MOTION PICTURE AND VIDEOTAPE EDITING AND SOUND CONTROL SYSTEM

Abstract of the Disclosure

Means including both method and apparatus for editing motion pictures and videotapes to a partially completed or finished state, and synchronizing and purifying their sound tracks. Footage to be edited is kept in a storage means, and brought by a transport from said storage means to a presentation means which transmits the image to a viewing means; footage address notation means, by which the viewer may make note of points within the footage of interest to him; address storage means, wherein are stored footage addresses; address association means, by which footage addresses stored in said address storage means may be associated with other data; text input means, by which text may be emplaced in the system and linked to footage addresses by said address association means; graphical input means, by which graphical symbolism may be emplaced in the system and linked to footage addresses by said address association means; selection input means, by which said text and graphics linked to footage addresses may be selected; footage rearrangement means, by which sequences selected by the user may be rearranged for viewing; sonic analysis means, analyzing the soundtrack of the footage into sonic components; sonic re-timing means, re-timing said sonic components in accordance with some timing signal; sonic reconstitutive means, reperforming the sound according to the new timing; sonic component visual display means, displaying said sonic components and other features of the soundtrack, and sonic component display modification means, permitting graphical modification of said sonic components discovered and stored by said sonic analysis and storage means, and other graphical modifications to the soundtrack.

Background of the Invention

This invention relates to the art of motion-picture and videotape production, and more particularly to an improved method and apparatus for editing the created footage into intermediate collections of shots or finished films or videotape shows.

It is to be understood that the terms "motion picture," "film" or "videotape" as used in this application are intended to refer not only to common motion pictures composed of image frames on sprocketed film, or to the common magnetic-oxide videotape recordings, but to any form of recording information to be presented to a final viewer sequentially as images, whether stored photographically, electronically, or by other means.

It is to be understood that the term "footage" as used in this application means a quantity of such film or videotape, or the contents of such a quantity of film or videotape.

It is to be understood that the term "shot" as used in this application means a consecutive segment of film or videotape.

In the production of motion-picture and videotape photoplays and shows, persons producing the work cannot confine their production activity to exact pre-planned scenes and shots, but create incidentally unwanted footage and shots of uncertain final use. The task of editing consists of discarding definitely unwanted footage and effecting trial combinations from among the shots considered usable; viewing these combinations and selecting from among them, and aggregating such combinations until a production is completed.

Although it is possible to envision roughly the nature of a planned sequence of known shots, unexpected flaws and virtues are frequently discovered upon viewing such sequences. Thus it is desirable for the editor to be enabled to plan quickly a new

sequence of footage, and for him to view such sequence as promptly and effortlessly as possible.

In the past, editing has been effected through the use of hand-operated transport means (rewinds) and viewing machines (viewers), together with the physical operation by the editor of cutting and splicing devices to join physically strips of film into a sequence. If he desires to see the shots in another combination, the editor must then either re-separate the entire sequence and reassemble in that new combination, or make individual changes in the existing combination until it satisfies him.

In these activities the editor must devote much attention to the storage and location of the footage which interests him. Usually he must keep written numerical records of the locations of the shots which he thinks he may use, with respect both to what reel a shot is on and at what position on the reel (generally in terms of feet) it is to be found. The management of these physical shot locations (or, as we shall call them, "addresses") occupies much of his attention.

A related problem is that of recording and synchronizing sound tracks to motion pictures and prearrangement of synchronization for recordings to be thus synchronized. Good quality speech recording synchronized with actors' lip movement is ordinarily best attainable with expensive recording equipment electrically linked to the motion picture camera or speed controlled by precision means, under recording circumstances requiring hushed surroundings. Recordings made with neither electrical connection to the camera nor precision speed control tend not to be correctly synchronized. Recordings made under poor recording circumstances tend to have undesirable background noises.

An alternative, called "wild" recording, is the creation

of a sound recording by actors watching the film, who attempt by mimicry to synchronize their speech with the depicted lip movement. The resulting recordings usually synchronize poorly to the film, due to the difficulty of acting with realism while attempting to match the pre-existent timing.

Summary of the Invention

It is with the above problems and considerations in mind that the present improved editing system has been evolved, permitting the editing of films and videotapes without extraneous physical operations or attention by the user to numerical information, permitting the concentration of the editor on aspects of the task relevant to his decision processes, in particular the contents of the shots and transitions among them.

It is, accordingly, among the primary objects of this invention to provide a method of editing in which the editor is freed from mechanical operations and concerns of storage and location, and permitted to deal with the symbolic manipulation of contents which are of editorial concern.

Another object of the invention is to provide a machine or system for editing which requires no concern with numerical addresses and permits operation by the editor through the symbolic manipulation of contents.

