

[54] **SENSING FIDUCIAL MARKINGS FROM MOTION PICTURE FILM**

[75] Inventor: **Robert F. Johnston, Wildwood, Ill.**
[73] Assignee: **Bell & Howell Company, Chicago, Ill.**
[22] Filed: **Aug. 27, 1971**
[21] Appl. No.: **175,483**

[52] U.S. Cl. **352/109, 352/38, 352/92, 352/110**
[51] Int. Cl. **G03b 41/10**
[58] Field of Search **352/109, 38, 92, 105, 110; 250/219 DR**

[56] **References Cited**

UNITED STATES PATENTS

3,539,250 11/1970 Johnston 352/107

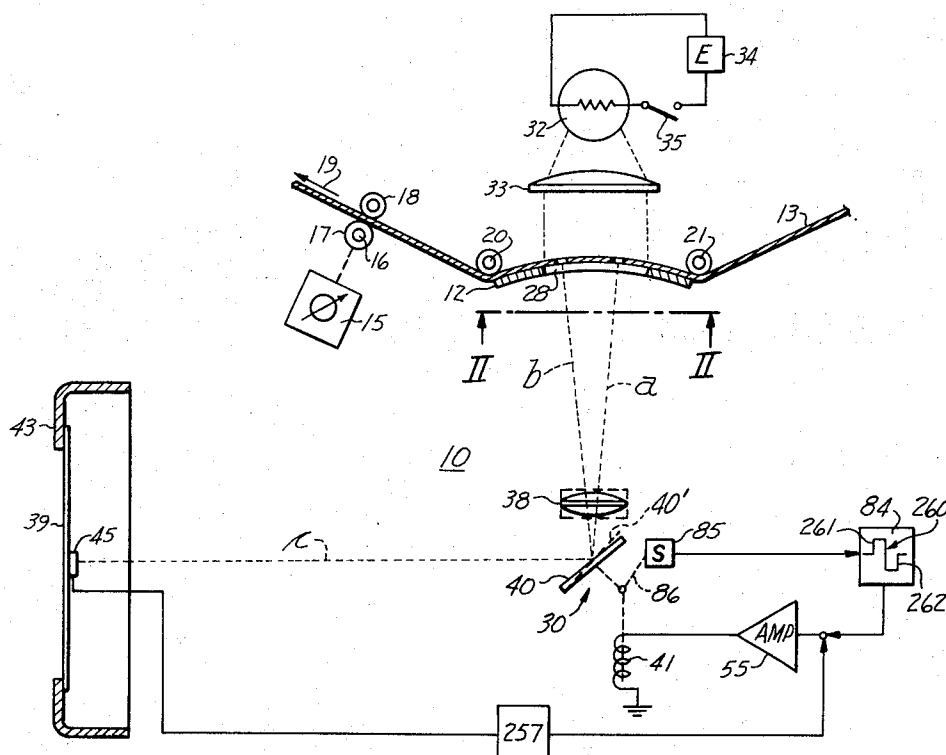
3,459,471 8/1969 Johnston 352/105

Primary Examiner—Robert P. Greiner
Attorney—Luc P. Benoit

[57] **ABSTRACT**

Fiducial markings having different relative contrasts are sensed from films in continuous film feed motion picture apparatus. Different first electric signals corresponding, respectively, to the different relative contrasts are generated in response to the fiducial markings. Sensing signals indicative of the fiducial markings substantially independently of the different relative contrasts are produced by converting the different first electric signals into corresponding second electric signals having at least one common characteristic. A film motion compensator is controlled with these second electric signals.

