

Aug. 28, 1962

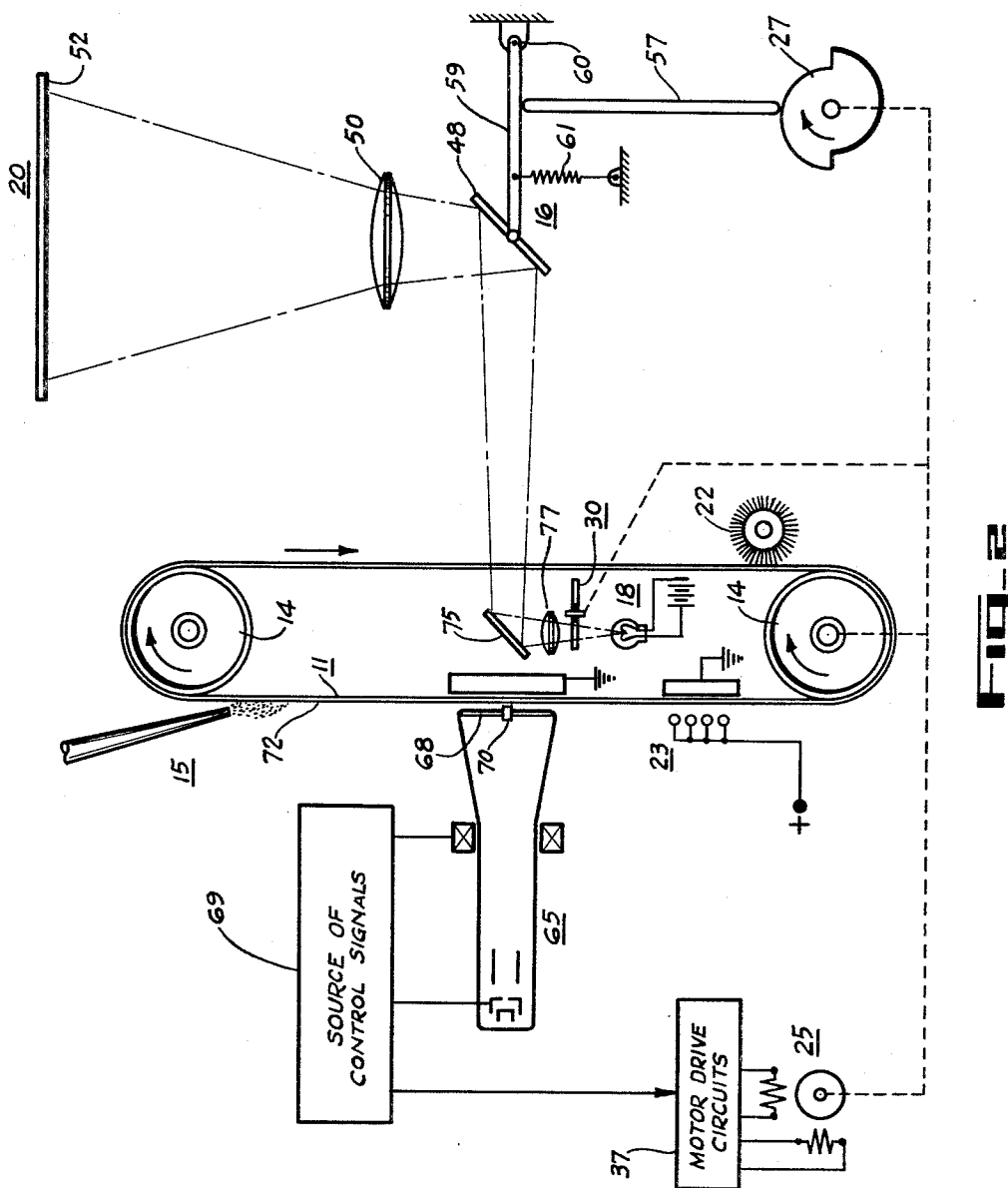
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3,051,044

