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Lieberfarb et al.

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[54] **SYSTEM AND METHOD FOR DISK SOFTWARE PUBLISHERS TO CONTROL DISK DISTRIBUTION**

Attorney, Agent, or Firm—Gottlieb, Rackman & Reisman

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[57] ABSTRACT

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A system for allowing software publishers to control which video standard(s) can be recovered from an optical disk containing video source material. The disk may be digitally encoded so that any of NTSC, PAL and other video signal standards can be generated upon proper decoding. But the disk also includes a code which can lock out one or more standards. Players for such disks may be capable of generating video signals according to all popular standards, in which case the user selects a desired standard. However, the player will generate a video signal of the selected standard only if there is an appropriate authorization code on the disk. The system allows manufacture of "universal" players without necessarily impacting the contractual and marketing plans of motion picture companies, for example, which release films in different territories at different times. The control technique can be extended to lock out specific territories. Each player has a built-in territory code. The player will play a disk only if the disk contains an authorization code for the player's specific territory.

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[52] U.S. Cl. **348/5.5; 348/441; 380/5**

[58] Field of Search **380/3, 4, 5, 20; 348/5.5, 441, 443, 558, 555**

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Primary Examiner—Stephen C. Buczinski

8 Claims, 11 Drawing Sheets

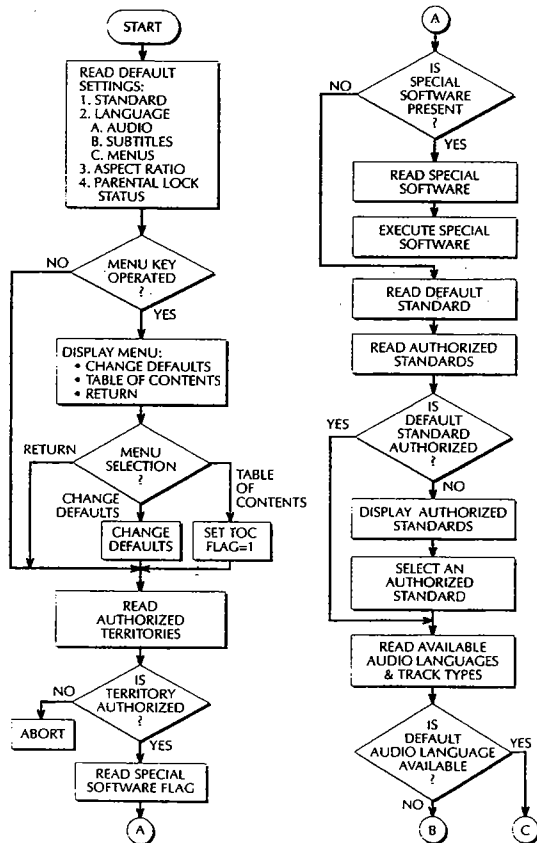


FIG. 1

PRIOR ART

VHS PLAYER

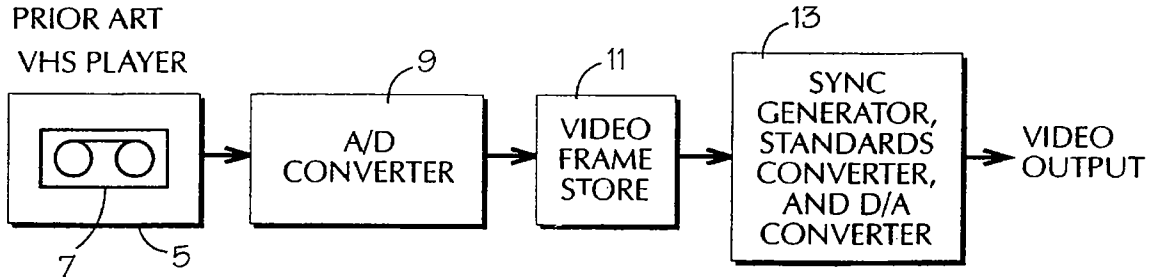


FIG. 8

PRIOR ART

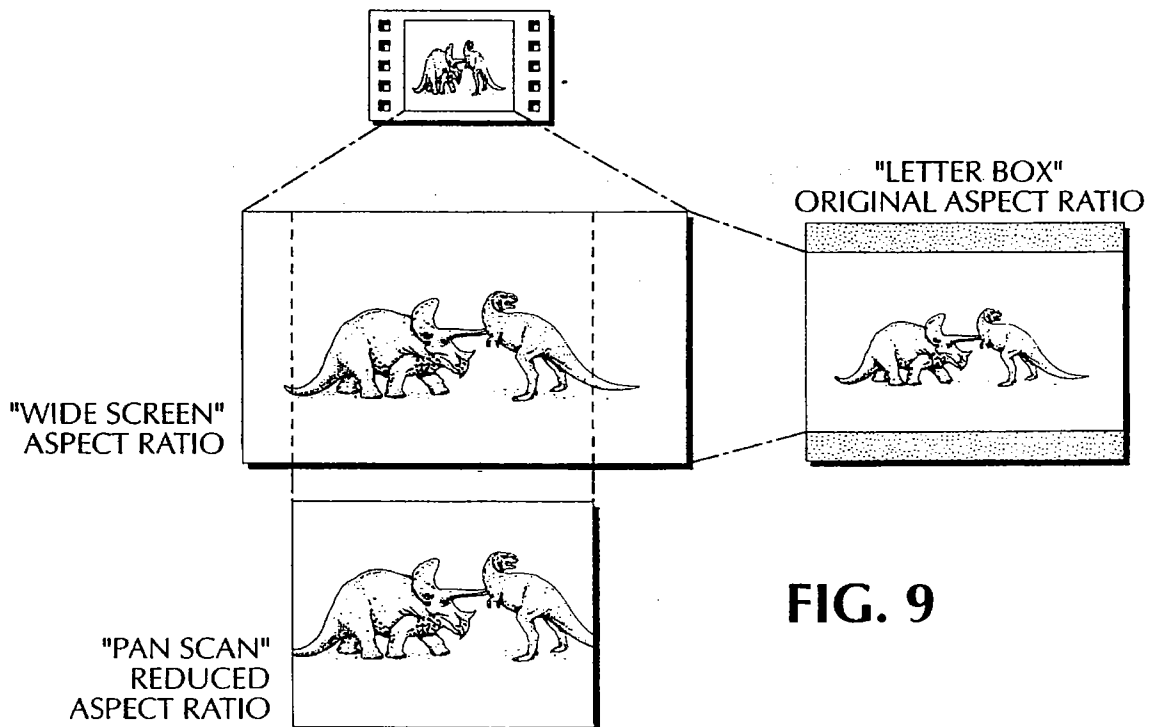
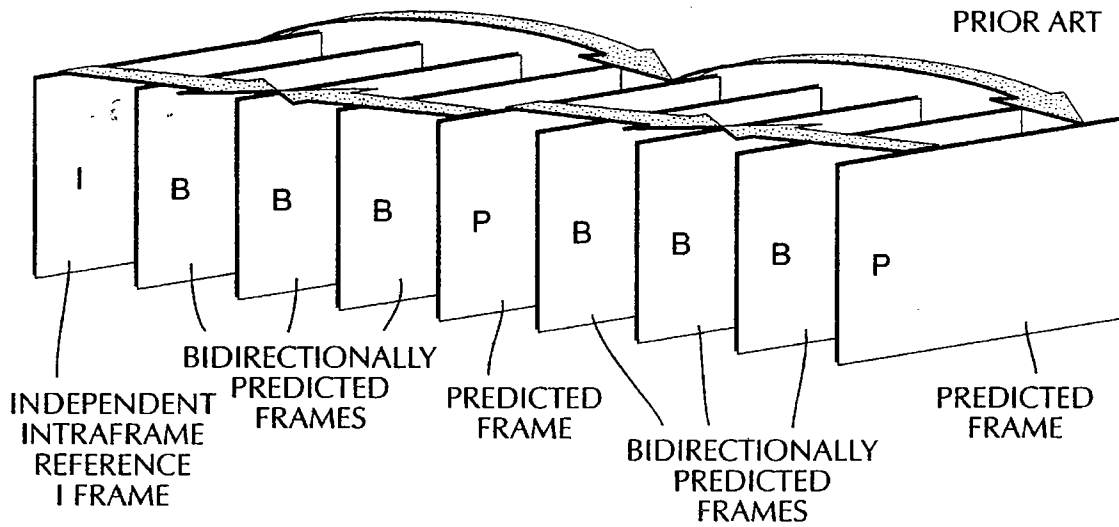


FIG. 9

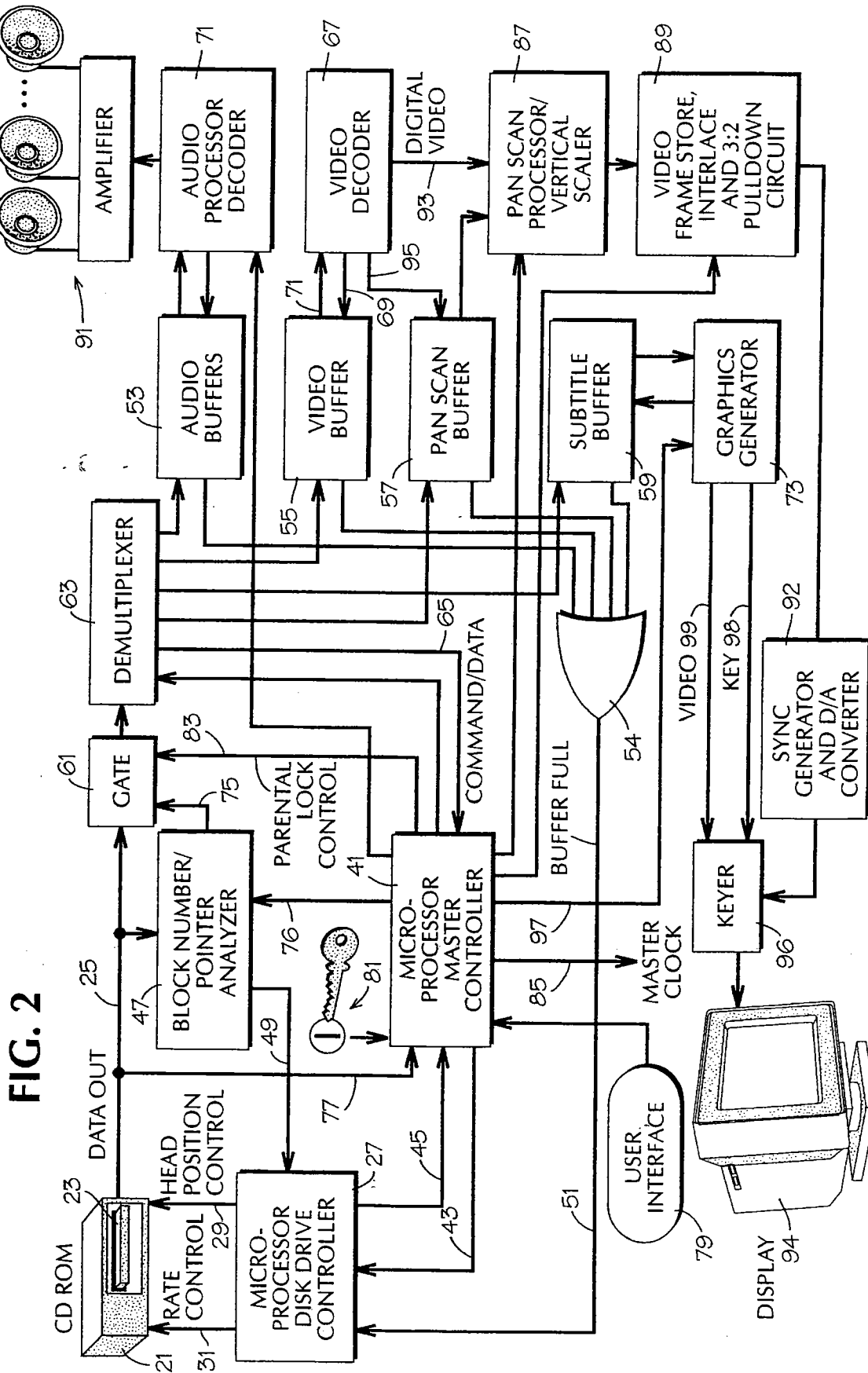


FIG. 3

BITS					
	MIN	MAX			COMMENTS
1			LEAD-IN SYNC BITS		
2	40	40	AUTHORIZED TERRITORIES		
3	1	1	SPECIAL SOFTWARE FLAG		
4	0	UNDET	SPECIAL SOFTWARE W/ENDING SYNC WORD		
5	12	12	AUTHORIZED STANDARDS		
6	100	100	AVAILABLE AUDIO LANGUAGES, M&E PLUS 99		N "1"s, MAX 16
7	0	48	TRACK TYPES		N x 3
8	0	64	TRACK CODING		N x 4
9	6	6	NUMBER OF "OTHER" AUDIO TRACKS		M = 0 TO 63
10	0	252	CODING FOR "OTHER" AUDIO TRACKS		M x 4
11	100	100	AVAILABLE DISPLAY LANGUAGES		P "1"s, MAX 99
12	1	1	SPECIAL MIXING/DELETION SOFTWARE FLAG		
13	0	UNDET	SPECIAL MIXING/DELETION SOFTWARE W/ENDING SYNC WORD		
14	0	UNDET	P x M STRINGS EACH ENDING WITH ESC CHARACTER		
15	100	100	AVAILABLE SUBTITLE LANGUAGES		R "1"s, MAX 99
16	4	4	MULTIPLE VERSION CODE		
17	1	1	SPECIAL VERSION SOFTWARE FLAG		
18	0	UNDET	SPECIAL VERSION SOFTWARE W/ENDING SYNC WORD		
19	1	1	VIDEO AVAILABILITY FLAG		
20	1	1	BASE ASPECT RATIO		
21	1	1	PAN SCAN AVAILABILITY		
22	20	20	TOTAL NUMBER OF DATA BLOCKS		
23	0	20	NUMBER OF DATA BLOCKS IN VERSION A		
24	0	20	NUMBER OF DATA BLOCKS IN VERSION B		
25	4	4	ORIGINAL FRAME RATE		
26	10	10	BLOCK TIME FACTOR		
27	0	UNDET	TABLE OF CONTENTS FOR FIRST VERSION FOR EACH CHAPTER: 8-BIT CHAPTER NUMBER 20-BIT STARTING BLOCK SERIAL BLOCK NUMBER 20-BIT BLOCK DURATION OF CHAPTER AVAILABLE CHAPTER DISPLAY LANGUAGES (100 BITS) LANGUAGE STRINGS IDENTIFYING CHAPTERS, EACH ENDING WITH ESC CHARACTER		
28	0	UNDET	TABLE OF CONTENTS FOR SECOND VERSION		
29	100	1200	ENCRYPTED AUTHORIZATION CODE FOR EACH STANDARD W/ENDING SYNC WORD		
30	1	1	DATA BLOCK COMMAND/DATA FLAG		
31	1	1	SUPPLEMENTAL SOFTWARE FLAG		
32	0	UNDET	SUPPLEMENTAL SOFTWARE W/ENDING SYNC WORD		