Another object of the invention is to perfect the synchronization of wild sound and thus render unnecessary simultaneous recording.

Another object of the invention is to improve the quality of sound recordings made with inferior equipment or in noisy surroundings in order to simplify the creation of an acceptable soundtrack.

Another object of the invention is to provide a simplified facility for audio mixing, i.e., combining several soundtracks while changing volume levels into a single soundtrack with all

sounds in appropriate proportion.

These and other objects of the invention, which will become hereafter more apparent, are achieved by storing the footage on videotape or other storage means, permitting an editor to control its movement through a presentation means while he views it on viewing means, such as a TV screen, and permitting him to define points within the footage, and permitting him to annotate these points or stretches of footage between them. In accordance with the invention, the points in the footage are identified by some signalling means such as a pushbutton, and the addresses of the locations of these points on the videotape are then stored in a location storage means, such as a computer disk memory. The user may then input to the computer strings of descriptive or mnemonic text, which are coupled to the footage addresses through an address association means, such as a linked list on computer disk storage. Through a text presentation means, such as a computer display coupled to the television screen, the text descriptions or mnemonics are presented again on a viewing means, and the user chooses the desired sequence through a selection input means, such as a light pen. The user may likewise use symbols or diagrams for the designation of shots and sequences he desires. In accordance with the invention, the shots thus designated, or copies of the shots, are automatically rearranged for viewing by a footage rearrangement means, such as four videotape recorders controlled by a general-purpose digital computer with a sorting program. The user then views the completed series of shots and may then make any desired change in the sequence with said selection input means, or change the text descriptions as desired.

Points which have been designated in the footage may be used as synchronization points for the sound track, which has been

broken into its constituent sonic components by a sonic analyzer.

These constituents may also be selectively removed or strengthened as guided by user manipulation of the visual display to remove noise and improve clarity and effect.

A feature of the invention resides in the fact that the user is unaware of the place of storage of a given shot.

Another feature of the invention resides in the fact that the user does not need to use any numbers or coded abbreviations, and may use only full English text as descriptions to control the sequencing of desired shots.

Another feature of the invention resides in the fact that the user may restore to its original length a shot which he previously has shortened.

Another feature of the invention resides in the fact that the user may effect fine trim between shots, and audio mixing, by manipulation of diagrams.

Another feature of the invention resides in the fact that extraneous details of exercising this craft, such as physical manipulation of rewinds and splicers, and the numerical annotation of film addresses, may be eliminated from the mental field of the working editor.

Another feature of the invention resides in the ability of the editor to obtain synchronization between photographed lip-movement and uncontrolled recordings.

Another feature of the invention resides in the ability of the editor to remove background noises which are visually discernible in a visual display of sonic components of recorded sound, and improve sound character and clarity by the same mechanism.

Brief Description of the Drawing

The specific details of apparatus suitable for practicing the method of this invention, and their mode of functioning, will be described in full, clear, concise, and exact terms in conjunction with the accompanying drawing, wherein:

FIG. 1 is a schematic perspective view of an editor's console, showing viewing screen and controls.

FIG. 2 is a top plan view of a function button panel, showing the different labelled function buttons.

FIG. 3 is a schematic drawing of the major parts and signal paths in the complete editing system.

FIG. 4 is a schematic view of the screen area showing a simulation of a list of shot descriptions as seen by the editor on a television screen.

FIG. 5 is a schematic view of the screen area showing a simulation of a list of shot descriptions and an assembly list onto which one shot description has been transferred.

FIG. 6 is a schematic view of the screen area showing a simulation of a combined display of script and shot diagrams as seen by the editor on a television screen.

FIG. 7 is a schematic view of the screen area showing the simulation of a trim control diagram as seen by an editor on a television screen.

FIG. 8 is a simulation of the sonic constituent display, showing the display of an array of sonic components as seen by the editor on a television screen.

FIG. 9 is a simulation of the sync map, showing the now line, volume contour and sync points.

FIG. 10 is a simulation of the audio mix map as seen by an editor on a television screen.

Description of the Preferred Embodiment

Referring now more particularly to the drawings, like numerals in the various figures will be employed to designate like parts.

As seen in FIG. 1, the user's apparatus for practicing the instant invention is shown in connection with a conventional television screen 1. Facing the user in front of the television screen are an array of function buttons 2, a cuing pushbutton 3, forward-and-back control wheel containing binary shaft encoder 4, a typewriter keyboard 5, and a light pen 6.

As seen in FIG. 2, the user selects functions from among various pushbuttons, 7 through 15. Their respective uses will be described in conjunction with specific operations.

