists of 10 cycles at 38 Khz, and is exactly 0.263 milliseconds long.

The 'bit-period' is defined as the elapsed time between the start of one burst and the start of the next, and can be of either of two durations, 1.05 ms and 2.1 ms, denoting logic '0' and logic '1' respectively.

A 10-bit transmission starts with a burst and ends with a burst, so each command contains 11 bursts, as shown in Figure 3.

The actual length of a 10-bit transmission will vary depending upon the quantities of 1's and 0's. The maximum length of a 10-bit transmission is 17.063 ms (four 0's and six 1's).

Table 1 : Pioneer LD1100 Videodisc Player - Control Codes

<u>Function</u>	<u>Control Code</u>									
	K0	K1	K2	D0	D1	D2	D3	D4	D5	D6
0	0	0	1	0	0	0	0	1	0	0
1	0	0	1	1	0	0	0	1	0	0
2	0	0	1	0	1	0	0	1	0	0
3	0	0	1	1	1	0	0	1	0	0
4	0	0	1	0	0	1	0	1	0	0
5	0	0	1	1	0	1	0	1	0	0
6	0	0	1	0	1	1	0	1	0	0
7	0	0	1	1	1	1	0	1	0	0
8	0	0	1	0	0	0	1	1	0	0
9	0	0	1	1	0	0	1	1	0	0
SEARCH	0	0	1	1	1	0	1	0	0	0
CHAPTER	0	0	1	0	0	1	1	0	0	0
FRAME	0	0	1	0	1	0	1	1	0	0
AUDIO LEFT	0	0	1	0	1	1	1	0	0	0
AUDIO RIGHT	0	0	1	1	1	0	1	1	0	0
STILL/STEP FORWARD	0	0	1	0	0	1	0	0	0	0
STILL/STEP REVERSE	0	0	1	1	0	0	1	0	0	0
SCAN FORWARD	0	0	1	0	1	0	0	0	0	0
SCAN REVERSE	0	0	1	1	1	1	0	0	0	0
FAST FORWARD	0	0	1	1	0	0	0	0	0	0
FAST REVERSE	0	0	1	0	1	1	0	0	0	0
SLOW FORWARD	0	0	1	1	1	0	0	0	0	0
SLOW REVERSE	0	0	1	0	0	0	1	0	0	0
PAUSE	0	0	1	0	1	0	1	0	0	0
PLAY	0	0	1	1	0	1	0	0	0	0
REJECT (STOP)	0	0	1	1	1	1	1	0	0	0

Figure 3

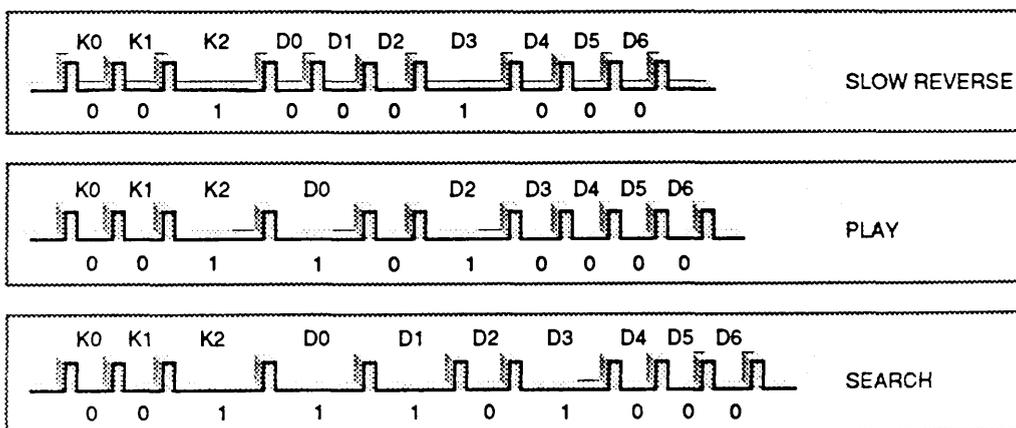
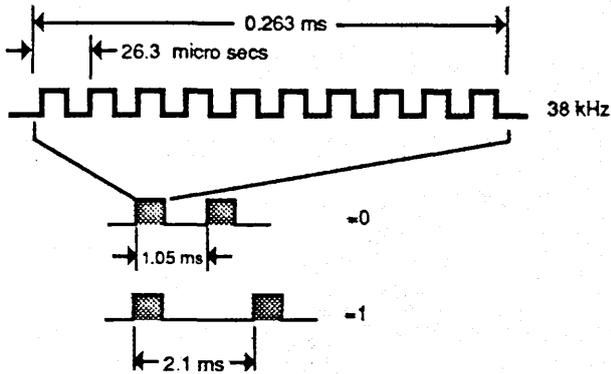


Figure 4



#### 4.5 Software Development Phase 1

This phase of software development consisted of several activities. These activities included the selection of a test videodisc, the development of assembly language test programs to produce player control signals using the VIA of the BBC microcomputer, the validation of the format of the control signals, and the development and test of programs to provide manual control of the player using the microcomputer keyboard.

The activities are described below.

##### 1) Selection of an appropriate commercial videodisc.

The disc selected was the Programme Development Videodisc, which was produced by the University of London Audio-Visual Centre [ULAVC]. This disc, which became available in February 1984, had been compiled specifically to offer more than a dozen different segments of video over a wide range of subjects, both as stills and motion pictures for use as test-beds for programming and analysis. The videodisc contains some paramedical segments which were of potential interest for later phases of the project. These included several histological slides, and a sequence illustrating a nursing technique for moving an injured patient.

2) Production of assembly language test programs to generate, using the Versatile Interface Adaptor (VIA) of the BBC micro, elements of the Pioneer LD1100 signal encoding format. (Ref. Section 4.4)

As noted in Section 4.3, the signal was generated on data pin PB7 of the VIA.

These programs included routines which generated

- a) a continuous 38 Khz carrier signal,
- b) a 0.263 msec burst of 38 Khz carrier signal,
- c) spaces for 0-bits and 1-bits in the LD1100 signal transmission code, and
- d) a 'Play' command.

These routines provided the basis for assembly language subroutines INIT, BRST, SP0, SP1 and DELAY used by subsequent programs VID1, VID2 and VID3.

As noted in the detailed descriptions of these subroutines in Appendix E, a significant amount of programming effort was required to ensure timing integrity of the output command signals.

3) Validation of the output signal format.

Output from the test routines was fed to a Hewlett-Packard Logic Analyser Model 1640, which contains memory for the storage, display and analysis of input signals. This allowed accurate visual checking of the signal format. Measurements of the carrier signal frequency and the timing of the carrier burst and the spaces for 0-bits and 1-bits were made using the logic analyser.

It was found that, although the 'Play' command format was generated as per the specification in Section 4.4 (within the estimated .01 margin of display read error of the Hewlett-Packard Analyser), the command was not recognised by the Pioneer player when fed to it using the player's remote control socket. After much experimentation, it was found that the original 'Play' command format was recognised by the player, but only if repeated at least three times in rapid succession. The approximate delay of 18 msec which was required between the command repetitions was established from considerations of the control signal encoding which has a

maximum length of 17.063 msec for a command transmission. (Ref. Section 4.4).

4) Development and test of programs to control the Pioneer LD1100 player using the BBC microcomputer keyboard.

These programs, VID1, VID2 and VID3 (Ref. Appendix E) use assembly language subroutines INIT, BRST, SP0, SP1 and DELAY, which were initially developed and tested as described above in 2) and 3). Combinations of these subroutines are used to generate the full range of control codes as defined in Section 4.4.

Program VID1

Program VID1 provides the capability as specified in Objective 2 (Section 4.1.1), for manual control of the player by a linked microcomputer system.

The program uses a BBC Basic language routine to present a videodisc player control menu. Commands are entered manually by a keypress, and the appropriate assembly language subroutine is called to generate the control code. On return, the control menu is re-presented.

The BBC function keys f0 - f9 are re-coded to allow keypresses to provide the player functions described in Section 4.3.1. The videodisc control menu in Photo 5 shows the list of player functions.

Photo 5



### Programs VID2 and VID3

Programs VID2 and VID3 were developed from VID1, to provide separate assembly language and BBC Basic routines.

Program VID2 consists of all the assembly language routines for the generation of player command codes, and may be loaded into memory by a BBC Basic application program.

Program VID3 is written in BBC Basic, and is entirely similar in function to VID1. However, in this case, the required VID2 routines are separately loaded by VID3 at run time.

Testing of these programs was performed manually. During testing, it was found that different player control commands required different numbers of repetitions, to be recognised predictably by the player. (Ref. Appendix E).

Validation of the command repetition numbers was performed using automatic loops for command generation.

## 5. SOFTWARE DEVELOPMENTS PHASES 2 AND 3

### 5.1 Software Development Phase 2

This phase of development had the objective of developing demonstration application programs in BBC Basic to illustrate full interactive control of the player. Since the courseware content was limited by video material on the ULAVC pilot video-disc, the demonstration programs were not designed with major pedagogical objectives.

Activities which were involved included

- 1) the development of procedures to link BBC Basic programs to the machine code routines which generate the player command codes,
- 2) the development of a program to demonstrate interactive video techniques which involve the presentation of still frames, and
- 3) the development of a program to demonstrate interactive video techniques which involve the presentation of video sequences and sub-sequences.

The activities are described below.

#### 1) Development of BBC Basic Linkage Procedures.

These procedures, which form program VID4, provide the linkage for any BBC Basic application program, to the machine code routines of program VID2 for the generation of player command codes.

The procedures PROCPLAY, PROCCHAPTER, PROCFRAME, PROCAUDIOL, PROCAUDIOR, PROCSTILLF, PROCSTILLR, PROCSCANF, PROCSCANR, PROCFASTF, PROCFASTR, PROCLOWR, PROCPAUSE, and PROCREJECT, link across to the functions provided by program VID2 (Section 4.5), and are self-explanatory.

Additional linkage procedures were developed for interactive application programs. These are

- a) PROCSEARCH(FR) which uses a passed parameter 'FR', which is an integer video frame number, to allow a search to a specific still frame, and
- b) PROCPLAYSEQ(S,E) which provides a sequential videodisc play sequence from a start-frame S to an end-frame E.

Other procedures PROCINIT and PROCDELAY(D) are used to set addresses for machine code calls, and to provide a delay of 'D' hundredths of a second, respectively.

2) Development of a program to demonstrate interactive video techniques, particularly those involving the presentation of individual still frames.

This program, VID5, uses individual histological slides (frames 30101 to 30123) of the ULAVC Programme Development Videodisc. A major aim in the development of this program was to validate linkage procedures contained within program VID4. A series of histological slides (9 in number, X56 magnification), is presented for student recognition. The student is allowed up to 3 attempts to identify the organ shown in the slide. A correct response results in an encouraging comment being presented to the student. If an incorrect response is received, and matches with another slide on the videodisc, then that slide is displayed, along with a remedial message. Thereafter the original slide is presented again for identification. The correct answer is provided to the student after three erroneous attempts at identification of a particular 'target' slide. The student's score is maintained, and is presented at the end of the program.

The particular frames (slides) used for identification within the program are,

<u>Frame</u>	<u>Organ</u>
30101	Ileum
30103	Stomach
30105	Lung
30107	Trachea
30111	Kidney
30117	Tongue
30119	Liver
30121	Testes
30123	Uterus

The program does not contain comprehensive input validation, since that was not a main objective. Free-format input is not accepted, and keyword recognition of input is

limited to matching the first three keyboard input characters with the first three characters of the organ names. More comprehensive, free-format, case-independent input checking could be developed.

3) Development of a program to demonstrate interactive video techniques, particularly those involving the presentation of video sequences and sub-sequences.

This program, VID6, uses a nursing sequence on 'Moving the Acute Spinal Injured Patient' (frames 45100 to 53360) of the ULAVC Programme Development Videodisc.

A major aim in the development of this program was to validate linkage procedures contained within program VID4, in relation to the playing of video sub-sequences.

The program initially presents the full video sequence of the nursing technique for moving an acute spinal injured patient. The student is then presented with a series of questions on the technique. When a question is answered correctly according to the input of certain keywords, the student is given an encouraging comment. When a question is answered incorrectly, a randomly selected message is presented to the student, and a remedial video subsequence is shown. Thereafter the original question is repeated, until the student answers correctly.

The program uses a procedure PROCSRCH-KEYWORD which searches for the occurrence of a keyword, anywhere within the input response string. More comprehensive routines would be required to search for combinations of multiple keywords.

## 5.2 Software Development Phase 3

This phase of development had the objective of developing demonstration application programs in an authoring language, to illustrate full interactive control of the LD1100 player using the BBC microcomputer.

Activities which were involved included

- 1) the development of a Microtext extension command module to control the player,
- 2) the development of a Microtext program to control the player using the BBC microcomputer keyboard,
- 3) the development of a Microtext program to demonstrate interactive video techniques which involve graphics overlay of still frames, and
- 4) the development of a Microtext program to demonstrate interactive video techniques which involve the presentation of video sequences and sub-sequences.

These activities are described later below.

### 1) General Aspects of Phase 3

This phase of software development contained some general features. These are now described.

- a) Microtext was used as the authoring language, being the only generally-available authoring facility for the BBC microcomputer in November 1984. The basic features of this frame-based language are described by Bevan and Watson (1983b). The full features of Microtext Version 3, which is the version used in this phase of development, are detailed by Bevan and Watson(1983a) and Murray and Bevan(1984). Appendix D provides a summary description of Microtext.

A pre-release copy of Microtext Version 3.3 which was developed at the National Physical Laboratory, was obtained.

Important features of Microtext Version 3.3 include the fact that it is ROM-based, a teletext graphics editor is present, and there is the facility to incorporate user-written assembly language extension command modules for control of peripheral devices.

- b) A VEL Beeblock BL.2K Mixer/ Genlock unit was incorporated into the hardware configuration. This allows the overlay of computer text and graphics with video on a single screen.

c) The Microtext programs VIDM2, VID.M3, VID.M5 and VID.M6 provide the functions of the programs VID2, VID3, VID5 and VID6, which are described in Sections 4.5 and 5.1. However, additional features are included in the Microtext programs, as detailed below.

1) Development of a Microtext extension command module to control the Pioneer LD1100 videodisc player.

This assembly-language extension command module, VIDM2, is the Microtext-based equivalent of program VID2 (Section 4.5), and contains similarly-coded subroutines. For example, in VIDM2, the Microtext extension commands \$INIT, \$PLAY, \$SEARCH, \$FRAME etc correspond to the VID2 subroutines INIT, PLAY, SEARCH, FRAME etc.

An additional command, \$LOOK, and associated subroutine was developed to look for a specified video frame. This allows a Microtext application program to give a command \$LOOK nnnnn where nnnnn is the required frame number.

The structure of the module had to comply with the parameter and table requirements for Microtext as described by Murray and Bevan. In particular, the Microtext command table and table of action addresses had to contain appropriate vectors.

The program was assembled and saved as a machine code extension command module X.VIDM2EX on disk. This module could then be loaded subsequently into memory, using the Microtext command 'FETCH X.VIDM2EX', and thus be used by application programs.

2) Development of a Microtext program to control the Pioneer LD1100 player using the BBC microcomputer keyboard.

Program VID.M3 provides the manual control, and is entirely similar in function to program VID3 (Section 4.5).

3) Development of a Microtext program to demonstrate interactive video techniques, particularly those involving graphics overlay of still frames.

Program VID.M5 is similar in function to the histological slide demonstration program VID5 (Section 5.1), but contains some additional processing features.

Program VID.M5 presents the student with the same sequence of histological slides for identification, as in program VID5. Again the student is allowed up to three attempts to identify the organ shown in the slide.

However, in program VID.M5, a correct response results not only in an encouraging comment being presented to the student, but also two identifying features of the slide being described to the student. The features are identified on the slide using superimposed program-generated text and teletext graphics.

If an incorrect response is received, the student is presented with a remedial message, followed by an identifying feature of the slide, as a hint. The original question is then presented again to the student.

If an incorrect response is received which matches with another slide on the videodisc, then that slide is displayed together with a remedial message, and followed by an identifying feature of that slide. Thereafter an identifying feature of the original slide is displayed, before the original question is asked again. All identifying features are described using text, and teletext graphics.

The correct answer, together with two identifying features, is provided to the student after three erroneous attempts at identification of a particular target slide.

The student's score is maintained, and is presented at the end of the program.

The following photographs (6 to 12) illustrate several screen displays of (colour) slides of the ileum, the uterus and the tongue. Photographs 7, 9, 10 and 12 depict identifying features using teletext graphics, some of which are in 'flashing' mode.

4) Development of a Microtext program to demonstrate interactive video techniques, particularly those involving the presentation of video sequences and sub-sequences.

Program VID.M6 is entirely similar in function to the nursing technique demonstration program VID6 (Section 5.1).

Some Microtext-based features are included e.g.  
a) input string validation for multiple, or combinations of, keywords, and b) the use of summary items to store student responses to a disk file.