FIG. 4

BITS				COMMENTS
MIN	MAX			
1	32	32	SYNC WORD	
2	20	20	SERIAL BLOCK NUMBER	
3	2	2	VERSION (A,B OR COMMON)	
4	0	2	2-BIT POINTER FLAG	
5	0	20	POINTER	
6	0	1	VIDEO PRESENT FLAG	
7	0	UNDET	VIDEO BLOCK W/ENDING SYNC WORD	
8	0	16	AUDIO TRACKS PRESENT	X "1"s, MAX=16
9	0	UNDET	X AUDIO LANGUAGE BLOCKS, EACH ENDING W/ESC CHARACTER	
10	0	63	"OTHER" AUDIO TRACKS PRESENT	Y "1"s, MAX=63
11	0	UNDET	Y "OTHER" AUDIO TRACK BLOCKS, EACH ENDING W/ESC CHARACTER	
12	0	99	SUBTITLE UPDATES PRESENT	Z "1"s, MAX=99
13	0	UNDET	Z SUBTITLE UPDATE BLOCKS, EACH ENDING W/ESC CHARACTER	
14	0	1	PAN SCAN UPDATE FLAG	
15	0	9	PAN SCAN UPDATE	
16	0	1	COMMAND/DATA PRESENT FLAG	
17	0	UNDET	COMMAND/DATA BLOCK ENDING W/ESCAPE CHARACTER	

