Revolutionary Technology

An introduction to the video and digital audio disc

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Preface

'Stereo sound and colour television pictures plucked off a spinning silver disc by a laser beam.' A few years ago this would have been science fiction, rather than a line from an advertisement for the Laservision optical video disc system. Add some type of autochanger and you can have almost non-stop television with stereo sound and broadcast quality pictures. Add a microprocessor and you have an interactive system for use in training and education. Use the 45 000 still-frame capability of some discs and you have a data-retrieval system second to none. All this and more is promised by the versatile video disc.

Without doubt the initial appeal of the video disc to the manufacturers was that the mass consumer market wanted a low-cost, simple device to replay television programmes at leisure. If, as was promised, video discs had arrived in the early 1970s they might have met this need, but with their launch in the 1980s they have to battle against an ever-increasing number of videocassette recorders, which have the advantage of being able to record as well as play back programmes, something no commercial domestic video disc is yet able to do. The promise of very cheap software for video discs has also taken a considerable knock from a development that ten years ago nobody foresaw – short-term or even overnight hire of video tapes on a huge scale.

The market is now seen to be evolving in two somewhat contradictory directions: domestic use with a low unit cost for both hardware and software; and an interactive device coupled to a microprocessor to enable very complex and effective teaching programmes to be created, with the penalty of far higher unit cost. Perhaps the bridge between these areas could be moderately priced domestic systems to be used with home computers for education and game playing. But it is possible that this divergence will stimulate the development of two or more incompatible systems – one for home and the other for professional use. Such a development could confuse the issue and the consumer further, as will the emergence of the three incompatible domestic players, one American, one Japanese and one European.

This book looks at the background to video discs in general, and then at the technical details of the three major competing systems. The applications for both domestic and industrial tasks are covered, as are some of the possibilities of interactive programming. For those interested in providing software for video discs we examine some unusual constraints, which are not found in ordinary film or tape production. The final chapter describes the compact digital audio disc, which uses a variation on the Laservision technology.

For all the undoubted technological magic of the video disc it is as well to remember that it is simply a means of storing and disseminating information, and that its success or failure depends entirely on whether the electronics giants feel it will be a financial success or not. So by putting the disc into perspective we should be able to moderate our enthusiasm for the technology and concentrate on developing ever-more interesting and rewarding uses for the video disc.

A final technical point: as this book was written in the UK, all the specifications given are for the PAL 625-line system unless otherwise stated. Figures for the NTSC player will of course be different.

Acknowledgements

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Any errors or omissions are, of course, the responsibility of the author.

D.K.M.

Contents

1

Introduction and background

The concept of the video disc is not new, or even of recent origin. In fact the first patent for a video disc was filed in London on 15 October 1926 and was for a system called Phonovision. The authors of the patent were none other than Television Ltd and that indefatigable pioneer of television, John Logie Baird.

In 1926 Baird was broadcasting experimental transmissions of his 30-line mechanical television system and it seems probable that Phonovision was seen as being a useful way in which consumers could use their apparatus when Baird was not transmitting. It could also have provided a mechanism by which Baird could store a copy of the images he transmitted. The Phonovision disc system was very simple, consisting of a 12-inch (30 cm) shellac disc, the grooves of which were modulated not by sound but by the 13 kHz bandwidth television pictures. Although Baird's television system was fast-scan – 12½ pictures per second with no interlacing – the 30 lines gave it a very reduced bandwidth, as well as a very low resolution. The sound was to have been recorded in a separate groove to the vision, and retrieved by a separate pick-up. In fact the stylus assembly would have had two points, one for sound and one for vision. The original Phonovision patent shows that the discs were intended to be replayed on a normal record player, the output of which was to be fed to a standard Baird Televisor, of which around 20 000 were in use in the mid 1930s.