RECORDING AND PROJECTION SYSTEM

Filed Sept. 9, 1959

4 Sheets-Sheet 2



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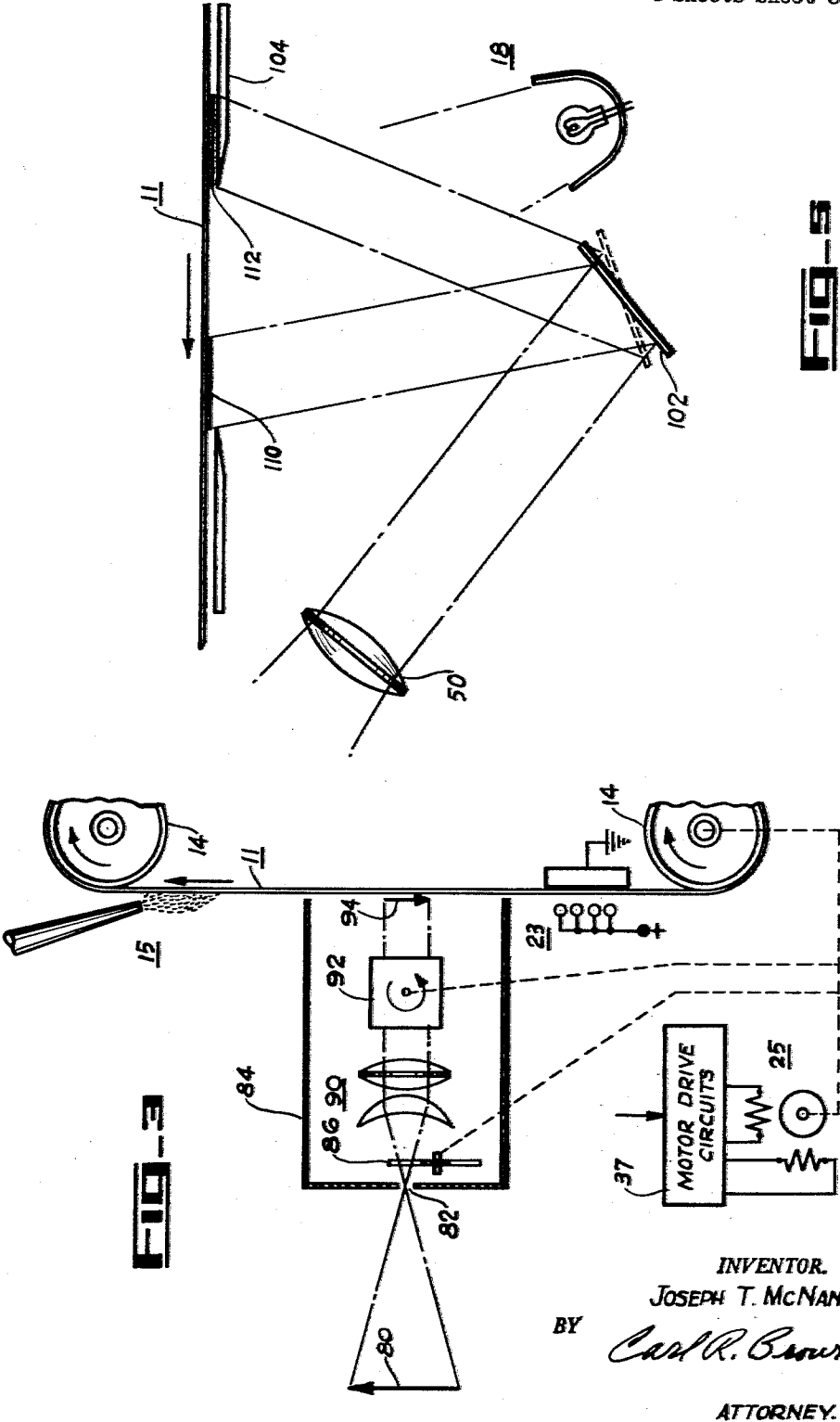
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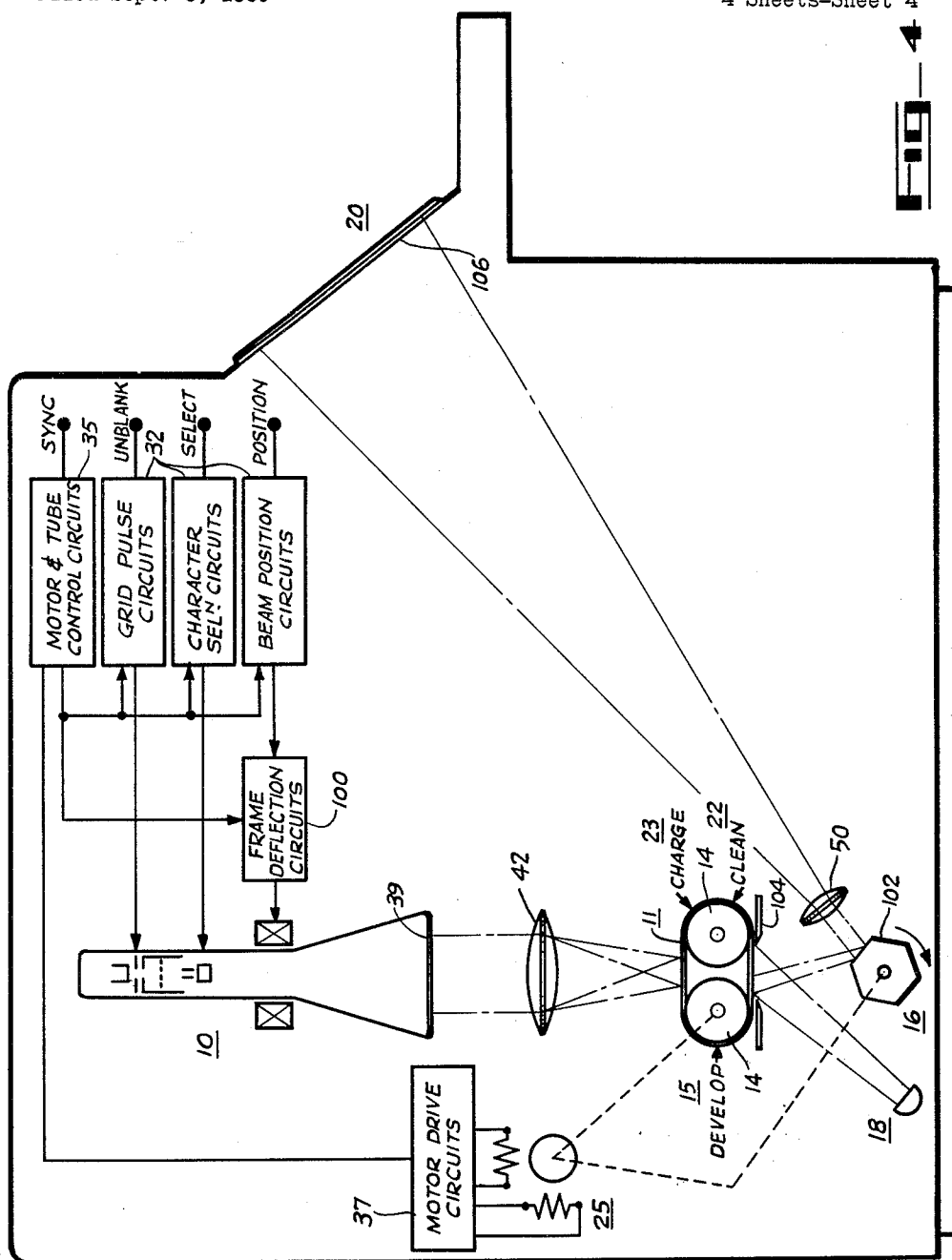


