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Gazale

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[54] **IMAGE RECORDING AND PROJECTION METHOD AND APPARATUS**

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[52] **U.S. Cl.** **352/40,** 352/44, 352/69, 352/70, 352/92, 352/94
[51] **Int. Cl.** **G03b 37/02**
[58] **Field of Search** 352/65, 69, 70, 92, 93, 352/94, 133, 134, 131, 39, 38, 40, 44; 353/94

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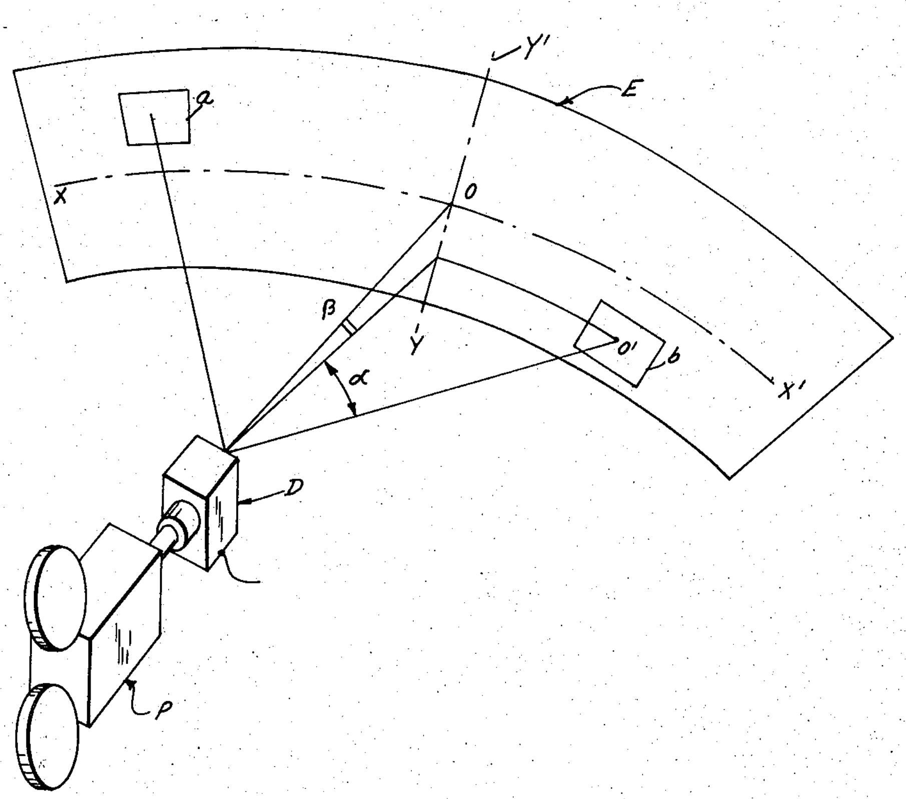
Primary Examiner—John M. Horan
Assistant Examiner—Russell E. Adams, Jr.

[57] **ABSTRACT**

In a pictorial projection method for creating an illusion of a large picture and an enhanced impression of space, pictorial images are successively projected through a projection system onto various areas of a screen substantially oversized relative to the projected image. A recorded site-azimuth code indicator associated with each image is read by the projection system and utilized to modify the projection axis thereof and so determine the relative projection position of the associated image on the oversized screen. In a method for recording the images and associated site-azimuth code indicators, the indicators may be either arbitrarily selected to form a desired projection pattern for the images or generated automatically during recording of the image to correspond to the site and azimuth of the axis of the image recording device.