As seen in FIG. 3, the user's controls 18 are interfaced by input lines 19 to a general-purpose digital computer 20, such as a Digital Equipment Corporation PDP-8 or IBM System/360 mod 92, having a magnetic disk memory 21. The user's controls are interfaced along input lines 19 as input devices in the standard manner, as will be appreciated by those skilled in the art, in such a way that the user's actions upon them will be transmitted to the computer in the form of binary information in respective codes for those units. Videotape recorders or VTRs 22, 23, 24, 25, 26 are likewise interfaced with the computer by output lines 27, 28, 29, 30, 31 in such manner that signals from the computer may cause them to start playing, stop playing, start recording, and stop recording. The computer is also linked to switching and attenuator matrix 32 by control line 33, in such manner that signals from the computer may command input to any VTR through input lines 34, 35, 36, 37, 38 and output from the output lines 39, 40, 41, 42, 43 of any VTR

to be connected to the input of any VTR or to the user television screen 44. The computer 20 also has input lines 45, 46, 47, 48, 49 through which it receives information from VTRs 22-26 telling the position of their tapes. The computer is also interfaced by means of analog-to-digital converters (not shown) to attenuator controls (not shown) which permit the computer to direct volume and brightness settings of the VTR outputs to any destination. Audio output from VTRs 22-26 may also be directed to user loudspeaker 50.

The computer is also interfaced to an instrumentation tape recorder and audio recorder 51, 52 by means of output lines 53, 54 and input lines 55, 56 which permit the computer to control the units and ascertain the position of the tapes. Signals representing the sonic outputs of these units travel on output lines 57, 58 to switch matrix 32 where they may be combined as output to user loudspeaker 50 or routed to input lines 34-38 of VTRs 22-26 or their own input lines 59, 60. Audio leaving switch matrix 32 may also be directed by the computer 20 on line 61 to sonic analyzer 62, where it is converted to its constituent frequencies whose measurements pass in digital form on line 63 to computer 20, which stores them on disk 21 or displays their representation, with or without modifications on screen 44 by means of computer-to-video display 64, or sends them to sonic restructuring unit 65 from which they may be heard as reconstituted sound from user loudspeaker 66. The reconstituted sound may also go via line 67 to switch matrix 32 and thence to inputs of VTRs 22-26.

To provide for the automatic finding and control of significant portions of stored motion pictures and videotapes, the addresses of points of interest in videotapes mounted on VTRs 22-26 are transmitted from VTRs 22-26 through address lines 45-49 to computer 20. Such addresses are when required stored in disk

memory 21 in a format illustrated below. This is the point location list. The format indicates the method of listing in digital storage the location addresses of event-points selected within a series of shots.

VIDEOTAPE POINT ADDRESS LIST

point's position in list	videotape address
.	.
.	.
.	.
(n)	videotape address of point n
(n+1)	videotape address of point n+1
(n+2)	videotape address of point n+2
.	.
.	.
.	.

A point in the videotape to be designated in the computer program as point n has its videotape address stored in location n of said list, its successor the address of point n+1 in the film is stored in location n+1, etc.

To provide for the labelling of portions of film by written information, means is required for storing and indexing said written information on computer disk 21. This means is illustrated below, in a format which represents the form of indexing textual information in digital storage.

TEXT-STRING LIST

point's position in list	ADDRESS OF TEXT STRING	
	start	end
.	.	.
.	.	.
.	.	.
(n)	address of start of text string n	address of end of text string n
(n+1)	address of start of text string n+1	address of end of text string n+1
.	.	.
.	.	.
.	.	.

The actual textual information is stored elsewhere in an undivided text area on the disk. Strings of text characters are denoted by a starting point representing the starting addresses of said text strings on the disk and endpoints representing the end addresses of said text strings on the disk. The nth location in said list stores the starting points and endpoints of the string to be known by the computer as string number n, the (n+1)th location in said list stores the starting points and endpoints of the string to be known by the computer as string number n+1, etc.

To provide a means for denoting a shot or portion of videotape and linking it to a textual name or description, a means, illustrated below, is provided for listing in digital storage the links between text strings and location addresses. This, the shot list, is composed of three parallel lists which correlate a shot or portion of film, as denoted in the shot-endpoint columns, with a string of text in the text-string list. Numbers in the shot endpoint lists denote points in the videotape point location list representing respectively start and finish of a shot or significant portion of film, and the number in the corresponding position of the text description list represents the textual string (as entered in the text-string list) with which the shot is correlated.

SHOT LIST

SHOT ENDPOINTS		TEXT STRING DESCRIPTIVE OF SHOT
start of shot on tape	end of shot on tape	

To provide a means of selecting shots, a viewing means incorporating also a selection facility is included in the system, as illustrated in FIG. 4. In this description list, the computer displays on the television screen 68 an array of textual descriptions 69, 70, 71 which have been indexed through the shot-list and text-string list from their locations on disk 21.