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RECORDING AND PROJECTION SYSTEM

4 Sheets-Sheet 4



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3,051,044

RECORDING AND PROJECTION SYSTEM

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Filed Sept. 9, 1959, Ser. No. 838,973

3 Claims. (Cl. 88—24)

This invention relates generally to a recording and projection system wherein light or electron images are recorded as electrostatic latent images.

More particularly, the invention relates to and includes an endless belt means capable of recording light or electron images presented thereto as electrostatic latent images thereupon. The latent image on the belt means is then converted through the use of liquid or powder developers into a visible image. The visible image may be transmitted from the belt means to a light transmitting means in the form of modulated light. Movement of the light transmitting means is synchronized with the movement of the belt means to present upon a final light receptive means a stationary reproduction of the originally presented image.

Light or electron images may be recorded respectively upon photoconductive or resistive media as electrostatic latent images. The latent images may be developed thereafter into visible images by application of electrostatically attractable powders, for example, as is taught in McNaney U.S. Patents Nos. 2,736,770, 2,808,023 and 2,824,813, or by liquids such as taught by the U.S. patent issued to Mayer, No. 2,890,174, patented June 9, 1959. Any of these well-known methods and apparatus may be used to develop the latent electrostatic image into the visible image.

In the prior art, the visible image was thereafter transferred from a continuous photoconductor belt through direct contact, as shown in McNaney U.S. Patent No. 2,736,770, to a paper or recording means. The actual physical transfer of the particles developing the latent image was necessary to record them upon the paper. The recorded images on paper then could subsequently be viewed. In modern day air traffic control systems, as well as air and land surveillance systems, government personnel and military commands oftentimes view situations in the air, on the land or on the sea as they occur. As considerable numbers of persons are present, a rather large room is often necessitated to house those who make their decisions on the basis of the recorded information. The recorded information therefore is desirably presented on a large screen. In prior art normal presentations, it is necessary that a series of photographs be taken of the situations displayed by the various radar displays. This photograph is subsequently developed in the normal time-consuming process of silver halide film development. Thereafter the film is dried. All these steps are necessary prior to affording one an opportunity to view the film. The film may be projected onto a large screen by projection through use of a light lantern. All this is very time consuming. It is highly desirable to a viewer to view the images or the radar presentations almost simultaneously with their recodation.