63 Claims, 17 Drawing Figures



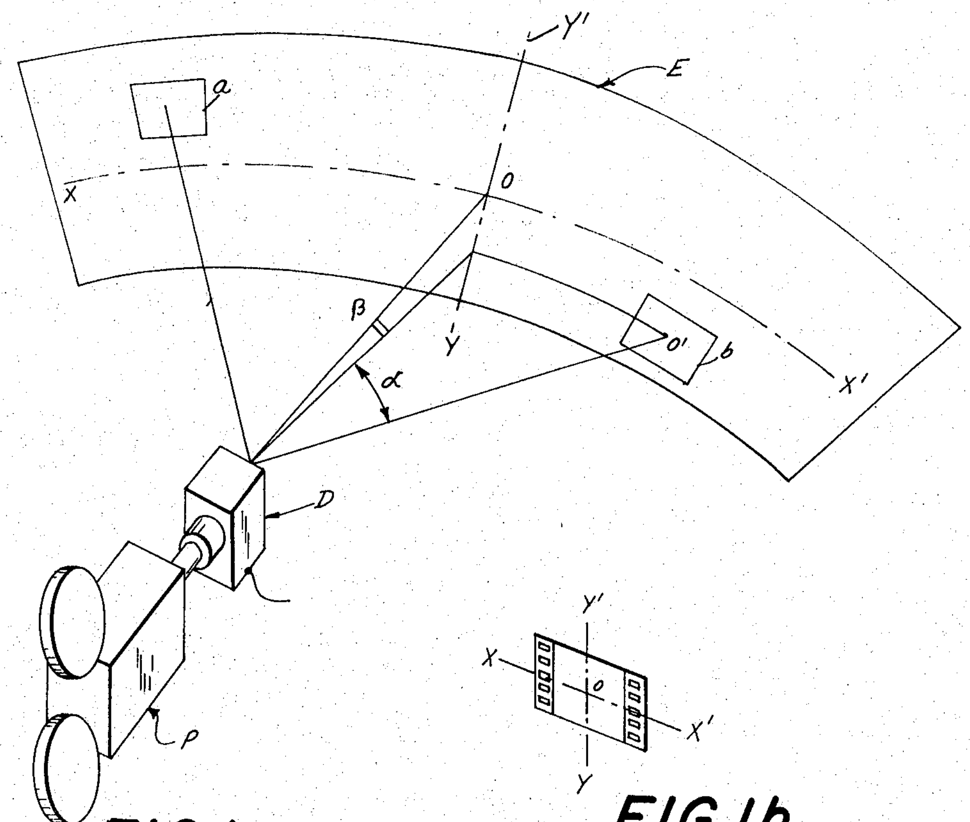


FIG. 1a

FIG. 1b

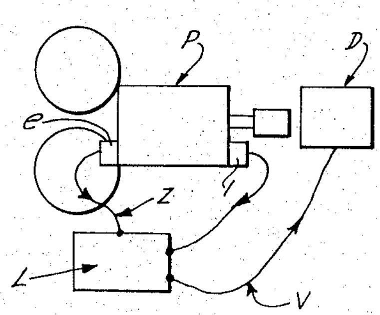


FIG. 1c

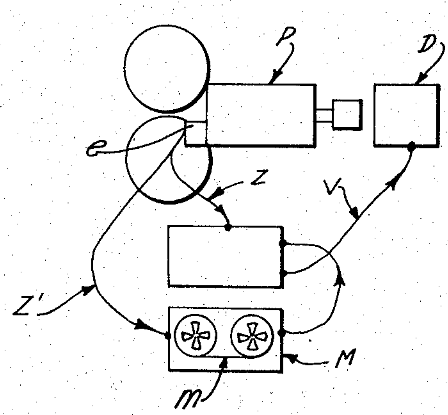


FIG. 1d

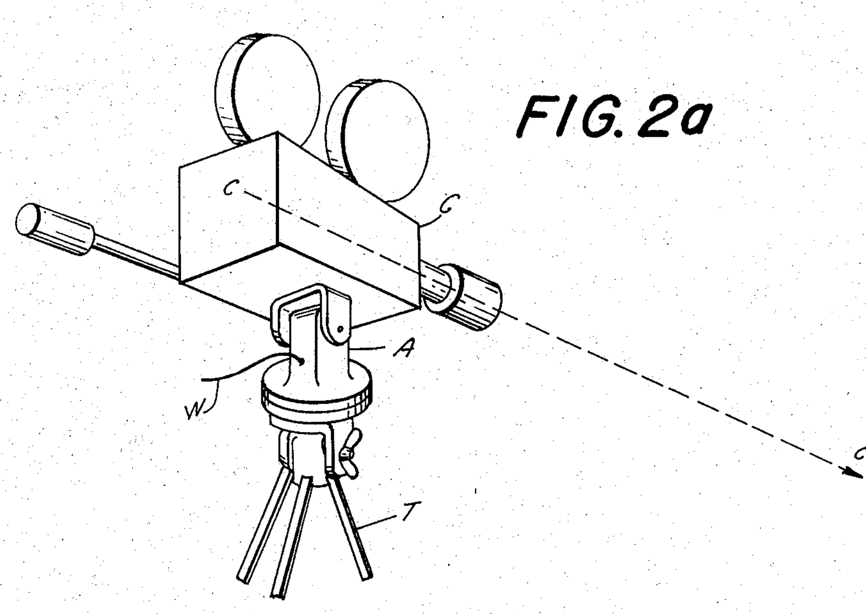


FIG. 2a

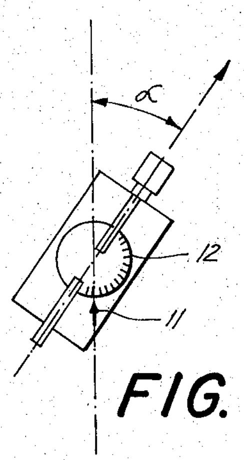
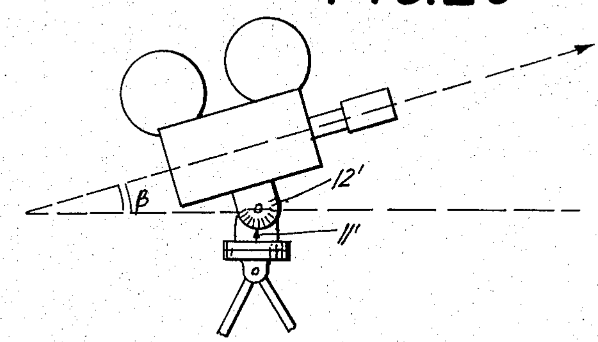
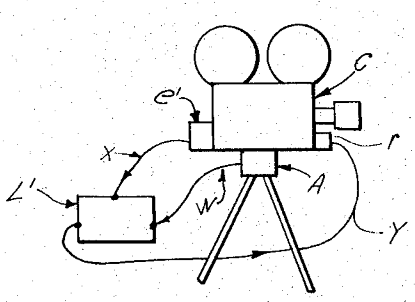


FIG. 2b

FIG. 2c





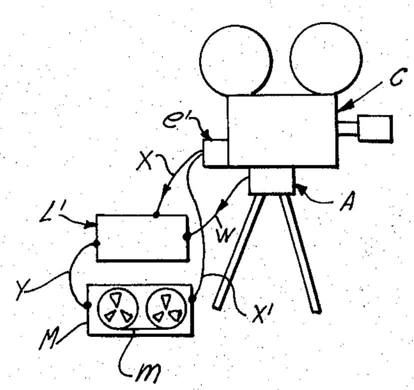


FIG. 2d

FIG. 2e

FIG. 3a

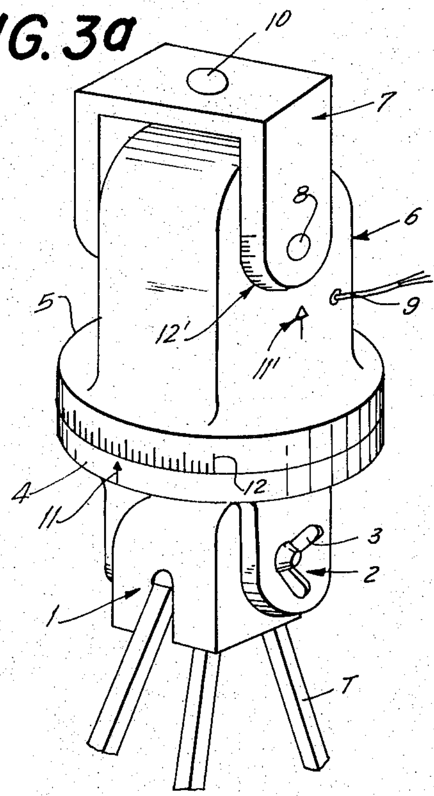
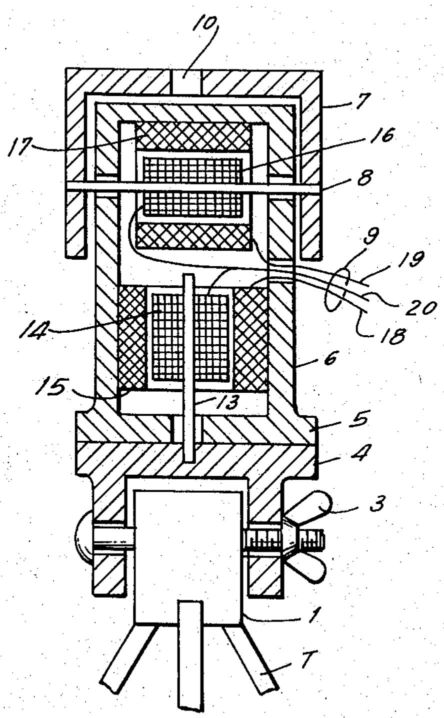