15 Claims, 21 Drawing Figures



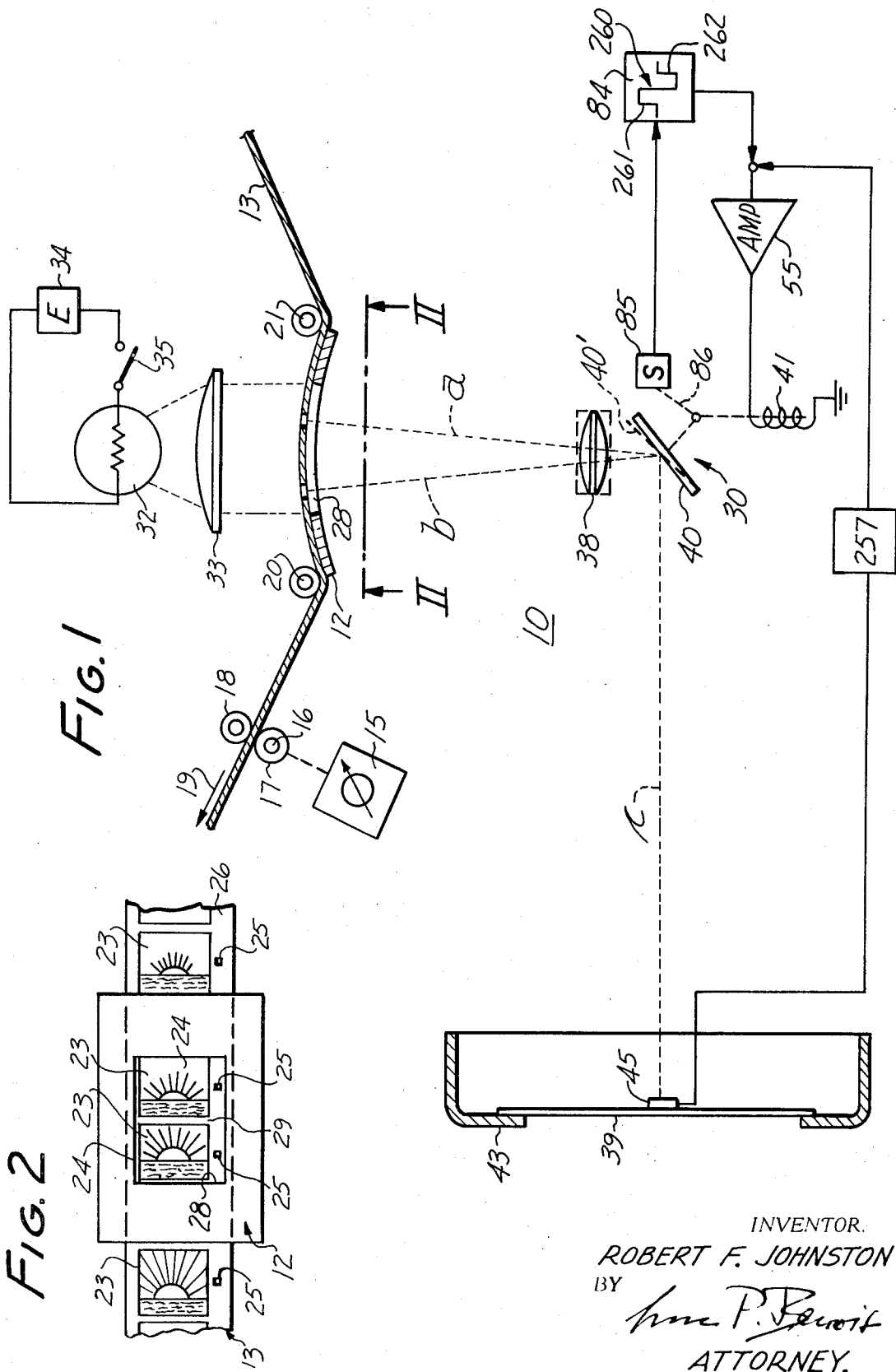


FIG. 4a

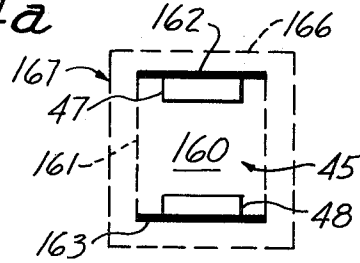


FIG. 4b

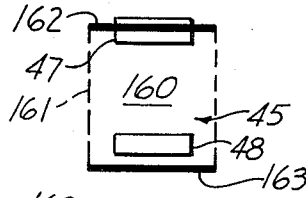


FIG. 4c

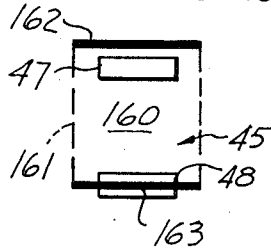


FIG. 3

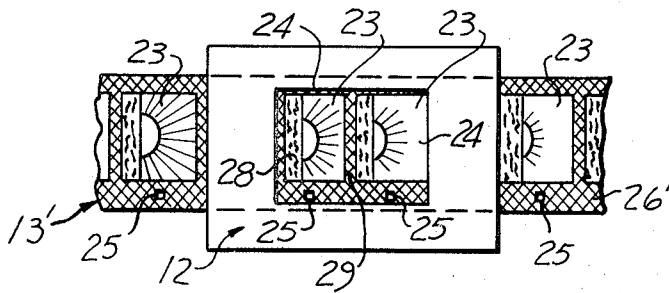


Fig. 5

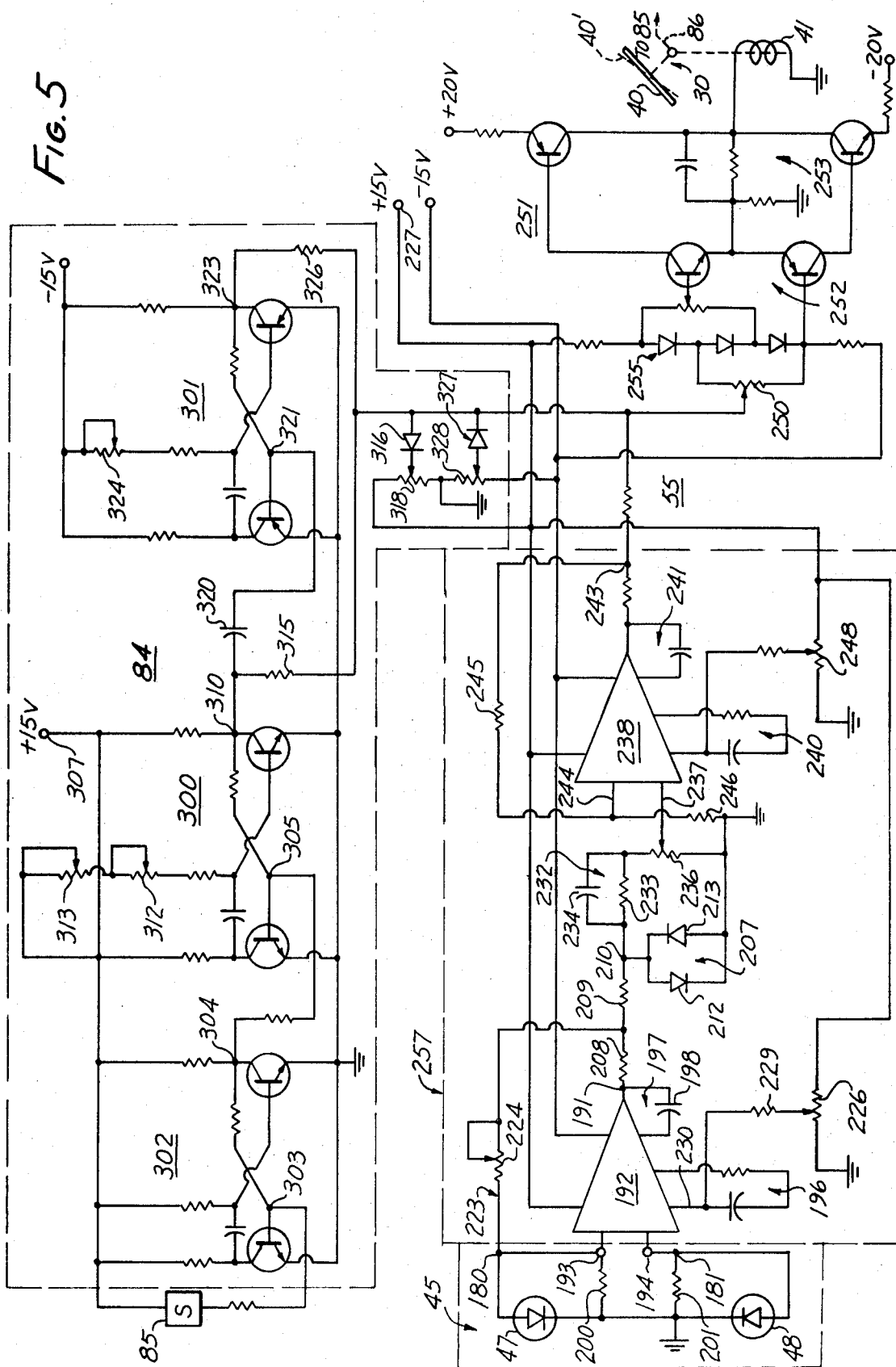


FIG. 10

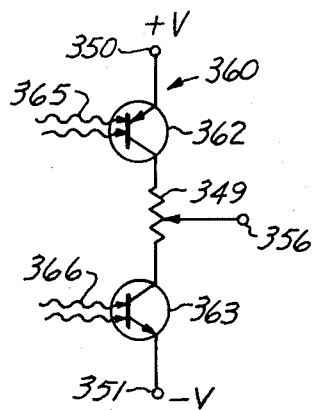
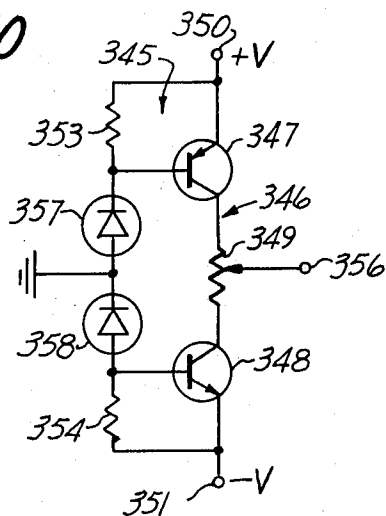