FIG. 5A

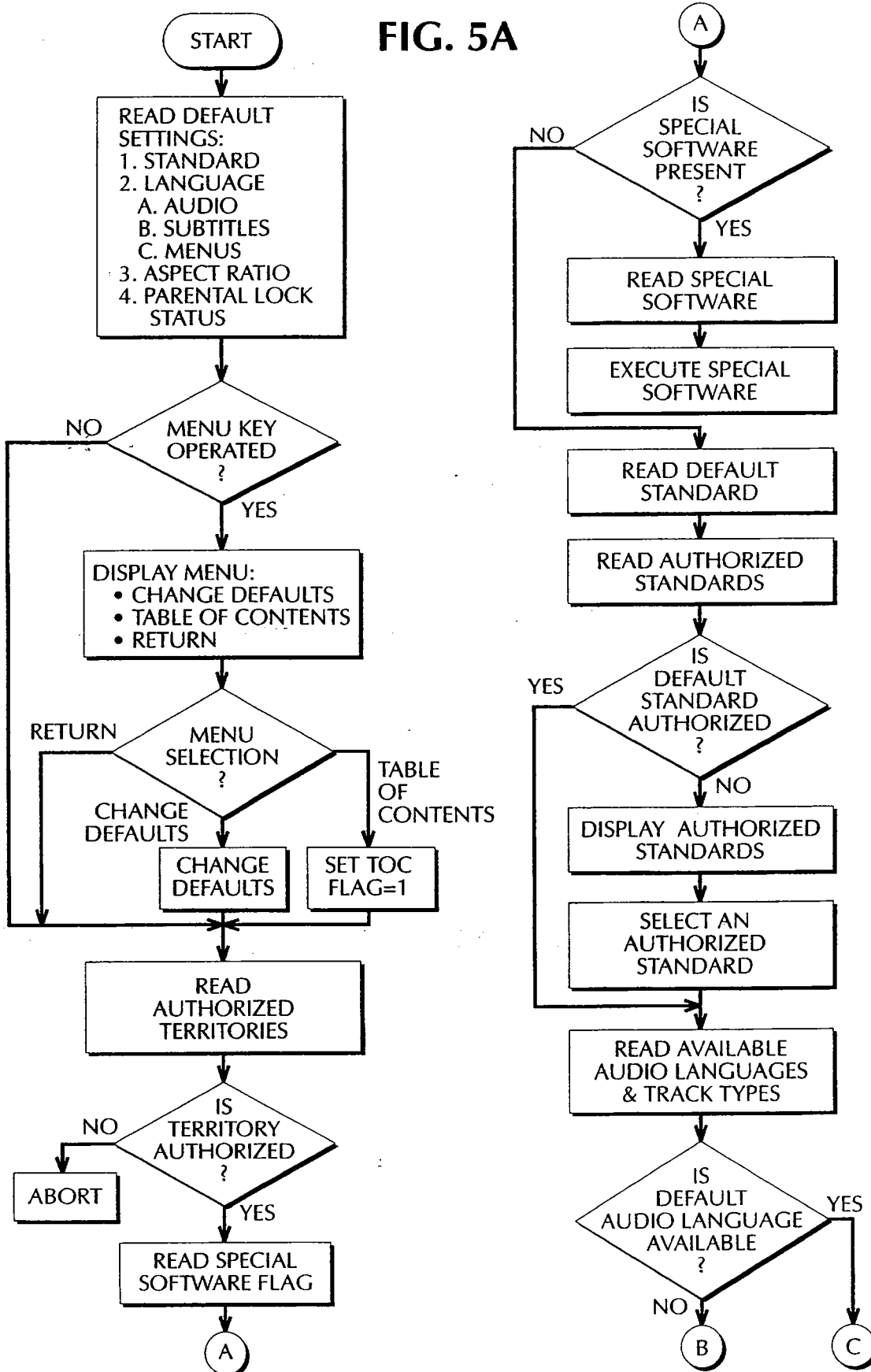


FIG. 5B

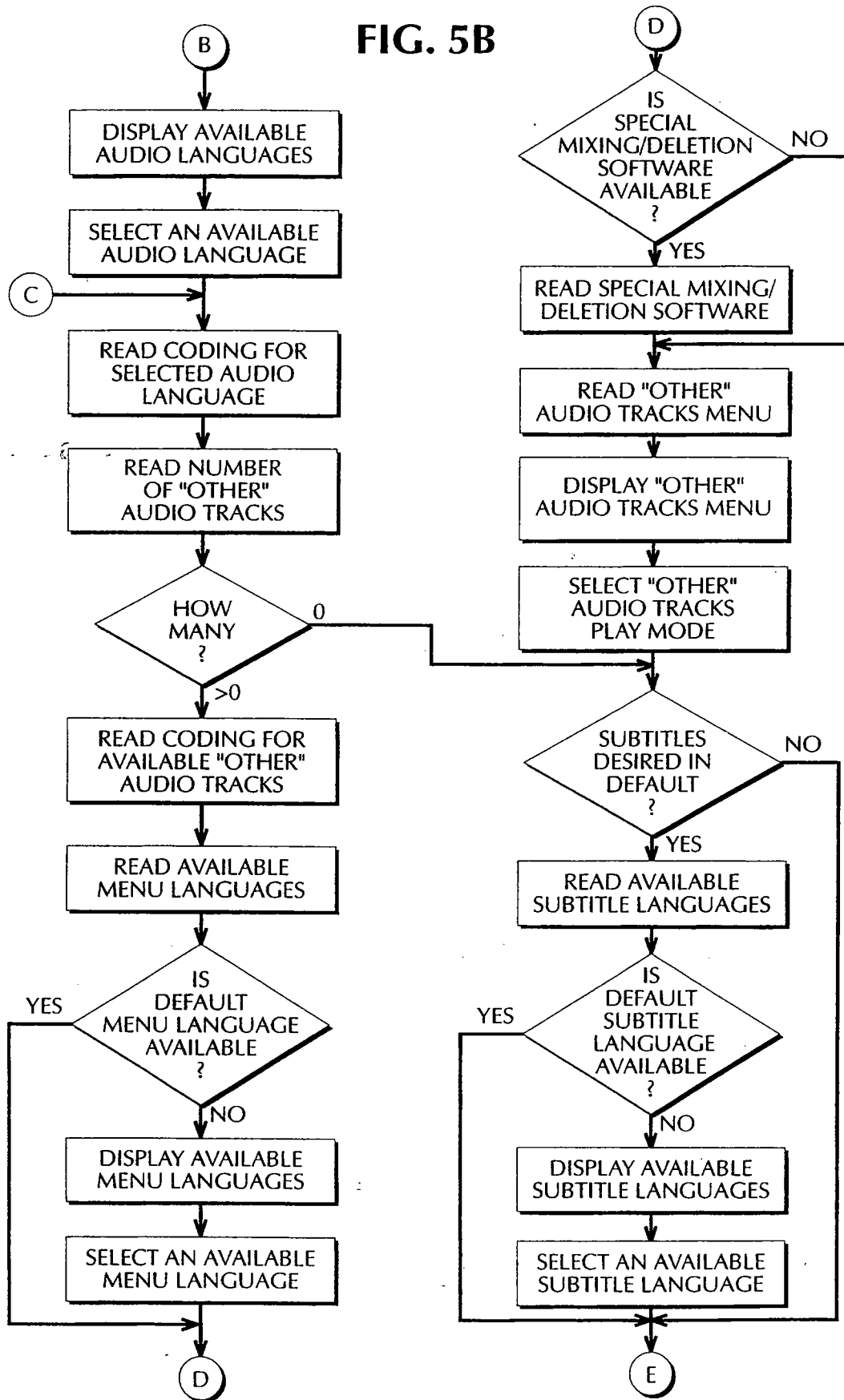


FIG. 5C

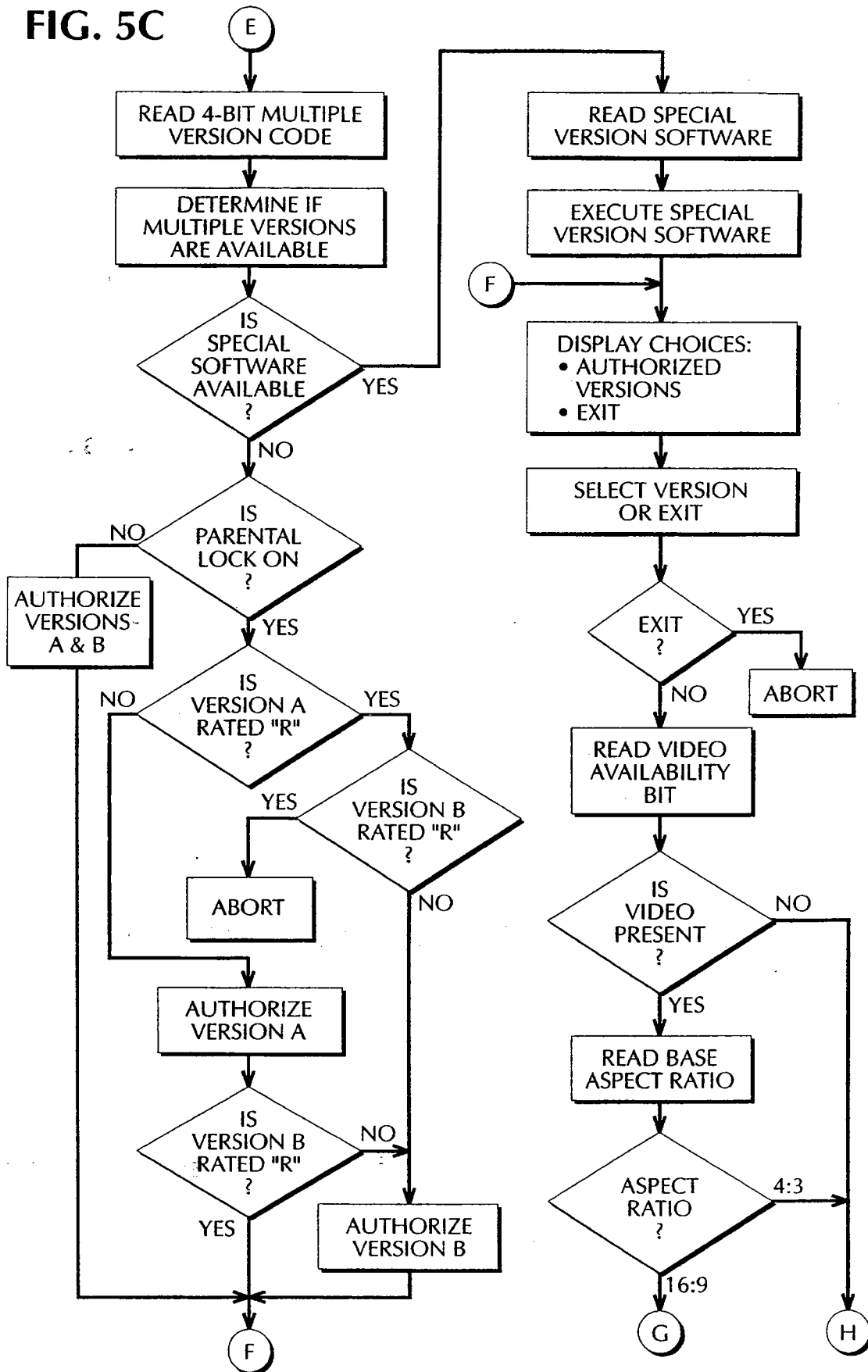


FIG. 5D

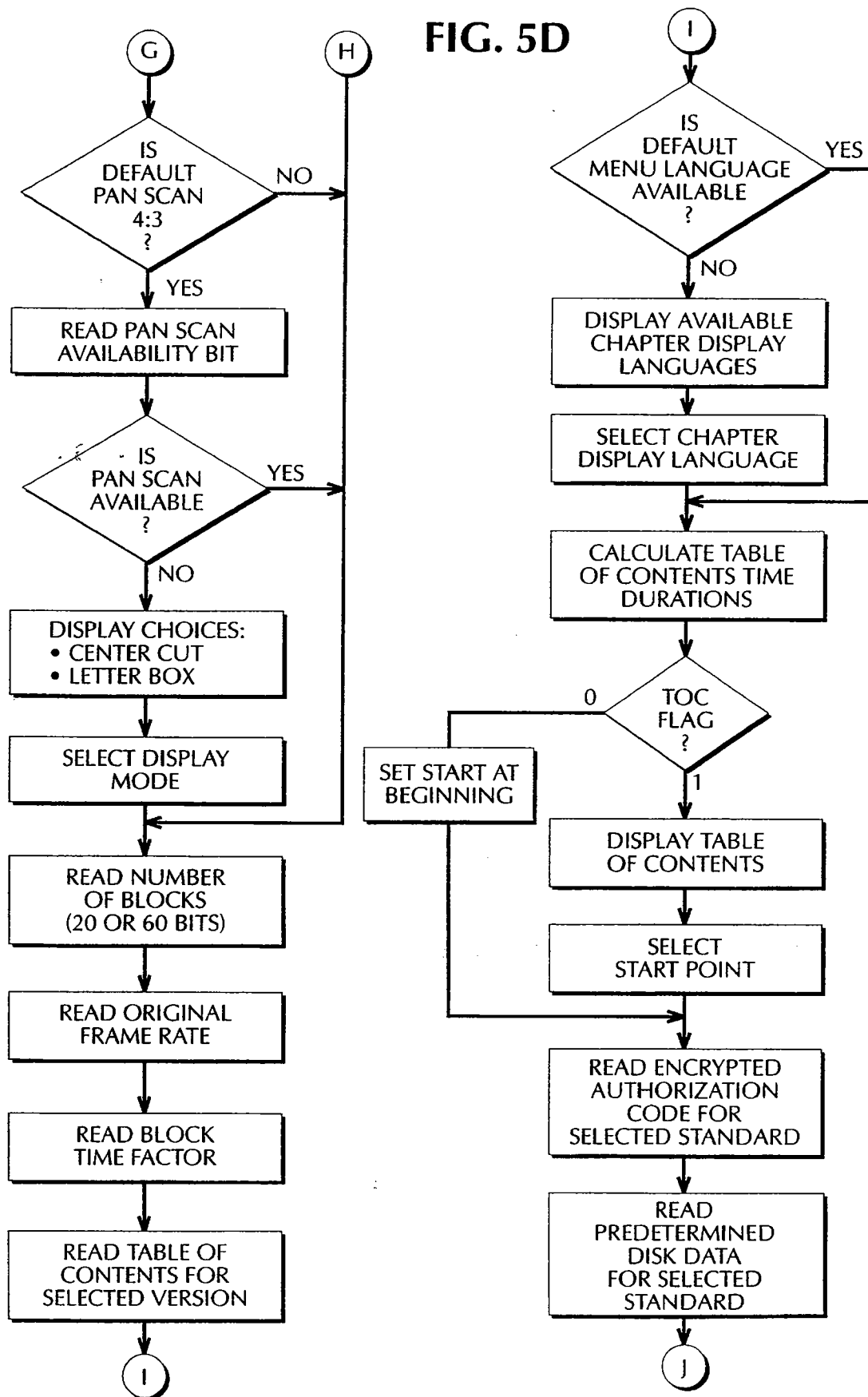


FIG. 5E

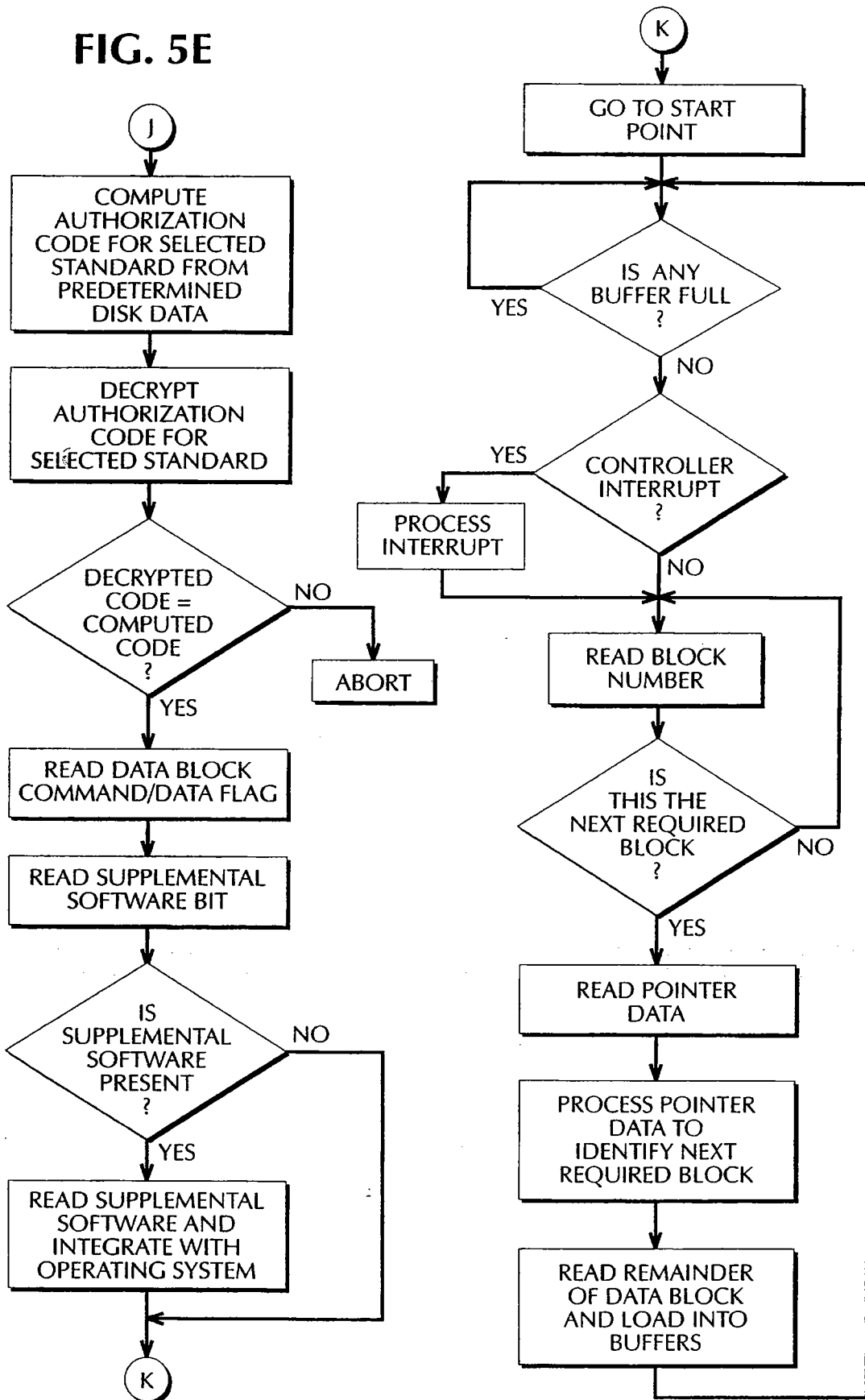
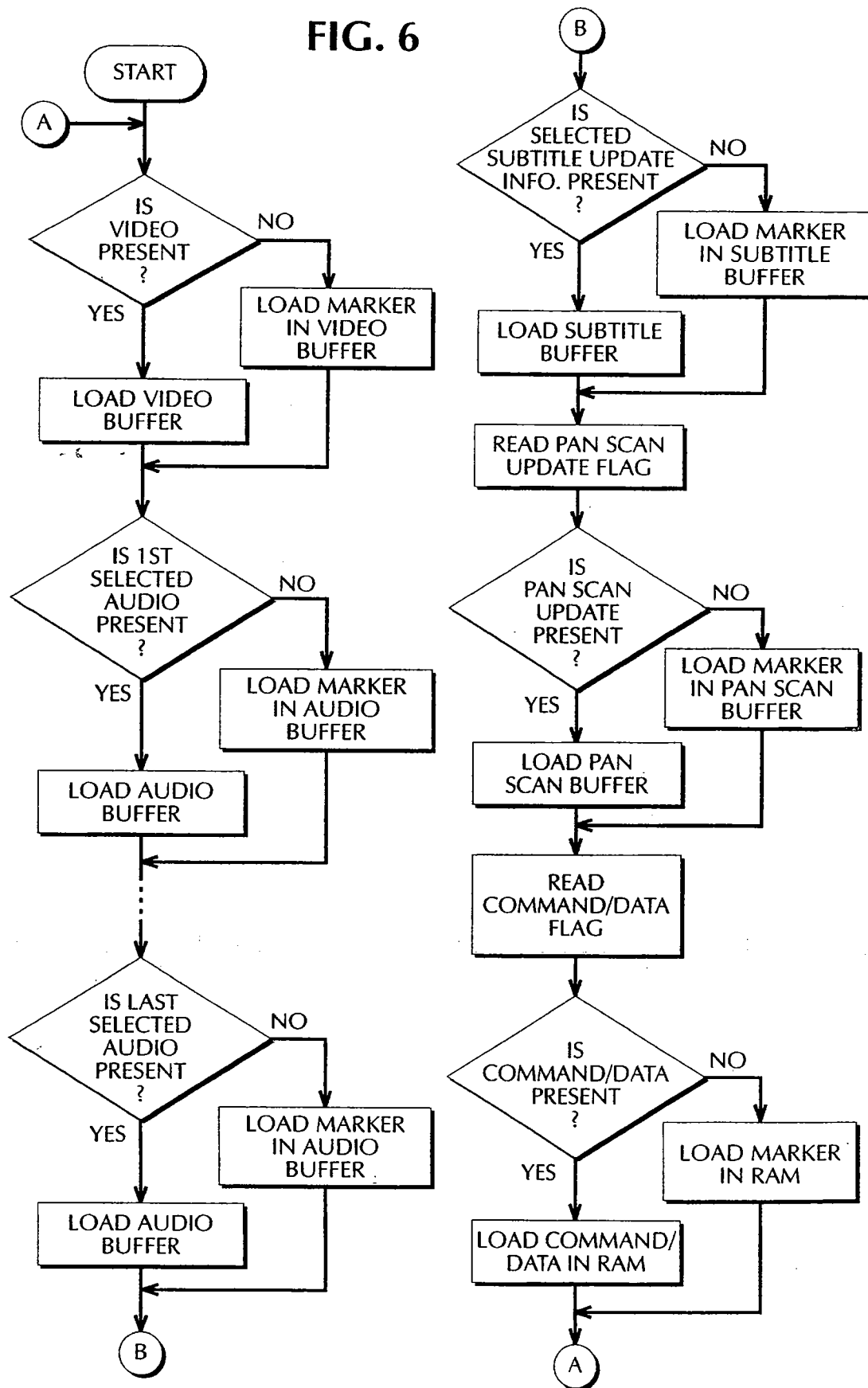


FIG. 6



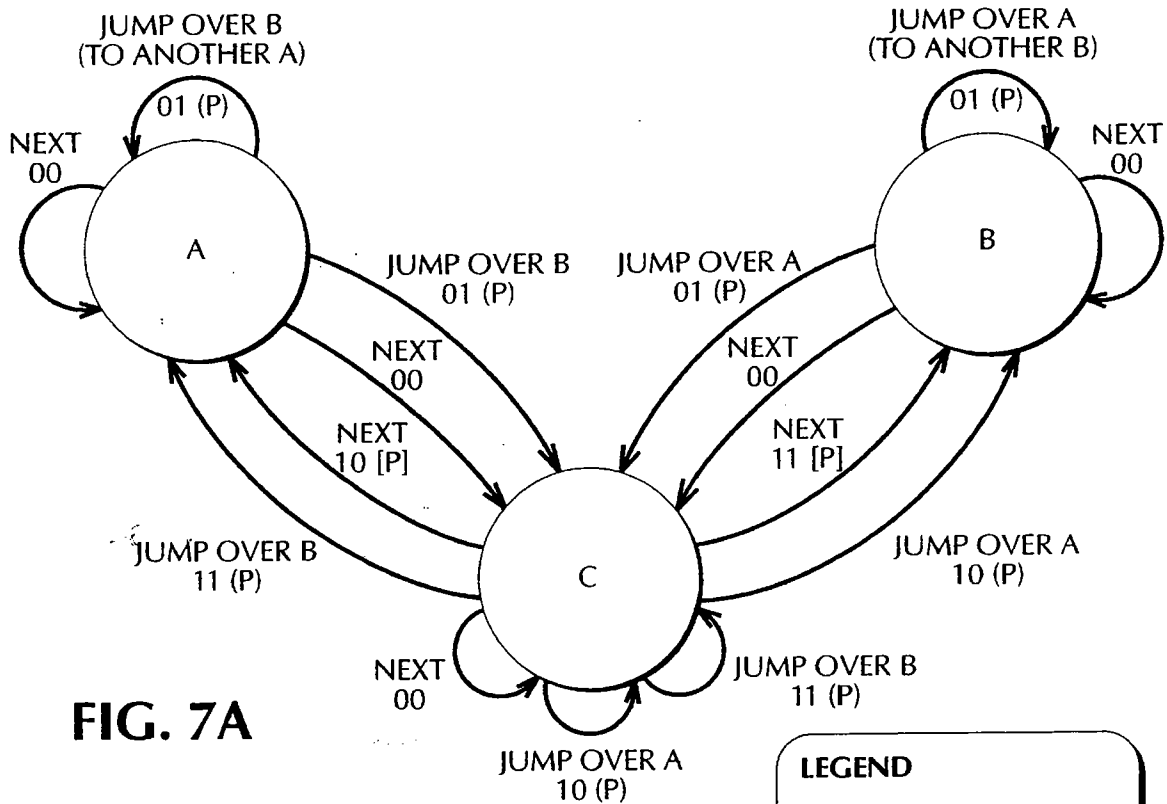


FIG. 7A

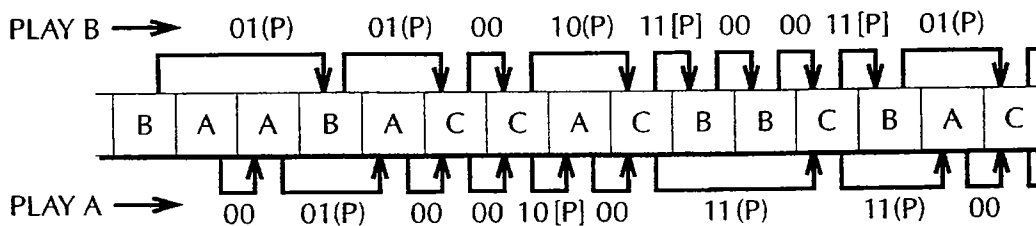
CODE

- 00 = Continue to next block
- 01 = Jump to same version or common, one pointer
- 10 = Branch from common:
Next block is an **A**, pointer is to a **B** or a **C**
(if version **A** is being played, continue to next block)
(if version **B** is being played, jump to block identified by pointer)
- 11 = Branch from common:
Next block is a **B**, pointer is to an **A** or a **C**
(if version **A** is being played, jump to block identified by pointer)
(if version **B** is being played, continue to next block)

LEGEND

- 10 (P) } Use Pointer P
- 11 (P) }
- 10 [P] } Ignore Pointer P
- 11 [P] }

FIG. 7B



SYSTEM AND METHOD FOR DISK SOFTWARE PUBLISHERS TO CONTROL DISK DISTRIBUTION

This invention relates to the generation of a video signal from play of a software (e.g., motion picture) carrier, and more particularly to a technique by which the software publisher can control where the software carrier may be played.