FIG. 3b



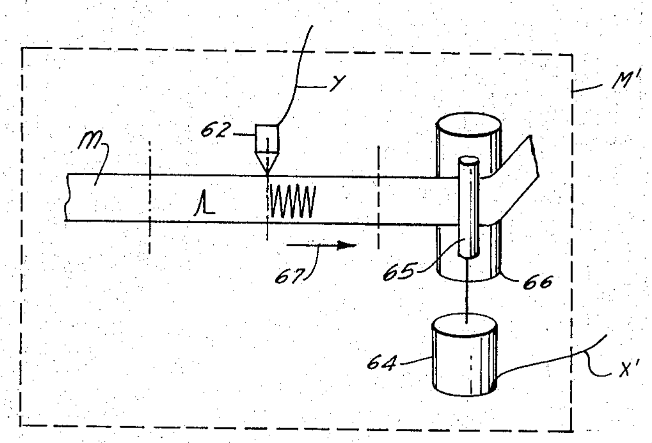


FIG. 4b

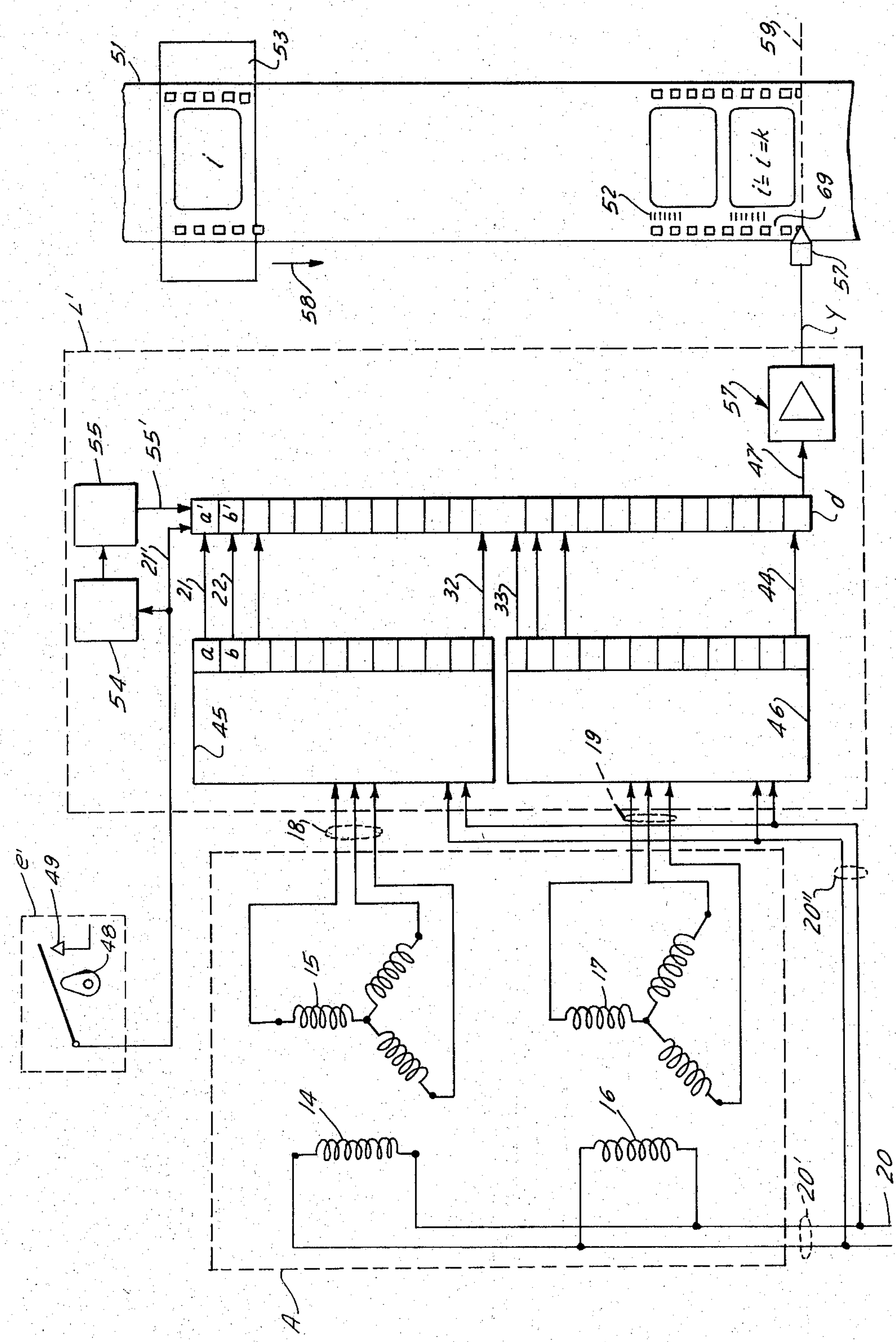
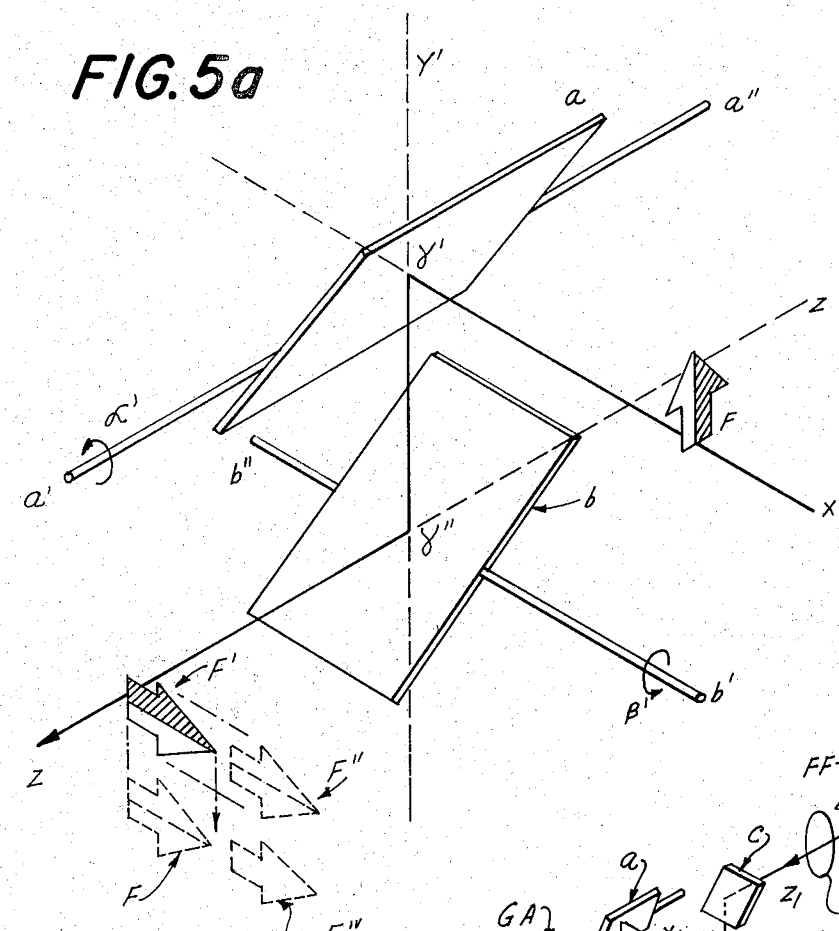


FIG. 4a

FIG. 5a



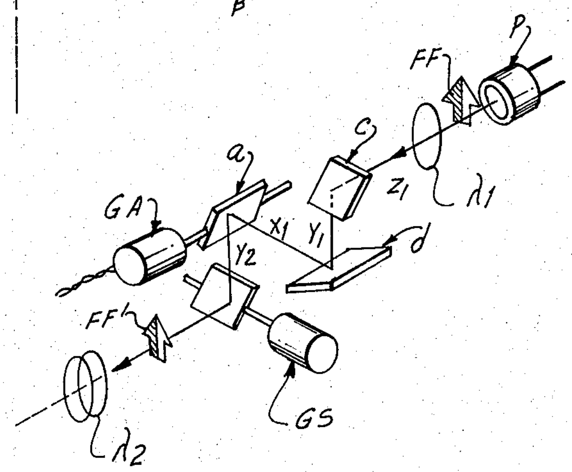


FIG. 5b

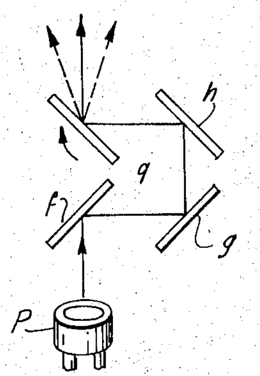
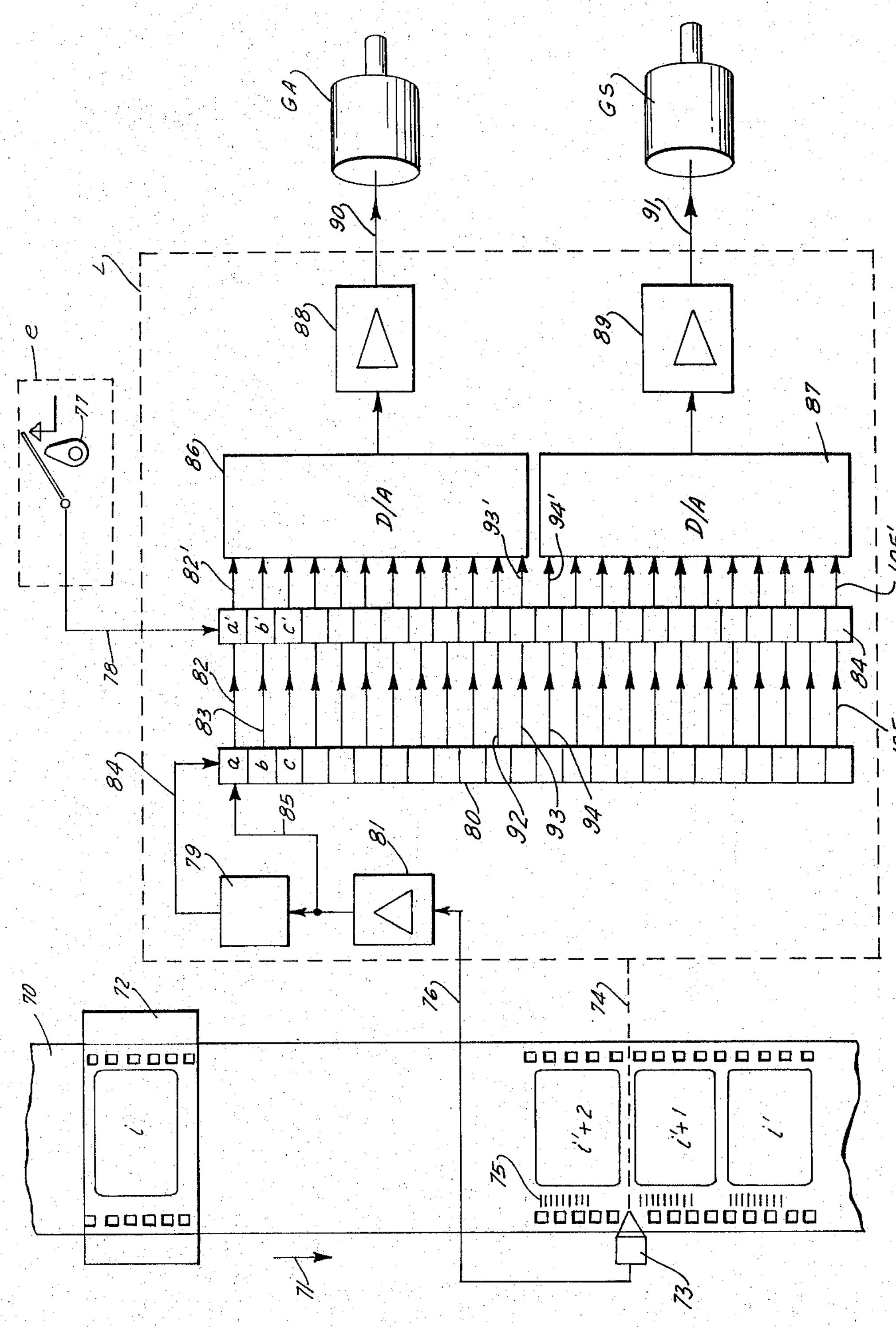


FIG. 5c

FIG. 6a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72
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74
75
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i'+2
i'+1
i'
71
73

IMAGE RECORDING AND PROJECTION METHOD AND APPARATUS

BACKGROUND OF THE INVENTION

The present invention concerns methods for projecting normal sized pictures upon a large screen to give the illusion of a large picture and an enhanced impression of space.

In every currently known "wide screen" process, large pictures are projected upon wide screens, hence giving an enhanced impression of space.