FIG. 11

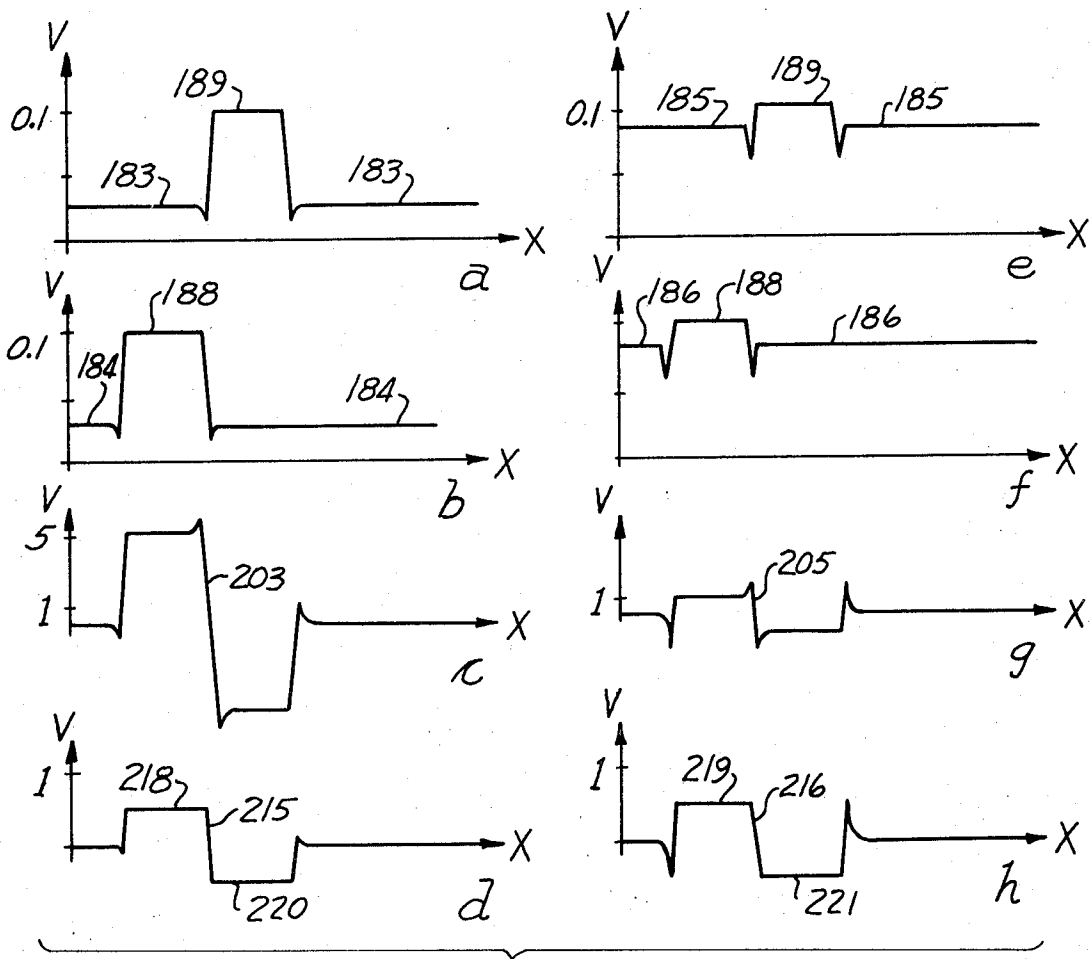
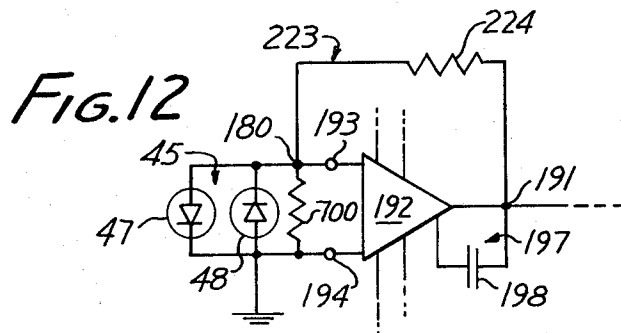
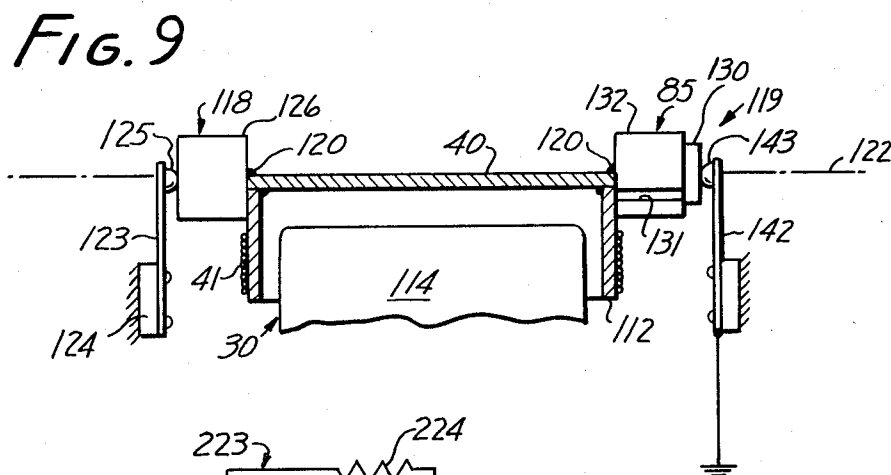
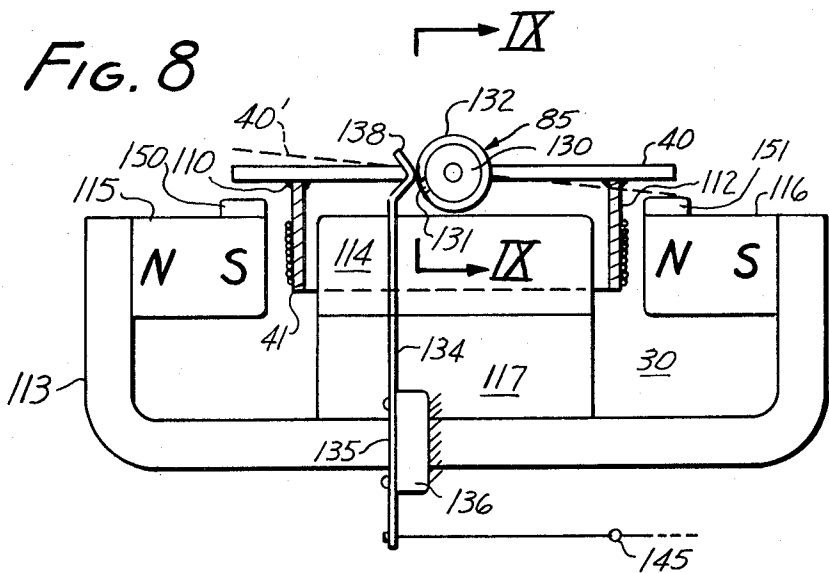


FIG. 7



SENSING FIDUCIAL MARKINGS FROM MOTION PICTURE FILM

CROSS-REFERENCE TO RELATED APPLICATIONS

Subject matter disclosed in the present patent application is disclosed and claimed in the following patent applications which are assigned to the subject assignee and which are herewith incorporated by reference herein:

Patent application Ser. No. 89,323, filed Nov. 13, 1970, by **Ellen B. Lancor, administratrix of Joseph H. Lancor, Jr., deceased, and Leonard A. Ferrari**;

Patent applications Ser. No. 105,515, filed Jan. 11, 1971, by **James G. Woodier**; and

Patent application Ser. No. 116,053, filed Feb. 17, 1971 by **Robert F. Johnston and Wieslaw Lichodziejewski**.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The subject invention relates to the sensing of fiducial markings, such as fiducial markings on motion picture film in continuous film feed motion picture apparatus.

2. Description of the Prior Art

While the prior art and the subject invention are primarily described with reference to non-intermittent or continuous motion picture apparatus, it should be understood that no limitation of the utility or applicability of the subject invention to that field is intended.

There exist many proposals for projecting motion pictures or other information from a continuously moving film with the aid of an optical compensator that tracks successive portions of the film. In many of these proposals, film sprocket holes are employed as fiducial markings for controlling proper synchronism between the optical compensator and the film. For instance, sprocket hole images are projected by way of the compensator as a reference for sensing movements of the supposedly stationary projected image. These sensed movements are thereafter employed to control the supply of power to the compensator so as to establish the desired tracking of the moving film. Similarly, sprocket hole images are employed to control the resetting of the compensator between subsequent tracking operations.

With past sprocket hole sensing methods, best results were obtained when the sprocket holes were located in an opaque or black film margin. In that case, the contrast between the sprocket hole apertures and the film margin was very high. However, methods relying on that high contrast were inoperative with the great bulk of motion picture film, since practically all commercially produced films and most amateur films produced in a printing process have transparent film margins.

An exploitation of the relatively small difference in light transmissibility between sprocket holes and transparent film stock has been tried but has not been generally successful in the past.

Further proposals in this area operate with light that is reflected from the transparent film margin. A dark background is provided behind the margin so that no light is reflected at sprocket hole locations. Operation with reflected light leads to a generally low efficiency

of the sensing process. Also, space problems at critical areas are encountered because of the necessity of a light source ahead of the film margin.

A further proposal attempts to sense sprocket holes in a transparent film margin by projecting a beam of light at an oblique angle through the margin. This beam is laterally deflected by the thin material between sprocket holes, but is capable of penetrating sprocket holes without lateral deflection. Accordingly, by sensing whether a lateral beam deflection is present or not it is at least theoretically possible to determine the occurrence of sprocket holes. In practice, this method is too delicate as to be of general use. Also, problems are encountered from the fact that the light beam has to impinge upon and emerge from the film margin at a relatively sharp angle.

SUMMARY OF THE INVENTION

The subject invention overcomes the above mentioned disadvantages and provides methods and apparatus for sensing fiducial markings having different relative contrasts from an information carrier. As this disclosure proceeds, it will, for instance, be recognized that the subject invention and preferred embodiments thereof provide methods and apparatus capable of sensing fiducial markings from films with transparent margin as well as films with opaque margin. This, in turn, provides, for instance, motion picture projectors or video film scanners which can interchangeably handle transparent-base and opaque-base film. Also, the sensing methods and apparatus according to the subject invention and preferred embodiments thereof are potentially insensitive to trademarks, trade names, and similar indications provided by the film manufacturer or processor in the film margin adjacent the fiducial markings. Moreover, sensing methods and apparatus according to the subject invention and preferred embodiments thereof permit motion picture apparatus to operate not only with transparent-margin and opaque-margin films, but also with the type of motion picture films which have a transparent halo around each sprocket hole in an otherwise opaque base.

In short, the subject invention provides a very substantial advance in the art under consideration and provides methods and apparatus of high versatility.

From one aspect thereof, the subject invention is concerned with a method of sensing fiducial markings having different relative contrasts from an information carrier, and resides in the improvement comprising, in combination, the steps of generating in response to the fiducial markings different first electric signals corresponding, respectively, to the different relative contrasts, and producing sensing signals indicative of the fiducial markings substantially independently of the different relative contrasts by converting the different first electric signals into corresponding second electric signals having at least one common characteristic.