To provide a means whereby shots chosen for assembly into sequence may be kept in mind and rearranged, a viewing means for identifying shots already chosen is provided by this system, as seen in FIG. 5. The screen 72 functions as the rearrangement buffering device for temporarily holding tentative assembly lists. The description list 73 contains textual descriptions 74, 75, 76 which are if selected transferred to assembly list 77 as seen in example 78.

To provide a means for internal accommodation within the digital computer system of the assembly lists thus created, a form of listing these materials is needed. Such a form is given below, in the assembly list storage list.

ASSEMBLY LIST STORAGE LIST

shot no.	text string	point no. of start trim point	point no. of end trim point

This list provides correlated positions of storage wherein are contained indexes of the starts and endpoints of the different shots.

To provide a means of surveying the available shots matching a portion of the script, a script map facility is provided as may best be seen in FIG. 6. On the screen 79 appear lines and directions in the script 80, 81, 82, 83 visually correlated with shot descriptions

84, 85, 86, 87, 88, 89 and lines of variable length representing those shots 90, 91, 92, 93, 94.

To provide a means for the storage of information required for the display of the script map as in FIG. 6, a storage means is required as shown in the format below. This is a schematic drawing of the script list storage, showing the indirect method of listing in digital storage the location addresses of script lines and descriptions and their correlated shots and videotape points.

SCRIPT LIST STORAGE

script string	film information	film item identity code	percentage of script string
.	.	.	.
.	.	.	.
.	.	.	.
string no. n	point or shot no. n	i	xx
string no. n+1	point or shot no. n+1	i	xx
.	.	.	.
.	.	.	.
.	.	.	.

Lines and directions in the script are stored as indexed strings referred to by reference to their positions on the text-string list, as are shot description strings. The film item identity code is as follows: 1 = shot start, 2 = shot end, 3 = single point. Script strings are stored in the script string list, corresponding film information units are stored on the film information list correlated with the script string list, identity codes are stored on the film item identity code list correlated with the film information list, proportion numbers are stored on percentage-of-script-string list correlated with the film information identity code list. The nth position in each list is occupied by the item known to the computer as the nth item on that list, the (n+1)th position on each list is occupied by the item known to the computer as the (n+1)th item on that list, etc. The film information in the film

information list is a point from the point list, correspondingly encoded in the film item identity code list with a 1 if it is a shot beginning, 2 if it is a shot end, and 3 if it is neither of those. The number in the percentage-of-script-string list represents the user's assignment to the indicated point of approximately where in the script string the point falls, a parameter required for the relative positioning and lengths of the shot-lines in the script map (FIG. 5).

To provide to the editor a graphical indication of trimming alternatives, the system includes a facility for displaying a "trim map," as seen in FIG. 7, which likewise uses screen 95 as a control mechanism. Two shots are schematically illustrated 96, 97, the leading shot 96 being distinguished by an arrow tail and the trailing shot 97 having an arrowhead. The two shots are shown annotated with the user descriptions of those two shots 98, 99. Points in the shots are shown as having been marked by the user 100-111. Annotated shot portions 105-106, 107-108, 110-111 are displayed with their annotations 112, 113, 114. Another shot-point 109 is annotated 115. Other non-annotated shot-points 100, 101, 102, 103, 104 are shown with contemplated trim-lines 105, 106, 107, 108.

To provide a means whereby prospective trim points may be indexed for reference and for modification, and conveniently displayed in the trim map of FIG. 7, a trimming list is provided on the disk file, as may best be seen below. What follows schematically represents the trim list, showing the method of listing in digital storage the trim addresses associated with a series of shots.

TRIM LIST

location in list	trim address no.
.	.
.	.
.	.
(n)	ADDRESS n
(n+1)	ADDRESS n+1
.	.
.	.
.	.

This list gathers together videotape points as listed in the videotape point list in the sequence required for display of trim alternatives. The nth address is occupied by the location on the videotape point list of what the computer knows as trim address n, the (n+1)th address is occupied by the location on the videotape point list of what the computer knows as trim address n+1, etc.

To provide a sequential record of the sonic constituents of a portion of the sound required in digital storage, a sonic constituent list is provided, as will be seen below.

SONIC CONSTITUENT LIST

time division (milliseconds)	amplitude of frequency components (128 frequency divisions)
.	.
.	.
.	.
t	(128 numbers)
t+1	(128 numbers)
.	.
.	.
.	.

This table is a schematic drawing of the sonic constituent list, showing the method of listing sonic constituents in digital computer storage. Times t are recorded in the time-division list, and the values of 128 frequency components are recorded in correlated positions of the amplitude list.