Many applications for commercial activities of such rapid recording and projection systems also exist, especially in air traffic control. As modern aircraft increase in speed and numbers, their control in and around airports necessitates traffic situation displays, preferably viewable immediately after presentation or detection by radars. To this end the present invention solves the problem of rapidly recording, and subsequently presenting for projection, the recorded images for viewable or other displays.

The present invention utilizes rapid conversion of the image presented in either light form through the use of

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a cathode ray tube, for example, or in electronic form through direct electron transfer, into electrostatic latent images. The electrostatic images are recorded as charge patterns or latent images upon an endless belt means. The belt means preferably is in continuous motion. The latent images recorded thereon are therefore transported rather rapidly from original recodation to a subsequent position for developing the image into visual images. Continued movement of the belt means presents the visual images to the next successive step at which the visual image, upon the endless belt means, is irradiated or illuminated, either by reflection of light therefrom, or, by shadowing of light therethrough, providing a visual light reproduction of the visual images. The belt in its continuous movement likewise presents an image that is moving therewith. Therefore, in order to stop the image upon a subsequent recording medium, light receptive means, or viewing screen, it is necessary to use a light transmitting means synchronized in movement with the movement of the belt means, so as to provide thereon a stationary image reproduction of the visual images. The light transmitting means may be a movable mirror, a rotating multisided mirror, or a prism.

It is therefore possible in the invention system herein presented to record an image at a time, a line at a time, or a frame at a time, as may be desired through proper timing and synchronizing of the movement of the belt means with the movement of the light transmitting means. The preferred embodiment of the present invention effects such synchronization through the utilization of a common motor or motive means to drive both the light transmitting means and the pulley driving means for the endless belt means. The light transmitting means of the preferred embodiment is synchronized with the movement of the belt means through use of cams to move a mirror, for example, back and forth, or oscillatingly in synchronism with the rotation of the endless belt. Of course, a multisided mirror or prism could be used and rotated in synchronization with the movement of the endless belt means by having the mirror or prism geared to the same shaft driving the belt means.

It can be seen from this specification infra, together with the drawing, that this system lends itself to very rapid subsequent presentation of the recorded data following its recodation. As there is no transfer of the information from the endless belt means for successive transmission onto other media (except as illuminated visual images), the possibility of error in transferring the information is reduced to a minimum, and speed is at a maximum. Likewise, the complexity of the system, as well as the small number of moving parts, provides the system a high degree of reliability.

Further, as the component parts of this invention are time tested components, each capable of adequately performing the function desired of it, and as the parts are generally commercially available, the novel combination also produces a system which is constructable with generally commercially available parts. This further increases the reliability and reduces the cost of constructing the overall system. As will later be seen, the system also is very flexible, in that it can record in the form of an image an object directly, can use a cathode ray tube or a shaped beam tube as its image source, or, can use electronic or electrostatic image sources and effect recodation of each. Such flexibility is highly desirable in today's complex information display, television communication and data processing systems, and further adds greatly to the desirability and utility of the invention.

In addition to the objects and advantages aforesated, it is a further object of the present invention to provide a system capable of rapidly recording and subsequently projecting images for viewing thereof, or for recodation,

which system is relatively simple in construction and highly reliable in operation.

It is another object of the present invention to provide a recording and projection system which is quite versatile in its reception of the form of information to be recorded thereon.

It is another object of the present invention to provide a system for recording and subsequent projection of the recorded matter, which system is relatively free of mechanical ineritas, thereby permitting a high speed of subsequent projection.

It is another object of the present invention to provide a recording portion of the recording and projection system which is in constant motion, thereby avoiding the necessity of starting and stopping said recording medium.

It is another object of the present invention to provide a system including light gathering and reflective means of relatively low inertia to permit compensation for the surface movement of the endless belt means, thereby providing a stationary final image projection.

Objects and advantages other than those set forth will be apparent from the following description when read in connection with the accompanying drawing, in which:

FIGURE 1 is a diagrammatic representation of the recording and projection system embodying the invention wherein the images are provided in the form of light on the face of a cathode ray tube;

FIGURE 2 is a diagrammatic representation of the invention wherein the images are presented in the form of electron charges through pin-type arrays herein exemplified as a cathode ray tube having pins passing through its screen or face to carry the electron image impinged thereon by conduction to direct contact with the recording or belt means;

FIGURE 3 is a further diagrammatic representation exemplifying an embodiment of the invention wherein the image is optically photographed and optically moved in synchronism with and for recordation on the belt means;

FIGURE 4 is a further embodiment of the present invention exemplified diagrammatically as encased in a projection console wherein the images are presented upon a shaped beam tube screen in the form of light, and recorded and transmitted from the belt means by a continuously rotating light transmitting means; and

FIGURE 5 is a detailed diagrammatic view of a light limiter means used in the embodiment of FIGURE 4.