As indicated above, the information carrier may be a motion picture film, and the fiducial markings may have different contrasts relative to the film base of the motion picture film. These different contrasts may, for instance be due to the fact that the film base of the motion picture film is transparent in one case and opaque in another case.

From another aspect thereof, the subject invention is concerned with a method of controlling a film motion compensator in a continuous film feed motion picture apparatus with the aid of fiducial markings provided on motion picture film bases having different optical characteristics. This aspect of the subject invention resides in the improvement, comprising in combination, the steps of electrooptically sensing the fiducial markings and generating first electric signals having different amplitude values in accordance with the different optical characteristics, converting the first electric signals into corresponding second electric signals having substantially equal amplitude values substantially independent of the different optical characteristics, and controlling the film motion compensator with the aid of the second electric signals.

The subject invention is also concerned with apparatus for sensing fiducial markings having different relative contrasts from an information carrier, and resides in the improvement comprising, in combination, first means for generating in response to the fiducial markings different first electric signals corresponding, respectively, to the different relative contrasts, and second means connected to the first means for converting the different first electric signals into corresponding second electric signals having at least one common characteristic whereby to produce sensing signals indicative of the fiducial markings substantially independent of the different relative contrasts.

The subject invention also resides in apparatus for controlling a film motion compensator in a continuous film feed motion picture apparatus with the aid of fiducial markings provided on motion picture film bases having different optical characteristics. This aspect of the invention more specifically resides in the improvement, comprising in combination, electrooptical sensing means for generating first electric signals having different amplitude values in accordance with the different optical characteristics, means connected to the sensing means for converting the first electric signals into corresponding second electric signals having substantially equal amplitude value substantially independent of the different optical characteristics, and means connected to the converting means for controlling the film motion compensator with the aid of the second electric signals.

The subject invention also resides in apparatus for controlling a film motion compensator in a continuous feed film motion picture apparatus with the aid of projected images of fiducial markings, comprising electrooptical signal generating means including two spaced photocell means for generating two output signals in response to projected images of fiducial markings and means connected to the two photocell means for providing a third signal corresponding to the difference between said two output signals, and signal amplitude limiter means connected to the electrooptical signal generating means for amplitude limiting the third signal, and means connected to the limiter means for controlling said compensator in response to said amplitude limited third signal.

BRIEF DESCRIPTION OF THE DRAWINGS

The subject invention will become more readily apparent from the following detailed description of

preferred embodiments thereof, illustrated by way of example in the accompanying drawings, in which:

FIG. 1 is a diagrammatic illustration of a non-intermittent or continuous film feed motion picture projector implementing a preferred embodiment of the subject invention when considered in conjunction with the other figures;

FIG. 2 is a view substantially along lines II — II of FIG. 1;

FIG. 3 is a view similar to FIG. 2 but illustrating a film with opaque film base or margin;

FIGS. 4a to 4c are diagrammatic illustrations of different phases of operation of the projector according to FIG. 1;

FIG. 5 is a circuit diagram of an apparatus in accordance with a preferred embodiment of the subject invention for use in the motion picture projector of FIG. 1;

FIG. 6 is a circuit diagram of a preferred operational amplifier or servo amplifier for use in the apparatus of FIG. 5;

FIGS. 7a to 7h are amplitude-versus-displacement plots illustrating different phases of operation of the embodiment of the subject invention according to FIG. 5;

FIG. 8 is a side view, partially in section, of a compensator for use in the projector of FIG. 1;

FIG. 9 is a section along line IX — IX of FIG. 8;

FIG. 10 is a circuit diagram of a fiducial marking sensor in accordance with a further preferred embodiment of the subject invention;

FIG. 11 is a circuit diagram of a further fiducial marking sensor in accordance with yet another preferred embodiment of the subject invention; and

FIG. 12 is a circuit diagram of a modification of the apparatus of FIG. 5.

DESCRIPTION OF PREFERRED EMBODIMENTS

By way of example, and not by way of limitation, the preferred embodiments are herein disclosed and illustrated with reference to the systems disclosed in the above mentioned copending patent applications.

The non-intermittent or continuous motion picture projector 10 shown in FIGS. 1, 2, and 3 has a film gate 12 which may be curved in accordance with well-known principles rendering the angular rate of film advance equal for different points of the film gate.

A conventional variable speed drive 15 has a capstan 16 which may have a rubber lining 17 that engages the film with the aid of a nip roller 18. The drive 15, which may comprise a variable-speed electric motor with reduction gear (not shown), is set at any practical speed to advance a motion picture film 13 through the film gate 12 in the direction of an arrow 19 at a substantially continuous and uniform rate (as distinguished from an intermittent film advance). Two guide rollers 20 and 21 assist the movement of the film into and out of the film gate.

In principle, a sprocket drive can be used for advancing the film 13. Where film sprocket holes are employed as control marks, it is, however, preferred that a capstan which does not wear out the sprocket hole areas be used as the power-transmitting device.

The film 13 bears a succession of optically reproducible recordings in the form of transparent

images 23 located in image frames 24 and typically representing a filmed scene. The film further has sprocket holes 25 along a margin 26 thereof. In accordance with known principles, the film gate has a projection aperture 28 whose length is at least equal to twice the height of each image frame 24 plus the height of an interframe space 29, so that the continuous motion compensator 30 is able to handle two full image frames in succession. The width of the projection aperture is sufficient for a projection of the sprocket hole that pertains to each projected image.

The film 13 at the projection aperture 28 is illuminated by a projector lamp 32 and condensor lens system 33. The lamp 32, which may have a conventional reflector (not shown), is energized from an electric power source 34 upon closure of a switch 35. A projector lens system 38 projects the illuminated images and sprocket holes by way of the continuous motion compensator 30 onto a conventional back-lighted screen 39. The back-lighted screen is shown by way of example, and a conventional front-lighted screen may be used instead.

The compensator 30 has a first-surface mirror 40 which is repeatedly advanceable by motive power applied to a coil 41 through a range of angular motion so as to compensate for the continuous movement of the film 13. The objective of the compensator mirror 40 is to maintain each projected image substantially stationary. Since the projection aperture 28 in the film gate 12 is larger than an image, the screen 39 is provided with an opaque frame 43 which blocks from the view of the observer the projected sprocket holes and also part of images other than the one image that is being projected for viewing at the particular time.

A device 45 is located at the screen for sensing relative movements of each displayed image in a first direction corresponding to the direction 19 of movement of the film 13. The device 45 also senses relative movements of displayed images in a second direction opposite the first direction just mentioned. These movements in a second direction occur, for instance, if the compensator mirror 40 overshoots in its forward motion the advance of the film.

By way of example and as shown in FIGS. 4a to 4c and 5, the motion sensing device 45 may include two conventional photovoltaic cells 47 and 48 located near each other. The luminous sprocket hole is projected by way of the compensator mirror 40 onto the light-sensitive parts of the photocells 47 and 48. Each of the photocells 47 and 48 produces a signal which varies as a function of the area of cell illumination.

It may be helpful to note at this juncture that the sensor 45 need not necessarily be located at the screen 39. Rather, the sensor 45 may be positioned closer to the compensator mirror 40 (such as within the projector housing), with a lens (not shown) being provided for imaging the illuminated sprocket hole onto the sensing device 45 after projection thereof by way of mirror 40.

The projected luminous sprocket hole images are shown in FIGS. 4a to 4c at 160 within an outline 161 and in relation to the photocells 47 and 48 of the sensor 45. In accordance with the teachings of the above mentioned Johnston and Lichodziejewski patent application or patent, at least two borderline element images 162 and 163 are projected along with the sprocket hole image 160.

As disclosed in that Johnston and Lichodziejewski patent application or patent, the sprocket hole image, the borderline images and luminous areas 166 adjacent the borderline images are preferably produced by transmitting light through the sprocket hole and adjacent film margin and projecting such transmitted light.