Furnishing the editor with means for altering frequency constituents of a recorded sound, the system has a sonic constituent

screen display provided by the computer, best seen in FIG. 8. An array of 64 x 64 dots is displayed on the screen 142, each dot having eight degrees of brightness (including extinction). The brightness of a point represents the comparative amplitude of a particular frequency (vertical dimension) at a particular time (horizontal dimension). The sound may be reconstituted through sonic restructuring unit 65 and played out through user loudspeaker 66, at which time the image of frequency-points displayed 110 moves past the now-line 111. The sonic output from the sonic reconstitution unit 65 at a given instant exactly reproduces the frequency-volume characteristics specified by the column of dots nearest the now-line at that instant.

To furnish the editor with similar but simplified means for synchronizing analyzed sound with existing film images, a sync map is provided as may be seen in FIG. 9. Like the sonic constituent screen display in FIG. 8, the sync map uses the screen 112 to display a visual presentation of sound 113 which the user may move in relation to a now-line 114 while hearing the output through sonic reconstitution unit 65 and user loudspeaker 66. In this case only some measure of the overall volume is indicated in the visual presentation of sound 113, but the user may annotate it with a text string 115 representing the dialog to be heard in the sound. Markings 116, 117, 118, 119, 120, 121, 122, 123 are also added by the user to indicate points of stress or mouth closure in speech, or other events in the audio.

To provide a sequential plan for computer reference in adjusting audio levels, an audio cue list is provided, which may be seen below. This shows the method of listing the audio cues in digital computer storage.

AUDIO CUE LIST

timing (milliseconds)	action
.	.
.	.
.	.
x:xx:xx	change audio setting of tape #__ to __
y:yy:yy	change audio setting of tape #__ to __
.	.
.	.
.	.

The adjustments to be made in audio playback from different units are listed in the action list while the instants at which the adjustment is to be made are listed in the timing list.

Furnishing an overall view of the separate sources of sound for a final audio mix, the invention provides an audio mix map, as will be seen in FIG. 10. This overview combines on the screen 124 views of different sound-sources 125, 126, 127, as previously seen, moving in the present instance together past a now-line 128 in conjunction with the mixture of these sound sources in playback or recording. The user may similarly control their movement past the now-line in order to make adjustments.

To provide a means for splitting one audio channel into two or more for stereophonic effect, or for assembling two or more audio channels from portions of others, the system provides separate-channel sonic constituent lists, as above, for each of the channels to be thus assembled.

Operation

In use, the foregoing described apparatus may be employed in practicing the method of this invention to edit videotapes and films and mix and match their soundtracks.

To operate the system, videotape footage, original or copied from film, is placed on VTR 22 and the controlling computer program is initiated. The user directs the presentation of the videotape on screen 1, and its motion forward or backward, by means of control wheel 4. The motion of this control wheel reaches the computer through a shaft encoder and is analyzed by the computer program. Depending on the wheel's movement, the computer directs the forward or backward motion of source VTR 22 at full speed, reduced speed, or halted viewing.

If the viewer wishes to change scenes, he presses SELECT button 15, and receives a sequence of presentations in the current mode. Upon reaching the desired part of the production he presses the MARK AND ANNOTATE button 7, thereby causing the select function to end.

The leftmost function buttons MARK & ANNOTATE 7, SCRIPT MAP 8, ASSEMBLE 9, TRIM 10 and AUDIO 11, are the principal definers of the activity state of the system each initiating a state described by its name. The five functions MARK & ANNOTATE, SCRIPT MAP, ASSEMBLE, TRIM and AUDIO are interlocked so that the user using one of the functions in relation to a specific scene may at any time switch to another of the functions, which will then relate to the same scene. Since materials stored in the system tend always to have a sequence, it is permissible for the user to enter any of these states from another and continue to work with approximately

the same material in approximately the same part of the corpus of his videotapes.

The MARK & ANNOTATE function permits points and portions of footage to be marked and annotated. When the user reaches a point on the footage which is of interest to him, he halts the videotape and designates the point of interest by cuing pushbutton 3.

The computer program's response to the pushbutton signal is to examine the current address of the operating VTR from the current address line 45-49, and store that address in a table in the videotape point address list. As that specific frame on the videotape is thenceforth identified to the computer as a marked point, whenever the same footage is shown the computer flashes at that frame a cuing mark on computer-to-video display 64 which is then seen on the screen 44.