In 1928 Baird patented an elegant but simple video disc player (Fig. 1.1). In this the record player turntable also acted as the scanning disc of the Televisor and so the problems of drifting synchronisation were eliminated. As far as is known,

289,104 COMPLETE SPECIFICATION 1 SHEET

[This Drawing is a reproduction of the Original on a reduced scale]

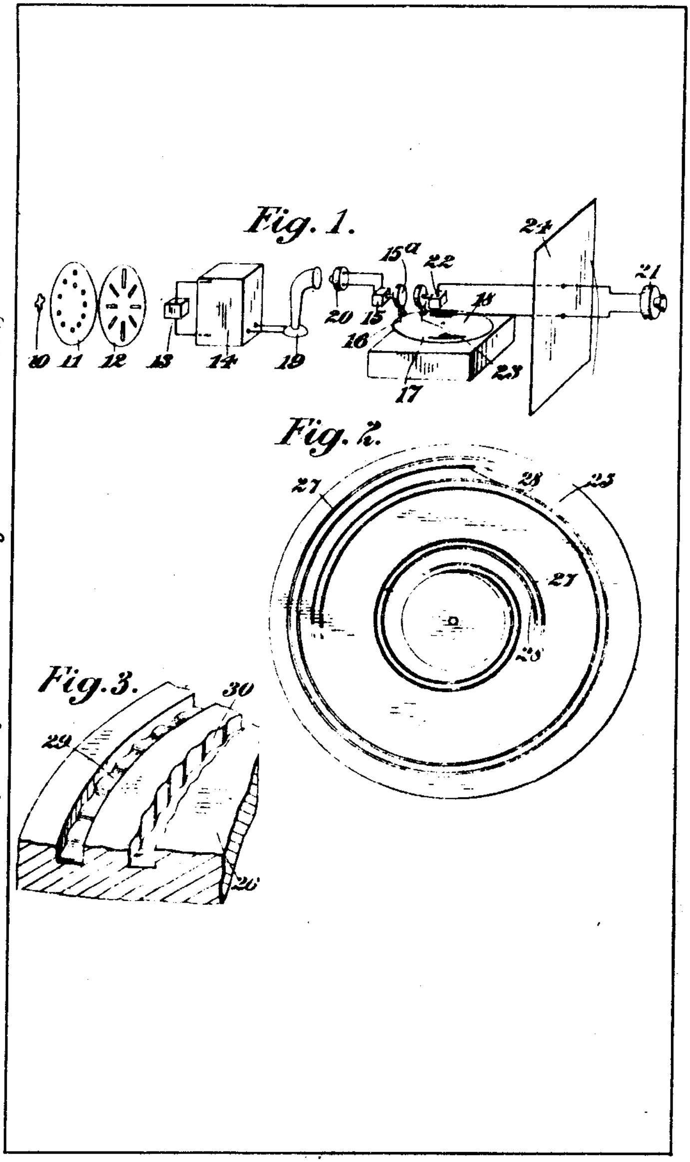

Fig. 1.1. Patent for the Baird video disc player

none of these players was ever offered for sale. However, a variation of the Baird disc was offered in Selfridges in London in June 1935, for 7 shillings (35p), by the Major Radiovision Co (Fig. 1.2). The double-sided mute disc contained a variety of pictures and ran for six minutes per side. In November 1936 the BBC, which had taken over Baird's experimental television transmissions in August 1932, launched the EMI 405-line all-electronic television system and in February 1937 the mechanical Baird system was dropped.

Fig. 1.2. Advertisement for a mechanical video disc system from the 1930s

Interest in video discs was then to remain dormant until the mid 1950s, when electronic television was developing in both Europe and the USA. Two different and somewhat opposing stimuli drove engineers back to video discs: the need for the broadcasters to have some type of instant replay, slow-motion device; and the vast untapped consumer market, to which the idea of 'video records' could be made to seem attractive. In 1955 Ampex were still working on their two-inch Quad broadcast black and white VTR prior to its launch in 1956, and the video cassette was unheard of. The idea of still frames, slow motion and fast motion from a helical scan VTR was inconceivable. But a magnetic disc, tracked by a precision pick-up head which could repeat or skip frames at will – that seemed more feasible, even though it would only be capable of storing about 30 seconds of colour television pictures and no sound.

The result was the broadcast disc player recorder type HS 100, of which the BBC Television Centre in London purchased the first example in the UK in autumn 1968. Capable of replaying pictures at any speed between still frame and double speed, the HS 100 worked by continuously recording, erasing and recording the last 36 seconds of signal fed to it. Rapid access to any part of the disc was possible, with a maximum access time of about 4½ seconds. The technology which made this possible was about the size of a large filing cabinet and needed a special vibration-free room to stand in – a far cry from a modern Laservision player.

From the technical standpoint the HS 100 was based on magnetic recording and playback, the actual recording being made on the four faces of two nickel-cobalt/rhodium alloy discs. These 16-inch (40 cm) diameter discs ran at 3000 rev/min, thus giving one television field per revolution. This is an important point to grasp, as all current domestic disc systems that offer still-picture and fast- and slow-motion effects rely on recording a discrete number of fields, usually two, per revolution. With the HS 100, still frame was produced by continually scanning a single track, while half speed was obtained by scanning every track for two revolutions of the disc.