BACKGROUND OF THE INVENTION

There are three primary color transmission standards in use today. The 525-line, 30-frames-per-second NTSC (National Television Systems Committee) standard is used in the United States, Canada, Central America, most of South America, and Japan. The 625-line, 25-frames-per-second PAL (Phase Alternation Each Line) standard is used in England, most countries and possessions influenced by the British Commonwealth, many western European countries and China. Finally, the 625-line, 25-frames-per-second SECAM (Sequential Color With [Avec] Memory) standard is used in France, countries and possessions influenced by France, the former Soviet Bloc nations including East Germany, and other areas influenced by them. Other standards are becoming available, such as HDTV (High Definition Television). The video signal according to each standard is unique, and an ordinary television receiver designed to process a video signal of one type cannot process a video signal of another.

The most widespread medium for distributing motion pictures is the videocassette. Because of the different television industry standards used throughout the world, there are an equal number of videocassette standards. An NTSC videotape sold in the United States, for example, will not play on most videocassette players to be found in England. To a far lesser extent, motion pictures are also distributed on optical disk media. These media are for the most part analog recordings, and once again media designed to play on players of one type are incompatible with players of another.

Digitally encoded optical disks are in theory far superior for the distribution of motion pictures and other forms of presentation. Especially advantageous is the use of "compressed video" by which it is possible to digitally encode a motion picture on a disk no larger than the present-day audio CD. Especially in the case of compressed video, where there is no real-time analog video signal on a disk, it should be possible to play the same disk throughout the world—the players in any given territory will generate an analog signal of the appropriate standard from the same digitally encoded video source information. It might be thought that software providers such as the motion picture industry would welcome the advent of such a "universal" disk, but this in fact is not the case.

There is a compelling business reason for this. New motion pictures, and their follow-up consumer versions, are released in different territories at different times; often, many months may elapse, for example, between the release of a motion picture in Australia and its subsequent release in the United States. Contractual and marketing arrangements will be compromised by players, or player add-ons, which allow a carrier intended for play on television receivers of only one type to be played on television receivers of another type. In addition to the motion picture companies not being protected from unauthorized multi-standard playback of their releases, if present practices do not change, then the artistic commu-

nity, and even the consumers who are responsible, will continue to object to the video degradation that results when converting from one standard to another. (High-quality conversion can be obtained today only at relatively high cost.)

Digitally encoded media facilitate the generation of high-quality video signals in conformance with all standards, and this only aggravates the problem faced by motion picture companies in their attempt to control the orderly release of new films throughout the world. Digital encoding makes it easier to generate analog video signals of all types. All players have to decode the same digital bit stream and generate an analog signal from it. Horizontal and vertical sync pulses have to be added to this analog signal, along with a frequency and phase reference for color signal encoding, with the synchronizing and reference signals being combined with the picture video signal to form what is known as a composite video waveform. It does not require too much additional circuitry to allow the same player to form composite video for all of the different standards. It thus becomes difficult to plan for orderly releases of films in different countries at different times.

Thus far it might appear that the problem pertains solely to video standards—how to control software carriers so that they play according to only a selected video standard. But the problem is more extended. It is sometimes desirable to distinguish between countries or territories that adhere to the same standard, so locking out standards, for example, will not always accomplish the broader objective. For example, for political reasons it might be desired to prevent play of a particular disk in China, but to prevent play according to the PAL standard would also preclude disk distribution in England. Thus while it is advantageous to exercise control over the video standards that are recoverable from a software carrier, it is also advantageous to exercise control over the territories in which a disk may be played.

It is therefore an object of this invention to provide a system and method for a software publisher to control the video standard(s) to which a video signal generated from the publisher's software carriers may conform.

It is also an object of this invention to provide a system and method for a software publisher to determine the territories in which the publisher's software carriers may be played.

SUMMARY OF THE INVENTION

The invention is a system that allows a software publisher to control which video standards can be recovered from software carriers. Each software carrier is a "master" in the sense that it can be used to play back the video program recorded on it according to all video standards, e.g., PAL, NTSC, etc. However, data on the carrier, preferably an optical disk, is coded by the publisher to authorize video signal generation conforming to only certain video standards. Players designed to play the disks may be equipped to form video signals of all types, with the user selecting a particular standard, but the player will not generate a video signal of a type which is not authorized by the program material itself.

As a single example, consider the case of a motion picture which is to be released first in the United States and thereafter in England. Let it be further assumed that the same players are sold in both countries, that is, while there may be differences such as the power supplies which are used, all players can generate video signals according to multiple

standards, including PAL and NTSC, with the user being able to select a desired standard by a switch setting or in accordance with a menu display. Because most television sets in England require video signals which conform to the PAL standard, the vast majority of viewers will be able to play the new release only if their players generate a PAL signal. If the software manufacturer codes the optical disks so that they lock out PAL signal generation, then the disks when initially released in the United States will not find a market in England. When it comes time to release disks in England, all that the manufacturer must do is to change the lock-out code on newly pressed disks so that PAL is now an allowed standard. The digital encoding of the underlying video program material need not be changed at all.

It must be understood that the principles of the present invention are not limited to any particular types of carriers or any particular kinds of software. It is true that the most widespread use foreseen for the invention is by the motion picture industry. An optical disk with a new movie recorded on it may be released in the United States, for example, with the disk being playable only in a machine which generates an NTSC video signal. That machine might be capable of generating, from the same digital encoding, video signals conforming to all of the video standards, but the disk itself would be released with a code which will prevent the player from outputting a video signal in any format other than NTSC. At some later date, when a PAL release is planned, the digital encoding can be changed slightly to authorize play according to an additional standard. Nevertheless, it is to be understood that the invention is not limited to a particular medium (for example, it is applicable to tape carriers and all digital storage media), nor is it limited to just the distribution of motion pictures. For example, in an extreme case, the invention is applicable to the distribution of a library of still pictures, in which case there is no "motion" at all. The term "software publisher" thus embraces much more than a motion picture company, and the term "carrier" embraces much more than a digitally encoded optical disk.

The control technique of the invention is independent of the coding of the underlying video source material, provided that the format of the digital encoding allows specification of allowed/disallowed broadcast standards. Obviously, the program material should be recorded so that all broadcast standards of interest are readily accommodated. Similarly, in addition to supporting multiple standards, the program material should be stored on the carrier so as to allow the highest quality video signal to be generated. Thus the encoded video program preferably allows the generation of video signals which represent different aspect ratios and which have different resolutions. While the optical disks may be encoded so that they accommodate maximally flexible playback and are "universal" in the sense that the same disk would be playable throughout the world, the present invention cuts down on this universality. In the broadest sense, the object of the invention is to allow the software publisher to control where the video material can be played. (This statement is to be taken in a macroscopic, not microscopic, sense. Obviously, in the example given above, if someone in England actually has an NTSC television receiver, he will be able to play in England a disk which is sold in the United States.)

The control described above is readily extended to distinguish among territories, even territories that adhere to the same standard. In the illustrative embodiment of the invention, every player has a built-in territory code, one of 40 different codes. Every disk has a 40-bit field in its lead-in

section, with each bit position corresponding to a different one of the forty territories. A particular player will play a disk only if the territory represented by its built-in territory code is "authorized" in the 40-bit field. If there are to be no purely territorial restrictions on play, a 1 is stored in each of the 40 bit positions of the authorization field on the disk. But any territory can be locked out simply by placing a 0 in the corresponding bit position. Players designed for play in the territory will not play the disk when they determine that play in their territory is not authorized.

The invention is disclosed in the context of an overall system which offers numerous advantageous features. The entire system is described although the appended claims are directed to specific features. The overall list of features which are of particular interest in the description below include:

Video standard and territorial lock out.

Play in multiple aspect ratios.

Play of multiple versions, e.g., PG-rated and R-rated, of the same motion picture from the same disk, with selective automatic parental disablement of R-rated play.

Encrypted authorization codes that prevent unauthorized publishers from producing playable disks.

Provision of multiple-language audio tracks and multiple-language subtitle tracks on a single disk, with the user specifying the language of choice.

Provision of multiple "other" audio tracks, e.g., each containing some component of orchestral music, with the user choosing the desired mix.

Variable rate encoding of data blocks, and efficient use of bit capacity with track switching and/or mixing, to allow all of the above capabilities on a single carrier.

Further objects, features and advantages of the invention will become apparent upon consideration of the following detailed description in conjunction with the drawing, in which:

FIG. 1 depicts a prior art system and typifies the lack of flexibility in, and the poor performance of, presently available media players;

FIG. 2 depicts the illustrative embodiment of the invention;

FIG. 3 is a chart which lists the fields in the lead-in portion of the digital data track of an optical disk that can be played in the system of FIG. 2;

FIG. 4 is a similar chart which lists the fields in each of the data blocks which follow the lead-in track section of FIG. 3;

FIGS. 5A-5E comprise a flowchart that illustrates the processing by the system of FIG. 2 of the data contained in the lead-in track section of an optical disk being played;

FIG. 6 is a flowchart that illustrates the processing of the data blocks, in the format depicted in FIG. 4, that follow the lead-in section of the track;

FIG. 7A is a state diagram and legend that characterize the manner in which the player of the invention reads only those data blocks on a disk track that are required for the play of a selected version of a motion picture or other video presentation, and FIG. 7B depicts the way in which one of two alternate versions can be played by following the rules illustrated by the state diagram of FIG. 7A;

FIG. 8 depicts symbolically a prior art technique used in compressing the digital representation of a video signal; and

FIG. 9 illustrates the relationships among three different image aspect ratios.

THE PRIOR ART

The limitations of the prior art are exemplified by the system of FIG. 1. Such a system is presently available for playing a single source of program material, usually a VHS videocassette, to generate a video signal conforming to a selected one of multiple standards. A system of this type is referred to as a multi-standard VCR, although stand-alone components are shown in the drawing. Typically, a VHS tape 7 has recorded on it an NTSC (analog) video signal, and the tape is played in a VHS player 5. The analog signal is converted to digital form in A/D converter 9, and the digital representations of successive frames are written into video frame store 11. Circuit 13 then deletes excess frames, or estimates and adds additional frames, necessary to conform to the selected standard, e.g., PAL. To convert from one standard to another, it is generally necessary to change the number of horizontal lines in a field or frame (image scaling). This is usually accomplished by dropping some lines, and/or repeating some or averaging successive lines to derive a new line to be inserted between them. The main function of circuit 13, of course, is to convert a digital frame representation to analog form as the video output.

Systems of the type shown in FIG. 1 generally degrade the video output. Conventional videocassettes deliver reduced quality video when they support more than one video standard. One reason is that there is a double conversion from analog to digital, and then back again. Another is that the image scaling is usually performed in a crude manner (deleting lines, repeating lines and averaging lines). There are known ways, however, to perform image scaling in the digital domain without degrading the picture. While not generally used, the technique is in the prior art and will therefore be described briefly as it is also used in the illustrative embodiment of the invention.

To give a concrete example, the PAL standard has 625 lines per frame, while the NTSC standard has 525 lines per frame. Because no part of the image is formed during the vertical retrace, not all of the horizontal line scans in either system are usable for representing image information. In the PAL standard there are nominally 576 lines per frame with image information, and in an NTSC frame there are nominally 483 lines with image information.

To convert from one standard to another, successive fields are first de-interlaced. Then 576 lines are converted to 483, or vice versa, and re-interlaced. How this is done is easy to visualize conceptually. Consider, for example, a very thin vertical slice through a PAL frame. The slice is broken down into its three color components. Image scaling for converting from PAL to NTSC, from a conceptual standpoint, is nothing more than drawing a curve based on 576 PAL pieces of color data and then dividing the curve into 483 parts to derive a piece of data for each horizontal line of the desired NTSC signal. In actuality, this is accomplished by a process of interpolation, and it is done digitally. (Image scaling, in general, may also involve a change in the aspect ratio, for example, in going from HDTV to NTSC, and may require clipping off information at both ends of every horizontal line.)

While prior art systems thus do provide for standards conversion, that is about the extent of their flexibility. The system of FIG. 2, on the other hand, offers unprecedented flexibility in ways not even contemplated in the prior art.

THE ILLUSTRATIVE SYSTEM OF THE INVENTION

The system of FIG. 2 includes a disk drive 21 for playing an optical disk 23. Digital data stored on the disk appears on

the DATA OUT conductor 25. The disk drive operation is governed by microprocessor disk drive controller 27. The read head is positioned by commands issued over HEAD POSITION CONTROL lead 29, and the speed of the disk rotation is governed by commands issued over RATE CONTROL conductor 31. Optical disks are usually driven at either constant linear velocity or constant angular velocity. (Another possibility involves the use of a discrete number of constant angular velocities.) Disks of the invention may be driven at constant linear velocity so that the linear length of track taken by each bit is the same whether a bit is recorded in an inner or outer portion of the track. This allows for the storage of the most data. A constant linear velocity requires that the rate of rotation of the disk decrease when outer tracks are being read. This type of optical disk control is conventional. For example, the CD audio standard also requires disks which are rotated at a constant linear rate.

Microprocessor 41 is the master controller of the system. As such, it issues commands to the disk drive controller over conductor 43 and it determines the status of the disk drive controller over conductor 45. The disk drive controller is provided with two other inputs. Block number/pointer analyzer 47 issues commands to the disk drive controller over conductor 49, and BUFFER FULL conductor 51 extends a control signal from OR gate 54 to the disk drive controller. These two inputs will be described below. (In general, although reference is made to individual conductors, it is to be understood that in context some of these conductors are in reality cables for extending bits in parallel. For example, while the output of OR gate 54 can be extended to the disk drive controller over a single conductor 51, block number/pointer analyzer 47 could be connected to the disk drive controller over a cable 49 so that multi-bit data can be sent in parallel rather than serially.)

An important feature of the system of FIG. 2 is that bit information is stored on the disk at a rate which varies according to the complexity of the encoded material. By this is meant not that the number of bits per second which actually appear on the DATA OUT conductor 25 varies, but rather that the number of bits which are used per second varies. Video information is stored in compressed digital form. FIG. 8 shows the manner in which video frames are coded according to the MPEG1 and MPEG2 standards. An independent I-frame is coded in its entirety. Predicted or P-frames are frames which are predicted based upon preceding independent frames, and the digital information that is actually required for a P frame simply represents the difference between the actual frame and its prediction. Bidirectionally predicted B-frames are frames which are predicted from I and/or P frames, with the information required for such a frame once again representing the difference between the actual and predicted forms. (As can be appreciated, fast forward and fast reverse functions, if desired, are best implemented using I-frames.) The number of bits required to represent any frame depends not only on its type, but also on the actual visual information which is to be represented. Obviously, it requires far fewer bits to represent a blue sky than it does to represent a field of flowers. The MPEG standards are designed to allow picture frames to be encoded with a minimal number of bits. Frame information is required at a constant rate. For example, if a motion picture film is represented in digital form on the disk, 24 frames will be represented for each second of play. The number of bits required for a frame differs radically from frame to frame. Since frames are processed at a constant rate, it is apparent that the number of bits which are processed (used) per second can vary from very low values

to very high values. Thus when bits are actually read from the disk, while they may be read from the disk at a constant rate, they are not necessarily processed at a constant rate.