While Johnston and Lichodziejewski did not subscribe to any particular theory, it is believed that the occurrence of the subject borderline images is due to diffraction or refraction, or to a combination of these phenomena. For instance, it appears that light proceeding through the film sprocket hole experiences a diffraction at the sprocket hole edges, resulting in a diffraction pattern including the subject borderline images. Alternatively or additionally, light which angularly enters the sprocket hole is reflected at an inside wall of the sprocket hole in a direction away from that sprocket hole. Furthermore, light which angularly enters the transparent film margin adjacent the sprocket hole in a direction toward the sprocket hole is deflected at a refractive angle towards the sprocket hole. That deflected light is thereupon reflected by the film-to-air interface at the sprocket hole. As a result, the light under consideration leaves the transparent film at an angle which carries it beyond the pull-in range of the projection lens. Similarly, light which angularly enters the film margin adjacent the sprocket hole in a direction away from the sprocket hole is deflected further away from the sprocket hole thereby providing for a dearth of transmitted light at sprocket hole edges.

Moreover, if the film is not exactly perpendicular to the optical axis of the projection lens, an image of the film thickness at the sprocket hole will be projected along with the sprocket hole image, further emphasizing the observed dark borderline. It will thus be appreciated that the dark borderline images may be due to anyone or more of the above mentioned optical effects.

The expression "borderline image" herein employed refers to a dark line which extends along at least one edge of the sprocket hole image. In practice, this borderline image may extend along two or more edges of the sprocket hole image. Since the expression "borderline" is broad enough to cover also a dark outline around the entire sprocket hole image, the somewhat more qualified expression "borderline element image" is herein employed to refer to a borderline portion that extends along a sprocket hole edge, and that may or may not be part of a borderline.

It should be understood at this juncture that the subject invention is broadly applicable to sensing systems for sprocket holes or other fiducial markings and is not limited in its application to the projection and utilization of the above mentioned borderline images. However, I have found that the use of these borderline images provides a particularly advantageous embodiment of the subject invention.

For the purpose of the subject disclosure it is assumed that the film 13 shown in FIG. 2 has a transparent base or film margin 26. By way of contrast, the film 13' shown in FIG. 3 has a film base or margin 26' of an opaque type. As is well known in the art, motion picture films developed by a reversal process typically have an opaque base or margin, and films produced in a negative-to-positive printing process typically have a

transparent base or margin. In practice, borderline images of the above mentioned type are observed in transparent-margin and in opaque-margin film, inasmuch as the opacity of opaque-margin film is not absolute, but allows for a reduced transmission of light through the film margin.

As shown in FIGS. 4a to 4c, a first borderline element image 162 appears at one side of the sprocket hole image 160 due to any one or more of the above mentioned diffraction, refraction, reflection or projecting effects. Similarly, a second borderline element image 163 appears at the opposite side of the sprocket hole image. Some of the light which penetrates the film margin 26 or 26' adjacent the particular sprocket hole 25 provides luminous areas 166 adjacent the borderline element images 162 and 163. In FIG. 4a, these luminous areas are shown consolidated into a halo 167. To avoid crowding, the luminous areas 166 have not been shown again in FIGS. 4b and 4c. It is, however, to be noted that the borderline element images are darker than both the sprocket hole image 160 and the adjacent luminous area 166.

As also shown in FIGS. 4a to 4c, the photocells 47 and 48 are long and narrow; extending with their long axes parallel to the borderline elements 162 and 163. For maximum sensitivity, the long axes of the light-sensitive areas of the photocells 47 and 48 may be substantially equal to the lengths of the borderline element images 162 and 163. It is, however, preferable in practice that the long axes of the photocells be somewhat shorter than the lengths of the borderline element image to avoid normal tolerance of the sprocket hole image sizes and positions from taking effect.

The short axes of the light-sensitive areas of the photocells 47 and 48 should be larger than the widths of the borderline element images 162 and 163 to avoid disturbances from dirt particles and normal irregularities in the sprocket hole edges. By way of example, the short axis of each photocell may be about four to five times the width of the corresponding borderline element image.

Photocells of the type shown at 47 and 48 are commercially available. Examples include the Hoffman silicon photocell type 58C and the type SS-12-LC photocell manufactured by the Solar Systems Division of Tyco Corporation.

Two nodes 180 and 181 are shown in FIG. 5 at the photocells 47 and 48, respectively, of the sensor 45. Signal voltages provided by the photocell 47 at node 180 are shown in FIGS. 7a and e for opaque-margin film and transparent-margin film, respectively. Similarly, signal voltages provided by the photocell 48 at the node 181 are shown in FIGS. 7b and f for opaque-margin film and transparent-margin film, respectively. It will be recalled in this connection that FIG. 3 shows an example of a film 13' with an opaque margin 26', and that an example of a film 13 with a transparent margin 26 is shown in FIG. 2. As seen from the base level 183 in FIG. 7a and the base level 184 in FIG. 7b, the photocells 47 and 48, respectively, produce a relatively low voltage level at the nodes 180 and 181, respectively, in response to illumination by way of the opaque film margin 26' shown in FIG. 3. In contrast thereto, and as seen from the higher base level 185 in FIG. 7e and from the higher base level 186 in

FIG. 7f, the photocells 47 and 48, respectively, produce at the nodes 180 and 181 a higher signal level in response to illumination through the transparent margin 26 of the film 13 shown in FIG. 2.

In the embodiment shown in FIG. 1, images are introduced onto the screen 39 from the bottom thereof. Accordingly, the lower photocell 48 first produces at the node 181 a signal having an amplitude 188 as shown in FIG. 7b in response to illumination by a new sprocket hole image 160. Thereafter, the upper photocell 47 produces at the node 180 a signal of an amplitude 189 as shown in FIG. 7a in response to illumination by the new sprocket hole 160. Undesignated signal spikes throughout FIG. 7 represent signal variations which occur when borderline element images 162 and 163 pass onto or over the photocells 47 and 48, respectively.

Since the transparency of the sprocket holes 25 is, of course, the same whether transparent or opaque film bases are used, it follows that the amplitude 188 provided according to FIG. 7f at the node 181 in response to illumination of the photocell 48 through a sprocket hole in a transparent film margin is the same as the above mentioned amplitude 188 shown in FIG. 7b and produced by the photocell 48 at the node 181 in response to illumination through a sprocket hole in an opaque film margin. Similarly, the amplitude 189 produced at the node 180 in response to illumination of the photocell 47 through a sprocket hole in a transparent film margin is, of course, the same as the above mentioned amplitude 189 produced at the node 180 by the photocell 47 in response to illumination through a sprocket hole in an opaque film margin. While the latter statement seems obvious, it should, however, be qualified in that it only holds true for signal amplitudes as considered with respect to the x-axis (e.g. absolute amplitude values).

What the sensing equipment is capable of distinguishing, however, are not absolute amplitudes values, but rather relative or effective amplitudes which are the difference between the levels 183 and 189 in FIG. 7a, the levels 184 and 188 in FIG. 7b, the levels 185 and 189 in FIG. 7e, and the levels 186 and 188 in FIG. 7f. In this connection it is noted that the difference between the levels 183 and 189 is much larger than the difference between the levels 185 and 189. Similarly, the difference between the levels 184 and 188 is much larger than the difference between the levels 186 and 188. These differences reflect themselves in the respective sensing signals as will presently be shown.

More specifically, FIGS. 7c and g show output voltage variations occurring at an output 191 of an operational amplifier 192 having an inverting input 193 and a non-inverting input 194, as shown in FIG. 5.

A circuit diagram of a suitable operational amplifier 192 is shown in FIG. 6. Those skilled in the art of integrated circuits will recognize that the operational amplifier 192 is available in monolithic form from several manufacturers as standardized circuit 1709 (for instance MOTOROLA OPAMP MC1709CL, or MICROSYSTEMS INTERNATIONAL OPAMP ML709C). In the type ML709C, NPN transistors having interconnected base and emitter circuits are substituted for the diodes shown in FIG. 6.

As shown at 196 in FIGS. 5 and 6, an input frequency compensation network is provided by a series connected capacitor and resistor. An output frequency compensation 197 is provided by a capacitor 198, also as shown in FIGS. 5 and 6. This combination with the valves indicated in FIGS. 5 and 6 provides a flat response out to approximately 200 kHz at 40 db gain. The remaining parts of the amplifier 192 are standard and this type of amplifier is that widely manufactured and employed that a specific description of its components beyond the showing thereof made in FIG. 6 is unnecessary.

Reverting to the sensor 45 as shown in FIG. 5, it is seen that the photocell 47 has a resistor 200 connected in parallel thereto, and that the photocell 48 has a resistor 201 connected in parallel thereto. The resistance values of the resistors 200 and 201 are preferably on the order of one-tenth or less of the source resistance of the photocell under full light level conditions. These resistors 200 and 201 force the photocells 47 and 48 to operate in the preferred short circuit mode, wherein the current is linearly related to the illumination. Moreover the resistors 200 and 201 increase the stability of the signal conditioner by shunting out the photocell capacitances.