Photo 6

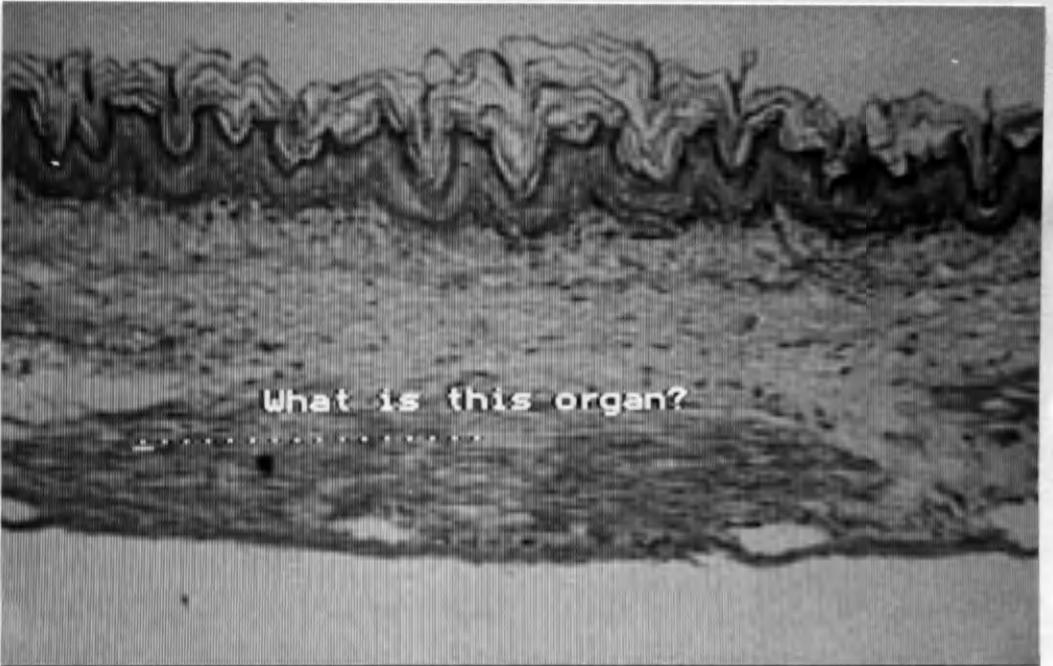


Photo 7

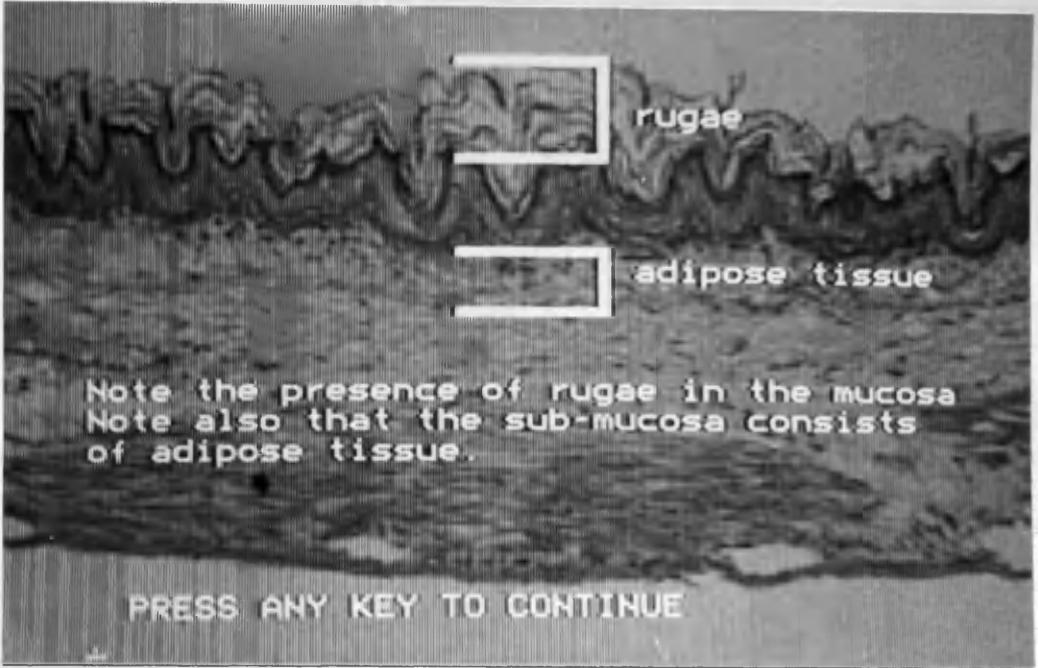


Photo 8

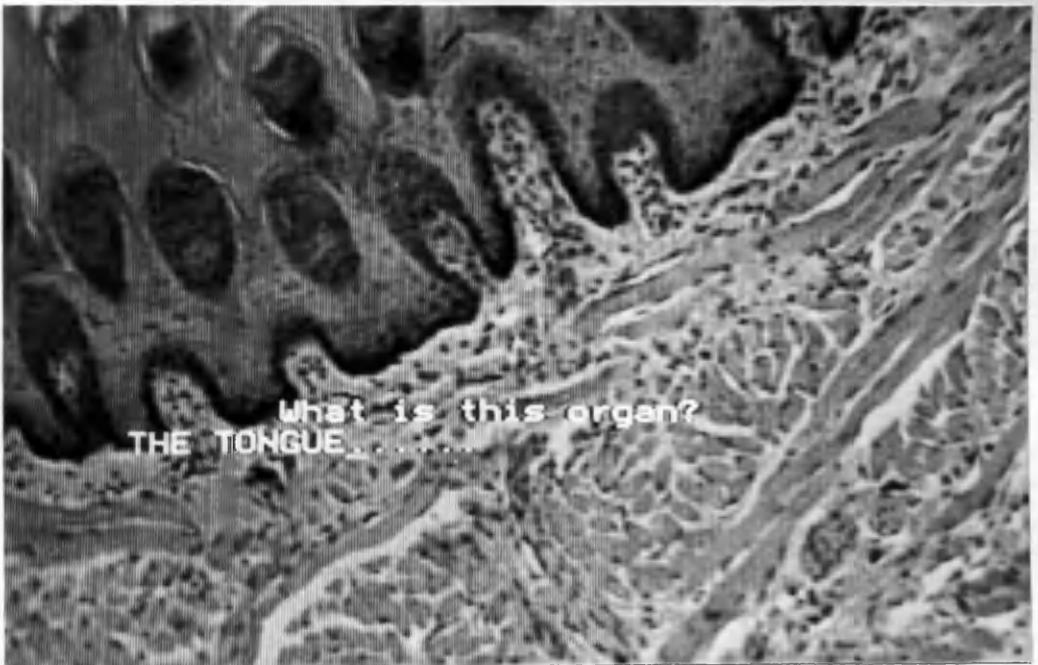


Photo 9



Photo 10

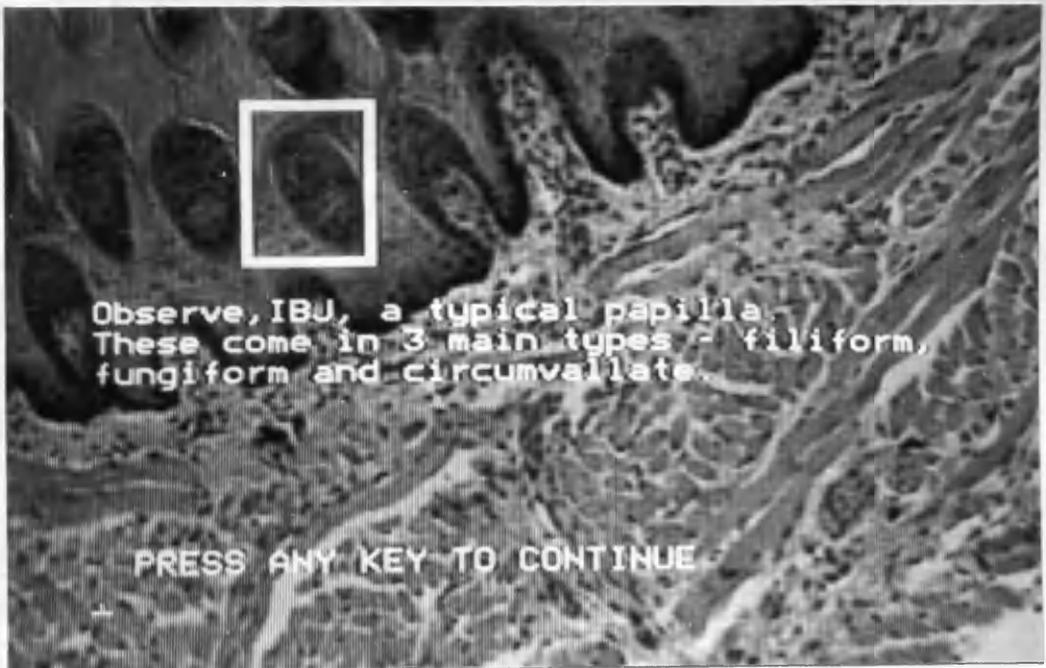


Photo 11

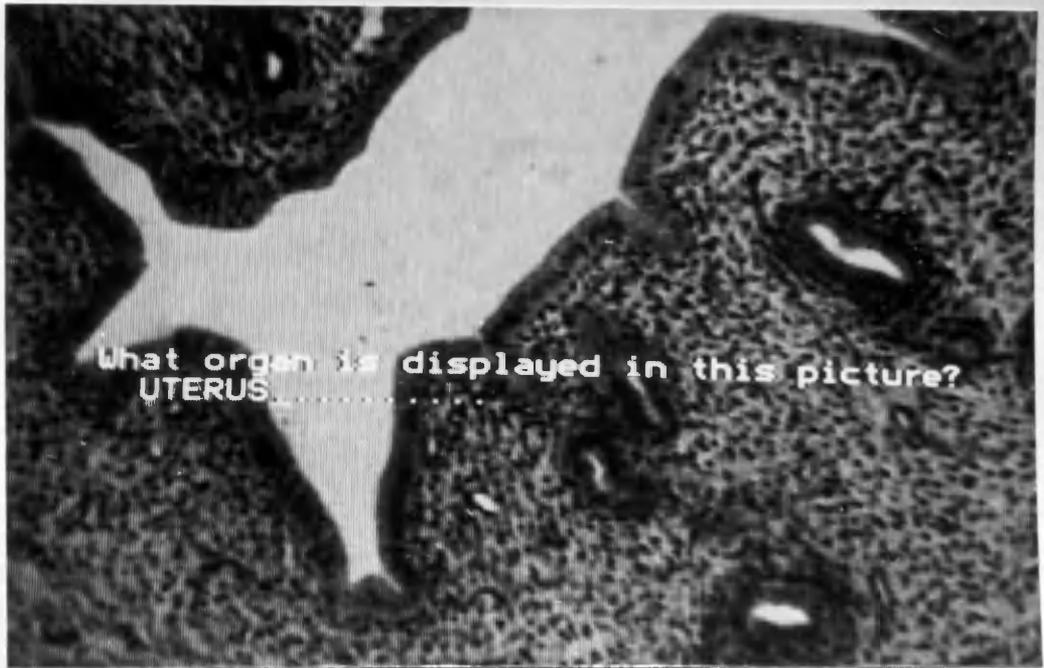
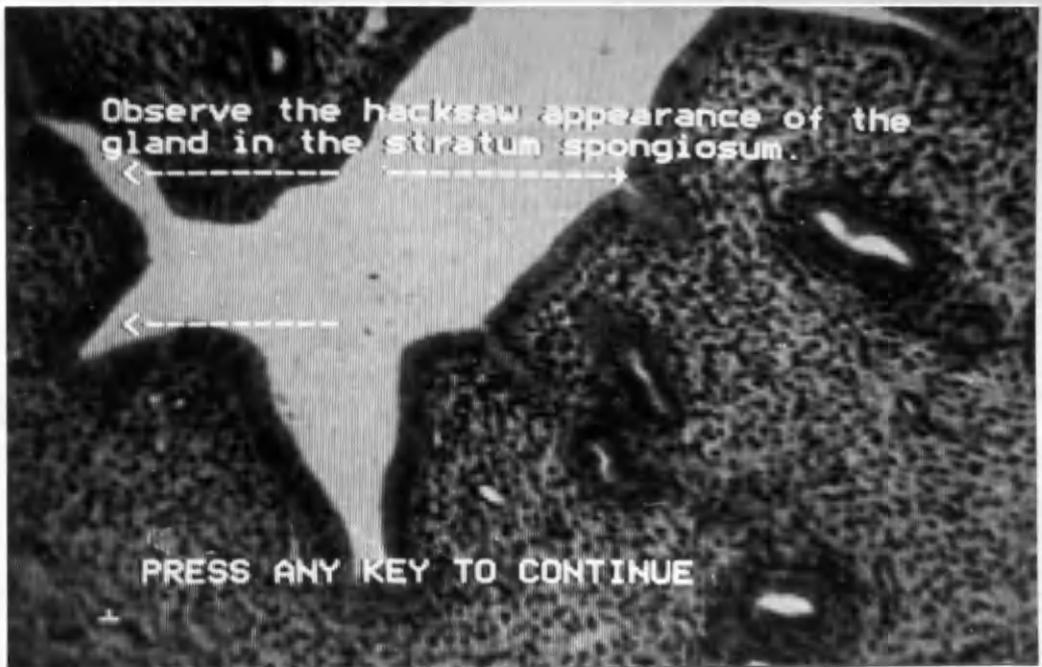


Photo 12



## 6. DISCUSSION

The development of the demonstration system was basically successful, in relation to the main objectives of Section 4.1.1. However, several technical difficulties were encountered which were due to deficiencies in the hardware configuration and to the limitations of the authoring software used, as discussed below.

The first objective was to configure a relatively low-cost hardware delivery system, and this was achieved at an approximate cost of £1250 for videodisc player, microcomputer with associated diskette drive, visual display unit and TV/monitor, in the configuration depicted in Figure 1, Page 30. Authoring required the addition of a printer costing approximately £200 for program and courseware listings, although this component was not essential for courseware delivery. Extension of the basic delivery system within Phase 3 of development involved the purchase of the ROM-based Microtext authoring language (£287) and the Beeblock Mixer/Genlock Unit (£290). The addition of this latter unit obviated the need for a separate visual display unit, resulting in the delivery system configuration of Figure 2, Page 33.

The Pioneer LD1100 player became unavailable commercially by the end of 1984, distribution having been terminated by Pioneer(UK) in mid-1984. Pioneer have now moved out of the U.K. market, as far as videodisc technology is concerned. This situation exemplifies the difficulty of establishing long-term research, educational or training strategies in the fast-moving and volatile video technology area, with its ever-present exposure to obsolescence.

The basic hardware delivery system was found to be robust and reliable. However, the addition of the Beeblock unit during Phase 3 generated some operational difficulties, as described later.

The development of the interfacing routines to drive the player using the VIA port of the BBC microcomputer proved to be difficult. This was initially due to the shortage of published material describing techniques for programming the VIA timers.

Another major problem in the development of the routines involved the generation of player control codes with correctly timed pulsed formats which were recognised consistently by the player. This required assembly language programming which incorporated timing loops based on machine code instruction cycle times. Again, it was established empirically that the control code recognition circuitry in the LD1100 player required that individual control commands be repeated in quick succession, to be accepted by the player. The number of repetitions which was required for consistent recognition, varied between different control commands, and this requirement had to be incorporated within the interfacing software routines. A significant amount of time was involved in overcoming this problem, and the details of the implementation are described in Appendix E.

A substantial difficulty was encountered due to the uni-directional synchronous nature of the interface. The lack of feedback or acknowledgement signals from the player meant that appropriate delay times had to be built into the application software, to ensure that each requested player operation had sufficient time to complete. Thus the Basic application programs contained linkage procedures to the machine code interfacing routines. These procedures included routines with, for example, fixed delay times for commands such as PLAY, FRAME etc., and calculated delay times for sequential play sequences. The required delay times were established empirically during program development. Insufficient delay could result in a missed player command and a possible system 'hang', and too much delay could result in an excessive user wait time for system response. The delay mechanisms could feasibly be incorporated into the interfacing routines which would then maintain not only the timing parameters for player functions but also maintain continuously, information on the status and location of the laser read head.

Barker(1983) has also noted similar difficulties with synchronous communications with an Intertec Superbrain microcomputer and a Philips professional VP705 player. An asynchronous communications interface, for example RS-232, provides the only real solution to these problems, and is now

currently available on several industrial videodisc players. The associated interfacing software involves a much simplified 'handshaking' procedure, based on the serial transmission of control code characters in ASCII format, and the receipt and recognition of acknowledgement signals from the player. It is, however, unfortunate that the current cost of such players typically exceeds £1400.

Notwithstanding the above developmental problems, the first two objectives were fully met, and a working system was configured, which provided full manual control of the player from the microcomputer keyboard. This system and the associated assembly language software routines laid the foundation for Phase 2 development, which had the objective of producing demonstration application programs in BBC Basic. The programs were developed to illustrate full interactive control of the player. Accordingly, they were not designed with complex or sophisticated instructional strategy to meet specific educational or training objectives. Essentially the courseware content was governed by the selection of video material which was available on the ULAVC pilot videodisc.

The two programs were successful in illustrating certain of the player control functions related to still frame access and sequential play. It was evident that control functions such as SCAN FORWARD, SCAN REVERSE, FAST FORWARD, FAST REVERSE have little or no practical value within interactive courseware. Functions such as STILL/STEP FORWARD, STILL/STEP REVERSE, SLOW FORWARD and SLOW REVERSE have limited specialist application e.g. the teaching of motor skills or sporting techniques. Functions AUDIO LEFT and AUDIO RIGHT would have value for courseware based on bi-lingual soundtracks, or for linguistics teaching. Functions CHAPTER and FRAME would have relevance for image/information retrieval applications.

Apart from any courseware design considerations, it was considered essential that the initial user interface with the delivery system should be as uncomplicated as possible. Accordingly, the system was established such that, after switching on all the hardware components, loading the videodisc into the player and inserting the program disk into the drive, the program was simply loaded using a BBC micro 'autoboot' by

simultaneously pressing the SHIFT and BREAK keys.

Software development Phase 3 involved the conversion into Microtext, of all the Phase 1 and Phase 2 machine code routines and Basic programs, with some added features (e.g. Text/graphics overlay). It was found that the machine code routines were fairly readily adaptable to the format required for a Microtext extension command module. The module required 2353 bytes of random access memory, and an interesting further activity would be to develop a video interface EPROM containing the extension command machine code routines, using a commercial EPROM programming device.

The Beeblock unit, while allowing video overlay, caused some operational and authoring difficulties. The unit ensures that the output of the micro is both line- and field- phased to the incoming video signal. However, the colour subcarrier phase is not fully synchronised, and this results in some text and graphics colours appearing 'washed out' when displayed as overlay on colour video. Monochrome white text and graphics were thus used in the demonstration programs. The unit was reliable in operation, except that switching it off could cause Microtext to crash, with the possible corruption of any memory-resident Microtext application program. A system crash also occurred occasionally, during program development, if the player was switched off manually when it was attached to the Beeblock unit. In all other respects the Beeblock unit performed very satisfactorily, and demonstrated a high level of tolerance to instability of the input locking signal, e.g. during 'scan' or 'fast forward' operations. The unit had no inbuilt capability to generate a quiescent dark background video signal, on which computer text could be overlaid, for example to display introductory frames. In practice, this was achieved by the application program selecting and displaying a suitable blank video frame on the videodisc, to use as a dark background.