One object of the present invention is to provide a recording and projection method which allows the generation of an enhanced impression of space by projecting upon a large screen a picture of regular dimensions.

Another object is to provide a projection process which allows one to locate, in azimuth and elevation upon an oversized screen, the projected image of a regular picture, through the use of a particular code indicating the location of the image upon the screen.

A further object is to provide such a projection process characterized by the utilization of normal projection methods associated with wide screens (the dimensions of which are much larger than would normally correspond to the projected pictures), the projection being oriented in azimuth and elevation towards varying regions of the wide screen, according to a recorded program which relates each picture to a corresponding region of the screen.

Yet another object is to provide a recording method wherein the program may be generated after or during pucture-taking, by capturing upon a support data corresponding to the position in space of the object being recorded.

Still another object is to provide such a recording method wherein the recorded program allows a sequence of recorded scenes to be restituted upon the screen in the exact relative location of the scenes as was present during recording by successively altering the projection axis in like manner as was the recording axis.

A final object is to provide apparatus for implementing the above methods.

SUMMARY OF THE INVENTION

The present method is adapted to the projection of moving pictures as well as still pictures, such as photographic slides.

In this method, the coded information representing the region of the screen where the projection of a particular frame is to occur is either directly recorded on the frame on a special track, or on some associated support, such as a magnetic tape whose motion is synchronized with the transition of the frames being projected, whether they be frames of a moving picture or still frames.

The region of the screen where a given frame is to be projected is defined by the inclination of the projection beam as it emerges from the projection system, this inclination being comprised of an azimuth and an elevation or site, the first being an inclination or orientation of the beam in a horizontal plane and the latter its inclination or orientation in a vertical plane. The coded information corresponding to the site (or elevation) and the azimuth is referred to as site-azimuth code (SAC) and is recorded either on the frame or on an auxiliary support. The SAC can either be generated during picture taking by some means of recording the inclination of the camera with respect to some fixed reference, or after picture taking by artificial methods assigning to each frame a particular SAC.

Projection upon a wide screen of a regular picture according to the present process gives the impression of a very large picture, and the projected image can shift around from a region of the screen to another from one moment to the next, according to the data contained in the SAC. The screen may be a very large section of a hollow sphere or cylinder. It may be, as an example, a section of a cylinder which is very wide in the horizontal plane, and of regular height in a vertical plane.

More particularly, the present invention resides in a method for recording and subsequently projecting pictures successively onto various areas of a substantially oversized screen in a predetermined pattern. During the recording process a pictorial image is recorded on a storage medium and an indicator of the relative projection position to be associated with the image is recorded on a storage medium; during the projection process the storage medium containing the associated indicator is read and the projection orientation of a projection system is adjusted in accordance therewith. The storage medium containing the image is also read and the image projected through the projection system onto a screen substantially oversized relative to the projected image.

The image may be recorded on photographic film or one frame of a cinematographic (motion picture) film. In an embodiment, the image and associated indicator are recorded on the same storage medium, typically sound cinematographic film. When the image and the associated indicator are recorded on the same frame of cinematographic film, the associated indicator is read prior to the image. Alternatively, the image and the associated indicator are recorded on different frames of the same cinematographic film, the associated indicator being recorded on a frame prior to the frame bearing the image. In another embodiment, the image and associated indicator are recorded on separate and distinct moving storage media, the motions of which storage media are synchronized together.

In a preferred embodiment of the recording process, the orientation of the image recording apparatus is recorded, in real time in the course of image recording, as the associated indicator, whereby upon projection of the image according to the associated indicator the image is projected onto a region of the screen corresponding to the real time position of the image during recording. In an alternate embodiment, the associated indicator is generated artificially and independently of the orientation of the image recording apparatus. In both embodiments the associated indicator is preferably recorded as a site-azimuth code.

The indicator-recording storage medium may be read in discrete steps or advanced continuously during reading. In the former case, the image-recording storage medium is also advanced during reading in discrete jumps; for example, jumps corresponding to frames of a cinematographic film.

The projection system preferably includes a plurality of mirrors rotatable about at least two orthogonal axes according to the associated indicator to cause a resultant two dimensional deflection of the projected image. In a similar system, one of the mirrors is rotatable about only one orthogonal axis according to the associated indicator to cause a resultant one dimensional deflection of the projected image.

Apparatus for recording and subsequently projecting pictures successively onto various areas of a substantially oversized screen in a predetermined pattern comprises a projection system and first and second storage media. The recording system includes means for recording a pictorial image on the first storage medium and means for recording an indicator of the relative projection position to be associated with the image on the second storage medium. In connection with the projection system are means for reading the second storage medium and adjusting the projection orientation of the projection system in accordance with the indicator thereon, and means for reading the first storage medium and projecting the recorded image through the projection system onto a screen substantially oversized relative to the projected image.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1***a* is a perspective view of a projection system comprising a projector and a large screen;

FIG. **1***b* is a perspective view of a frame as it appears in the window of the projector;

FIG. **1***c* is a side elevational view of one embodiment of a projection system wherein the SAC is recorded on the film itself.

FIG. **1***d* is a side elevational view of another embodiment of the projection system wherein the SAC is recorded on an auxiliary support, such as magnetic tape;

FIG. **2***a* is a perspective view of a camera mounted in a tripod through an articulation allowing orientation in site and azimuth of the camera;

FIG. **2***b* is a top elevational view of the camera of FIG. **1***a;*

FIG. **2***c* is a side elevational view of the same;

FIG. **2***d* is a side elevational view of one embodiment of the recording system wherein the SAC is recorded on the film itself;

FIG. **2***e* is a side elevational view of another embodiment of the recording system wherein the SAC is recorded on an auxiliary support;

FIG. **3***a* is an isometric view to an enlarged scale of the articulation comprising the apparatus which measures site and azimuth of the camera of FIG. **2***a*.

FIG. **3***b* is a vertical cross section of FIG. **3***a;*

FIG. **4***a* is a schematic view of the recording system corresponding to FIG. **2***d;*

FIG. **4***b* is a partial schematic view of the recording system corresponding to FIG. **2***e;*

FIG. **5***a* is a schematic view of a deflection system using two mirrors and three reference axes.

FIG. **5***b* is a schematic view of a deflection system analogous to that of FIG. **5***a*, to which two fixed mirrors are added.

FIG. **5***c* is a schematic view of a fixed-site and variable azimuth projection system in which all four mirrors are vertical.

FIG. **6***a* is a schematic view of the projection system of FIGS. **1***c* and **1***d*.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1***a* shows a projector P equipped with a deflector D which orientates the projection beam toward any location of screen E. Two locations *a* and *b* are shown corresponding to two different instants of the projection.

FIG. **1***b* represents a frame being projected, as it is standing in the projection window. We call plane X that plane containing axis *xx'* which is perpendicular to the frame plane. Curve XOX' of FIG. **1***a* represents the intersection of Plane X and screen E. Similarly, we call plane Y that plane containing axis *yy'* which is perpendicular to the frame plane. Curve YOY' of FIG. **1***a* represents the intersection of plane Y and screen E. Point O cuts each of XOX' and YOY' in half. In practice, plane Y will be vertical, however, plane X may not necessarily be horizontal, since it may happen that the projector be physically located higher than the horizontal axis of the screen. In FIG. **1***a*, image *b* has *o'* for center and angles α and β are respectively its azimuth and site.

In the case illustrated by FIG. **1***c*, the SAC is recorded on the film itself, and reader *l* is that device which reads the SAC off of the film and transmits to the logic L.

FIG. **1***d*, shows magnetic tape *m* being read by tape reader M which advances step by step as it receives stepping pulses from emitter *e* which is coupled to projector P.

The present invention, as far as the projection or restitution system is concerned, is illustrated firstly by a reading device which reads the SAC off either the film itself or an auxiliary support. In the first case, the reading device is represented by *l* in FIG. **1***c*. In the second case, such as that represented by FIG. **1***d*, the reading device is comprised of tape reader M and pulse emitter *e* which is coupled to projector P.

Still as far as the projection or restitution system is concerned, the present invention is characterized secondly by a positioning device represented by symbol D in FIGS. **1***a*, **1***c* and **1***d*, which orientates the projection beam according to the SAC read by the reading device.

The present invention is characterized thirdly by logic L shown on FIGS. **1***e* and **1***d*, which translates the SAC into corresponding electric signals which operate the deflection system. The devices described pertain to the projection or restitution system regardless of the method in which the SAC is generated and recorded.

As far as the generation and recording of the SAC is concerned, the present invention comprises encoding systems referred to as "real time encoding" systems which measure and record, during filming, inclination of the camera with respect to a fixed frame of reference, such as a tripod for example. The present invention also comprises SAC generation and recording systems referred to as "post-encoding" systems which generate the SAC artifically, after filming.