The photosensor 45 is of a differential type since the photosensors 47 and 48 are, respectively, connected to the inverting and non-inverting inputs 193 and 194 of the amplifier 192. In consequence, the signal characteristics shown in FIGS. 7a and b provide at the output 191 of the amplifier 192 a signal characteristic of the type shown at 203 in FIG. 7c. It will be noted that the base levels 183 and 184 are mutually compensated in the characteristic 203 of FIG. 7c. Similarly, the high base levels 185 and 186 of FIGS. 7e and f are compensated in the signal characteristic 205 shown in FIG. 7g. In consequence, the amplitude of the signal voltage characteristic 205, which occurs at the amplifier output 191 in response to the combined signal characteristics shown in FIGS. 7e and f, is much smaller than the amplitude of the signal characteristic 203.

A comparison of the characteristics or wave forms 203 and 205 indicates why attempts to design fiducial marking sensing systems that would interchangeably accept transparent-base film and opaque-base film were so far fraught with difficulties. In particular, practical tests have verified that important factors, such as system damping and servo-pull-in after retrace of the compensator mirror 40, are functions of the amplitude of the fiducial marking sensing signal. This being the case, transparent-margin film and opaque-margin film could not be interchanged without considerable adjustment work.

In accordance with the illustrated preferred embodiment of the subject invention, a bidirectional limiter 207 is provided and is connected to the amplifier output 191 by way of a resistor 208 and a node 210. The limiter 207 is composed of a resistor 209 connected to the node 210, and a pair of oppositely poled and parallel-connected diodes 212 and 213, each diode being connected between the node 210 and ground. By way of example, the diodes 212 and 213 may be of the type IN4002.

FIG. 7d shows the wave shape characteristic 215 occurring at the node 210 by operation of the limiter 207

in the case of film with the opaque margin 26' as shown in FIG. 3. FIG. 7h shows the wave shape characteristic 216 occurring at the node 210 by operation of the limiter 207 in the case of film with the transparent margin 26 shown in FIG. 2. It is seen from a comparison of FIGS. 7d and h that the positive amplitudes 218 and 219 of the wave shapes 215 and 216 are equal and that the negative amplitudes 220 and 221 of the wave shapes 215 and 216 are also equal.

In other words, the wave shapes 215 and 216 present fiducial marking sensing signals which are indicative of the sensed fiducial markings substantially independently of the different relative contrasts between the sprocket holes 25 and the film margins 26 and 26'.

Reviewing FIGS. 7a to h it may be stated that the photosensor 45 generates in response to the fiducial markings 25 different first electric signals corresponding, respectively, to the different relative contrasts between the markings 25 and the bases 26 and 26' (see FIGS. 2, 3, and 7a, b, e and f).

The operational amplifier 192 and the limiter 207 cooperate in producing the contrast-independent signals illustrated in FIGS. 7d and h by converting the different first electric signals provided by the sensor 45 into corresponding second electric signals having at least one common characteristic. According to FIGS. 7d and h, this common characteristic in the illustrated preferred embodiment is manifested by equal amplitude values.

In the preferred embodiment shown in FIG. 5, the latter conversion is effected by having the amplifier 192 increase the amplitudes of the signals provided by the sensor 45 to values which provide for a sufficient leeway for amplitude limitation, and by having the limiter 207 effect such amplitude limitation to equal amplitude values of all kinds of film base or margin transparency or opacity.

A feedback path 223 extends from the amplifier output 191 by way of the resistor 208 and a feedback resistor 224 to the inverting input 193 of the amplifier 192. The feedback resistor 224 is adjustable to permit adjustments of the amplifier gain. A zero adjustment potentiometer 226 is connected between the positive terminal 227 of a power supply (not shown) and ground. The wiper arm of the potentiometer 226 is connected by a resistor 229 and by a lead 230 (see FIGS. 5 and 6) to one side of the input frequency compensation of the amplifier 192. As its name implies, the zero adjustment potentiometer 226 provides for the application of an adjustable bias to one side of the input frequency compensation of the amplifier 192 to permit adjustment of the amplifier output to zero voltage level when both photocells 47 and 48 are initially exposed to equal illumination for adjustment purposes.

In a prototype of the illustrated embodiment, the resistor 208 had a value of 47 ohms and the resistor 209 ahead of the limiter node 210 had a value of 1 kilohm.

Considering the wave shapes 215 and 216 shown in FIGS. 7d and h, the amplifier 192 and limiter 207 may jointly be considered a signal conditioning circuit. The output signal of this conditioning circuit, which appears at the node 210 is next fed to a lead network 232 composed of a resistor 233 and a capacitor 234 connected in parallel to that resistor, and of a variable resistor 236. This lead network corrects the phasing of the

system to compensate for the inertial lag in the drive transducer 41 of the compensator mirror 40.

The variable resistor has its wiper arm connected to the non-inverting input 237 of a feedback amplifier 238. In a prototype of the illustrated preferred embodiment, the feedback amplifier 238 is identical in design to the feedback amplifier 192 so that reference may be had to the previously described FIG. 6 of the drawings. Also, the input frequency compensation 240 of the amplifier 238 was identical to the input frequency compensation 196 of the amplifier 192, and the output frequency compensation 241 of this amplifier 238 was identical to the output frequency compensation 197 of the amplifier 192.

The gain of the amplifier 238 is set by means of a feedback voltage divider between the amplifier output 243 and the inverting input 244. This feedback voltage divider includes a feedback resistor 245 and a resistor 246 connected between the inverting input 244 and ground. For optimum stability, the feedback ratio is made as low as possible consistent with ample system gain. The amplifier output at 243 is zeroed by means of an offset adjustment potentiometer 248 which corresponds to the above mentioned zero adjustment potentiometer 226.

The amplified sprocket hole sensing signal is applied by way of an adjustable potentiometer 250 to an output amplifier 251. This output amplifier is composed of a pair of complementary drivers 252 and a complementary output stage 253. The driver and output stages 252 and 253 are of a conventional design and a conventional chain of diodes 255 is employed at the driver stage 253 to obtain proper bias for Class B operation. The compensator mirror drive coil 41 is connected to and energized by the output stage 253.

The power supply (not shown) for energizing the circuits and components shown in FIG. 5 may also be of a conventional design providing high output voltage stability.

In the diagrammatic view of FIG. 1, the signal conditioning circuits composed of the operational amplifier 192, the limiter 207, the lead network 232 and the amplifier 238 are represented by a block 257. The amplifier 251, on the other hand, is represented by a triangular block 55.

Further details of the operation of the circuits so far discussed may now be considered with the aid of FIGS. 1, 4 and 7. In the illustrated preferred embodiment, no routine sawtooth motion is imposed on the compensator mirror 40 as was the case with some prior-art proposals. Rather, the mirror is only advanced in accordance with the then prevailing demands of the system aiming at a stabilization of displayed images in a substantially stationary condition.

To illustrate this principle, a dotted line *a* in FIG. 1 approximately designates a ray of light emanating from the center of an image 23 initially appearing in the aperture 28 of the film gate 12 for projection by the objective 38 and via the compensator mirror 40 onto the screen 39. A dotted line *b*, on the other hand, approximately designates a ray of light emanating from the center of the same image, after that image has traveled along the film gate 12 to its extreme position in the aperture 28, just before the compensator mirror 40 is reset onto the next succeeding image. The stop plane of

the lens 38 is preferably in front of the lens near the mirror 40.

The letter *c* in FIG. 1 designates a ray of light leading from the compensator mirror 40 to the center of the projected image on the screen 39. To maintain each projected image stationary during the movement of the image center lines from *a* to *b*, the mirror has to advance during such movement by an angle of magnitude substantially equal to one-half of the magnitude of the angle between the lines *a* and *b*.

To provide for such a mirror advance, the mirror 40 is wide enough to receive and project images of the sprocket holes 25 which are illuminated by the projector lamp 32. Where the mirror 40 operates in substantially collimated light, as is preferably the case, reduction of the mirror size reduces the total light level, but does not as such suppress passage of the sprocket hole image. As indicated above, borderline element images and adjacent luminous areas are projected to the sensing device 45 along with the sprocket hole images (see FIGS. 4a to c). The relationship between the photocells 47 and 48 and the projected elements 160, 162, 163 and 166 is as shown in FIG. 4a when the mirror 40 tracks the film 13 perfectly (assuming no offset is introduced by the servo system).