Referring more particularly to FIGURE 1, we have there shown, diagrammatically, a recording and projection system in accordance with the present invention. A means 10, exemplified as a cathode ray tube or a shaped beam tube, is used to present predetermined intelligible information or images. An endless belt means 11, responsive to the images presented by the means 10, records the images from means 10 thereon as electrostatic latent images. The endless belt means 11 is exemplified in this embodiment as a belt having a photoconductive surface thereupon to respond to light images and transform the light images into electrostatic latent images. The belt means 11 is carried by means 14 shown as pulleys, at least one of the pulleys being driven for rotation. The belt means 11 rotates upon the pulleys in the direction of its endlessness. The latent image is recorded upon the belt means 11 from the means 10, and is transported from this point of origin to subsequent points for development, irradiation and subsequent projection as visual images from the belt means to a light transmitting means 16. The latent images, of course, are developed by a developing means 15, disposed adjacent the belt means 11, which is exemplified herein as an orifice blowing electrostatically attractable particles or powders onto the image. For various detailed constructions thereof, reference may be had to U.S. Patents Nos. 2,808,023 and 2,824,813. The powders, of course, adhere to the electrostatic latent

image and convert it into a visual image. As previously stated, liquid electrostatic developers could also be used. The visual image may then be illuminated by a light means 18. Light means 18 is shown here irradiating the visual image by reflecting light modulated in accord with the visual images from the light reflecting photoconductive surface to the light transmitting means 16. The light transmitting means 16 is exemplified in this embodiment as the mirror capable of moving back and forth, in an oscillatory movement and in movement synchronized with the rotation of belt means. Means 16 is disposed in light-receiving relation to the irradiated visual images to redirect the visual images from the belt means to a light receptive means 20. Light receptive means 20 may be photographic film, photoconductive surface or a screen, and is herein exemplified as a screen.

Of course, as the endless belt means 11 continues in its motion in the direction of its endlessness about the pulleys 14, the visual images must be removed before further latent images can be received. Means 22 is provided to remove the visual images from the belt means 11, and, subsequent thereto means 23 is so disposed as to re-charge the belt means to again be receptive to renewed latent image orientation thereon. Both means 22, herein exemplified as a brush, for example, and means 23 herein exemplified as a plurality of high potential carrying charging wires, are old in the art and well-known.

Normally, a continually rotating belt means 11 would result in a jittery or irradically moving visual image to be presented on a light receptive means. It is therefore necessary to compensate for the movement of the belt means by synchronizing the movement of the belt means 11 with the movement or rotation of light transmitting means 16. Such synchronizing will achieve stationary reproduction of the visual images irradiated upon the belt means 11 upon the presentation of the images at the light receptive means or screen 20. In the present embodiment the synchronization is accomplished through use of a common motor drive 25, which rotates simultaneously the pulleys 14 carrying the endless belt means 11, as well as a cam 27 for the movement of the light transmitting means 16. The motor drive 25 is operated under command of the same sync signals as is the tube 10; therefore, cathode ray tube displays, belt movement and light transmitting means are all under control of a common sync signal. Of course, the control is unidirectional; there is no feedback exemplified in this system.

In addition, of course, if it is desired, the light means 18 may also be shuttered by utilization of a shutter cam arrangement 30 also driven by the motor 25. The synchronized system described is exemplary, and is shown in a very simplified form so as to reduce to a minimum the parts or portions of this system which are unreliable or have lost motion.

Examining FIGURE 1 in greater detail, the tube 10, for example, may be of the type shown in my U.S. Patent No. 2,735,956 or 2,761,988. Each of these tubes may be driven by the exemplary circuitry herein collectively shown as tube circuits 32 in accordance with the detailed teachings of McNaney U.S. Patents Nos. 2,736,770 and 2,850,723. Of course it should be understood that, while a character display or shaped beam tube is actually shown as means 10, any type of cathode ray tube presenting information such as radar or Lissajous type information could be utilized, provided the information desired to be recorded is so presented.