Microtext was found to be an easily-learned and usable authoring language, with powerful screen editing, string matching and extension command capabilities, and excellent supporting documentation. The demonstration interactive Microtext programs were successfully developed, and the system

was set up such that they could be loaded and run automatically using the SHIFT/BREAK key combination. The version of Microtext used, however, displayed some shortcomings. In particular, teletext graphics are too limited for CAL programs - high resolution drawing routines would have been found to be valuable. Again, when developing teletext overlays, the structure of the Microtext frame with its additional 'frame number' line caused overlay misalignment between edit and run modes. Also, the lack of arithmetic routines, other than simple addition and subtraction of integers up to 255, caused difficulties in the design and coding of delay time procedures. Later versions of Microtext contain floating point arithmetic routines which provide for all arithmetic operations. Because Microtext makes it easy to produce drill and practice programs, there could be a tendency by users not to exploit the system fully to produce more sophisticated types of CAL, e.g. tutorial, simulation, problem-solving, or student-controlled exploration. The inclusion within Microtext of BBC OS calls and graphics is useful, but means that programs containing them cannot be transported onto other microcomputer-based versions of the language.

However, the limitations exhibited by the delivery system do not detract significantly from its potential ability to provide a base for further research work. In particular, it would be feasible to use the system as a vehicle for an interactive educational application. The Queen's College, Glasgow, specialises in health care courses and, over the years, has established a library of medical and paramedical video cassette programmes, many of which were produced 'in-house'. These programmes cover such subject areas as short wave diathermy, Rheumatoid Arthritis, practical anatomy of the trunk, practical anatomy of the knee, and topics in Biomechanics.

Assuming that the learning objectives which one of these video programmes was designed to meet were suitable for interactive delivery, then such an application might be developed. This approach, although inferior to one in which all the video material is developed within an integrated interactive courseware design, would have the economic

advantage of elimination of the high cost of production of original video material.

It may also be possible to avoid the high costs associated both with premastering onto broadcast format videotape, and with conventional disc mastering. Recently, a recordable laser videodisc (RLV) cutting facility has become available commercially in the U.K., which can handle several master tape formats, including VHS [Bayard-White(1987a)]. The process produces a single sided master CAV disc in either glass or acrylic, conforming fully to the Laservision standard, with a mastering cost of between £400 and £600 and an optional 24-hour mastering service. Assuming satisfactory quality of recorded source material, and final image quality of the master, such a disc could provide the basic subject content round which the courseware could be designed. An alternative approach would be to purchase a copy of a 'generic' videodisc in a suitable subject area, for example Anatomy, assuming that it were commercially available. In either case, the project would require, as a minimum, an instructional designer and a subject specialist, to perform functions as described in Appendix B.2.

Dependent upon the subject material, the instructional design could encompass the development and use of more complex interactive facilities based on still video frame images. In particular, high resolution graphics screens produced by commercial packages, for example AMX Superart, could be loaded by Microtext for the purpose of overlaid highlighting of video pictures. Again, there is a growing need for the use of image content analysis as a feature of interactive design. Techniques are required whereby the author can specify the portions of an image which contain the most important pieces of pictorial information. Thus the student, using an appropriate pointing device (cursor keys, light pen, mouse, touch screen) could identify image features when requested by the program. Clark and Sandford (1986) have described the use of semantic descriptors and maps of meaning for videodisc images, whereby the attributes of elements of the image are described by a superimposed grid map. The same authors have since produced an initial implementation of this concept as a commercially-available 'pointing-device' utility linking to Microtext.

The instructional design might also incorporate 'user control options' as advocated by Cohen(1984) and Laurillard(1984). These are built-in options which allow the student to: a) exit any part of the program whenever he or she desires, b) choose to review certain sections of the content or the directions, c) go to a HELP sequence upon request, and d) change various parameters of the lesson upon request (e.g. take a post-test and go on, choose which lesson comes next, etc.). Cohen states that 'such features ensure a richer instructional dialogue between the learner and the material and promote a greater amount of achievement. This type of learning would encourage a more deductive approach and allow the student to take more responsibility for his or her learning'.

Regardless of the courseware design, validation and evaluation of the courseware would be essential activities. Validation would ensure the appropriateness of content and pedagogical approach for the selected group or cohort of paramedical students. Evaluation would involve both developmental and field testing. The latter activity, which could be based on mastery-learning, might be supported by the courseware, using automatic storage of student results obtained during an interactive post-test. The evaluation might also include a comparative study of student performance using the interactive delivery system versus passive videotape presentation.

Bejar(1982) provides a balanced view for the future of interactive video -

'Education will continue to be for the foreseeable future an activity in which machines can have only a very limited role, and nontechnical issues are the order of the day. Nevertheless, I would like to think that technology, if intelligently used, can make the ideal of equal educational opportunity a little bit more reachable by making richer educational experiences accessible to a larger number of students. Videodisc technology has the potential of contributing to that goal'.

Certainly, the successful technical development of this project has demonstrated to this author the potential of interactive video as an educational tool.

To date, much research and commercial development has concentrated on the hardware and software technologies of authoring and delivery systems. It is clear that a change of emphasis is now required towards the production of high quality courseware which is designed, validated and evaluated on the basis of its efficacy in meeting learning objectives for the students being taught.

However, developments may be limited by various factors, which are now discussed. The interactive video medium may demand more rigour in applying learning theory than any other medium, simply because its tools are so much more powerful. Correspondingly, there is a greater demand upon the authoring team - instructional designer, subject specialist, script-writer, television producer and computer programmer. The high labour cost of original courseware development by such an authoring team can be inhibitory, particularly within the U.K. educational environment. Again, three main factors relating to delivery systems may affect the rate at which interactive video may be embraced within the field of education. Firstly, such a fast-moving technology has an inherent capacity for obsolescence. This can result in the curtailed availability of hardware for subsequent promotion and distribution of courseware which has been developed. Secondly, the range of interactive video delivery systems which are becoming commercially available provides a scenario for courseware incompatibility. Similar problems related to incompatibility and non-standardisation of hardware and associated software have been experienced already in education. The audio-visual centres of many institutions are still contending with different videotape media standards, and computer centres are increasingly involved in data and software transporting among different and incompatible computer systems. Thirdly, the trend among commercial manufacturers has been to market their delivery systems for industrial or commercial training applications. Targeting of this more lucrative market area will undoubtedly have the effect of maintaining delivery system costs at levels which, for an educational market, are adversely high. These constraints and other factors may moderate the pace of development of the medium and its technology. Other

innovative technologies such as educational film, television, video and indeed, CAL, took a long time to become established and have not permeated education to the extent prophesied by early forecasters.

It may be that the future of interactive video in higher education in the U.K. will depend upon some injection of financial support from the Government, such as was made available for the Interactive Video in Schools (IVIS) Project and the Interactive Video in Industry and Further Education (IVIFE) Programme [Bayard-White(1988)]. In the absence of such a Government-funded initiative, it would appear that institutions must begin to work together in order to spread the development cost of educational courseware of mutual interest.

Notwithstanding the foregoing difficulties and constraints, interactive video has real potential to enrich student learning experience. Ultimately the real test of the medium will lie in the reactions and learning results of the student 'consumer'. This, in turn, will depend upon the ways instructional designers and developers make use of the medium and the opportunities it offers.

## APPENDIX A

### Videodisc Technology

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## A. VIDEODISC TECHNOLOGY

### A.1 Basic Elements of Video Technology

The development of television in different parts of the world has resulted in different and incompatible ways of composing and transmitting a television signal.

Standards have been defined for the various components of the signal, the most important being the line standard, the field standard and the colour standard. In practice, these three standards are bound together to form different broadcast systems or standards. Currently there are three dominant broadcast systems, PAL, NTSC and SECAM. The initials really describe the different colour standards, but in general they are used to refer to the complete sets of technical standards (line,field,colour) by which video programmes are recorded, transmitted and displayed, whether on broadcast television or non-broadcast video.

The broadcast standards are :

NTSC which was established by the American National Television Standards Committee in the 1950's, and is used principally in the U.S., Canada and Japan.

PAL (Phase Alternate Line) which was developed in West Germany and is used in the U.K., most of Europe, the Middle East, Africa, Australasia and South America.

SECAM (Séquentiel Couleur à Mémoire) which was developed in France, and is used in the U.S.S.R. and its satellites, and in some Middle Eastern and African countries.

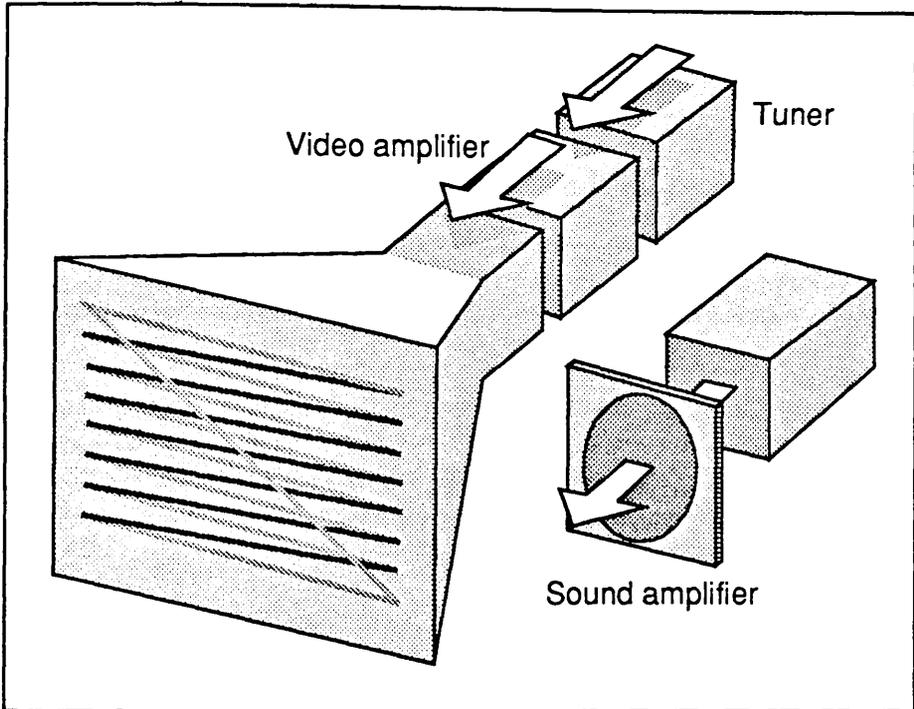
#### The Line Standard

The illusion of a moving picture on a TV screen is created by a single beam of light moving at high speed back and forth across the screen. The incoming video signal directs an electron beam to scan a grid on the phosphor-coated screen of the TV cathode ray tube. The impact of the high energy electrons, which are accelerated by a high voltage and focussed

by magnetic deflection coils, causes the emission of light from the phosphor.

The fixed path which the electron beam follows, is arranged as a number of parallel 'scan lines', running at a slight angle from the upper lefthand to the lower righthand corners of the screen. These may be seen in the drawing of the television screen in Figure A1.

Figure A1.



The rate or rhythm of the scanning electron spot is synchronised by a 'line synchronisation pulse' which is contained within the incoming video signal.

The number of scan lines used to make up one screen is called the 'Line Standard' and is now commonly 525 (NTSC) and 625 (SECAM). The pattern of lines on the screen is called the 'raster'.

### The Field Standard

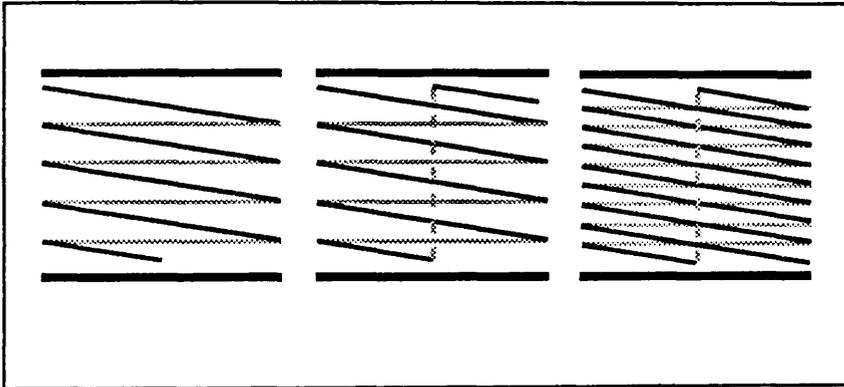
Video comprises a series of individual frames, which are presented uniformly at fixed speed, with each frame differing slightly from the last. When the eye is presented with such a series of constantly changing images, moving so quickly as to

be individually unidentifiable, the brain interprets the series as one coherently moving picture. However, unless the rate at which the images is presented is greater than about 45 per second, the human observer will detect a 'flicker', as each image flashes on and off the screen.

In video, each frame is drawn on the screen in two separate, interlaced passes. The first time only the even-numbered scan lines are presented, the second only the odd-numbered ones. Thus two images are presented for each frame, and the rate at which images are presented is high enough to eliminate conspicuous flicker.

Figure A2 illustrates field scanning and interlacing.

Figure A2.



The two interlaced patterns are called 'fields' and the rate or frequency at which they occur is called the 'Field Standard'. The field standard tends to be synchronised to the mains power supply frequency - 25 frames (or 50 fields) per second where the supply frequency is 50 Hz, and 30 frames (or 60 fields) per second where it is 60 Hz. Thus, NTSC runs at 30 frames per second and PAL and SECAM run at 25 frames per second.

After each field scan, the scanning spot shoots from the lower righthand corner back to the upper lefthand corner of the screen. This 'flyback' motion is synchronised by a 'field synchronisation pulse' on the input video signal.

## The Colour Standard

The human eye gathers information about picture brightness (luminance) and colour (chrominance). Correspondingly a video signal transmits similar information in composing a picture.

The primary colours are red, green and blue, which when projected in equal quantities produce pure white. The combination of these three colours in different proportions produce the complete colour spectrum.

The luminance signal is comprised always of 30% red, 59% green and 11% blue. This colour combination produces shades of black, grey and white.

The chrominance signal contains colour difference information i.e. it contains coded information which identifies how the true colour of each picture dot differs from that contained within the monochrome luminance signal.

The luminance and chrominance signals are separate. They are required together in the production of a true colour picture. The luminance signal modifies the chrominance signal to determine the 'hue' or 'tint' of a colour and the colour's 'depth' or 'saturation'. Together the luminance and chrominance signals provide the basis of the 'Colour Standard'. The two signals are separate and are transmitted separately. Accordingly, monochrome TV receivers can ignore the colour signal to produce a black and white picture.

NTSC and PAL transmit the three colour components of the chrominance signal simultaneously, but SECAM sends the components sequentially.

## Compatibility of the Broadcast Standards

NTSC is incompatible with PAL and SECAM, having different line, field and colour standards. PAL and SECAM are often produced to the same line and field standards, but having different colour standards, will only play interchangeably in monochrome. The incompatibility of standards can present very real problems in relation to the development, mastering and distribution of non-broadcast video material. For example, an NTSC laserdisc will not run on a PAL laserdisc player. Only the VHD videodisc system can handle NTSC, PAL and SECAM video material on one player.

## A.2 Videodisc Formats

A videodisc is a mass storage medium for audio and video information, which is displayed on a standard television receiver using a videodisc player.

The videodisc, which is approximately the diameter of an LP record, has its information stored in microscopic pits in tracks on the disc surface. The information is read either optically or mechanically from the pits, which vary in length and density.

Early videodisc formats were designed and developed by a range of international companies, and a description of these is provided by Sigel et al(1980) and Sustik(1980b).

Essentially, four different formats were in existence (although not all in the U.K.) in the early 1980's - Optical Transmissive, Optical Reflective, Capacitance Grooveless and Capacitance Grooved.

Optical discs are read by a low-power laser, the light from which is modulated as it strikes the pits in the disc surface. Optically reflective discs have an aluminium film coating which causes the laser beam to be reflected back to a photocell detector. Optically transmissive discs are transparent and allow the laser beam to shine through the disc to photocells located on the other side of the disc.

Capacitance or mechanical discs are read by a stylus which tracks across the surface of the disc, and which senses the electrical capacity changes between the pits and the stylus.

The first PAL standard videodisc players in the U.K. were introduced in January 1983 [Clark(1983b)].

Since 1985 there have only been two systems available commercially in the U.K. - the optical reflective and the capacitance grooveless.

The optical reflective system generally available is the 'Laservision' system developed and produced by Philips in the Netherlands, and manufactured under licence by other companies e.g. Pioneer and Sony.

The capacitance grooveless system is the Video High Density (VHD) system developed in Japan by JVC, and it is supported in the U.K. by JVC's European partner, Thorn-EMI.

### A.3 The Laservision Format

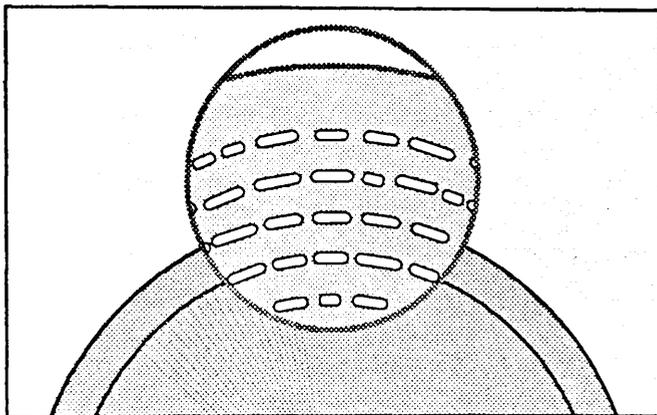
Philips, in conjunction with other organisations, issued the first videodisc standard in 1976, based on prototype systems which Philips had demonstrated in 1972.

An early description of the features of this format is provided by Bennion and Schneider(1975), and Maxwell-Hyslop(1981b) provides diagrams of the layout of video material on a Laserdisc.

The optical discs are 11.9" in diameter, and contain a spiral track of minute pits embedded within a reflective aluminium layer.