Similar considerations apply to any audio stored on the disk. Any data block may contain the bit information required for a variable number of image frames. Any data block may similarly contain the bit information required for a variable time duration of a variable number of even numerous audio tracks. (There is just one physical track. The reference to multiple audio tracks is to different series of time-division slices containing respective audio materials.) The audio tracks contain digital information, which may also be in compressed form. This means that if there is information stored in any data block for a particular audio track, those bits do not necessarily represent the same time duration. It might be thought that the duration of the sound recorded for any audio track corresponding to any picture frames represented in a block would be the duration of the picture frames. However, that is not necessarily true. This means that audio information may be read before it is actually needed, with the reading of more audio information pausing when a sufficient amount has already accumulated or with audio not being included in some data blocks to compensate for the preceding over-supply. This leads to the concept of buffering, the function of audio buffers 53, video buffer 55, pan scan buffer 57, subtitle buffer 59, and OR gate 54 which generates the BUFFER FULL signal.

As each data block is read from the disk, it passes through gate 61, provided the gate is open, and the bit fields are distributed by demultiplexer 63 to the various buffers and, over the COMMAND/DATA line 65, to master controller 41. Each data block in the illustrative embodiment of the invention contains video bit information corresponding to a variable number of picture frames. As discussed above, there may be a large number of bits, or a small number, or even no bits (for example, if the particular disk being played does not represent any video). Successive groups of video data are stored in video buffer 55 separated by markers. Video decoder 67 issues a command over conductor 69 when it wants to be furnished with a new batch of data over conductor 71. Commands are issued at a steady rate, although the number of bits furnished in reply vary in accordance with the number of bits required for the particular frames being processed. The rate at which bits are read from the disk drive is high enough to accommodate frames which require maximal information, but most frames do not. This means that the rate at which data blocks are actually read is higher than the rate at which they are used. This does not mean, however, that a well-designed system should delay reading of a block of data until the data is actually required for processing. For one thing, when data is actually required, the read head may not be positioned at the start of the desired data block. It is for this reason that buffering is provided. The video buffer 55 contains the bit information for a number of successive frames (the actual number depending upon the rate at which bits are read, the rate at which frames are processed, etc., as is known in the art), and video data block information is read out of the video buffer at a constant frame rate determined by video decoder 67. Video data is delivered to the buffer only until the buffer is full. Once the buffer is full, no more information should be delivered because it cannot be stored. When the video buffer is full, a signal on conductor 69 causes the output of OR gate 54 to go high to inform disk drive controller 27 that one of the buffers is full.

Similar remarks apply to the three other types of buffers. (There is a single subtitle buffer 59, a single pan scan buffer

57, and numerous audio buffers 53, the purpose of all of which will be described below.) When any of these buffers is full, its corresponding output causes OR gate 54 to control the BUFFER FULL conductor to go high and to so inform the disk drive controller that one of the buffers is full. Audio buffers 53 and subtitle buffer 59 operate in a manner comparable to that described for video buffer 55. Audio processor decoder 71 issues a command to the audio buffers when it requires audio track data, at which time the audio buffers furnish such data. Similarly, graphics generator 73 retrieves data from subtitle buffer 59, and pan scan processor/vertical scaler 87 receives data from pan scan buffer 57 as will be described below.

When any one of the four buffers is full (which includes any one of the individual buffers within the block 53), the disk drive controller 27 causes the disk drive to stop reading data. Data is not read again until all of the buffers can accept it, i.e., until no buffer is full and conductor 51 goes low. (Conversely, if the buffers are being depleted of data too rapidly, an adjustment in the RATE CONTROL signal on conductor 31 increases the disk speed and thus the rate at which the buffers are filled.)

This discussion of buffering arose from a consideration of the BUFFER FULL input 51 to the disk drive controller 27. The other input which remains to be described is that represented by cable 49. As will be described below, every data block has a serial block number as well as pointer information at its beginning. Circuit 47 reads the serial block number and analyzes the pointer information. The pointer, a serial block number, points to the next data block which should be read. This information is furnished to the disk drive controller over cable 49. It is in this way that the disk drive controller can control positioning of the read head of the disk drive so that the desired data block can be accessed. Many times the wrong block will be read—this is to be expected in the case of a jump to a new block, as is the case, for example, when a jump is made from one track to another when playing a CD audio disk. If the disk drive reads a data block whose serial block number is too high or too low, this is determined by block number/pointer analyzer 47 which then issues a new command over cable 49 to the disk drive controller to cause it to read another block with a lower or higher serial block number respectively. During the time that the read head is positioning itself to read a new block, the data which is read is not actually used. Gate 61 remains closed so that the information is not delivered to the demultiplexer 63 for distribution to the four buffers and to the master controller 41 over the COMMAND/DATA lead. It is only when the correct data block is reached, as determined by circuit 47 analyzing the serial block number at the start of the block, that conductor 75 is pulsed high to open gate 61.

The remainder of the block is then delivered to the demultiplexer. The data bits read from the disk are also delivered to the microprocessor master controller 41 over conductor 77. Each data block contains not only bit information which must be distributed to the various buffers, but also control information, e.g., bits that identify the kind of data actually to be found in the block. The identification bits (flags and the like, as will be described below) are furnished to the master controller so that it is in control of the system at all times. The identification bits are used by the demultiplexer to control data distribution to the various buffers. (The master controller issues commands over conductor 76 to the block number/pointer analyzer 47 which exercise not only general control over this element, but also specific control by causing element 47 to turn off the enabling signal

on conductor 75 as is appropriate to prevent full data blocks from entering the demultiplexer if they are not required for subsequent processing.)

The master controller is at the heart of the system and in fact carries out the bulk of the processing to be described below. The user of the player communicates with the master controller via an interface 79, typically a keyboard. The user also is provided with a key and lock mechanism, shown symbolically by the numeral 81, which is referred to herein as the "parental lock" option. If the lock is turned on, then R-rated motion pictures will not play. The manner in which this is controlled by bits actually represented on the disk will be described below. If the lock is on, and only an R-rated picture is on the disk, a disabling signal on PARENTAL LOCK CONTROL conductor 83 closes gate 61. No data bits are transmitted through the gate and the disk cannot be played. As will become apparent below, if the disk also has on it a version of the fill which is not R-rated, it will play if it is selected by the viewer. Although the parental lock feature is shown as requiring the use of an actual key and lock, it is to be understood that the feature can be implemented by requiring keyboard entries known only to a child's parents. The manner of informing the master controller that R-rated versions of a motion picture should not be viewed is not restricted to any one form. Just as physical keys and coded keys are alternatively used to control access to a computer, so they can be in the system of FIG. 2. What is important is the way in which two different versions can be represented on the same disk (without requiring the full version of each), and how the system determines whether a selected version may be played in the first place. This will be described below.

Master controller 41 includes several other outputs which have not been described thus far. Conductor 85 represents a MASTER CLOCK bus which is extended to all of the sub-systems shown in FIG. 2. In any digital system, a master clock signal is required to control the proper phasing of the various circuits. The six other outputs of the master controller are extended to demultiplexer 63, audio processor decoder 71, pan scan processor/vertical scaler 87, video frame store, interlace and 3:2 pulldown circuit 89, graphics generator 73, and sync generator and DVA converter 92. These are control leads for governing the operations of the individual circuit blocks.

Audio processor decoder 71 processes the data in buffers 53 and derives individual audio analog signals which are extended to an amplifier/speaker system shown symbolically by the numeral 91. Video decoder 67 derives a DIGITAL VIDEO signal on conductor 93 from the compressed video data which is read from buffer 55. The digital video is fed to pan scan processor/vertical scaler 87 frame by frame. The particular video coding/decoding that is employed is not a feature of the present invention. A preferred standard would be one along the lines of MPEG1 and MPEG2, but these are only illustrative. The same is true of the audio track coding. The present invention is not limited to particular coding methods.

The operations of circuits 57 and 87 can be best understood by first considering the symbolic drawing of FIG. 9. The digital information which is stored on the optical disk in the preferred embodiment of the invention characterizes frames having a "master" aspect ratio of 16:9, the so-called "wide screen" image. The master aspect ratio is shown on the upper left in FIG. 9. If the ultimate analog signal to be displayed on the user's television receiver requires this aspect ratio, and the number of horizontal scan lines with picture information (as opposed to horizontal scan lines

which occur during vertical retrace) corresponds with the number of horizontal lines represented by the video bit information stored on the disk, then the generation of the video analog signal is straightforward. But if the television receiver of the user accommodates a TV signal having a 4:3 aspect ratio, and the master aspect ratio on the disk is 16:9 rather than 4:3, then there are two choices. One is to display the original picture in "letter box" form. As depicted on the right side of FIG. 9, what is done in this case is to vertically compress uniformly a master image so that its horizontal dimension fits into the confines of the television receiver. This results in the vertical dimension being shortened at the same time so that it fills less than the full height of the TV display area. What this means is that the horizontal line scans at the top and bottom of each overall frame must be blanked, with dark bands forming in their place—but the original aspect ratio is preserved. The other option is for a "pan scan" reduced aspect ratio. What this involves is superimposing a box having a 4:3 aspect ratio on the original wide screen image. As a result, the left side of the picture, the right side, or both sides, are clipped off. (In all cases, even if a wide screen image corresponding to a 16:9 master aspect ratio is to be shown, it may be necessary to form a number of horizontal line scans which is different from the number of horizontal lines represented on the disk. The number of horizontal lines is a function of the video signal standard to which the video output must conform. Changing the number of lines is a process known as vertical scaling, as described above.)

With respect to pan scan processing, it will be apparent from FIG. 9 that in order to identify that portion of a 16:9 master aspect ratio picture which should be used to form a pan scan reduced aspect ratio picture, all that is required is to specify the starting point along each horizontal line scan of the information that should be used. Specifying a single number (e.g., column 200 out of a total of 960 columns) suffices for this purpose. The issue, however, is whether the same column is always used. In some cases the player may be told that if a 4:3 aspect ratio is desired, it should always be taken from the middle of the wide screen image. In other cases, a variable column starting point may be desired, in which case a data block actually contains information which represents the starting column number which should be used from that point until another change is effected.

As will become apparent below, the video information in each data block includes a flag which represents whether the pan scan column information should be updated. If there is such a flag, video decoder 67 issues a command over conductor 95 to pan scan buffer 57. At this time the buffer accepts a pan scan update from demultiplexer 63. That update remains in the buffer, for use by pan scan processor/vertical scaler 87 with the succeeding frames, until another change takes place.

It is in pan scan processor/vertical scaler 87 that the number of horizontal lines is adjusted and the aspect ratio is changed. The digital video is furnished by video decoder 67 and the pan scan information, if it is required, is provided by buffer 57. The output of circuit 87 consists of uncompressed digital video, in the desired aspect ratio and represented by the number of horizontal lines required for the selected television standard.

Once video frame information is stored digitally in frame store 89, it can be broken up into interlaced fields if the selected standard requires it. Also, 3:2 pulldown is the technique used to convert 24-frames-per-second motion pictures to 60-fields-per-second video (the nominal values of 24 and 60 are in reality 23.97 and 59.94); to convert data

representative of a motion picture to an NTSC format, frame information (data blocks) must be read at the rate of 24 per second. (As is standard in the art, such a transformation applies frame 1 of the source material to fields 1, 2 and 3 of the video signal, frame 2 of the source material to fields 4 and 5 of the video signal, frame 3 of the source material to fields 6, 7 and 8, etc., thus yielding 60 fields for 24 original frames.) On the other hand, conversion to the PAL standard is relatively simple, and 3:2 pulldown is not required. The PAL standard requires 50 fields per second. Frames are processed at the rate of 25 per second, and every frame is used to form two fields. (Because motion picture films are shot at the rate of 24 frames per second yet processed at the rate of 25 per second when converting to PAL, everything which occurs on the TV screen takes place 4% faster in Europe than it does in the United States.) Whether the frames are processed at the rate of 25 per second or 24 per second is controlled by changing the frequency of the MASTER CLOCK signal on bus 85.

The output of block 89 is digital, and is extended to sync generator and D/A converter 92. It is in this element that appropriate sync pulses are inserted into the fields, and the digital information is converted to analog. Any subtitles that are required are contained in buffer 59. Under control of microprocessor 41, commands are issued over control lead 97 to graphics generator 73. This conventional circuit retrieves coded character information from the subtitle buffer, and generates a VIDEO signal on conductor 99 which depicts the subtitles. The KEY signal is generated on conductor 98, and the two signals are extended to a conventional keyer circuit 96. This device merges the subtitles with the video image (utilizing hard or linear keying at the manufacturer's option, as is known in the art), and extends the composite video signal to a conventional TV display device 94.

LEAD-IN TRACK FIELDS

Before proceeding with a description of the detailed processing, it will be helpful to consider the information which is stored in the lead-in portion of the disk track. This information is stored in individual fields as depicted in FIG. 3, and it is this information which controls subsequent processing of the data read from the disk. The format of a data block is shown in FIG. 4, but for an understanding of how the data in this block is used, it is necessary to appreciate the set-up information which is read first.

Referring to FIG. 3, at the start of the track there are a number of lead-in sync bits. Although for all other entries minimum and maximum numbers of bits are depicted in the appropriate columns, no such numbers are provided for the lead-in sync bits. The number of sync bits required at the beginning of the track depends on the hardware employed. Given the particular hardware and range of disk speeds involved, a sufficient number of sync bits are provided at the start of the track to allow the circuits involved with reading the disk, including disk drive controller 27 and block number/pointer analyzer 47, to synchronize themselves to the bit stream on DATA OUT conductor 25. Bit synchronization is a technique well known in digital systems.

The second field consists of 40 bits representing authorized territories. There are several ways in which software publishers can lock out play of their software. The most important involve controlling whether R-rated motion pictures can be played (the parental lock out option), and whether the final analog output video signal can assume the

standard selected by the user. It is in this way, for example, that a software publisher might allow a motion picture to be played on an NTSC receiver but not a PAL receiver. But as long as the player is provided with this kind of lock out control, it can be extended to territories. All players used with the disks of the invention conform to the same set of specifications. One feature of the design is that each player is provided with a representation of the territory or territories for which it has been intended for sale. For example, the territory or territories can be represented by the settings of a DIP switch, a code stored in a microprocessor ROM (e.g., in master controller 41) or the like. It is assumed that there are a total of 40 possible territories. Each disk has a 40-bit field in its lead-in section, each bit of which is associated with one of the 40 territories. A 1 in any bit position is an indication that the disk is authorized for play in the respective territory, and a 0 is an indication that it is not. A player whose code indicates that it is for sale in China, for example, will not play a disk if there is a 0 in the 40-bit territory field at the position associated with China.