It is customary in computer control equipment to provide the sync signal aforesaid to provide to all the rest of the equipment a timing signal, thereby synchronizing operation of the constituent parts. FIGURE 1 exemplifies the presentation of such a signal to a motor and tube control circuitry 35. The output of circuitry 35, namely, a sync signal, is furnished to the tube control circuitry 32, and the motor drive circuitry 37. For specific embodiments and constructions of exemplary

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motor and tube control circuitry and motor drive circuitry, reference may be had to McNaney U.S. Patent No. 2,736,770. As exemplified in the embodiment of FIGURE 1, it should be understood that there is no return feedback or servo-loop operation of the synchronizing system, but the system only operates under the control of the sync signal to provide the necessary timing for each of the components. The present invention, however, should not be limited solely to a unidirectional sync signal control, as those skilled in the art could easily use a more complex servo system with correction signals from the various components being fed back to the signal originating components, the differences compared, and corrections interjected into the system to maintain synchronized operation. Such a more complex system is not herein shown.

As the characters are then presented on the screen 39 of the tube 10, in light and shadow representation, lens 42 may be used to collimate the light images from screen 39 for presentation onto an image reflecting means 115 and then onto the endless belt means 11. As light and shadow is being used as the source of intelligible images, the endless belt means 11 used with such light and shadow images preferably uses a photoconductive surface 45 disposed on, or carried upon, the endless belt means 11. For details as to the method of operation of the photoconductors upon receipt of light excitation and recordation thereupon as electrostatic latent images, reference may be had to McNaney U.S. Patent No. 2,736,770. If photoconductive surface 45 is used, a transparent or a non-transparent conductor may serve as the basic portion of the endless belt means 11. The conductor may be used to carry away the charges dissipated as a result of illumination of desired areas of the photoconductor. The latent images may be developed, as is shown in FIGURE 1, at the subsequent step along the rotation of the belt means 11, by electrostatically attractable particle means 15. Means 15 could also be a means for developing the latent images and rendering them visible as is taught in Mayer U.S. Patent No. 2,877,133, assigned to the common assignee hereof, and 2,890,174, 2,891,911 and 2,878,120. All these patents teach the art in utilizing electrostatically attractable particles suspended in liquids as means for development of latent images.

As the visible image is disposed so as to communicate with the light illumination under the influence of the light means 18, the visual image may be reflected by the radiation of light means 18 thereupon, from the photoconductive material (which acts as a light reflector) to the surface of a movable mirror 48. Mirror 48 is included and a part of the light transmitting means 16. Mirror 48, in its predetermined movement and positioning, redirects the visual images therefrom to a lens means 50. Lens 50 images the visual image onto the light receptive means 20. While the light receptive means 20 is herein exemplified as a screen 52, it should be understood as previously stated that any means of recording light information such as photoconductors, light responsive photographic paper, beaded reflective screens and the like, may all be utilized to provide an instantaneous or a permanent record of the visual images presented thereon. While the light means 18 may continuously illuminate the area on the belt means 11 carrying the visual images, if it is desired to use a frame-at-a-time projection, for example, the light 18 may be shuttered by a shutter means 30. Shutter 55 may interrupt the presentation of light to the belt means 11 as desired, and may be synchronized to belt means and light transmitting means by having its shaft mechanically linked to the common drive shaft of motor 25.

To effect back and forth motion or oscillatory movement of mirror 48, there is used a cam 27 driven by the motor 25. A cam follower or connecting rod 57 rides along the cammed surfaces of the cam 27, and, being

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connected with a bar lever and crank arrangement 59 wherein up and down movement of the bar 59 causes a rotation of the crank carrying the mirror, and causes desired oscillatory movement of the mirror 48. Such bar lever and crank movement is well-known in the art, and is therefore merely diagrammatically shown herein. The end of the bar 59 and mirror 48 may be resiliently mounted with respect to a fixed point 60 by, for example, a spring 61. Therefore, upward movement of the connecting rod 57 exerts a pressure against the bar 59 to cause rotary motion by the crank carrying the mirror 48, thereby moving the mirror in synchronism with the rotation of the belt means 11.

To avoid blurring of images recorded on the belt means 11, it may be necessary to compensate for the movement of the belt means upon the presentation of radar information, for example, on the screen 39 of tube 10, by movement of the information in synchronism with the movement of the belt means 11. This may be accomplished by an image reflecting means 115 supported in the path of light rays from the tube 10 between the lens 42 and the endless belt means 11. The image reflecting means 115 may consist of a mirror 116, which is rotatable about a fixed point 117, by a bar 118 and a connecting rod 119, similar to that which is used in combination with the light transmitting means 16. To effect a back and forth motion or oscillatory movement of mirror 116, there is a cam 114 driven by the motor 25. The cam follower and connecting rod 119 ride along the cammed surfaces of the cam 114, and are connected with a bar lever and crank arrangement 118, wherein up and down movements of the bar 118 cause corresponding movements of the mirror 116. The end of the bar 118 and mirror 116 may be resiliently mounted with respect to a fixed point 117 by, for example, a spring 113. Therefore, upward movement of the connecting rod 119 exerts a pressure against the bar 118 to cause motion by the crank carrying the mirror 116, thereby moving the mirror in synchronism with the rotation of the belt means 11. Images from the screen 39 of tube 10 may be made to move at the same rate of travel as the surface of the belt means 11. The mirror 116 therefore permits images to be recorded on the belt means as stationary latent images.