The complete video signal (luminance, chrominance and synchronisation pulses) together with the audio sound information in two channels, are stored on the track by variations in the length and spacing of the pits (Figure A3).

Figure A3.



An appropriate player plays back the disc by rotating it, and scanning it with a laser beam which is focussed on the track containing the required frame (Figure A4 overleaf).

Figure A5 overleaf provides a schematic diagram of the playback unit, and illustrates how the disc (1) is actually scanned from below by light from a He-Ne laser (2). The objective (3) is kept focussed on the disc by a system similar to a loudspeaker mechanism. A pivoting mirror (4) ensures that the beam remains centred on the track. The prism (5) separates incident and reflected light, and the detector (6) converts the reflected light into electrical signals.

Figure A4.

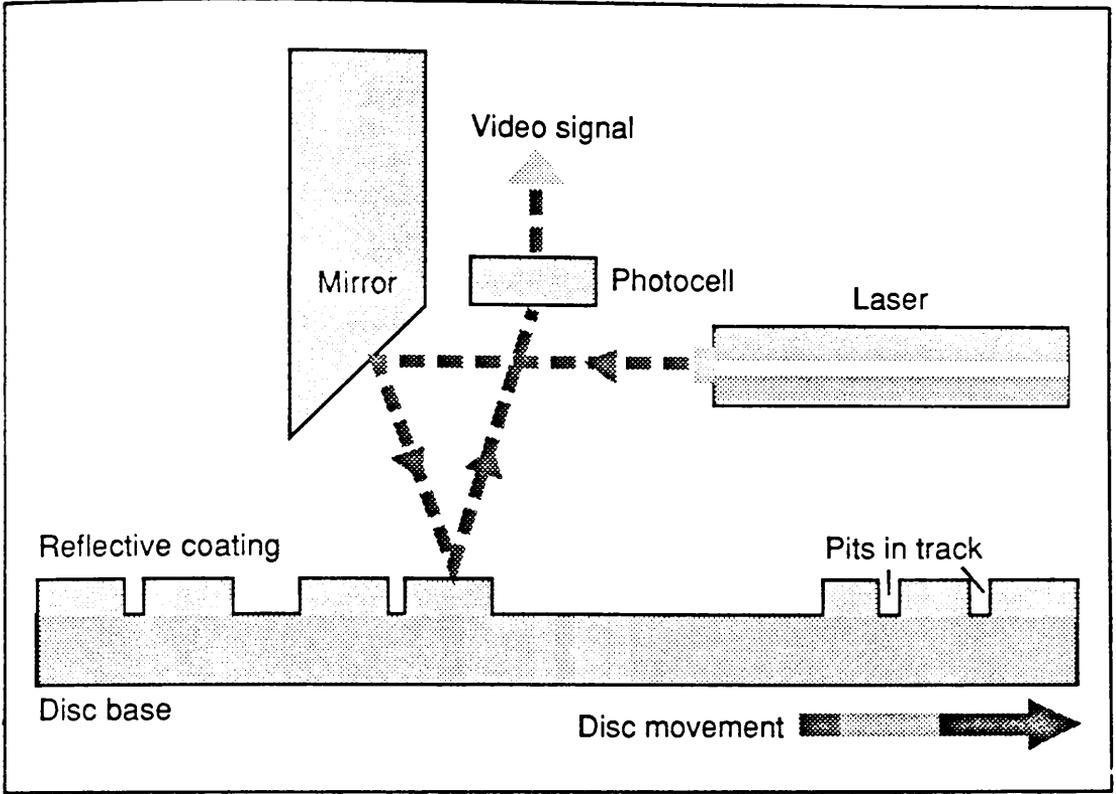
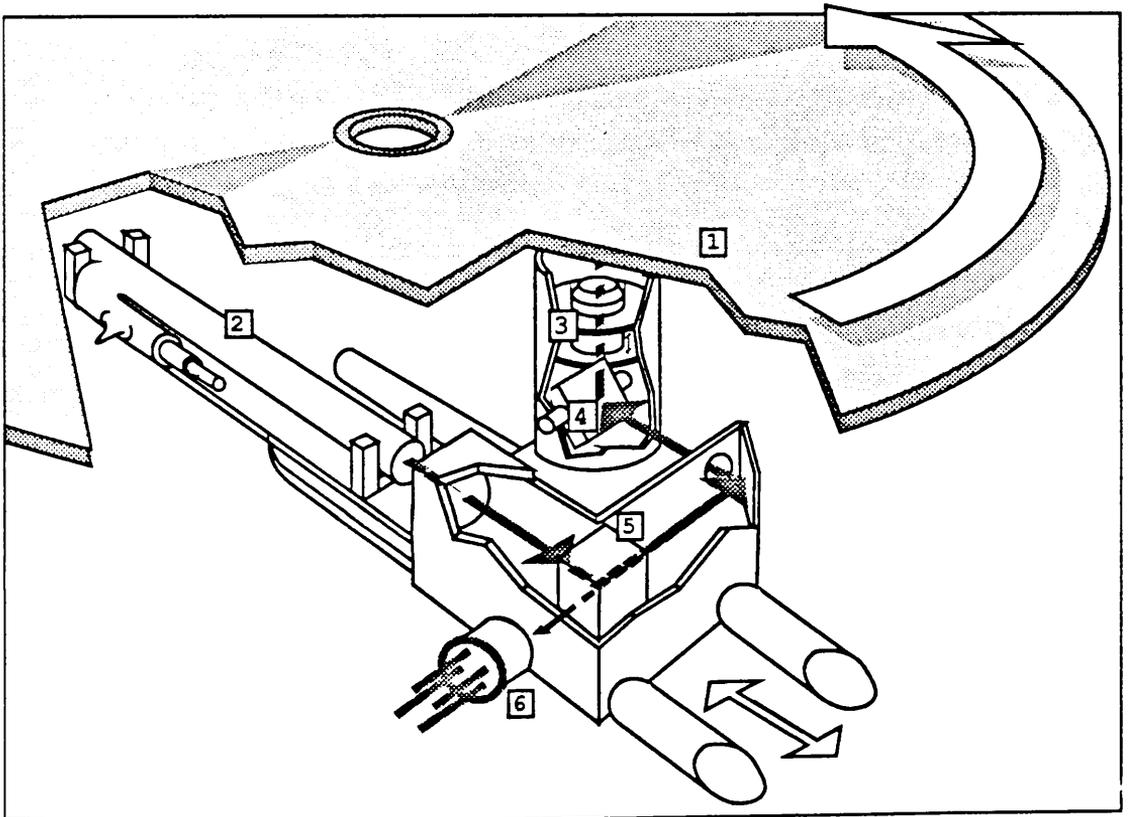


Figure A5.



Reflected light from the disc is modulated with the track information and passed to a photosensitive diode. This detector transforms the light variations into electrical signals which are processed to decode the video, audio and control information.

A tough, smooth plastic coating of polymethyl methacrylate shields the information stored in the aluminium layer from damage and pollution.

The optical scanning facility provides high reliability and long life for both videodisc and player, since there is no mechanical contact between the disc and the laser read-out device.

There are two types of laserdiscs - 'active play' or CAV (Constant Angular Velocity), and 'long play' or CLV (Constant Linear Velocity).

### CAV Discs

A CAV disc rotates with a constant angular velocity of 1500 revolutions per minute, such that the time for one disc revolution is exactly equal to the time for one video frame to be presented on the TV screen. On a CAV disc, as the track radius increases, so also does the mean linear length and spacing of the pits. These discs contain a maximum of 55,500 frames per side, which corresponds to a playing time of 37 minutes, based on the PAL field standard of 25 frames per second.

Apart from normal play, CAV discs provide the capability of special effects such as reverse motion, slow motion (forward and reverse), fast motion (forward and reverse), still frame presentation, and frame-by-frame presentation (still/step forward and still/step reverse).

Each of the frames on a CAV disc is individually indexed with a 5-digit number which may be displayed in the top lefthand corner of the TV screen. This frame number provides the facility for searching for, and displaying, individual frames. Any such frame can be randomly accessed and displayed in less than 5 seconds.

In addition, CAV discs can have video programme segments numbered by chapter numbers, which allows the facility for

searching for, and playback of, a particular chapter.

CAV discs can also have individual frames identified by a picture stop code, which will automatically stop the player at that point, and display the corresponding still frame.

There are two audio channels for either stereo sound or two different commentaries (perhaps in two different languages). Alternatively an audio channel may be used to store a computer control program in digital form. Such a program could subsequently be loaded into an educational/institutional player with appropriate built-in microprocessor and memory, for interactive applications.

Normal audio sound is not usually available in any mode other than the normal playing mode of 25 frames per second. The sound is muted during still frame, slow motion etc.

CAV discs are used for interactive videodisc applications, because of their special effects capabilities.

### CLV Discs

A CLV disc has a fixed track length assigned to each frame, so that each frame is recorded in the same amount of space. Thus the mean length and spacing of the pits is constant over the disc, which therefore contains more information, resulting in a playing time of about 60 minutes per side.

The CLV disc rotates with constant linear velocity along the spiral track, which means that the disc rotation speed decreases linearly with increasing track radius.

CLV discs can only be played at normal speed (25 frames per second) in a forward direction - they cannot be used to obtain any of the special effects available with CAV discs.

Videodisc players designed for Laservision discs automatically identify the type of disc, CAV or CLV, and provide the corresponding access and playback facilities.

#### A.4 The Video High Density (VHD) Format

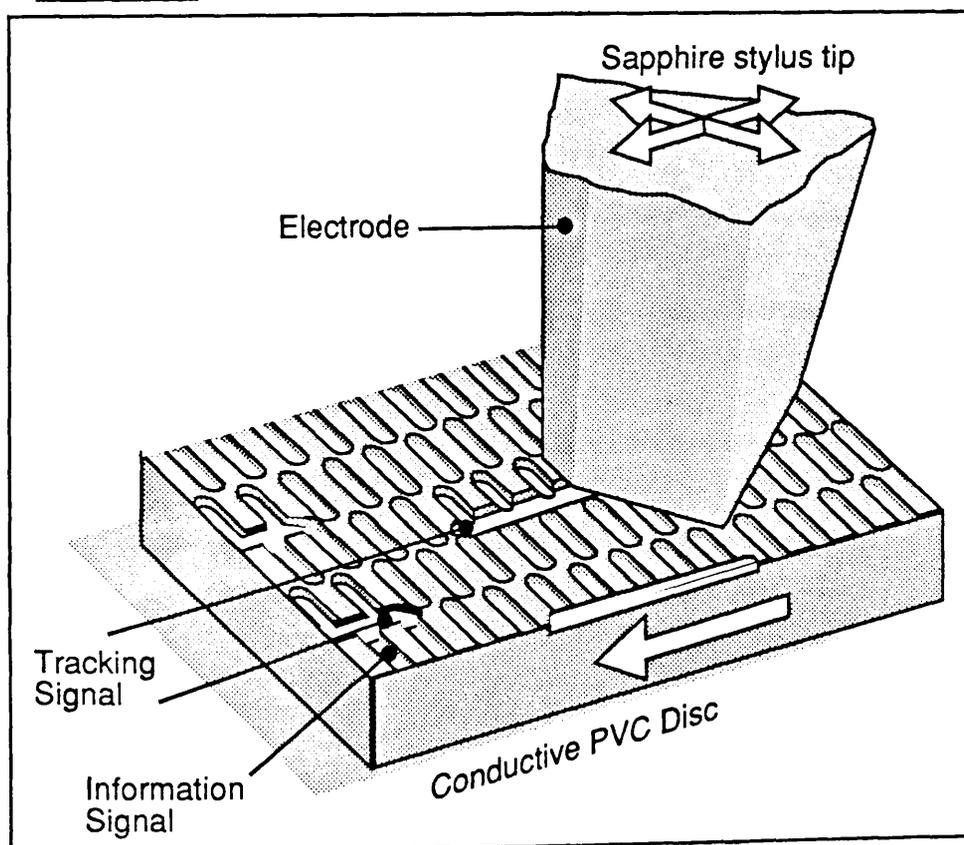
An early description of the main technical features of this system, which was announced in 1979, is provided by Sigel et al(1980).

The VHD discs are 10.2" in diameter and contain the video and audio signals as pits in a spiral track in a conductive PVC surface. The disc is normally protected when not in use, by storage in a plastic 'caddy' from which it is automatically removed when inserted into the player.

VHD is a capacitance-sensing system, in that the information encoded in the shallow pits is read via an electrode-bearing sensor or stylus. This sensor detects the difference in electrical capacitance due to the pattern of pits on the recorded surface.

Additional signals, used exclusively for stylus tracking, are recorded along with, but separately from, the video/audio signal (Figure A6).

Figure A6.



Due to the contact between stylus and disc surface, very slight wear is experienced both of the stylus and of the surface. This wear can increase considerably with increasing 'freeze-frame' access.

The disc holds a maximum of 45000 frames per side and has a linear playing time of 60 minutes per side.

VHD assigns two frames per revolution, which has implications for still frame (freeze-frame). It is not possible to hold a still frame stable on the screen if the reading stylus is sensing two different images in each revolution. This problem may be overcome, however, by identifying, before mastering, the material to be used as still frame, and recording it on two consecutive frames.

PAL-standard VHD discs rotate at 25 frames per second, corresponding to 750 revolutions per minute.

NTSC discs rotate at 30 frames per second, corresponding to 900 revolutions per minute.

VHD players are multi-standard, and can automatically recognise and play either PAL or NTSC discs.

As with Laservision discs, frame numbers, chapter numbers and automatic picture stops may be coded on a VHD disc, although there are some technical constraints with VHD. For example, a space of at least five tracks (ten frames) is required between consecutive picture stops. Also, a 'landing pad' of at least 24 frames is required for a chapter number corresponding to the start of a segment with an soundtrack.

Except for the potential still-frame problems noted above, VHD discs can provide all of the special effects (reverse motion, slow motion etc.) which are described above for Laservision CAV discs.

An advantage of VHD discs is that they can be pressed on almost conventional audio presses, whereas optical discs require the application of a reflective coating as part of the production process [Fox(1981)].

## APPENDIX B

### Videodisc Authoring and Production

#### Contents

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## B. VIDEODISC AUTHORIZING AND PRODUCTION

There are several decision/task areas in the authoring and production of videodiscs. These are - the delivery system, the composition of the authoring team, instructional development, author mock-up and simulation prior to mastering, mastering, mastering and replication, and evaluation.

These areas are discussed below.

### B.1 Delivery System

There are three primary delivery systems. These are,

- a) manually controlled videodisc players,
- b) players with built-in microprocessor control, and
- c) computer-controlled players.

Players in category b) normally have either an in-built RAM memory into which the controlling computer program may be loaded from a videodisc audio track, or the facility of using programs stored in a removeable ROM-based cartridge.

Players in both categories b) and c) may use either a single monitor screen onto which computer-generated text or graphics are alternately displayed. Other possibilities include either separate screens for simultaneous presentation of computer text or graphics and videodisc pictures, or a single screen onto which the computer-generated- and videodisc-material may be alternated or mixed to provide overlay presentation.

All three delivery systems vary in the amount and level of user control which they allow.

The Nebraska Videodisc Design/Production Group [Christie and Nugent(1981)] have formalised a classification of delivery systems according to their degree of interactive capacity. The classification levels are -

Level 1 'Domestic players' with little or no processing power, which respond to hand-set control only. These players have no programmable memory, but are capable of manual interaction with the user. Chapterisation, automatic picture stops, frame search and the normal

optical videodisc features (fast and slow motion, freeze frame, dual channel audio and so on) are available at this level.

The players return no information to the outside world apart from the video image.

Level 2 'Educational/Industrial players' with built-in programmable memory. These players can be programmed by down-loading control instructions from the audio track of the disc. Branching based on user input makes it possible to achieve a higher level of interactivity.

Level 3 The player is interfaced with an auxiliary computer. At this level the videodisc functions primarily as a peripheral device, while the computer provides most of the interaction for the user.

Very complex branching strategies, and scorekeeping, are possible. At this level the player functions with two-way communications control with the computer.

## B.2 Authoring Team

The complexity of creating interactive courseware requires the establishment of a design/production authoring team.

Schwarz(1982) suggests that a team comprising a media producer, an instructional designer and a subject matter specialist, is required. The instructional designer develops valid learning strategies, defines learning objectives precisely, and determines appropriate 'testing points'. The subject matter expert provides both theoretical and practical knowledge and determines appropriate remedial material. The media producer has a two-fold role as a media expert and an interactive video expert, and provides guidance to the team throughout the design process.

Daynes(1982) asserts that the authoring team should include an instructional developer, at least one content specialist, a scriptwriter, an engineer, a computer programmer, and a television producer/ director. It may be argued that all

of these roles are important because a good interactive programme requires a combination of techniques used in education, film and video motion pictures, still-frame pictures and graphics, and computer programming. The development of authoring systems and languages as described in Section B.4 may result in the overlap or combination of the roles of instructional developer, content specialist, scriptwriter and/or computer programmer.

### B.3 Instructional Development

The process of instructional design has as its precept the facilitation of student learning.

A model of learning based on three 'domains' of learning objectives has been developed by Bloom et al(1956). The cognitive domain is concerned with the learning of knowledge and its application, i.e. thinking, interpreting, analysis, synthesis, etc. The psychomotor domain includes the learning of practical tasks which require perception, decision and action. The affective domain is concerned with the learning of feelings, preferences and value systems.

Bunderson(1981) summarises the CAL strategies which have achieved prominence during 20 years of research :

Kind of Learning Objective	Basic Strategy
Memory or simple skills	Drill or generated practice
Concepts or rules	Tutorial or Rule-example-practice with advisor
Integration of concepts and simple skills and problem-solving	Simulations or games

It is apparent that cognitive objectives have predominated CAL developments, and may thus be conspicuous in the future in relation to interactive video courseware development.

However, the work of Kempf(1981), Ferrier(1982), and Hon(1982,1983), for example, has illustrated the potential of interactive videodisc to achieve psychomotor or affective objectives.

In common with all other CAL software, interactive video courseware incorporates basic and complex instructional strategies, sometimes in combination, which are designed to meet the desired learning objectives or outcomes.