As an example of the use of such a feature, consider a player intended for sale in a particular country. A software publisher might put out a motion picture film which for contractual reasons is not to be released in that country. It is for this reason that a 0 would be stored in the bit position associated with that country in the authorized territories field of the lead-in section of the track. Upon sensing this bit, master controller 41 would cause circuit 47 to generate an inhibit signal on conductor 75 which would permanently cause gate 61 to block all data from passing through it.

The third field is a single bit, a flag which indicates whether there is any information in the following field. This information is termed herein "special software." The player of FIG. 2 ordinarily executes the same software code, typically contained in read-only memory. It is this code which will be described in connection with the flowcharts of the drawing. However, since the player is microprocessor controlled, there is no reason why it cannot be used for some even totally unrelated purpose, and this can be enabled simply by loading software from the disk. If the special software flag is a 1, then master controller 41 reads on conductor 77 the software which immediately follows in field 4. Thus depending on whether the special software flag is a 0 or a 1, the fourth field is either empty or contains software of undetermined length. At the end of the software there is a sync word which is unique in the sense that this word is not allowed to occur anywhere in the overall data stream. When the sync word pattern appears, it is an indication that the preceding data field has come to an end, and a new field follows. (In the event data having the sync word pattern would otherwise appear in the data stream and be misinterpreted as a sync word, it can be avoided using known techniques. For example, if the sync word consists of 32 bits of a predetermined pattern, and some overall data sequence includes this pattern within it, then after 31 bits of the data pattern are recorded, an extra bit, having a value opposite that of the last bit in the sync word pattern, may be inserted in the bit stream. When the player sees this bit, it discards it and treats the following bit as a data bit instead of the last bit of the sync word.)

An example of special software might be software for controlling video games. While the player is provided with an operating system designed for the play of motion pictures and multi-track audios, it is certainly feasible for the player to perform additional and/or different functions involved in the play of video games. This is especially true if the user interface is detachable and joysticks and the like may be

connected in place of a keyboard to accommodate game-playing peripheral equipment. The system can be converted to a video game player simply by storing the necessary software as it is read from the disk. While in the flowcharts to be described below the special software is shown as being self-contained and not involving the standard processing steps, the special software can certainly call operating system subroutines for execution in order to take advantage of the built-in code.

The fifth field consists of 12 bit positions, each corresponding to a different standard. Standards include 1250-line European HDTV, 1125-line Japanese HDTV, 1050-line proposed American HDTV (as well as 1080-line and 787-line proposed standards), 625-line PAL, 525-line NTSC, 625-line SECAM, 360-line "letter box", etc. It is even possible to accommodate future standards, although to form an appropriate video signal in such a case different software would be required. However, that simply entails providing software on a disk to supplement the built-in operating system.

As a single example, if the first bit position of the 12-bit field corresponds to the NTSC standard, and if the user selects an NTSC standard for play on his TV receiver, or if that is his default setting (as will be discussed below), then an NTSC signal will be generated only if the first bit in the authorized standards field is a 1.

Field 6 always contains 100 bits. These bits represent respective audio languages—dialog—for a motion picture. It is rare that so many foreign-language versions of the same motion picture will be prepared, and it is not contemplated that so many versions will actually be included on a disk. In fact, there are a maximum of 16 audio tracks which can contain dialog in different languages. Each of the 100 bits, except the first, represents one of 99 languages. If there is a 1 in the corresponding bit position, it is an indication that there is an audio track with dialog in the corresponding language.

The first of the 100 bit positions does not really correspond with a language. Instead, a 1 in the first bit position means that there is a music and effects ("M&E") track. (By "effects" is meant such things as the sound associated with thunder, gunshots and the like.) As indicated in the Comments field on FIG. 3, there are N "1"s in field 6 of the lead-in section of the overall track, where N has a maximum value of 16 (one M&E track and up to 15 dialog tracks, or up to 16 dialog tracks without M&E). As a single example, suppose that the third bit position corresponds with French, the fifth corresponds with Greek, and the 100-bit field is 10101000 . . . 0. This means that there is an M&E track, as well as French and Greek dialog tracks. It does not mean that every single data block on the disk includes bit information which represents M&E, and French and Greek dialog. What it does mean is that any data block has at most three audio tracks with M&E and/or dialog. It also means that any data block which has such audio track information contains the information in the order M&E, French, Greek. Just how the system determines which specific data blocks contain audio information for those languages represented in the 100-bit field will be described below in connection with the fields contained in a data block.

It should be understood that the language audio tracks do not necessarily include just dialog. As will be described shortly, it is possible to mix an M&E track with a French dialog track, with the result being a complete audio track suitable for play in France. But it is certainly possible that a particular audio track will include pre-mixed M&E and

original dialog. For example, if bit position 10 of the 100-bit field represents English dialog and there is a 1 stored there, it means that there is an English language version of audio on the disk. However, it is possible that in the corresponding audio track there is not only English dialog, but a fall sound track including the M&E. At the same time, there may be M&E in a separate track, if there is a 1 in the first bit position of the 100-bit field. How the various tracks are processed in order to derive a complete sound track for play in any given language depends on subsequent information. Field 6 simply represents which audio languages are available, as well as whether there is a separate M&E track (without any dialog).

There is another piece of information which is necessary in order for the audio scheme to function, and that information is represented in field 7. For each of the N available audio language tracks (up to a maximum of 16), there is a 3-bit code in the seventh field. Before describing the meaning of the codes, it must be understood how the codes are associated with particular tracks and languages. Suppose that field 6 is 101010000100 . . . 0 which is interpreted to mean that there is an M&E track, a French track, a Greek track and an English track. From this information alone, there is no way to tell whether there is even any M&E in the French, Greek and English tracks. All that is known language-wise is that dialog is available in only three languages. For this example, there would be 12 bits in field 7. The first three bits are associated with the M&E track, the second three bits are associated with the French track, and the third and fourth 3-bit codes are associated with the Greek and English tracks respectively. The 3-bit codes are as follows:

000—mixing master (M&E)

001—switching master (M&E)

010—dialog+(M&E), complete audio track

011—track to be mixed with mixing master

100—track to be switched with switching master

These five codes are all that are necessary to form complete sound tracks in the three available languages, French, Greek and English. How the tracks are combined will be described below, but what should be borne in mind is that the purpose of the entire arrangement is to provide sound tracks in many languages (up to 15), without requiring what might be a 2-hour audio recording for each. In fact, if a movie is two hours long, but the actual dialog is only 30 minutes, the goal is to record one fall track (M&E or original sound track), with only a 30-minute audio recording of dialog for a particular language.

Field 8 contains $N \times 4$ bits, that is, 4 bits for each of the N "1"s in field 6. There is thus a 4-bit code in field 8 for each audio language track which is available on the disk. The 4-bit code represents the track type, and there are a maximum of sixteen possibilities. Typical track types are single-channel mono, two-channel Dolby, 5.1-channel Musicam, etc. [The term 5.1-channel refers to left, right, center, left rear and right rear channels, together with a sub-woofer channel.] The 4-bit track type codes allow the master controller to determine the manner in which audio processor decoder 71 operates on the data in the up-to-16 audio tracks to derive analog outputs for speaker system 91.

Considering again field 7, there are several ways in which a complete sound track, in a selected language, can be derived from the disk. The operation of mixing involves mixing (adding together) two sound tracks. The operation of switching involves switching between two sound tracks, and playing only one of them at any given time. The first track is always M&E, if it is available. The code for this track is

always 000 or 001. If the code is 000, it means that there is no dialog in the track and its M&E is to be mixed with the selected language track. If the code 011 is associated with the French track, for example, it means that the first and third tracks should be mixed at all times. The dialog, when there is dialog, appears in the French track, and mixing it with the mixing master provides a complete French sound track. On the other hand, the first track may be a switching master. What this means is that music and effects are recorded in this track, with or without dialog. The French track in this case would be represented by a 100 code. It contains M&E and dialog, but only when there is dialog. The M&E track, the first, is played alone when there is no dialog, but the fifth track is played alone when there is. The tracks are switched, not mixed. The French track, when dialog is recorded in it, includes not only dialog but M&E as well since this would be the only source of M&E in a switched type operation.

The fifth possibility (010) is that a particular track happens to contain the original sound track, M&E together with dialog in the original language. If the dialog is in the selected language, the track can be played from beginning to end, by itself. This track can also serve as a switching master (code 001) for other languages.

When it comes to mixing tracks, whatever audios are in the two specified tracks (the mixing master and the track which is mixed with it) are simply added together at all times; whatever audio there is in the two tracks gets played. It is only when switching between the switching master and the track with which it is switched that one track gets played in lieu of the other. It is true that each track may contain audio information only when the other does not (which would allow mixing), but it is conceivable that the switching master will also include dialog, i.e., if it is a recording of the original sound track of the motion picture. That is why switching is employed—only one track is heard from at any given moment. As will be described below, each data block includes bits which inform the master controller which audio tracks actually contain data in that block. If a selected audio language track with an original 100 track code has data in any data block, then the audio processor decoder 71 processes the data in that audio track to the exclusion of any data which might be in the switching master track.

Field 9 on FIG. 3 contains six bits which are coded to represent a number M. This is the number of "other" audio tracks, separate and apart from the up-to-16 audio language tracks. The usual use for these tracks is to represent, in compressed digital form, individual instruments or mixes of instruments, with the user having the option of combining them. In an extreme form, there could be 63 separate instrumental tracks, with the user being able to combine any tracks he desires, and to set their relative levels before mixing. If one of the tracks contains the combined sound to begin with, it is possible to delete an instrument from the orchestral mix by specifying that its information content should be deleted, or subtracted, from the orchestral mix. This would allow a user, for example, to play his piano to the accompaniment of an orchestra playing a concerto from which piano play has been eliminated. It would also allow a user to single out a particular instrument to facilitate practice. Precisely what the user does with the "other" audio tracks is determined by menu selections which are made available to him. Field 8 simply identifies how many "other" audio tracks are present on the disk. (The term "other" audio tracks would appear to be rather non-descriptive, but this isn't the case. The intent is that the term subsume any audio track usage other than the provision of sound tracks for motion pictures. Rather than to have orchestral music in

these "other" audio tracks, for example, it is possible to have individual vocalists, allowing a user to study different harmonizations.)

It is apparent that if there are indeed 63 "other" audio tracks, then much if not most of the disk capacity may be allocated to audio data. But that is precisely why so many audio tracks are made available. It is certainly contemplated that some disks playable in the system of FIG. 2 will not include video. In fact, field 19, to be described below, is a 1-bit field which informs the master controller whether there is any video data at all on the disk.

Once it is determined that there are M "other" audio tracks, the next field specifies how each track is coded. As in the case of field 8, a 4-bit code is used for each of the "other" audio tracks. Thus the number of bits in field 10 can be as low as 0 (if there are no "other" audio tracks) or as high as 252 (63×4).

While the player can determine from reading fields 9 and 10 how many "other" audio tracks there are, the user has to be told what is in these tracks in order that he know what to do with them. There is a description of each track, and it is in multiple languages. The first thing that the player must be given is a list of the languages in which there are descriptions of the "other" audio tracks. A 100-bit field is used for this purpose. As indicated in FIG. 3, field 11 has 100 bits. A 1 in any bit position is an indication that track definitions are available in the respective language. The correspondence between bit positions and languages is the same in field 11 as it is in field 6. It will be recalled that the first bit position in field 6 corresponds to M&E, not a traditional "language". The first bit position in field 11 is thus not used, and there can be at most 99 "1"s in field 11.

Before the track definitions are actually read and processed, the player must determine what menu choices to provide the user. Suppose, for example, that there are ten "other" audio tracks, each having sounds of different orchestral instruments. Once the track definitions in the selected language are made available to the operating system, it can display a standard menu to the user. The user can then pick particular tracks to be played together, particular tracks to be deleted, their relative sound levels, and other "standard" choices. However, in case the "other" audio tracks do not represent orchestral music, or they do represent it but in a way that requires unusual menu selections, the standard operating system software for interfacing with the user so that the system can determine what is to be done with the "other" audio tracks will not suffice. To accommodate unusual situations, the operating system must be provided with special software for the creation of the menu, as well as to control how the selected tracks are mixed/deleted following user selections. The technique used is the same as the technique described above in connection with loading special software for changing the overall operation of the player (fields 3 and 4). Field 12 is a single bit. If it is a 1, it is an indication that there is a field 13 which contains special mixing/deletion software. As indicated on FIG. 3, field 13 thus has anywhere from no bits to an undetermined number which is dependent on the length of the special software to be loaded into the machine from the disk. The special software ends with a sync word so that the player will know when the next field begins.

The next field, field 14, consists of the track definitions themselves. Since there are M "other" audio tracks, and there are P languages in which they are to be defined for the user, P×M character strings are represented in field 14. Each string is separated from the next by an escape character. First there are M character strings (track definitions) in the first

language corresponding to the first position in field 11 which contains a 1, then there are M character strings in the second language corresponding to the second bit position in field 11 which contains a 1, etc. As will be described below, the user informs the player in which of the available languages the menu which includes the track definitions should be displayed. While the entire DATA OUT bit stream from the disk drive is extended to the master controller in the system of FIG. 2, only the character strings corresponding to the selected language are processed. They are processed and displayed in accordance with the standard software, or the special mixing/deletion software which was just read from field 12 if such software is included on the disk. (It should be noted that it is the function of demultiplexer 63 to distribute to the several buffers only the respective data bits that are intended for them. It is controller 41 that tells the demultiplexer what to do after the controller interprets the information in both the lead-in track section and the individual data blocks.)

As described in connection with FIG. 2, provision is made for the insertion of subtitles. The language is selected by the user as will be described, but the player must be told the languages in which subtitles are available. Another 100-bit field is used for this purpose. As indicated in line 15 of FIG. 3, the "1"s in the field represent the individual languages available for subtitles. As is the case with the available display languages, there is a maximum of 99 since the first bit position corresponds to M&E which is not strictly speaking a "language."

Field 16 is a 4-bit multiple version code. The player is informed not only whether there are two versions of the same video presentation on the disk, but also what the choices are with respect to them. The first bit is a 0 if there is only one version on the disk, in which case the second and fourth bits are ignored. Bit 1 has a value of 1 if there are two versions on the disk. The second bit in the code tells the player whether the parental lock option is to be implemented, or whether a different criterion is to be used in selecting which version is played. The usual situation is where the parental lock option is implemented, in which case the bit in the second position of the 4-bit code is a 0. This informs the player that it should determine whether the parental lock option is "on." If it is, R-rated (or, more broadly, adult-rated) versions should not be played. The bit in position 3 of the code is an indication whether version A (the first or only version) is R-rated or not (0=no, 1=yes), and the fourth bit in the code provides the same information for version B if there are two versions; if there is only one version, the fourth bit is ignored. This is all the information the player needs to determine whether either or both of two versions can be played. When there are two versions of the same motion picture on the disk, the user is asked to select one of them. But if the parental lock option is "on" and one of the two versions is R-rated, the user is given only the choice of playing the non-adult version, or playing neither, as will be described below. If both versions are R-rated and the parental lock option is "on", then the user can watch neither version.