In real-time encoding, each frame is accompanied by a code which reflects site and azimuth of the camera at the very moment that this particular frame is being shot and recorded on film. This method is illustrated by FIGS. **2***a*, **2***b*, **2***c* which represent camera C mounted on Tripod T through an articulation A which allows orientation of camera C in site and azimuth with respect to Tripod T. Axis *cc'* is the optical axis of the camera lens system. System A is designed to measure inclination of axis *cc'* with respect to a horizontal plane, thus giving site, and its inclination with respect to a vertical plane, thus giving azimuth. System A generates the SAC, which it transmits to the logic through cable W.

FIG. 2*d* illustrates the case where the SAC is recorded on the film itself. In this figure signals are transmitted from device A, through cable W to logic L′ which converts these signals to codes which in turn are recorded upon the film through recorder *r*. In the case where SAC is recorded on an auxiliary support, such as magnetic tape *m* of FIG. 2*e*, the signals generated by A are transmitted through cable W to logic L′ which in turn converts these signals to SAC signals which are transmitted to tape recorder M.

Emitter *e*′ is a device which is coupled to camera C and generates synchronizing pulses to logic L′ as well as a recorder M. Emitter *e*′ can be either a pair of contacts operated by the motor of camera C or some opto-electronic system detecting film motion.

As far as SAC generation and recording, therefore, the present invention is characterized firstly by a device A called inclination sensor, secondly by a recording system, represented by *r* in FIG. 2*d* and by M in FIG. 2*e*, and thirdly by a writing logic L′.

FIGS. 3*a* and 3*b* illustrate the detail of articulation A of FIGS. 2*a* and 2*b* and 2*c* containing the inclination sensor which measures angles α and β shown on these figures, in real time, while filming proceeds. Tripod T is connected to a piece **1** on which a U-shaped piece **2** is articulated. The camera operator, once he has firmly fixed tripod T, orientates piece **2** so that platen **4** is horizontal. He then locks piece **2** in place by fastening butterfly screw **3.** Platen **5** rotates over platen **4,** and the azimuth angle between the two can be read thanks to a cursor **11** which faces graduations **12** of platen **5.** Platen **5** carries box **6** containing site and azimuth measuring devices. U-shaped piece **7** is articulated in rod **8** with respect to box **6.** The camera is attached at point **10** to piece **7** for movement therewith. Site angle can be read thanks to cursor **11′** on box **6,** which faces graduations **12** on piece **7.**

Box **6** contains two classical shaft encoders, and FIG. 3*b* shows as a possible example encoders of the three-phase servo type. Obviously, any other shaft encoding method is applicable to the present invention, such as classical binary shaft encoders. Each of the two encoders represented in FIG. 3*b* comprises a rotor winding connected to the reference AC power supply, and three stator windings generate the three sine waves carrying the information corresponding to the measurement of the angle between stator and rotor.

In FIG. 3*b*, rotor winding **14** of the azimuth servo is secured to shaft **13,** for rotation therewith, shaft **13** which is being secured to the platen **4** upon which platen **5** revolves. Stator **15** is, of course, fixedly secured to box **6.** Similarly, the rotor winding **16** of the site servo is secured to shaft **8** for rotation therewith, shaft **8** being secured to piece **7.** Stator **17** is, of course secured to box **6.**

The set of three wires **18** and the set of three wires **19** carry, respectively, azimuth and site signals. Those six wires together with the two wires **20,** which carry the reference signal, comprise cable **9** of FIG. 3*b.*

In FIG. 4*a*, dotted line A surrounds a portion of the drawing containing rotor windings, **14** and **16** of the azimuth and site servos, respectively, as well as stator windings **15** and **17** of the same servos. The reference signal carried by wire pair **20** feeds rotor windings **14** and **16** through wire pair **20′**. The same reference signal feeds logic L′ through wire pair **20″**.

The set of three wires **18** feed a synchro to digital converter **46** of classical design, which is also fed by the reference signal. Similarly, the set of three wires **19** feeds a synchro to digital converter **47** of the same type as **46,** which is also fed by the reference signal.

FIG. 4*a* represents, as an example, 12-bit converters, which correspond to dividing the circumference into 4,096 parts. In practice, higher or lower precisions may be required, and encoders as well as converters readily available in industry are very well adapted to precisions of this order. Bits **21** to **32** represent azimuth code, and bits **33** to **44** represent site code. Together, bits **21–44** represent the SAC. Along with every frame that is recorded on film **51** of FIGS. 4*a*, the corresponding **24** bit SAC must be recorded in real time during the fraction of a second during which the frame is exposed.

FIG. 4*a* represents a recording mode for those 24 bits upon track **52** of film **51.** This track may be optical or magnetic, and recording head **57** is therefore of the corresponding type. Film **51** is shown on the figure at an instant when frame *i* is stationary in front of window **53.** Arrow **58** shows direction of motion of the film. On the lower part of the film, frame of rank $i' = i - k$ is represented. This frame is ahead of frame *i* by exactly *k* frames, where *k* is a constant figure which, once it is decided upon, has to be rigidly respected through the system, in very much the same way as the advance of the sound track in sound-on-film recording. As frame *i* is still at the window, frame *i*′ is just ahead of an imaginary line **59,** in the plane of writing head **57.**

In order to simplify description of the writing method, it is assumed that progression of the film under head **57** is exactly synchronous with its progression under window **53.** This progression proceeds in discrete steps, thanks to a mechanism of the Malta-Cross type or any other equivalent mechanism. This assumption is not necessarily realized in practice, and the present invention applies as well to systems where progression of the film under the recording head is continuous at constant speed, while it proceeds in discrete jumps under the window, as is the case in sound-on-film recording. The following description of the SAC recording system applied to this case as well, provided that it is assumed that the leading edge of frame *i–k* crosses line **59** precisely at the instant when frame *i–l* begins to leave the window, to be succeeded by frame *i*.

Means of attaining uniform film speed under the writing head, while it proceeds in jumps under the window, are too classical to be described in the present invention.

The recording systems of the present invention may use existing cameras designed for multi-track sound recording by devoting one of these tracks to SAC recording.

Emitter *e*′ of FIG. 4*a* is made up of cam **48** and contactor **49.** This device generates an electrical pulse called image pulse corresponding to the precise instant when one frame begins to leave the window. In the case where the film proceeds at uniform speed under the recording head, it is more advantageous to have the image pulse correspond to shutter operation rather than film motion, since it allows the recording of the camera SAC at the precise instant when frame *i* was being exposed, rather than the instant when frame *i* – *l* was beginning to leave the window.

In practice, it is assumed that at a filming rate of 24 frames per second, the time that elapses between the image pulse and stabilization of the new frame is of the order of one ninety-sixth of a second; that is to say a little more than 10 milliseconds. It is precisely during these 10 milliseconds that the data available over wires **21** to **44** must be transfered to track **52.**

The method shown on FIG. **4***a*, as an illustration, consists in first transfering bits **21** to **44** to a 24 bit shift register **47**, this transfer occurring in parallel, then to transfer serially, bit by bit, the contents of shift register **47** to write head **57.** Shift register **47** is a classical parallel-load, serial read-out register of a type readily available on the market.

In FIG. **4***a*, bit *a'* shifts to bit *b'*, and so on, until ultimate bit *d* which exits from the shift register over wire **47'** towards the write amplifier. Shift register **47** possesses **24** parallel inputs **21** to **44.** Furthermore, it possesses a clock input **55'** and a load input **21'**. The image impulse generated by *e'* is connected to the register in load input **21'** and causes the SAC to be loaded in parallel from the synchro-to-digital converters into shift register **47.** Furthermore, the same pulse arriving over wire *x*, after having transited through a delaying circuit **54**, starts a clock **55** which attacks register **47** at input **55'**, and advances the shifting of the register, which transfers the SAC, bit by bit, towards shaping and amplifying circuits **57** before attacking recording head **57.** Device **55** also contains a counter which stops the clock after 24 pulses.

In the case when the film is proceeding at uniform speed under the write head, at 24 frames per second, frame time is slightly over 40 milliseconds. If all 24 bits must be allowed to be recorded in less than half this time, for instance, then a clock rate of 1,200 pulses per second is adequate. This corresponds to recording frequencies and recording densities which are very easily implemented. In the case when the film is proceeding in discrete jumps under the recording head, the time allowed for recording is the transition time, that is about 10 milliseconds. If it is assumed that all 24 bits are recorded in half the allowed time, this corresponds to a recording frequency of 5,000 cycles per second, which is still extremely reasonable.