It is important to understand that slow motion is obtained by the repetition of television fields that were recorded at the correct rate. While this allows the user to decide which scenes to have at slow speed after the initial recording there is a penalty to pay. With film slow motion, the 'recording' is done at a rate which is faster than normal and the film is then projected at the normal 25 frames per second. That is, film shot at 125 frames per second and projected at 25 frames per second gives one-fifth slow motion. This means that more information is recorded in a given time and so definition is not reduced on replay. However, with the HS 100 and all subsequent disc players, slow motion involves a loss of definition, as information is 'stretched out' to fill a required time slot. This loss of definition means that very fast motion will appear jerky, or may even vanish on slow motion. For instance, a balloon bursting cannot be slowed down and seen exploding, as it is too fast an event. All that will be seen is a whole balloon that immediately turns to ragged remains because the actual explosion is much shorter than the television 'exposure' time. This problem is still with us in all disc players.

While the broadcast fraternity were developing the HS100 (which is now obsolete), a number of groups, large and small, were experimenting with various disc systems for domestic use. Some of these were, to say the least, obscure, if not positively bizarre, while some others, such as the Philips VLP (video long play), have undergone a long gestation period to emerge as Laservision. Before we go on to examine some of these systems it is worth considering how the 40 or so disc systems that have existed over the last 20 years can be classified in terms of the technology employed.

Mechanical systems are the simplest of the four main ways of getting signals off a disc and it was such a system that both Baird, with Phonovision, and the first true commercial disc system, Teldec, used. Both depended on a stylus tracking a modulated spiral groove in a manner rather like a normal audio LP. Mechanical systems have the advantages of low-cost, simple technology and a degree of robustness not found in some of the more sophisticated systems. It is equally true that they suffer from limitations of the picture quality and life of the discs. There is now no commercial disc system based on mechanical playback.

Capacitive disc systems are next in ascending order of complexity and cost, and have been developed by a number of companies over the years. These rely on information being encoded as capacitance variations in the disc which are detected by a stylus on replay. The stylus acts as the 'other plate' of the capacitor. A number of variations in replay technology are possible, including grooved track-following and electronic grooveless systems. These are represented today by the RCA's CED and JVC's VHD systems respectively. It seems unlikely that a capacitive system which offers recording as well as playback could be developed for home use.

Optical systems are, currently, the most complex of the domestic disc players but they also offer the most interesting features and best picture quality. A number of systems have been developed, some using lasers and other incandescent light sources to retrieve the signals from the disc. Some have been of a transmissive nature, whilst others have relied on reflected light. The Laservision system is of the latter type. Experimental optical players have been demonstrated which use the same laser to record information, as well as playing it back. Discs made of transparent plastic, floppy photographic film and metallised plastic have all been demonstrated.

Magnetic disc players, which have already been mentioned, have been adapted for broadcast use. On the domestic front, experimental magnetic recorder/replay units have been demonstrated, but none has reached the market place. The technology seems to offer the best possibilities for recording, playback and erasure on a single domestic unit, but it appears that no major group is researching this aspect at present.

There are, then, four discrete types of technology which are applicable to domestic video discs – mechanical, capacitive, optical and magnetic. Before we go on to examine the three current commercial systems – RCA's capacitive disc, JVC's capacitive disc and Philip's Laservision optical disc – we will set the scene by looking at the first commercial, colour-capable domestic video disc, Teldec, and then briefly look at some of the various attempts to produce viable disc systems.

Teldec

It was in Berlin in June 1970 that three companies demonstrated what they called 'the world's first video disc for monochrome recording' – presumably they were conveniently forgetting the work of J.L. Baird. AEG-Telefunken and Decca had formed a joint subsidiary called Teldec to develop this video disc system which was demonstrated in colour in August 1971. The commercial launch in West Germany was in 1974 and 1975 saw a change of name to TeD and the addition of stereo sound, but by 1980 the system had disappeared from the commercial scene. Although obsolete, the simplicity of Teldec makes it ideal as an introduction to understanding some of the problems that all disc systems have to overcome.