The basic principles of stopping the image as displayed on a tube 10 through utilization of the moving mirror, rotating prism or multisided mirror, are shown in McNaney U.S. Patent No. 2,898,176.

FIGURE 2 shows a further embodiment of the invention wherein the predetermined intelligible images are presented by a means 65. Means 65 may, if desired, be an electrically actuatable array of pins capable of transmitting electrical energy therethrough in response to a program presented to said pins, presenting electron images to the belt means 11, or, as herein exemplified, it may be a cathode ray tube having such pins imbedded in its screen 68 capable of presenting electron images thereon, for example, from television receiving circuitry or another source of control signals 69. Tube 65 and its circuitry are not shown in detail, as circuitry representative of the type that may be used is clearly set forth in McNaney U.S. Patent No. 2,777,745, in FIGURES 1 and 7 thereof. Therefore, for at least certain types of tube operation and construction, reference may be had to U.S. Patent No. 2,777,745. While a photoconductive type surface could be used to record the information presented in electron form, a further type of belt means 11 could be used, and is exemplified in FIGURE 2, wherein the belt 72 is a transparent belt of highly resistive material. The resistive material is capable of holding electron charges thereupon as latent images. Belt 72 is disposed adjacent pins 70 recording thereon as latent images by direct or adjacent influence of the electrons at pins 70 of the electron image information tube 68. It also should be understood that similar pins 70 may be supported adjacent belt 72 and energized directly through

circuit means in response to raster scan type of input signal information. The belt 72 may be made of a substance sold under the trademark "Mylar." Belt 72 therefore is highly resistive material capable of retaining the latent electrostatic charges thereon, and is also transparent to light irradiation therethrough. Therefore, the irradiating means or light means 18 may be disposed within or inside the rotating belt means 11 irradiating or projecting light from the light means through the belt 72. The visual image is thereby shadowed or illuminated, projecting it onto the surface of mirror 48 of the light transmitting means 16 for retransmission onto the light receptive means 20 as a stationary image. While light means 18 may directly illuminate or irradiate the visual images on the belt means 11, it may do so indirectly through the utilization of an additional reflective means or the mirror 75. Light may be collimated thereonto by a lens 77. Here again, if it is desired to interrupt the light, the shutter means 30 may be synchronized with rotating belt means 11 and the light transmitting means 16 through common motor drive 25.

FIGURE 3 shows a partial system which may in its remainder be made in accord with the rest of FIGURE 1 or FIGURE 2. The embodiment of FIGURE 3 shows an image 80 being photographed through an aperture 82 of a light excluding housing 84, which housing is positioned in light transmitting and retaining relation to the belt means 11. A rotating shutter 86 also driven by motor means 25 is thereby synchronized with the movement of the belt means 11. A lens system 90 transmits the light gathered through the aperture 82 and projects the same onto a prism 92. While the prism 92 is shown as four-sided, this is exemplary only, and of course, a three-sided prism or a plurality of sides of prism may be used, as long as they are properly oriented with respect to the rotation under the influence of the motive means 25 to effect movement of the reproduced image 94 of the photographed image 80, so as to move the image 94 at the same rate of travel as the surface of the belt means 11. Prism 92 therefore permits the photographed image 94 to be recorded on the belt means 11 as a stationary latent image. The remainder of the system, of course, can be the same as that exemplified by FIGURES 1 and 2.

FIGURE 4 shows a further embodiment of the invention encased preferably in a console housing diagrammatically shown herein. Shaped beam tube 10 is utilized to present information as is shown in FIGURE 1. Many of the components of the system of FIGURE 4 are identical to FIGURE 1 or 2. An additional frame deflection circuitry 100 may be provided to cause a frame-at-a-time deflection of the presented information. The frame deflection circuitry and the character selection circuitry, exemplified generally as 32, may of course be identical to that shown in McNaney U.S. Patent No. 2,850,723. The frame deflection circuitry would provide an additional function of causing a frame of information to be moved from one part of the screen 32 to another in synchronism with belt 10 movements. Another major change in the embodiment of FIGURE 4 is use of multisided mirrors or prisms 102. Light transmitting means 16 using mirrors or prisms 102 would rotate constantly. Further, the embodiment of FIGURE 4 is particularly set forth in a preferred way to effect frame-at-a-time presentation. Light means 18 continuously illuminates an area on the belt means 11, where the visual images to be displayed are recorded. To prevent overlap in illuminations and projection of subsequent frames of visual images, a light limiter means 104 is used. The light limiter means 104 is disposed adjacent the area on the belt means 11, at which the visual images are irradiated by the light means 18. Limiter means 104 limits the area of irradiation on the belt means 11 to provide irradiation only of one frame at a time. Thus, only one frame at a time is transmitted to the continuously rotating prism or multisided mirror 102. The light transmitting means 16 is synchronized with the