Circuits **56** depend upon the recording mode chosen from among the many modes presently available. As an illustration, it is possible to use non-return to zero or double frequency recording, such as is widely used in magnetic recording, and which possesses the advantage of generating its own clock signal upon reading.

Delay circuit **54** is intended on the one hand to allow transfer of data from register **21** to shift register **44** before serialization begins, and on the other hand, in the case of film motion in discrete jumps, to allow the film to reach a constant speed before beginning to record. A delay of 4 to 5 milliseconds should be more than adequate. In FIG. **4***a*, region **69** of the recording track corresponds to the interval between line **59** and the beginning of recording **52** due to the delay introduced by circuit **54.** Also in FIG. **4***a*, the area circumscribed by the dotted line marked A corresponds to articulation A of FIG. **2***a*.

Wires **18, 19** and **20** together comprise cable W. Similarly, the area circumscribed by dotted line L' corresponds to recording logic L' of FIG. **2***d* and **2***c*. In FIG. **4***a*, wires y carrying the signal from logic L' to the recording head **57.** Recorder *r* of FIG. **2***d* corresponds to recording head **57** of FIG. **4***a*.

FIG. **4***b* represents the case where SAC is recorded upon an auxiliary support. In this case, elements A, L' and e' are identical to those of FIG. **4***a*. Output *y* now is connected to magnetic recording head **62.** Tape **61** is driven, for example, by stepping motor **64** through pulses received from emitter *e'* over wire *x'*.

To each frame of film corresponds a recording on tape *m*. It is quite possible to envisage, without changing the system, that motor **64** is rotating at constant speed instead of in discrete steps, and that its rotation speed is synchronized with film motion, through synchronizing pulses received from emitter *e'* over wire *x'*.

In FIG. **4***b*, motor **64** drives magnetic tape *m* through pinch rollers **65** and **66.** Tape motion is represented by arrow **67.**

The area surrounded by dotted line M' of FIG. **4***b* corresponds to recorder M' of FIG. **2***e* which has inputs *y* and *x'*. Input *x'* of FIG. **4***b* comes from emitter *e'* of FIG. **4***a*. Connections *x* and *x'* carry the same signal coming from cam **48** and contact **49.**

Upon projection, or restitution, the projection beam coming out of projector P must be deflected in site and azimuth according to the information contained in the SAC, whether this is read off the film itself or an auxiliary support. Systems can be conceived where projector P itself or a portion thereof is mounted on a mechanically orientable system, which is then rotated in site and azimuth according to the SAC. These systems require moving rather heavy mechanical parts, and the system response cannot be fast enough to meet system requirements, which are that the beam must be totally deflected in site and azimuth in less than 10 milliseconds, which is the time taken by one frame to replace the preceding frame in the projection window, at a speed of 24 frames per second.

The present invention covers a device consisting of two very light mirrors, one for site and the other for azimuth, which can be rotated about two orthogonal axes; the mirrors are mounted in such a way that the total deflection of the projection beam is the resultant of two orthogonal deflections.

FIG. **5***a* represents three orthogonal axes *xx'*, *yy'* and *zz'*. Axes *xx'* and *yy'* intersect at γ' while axes *yy'* and *zz'* intersect at γ''. Mirror *a* is attached to an axle *a'a''* which runs parallel to *zz'* through point γ'. Similarly, mirror *b* is attached to axle *b'b''* which runs parallel to *xx'* through point γ''. An arrow F which is projected along axis *xx'* in the direction *x* toward *x'* is first reflected by mirror *a* then by mirror *b*, and casts an image F' along axis *zz'* when mirrors *a* and *b* make an angle of 45° with axes *xx'* and *zz'* respectively. A rotation α' of axis *a'a''* causes the image to slide from F' onto F''. Similarly, a rotation B' of axis *b'b''* causes the image to slide from F' to F''. The conjunction of rotations α' and B' causes a composition of the above two displacements, and the arrow slides from F to FIV.

As shown in FIG. **5***a*, the arrow image is subjected to rotation which must be compensated for in order to restore its original orientation. This is the role of fixed mirrors *c* and *d*, which are used in conjunction with mirrors *a* and *b*. In FIG. **5***b*, axis x_1 is axis *xx'* of FIG. **5***a*. Similarly, axes *y2* and *z2* of FIG. **5***b* are respectively axes *yy'* and *zz'* of FIG. **5***a*. Axes y_1 and z_1 are parallel to y_2 and z_2 respectively. Mirror *d* is inclined at 45° with respect to each of axes x_1 and y_1 and its plane is parallel to axes z_1 and z_2. Similarly, mirror *c* is inclined at 45° with respect to each of axes x_1 and y_1 and its plane is parallel to axis x_1. Thanks to mirrors *c* and *d*, arrows FF and FF' have exactly the same orientation.

Considering that axes y_1 and y_2 are vertical, rotation of mirror *a* causes an azimuth displacement of arrow FF', while rotation of mirror *b* causes a site displacement of the arrow.

In FIG. **5***b*, the organs GA and GS rotate mirrors *a* and *b* around their respective axes. Mirrors *a*, *b*, *c* and *d*, together with organs GA and GS can be mounted inside a box having two windows, one centered around axis z_1, and the other around axis z_2. This box is inserted between projector P and the screen, very near the projector, so that the first of these two windows faces the projector, and the box is oriented in such a way that axis *z* is the optical axis of the projector. Lens systems λ1 and λ2 are disposed respectively, at the input and output windows of the box to improve the optical properties of the system.

FIG. **5***c* represents a simplified case where it is required to orientate the beam in azimuth only, the site being fixed. Mirrors *f*, *g*, *h* and *q* are all vertical. Mirrors, *f*, *g* and *h* are fixed, while *q* can rotate about a vertical axis. Mirror *f* intercepts the beam emerging from projector P. It is inclined at 45° with respect to the optical axis of P, and reflects the beam towards mirror *g*, parallel to mirror *f*, which in turn sends the beam towards mirror *h*, perpendicular to mirror *g*. Finally, mirror *h* reflects the beam toward mirror *q*, which sends the beam towards a region of the screen depending on the rotation of mirror *q*, which is actuated by an organ not shown in FIG. **5***c*.

FIG. **6***a* illustrates the principle of the read-out logic L of FIGS. **1***c* and **1***d*. Film **70** moves in front of window **72** and reading head **73** with arrow **71** indicating the direction of motion.

At the instant considered in FIG. **6***a*, frame i is standing at the window. To simplify the description of principle, it is assumed that film motion under the reading head as absolutely synchronous with that of the film under the window, and proceeds in discrete jumps. Frame *i'* of FIG. **6***a* is itself frame *i–k* of FIG. **4***a*, that is to say, that very frame on whose margin the SAC recorded is that corresponding to frame *i*.

At the instant considered in FIG. **6***a*, it is not frame *i'* which is about to cross the reading head line **74**, but frame *i'* + 2. This means that frame *i'* has already passed two frames ago. The reason for this is that it is required that when frame *i'* comes in front of the window and is stabilized, deflection system D of FIG. **1***a* must have already read and executed the SAC corresponding to frame *i*. To achieve this, the system must have already read the SAC off the margin of frame *i'*, and stored it until the image pulse announcing the arrival of frame *i* is generated by cam **77** of emitter *e* and appears on wire **78.**

One method according to the present invention consists in using double-buffering. The first of two registers receives data from the film and transmits it to the second register, which in turn transmits it to the conversion devices which drive the mirror actuators.

The first of these two registers is shift register **80** which receives the SAC from the film and transmits it to register **84.** Reading head **73** reads data **75** recorded on the film track and transmits it over connection **76** to circuit **81,** which amplifies and shapes the signal before transmitting it to circuit **79** which restores or extracts the clock from the signal itself according to well-known methods such as those used for instance in non-return to zero double frequency recording. The clock signal is sent over wire **84** to the clock input of shift register **80,** and the data signal is transmitted serially over wire **85** to the data input of the shift register. This is a classical serial-in parallel-out shift register. Flip-flops *a*, *b*, and *c* represent the first three positions of shift register **80,** while *a'*, *b'* and *c'* represent the corresponding positions of register **84.** This is a classical parallel-load register with parallel read-out. Input **78** controls parallel loading of inputs **82** through **102.** When the register is loaded, content bits appear on wires **82'** through **105'**.

Upon arrival of a clock pulse on **84,** Data appearing on **85** is introduced into position *a* of shift register **80,** while data previously contained on *a* is introduced into position *b*, and so on. Upon the occurence of the twenty-fourth clock pulse, the last SAC bit is introduced into position *a*, which now contains in sequence all 12 site bits and all 12 azimuth bits. The clock pulse ceasing to arrive, this information remains frozen in the shift register until the next frame, when the new SAC will be loaded, thus pushing out the previous SAC.