The Teldec disc was 210 mm in diameter, 0.1 mm thick and made of polyvinyl chloride (PVC). In other words it was a floppy disc, very similar in appearance to the audio discs sometimes given away in magazines. A single frame was recorded in each revolution, giving a rotational speed of 1500 rev/min, and in keeping with the audio record industry a ratio of 2:1 was used for the ratio of diameter of the outer to inner grooves. This leads to 140 grooves per millimetre for a 25-frames per second, 625-line picture and hence a playing time of five minutes. In 1973 this was increased to ten minutes per side by a rearrangement of the disc pressing technique.

The groove spacing on the original system was only 7.3 μm, and 'hill and dale' modulation was employed. This was the system that Edison used on his phonograph, but which was displaced by the lateral modulation system that is used on current audio LPs. Rather than direct recording, a carrier of constant amplitude is frequency modulated by the video signal. Because of this, only crests and troughs of constant height are engraved in the microgrooves. The disc in fact does not rest on a turntable but, being almost weightless, floats on a cushion of air which is forced up under the disc by the drive motor (see Fig. 1.3). A central vertical shaft holds the disc in

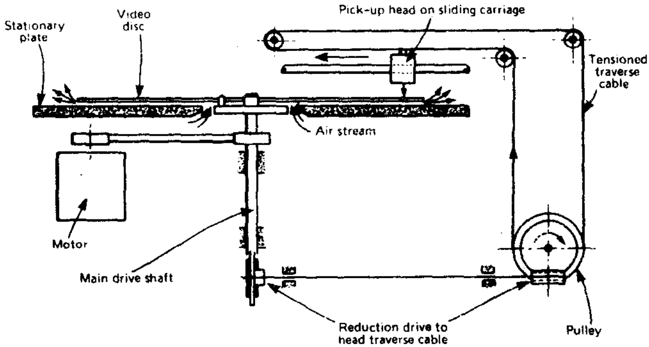

Fig. 1.3. Mechanical arrangement for the Teldec or TeD video disc system

place. We have already noted that a mechanical stylus is used to retrieve the signals from the disc but, bearing in mind the very small size of the grooves, it is not surprising that the Teldec stylus is rather different from that found on a normal audio record deck. Remember that the groove is only 0.007 mm wide and 0.001 mm deep – the crests and troughs formed by the signal in the groove are the same order of magnitude as the wavelength of visible light – and that the disc moves at a velocity of 16.1 metres per second. Incredibly, the groove on a single side of a Teldec disc is about 3.5 km long!

So it can be seen that the engineering problems to be overcome are quite formidable. Part of the solution was the revolutionary new pick-up made of diamond and shaped rather like a sled runner. The diamond is bonded to a piezo ceramic transducer, which transforms pressure fluctuations generated by the groove waves into an electrical signal. The stylus is about four signal crests in length and is pressed down on to the disc by the pick-up arm. The grooves modulate the stylus and the output signals are fed to the electronic circuits of the player.

In common with some, but not all, domestic disc systems the bandwidth of Teldec was less than that of a normal TV signal and so various tricks have to be employed to get a recoverable colour TV signal from the disc. As this problem is common to most domestic video systems we will look at it in more detail.

A normal PAL colour signal has a bandwidth of about 5.0 MHz, which is beyond the capabilities of all domestic video recorders and disc systems, apart from the Laservision optical system. As with an ordinary audio reel-to-reel recorder, the faster the tape speed the better the frequency response. That is why VTRs use a rotary video head system to get a high writing speed – about 4 metres per second. Even so, this gives a bandwidth of only about 3 MHz, still less than the 5 MHz that a broadcast signal requires. Broadcast VTRs can record and replay the full bandwidth signal by using even higher writing speeds, but for domestic use a system called 'colour-under recording' has been developed. In this the full bandwidth signal has the colour component, which in PAL is centred around 4.43 MHz, filtered off from the luminance, which in turn is filtered and limited to about 3 MHz. The chroma signal is then divided down to around 600 kHz and recorded under the luminance signal. On replay it is multiplied up by the same factor, giving a normal PAL signal. Admittedly the exact relationship of line frequency to subcarrier frequency has been lost and the resolution has been reduced but for domestic use the results are acceptable. RCA's CED and JVC's VHD both use variations of this theme.

Teldec used a colour-under frequency of 500 kHz which, with the luminance component, fits into the 2.8 MHz bandwidth of the system. However, they also adopted a unique sequential colour system, initially developed for broadcast VTR users, called TRIPAL. This is a line sequential system in which delay lines, filters and electronic switches are used in the master disc recorder to produce sequential red, green and blue signals.