On the other hand, it is possible that there will be two versions of the same material on the disk, but it is not a question of one of them being adult-rated and the other not. For example, one version might be a teaching film including questions and answers, and the other might involve a test on the same subject matter including just questions. For the most part the two versions would be the same. In such a case, the first bit in field 16 would still be a 1 to indicate that two versions are available, but the second bit would now be a 1

instead of a 0, to indicate that the choice between the two versions does not depend on whether they are R-rated or not. A 1 in the second bit position is an indication that the third and fourth bits characterize the two versions respectively with respect to a characteristic other than rating.

What the third and fourth bits actually mean in this case, and what menu choices are provided the user, has to be determined by resorting to different criteria. The same technique that was used twice previously is now used once again—special software is provided along with the version codes. Field 17 consists of a single bit which serves as a flag to indicate whether special version software is available. If the bit is a 1, then field 18 is read to access the software. As in the case of the two earlier software fields, field 18 terminates with a sync word to indicate the start of the next field. The special software controls a menu presentation that is unique for the particular disk.

The next field consists of a single bit. As indicated in FIG. 3, it informs the player whether video data is available. If it isn't, it simply means that there are no video data block fields in the overall data blocks to be described in connection with FIG. 4.

Field 20 is a single bit, and it identifies the base or master aspect ratio. If the bit has a value of 0, it is an indication that any video on the disk has a 16:9 "wide screen" aspect ratio, as depicted in FIG. 9. On the other hand, if the bit is a 1, it is an indication that the aspect ratio of the video on the disk is 4:3.

As described above, if the original video has a "wide screen" aspect ratio, then there are two ways in which a 4:3 reduced aspect ratio can be derived. One way is to form the video image from the middle part of the "wide screen" original. Another way is to "pan scan" in the sense that the section of the original image which is actually utilized is not necessarily always the middle part. In fact, FIG. 9 shows the use of more information on the left than on the right of the original image. Field 21 is a single bit which is indicative of pan scan availability. If field 20 is a 1, the base aspect ratio is 4:3 so that pan scan availability is irrelevant—the single bit in field 21 is simply ignored. But if the base aspect ratio is 16:9 (field 20 has a 0), the value of the bit in field 21 tells the player whether the subsequent data blocks provide starting column information which can be loaded into pan scan buffer 57 on FIG. 2. If the bit in field 21 is a 0, the data blocks do not include column number information, and if the video is to be played in a 4:3 aspect ratio from a "wide screen" original, then the video image is formed from the middle part of each original frame. On the other hand, if pan scan information is available in the data blocks, then buffer 57 on FIG. 2 is updated as required and the final video formed will have an added degree of variability.

Field 22 is a 20-bit number which represents the total number of data blocks on the disk. However, if there are two different versions, while they have many data blocks in common, the remaining numbers of blocks in the two versions may be different. For example, a scene might be completely omitted from one of the versions, in which case it would have a smaller total number of data blocks. For this reason, if field 16 indicates that there are two versions of a motion picture or other source material on the disk, field 23 provides the total number of data blocks in version A, and field 24 provides the total number of data blocks in version B. Both fields are omitted if there is only one version on the disk.

Each data block may include video information for a variable number of frames. The system could determine the total playing time from the number of data blocks (either the

total number if there is only a single version, or two different numbers if there are two versions), only if the system is informed of the original frame rate and the average number of frames represented in each block for the disk as a whole. Two disks with the same number of data blocks will have different running times if the original source material for one of them was motion picture film whose frames were generated at the rate of 24 per second and the other had an original source material derived from a 30 frame-per-second video camera. Field 25 is a 4-bit value that identifies the original frame rate (24, 30, etc.), a number necessary for proper generation of the video signal. Although the time represented by each data block could be determined from the frame rate if each data block contains only one frame, it is possible to store more or less than one frame of data in each data block. Also, there may be no frame information at all, i.e., the video availability flag in field 19 may be 0. Consequently, field 26 is provided. This field contains a 10-bit number which represents the block time factor, i.e., the average time duration represented by each block. Multiplication of the block time factor by the total number of blocks (or the total number in a particular version) yields the running time. (In practice, the block time factor is about the same for both versions on a disk. If desired, individual block time factors can be provided.)

As is common practice with optical disks in general, the disk of the invention may be provided with a table of contents for allowing the user to select a particular part to play, or simply to inform the user of precisely what is on the disk and how long each part takes to play. Field 27, if included, is a table of contents. If only one version of the source material is on the disk, then there is only one table of contents. Otherwise, there is an additional field 28 which consists of the table of contents for the second version. FIG. 3 sets forth the sub-fields in field 27.

For lack of a better term, the video presentation is divided up into what are called "chapters." For each chapter the table of contents includes an 8-bit chapter number, thus allowing a maximum of 255 individual chapters. Following each chapter number there is a 20-bit starting block serial block number. It will be recalled that all of the data blocks on the disk are numbered serially. In other words, while data blocks may be common to both versions A and B, or unique to only one of them, the numbers of the data blocks are in serial order along the disk track. The table of contents includes the serial block number of the data block which is the starting block for each chapter.

Similarly, in order to determine the play time for each chapter, the system must know how many blocks are included in each chapter. For this reason, the next piece of information is a 20-bit block duration. Multiplying this number by the block time factor allows the play time of each chapter to be determined. Alternatively, the actual running time for each chapter could be provided instead of the block duration. (Such information could be provided for different versions and standards.)

In order to display the title of each chapter, language strings must be provided. Once again, the system must be advised of the languages which are available for displaying chapter titles so that the user might select one of them. The usual technique of providing a 100-bit block for identifying available languages is employed.

Finally, the actual language strings for identifying individual chapters are provided. Each string ends with an escape character to separate it from the next string. This is the same technique used in connection with the "other" audio track definitions discussed above in connection with field 14.

Field 29 has a minimum of 100 bits and a maximum of 1200 bits. It will be recalled that there can be up to 12 authorized standards, i.e., the final video output can be in up to 12 different formats. In order to insure conformance with quality standards agreed upon by all manufacturers of players and all software publishers who have agreed to support a common set of specifications, it is possible to prevent unauthorized software publishers from publishing disks which will play on players of the invention. Moreover, it is possible to limit particular publishers to the manufacture of disks which will play according to only a sub-set of the 12 standards. For example, if royalties are to be paid on each disk which is manufactured according to the agreed-upon specifications, and the royalties vary in accordance with the number of standards according to which a disk can be played, it is possible to limit certain software manufacturers to only the sub-set of standards for which they have agreed to pay. For this reason, there is an encrypted authorization code for each standard; the codes are all stored in field 29. The disk will play according to a particular standard only if the proper encrypted authorization code is contained on the disk. Field 29 includes 100 bits for each of the standards authorized in field 5. Since at least one standard must be authorized there are at least 100 bits. The maximum number of bits is 1200 if all 12 standards are authorized.

The encryption scheme is based upon the principles of public-key cryptography. Public-key cryptography is by now well known, and a particularly clear exposition of the subject is to be found in the August 1979 issue of Scientific American, in an article by Hellman entitled "The Mathematics of Public-Key Cryptography." The use of a public-key cryptosystem allows a message to be encrypted at site A in accordance with a secret key, transmitted to site B, and decrypted at site B in accordance with a public key. The secret key for encrypting the message is known only to the transmitter. Such a scheme is typically used to authenticate a message. Upon decryption of the transmitted encrypted message at the receiving site, the message will be intelligible only if it was encrypted with the paired private key. And since the private key is private, if the decrypted message is intelligible, it must have originated with the owner of the private key.

Public-key cryptography is used in the invention in the following way. The actual data on the track is processed by the software publisher in accordance with a predetermined algorithm. The details of the processing are not important. Any non-trivial processing that provides, for example, a 100-bit result based on the disk data will suffice. The 100-bit result is a "message" to be transmitted via the disk in anywhere from one to twelve encrypted forms. There are 12 cryptosystem key pairs, each associated with a different one of the standards. The private key for the first standard authorized on the disk is used to encrypt the 100-bit message and the 100-bit encryption is stored in field 29. This encryption is the authorization code for the particular standard. The same thing is done for all of the other standards authorized for the particular disk, with the private key associated with each of these standards being used in each case.

The player operating system computes the same 100-bit result or message that was originally computed by the software publisher. The player software then uses the public key associated with each of the standards authorized on the disk to decrypt the respective encrypted authorization code for that standard. The decrypted message should match the message computed by the operating system after processing the disk data. If they do not match, it is an indication that the software publisher did not have the private key for encrypt-

ing the authorization code for the particular standard, and the player will not produce a video signal according to that standard.

To explain this in another way, let it be assumed that the private key for authorized standard N on the disk gives rise to an encrypted message $Pri_N(X)$, where X is a message to be encrypted. Similarly, the function $Pub_N(X)$ represents the decryption of a function X using a paired public key. Let it further be assumed that the predetermined algorithm for processing the data on the disk is known by all player manufacturers and software publishers, and gives rise to a 100-bit result which is treated as a "message" M whose content (value) depends on the disk data. For standard N, the software publisher, after first deriving M, stores on the disk the 100-bit encrypted authorization code $Pri_N(M)$. The player first derives the value M in the same way that the software publisher did. The player software then uses the public key associated with standard N for decrypting the encrypted authorization code. The operating system thus derives $Pub_N(Pri_N(M))$. Since decryption of an encrypted message should result in the original message, the result of this decryption should be the same value M which the operating system derives by processing the disk data. If it is, then the particular standard is not only authorized, but the publisher has the right to authorize it. On the other hand, if the decryption of the encrypted authorization code M does not match the algorithmic result M derived by the player (because the software publisher did not have the private key with which to derive $Pri_N(M)$), then that particular standard is locked out.

While such a scheme works in the abstract, there is one practical problem which must be overcome. Suppose, for example, that the algorithm used to derive the original "message" M involves processing 20 data blocks on the disk with predetermined serial block numbers. (The processing might be something as simple as multiplying by each other successive groups of 100 bits each, and using as the result of each multiplication—for the next multiplication—only the 100 least significant bits.) A publisher who is not empowered to authorize standard N on a disk may nevertheless wish to do so. He does not know the private key with which to encrypt the derived value M which is applicable to his software. Consequently, he does not know what 100-bit encrypted code he should put on the disk which will decrypt in a player to the value M. But what he can do is copy the 20 predetermined data blocks from some other legitimate disk and put them on his own disk, and also copy the encrypted authorization code in field 29. Those 20 data blocks, when processed in a player, will result in the value M, and it will match the "stolen" encrypted authorization code after it is decrypted in the player. Of course, the software publisher may have committed copyright infringement, but that simply compounds the felony. The practical problem which the software publisher faces is that he will have data blocks which are "played" and which will be totally out of context insofar as his motion picture is concerned. However, because the way that multiple versions of a motion picture can be stored on the same disk in the first place is that the player can be controlled to skip over the play of certain data blocks, as will be described below, the software publisher can encode his other data blocks so that the copied data blocks are not played. In this way, the encryption protection can be rendered ineffective.

The solution is that while the algorithm that derives the "message" M in the first place may also operate on predetermined data blocks, it should operate on at least the lead-in section of the track. There is no way that an unauthorized

publisher can copy the lead-in track fields from another disk because that would give a player incorrect information about the video and audio contents on the unauthorized publisher's disk. The lead-in data is a function of the particular subject matter of the disk, and it must appear in the track in order for the disk to play properly. Thus the information represented on FIG. 3 can be treated as the "message" M whose encryptions, one for each authorized standard, are derived using respective private keys and are stored in lead-in field 29. (Strictly speaking, the "message" M is the result of processing all fields except field 29. Also, the longer fields, such as those containing software, can be omitted from the processing.) The player derives the same "message", decrypts an encrypted authorization code with the public key associated with the respective standard, and then compares the two. If they don't match, the player determines that that particular standard has not been authorized for the particular disk's publisher.

The encrypted authorization code field is shown toward the end of FIG. 3 and thus the corresponding processing is depicted toward the end of the flowchart of FIGS. 5A-5C to be discussed below. The positioning of the encrypted authorization code field as shown facilitates a description of its processing, but in fact the field may advantageously be placed at the start of the processing. It will be recalled that special software may be read from the disk to modify the normal player sequencing. It is therefore conceivable that a counterfeiter could write special software which causes the authorization code processing to be bypassed. By doing the processing before any special software is even read, the processing cannot be bypassed.

Returning to a description of the lead-in track fields, field 30 is a 1-bit data block command/data flag. This bit informs the operating system whether the data blocks include command information or data which is to be read during play of the disk. How the system determines whether a particular data block contains commands or data will be explained below. Field 30 simply indicates whether there is any such information at all. Finally, fields 31 and 32 are catch-all fields for allowing the disk to control unusual ways in which the player processes the information on the disk. It will be recalled that field 3 contains a flag which indicates whether field 4 contains special software which causes the player to operate in accordance with a program that is totally different from that usually employed, field 12 indicates whether field 13 contains special mixing/deletion software for use with the "other" audio tracks, and field 17 contains a flag which indicates whether field 18 contains special version software for processing the 4-bit multiple version code. Field 31 indicates whether there is "supplemental" software in field 32. The supplemental software is different from the special software of field 4 in that the software in field 4 is basically a substitute for the processing which is normally used, while the supplemental software generally works with that code, in conjunction with commands and data which are to be found in the data blocks.

Typically, the supplemental software would allow play of a video game, with related commands and data in the data blocks determining the course of play. But there are other uses of this technique. As another example of the way in which supplemental software, and commands and data in the data blocks, can be used, consider a disk designed to play a classic motion picture with subtitles, but which is also provided with a critical commentary which is to be displayed periodically in lieu of subtitles, perhaps during moments when the screen is caused to go blank except for the critical commentary. To show the flexibility which is

possible, let us even consider a case where the critical commentary is to be in a different language. What is required in such a case is that the subtitle buffer 59 on FIG. 2 be loaded during the play of some data blocks with subtitles in one language and with subtitles in another language during play of other data blocks (some data blocks thus containing subtitles corresponding to the original motion picture, and others containing critical commentary in another language). In such a case, the system must somehow be told to switch back and forth between language subtitles, i.e., different subtitle tracks have to be processed in different data blocks. This can be conveniently controlled by issuing commands in the data blocks themselves. Similarly, if it is desired to blank the screen and interrupt the picture during display of commentary, a data block might include a data value which represents the duration of the blanking. Alternatively, if a commentary is to be made in a different language, it could be a different audio track which is selected for the purpose. In any case, the special software loaded from field 32 would control the processing of the commands and data contained in the data blocks, and would work in conjunction with the operating system of the player.