The implementation of these strategies, within the complex media environment of interactive video, exhibit practical difficulties for the author or instructional developer. 'Scripting' techniques for interactive video courseware can be useful in this respect, comprising 'story-board' forms to describe film motion sequences and associated audio, 'still frame' forms for computer display still frame layout, and 'flowchart' forms to describe the interactive branching network.

The Nebraska Videodisc Design/Production Group [Daynes(1982)] have defined seven sets of videodisc frames which may be used in combination to achieve the desired instructional strategy. The 'orientation' set provides information such as the segment title, the table of contents(menu), behavioural objectives, and the length of the segment. The 'content' set provides the instructional material. The 'decision' set is a still frame offering an either/or option to the student, and always requires a student input response. The 'strategy' or 'comment' set is designed to provide advice to the user on how best to achieve a learning objective. The 'summary' set concludes the content and states concisely what new skills or knowledge should have been acquired. The 'problem' set consists of partitions of fixed numbers of problems, which are intended to test mastery of the stated objectives, and/or illustrate worked-out example problems. The 'help' set provides assistance to students who become lost or confused.

#### B.4 Author Mock-up and Simulation

During this phase of development, the components of the interactive programme (ie motion sequences, still frames, branching logic, etc) are reviewed and tested prior to the production of a premaster.

The programme is evaluated in terms of consistency, validity and educational purpose ; this step is necessary due to the high costs and inconvenience of producing a premaster.

Merrill(1980) describes a special form which was developed at Brigham Young University for scripting an interactive video programme, and which incorporates all the aspects of the three forms described in B.3 above. This form is used by authors and reviewers to analyse the content and logic of the programme prior to its actual production. The form has a section to describe a short motion sequence, a section showing the layout of a textual still frame which follows the motion sequence, and a section with branching information corresponding to user input responses.

This phase can also allow some limited formative evaluation prior to the expensive premastering and mastering phases. However, the unique capabilities of videodisc are difficult to simulate prior to mastering, and a later formative evaluation stage could use a videocassette containing the edited videodisc motion sequences and still frames produced during premastering.

Authoring systems have been developed which allow the structured development of interactive video programmes, particularly those of Nebraska Level 3. Such systems can be particularly valuable not only in reducing the courseware development time, but also in providing courseware lesson simulation in student mode. Authoring systems or languages do not eliminate the need for careful instructional design or detailed flowcharting. However, such systems allow teachers or instructors with no traditional programming ability, to develop applications courseware. 'Editing' functions within the systems, facilitate courseware development and provide automatic code generation for computer and video player control.

Authoring systems are usually one of two types - frame-based or line-based.

Frame-based systems use a series of individual screens in the courseware design. The frames or screens created by the author include text, graphics, instructions or questions, and appear to the student in the final programme exactly as they are designed at the initial authoring stage. The links between these frames, the branching strategies, and the points at which video sequences are interspersed with computer generated text or graphics, are all established within the structured authoring process. A typical frame-based system is Microtext developed at the National Physical Laboratory [Bevan and Watson(1983a),(1983b)], and which is described in Appendix D.

Copeland(1983b) describes a frame-based authoring system, CAVIS, where the author uses inbuilt text menus to select from a variety of options. These options include the use of a full screen editor to produce the 'pages' or frames of text and/or colour graphics for inclusion within the lesson. The pages may be revised, stored on magnetic disc, and retrieved on a random access basis according to the interactive structure built into the courseware. In CAVIS, the structure itself is called a 'presentation', and this is created and manipulated using menu options. The presentation can be run in simulated student mode with video sequences replaced by informative dummy messages. Alternatively, if the video material is available on VHS videocassette, a full student mode simulation can be made, and an authoring mode option is available to allow accurate superpositioning of text and diagrams on video pictures, while the video is running.

Line-based authoring systems provide similar functions to frame-based systems, but have a structure similar to computer programming languages and require long series of individual instructions to create screens and the courseware logic.

Ixer(1984) describes the PHILVAS authoring system which was developed by Philips Corporation for use with the Philips VP835 videodisc player, and which is essentially a line-based system. Philvas was designed for operation with the version of the player with an inbuilt Z80A microprocessor and associated 48K RAM option, a television with teletext facility, a personal

computer with UCSD - Pascal capability, and a printer. The personal micro is the vehicle used for courseware authoring in PHILVAS. In the PHILVAS environment, a script consists of program and text fragments, and each fragment can be edited and tested separately. Program fragments consist of commands which specify the type of action to be performed by the videodisc player. Text fragments consist of teletext information which is displayed on the TV screen. The two types of fragments are created and modified using a program editor and a teletext editor. In particular, the teletext editor enables the author to manipulate text and graphics on the screen, including the ability to change layout, colour and graphics display until the presentation is satisfactory, when it can then be committed to the script file. This editor can be used in two modes, dependent upon the availability of the full videodisc equipment. If this is available, text may be displayed on both the VDU and the TV screen, and still pictures may be labelled and text may be positioned precisely on motion sequences. If the videodisc equipment is not available, text generation and display can continue using the VDU only. A powerful feature of PHILVAS is the Simulator which allows the author to test a complete lesson (or part of it), either with or without the videodisc equipment connected to the computer. Finally the Compressor can be used to produce a compressed version of the script for storage on a floppy disc, EPROM cartridge, or the videodisc's audio II channel. Thus the script (ie control program) may be loaded into the inbuilt CPU either from the external microcomputer, or from the videodisc audio channel, or by means of an EPROM cartridge plugged into a slot in the front of the video player. Although powerful, PHILVAS has limitations in that it can only be used in conjunction with Philips' own equipment, and is relatively expensive. In addition, no facilities exist for the development of high resolution graphics or the use of fonts other than teletext.

The development of authoring systems such as those described above is seen as a potentially rapid growth area in CAL. Systems which offer improved ease of learning for authors, improved efficiency in lesson creation and extensive editing support will reduce courseware development time.

Features which facilitate student mode simulation with or without the associated video material, are particularly valuable.

### B.5 Premastering

During this phase, the appropriate video material is committed to its final form on either film or videotape prior to mastering.

Griffiths(1984) and Maxwell-Hyslop(1981b) provide details of the technical requirements for the master recording for acceptance by an appropriate videodisc mastering agency. In particular, for PAL Laservision discs, the master recording must be an edited and frame synchronised videotape produced on a 'broadcast' format ( 2-inch Quad or 1-inch type C Helical). Alternatively, a completely edited 16 mm or 35 mm film which has been transferred to videotape may be used. Griffiths comments on the high expense of production using film or 1-inch C format, and examines the potential difficulties of producing source material on a cheaper format, e.g. BVU or U-matic videotape. In particular, the Laservision mastering specification requires that 'during the programme compilation, the use of 8-field PAL videotape editing should ensure perfect edits'. Such edits are essential if, for example, animated sequences are to be created from a series of graphics images. However, BVU and U-matic formats are only capable of 4-field edits, and when they are transferred to broadcast format via a timebase corrector, a sideways shift in the picture can result.

Clark(1983a) also highlights this difficulty, which may be overcome by the use of specialised edit-control equipment, to ensure this crucial requirement of the colour subcarrier phase being continuous throughout the whole tape. Clark also specifies the need for the preservation of field dominance throughout the tape. This requirement is particularly relevant for still-frame images, and ensures that the 'lace' and 'interlace' fields which constitute the frame correspond with each other, when they are subsequently transferred to the videodisc. If field dominance is not preserved, then blurred or flickering still frames will result. Clark describes how preservation of field dominance can be achieved during editing

by the unique labelling with a standard (EBU or SMPTE) timecode of each frame. This timecode also indicates to the mastering facility which picture numbers are to apply to each videodisc frame. In applications where chapter and automatic picture stops are used (primarily Level 1 programmes), a list is required for the mastering facility, specifying the frame numbers at which the chapter or picture stops are to be located. Alternatively, as described by Maxwell-Hyslop (1981a,1981b), cue codes may be inserted into unused lines at the top of the video field, to specify the chapter numbers and pre-programmed still frames (autostops).

## **B.6 Mastering and Replication**

This phase involves the services of a videodisc mastering plant or facility to process the master videotape.

Fox(1981) describes this process which transfers the video material onto a polished plate glass master disc coated with a photo-resist, using a laser beam recorder. The exposed disc is then developed photographically and etched to form a spiral of microscopic pits on the glass surface. Additional stages of silver and nickel electroplating are used to produce disc 'generations' viz. 'father', 'mother', and finally 'sons' which are the nickel stampers which are used to make multiple production discs which are identical to the initial master disc. Two-sided discs are produced by glueing, back-to-back, corresponding pairs of production discs.

A major problem which can be encountered in the mastering process is 'bit dropout' or 'loss of frames'. Although the loss of a single frame has little effect on motion sequences, it can be serious for some applications which make use of still frames. Different bit error rates are acceptable for different types of information, depending on the application and the complexity of the hardware, and can be quite high for video applications but still be acceptable.

Fox describes how early disc quality control involved manual checking by a skilled worker of each two-hour disc by playing it in real-time. This inefficient process will inevitably be superceded by a more cost-effective automatic one.

## B.7 Evaluation

Evaluation is an essential phase of instructional materials development and production.

A distinction is drawn here between validation and evaluation.

Validation is the process by which experts give their opinions on content, accuracy, relevance, pedagogical treatment, etc. The content is checked for correctness by a subject specialist, and the treatment given to the content is checked by an instructional designer/developer or experienced teacher. This latter pedagogical check verifies, for example, that the language is well chosen for the intended population, the examples and explanations are relevant to their interests and prior learning, the visual and graphic presentations really communicate what they should, and the materials really do relate to the learning objectives that gave rise to the courseware development. A secondary type of validation, computer program validation, is carried out during developmental testing of interactive courseware material. This validation checks all the pathways of the computer control program for logical and technical correctness and robustness.

Evaluation is specifically concerned with measuring the results achieved by the materials when used by the learners.

Romiszowski(1986) distinguishes between two forms of instructional material evaluation. These are the developmental testing of each segment of the material as it is written, and the field-testing of units or total course packages in simulated or real-life conditions.

Developmental testing, according to Romiszowski, requires a 'clinical' approach in attempting an analysis of the instructional effectiveness of courseware, and uses a relatively small number of students as 'informants' or 'partners' within the courseware design process. Careful observation is required, identifying any non-verbal signs of difficulty or boredom. If identified, investigation of the causes is performed by questioning the students and suggesting possible modifications for their approval. Thus the author really rewrites the material during the testing session, in looking for better ways of presentation or explanation that

overcome the learning difficulty encountered. Essentially, developmental testing is based on qualitative analysis.

Field testing follows developmental testing and provides different evaluation functions based on a quantitative analysis. Field testing requires larger groups of students, and involves the gathering of information in the form of test results and, possibly, opinion questionnaires. Quantitative data is collected, such as test scores, error rates, and percentages in favour of certain aspects of the package being tested. Romiszowski indicates that some type of mathematical/statistical treatment of the results may be required, but that this may not be extensive. He asserts that instructional design is not a project of research, in which a hypothesis related to the design is proved or disproved. Rather, the task is one of 'product development' and the only test of significance which requires to be applied is 'if a significantly large part of the test group make a particular type of error, then something should be done to improve the materials'. The evaluation process should be based on mastery-learning in which the effectiveness of the instructional process is measured in terms of the mastery of specified, predetermined learning objectives. Such measurements could include 'double percentage' or 'mean gain'. Double percentage, say 80-90, defines the expected standard of achievement as : 80% of the students in the target group should score at least 90% on a properly constructed post-test that covers all the objectives. Mean gain may be calculated as the mean difference between post-test and pre-test scores, for the target group.

## APPENDIX C

### The Versatile Interface Adaptor

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## C. THE VERSATILE INTERFACE ADAPTOR

Many of the input/output facilities of the BBC microcomputer are made possible because of the presence of an on-board VIA (Versatile Interface Adaptor), which drives the User and Parallel Printer ports.

The R6522 VIA [VIA(1979),Coll(1982)] features two 8-bit bidirectional I/O data ports, four I/O control lines, two independent 16-bit timers and an 8-bit serial to parallel/parallel to serial Shift Register. Seven detectable I/O conditions are indicated in an Interrupt Flag Register. These conditions may be programmed to issue an interrupt request to the processor to allow polled and/ or immediate processor response to selective I/O line, timer, and Shift Register operation.

Control and monitoring of peripheral devices is handled primarily through the two 8-bit I/O ports, Port A (Printer Port) and Port B (User Port).

Each I/O line can be programmed to latch input data, and the four I/O control lines provide a handshaking capability to allow control of data transfer between the VIA and the interfacing peripheral devices.

One I/O line can be selectively controlled by a timer to generate a programmable-frequency square wave or a variable-width rectangular wave. This facility within the VIA is one which features in the design of the programming interface between the BBC microcomputer and the Pioneer videodisc player in this project, by providing a capability to generate a 38 Khz carrier signal as described in Section 4.4.

The VIA is shown overleaf in Figure C1, and can be considered as two halves, each of which is mainly a duplication of the other, viz. Port A and Port B.

The User Port B has the following facilities :

- a) An 8-bit digital parallel set of data lines (Pins PB0-PB7), with individual programming for input or output.



The R6522 VIA chip has several versions which vary in processor frequency and operating temperature range, and the chip currently installed in the BBC micro operates at 1 Mhz frequency.

## C.1 The BBC Microcomputer and VIA Addressing

The R6522 VIA is accessed through the BBC microcomputer memory-mapped input/output area 'SHEILA' (memory address range &FE00 - &FEFF ). The BBC microcomputer architecture is designed such that a location address in the interface chip and a location address in RAM are entirely similar in concept.

Each of the addresses allocated for VIA operations corresponds to an R6522 internal register, and four register select lines are normally connected to the BBC microprocessor address bus lines (A0 - A3 in Figure C1). This allows the processor to select the internal R6522 register which is to be accessed, giving sixteen possible combinations for VIA register addressing.

Eight of these combinations are illustrated in Figure C2, where the following VIA abbreviations are used :

IRB	-	Input Register (Port B)
ORB	-	Output Register (Port B)
DDRB	-	Data Direction Register (Port B)
T1	-	Timer 1
T1C-L	-	Timer 1 Counter (Low byte)
T1L-L	-	Timer 1 Latch (Low byte)
T1C-H	-	Timer 1 Counter (High byte)
T1L-H	-	Timer 1 Latch (High byte)
T2	-	Timer 2
T2C-L	-	Timer 2 Counter (Low byte)
T2L-L	-	Timer 2 Latch (Low byte)
T2C-H	-	Timer 2 Counter (High byte)
ACR	-	Auxiliary Control Register
IFR	-	Interrupt Flag Register

**Figure C2 - User Port VIA Registers/ Addressing**

SHELLA ADDRESS (HEX)	VIA REGISTER	WRITE	READ
FE60	IRB/ORB	Write data to 8 I/O lines. Clear CB1 and CB2 interrupt Flags (IFR3 and IFR4)	Read data from 8 I/O lines. Clear CB1 and CB2 Interrupt Flags (IFR3 and IFR4)
FE62	DDRB	Write to Data Direction Register	Read from Data Direction Register
FE64	T1	Write least significant byte (into T1L-L)	Read least signific- ant byte(from T1C-L). Clear T1 interrupt Flag (IFR6)
FE65	T1	Write most significant byte (into T1L-H and T1C-H). Transfer T1L-L to T1C-L. Clear T1 Interrupt Flag (IFR6). Start T1 counting.	Read most significant byte (from T1C-H)
FE68	T2	Write least significant byte (into T2L-L)	Read least signific- ant byte(from T2C-L). Clear T2 Interrupt Flag (IFR5)
FE69	T2	Write most significant byte (into T2C-H). Transfer T2L-L to T2C-L. Clear T2 Interrupt Flag (IFR5). Start T2 counting.	Read most significant byte (from T2C-H).
FE6B	ACR	Write ACR	Read ACR
FE6D	IFR	Write IFR	Read IFR

## C.2 Auxiliary Control Register (ACR)

The ACR selects the operating mode for the two interval timers (T1 and T2) and the Serial Register (SR).

The organisation of the ACR is shown in Figure C3.

Figure C3 - The Auxiliary Control Register

Bit No.	7	6	5	4	3	2	1	0
Name	ACR7	ACR6	ACR5	ACR4	ACR3	ACR2	ACR1	ACR0
	Timer 1 Control		Timer 2 Ctrl.	Shift Register Control			Port B Latch Enable	Port A Latch Enable

The application under discussion uses Timer 1 and Timer 2 Control, and the mode settings for these are shown in Figure C4 overleaf.

Figure C4 - Timer Control Modes

TIMER 1 CONTROL

ACR7	ACR6	MODE
1	0	T1 one-shot mode. Generate a single time-out interrupt each time T1 is loaded. Disable PB7 output.
0	1	T1 free-running mode. Generate continuous interrupts. Disable PB7 output.
1	0	T1 one-shot mode. Generate a single time-out interrupt and an output pulse on PB7 each time T1 is loaded.
1	1	T1 free-running mode. Generate continuous interrupts and toggle the output on PB7.

TIMER 2 CONTROL

ACR5	
0	T2 acts as an interval timer in one-shot mode.
1	T2 counts a predetermined number of pulses on PB6.

### C.3 Interrupt Flag Register (IFR)

The IFR's functions include the detection of up to seven I/O conditions associated with the interval timers (T1 and T2), the control lines (CA1, CA2, CB1, and CB2), and the Shift Register (SR).

The Interrupt Flags within the IFR are shown in Figure C5.

Figure C5 - The Interrupt Flag Register

Bit no.	7	6	5	4	3	2	1	0
Name	IFR7	IFR6	IFR5	IFR4	IFR3	IFR2	IFR1	IFR0
Function	IRQ	T1	T2	CB1	CB2	SR	CA1	CA2

Bits IFR5 and IFR6 are set to 1, when Timer 2 and Timer 1 time-out, respectively.

### C.4 Timers

As noted above, the mode of use of the user port timers, Timer 1 and Timer 2, is controlled by the settings of bits ACR5 - ACR7 of the Auxiliary Control Register.

Each timer consists of 'latches' and 'counters'. The counters are continuously decremented, providing an appropriate 'time-out interrupt' and setting the corresponding interrupt flag (IFR5 or IFR6) in the Interrupt Flag Register.