If the mirror advance leads the film, the sprocket hole image 160 moves downwardly as seen in FIG. 4b, placing the borderline 162 onto the photocell 47, as shown in FIG. 4b. This provides an error signal of a first polarity. If the mirror advance lags the film, the borderline 163 moves onto the photocell 48 as shown in FIG. 4c, providing an error signal of the opposite polarity.

These error signals are applied to the servo amplifier 55 which drives the compensator mirror correspondingly.

As has been disclosed in the above mentioned Lancor and Ferrari patent application or patent, a substantially constant tracking error may be provided between the angular advance of the mirror 40 and the continuously moving film 13. The tracking error is preferably realized by frictional and other damping of the driven compensator part including the mirror 40. Bias or suspension springs at the driven compensator part are preferably avoided. Nevertheless, the practice of the subject invention is not limited to systems without spring bias at the compensator.

The photocells 47 and 48 translate the above mentioned tracking error into a corresponding error signal which acts on the servo amplifier 55. The amplifier, in turn, produces a corresponding drive current for the compensator coil 40 which develops an advance torque for the mirror in accordance with the mirror tracking error. In this manner, the projected image is displayed in a substantially steady manner, without undue jitter.

As has been further disclosed in the above mentioned Lancor and Ferrari patent application or patent, and as will be more fully mentioned below, a direct-current level may be applied to the servo amplifier 55 in lieu of or in addition to the drive current provided by the tracking error, in order to provide for a biasing of the mirror 40 in a direction opposite to the direction of mirror advance during the display of each image. This further helps eliminate the need for the traditional bias spring at the mirror 40 or at least permitting the use of only a weak mirror suspension or bias spring. If no mir-

ror bias spring is used, the amplifier 55 does not have to provide a mirror drive current that increases in a saw-tooth fashion to overcome the force of a mirror bias spring as the display of the image progresses. Similarly, if a spring of low spring constant is used for mirror suspension or other purposes, the servo amplifier 55 still does not have to provide a mirror drive current that rises to as high a magnitude as would be required if the spring had a sufficiently high spring constant to effect an automatic resetting of the mirror 40 between the image displays or to act as the sole agency for precluding overshooting of the mirror 40 during image display.

In addition, the amplifier 55 is constructed in a double-ended fashion to develop and apply to the mirror drive coil 41 a decelerating current when a large excursion of the error signal developed by the sensing device 45 indicates the danger of ringing of the servo system. These features are more fully disclosed in the above mentioned copending Lancor and Ferrari patent application or patent.

The requisite direct-current level for biasing the mirror 40 in a direction opposite to the direction of the mirror advance during image display may be provided by developing a direct current potential with the aid of a potentiometer 248 shown in FIG. 5. In this manner, an adjustable current is provided in the drive coil 41 for biasing the compensator mirror 40 in a direction opposite to or against the direction of mirror advance during image display.

During image display, undesired image movements are easily reduced by increasing the gain of the amplifier 55. This gain is preferably higher than 100 (one-hundred) and may be in the thousands.

Upon completion of the display of an image, the compensator mirror 40 is angularly reset preparatory to the display of the next image. As disclosed in the above mentioned copending Lancor and Ferrari patent application or patent, timed electric pulse doublets are applied to the compensator coil 41 for resetting the mirror 40 between image displays.

In FIG. 1, a block 84 symbolically shows a pulse doublet generator which provides an electric doublet 260 for resetting the compensator mirror 40. The pulse doublet 260 is composed of an initial pulse 261 for accelerating the mirror 40 backwardly and a subsequent pulse 262 for decelerating or braking the backward movement of the compensator mirror so that this mirror will be reset to an initial position preparatory to the display of the next image.

Pursuant to the above mentioned Woodier patent application or patent, a commutator or rotary switch at the compensator mirror is employed for timing the doublet generator 84. Of course, other timing devices, such as photosensors beyond the mirror 40 as seen from the film gate may be employed, if desired. However, utilization of a mirror-driven commutator or rotary switch has been preferred for a prototype of the illustrated embodiment. This rotary switch is symbolically indicated at 85 in FIG. 1 where a dotted line 86 depicts a coupling between the compensator mirror 40 and the switch 85. The switch 85 initiates operation of the doublet generator 84 each time the extreme advanced position 40' of the compensator mirror indicates a need for a mirror resetting operation.

For a practical design of the compensator 30 with switch 85, reference may be had to FIGS. 8 and 9 of the drawings.

In the compensator embodiment shown in FIGS. 8 and 9 the compensator mirror 40 is mounted by means of cement 110 on a short tube 112 of non-magnetic material. The mirror drive coil 41 is wound on the tube 112. The tube 112 with drive coil 41 partially extends between pole pieces of a magnetic armature which may be of a conventional permanent-magnet type, having a central core 114 of soft magnetic material and permanent-magnetic pole pieces 115 and 116. The central core 114 is mounted on a post 117 of non-magnetic material. Suitable fasteners (not shown) retain the pole pieces 115 and 116, the central core 114 and the post 117 in position relative to the main body of the armature 113. Mechanical stops 150 and 151 may be provided to avoid contact of the coil 41 or tube 112 with the pole pieces 115 and 116 and the core 114. In contrast to prior-art stops, these stops are so positioned as to be not regularly contacted by the driven compensator part. Rather, these stops are placed beyond the regular range of motion of the driven compensator part.

Two bearings 118 and 119 are coupled to the mirror 40 and tube 112 by cement bonds 120 and mount the compensator mirror 40 for pivotal or angular movement about an axis 122. A mounting blade 123 is fixedly held at one end as shown at 124 and carries at the other end a pivot member 125 which frictionally engages the bearing member 126.

The signal generating device or rotary switch 85 is combined with the bearing 119 and includes a core 130 of electrically conducting material. The core 130 has an integral radial projection 131 which forms an electrical switch contact. A sleeve 132 of electrically insulating material circumferentially covers the conducting core 130, except for the switch contact 131.

An electrical contact blade 134 has one of its ends 135 fixedly mounted as shown at 136. The other end 138 of the contact blade 135 is in engagement with the insulating sleeve 132 of the rotary switch 85.

The rotary switch 85 is coupled to and actuated by the compensator advancing coil 41. In the illustrated embodiment, the rotary switch 85 is also coupled to the compensator mirror 40 by a cement bond 120. In this manner, the moving portion of the rotary switch 85, including the elements 130, 131 and 132, follows the angular movement of the mirror 40. The angular position of the switch contact 131 relative to the reflecting surface of the mirror 40 is such that the movable switch contact 131 engages the contact tip of the blade 134 upon attainment of the angular position 40' by the compensator mirror 40. It may be said that the switch contact 131 is at the beginning of a compensating operation displaced from the contact tip of the blade 134 by an angle which corresponds to the angle by which the compensator mirror has to be displaced for a complete display of a projected image.

The conductive core 130 of the rotary switch 85 is grounded by way of an electrically conducting mirror mounting blade 142 and an electrically conducting pivot member 143 connected to the blade 142 and contacting the core 130, as shown in FIG. 9, or alternatively by a flexible lead (not shown) connecting the core 130 to ground.

The rotary switch 85 initiates operation of the doublet generator upon engagement of the rotary contact 131 with the contact blade 138 (see FIG. 8). In the preferred embodiment shown in FIG. 5 the doublet generator comprises a pair of monostable multivibrators 300 and 301.

In the preferred embodiment shown in FIG. 5, the doublet generator also includes a further monostable multivibrator 302 which may be considered part of the rotary switch 85, if desired. The multivibrator 302 is of a conventional transistor design and has an input 303 connected to the switch 85 and an output 304 coupled to an input 305 of the multivibrator 300.

Upon engagement of the rotary contact 131 and contact blade 138 (see FIG. 8) the switch 85 applies voltage from the positive supply voltage terminal 307 to the multivibrator input 303. The time constant of the multivibrator 302 is approximately four milliseconds so that an output pulse of about four milliseconds duration is generated at the multivibrator output 304. In practical terms the multivibrator 302 operates as a device for protecting the mirror compensator 30 since it effectively disarms the switch 85 for four milliseconds and prevents the high frequency electromechanical oscillations that otherwise tend to occur at the compensator 30 when bias circuits are improperly adjusted and override the input signal so that the movable compensator part is rotated in the direction of closure of the switch 85. The protective multivibrator 302 may also be considered a pulse shaper in that it generates a unitary pulse in response to each closure of the switch 85, free from contact noise or contact bouncing effects.