The user may create an annotation to such a videotape address point, or create an annotation between two videotape address points, thus defining a shot or portion of film. To annotate a point in the videotape he presses POINT 12, after stopping the videotape being viewed at the desired point; to annotate a shot he presses SHOT after stopping the videotape being viewed at one of two desired endpoints, then moves that videotape to the other endpoint, which must have been previously defined by means of MARK & ANNOTATE/POINT. To annotate a sequence, the user presses MARK & ANNOTATE, followed by SEQUENCE 14. The sequences associated with the region wherein he is working will then be available, first as assembly lists (to be discussed below) which he may name or, if he turns control wheel 4, as sets of shots which he may view, in which case the sequence will be defined as the next two locations at

locations at which he presses button POINT 12.

To create an annotation, the user types a textual description into the typewriter keyboard 5. The characters are transmitted as parallel digital signals in the standard manner to digital computer 20, which stores them on disk file 21 and stores their string address on the text-string list. A text program then displays the text by means of computer-to-video display 64 on television screen 44 by methods well known to practitioners of the art. The user watches the television screen 44 for confirmation of his typing as it takes place. If he desires to make any changes in the text he has typed, to correct errors or change phrasing, he presses editing buttons 12A, 13A, 14A in order to perform operations of insertion, deletion or rearrangement of characters or words upon the screen. He then effects the desired editorial changes through the use of light pen and typewriter keyboard upon the television screen, as will be understood by practitioners of the art.

When an annotation has been completed, the user so informs the computer by re-activitating control wheel 4 or one of the function buttons 7-15.

Lookup of materials in the system takes place through the SELECT function, as controlled by SELECT button 15. The SELECT function permits the user to obtain what has previously been labelled by means of MARK & ANNOTATE. By pressing SELECT 15 followed by POINT 12, the user sees a list of the previously-annotated points. By pressing SELECT 15 followed by SHOT 13, the user sees a list of the previously-annotated shots. By pressing SELECT 15 followed by SEQUENCE 14, the user sees a list of the previously-annotated sequences. He may then point with light-pen 6 at a specific element on the list thus brought up, and then specify a function from among function buttons MARK & ANNOTATE 7, SCRIPT MAP 8,

ASSEMBLE 9, TRIM 10, AUDIO 11. Work under the new function will commence at the portion of the corpus that has been defined by the light-pen selection.

Through the use of the SCRIPT MAP function, the user creates a visible correlation between the footage and a photoplay script. When the user has seen a shot he wishes to map to the script, he presses MARK & ANNOTATE button 7 followed by SCRIPT MAP button 8, causing the system to enter SCRIPT MAP state. A display of the script, which has already been entered in the computer and is stored on the computer disk file, then occurs. The control wheel 4 now controls the movement of the script up and down the screen. When the appropriate portion of the script is reached, the user points with the light pen to the approximate point in the script to which the shot address most recently viewed corresponds. The computer program then prepares entries for the script list, causing the point address no. to be stored in the film information list, its item code to be stored in the film item identity code, and its percentage of script string to be estimated by the program on the basis of the point selected with the light pen and entered in that column. The computer then, through a computer program, emplaces a vertical line on the right-hand side of the screen to represent the shot, and shows as well the shot description, as illustrated in examples FIG. 6.

Resequencing of shots in this system takes place through the use of the ASSEMBLE function, effected by the ASSEMBLE button 9. Pressing the ASSEMBLE button 9 causes the system to enter ASSEMBLE state. This causes an assembly list to appear on the screen. Depending on whether the previous function was SCRIPT MAP

or SELECT, a visible part of the script map or the shot directory will remain on the screen. In FIG. 5 the assembly list is shown in conjunction with part of the shot directory.

The editor may dictate the rearrangement of shots by the following method: pointing at descriptions of the desired shots in the lefthand description list 73 causes these descriptions to move to the righthand assembly list 77 through the intercession of the ASSEMBLE computer program. To the assembly list as viewed on the screen corresponds an assembly list on the computer disk file (not shown), holding numbers designating entries on the shot list in the format shown on p. 12.

To view the resequenced materials, the user presses the SELECT button while in ASSEMBLE state and is shown a succession of assembly lists on the screen. He moves through these using control wheel 4 until he finds the desired shot list. He then touches the lightpen to the description of the shot he wishes to view at the beginning.

When a shot description is copied to the assembly list, it may at any time be repositioned in the righthand list by pressing MOVE 14A and pointing to a position between descriptions already on that list. It will then be transferred in the display to the point designated, and the data entries on the corresponding computer list correspondingly rearranged.

The user may perform the MOVE editing operation on the assembly list at any time, to change the order of the shot descriptions, the corresponding lists, and any resulting presentation.

To carry out the rearrangement thus directed, the computer consults the location address list, described earlier, and calculates the lengths and positions of the shots on the assembly list.