The latches are used as stores for the 16-bit timing periods, and are copied automatically into the counters, once only for 'one-shot', or repeatedly for 'free-run' operation.

Since the BBC microcomputer uses a 1 Mhz bus system, each timing period can be a maximum of 65.5 milliseconds in length.

## C.5 Timer 2 - One-Shot Operation

In this mode of operation, the timer is set to produce an interrupt flag (IFR5) at the end of the specified period.

Reference Jones(1988), subroutine DELAY (lines 5120-5310) of program VID1 illustrates the use of Timer 2 in this mode to generate a delay of &4700 (i.e. 18176) microseconds. Firstly the IFR is reset to 00 by

```
LDX E00
STX &FE6D
```

The least significant byte of the 16-bit delay viz. 00 is then written into the low latch of Timer 2 by

```
LDA E&00
STA &FE68
```

The most significant byte of the delay viz. 47 is written into the high counter of Timer 2, and Timer 2 is initiated by

```
LDA E&47
STA &FE69
```

The IFR is then read and checked for Timer 2 time-out by the loop

```
.TSTINTD
LDA &FE6D
AND E&20
BEQ TSTINTD
```

## C.6 Timer 1 - One-Shot Operation

Similarly to Timer 2, this mode of operation produces an interrupt flag (IFR6) at the end of a specified period.

However, with Timer 1, when the time-out interrupt occurs, an output on pin PB7 can be enabled or disabled, dependent upon the prior setting of the Timer 1 control bits ACR6 and ACR7 of the Auxiliary Control Register.

Dependent upon the initial state of PB7 (high/ low), a reverse output transition will take place (high to low, or low

to high) for the duration of one VIA chip clock pulse (i.e. one microsecond on the BBC microcomputer).

For example, if a time delay of 2 milliseconds were required, Timer 1 would have to be loaded with the value 2000 (i.e. &07D0).

Firstly the Timer 1 control bits ACR7, ACR6 of the Auxiliary Control Register are set to 1 0 to ensure that Timer 1 is in one-shot mode with PB7 output enabled. This may be done by

```
LDA £&80
STA &FE6B
```

The IFR is then reset to 00 by

```
LDX £00
STX &FE6D
```

The least significant byte of the delay is then written into the low latch of Timer 1 by

```
LDA £&D0
STA &FE64
```

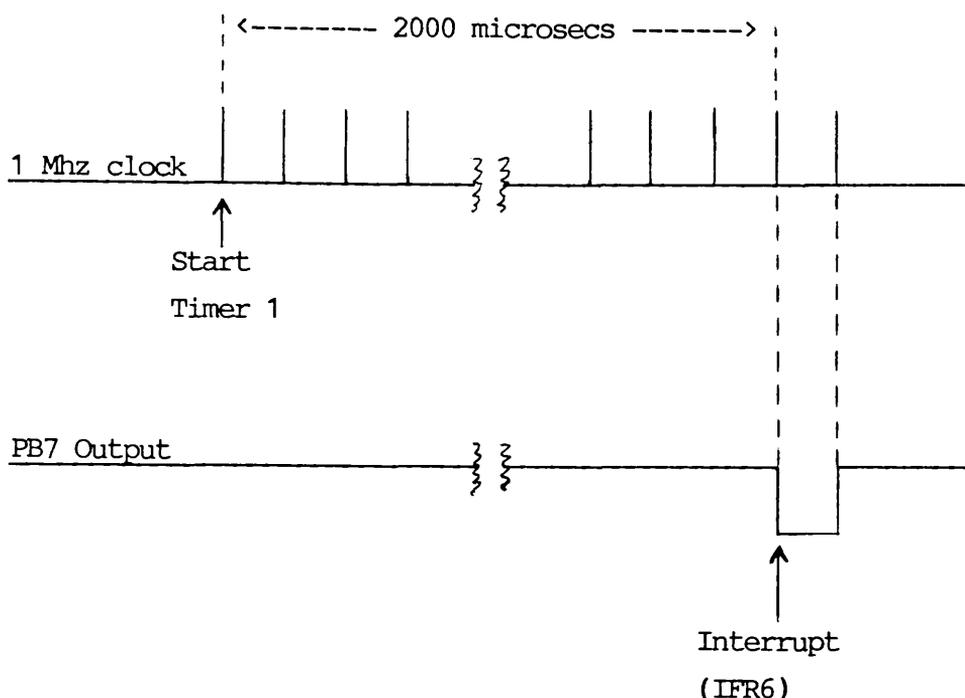
The most significant byte of the delay is then written into the high latch of Timer 1, and Timer 1 is initiated by

```
LDA £&07
STA &FE65
```

After 2 milliseconds, the counter will have reached &0000 and the Interrupt Flag IFR6 will be set.

The operation is shown in Figure C6 overleaf.

Figure C6 - Timer 1 - One-shot Example



In practice, the write timing characteristics of the R6522 VIA are such that there is a maximum overhead of two microseconds with this timer operation. In other words, a more accurate timing operation would be obtained by loading the latches with 1998 i.e. &07CE.

### C.7 Timer 1 - Free-Running Operation

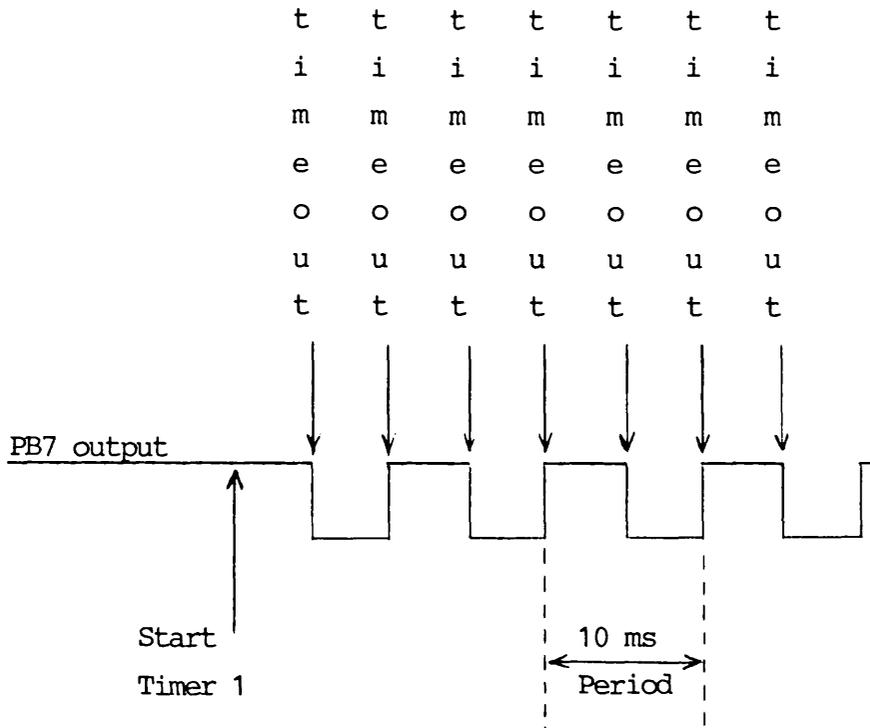
This mode of operation allows a pulse-train to be generated at output PB7, if it is enabled.

The required timing period is loaded into the timer latches, and the timer automatically re-loads this value and sets a new interrupt (IFR6) at the end of every time-out.

If output on PB7 is enabled, then its state will be reversed (high/low or low/high) at each interrupt, and a pulse-train will be generated.

For example, a square-wave pulse-train with a frequency of 100 Hz has a period of .01 seconds i.e. 10 millisecc. This would require Timer 1 to time-out every 5 milliseconds in free-running mode, as illustrated in Figure C7.

Figure C7 - Pulse-train example



Setting up the timer to generate this pulse-train may be done in similar fashion to Timer 1 one-shot operation. However, in this case the ACR is set by storing &C0 in it, and the Timer 1 latches would be loaded with 5000 i.e. &1388. (or more accurately, &1386, due to the timing overhead mentioned above.)

## APPENDIX D

### Summary Description of Microtext 3.3

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## D. SUMMARY DESCRIPTION OF MICROTTEXT VERSION 3

### D.1 Introduction

Microtext is a powerful yet relatively simple-to-use authoring system for the development of interactive educational applications and computer-based training.

A comprehensive description of the facilities of Microtext Version 3 is provided by Bevan and Watson (1983a) and Murray and Bevan(1984).

In early 1985, two versions of Microtext were available for the BBC microcomputer. Version 2 was marketed by Acornsoft Ltd. and was tape- or disk- based at a cost of approximately £50. Version 3, also known as Microtext Plus, was available from the National Physical Laboratory on either disk or EPROM, and cost £287. This latter, professional version, has added facilities for file handling and enables Microtext to make use of the BBC high resolution screen modes. It also allows linkage to user-developed and customised assembly language routines to interface with external devices and peripherals.

A Microtext 'Publishing System' is also available, and allows packages using the authoring system to be produced and published in a secure form. A 'Delivery System' runs encoded Microtext application programs.

Implementations of Microtext are now available for various microcomputer systems - CBM64, Apple IIe, BBC Model B and upwards, Commodore 4000/8000, and machines with the operating systems CPM/80, CPM/86, MSDOS and PCDOS.

### D.2 Microtext Lesson Structure

Microtext is a frame-based authoring system, and an interactive lesson written in it is composed of a series of VDU frames which can be combined together to form lesson modules.

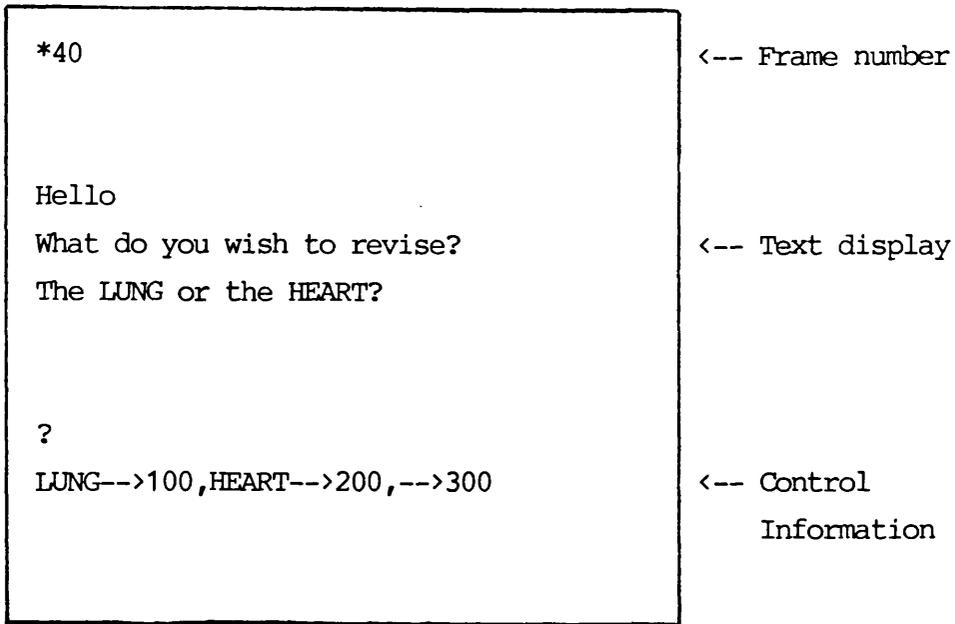
A frame editing facility is included, and can be used to create and modify frames.

A Microtext lesson consists of a series of numbered frames, each of which has the same basic structure. Each frame contains a frame number in the range 1-999, optional text for

display to the student, and control information that is used to specify the direction that the student-computer dialogue should take.

This logical structure of a Microtext frame is shown in Figure D1.

**Figure D1 - Logical Structure of a Microtext Frame**



The control information includes response matching and branching information. Additional frame contents may include comments for program documentation and run-time commands.

Microtext can be used in screen modes 4,6 and 7 on all BBC 'B' microcomputers, and modes 3,1 and 0 are also available in the ROM version.

Figure D2 overleaf shows the screen layout for the available modes.

Figure D2 - Screen Layout for Available Modes

<u>Mode</u>	<u>Text</u>	<u>Colours</u>	<u>Graphics</u>	<u>Extra Memory Requd.</u>
7	40x25	7	80x69	-
6	40x25	2	-	7k
4	40x32	2	320x256	9k
3	80x25	2	-	15k (ROM needed)
1	40x32	4	320x256	19k (ROM needed)
0	80x32	2	640x256	19k (ROM needed)

(The 20-column modes 2 and 5 are not supported)

In practice, the number of lines available for text is less than the values 25 and 32 given above, due to the control line containing the frame number, and to status information and command lines at the foot of the screen.

The Microtext authoring system can function in any one of four operating modes. These are,

- (1) Command Mode,
- (2) Edit Mode,
- (3) Test Mode and
- (4) Run Mode.

The first three modes are used by the lesson author to create, modify and test courseware. The fourth mode is used during student interaction.

Command mode is entered by default when the system is first loaded into the computer. Other modes may be invoked by entering appropriate commands on the microcomputer keyboard.

Figure D3 overleaf provides a summary of Microtext commands.

## Figure D3 - Microtext Commands

### A) Command Mode

COMMENT	FRAME	PRINT
CONTINUE	FREE	RUN
COPY	HELP	SAVE
ERASE	LIST	SUMMARY
EXIT	LOAD	TEST
EXTRA *	NAME	VARIABLES
FETCH *	NEW	<escape>

### B) Run Mode

<u>General</u>	<u>Graphics and Sound</u>	<u>File Handling</u>
\$ALLOW	\$COLOUR	\$EOF *
\$BASIC *	\$GCOL	\$INPUT *
\$CASE	\$PLOT	\$OPENIN *
\$CLEAR	\$MOVE	\$OPENOUT *
\$COMMENT	\$DRAW	\$OPENUP *
\$END	\$POINT	\$OUTPUT *
\$EXIT *	\$TRIANGLE	\$RECORD *
\$FIX	\$ORIGIN	
\$HELP	\$PALETTE	
\$JOIN	\$CHARACTER	
\$LINE	\$SOUND	
\$MARGIN *	\$ENVELOPE	
\$MODE	\$BEEP	
\$NEW		
\$PAUSE		
\$PROMPT *		
\$RANDOM		
\$SCROLL		
\$SUMMARY		
\$TIME		
\$TRACE		
\$WAITCR *		

\* Only available with Microtext Plus (Version 3).

### D.3 Authoring in Microtext

The edit mode of operation allows lessons and frames to be created by the author. A FRAME command is issued, followed by appropriate use of the screen editor, to generate each individual frame in a module.

During editing, the user may enter textual material into a newly created frame, or may rearrange or modify an existing frame. The Microtext editor has a full range of screen editing facilities, including standard cursor control keys and key combinations to allow character or line insertion or deletion. The BBC microcomputer function keys can be used in combination to produce colour effects and to generate teletext characters.

The test mode of operation facilitates testing and debugging. In this mode the program can be started from any point, and execution can be interrupted by means of the 'escape' key. Options available after interruption include - continuing the program, stopping the run, going to a previous or specified frame, editing the current frame, or displaying the variables on the screen. In this mode, the module and frame numbers are continuously displayed at the bottom of the screen, to assist debugging.

The command mode provides a wide range of commands, which may be classified broadly into three types - direct, indirect and extension. Those of the first type are issued directly by the user when operating Microtext in command mode. Those of the second type are used as embedded commands within a lesson module and are executed only when Microtext is in run mode ; all embedded commands commence with a \$ symbol. Commands of the third type can be issued either directly in command mode, or can be embedded and thus executed in run mode to control the student-computer dialogue. Extension commands are discussed further in the next section.

### D.4 Extension Commands within Microtext Version 3

The most significant additional facility provided by this version is that user-defined extension commands can be created. These provide additional run-time commands to extend the capability of the standard Microtext package. The commands are implemented by modules written in machine code and stored on

disk. When required, a module may be loaded by the FETCH command, when the system is in command mode.

A number of demonstration extension commands for which code has already been written were provided on a library disk. These sample commands, e.g. \$ADVAL, \$INKEY, \$CHIN, \$INRS, demonstrated the reading of input data from the analogue port, the keyboard, and the RS423 port.

Creation of new extension commands requires the use of the built-in assembler in BBC Basic, which is described, for example, by Stephenson(1983) and Coll(1982). The module structure has to comply with Microtext design requirements. In particular, the extension command module has to be assembled such that it will load at the bottom of available memory, and it has to contain a command table and an associated command execution vector address table. These tables must comply with a defined format.

A number of Microtext subroutines are provided and may be called within extension command modules. These subroutines are accessed via a jump-table with vectors relative to a base address in Microtext.

A library handler is also available, and allows the writer of extension commands to build up a library of commands in the form of source-code files. However, this was not present in the pre-release Microtext V3 package which was used in Phase 3 of this project.

## APPENDIX E

### Program Descriptions

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All detailed program and coding references in this Appendix relate to program listings in [Jones(1988)].

## E. PROGRAM DESCRIPTIONS

All detailed program and coding references in this Appendix relate to the program listings in [Jones(1988)].

### E.1 Program TEST1 - GENERATE CONTINUOUS 38 Khz CARRIER SIGNAL

This program is written in BBC Assembly Language.

#### Program Description

The program is a test subroutine which was developed to generate a continuous 38 Khz carrier signal on the BBC User Port data pin PB7.

The carrier signal is generated by using the Versatile Interface Adaptor with Timer-1 in free-running mode. (Ref. Appendix C.7).

#### Program Details

The program is assembled into memory addresses &900 upwards - this space is available, being used normally as workspace for RS423 operations. After assembly, the program is run directly by entering the command CALL &900.

Referencing and loading of the VIA Auxiliary Control Register, and the low and high latches of Timer-1 are performed using the OSBYTE call &97 which writes into the memory-mapped input/output area 'SHEILA' [Coll, pp 435-437].

The X-register contains the SHEILA offset address of either the Auxiliary Control Register or Timer-1 latch. The Y-register contains the control byte pattern to be loaded into the Register or latch. The accumulator A contains the OSBYTE call number (&97), and the OSBYTE call is made using JSR &FFF4.