When the frame starts moving, the image pulse sent by cam **77** of emitter *e* is transmitted to input **78,** of register **84,** hence transferring, in parallel the contents of register **80** to register **84.** For example, the bit in position *a* is transmitted to position *a'* over wire **82.** The content of position *a'* appears on wire **82'**. At the instant when frame *i'* + 1 begins to move in front of the read head, to be succeeded by frame *i'* + 2, the SAC of image *i* moves from register **80** to register **84,** so that when frame *i* is stabilized in the window, its own SAC is already present in register **84.**

This very same SAC had been read by the reading head when frame *i'* was crossing its line. Contents of register **84** are split into two groups of 12 bits each, each group being connected a digital-to-analog converter. Bits **82'** to **93'** corresponding to azimuth code feed D/A converter **86** of FIG. **6***a*, while bits **94'** to **105'** corresponding to site code feed D/A converter **87.** The output of converter **86** is passed through a special amplifier **88** which, in turn, drives azimuth galvanometer GA through connection **90.** Similarly, the output of converter **87** is passed through special amplifier **89** which, in turn, drives site galvanometer GS through connection **91.**

Circuits surrounded by dotted line L in FIG. **6***a* correspond to read-out logic L of FIGS. **1***c* and **1***d*. Galvanometers GA and GS of FIG. **6***a* are the same as those of FIG. **5***b* which represents deflector D of FIGS. **1***a*, **1***c* and **1***d*. Circuits surrounded by dotted line *e* of FIG. **6***a* correspond to emitter *e* of FIGS. **1***c* and **1***d*.

The reason why reading head **73** is ahead of the window in FIG. **6***a* is that presently used systems of sound-on-film recording are constructed in such a way that the sound reading devices are ahead of the projection window. Thus the present invention can take advantage of such systems, without change, by using one of the sound tracks for SAC recording. Existing projectors can be modified, however, so that the reading head, instead of leading the window by *k* frames, is lagging behind the window exactly two frames. In this case, figure Ga must be modified so that it is frame *i'* and not frame

i that is presently at the window. Reading head is therefore just about to read the SAC off the margin of frames $i'+2$, when frame i' being projected. The consequence of this construction is that the SAC of frame i' is on the margin of frame i' itself. This presents considerable advantages, since each frame carries its own SAC, hence solving cutting, splicing and editing problems. Since each frame carries its own SAC, FIG. **6a**, which illustrates projection of cinematographic film, if modified so that reading head lags behind the window, can also be used to illustrate projection of still frames or slides. One possible scheme consists of reading the SAC off the margin of the frame as it is being introduced into the projector and generating an image pulse artificially after the frame is completely introduced.

In the case where auxiliary recording on tape is used in conjunction with still slides, it is more advantageous to have the tape proceed at constant speed, and generate synchronization pulses which advance the projector step by step. It is clear that the same magnetic tape may carry, on adjacent tracks, sound recordings to accompany slide projection.

FIGS. **5b** and **6a** show actuator organs GA and GS whose function is to rotate mirrors a and b through angles α' and β', respectively, pursuant to the SAC. Since a beam is rotated by twice the rotation angle of the mirror upon which it is reflected, the devices shown in FIG. **6a**, and particularly amplifiers **88** and **89** thereof, will have to be adjusted so that angles α' and β' of FIG. **5a** are respectively equal to one half of angles α and β of FIG. **1a**.

Various types of organs GA and GS can be used in application of the principles described in the present invention. As an example, actuators can be used consisting of moving coil or moving iron galvanometers. With existing galvanometers in industry attached to light mirrors, response times of the order of half a millisecond can be attained, which is faster than required by the systems described in the present invention. The use of galvanometers and linear amplifiers presupposes, as shown in FIG. **6a**, the conversion of SAC from its digital form to an analog signal. This is easily achieved through digital to analog converters of the type widely available on the market.

The principles described in the present invention can also be implemented using other positioning systems, such as those commonly employed in numerical control. These may be devices where the actuator consists of a motor coupled to a binary disk which measures at every instant the actual rotation and compares it to the desired rotation shown on output register **84** of FIG. **6a**. There are also available on the market actuating devices which can convert binary data directly into a corresponding mechanical displacement.

The principles described in the present invention are also applicable to systems where SAC is read off an auxiliary support such as magnetic tape m of FIG. **1d**. In this case, the system is analogous to that illustrated by FIG. **4b** which corresponds to the writing operation. Indeed it suffices to consider that head **62** is now a reading head instead of a writing head and that connections x' and y of FIG. **4b** correspond to connections z' and u' of FIG. **1d**, where it is understood that this same connection u' corresponds to connection **76** of FIG. **6a**.

Furthermore, the principles described in the present invention are applicable to post-encoding systems, where the SAC is created artificially, after filming, instead of being generated in real-time. Post encoding generated SAC can be recorded either on the film itself or on an associated support such as magnetic tape. In either mode, it may be found advantageous to start out by recording the artificially generated SAC on magnetic tape, and then transfer it if necessary upon the film. Generation and recording of the SAC can be realized by means of a system comprising a monitoring projector or viewer and a magnetic tape recorder in an arrangement similar to that of FIG. **2e**, where camera C is replaced by a projector or viewer which can be advanced frame by frame and which drives recorder M in synchronism. The SAC is generated by articulation A as the viewer is moved in site and azimuth by the operator. Another arrangement can be realized, where the viewer is dismounted from articulation A, the latter being manually operated by a sort of manually operated joystick.

From the preceding description, it is obvious that, if it is required to project a frame carrying a SAC on a screen of regular dimensions, the frame can be projected by means of a regular projector, that is to say one that ignores the SAC recording. Similarly, one can use a projection system similar to those described in the present invention by disabling deflector D in such a manner that projection proceeds upon a fixed region of the screen. This is particularly advantageous in case of failure of any part of the deflection system, since projection can still proceed upon a fixed region of the screen.

By way of contrast with the known systems for stabilizing a series of projected images by comparison of a projected optical reference point with an external fixed point (such as a photo-sensor at a reference point on the screen), the present invention provides a system for varying the location of a series of projected images exclusively in accordance with information contained in a SAC code—whether stated in orthogonal, polar or other coordinate systems—without respect to any external fixed point.

Now that various embodiments of the present invention have been shown and described in detail, various modifications and variations thereof will become readily apparent to those skilled in the art. For example, still slides are now available with a magnetic strip for the recording of a voice or sound to accompany projection of the slide; obviously such slides could be utilized as the storage medium for both the pictorial image and the indicator of the present the pictorial image being recorded on the photographic elements and the indicator being recorded on the magnetic strip. Accordingly, the scope of the present invention is to be considered as limited only by the appended claims, and not by the foregoing disclosure.

I claim:

1. A method for recording and subsequently projecting pictures successively onto various areas of a substantially oversized screen in a predetermined pattern comprising the steps of:

A. recording on a storage medium a pictorial image;

B. recording on a storage medium an indicator in site-azimuth code of the relative projection position to be associated with the image, the orientation of the image recording apparatus being recorded in real time in the course of image recording as the associated indicator;

C. reading the storage medium containing the associated indicator and adjusting the projection orientation of a projection system exclusively in accordance with information contained in the associated indicator; and

D. reading the storage medium containing the image and projecting the image through the projection system onto a screen substantially oversized relative to the projected image;

whereby upon projection of the image according to the associated indicator the image is projected onto a region of the screen corresponding to the real time position of the image during recording.

2. The method of claim **1** wherein the image is recorded on photographic film.

3. The method of claim **2** wherein the image is recorded on one frame of a cinematographic film.

4. The method of claim **1** wherein the image and associated indicator are recorded on the same storage medium.

5. The method of claim **4** wherein the image and the associated indicator are recorded on the same storage medium, the storage medium comprising sound cinematographic film.

6. The method of claim **4** wherein the image and the associated indicator are recorded on the same frame of cinematographic film.

7. The method of claim **5** wherein the associated indicator is read prior to the image.

8. The method of claim **1** wherein the image and the associated indicator are recorded on different frames of the same cinematographic film, the associated indicator being recorded on a frame prior to the frame bearing the image.

9. The method of claim **1** wherein the image and associated indicator are recorded on separate and distinct moving storage media, the motions of which storage media are synchronized together.

10. The method according to claim **1** wherein the associated indicator is recorded as bits representing a site-azimuth code.

11. The method of claim **1** wherein the indicator-recording storage medium is read in discrete steps.

12. The method of claim **11** wherein the image-recording storage medium is advanced during reading in discrete jumps corresponding to frames of a cinematographic film.

13. The method of claim **1** wherein the indicator-recording storage medium is advanced continuously during reading.

14. The method of claim **1** wherein the projection system includes a pair of mirrors rotatable about different orthogonal axes according to the associated indicator to cause a resultant two dimensional deflector of the projected image.