By means of a sorting program, whose characteristics will be well known to practitioners of the art, the computer pre-plans the succession of videotape movements required to copy the desired shots on videotape recorders 22-26 in the most efficient manner, in such a way that two consecutive shots are not on the same recorder. It then effects the required copying from VTR 22, by transferring the contents of the specified videotape recordings to the succession of recorders so specified in the correct sequence and position.

When the transfers necessary for showing the sequence have been completed, the computer shows the sequence of shots requested. To make changes in the sequence of the shots thus viewed, the user calls the assembly list for the sequence and makes the desired changes by rearranging the shot descriptions on the screen with the MOVE button 14A and the light pen. The computer then directs the copying of the specified shots in some sequence which permits their showing in the newly specified sequence.

To make trimming adjustments at the beginnings and ends of shots, the system provides a function called TRIM MAP, invoked by TRIM button 10. The editor calls a trimming map by halting the videotape near the end or beginning of a shot and pressing the button TRIM 10. The button TRIM 10 communicates with a computer program which displays on the television screen 1 a trimming map, as may be seen in FIG. 7.

The trimming map, generated by a computer program, is a diagram representing two shots to be connected, and one or more possible interconnections of interest to the editor. The leading shot is represented pictorially by the tail of an arrow 96 at the top of the screen, and the trailing shot is represented pictorially

by the head of an arrow 97 at the bottom of the screen. The shot descriptions 98, 99 are displayed on the screen with their respective arrows 96, 97. Any other annotated points 100-111 are also diagrammatically indicated and annotated 112, 113, 114.

Any annotations of points within the shot are likewise displayed as in example 115.

When the trimming map has been called by pressing TRIM button 10, the user may make fine trimming adjustments between shots. To indicate a cutting-point, or point at which to make a transition, the user presses the button INSERT 12A and points with light pen 6 at the representation of the arrow, at a point along the line proportionally representing approximately the place in the shot at which he would like to make the cut. A mark appears at that point on the line, as shown in FIG. 7 in examples 111-115, and the corresponding point is adjusted on the trim list.

To indicate a cut he wishes to see, the editor then presses SEQUENCE 14. With the light pen 6 he points at one cutting-point on each arrow. Signals from the light pen go to the computer 20, which consults a program and then adds to the screen display a dotted line or transition-line 105, 106, 107, 108 between the marks representing the two cutting-points that have been thus specified together.

To see a transition he has so specified, the user points with a light-pen at one of the transition-lines 105, 106, 107, 108 and presses cue button 3. The computer consults the list of transitions, ascertains the cutting-points involved, and displays the two consecutive shots from two VTRs, intercut in proportion to the marks on the arrows.

The user may adjust a transition by pressing the MOVE

button 14A, pointing with the light pen 6 at the point in a shot which is to be moved, and moving the light pen to the new point on the shot-line. The computer program receives the signals from the buttons and light pen, correlates them with the computer program, adjusts the position of the cutting-point on the point list, and modifies the display to show the transition-line in its new position.

Fades and dissolves are specified in the trim map by marking a cut-line with the light-pen after pressing INSERT 12A, and typing on keyboard 5 the letter F (for fade) or D (for dissolve) and a number preceded by or containing a decimal point, which specifies in seconds the fraction of a second or longer period of time over which the fade or dissolve is to occur.

If the improvement of recording quality is needed for speech or sound stored on audio recorder 52 or instrumentation recorder 51, or sound tracks of videotape recorders 22 to 26, this audio output is played under control of the computer 20 by control lines 53, 54, 27-31 through switch and attenuator matrix 32 to sonic analyzer 62, which performs an analog-to-digital conversion and a Fast Fourier Transform to obtain the frequency and amplitude components of the sound, which pass in digital form through line 63 to computer 20 which stores them on disk 21 in the sonic constituent list, shown earlier.

The user invokes this function by pressing AUDIO 11 and modifies the sound by pressing the MODIFY SOUND button 14B, whereupon a sonic display such as that in FIG. 8 appears on the screen. Using control wheel 4 the user causes the sonic display to travel through the now-line 143, and hears concurrently its regenerated form through sonic reconstruction unit 65 and speaker 66.

Using the light pen 6 he may modify the display, pressing the light pen 6 to the screen once to decrease the value of a point indicated and twice to increase it. By this method he may remove sounds (such as background hiss or an automobile horn) which are visible through such a display but not removable by automatic means, or he may by trial-and-error improve the recording, as for instance by adding "realism" to a poor voice recording by accentuating higher frequencies characteristic of a particular speaker.

If lip-synchronization is desired between film and recorded sound on some recording unit 51, 52, 22-26, the user presses SYNC button 13B and the sound needful of synchronizing is played through sonic analyzer 62, which performs an analog-to-digital conversion and a Fast Fourier Transform to obtain the frequency and amplitude components of the sound, which pass in digital form through line 63 to computer 20, which stores them on disk 21 in the sonic constituent list shown earlier.