The Timer-1 delay is set to 11 microseconds (lines 240,290), which actually provides a 13 microsecond delay. This is because Timer-1 carries an overhead of two VIA clock cycles, each of 1 microsecond, since the VIA clock runs at 1 Mhz.

The period of the continuous pulsed carrier signal is thus 26 microseconds, and the frequency of the carrier signal is actually 38.61 Khz. (Ref. Appendix C.7).

## E.2 Program TEST2 - GENERATE CONTINUOUS 38 Khz CARRIER SIGNAL

This program is written in BBC Assembly Language.

### Program Description

The program is a test subroutine which generates a continuous 38 Khz carrier signal on the BBC User Port data pin PB7.

The program is an extension of program TEST1 (Ref. Appendix E.1), and the program description and program details of TEST1 are relevant to TEST2.

However, TEST2 differs in two respects. These are,

- 1) TEST2 contains an initialisation routine for the user port (program lines 70-210). This is necessary to ensure not only that PB7 is the only output control line, but also to set PB7 as output low initially. The latter is necessary to comply with the signal transmission code as defined in Section 4.4, which requires the quiescent condition of the signal to be at zero voltage level.
- 2) OSBYTE calls are not used to load the Timer latches etc. Direct writing of byte values (using STA) is made to the required memory mapped input/output area 'SHEILA'.

E.3 Program VID1 - PIONEER LD1100 VIDEODISC PLAYER CONTROL USING  
BBC MICROCOMPUTER KEYBOARD. (Program Version A)

This program is written in a combination of BBC Basic and BBC Assembly Language.

Program Description

The program provides manual control of the videodisc player from the BBC microcomputer keyboard.

Assembly language subroutines send control codes, via the LD1100 player control jack, to drive the player. The control jack is linked to data pin PB7 and the ground pin of the BBC microcomputer user port.

The control codes which may be generated by appropriate subroutine calls are,

PLAY, SEARCH, CHAPTER, FRAME, AUDIOL, AUDIOR, STILLF,  
STILLR, SCANF, SCANR, FASTF, FASTR, SLOWF, SLOWR,  
PAUSE, REJECT, ZERO, ONE, TWO, THREE, FOUR, FIVE, SIX,  
SEVEN, EIGHT, NINE.

The control codes are defined in Section 4.4.

Additional assembly language subroutines (INIT, BRST, SP0, SP1, and DELAY) are used to produce the encoding format for the control signals. These subroutines generate respectively, a 0.263 millisecond burst of 38 Khz carrier signal, a space for 0-bits in the signal transmission code, a space for 1-bits in the signal transmission code, and an 18 millisecond delay between control code repetitions.

The BBC Basic language routine presents a videodisc player control menu. Commands are entered manually by a keypress, and the appropriate assembly language subroutine is called to generate the control code. On return, the control menu is re-presented.

The BBC function keys f0-f9 are re-coded to allow keypresses as follows:-

P - Play  
S - Search  
C - Chapter (Off/On)  
F - Frame (Off/On)  
L - Audio Left (Off/On)  
R - Audio Right (Off/On)  
f0 - Still/Step Forward  
f1 - Still/Step Reverse  
f2 - Scan Forward  
f3 - Scan Reverse  
f4 - Fast Forward  
f5 - Fast Reverse  
f6 - Slow Forward  
f7 - Slow Reverse  
f8 - Pause  
f9 - Reject  
0 to 9 - 0 to 9  
Q - Quit (End program)

A full description of these functions is provided in Section 4.3.1.

### Program Details

#### Subroutine INIT (Lines 690-770)

This subroutine is called once only, from the BBC Basic language routine, and is used to initialise the Versatile Interface Adaptor, and to ensure that initially data pin PB7 is set 'output low'.

#### Subroutine BRST (Lines 4200-4580)

This subroutine generates a 0.263 millisecond burst of 38 Khz carrier signal on user port data pin PB7.

The carrier signal is generated using the Versatile Interface Adaptor with Timer-1 in free-running mode (Ref.

Appendix C.7), and the length of the carrier burst is established using Timer-2 in one-shot mode. (Ref. Appendix C.5).

The subroutine takes 289 microseconds from entry to exit, and the timing considerations are,

a) The 6502 microprocessor of the BBC micro uses a 2Mhz clock, resulting in a 0.5 microsecond machine cycle.

b) The following 6502 instructions are used in the subroutine BRST:

INSTRUCTION	ADDRESSING MODE	CYCLES	EXEC TIME (microsec)
AND	Immediate	2	1
BEQ	Relative (same page)	3	1.5
LDA	Absolute	4	2
LDA	Immediate	2	1
LDX	Immediate	2	1
NOP	Implied	2	1
STA	Absolute	4	2
STX	Absolute	4	2
RTS	Implied	6	3

c) Reference Figure E1 overleaf, timing points and sections are as follows:

Point A - Time 0 (Entry to subroutine BRST).

Section AB - Execution time for program instructions  
4310-4420.

Point B - Start of Timer-2.

Section BC - Execution time for program instructions  
4440-4450.

Point C - Start of Timer-1 free-run and  
start of program loop 4470-4490.

Section DE - Burst of 10 cycles, each of 26 micro-  
second period.

Section BG - Duration of Timer-2 (257 microseconds).

Figure E1 Timing of BRST subroutine (All figures in microseconds)

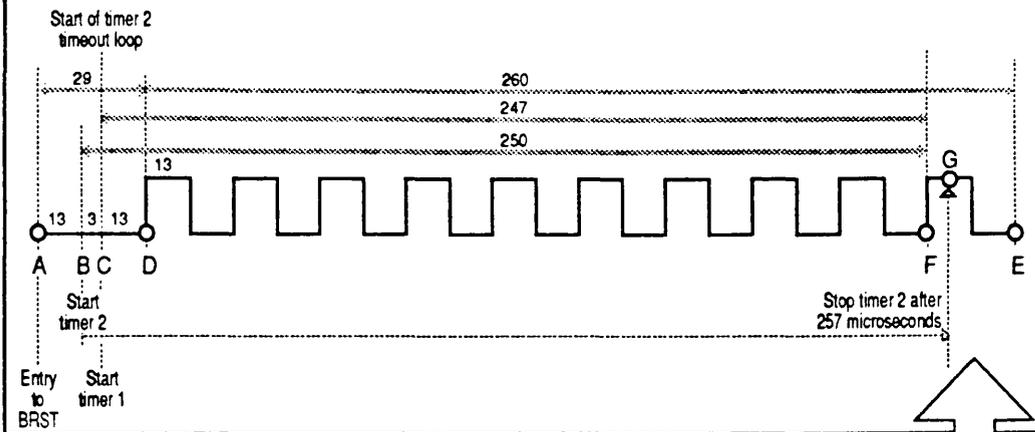


Figure E3  
General timing diagram  
(BRST)

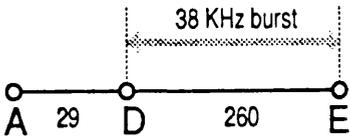
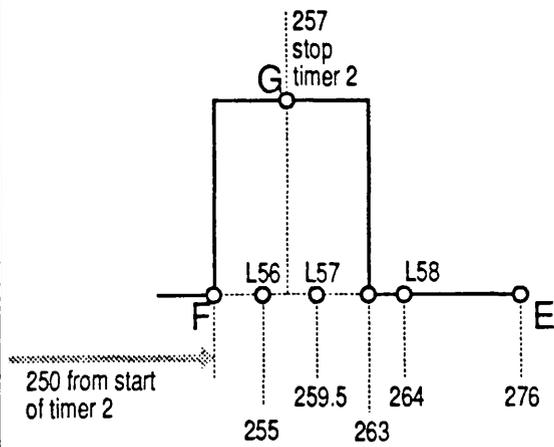


Figure E2  
Detail of timing (section FE)



d) The duration of Timer-2 is critical to allow the generation of the required number of pulses, particularly with reference to the loop timing of instructions 4470-4490. These instructions take 4.5 microseconds for each loop.

Reference Figure E2, and noting that Point F corresponds to 250 microseconds from the start of Timer-2, i.e. 247 microseconds from the start of the loop, then L56, L57, L58 are the timing points of the end of execution of the last (BEQ) instruction in the loop, for iterations 56, 57, 58 respectively. Timer-2 is set to time-out after 257 microseconds, and this will thus be detected during loop iteration 58.

The Section L58-E corresponds to the timing of instructions 4500-4580, with the NOP instructions providing the necessary timing tuning.

e) The general timing for BRST is shown in Figure E3, which should be related to the requirements as described in Section 4.4.

f) The actual frequency of the carrier signal which is generated is given by

$$f = p^{-1} \quad \text{where } p \text{ is the period of the pulses.}$$

$$\text{Since } p = 26 \text{ microsecs, then } f = 26^{-1} \times 10^6 \text{ Hz} \\ \text{i.e. } f = 38.61 \text{ Khz}$$

In practice, this frequency is within the practical margin of error of the Pioneer control signal specification of 38 Khz, to allow the unit to detect the signal.

It is to be noted that, because Timer-1 carries an overhead of two VIA clock cycles per timing operation, the accurate 13 microsecond semi-period is obtained by setting the Timer-1 delay to 11 microseconds. (Program line 4350).

Subroutine SP0 (Lines 4600-4850)

This subroutine generates a 'space' representing a 0-bit in the LD1100 signal transmission code. In this context, a 'space' is denoted by a steady state voltage on user port PB7, for a duration of 755 microseconds.

The duration of the routine is controlled both by instruction timing, and by using the Versatile Interface Adaptor with Timer-2 in one-shot mode. (Ref. Appendix C.5).

The subroutine execution time of 755 microseconds from entry to exit results from the following timing considerations.

- a) Timing for individual 6502 instructions AND, BEQ, LDA, LDX, NOP, STA, STX, RTS is as detailed above for subroutine BRST.

Reference Figure E4, timing points and sections are,

- Point A - Time 0 (Entry to subroutine SP0).  
Section AB - Execution time for program instructions 4690-4760.  
Point B - Start of Timer-2 and start of program loop 4780-4800.  
Section AC - Total duration of subroutine. (755 microseconds).  
Section BD - Duration of Timer-2. (732 microsecs).

- b) As with subroutine BRST, the duration of Timer-2 is critical in relation to the timing of the loop instructions. These instructions are program lines 4780-4800, and again these take 4.5 microseconds for each loop iteration.

Reference Figure E4 overleaf, points L163 and L164 are the timing points of the end of execution of loop iterations 163 and 164 respectively.

Timer-2 is set to timeout after 732 microseconds, and this will thus be detected during loop iteration 164.

The section L164-C corresponds to the timing of instructions 4810-4850 with the NOP instructions providing timing tuning.

Figure E4 Timing of SP0 subroutine (All figures in microseconds)

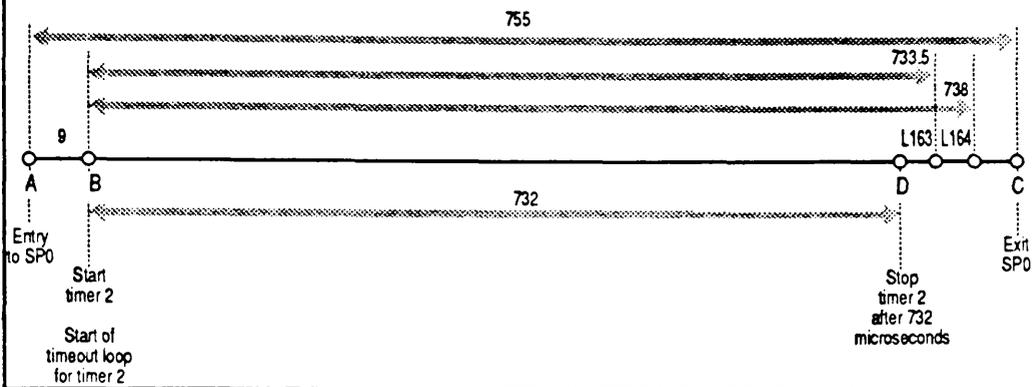


Figure E5 Timing of SP1 subroutine (All figures in microseconds)

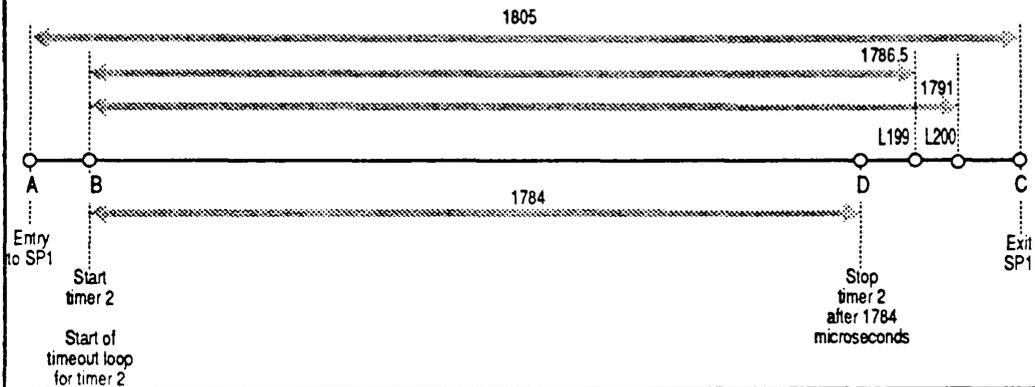
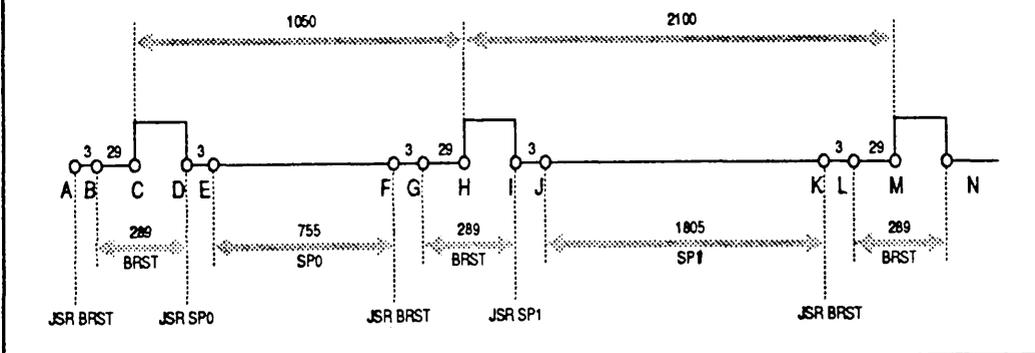


Figure E6 Control code general timing (All figures in microseconds)



Subroutine SP1 (Lines 4870-5090)

This subroutine generates a 'space' representing a 1-bit in the LD1100 signal transmission code. In this case, a 'space' is denoted by a steady state voltage on user port PB7, for a duration of 1805 microseconds.

As with SP0, the duration of this routine is controlled both by instruction timing, and by using the VIA with Timer-2 in one-shot mode. (Ref. Appendix C.5).

The subroutine execution time of 1805 microseconds from entry to exit results from the following considerations.

a) Timing for individual 6502 instructions AND, BEQ, LDA, LDX, NOP, STA, STX, RTS is as detailed above for subroutine BRST.

b) Reference Figure E5, timing points and sections are,

Point A - Time 0 (Entry to subroutine SP1).

Section AB - Execution time for program instructions 4960-5030.

Point B - Start of Timer-2 and start of program loop 5050-5070.

Section AC - Total duration of subroutine.

(1805 microseconds)

Section BD - Duration of Timer-2. (1784 microsec).

c) As with subroutines BRST and SP0, the duration of Timer-2 is important in relation to the loop timing. The loop instructions are program lines 5050-5070, and again these take 4.5 microseconds for each iteration.

Reference Figure E5, points L199 and L200 are the timing points of the end of execution of iterations 199 and 200 respectively.

Timer-2 is set to timeout after 1784 microseconds, and this will thus be detected during loop iteration 200.

The section L200-C corresponds to the timing of the STX and RTS instructions (5080,5090).

Subroutine PLAY (Lines 820-930)

This subroutine generates the control code 0011010000 for the LD1100 player. The control code digits are generated by jumps to appropriate subroutines as follows:

0 - JSR BRST : JSR SP0

1 - JSR BRST : JSR SP1

The control code is terminated by a delimiting burst, i.e. by JSR BRST.

The following points relate to timing. (Ref. Section 4.4, Figure 4) :

a) Figure E6 illustrates the generation of two consecutive control code bits, 0 and 1.

Timing points and sections are,

- Point A - Start of execution of JSR BRST instruction.
- Section AB - Execution time for JSR instruction.
- Section BCD - Execution time for subroutine BRST.  
(Ref. Figures E1,E3)
- Point D - Start of execution of JSR SP0 instruction.
- Section DE - Execution time for JSR instruction.
- Section EF - Execution time for subroutine SP0.
- Point F - Start of execution of JSR BRST instruction.
- Section FG - Execution time for JSR instruction.
- Section GHI - Execution time for subroutine BRST.
- Point I - Start of execution of JSR SP1 instruction.
- Section IJ - Execution time for JSR instruction.
- Section JK - Execution time for subroutine SP1.
- Point K - Start of execution of JSR BRST instruction.
- Section KL - Execution time for JSR instruction.
- Section LMN - Execution time for subroutine BRST.

Section CH - Corresponds to the 1.05 ms bit period for logic 0, as defined in Section 4.4, and shown in Figure 4.

Section HM - Corresponds to the 2.1 ms bit period for logic 1, as defined in Section 4.4, and shown in Figure 4.

- b) Repetition of the control code was found to be necessary, to ensure recognition by the Pioneer LD1100 player. Thus the PLAY command is generated 10 times in the subroutine, with each repetition followed by an 18 millisecond delay, which is provided by subroutine DELAY.

#### Other Control Code Generation Subroutines (Lines 950 to 4180)

The other subroutines SEARCH, CHAPTER, FRAME, AUDIOR, AUDIOR, STILLF, STILLR, SCANF, SCANR, FASTF, FASTR, SLOWF, SLOWR, PAUSE, REJECT, ZERO, NUMB1, TWO, THREE, FOUR, FIVE, SIX, SEVEN, EIGHT, NINE have similar structures to subroutine PLAY.