rotation of belt means 11, both being driven by a common motor 25 whose control is synchronized with the display of tube 10. Therefore, a stationary image of the recorded visual images of belt means 11 is shown, frame-at-a-time, upon the light receptive means 20. The light from a surface of the light transmitting means 102 is collimated by lens 50 for projection onto the light receptive means 20. The light receptive means 20 is herein exemplified as a ground glass screen 106. Screen 106 may be viewed from the opposite side thereof by a viewer.

The light limiter means 104, shown in greater detail in FIGURE 5, is so constructed in relation to the position of the mirror surface 102 as to permit the illumination by the light 18 of only one frame at a time; namely, frame 110, on the belt means 11. A successive frame 112 will be denied irradiation until full presentation of the next of the surfaces of the mirror 102 is made to the belt means 11. By that time, the frame 110 will have advanced to a position under light limiter means 104 and be denied illumination. Frame 112 will then have advanced to the illuminated position within the area permitted by the light limiter means 104 on the belt means 11. The illuminated frame, of course, will be transmitted from the light transmitting means 102 through the lens means 50 to subsequent presentation on the light receptive means 20.

Using the teachings of Rosenthal, U.S. Patent No. 2,844,648, and the limiter means 104, continuous frame-at-a-time presentation can be made in a manner which eliminates lag between the successively displayed frames, and thereby, presentation "flicker."

The particular embodiments of the invention illustrated and described herein are illustrative only, and the invention includes such other modifications and equivalents as may readily appear to those skilled in the art, within the scope of the appended claims.

I claim:

1. The combination comprising: a stationary cathode ray tube having a faceplate; means for producing a complete visual display on said faceplate; a xerographic recording system, said system comprising a continuously moving endless belt clad with a photoconductive material; means for simultaneously recording all elements of said complete visual display upon said belt in the form of a latent electrostatic image which is stationary with respect to said continuously moving belt, said means comprising movable optical unit means for causing said complete display to be projected onto said continuously moving belt so that the image projected upon said belt moves at the same speed as said belt thereby providing no relative movement between said belt and said projected image; means for developing said latent electrostatic image upon said belt by xerographic methods to produce a visible image corresponding to said complete display; and means for projecting said developed visible image from said moving belt onto a stationary viewing screen, said means comprising second movable optical unit means for causing said complete visible image to appear as a stationary projected image upon said screen, whereby the complete display that appeared on said faceplate of said tube is reproduced in its entirety on said screen.

2. The combination comprising: a stationary cathode ray tube having a faceplate; means for producing a complete frame of information on said faceplate; a xerographic recording system, said system comprising a continuously moving endless belt clad with a photoconductive material; means for simultaneously recording said complete frame of information from said faceplate onto said continuously moving belt in the form of a latent electrostatic image which is stationary with respect to said continuously moving belt, said means comprising movable mirror means for causing said complete frame to be projected as a stationary image upon said moving belt; means for developing said latent electrostatic image upon said belt by xerographic methods to produce a visible image corresponding to said complete frame; and means

for projecting said developed visible image from said moving belt onto a stationary viewing screen, said means comprising second movable mirror means for causing said complete visible image to appear as a stationary image upon said screen, whereby the complete frame of information that appeared on said faceplate of said tube is reproduced in its entirety on said screen.

3. The combination comprising: a stationary cathode ray tube having a faceplate; means for producing successive displays on said faceplate; a xerographic recording system, said system comprising a continuously moving endless belt clad with a photoconductive material; means for projecting said displays in a frame-by-frame manner from said faceplate onto said belt as stationary images, said means comprising a pivotable mirror whose movement is synchronized with the movement of said belt for causing said successive frames that form said displays to be projected as stationary images upon successive areas of said moving belt; means for developing said exposed areas of said belt by xerographic methods to produce successive visible images corresponding to

said successive displays; and means for projecting said visible images from said belt onto a stationary viewing screen, said means comprising second pivotable mirror whose movement is synchronized with the movement of said belt for causing said visible images to appear on said stationary screen as successive stationary images.

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