PROCESSING OF THE LEAD-IN TRACK FIELDS

The flowchart of FIGS. 5A-5E depicts the processing of the information in the lead-in track fields. A description of this preliminary processing is presented at this point, with the functions of the individual fields in mind. The fields in the data blocks, as well as processing of the data blocks, are discussed below.

The system processing begins, as shown at the top of FIG. 5A, with the reading of default settings. These are settings established by DIP switches, ROM codes, or the use of any other device or technique which configures the system on power-up. It is typical in microprocessor-based systems to reset all flags and to read default settings when power is first turned on.

There are four default settings which are thus determined in order to configure the system. The first is the standard—players sold in the United States, for example, will typically be configured, in the default state, to produce an NTSC video signal.

The next default setting is language—the sound track dialog language, the subtitle language (if any), and the language in which menus are to be presented on the display. In the United States, for example, the default language would be English. If the user does not inform the player that a language other than English is desired for one or more of these functions, audio language track 10 will be used to generate the sound track, and character strings in the English language will be used in setting up the mixing/deletion menu for the “other” audio tracks and for the table of contents. As for subtitles, the usual default is “no language.”

The third default is the aspect ratio, 4:3 in the United States. The aspect ratio determines the relative dimensions of the display represented by the final video output signal.

Finally, the parental lock status is determined. In the system of FIG. 2, this simply entails a determination of the setting of lock 81. But it is also possible to dispense with a physical lock and key, and to store the parental lock status in non-volatile memory after first inputting on the keyboard a password known only to the persons who exercise control over the lock function.

As in many consumer electronic devices, the keyboard can be used by the user at any time to interrogate or control

the player. Routine control sequences which are standard in the art are not shown in the flowcharts. For example, the keyboard, or an associated remote control device, can be used to control the volume, fast forward, a jump to a specified chapter, etc. The normal processing can be interrupted to control a display by operating a menu key, as is known in the art. At the start of the processing of FIG. 5A, there is shown a test for determining whether the menu key is operated. The reason for showing an interrogation of whether the menu key is operated at the start of the processing, as opposed to any other time during play of the disk, is that this is the mechanism by which default settings can be changed. If the menu key is operated when power is first turned on, the system displays a menu. As indicated in the flowchart, the user is given the choice of changing defaults, viewing the table of contents for the disk, and/or (in case the menu key was operated accidentally) simply returning to the processing without changing anything. As indicated, depending on the menu selection, the defaults are changed, the entire menu selection process is aborted, or a TOC (table of contents) flag is set to 1. This flag will be examined later to determine whether the table of contents should be displayed.

Thus far, no information from the disk has been processed. (In this description, references are sometimes made to reading a field and sometimes made to processing a field. It is to be understood that even when it is said that after a certain processing step a field is read, the field may actually have been read earlier but stored in a buffer for later use. Depending on the context, reading a field means to actually read it so that the bits appear on the DATA OUT conductor 25 in FIG. 2, or to do something with the data if it has been read earlier and buffered.) Referring to FIG. 3, the first information field which is read from the lead-in track section is a 40-bit field representing authorized territories. Next, a check is made to see whether the territory in which the player was intended for use is one of those authorized on the disk. The player territory is also a kind of default setting, but it is not grouped with the others because it cannot be changed by the user. (To allow a purchaser who moves from one territory to another to use his player, the player territory can be changed by an authorized technician.) If the player has been designed for use in China, for example, and China is not one of the territories authorized on the disk, play of the disk is aborted.

On the other hand, if the disk has been authorized for play in the player territory, field 3 is read. This single bit simply tells the system whether special software is present. As shown in the flowchart, if it is present then the special software is read from field 4 and executed. The processing terminates with the “execute special software” step. This is intended to show that the special software in field 4 basically replaces the built-in operating system. Such software will be employed when a radical change in the overall use of the player is involved. (As mentioned above, this is not to say that the special software may not call BIOS routines and the like from the ROM chips containing the operating system.)

If there is no special software present, the system reads the default standard, e.g., it determines that an NTSC standard is to be employed. If the user has changed the default standard through a menu selection, e.g., to PAL, then PAL is the new default standard. The system then accesses field 5 which authorizes up to 12 standards. The test which is performed is to determine whether the default standard (the original, or as changed at the start of the processing) is authorized. If it is not, a menu is displayed which shows the user the authorized standards, and he then selects one. After

an appropriate selection is made, or if the default standard is authorized, the system processes fields 6 and 7. The reading of field 6 informs the player of the available audio languages (up to 16, including M&E and 15 languages).

Once again, a default value is tested against a set of allowed options. Earlier, it was the default standard that was tested against the authorized standards read from the disk. This time it is the default audio language (either the default language on power-up or a different language selected by the user if the menu key was operated) that is compared with all of those available. As shown in the flowchart, if the default language is not available, a display is formed which lists the available audio languages, and the user selects one of them. The system then reads the track types in field 7. This is the field which informs the operating system whether there is an M&E track, whether it is to be used as a mixing or a switching master, and whether the selected language track is a complete audio track, is to be mixed with the mixing master, or to be switched with the switching master. Next, the track codings are read from field 8. Given the selected language, and its track type and track coding, as well as information about M&E, mixing and switching, the operating system has all of the information it needs to generate a sound track for the accompanying motion picture which meets the needs of the viewer.

The next thing that is done is to read field 9 to determine the number of "other" audio tracks which are on the disk, anywhere from none up to 63. If there are indeed no "other" audio tracks, all of the processing to determine what is to be done with them is bypassed. But if there are such tracks, field 10 is first read to determine how they are coded. Since the user has to be told what is in the tracks before he can determine what is to be done with them, the system must next determine from reading field 11 the "other" track menu languages which are on the disk. The usual type of check is then made to see whether the menu is available in the default language. If it is not, the available languages are displayed and the user selects one of them.

As described above, the operating system may execute a standard routine for reading the menu, displaying it, and interacting with the user as the user determines what should be done with the "other" audio tracks. But in the event special mixing or deletion is to be accomplished, special mixing/deletion software is required. Field 12 is read to see whether such software is available and, as indicated in the flowchart, any special mixing/deletion software which is on the disk is read from field 13. Only then are the actual menu items (in the selected language) read from field 14 and displayed for the user. Using the menus made available by the operating system, the user selects the play mode for the "other" audio tracks. He can, for example, mix them in any allowed way, use what is in a track for deletion (by phase inversion) from another more inclusive track, adjust one track for exclusive play, adjust relative audio levels, etc.. The special mixing/deletion software, of course, can provide these options as well as others not routinely offered.

As shown in FIG. 5B, subtitle information is now processed according to the established pattern. First, the system determines whether subtitles are desired at all. At the very beginning of the processing in FIG. 5A, it will be recalled that one of the default settings is the subtitle language. The usual default setting will be that subtitles are not desired. If that is in fact the case, the subtitle processing is skipped entirely. But if subtitles are desired, the available subtitle languages are read from field 15. A test is then made to see if the default subtitle language is available. If it is not, the available subtitle languages are displayed and the user selects one of them.

Next, the 4-bit multiple version code in field 16 is read. The first bit indicates whether there are two versions available, or only one. A branch is not made at this point because first the system must determine whether special version software is available, and this is determined from field 17. If special version software is available, it is read from field 18 and executed. To the extent that this software must know whether multiple versions are available, and what the codes in the third and fourth bit positions represent, that has already been determined. Although indicated in the flowchart that the choices displayed for the user are to select among authorized versions, or to exit, it is to be understood that the display choices will generally be different if special version software is executed. Also, it should be understood that there may be special version software even if there is only one version that can be played. For example, it may be appropriate to warn a viewer that a particular program may be extraordinarily unsettling, and to ask for a "continue" response before play begins—all of this being separate and apart from an R-rating.

If special version software is not available, then bits 3 and 4 in the 4-bit multiple version code field are used for rating purposes. A test is performed to see whether the parental lock is on. If it is not, then there are no restrictions on the play of versions A and B, and both versions are authorized. If it was previously determined that there is only one version, then that version is considered to be version A and it is authorized.

On the other hand, if the parental lock is on, tests must be performed to see whether the versions on the disk are R-rated. As shown in FIG. 5C, if version A is R-rated, and so is version B, then play of the system is aborted; although not shown, an appropriate message may be displayed to advise the user why play has stopped. If version A is R-rated but version B is not, then only version B is authorized. On the other hand, if version A is not R-rated but version B is, only version A is authorized. Finally, even if the parental lock is on, if neither version is R-rated, then both versions are authorized.

The system next displays the choices available to the user. He can choose from among the authorized versions, or he can exit and stop playing the disk. (This latter case might arise, for example, if a child tries to watch an R-rated version, is told that it cannot be played, and a decision is made to go on to something else more interesting.)

If there is only one version available, if it is not R-rated, and if there is no special version software, then there may be no need for a display—there is only one motion picture which can be played, and there are no restrictions on who can watch it. Nevertheless, as shown in the flowchart, the user is still given a choice between play of the disk and aborting play. The system could be designed to skip the display in such a case and simply to assume that the user wants to watch the only motion picture version which is on the disk. On the other hand, generating the display allows the user to verify that the disk he put in the player is indeed the disk he wants.

Although the invention has been described thus far in terms of one or two versions of a motion picture on a disk, it is to be understood that there can be three or more versions. This is one of the main reasons for providing the capability of reading special version software in the first place. This software can include all of the information required about the several versions from which menu displays are formed so that the user can select what is to be played. As mentioned above, the special version software

can allow choices between teaching and test modes, and other options having nothing to do with whether particular motion pictures are adult-rated.

The system next reads the video availability bit in field 11, and thus determines whether the data blocks which will be processed subsequently contain video data. If video data is present, then the base or master aspect ratio in which it has been stored on the disk must be determined. The next step thus involves reading field 20 to ascertain whether the base or master aspect ratio is 16:9 or 4:3. If the master aspect ratio is 4:3, the next five steps are skipped because pan scan availability is irrelevant. If the default aspect ratio is 4:3, then there is a one-to-one correspondence between stored and displayed frames; if the default aspect ratio is 16:9, then a 4:3 frame is displayed on a wide screen with a dark band at either side. (Alternatively, the 4:3 image could be expanded to fill the 16:9 screen, with resulting loss of top and/or bottom information.) But if the base aspect ratio is 16:9, as shown on FIG. 9, there are several possibilities which must be explored.

One of the default values which is determined at the very start of the processing is the aspect ratio. The operating system checks whether the default aspect ratio is pan scan 4:3. Referring to FIG. 9, if the master aspect ratio is "wide screen" (the flowchart branch being processed), then the possibilities are letter box, pan scan centered on the wide screen image (not shown in FIG. 9), or pan scan variable (i.e., with a variable starting column number). If the default is not pan scan 4:3, then there are no choices to be made by the user now. The default is either wide screen or letter box, and subsequent processing is in accordance with the default which has already been determined.

On the other hand, if the default is pan scan 4:3, the issue is whether variable pan scan information is on the disk. The pan scan availability bit in field 21 is read. If pan scan is available, it means that the data blocks will specify to the operating system the starting column numbers for the pan scan—the user need select nothing at this point. On the other hand, if pan scan is not available, and this was the user's default, he must decide from among two possibilities—a center cut, in which the middle part of every wide screen frame is displayed, or a letter box form in which the entirety of every frame can be seen, but the display has dark bands at the top and bottom. A menu display is formed, and the user selects one of the two modes.

This use of a common aspect ratio on the disk which nevertheless allows the user to select from many different kinds of display exemplifies the design approach of the invention. The basic idea is to provide maximum flexibility while nevertheless storing all of the required data on an optical disk roughly the size of a conventional CD. Once a wide screen motion picture is stored on the disk, almost no additional real estate is required to allow the user to generate a video output having some other aspect ratio. Although there may be up to 15 languages in which dialog can be heard, there are nowhere near 15 full sound tracks because of the mixing and switching capabilities built into the player and the manner in which redundant information is eliminated from the audio language tracks. The same thing applies to video standards. While up to now high-quality video has required a medium which can be played only in NTSC, or PAL, etc., the present invention allows the same disk to give rise to video signals in up to 12 standards. One of the advantages of the invention is that it greatly reduces the number of different disks that must be produced, for example, by a motion picture company that distributes its movies throughout the world. While it is true that some

fields may have to be changed from time to time, for example, different standards have to be authorized when videos are released in NTSC and in PAL at different times, such changes are relatively trivial and are easily made.

Once a decision on the display mode is made, field 22 is read to determine the total number of data blocks on the disk. If there are multiple versions, fields 23 and 24 are also read in order to determine the total number of data blocks in each of the versions. Field 25 is then read to determine the original frame rate, and field 26 is read to determine the block time factor.

Field 27 is then processed. It will be recalled from FIG. 3 that this is the field that contains all of the necessary information for display of the table of contents. The table of contents for the selected version (field 27 if there is only one version, or there are two and the first has been selected; or field 28 if there are two versions and the second has been selected) includes a 100-bit representation of the available chapter display languages. The default menu language is checked against those which are available. If the default menu language is not available, the user is informed of those languages in which chapter titles can be displayed, and he selects from among them. Once it has been determined in which language to display chapter information, the various table of contents time durations are calculated. Since it is known how many blocks are in each chapter, the duration of each chapter can be determined by multiplying the number of blocks by the block time factor.

The table of contents is not necessarily displayed. It is displayed only if the TOC flag was set at the start of the processing, the user having indicated that the table of contents should be displayed. If the TOC flag is 0, there is no need to display the table of contents. The system automatically selects the first data block as the starting point, that is, play of the disk starts at the beginning. On the other hand, if the TOC flag is a 1, the table of contents is displayed and the user is given the option of selecting the start point.

Following the table or tables of contents on the disk are the encrypted authorization codes for the standards authorized in field 5. The operating system reads the encrypted authorization code for the standard which has been selected. It then reads the predetermined data for the selected standard. It will be recalled that for each of the 12 possible standards, predetermined data on the disk is processed to derive a "message" M which serves as an authorization code. It is this authorization code that is stored in encrypted form on the disk using the private key associated with each standard. The data which is read from the disk may be different for each standard, as long as the same data is read and processed both during the encryption process and when the player derives the "message" M on its own. As discussed above, it is preferred that the data include at least part of the lead-in fields because it would be self-defeating for an authorized publisher to copy this data.

After the predetermined data for the selected standard is read, the authorization code ("message" M) is computed from the data. Using the public key associated with the selected standard, which key is built into the operating system, the stored authorization code on the disk for the selected standard is decrypted. The test for whether the software publisher has been authorized to publish disks which will play as video signals in the selected standard involves comparing the decrypted authorization code with the computed authorization code. If they do not match, play is aborted.

If the two codes do match, field 30 is read. This single bit simply informs the master processor whether there are any