It was established during program testing that different commands required different numbers of repetitions, to allow predictable recognition by the player. In particular, if the FRAME command was repeated more than three times, then multiple recognition by the player could occur, resulting in two or more FRAME operations being performed by the player. Again, in relation to the numeric control codes, a repetition of five was found necessary - a smaller value could result in non-recognition by the player, and a larger value could result in multiple recognition by the player.

The coding for these subroutines, together with the PLAY subroutine, could be made more elegant by having the functions incorporated within a larger, more general control code generation subroutine. This subroutine would require to decode a passed parameter byte containing the low order bits of the required control code, and then make the necessary JSR's to subroutines BRST, SP0, SP1, and DELAY. However, this would require significant modification to BRST, SP0 and SP1 to maintain the timing integrity which is illustrated in Figures E1, E2, E4, E5, E6.

### Subroutine DELAY (Lines 5100-5310)

This subroutine generates an 18 msec (actually 18.19 ms) delay, and is used by the control code generation subroutines PLAY, SEARCH, etc., to provide a delay between control code repetitions.

The delay time is established mainly by using the VIA with Timer-2 in one-shot mode to control the delay timing. Timer-2 is set to timeout after 18176 microseconds, and the balance of the delay time is provided by instruction timing.

### General points relating to Program VID1

The machine code part of the program is assembled at memory locations &7400 upwards - this space is available, being normally reserved for high resolution graphics.

The label for subroutine NUMB1 is so named, since 'ONE' gives a BBC Basic syntax error, being interpreted as an 'ON' instruction.

E.4 Program VID2 - INTERFACING ROUTINES FOR PIONEER LD1100  
VIDEODISC PLAYER AND BBC MICROCOMPUTER.

This program is written in BBC Assembly Language.

Program Description

The program consists of all the assembly language subroutines contained within program VID1. (Lines 660 to 5320). A comprehensive description of these subroutines is given in Appendix E.3.

The program is assembled into RAM addresses &7400 upwards, and is saved as machine code program 'VID2OBJ' on disc, using the \*SAVE command of the BBC microcomputer.

The routines within this program can subsequently be re-loaded into the original addresses, by any BBC Basic application program. This may be done by incorporating a program statement \*LOAD "VID2OBJ" within the application program.

E.5 Program VID3 - PIONEER LD1100 VIDEODISC PLAYER CONTROL USING  
BBC MICROCOMPUTER KEYBOARD. (Program Version B)

This program is written in BBC Basic.

Program Description

The program provides manual control of the videodisc player from the BBC microcomputer keyboard.

The program is entirely similar in function to program VID1 (Appendix E.3), with VID3 providing the corresponding Basic language routine. However, in this case, the necessary assembly language subroutines are contained in a separate machine code program VID2OBJ, which is loaded initially into locations &7400 upwards, by the \*LOAD "VID2OBJ" instruction at program line 250. (Ref. Appendix E.4).

The addresses for subroutine calls from program VID3 are established by program lines 270-530.

E.6 Program VID4 - APPLICATION PROGRAM LINKAGE PROCEDURES  
TO VID2OBJ.

This program is written in BBC Basic.

Program Description

The program consists of linkage procedures which call machine code routines contained in the separately-loaded module 'VID2OBJ'.

The program VID4 may be included in any Basic language application program which uses the Pioneer LD1100 videodisc player.

The linkage procedures are,

PROCINIT, PROCPLAY, PROCSEARCH, PROCCHAPTER, PROCFRAME,  
PROCAUDIOL, PROCAUDIOR, PROCSTILLF, PROCSTILLR,  
PROCSCANF, PROCSCANR, PROCFASTF, PROCFASTR, PROCSLOWF,  
PROCSLOWR, PROCPAUSE, PROCREJECT, PROCPLAYSEQ, and PROCDELAY.

with functions as follows:

PROCINIT	- Set addresses for machine code calls
PROCPLAY	- 'Play' command
PROCSEARCH(FR)	- Search for video frame 'FR'
PROCCHAPTER	- 'Chapter' toggle command
PROCFRAME	- 'Frame' toggle command
PROCAUDIOL	- 'Audio Left' toggle command
PROCAUDIOR	- 'Audio Right' toggle command
PROCSTILLF	- 'Still/Step Forward' command
PROCSTILLR	- 'Still/Step Reverse' command
PROCSCANF	- 'Scan Forward' command
PROCSCANR	- 'Scan Reverse' command
PROCFASTF	- 'Fast Forward' command
PROCFASTR	- 'Fast Reverse' command
PROCSLOWF	- 'Slow Forward' command
PROCSLOWR	- 'Slow Reverse' command
PROCPAUSE	- 'Pause' command
PROCREJECT	- 'Reject' command (Stop player)
PROCPLAYSEQ(S,E)	- Command to play from frame 'S' to frame 'E'
PROCDELAY(D)	- Provide delay of 'D' hundredths of a second

## Program Details

### PROCINIT (Lines 8420-8760)

This procedure establishes the addresses for calls made to the machine code interfacing routine VID2OBJ, which is loaded at program line 5.

The VIA is then initialised by CALL INIT, before the procedure returns.

### PROCSEARCH(FR) (Lines 8820-9100)

The procedure accepts a passed parameter 'FR' which is an integer video frame number.

A 'search' command is made via CALL SEARCH, then the individual digits of FR are stored in the five elements of array D, with D(4) containing the 'units' digit, D(3) the 'tens' digit etc. Thereafter, CALLs are made to the appropriate machine code routines ZERO, NUMB1, TWO, ....., NINE, corresponding to the digit sequence of the required frame number. Finally, another CALL SEARCH is given, to provide the search to the required frame.

The calls to the machine code routines are separated by a delay (of six hundredths of a second), to ensure timely recognition by the player.

### PROCDELAY(D) (Lines 9760-9800)

The parameter (D) passed to this procedure is the delay-time required, in hundredths of a second.

The procedure simply uses the BBC Basic pseudo-variable TIME to set and check the delay.

### PROCPLAYSEQ(S,E) (Lines 9680-9740)

This procedure provides a sequential videodisc play sequence from a start-frame S to an end-frame E.

First of all, PROCSEARCH is called to search to the start-frame S. This is followed by a delay of two seconds to allow time for the physical search to be made by the player.

The PLAY command is then given via PROCPLAY, and procedure PROCPLAYSEQ establishes the delay-time necessary for the video sequence, on the basis that the sequential play rate is

25 frames per second.

PROCDELAY is then called, to provide the necessary delay.

Procedures PROCPLAY, PROCCHAPTER, PROCFRAME, etc.

The remaining procedures in VID4 simply CALL the appropriate machine code subroutine.

General points relating to Program VID4

The program VID4 consists of program lines 4,5,7999 and 8000-9800. This allows a Basic application program using these procedures to have line numbers in the range 10 to 7990, for practical purposes.

Line 4 sets HIMEM to &73F0, thereby protecting the loaded module from being overwritten by the Basic stack of the application program.

An ASCII version of VID4, viz. VID4SP, was created on disc using the BBC microcomputer \*SPOOL command. This allows subsequent ease of merging of these procedures into a Basic application program, using the BBC micro \*EXEC command.

This program is written in BBC Basic.

### Program Description

This is a demonstration program using the Pioneer LD1100 videodisc player, and a test videodisc viz. the University of London Programme Development Videodisc, 1984.

The program uses histological slides (Frames 30101 to 30123) to demonstrate the use of interactive video techniques, particularly those involving the presentation of individual still frames.

A major aim in the development of this program was to validate programs VID4SP and VID2OBJ. (Ref. Appendices E.6 and E.4).

A series of histological slides (9 in number, x56 magnification) is presented for student recognition. The student is allowed up to three attempts to identify the organ shown in the slide. A correct response results in an encouraging comment being presented to the student. If an incorrect response is received, and matches with another slide on the videodisc, then that slide is displayed, along with a remedial message. Thereafter the original slide is presented again for identification. The correct answer is provided to the student after three erroneous attempts at identification of a particular 'target' slide. The student's score is maintained, and is presented at the end of the program.

The program uses procedures which are merged into program lines 8000 upwards, from a separate ASCII program file, 'VID4SP', which was stored on disc. (Ref. Appendix E.6).

The procedures within VID4SP are used to call machine code routines to control the videodisc player. The machine code routines are contained in a module 'VID2OBJ' which is initially loaded at program line 5. (Ref. Appendix E.4).

The particular frames (slides) used for identification within the program are,

<u>Frame</u>	<u>Organ</u>
30101	Ileum
30103	Stomach
30105	Lung
30107	Trachea
30111	Kidney
30117	Tongue
30119	Liver
30121	Testes
30123	Uterus

### Program Details

Procedure PROCQUESTION (lines 1130-1490) presents each question, then accepts and checks the student's response. For the purpose of this demonstration program, comprehensive input validation is not carried out, nor is free-format input accepted. Keyword recognition of input is limited to matching the first three keyboard input characters with the first three characters of the above organ names. More comprehensive free-format, case independent input checking could be developed.

Frame 30090 (line 580) is a blank video frame, and is used by the program to provide a black background for the superimposed program-generated text, if a mixed output is used on a single screen.

This program is written in BBC Basic.

### Program Description

This is a demonstration program using the Pioneer LD1100 videodisc player, and a test videodisc, viz. the University of London Programme Development Videodisc, 1984.

The program uses a nursing sequence on 'Moving the Acute Spinal Injured Patient', (frames 45100 to 53360), to demonstrate the use of interactive video techniques, particularly those involving the presentation of video sequences and sub-sequences.

A main aim in the development of this program was to validate programs VID4SP and VID2OBJ, in relation to the playing of video subsequences.

The program initially presents the full video sequence of the nursing technique for moving an acute spinal injured patient. The student is then presented with a series of questions on the technique. When a question is answered correctly according to the input of certain keywords, the student is given an encouraging comment. When a question is answered incorrectly, a randomly generated message is presented to the student, and a remedial video subsequence is shown. Thereafter the original question is repeated, until the student answers correctly.

The program uses procedures which are merged into program lines 8000 upwards, from a separate ASCII program file, VID4SP, which was stored on disc. (Ref. Appendix E.6).

The procedures within VID4SP are used to call machine code routines to control the videodisc player. The machine code routines are contained in a module 'VID2OBJ', (Ref. Appendix E.4), which is initially loaded at program line 5.

## Program Details

Certain operations involving the videodisc player require time for completion, and program VID6 uses procedure PROCDELAY several times, to establish the appropriate delay time (in hundredths of a second). Examples of this are shown at line 530 (after PROCPLAY), at line 550 (after PROCSEARCH), and at line 2920 (after PROCSEARCH).

Frame 49130 (referred to in line 540) is a blank video frame, and is used by the program to provide a black background for the superimposed program-generated text, if a mixed output is used on a single screen.

The message given to the student who enters an incorrect response, is randomly selected from five messages (lines 2550,2560).

Procedure PROCSRCH-KEYWORD (lines 2010-2060) searches for the occurrence of a particular passed parameter keyword, anywhere in the input response string. The procedure is used in procedures PROCQ1, PROCQ2, ... PROCQ10 (lines 1610-2000) in checking the responses to Questions 1, 2, ..., 10 respectively. These procedures PROCQ1 - PROCQ10 only search for the occurrence of one or two individual keywords, but could be made more comprehensive by incorporation of case-independent routines, and routines to search for combinations of multiple keywords.

E.9 Program VIDM2 - INTERFACING ROUTINES FOR PIONEER LD1100  
VIDEODISC PLAYER AND BBC MICROCOMPUTER.  
(Microtext Extension Command Module)

This program is written in BBC Assembly Language.

Program Description

This program is a Microtext extension command module (Ref. Appendix D ), consisting of assembly language subroutines which allow programs written in Microtext to control a Pioneer LD1100 Videodisc Player.

The subroutines send control codes, via the LD1100 player control jack, to drive the player. The control jack is linked to data pin PB7 and the ground pin of the BBC microcomputer user port.

This extension command module is the Microtext-based equivalent of program VID2 (Ref. Section E.4 ) and contains similarly-coded subroutines. For example, the Microtext extension command \$INIT relates to the VID2 subroutine INIT, and there is a similar correspondence for commands \$PLAY, \$SEARCH, \$FRAME etc.

There is one anomaly, in that the corresponding command to the PAUSE call of VID2, is named \$HOLD. This is because \$PAUSE is already a run-time Microtext command. (Ref. Appendix D).

An additional command, \$LOOK, has no equivalent within VID2, and is described below.

Program Details

\$LOOK Command

The command \$LOOK invokes a subroutine (lines 5060-5820) to look for a specified video frame. This allows a Microtext application program to give a command \$LOOK nnnnn where nnnnn is the required frame number.

Subroutine LOOK gives a search command (via JSR SEARCH) then examines each of the parameter digits nnnnn in turn, and calls (via JSR's) the appropriate sequence of subroutines ZERO,

NUMB1, TWO, ....., NINE to generate the player control codes.

Subroutine LOOK also uses a Microtext subroutine NSPGET in the decoding of the parameter. NSPGET gets the next non-space character from the current Microtext command line, and returns it in the accumulator.

Subroutine LOOK finally gives another JSR SEARCH to seek to the desired frame.

### Other Subroutines

Other subroutines contained within the module are BRST, SP0, SP1, and DELAY, and correspond exactly to those within programs VID1 and VID2. (Ref. Appendices E.3 and E.4).

An additional subroutine, IDLE, is used within the module, to generate a 65.5 millisecond delay between control code repetitions, and is similar in structure to subroutine DELAY.

The program is assembled and saved as a machine code extension command module X.VIDM2EX on disc, using the \*SAVE command of the BBC microcomputer.

The start address for the machine code assembly is given by AUXTAB=PAGE, where PAGE corresponds to the bottom of available memory (normally &1900 for ROM-based Microtext with a standard disc configuration).

The base address of ROM-based Microtext is defined at line 480, and the address of subroutine NSPGET is defined at line 560, vectored relative to the base address START of Microtext.

The Microtext command table (lines 650-1230) and the table of action addresses (lines 1250-1530) are defined according to the format described by Murray and Bevan.

E.10 Program VID.M3 - PIONEER LD1100 VIDEODISC PLAYER CONTROL  
USING BBC MICROCOMPUTER KEYBOARD.  
(Microtext Version)

This program is written in Microtext.

Program Description

The program provides manual control of the videodisc player from the BBC microcomputer keyboard.

The program is entirely similar in function to program VID3 (and program VID1). (Appendices E.5, E.3).

However, in this case the necessary Microtext extension command module X.VIDM2EX ( Appendix E.9 ) is loaded initially, before VID.M3 is run, using a Microtext 'FETCH X.VIDM2EX' command.

There is a minor difference from VID3 in processing, in that the function keys are re-coded to ASCII codes 100 upwards, for input command keypresses.

This program is written in Microtext.

Program Description

This program is a Microtext version of program VID5 (Appendix E.7) and is similar in function, but contains some additional processing features.

The student is presented with the same sequence of histological slides for identification, as in program VID5. Again the student is allowed up to three attempts to identify the organ shown in the slide.

In this program, a correct response results in not only an encouraging comment being presented to the student, but also two identifying features of the slide being described to the student. The features are identified on the slide using superimposed program-generated text and Teletext graphics.

If an incorrect response is received, the student is presented with a remedial message, followed by an identifying feature of the slide, as a hint. The original question is then presented again to the student.

If an incorrect response is received which matches with another slide on the videodisc, then that slide is displayed together with a remedial message, and followed by an identifying feature of that slide. Thereafter an identifying feature of the original slide is displayed, before the original question is asked again. All identifying features are described using text, and Teletext graphics.

The correct answer, together with two identifying features, is provided to the student after three erroneous attempts at identification of a particular target slide.

The student's score is maintained, and is presented at the end of the program.

### Program Details

The sections of Microtext program VID.M5 are labelled with the same procedure names as program VID5, to provide legibility and ease of comparison with the program structure of VID5.

Due to the features of Microtext input response matching, viz. case-independent and with automatic keyword searching within input character strings, it can be seen from Microtext Frame \*370 that the keyword matches required are - ILE, STOM, LUN, TRA, KID, TON, LIV, TEST and UTER for the respective organs presented.

Microtext Frames \*900 to \*985 contain the identifying features, presented in Teletext graphics.

This program is written in Microtext.

Program Description

This program is a Microtext version of program VID6 (Appendix E.8 ), and is similar in function, but contains a few additional processing features, detailed below.

Program Details

The sections of Microtext program VID.M6 are labelled with the same procedure names as VID6, to provide legibility and ease of comparison with the program structure of VID6.

The keyword matches for correct responses are shown in Microtext Frames \*350 - \*378. For example, Frame \*364 will accept any of the characters 1 or ONE or I in the input string as correct, providing that a leading and a trailing blank are present i.e.

b1b    bONEb    bIb

Frame \*364 illustrates the test for the occurrence of at least one of a multiple number of keywords, viz. SPINE or LUMBAR or CURVE.

Frame \*374 illustrates the use of the Boolean operator & in the matching of two keywords in the input string.

In all the above cases, any of the input characters could be in lower case. Microtext converts to upper case before performing input string matching.

The handling and storage of summary items is illustrated in Frames \*110, \*385, \*390, and \*750. In Frame \*750, all previous summary items denoted by \*\* will be saved on disc with a filename of <NAME> i.e. of the student's initials, and may be subsequently printed out using the \$SUMMARY PRINT command, in Microtext author mode.

Standard Microtext contains no arithmetic operations or functions other than simple addition and subtraction, and it was not possible to include a general routine within the

program which would allow calculation of the delay time necessary for sequential video play from frame X to frame Y. The delay is calculated as  $(Y-X)*10/25$  tenths of a second, and this was manually calculated and inserted to allow its use within a \$PAUSE <DELAY> command. Microtext Frames \*200 and \*250 - \*270 provide illustrations of this feature.

The use of the \$PAUSE command is satisfactory, provided that the delay required is less than, or equal to, 25.5 seconds, i.e. 255 tenths of a second, due to the byte size restriction of the counter used by the command.

Larger delays require the use of the \$TIME Microtext command within a programmed loop - Frames \*200 - \*220 illustrate a simple loop which provides a delay of 330 seconds, the full video sequence time.

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