On replay, the stylus produces a composite vision plus sound signal of about 20 mV amplitude, from which the audio is filtered off and demodulated separately. The HF luminance of the video is amplified, demodulated and fed to the matrix adder. The LF chroma is fed to the TRIPAL switch. Since each colour – red, green, blue – is recorded on a line-by-line sequential basis, two delay lines of 64 μs (1 line) duration are used to make all three chroma signals available to the switch simultaneously. From these the standard B-Y and R-Y colour difference signals are developed and fed to the quadrature modulator. This 4.43 MHz modulated chroma signal is then combined with the luminance in the adder to form a standard PAL signal. The audio signal is also frequency modulated and recorded along with the vision signal, being filtered out on replay. The sound and vision signals are then combined and sent to the UHF modulator for feeding to a standard TV aerial socket. Mastering Teldec discs is done via the normal audio disc pressing system, although the discs are stamped from a continuous sheet of PVC. The actual copper blank is cut at only 60 rev/min instead of the replay speed of 1500 rev/min in order to improve the picture quality.

Although relatively robust, production versions of Teldec discs were housed in protective sleeves, from which they were extracted automatically by the player after loading. This system is employed by CED and VHD, and is indicative of the relatively low immunity to physical damage inherent in all mechanical or pseudo-mechanical disc systems. Teldec also demonstrated an 'auto-changer' version of the player capable of taking three different lengths of programme, with a change time of less than one second between discs.

Due to the contact nature of the system, true still frame – repetition of a single groove – was not possible. After all, the design life of the disc was only 1000 plays, which would be used up in about 45 seconds of still play. A 'repeat' function was possible to allow a series of 25 grooves (frames) to be repeated, giving about one second's worth of picture. In Europe in 1976 the player sold for the equivalent of about £120 and discs cost around £2.50.

The engineering problems that the Teldec team overcame are those that face the manufacturers today. The commercial problems – limited and rather expensive software – they failed to beat and the system died. These, too, are the problems that Philips, JVC and others need to take on and overcome today.

I/O Metric

We have already said that over 40 different systems have been developed to various states of completeness over the years, and brief details of these are given in the Appendix. One system which never reached the market is particularly significant, and that is the film-based optical system from the American I/O Metric Corporation (Fig. 1.4). The elegance of this system, which used photographically reproducible discs and an ordinary incandescent light bulb as the player detector, was noteworthy. From the outset I/O Metric aimed their product not just at the consumer market, which had been Teldec's goal, but also at the industrial and commercial sectors. Today it is these areas which are seen as being prime targets for the application of disc technology.

The use of optical non-contact technology enabled a range of stop motion, rapid access and other visual effects to be

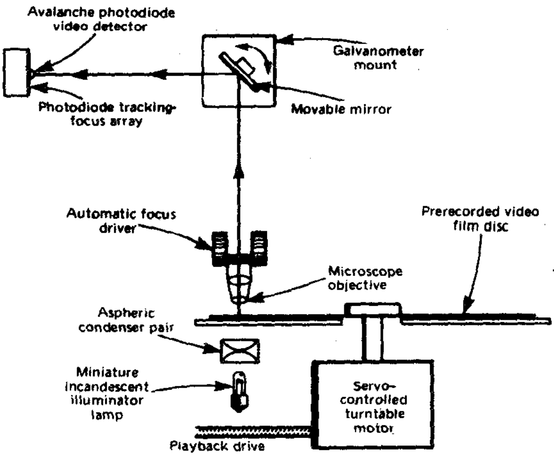

Fig. 1.4. Block diagram of the I/O Metric optical disc player

produced, with no lifetime limit to the disc, thus making it ideal for archival use. The film-based discs were produced by exposing a master disc to the modulated light of a low-power laser. The disc could then be photographically developed in under ten minutes in an automated film processor. After development it could be immediately replayed or else used to produce further copies by a simple contact printing process. All the expensive mastering techniques of Teldec – or the current systems – with their attendant multi-stage master-mother-daughter pressings and so on, were therefore bypassed.

Physically, the disc was 33 cm in diameter and contained a continuous spiral video track of 2.7 μm pitch, thus giving a playing time of around 20 minutes. As the discs were essentially single-sided, increased playing time was obtained by sandwiching several discs together and refocusing the scanning light from one disc to the next. I/O Metric at one point demonstrated a four-disc sandwich with 80 minutes of playing