A sync map, as shown in FIG. 9, is then created by a computer program, showing the average volume contour 113 of the converted sound. The user may employ control wheel 4 to move this display under now-line 114 and concurrently hear it through sonic reconstruction unit 65 and speaker 66. The user may annotate it with typewriter keyboard 5, which causes each character typed to appear under the now-line as an annotation 115 and thenceforward to remain in the same relative position to volume contour 113. The user may also create sync points (116-123) indicating points of stress or other features in speech or sound. Upon pressing the space bar of keyboard 5, the user now obtains the visual presentation of the videotape scene which he last saw, which he may move through at varying speed using control wheel 4. At sig-

nificant synchronization points in the videotape, such as explosions, door slams, mouth closures, widest-mouth positions, etc., the user presses cuing button 3. The computer lists these cue-points and correlates them with sync-points 116-123 established earlier.

By pressing the space bar of keyboard 5, the user causes the system to replay the scene, reconstituting the sound through sonic reconstruction unit 65 but in a timing which hastens or retards the designated sync points of the sound in exact synchrony with the cue-points specified by the user in the footage, all with no modification of the reconstructed frequencies and with smooth interpolative stretching or compressing of the time periods so specified. The user may alter the sync-points and cue-points respectively with buttons INSERT 12A, DELETE 13A and MOVE 14A until satisfied with the resulting synchronization.

If it is desired to synchronize one recorded sound or utterance with another recorded sound or utterance, the two having corresponding parts (as for example one being a poor-quality recording made in synchronization with a motion picture, the other being a high-quality wild recording from the same script) the user may call both to a sync map and mark their corresponding parts. The timing of either can then be applied to the re-constituted timing of the other.

If it is desired to create more than one audio channel from the available recordings, the visual sound-control facilities are used in two ways. By the use of light pen 6 on sync maps such as that in FIG. 9, one for each channel of audio desired, he may create cuing points such as 116-123 for each channel, permitting the digitized sonic constituents to be reconstituted in the desired synchronization. Such cuing points may be annotated with

symbols such as musical notes, as well as the text mentioned earlier. By the use of light pen 6 on sonic constituent displays such as that in FIG. 5, he may indicate certain areas of the sonic cloud, and direct the machine to copy or transfer to the respective sonic constituent lists for each channel, of the type shown on p. 15, the components of sound so indicated with the light pen. With the light pen he may also divide sonic constituents, by pressing the light pen to a dot once for each level of intensity he wants transferred to a corresponding position on a separate channel. This enables a retroactive division of the sound into separate channels.

The user may obtain automatic adjustment of intensity and phase of the separate audio channels to be reconstituted by creating on the screen with light pen 6 a diagram of the virtual positions, in an imaginary physical arrangement, of the sound source assigned to a channel, and the virtual positions of the separate imaginary microphones. The system is programmed, employing means well understood in the field of frequency analysis and synthesis, for the automatic re-channeling, with appropriate volume and phase adjustments, of the sound as it would have been recorded in the setup he has diagrammed. By indicating in the diagram the virtual positions of imaginary walls, the user may cause the system to add to the reconstitution those echoes which the walls depicted would produce.

When the desired show has been completed in its visual aspect, with respect to all the shots in their correct sequence and cutting-points, the user may direct the mixing of the audio, in its respective volume, by tracing a diagram of the desired volume-settings of different sound components. By pressing the MIX button

12B he summons to the screen the audio mix map shown in FIG. 10, with horizontal lines representing the separate audio tracks which have been selected after pressing the SELECT button 15. Event-points and annotations associated with the shots are shown also. To establish mixing levels, the user presses the INSERT button 12A and draws with the light pen upon the screen, creating desired volume contours 125, 126, 127. These create corresponding audio cues in the audio cue list depicted earlier. The user may then use control wheel 4 to begin the audio output, and hear the mixed tracks together in the proportions specified by volume contours 125, 126, 127. To modify the volume contours he may use the MOVE button 14A to empower the light-pen to raise or lower a portion of a volume contour. The complete mixed audio is played out or recorded under user command, and the component diagrams 125, 126, 127 move concurrently beneath now-line 128 as this occurs.

The final production is created as follows from the different lists within the computer 20 and disk 21: if the original is a videotape, it is placed on one VTR and a second-generation copy is produced on another VTR. If the original is a film, computer 20 prints out a negative-cutting list on a peripheral printer (not shown) or creates an information file on a paper tape punch (not shown) or other peripheral device which may be used in conjunction with an automated optical printer to produce the film master automatically from the original without human intervention.