15. The method of claim **1** wherein the projection system includes a mirror rotatable about only one orthogonal axis according to the associated indicator to cause a resultant one dimensional deflection of the projected image.

16. Apparatus for recording and subsequently projecting pictures successively onto various areas of a substantially oversized screen in a predetermined pattern comprising:

A. a projection system;

B. first and second storage media;

C. means for recording a pictorial image on said first storage medium;

D. means for recording an indicator in site-azimuth code of the relative projection position to be associated with the image on said second storage medium, the associated indicator representing the orientation of the image recording apparatus in real time in the course of image recording;

E. means for reading said second storage medium and adjusting the projection orientation of said projection system exclusively in accordance with information contained in the associated indicator thereon; and

F. means for reading said first storage medium and projecting the recorded image through said projection system onto a screen substantially oversized relative to the projected image;

whereby upon projection of the image according to the associated indicator the image is projected onto a region of the screen corresponding to the real time position of the image during recording.

17. A method for recording pictures for subsequent projection successively on to various areas of a substantially oversized screen in a predetermined pattern comprising the steps of:

A. recording on a storage medium pictorial images; and

B. recording on a storage medium for each image an indicator in site-azimuth code of the relative projection position to be associated with the image, the orientation of the image recording apparatus being recorded in real time in the course of image recording as the associated indicator;

whereby subsequent successive projection of each image through a projection system onto a screen substantially oversized relative to the projected image may be modified by adjusting the projection orientation of the projection system in accordance with the indicator associated with the image to project the image onto a region of the screen corresponding to the position of the image during recording.

18. The method of claim **17** wherein the images are recorded on photographic film.

19. The method of claim **18** wherein each image is recorded on one frame of a cinematographic film.

20. The method of claim **17** wherein the images and the associated indicators are recorded on the same storage medium.

21. The method of claim **20** wherein the images and the associated indicators are recorded on the same storage medium, the storage medium comprising sound cinematographic film.

22. The method of claim **20** wherein each image and its associated indicator are recorded on the same frame of cinematographic film.

23. The method of claim **20** wherein each image and associated indicator are recorded on different frames of the same cinematographic film, the associated indicator being recorded on a frame prior to the frame bearing the image.

24. The method of claim **17** wherein the images and associated indicators are recorded on separate and distinct moving storage media, the motions of which storage media are synchronized together.

25. A method according to claim 17 wherein each associated indicator is recorded as bits representing a site-azimuth code.

26. The method of claim 17 wherein the indicator-recording storage medium is advanced in discrete steps during recording.

27. The method of claim 26 wherein the image-recording storage medium is advanced in discrete jumps corresponding to frames of a cinematographic film.

28. The method of claim 17 wherein the indicator-recording storage medium is advanced continuously during recording.

29. Apparatus for recording pictures for subsequent projection successively onto various areas of a substantially oversized screen in a predetermined pattern comprising:

A. first and second storage media;

B. means for successively recording pictorial images on said first storage medium; and

C. means for successively recording indicators of the relative projection position to be associated with each image on said second storage medium, the orientation of the image recording apparatus being recorded in real time in the course of image recording as the associated indicator;

whereby subsequent projection of each recorded image through a projection system onto a screen substantially oversized relative to the projected image is modifiable according to the recorded associated indicator to project the image onto a region of the screen corresponding to the position of the image during recording.

30. A method for projecting pictures successively onto various areas of a substantially oversized screen in a predetermined pattern comprising the steps of:

A. reading a storage medium containing the projection position indicators associated with the pictorial images to be projected and successively adjusting the projection orientation of a projection system exclusively in accordance with information contained in the associated indicators, the associated indicators representing the orientation of the image recording apparatus in the course of real time image recording; and

B. reading a storage medium containing the images and projecting the images through the projection system onto a screen substantially oversized relative to the projected images

to project the images onto regions of the screen corresponding to the real time position of the images during recording.

31. The method of claim 30 wherein the storage medium containing the images is photographic film.

32. The method of claim 31 wherein the storage medium containing the images is cinematographic film and each frame thereof contains a single image.

33. The method of claim 30 wherein the same storage medium contains the images and associated indicators.

34. The method of claim 33 wherein the same storage medium is sound cinematographic film.

35. The method of claim 34 wherein the same storage medium is cinematographic film and each image and associated indicator are read from the same frame thereof.

36. The method of claim 35 wherein each associated indicator is read prior to the image.

37. The method of claim 34 wherein the same storage medium is cinematographic film and each image and associated indicator are read from different frames thereof, the frame bearing associated indicator being read prior to the frame bearing the image.

38. The method of claim 30 wherein the image and associated indicator are read from separate and distinct moving storage media, the motions of which storage media are synchronized together.

39. A method according to claim 30 wherein each associated indicator is comprised of bits read as a site-azimuth code.

40. The method of claim 30 wherein the indicator-containing storage medium is read in discrete steps.

41. The method of claim 40 wherein the image-containing storage medium is advanced during reading in discrete jumps corresponding to frames of a cinematographic film.

42. The method of claim 30 wherein the indicator-containing storage medium is advanced continuously during reading.

43. The method of claim 30 wherein the projection system includes a pair of mirrors rotatable about different orthogonal axes according to the associated indicators to cause a resultant two dimensional deflection of the projected images.

44. The method of claim 30 wherein the projection system includes a mirror rotatable about only one orthogonal axis according to the associated indicators to cause a resultant one dimensional deflection of the projected images.

45. Apparatus for projecting pictures successively onto various areas of a substantially oversized screen in a predetermined pattern comprising:

A. a projection system;

B. first and second storage media; said first storage medium bearing pictorial images and said second storage medium bearing indicators of the relative projection positions to be associated with the images, the associated indicators representing the orientation of the image recording apparatus in the course of real time image recording;

C. means for reading said second storage medium and adjusting the projection orientation of said projection system exclusively in accordance with information contained in the associated indicators thereon; and

D. means for reading said first storage medium and projecting the images through said projection system onto a screen substantially oversized relative to the projected images to project the images onto regions of the screen corresponding to the real time position of the images during image recording.

46. The method of claim 1 wherein in step (B) the indicator is electromagnetically recorded on the storage medium, and in step (C) the associated indicator is electromagnetically read from the storage medium containing the associated indicator.

47. The method of claim 1 wherein in step (C) the projection orientation of the projection system is adjusted exclusively in accordance with the information contained in the indicator.

48. The apparatus of claim 16 wherein said projection system includes a pair of mirrors rotatable about different orthogonal axes according to the associated

indicator to cause a resultant two dimensional deflection of the projected image.

49. The apparatus of claim **16** wherein said projection system includes a mirror rotatable about only one orthogonal axis according to the associated indicator to cause a resultant one dimensional deflection of the projected image.

50. The apparatus of claim **16** wherein said indicator recording means records the indicator electromagnetically on said second storage medium, and said means for reading said second storage medium electromagnetically reads the indicator.

51. The apparatus of claim **16** wherein said projection orientation adjusting means adjusts the projection orientation of said projection system exclusively in accordance with the information contained in the indicator.

52. The apparatus of claim **16** wherein said indicator recording means records the indicator as bits representing a site-azimuth code, and said means for reading said second storage medium reads the bits of the indicator on said second storage medium as a site-azimuth code.

53. The method of claim **17** wherein in step (B) the indicator is electromagnetically recorded on the storage medium.

54. The apparatus of claim **29** wherein said indicator recording means electromagnetically records the indicators on said second storage medium.

55. The apparatus of claim **29** wherein said indicator recording means records each indicator as bits representing a site-azimuth code.

56. The method of claim **30** wherein in step (A) the indicators are electromagnetically read from said storage medium.

57. The method of claim **30** wherein in step (A) the projection orientation of the projection system is adjusted exclusively in accordance with the information contained in the indicators.

58. The apparatus of claim **45** wherein said projection system includes a pair of mirrors rotatable about different orthogonal axes according to the indicators to cause a resultant two dimensional deflection of the projected images.

59. The apparatus of claim **45** wherein said projection system includes a mirror rotatable about only one orthogonal axis according to the indicators to cause a resultant one dimensional deflection of the projected images.

60. The apparatus of claim **45** wherein the indicators are electromagnetically recorded on said second storage medium, and said means for reading said second storage medium reads the indicators electromagnetically from said second storage medium.

61. The apparatus of claim **45** wherein said projection orientation adjusting means adjusts the projection orientation of said projection system exclusively in accordance with the information contained in the indicators.

62. The apparatus of claim **45** wherein the indicators are recorded as bits representing a site-azimuth code.

63. The apparatus of claim **45** including means for advancing the indicator-containing storage medium continuously during reading.

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