The leading edge of the output pulse of the multivibrator 302 causes the multivibrator 300 to generate at its output 310 a pulse of the type shown at 261 in FIG. 1. That pulse, it will be recalled, is part of the pulse doublet 260 and serves to accelerate and actuate the compensator mirror 40 in the resetting direction. In the preferred embodiment shown in FIG. 5, the multivibrator 300 generates a positive pulse at its output 310 since that is the polarity which, after amplification of the pulse at 251, will in the particular illustrated embodiment drive the compensator mirror 40 from its advanced position 40' to its initial position preparatory to the display of the next image.

The multivibrator 300 includes a pair of series-connected variable resistors 312 and 313 with which the width of the pulse generated at the output 310 may be adjusted. By way of example, the resistor 312 may have a maximum value of, say, 50 kilohms for effecting rough adjustments and the resistor 313 may have a maximum value of, say, 10 kilohms for effecting fine adjustments of the pulse width. A practical range of adjustment for motion picture display purposes has been found to be from 0.25 to 1.0 milliseconds.

The output 310 of the multivibrator 300 is coupled by way of a resistor 315 to the driver stage 252 of the power amplifier 251 and, by way of a diode 316 to a variable potentiometer 318. The potentiometer 318 serves the adjustment of the height of the pulse generated by the multivibrator 300 and applied to the amplifier 251. The diode 316 serves as a diode limiter and the variable potentiometer 318 applies an adjustable back bias to the diode 316.

The power amplifier 251 amplifies the pulse generated by the multivibrator 300 and applies the amplified pulse to the drive coil 41 of the compensator 30 for a resetting of the mirror 40. In practice, such a resetting operation is very delicate, since an excess of resetting energy will cause the mirror 40 to overshoot in its resetting direction, while a deficiency in the resetting energy will provoke an incomplete resetting operation.

These deficiencies are remedied by generating and utilizing the second pulse 262 subsequent to the pulse 261 (see FIG. 1). To this end, the output 310 of the multivibrator 300 is coupled by way of a capacitor 320 to the input 321 of the multivibrator 301. The trailing edge of the pulse generated by the multivibrator 300 triggers the multivibrator 301 whereby a pulse is generated at the output 323 of the multivibrator 301. That pulse is of a polarity opposite to the polarity generated by the multivibrator 300 at the output 310. For instance, if the pulse generated at 310 is positive, then the pulse generated at 323 is negative, assuming that a positive pulse will cause resetting of the mirror 40 while a negative pulse will cause deceleration of the mirror resetting operation.

The multivibrator 301, which is also of a conventional design, includes a variable resistor 324 for adjusting the width of the pulse generated at 323. The width of the pulse generated at 323 may be adjustable over substantially the same range as the width of the pulse generated at 310.

The output 323 of the multivibrator 301 is connected by way of a resistor 326 to the amplifier 251 and also to a diode 327 which, in turn, is connected to a variable potentiometer 328. The diode 327 serves as a diode limiter and the potentiometer 328 provides an adjustable back bias for that limiter whereby the height of the pulse generated by the multivibrator 301 is adjustable. The power amplifier 251 amplifies the pulse generated by the multivibrator 301 and applies the amplified pulse to the mirror drive coil 41 for decelerating of the mirror resetting operation.

By adjusting the variable resistors 312, 313, and 324, and the variable potentiometers 318 and 328 it is readily possible to provide a system in which the compensator mirror 40 is reset from the advanced position 40' to an initial position within the pull-in range of the photoelectric servo including the sensor 45 with signal conditioning circuit 257 and amplifier 55 (or 251). No electronic switch means are in the illustrated embodiment required for deactivating the photoelectric servo during resetting operations, since the multivibrators 300 and 301 and the amplifier 251 are so designed that the amplifier 251 is driven into saturation by the pulse doublet generated by the multivibrators 300 and 301 so that the photoelectric servo is effectively decoupled from the mirror drive coil 41 during resetting operations.

The electrooptical sensing means shown in FIG. 5, including the sensor 45 and the operational amplifier 192, are presently preferred for their high quality of operation. If desired, however, simplified differential photocell means may be substituted therefor.

By way of example, FIG. 10 of the drawings shows an electrooptical sprocket hole sensor 345 in accordance with a further preferred embodiment of the subject in-

vention. The sensor 345 has a differential amplifier 346 including a PNP transistor 347 and an NPN transistor 348 and a variable potentiometer 349 differentially interconnecting the transistors 347 and 348.

The emitter of the transistor 347 is connected to the positive terminal 350 of a power supply (not shown). The emitter of the transistor 348 is connected to the negative terminal 351 of the power supply. The emitter and base of the transistor 347 are interconnected by a resistor 353, and the emitter and base of the transistor 348 are interconnected by a resistor 354. A photoconductive photocell 357 is connected between the base of the transistor 347 and ground, and a photoconductive photocell 358 is connected between the base of the transistor 348 and ground.

The photocells 357 and 358 operationally correspond to the above mentioned photocells 47 and 48, and may be considered substituted for those photocells in the showing of FIGS. 4a to c.

The sensor 345 of FIG. 10 is basically of complementary circuit. When no light is present the photocell currents are virtually zero and the transistors are cut off. When both photocells 357 and 358 are exposed to full illumination, the transistors 347 and 348 are turned on and current flows through the potentiometer 349. Under this condition the potentiometer 349 is adjusted so that zero voltage is obtained at the output terminal 356.

The lower photocell 358 draws less current than the upper photocell 357 when that lower photocell is blocked by the lower borderline element image 163 in the manner shown for the photocell 48 in FIG. 4c. This reduces the collector current of the transistor 348 whereby a positive voltage is provided at the output terminal 356 (assuming a load resistor to be connected to that terminal).

Conversely, if the upper borderline image element 162 is located on the photocell 357 in the manner shown in FIG. 4b for the photocell 47, then the collector current of the upper transistor 347 is reduced, causing occurrence of a negative voltage at the output 356.

When the sensor 345 is used in lieu of the sensor 45 and operational amplifier 192 in the embodiment of FIG. 5, then the sensor output 356 is connected to the node 210, preferably by way of the resistor 209. The potentiometer 236 shown in FIG. 5 may then be considered a load resistor for the sensor 345. That load resistor is grounded at one end thereof so that generation of the above mentioned positive and negative sensing signal voltages is rendered possible. Connection of the sensor output 356 to the node 210 introduces the amplitude limiter 207 into the circuit together with the above mentioned lead network 232. The gain of the differential amplifier 346 is sufficiently high to render the limiter action shown in FIGS. 7d and h possible. The operation of the sensor 345 shown in FIG. 10 and the limiter 207 shown in FIG. 5 then proceeds substantially as shown in FIG. 7d for opaque-margin film and FIG. 7h for transparent-margin film.

A further electrooptical sprocket hole sensor 360 in accordance with yet another embodiment of the subject invention is shown in FIG. 11. Like reference numerals as among FIGS. 10 and 11 designate like or functionally equivalent parts.

The electrooptical sensor 360 of FIG. 11 comprises a PNP phototransistor 362 and an NPN phototransistor 363 differentially interconnected by a variable potentiometer 349. The emitter of the phototransistor 362 is connected to the positive supply terminal 350, and the emitter of the phototransistor 363 is connected to the negative power supply terminal 351. Undulated arrows 365 at the phototransistor 362 and 366 at the phototransistor 363 indicate light radiations in a luminous sprocket hole 160 (see FIG. 4) which is projected onto the phototransistor 362 and 363.

Initially, both phototransistors are fully illuminated and the potentiometer 349 is adjusted so that zero output voltage appears at the terminal 356 in that condition.

A positive sensing signal is provided at the output terminal 356 when the lower phototransistor 363 is blocked by the lower borderline element image 163 in the manner shown in FIG. 4c for the photocell 48. Conversely, a negative sensing signal is provided at the output 356 when the upper borderline element image 162 blocks the transistor 362 in the manner indicated for the photocell 47 in FIG. 4b. The phototransistors 362 and 363 thus provide the function of the photocells 47 and 48 and the operational amplifier 192 shown in FIG. 5, or of the photoconductors 357 and 358 and the transistors 347 and 348 shown in FIG. 10.

The sensor 360 of FIG. 11 may be connected to the node 210 shown in FIG. 5 by way of the resistor 209 and in lieu of the sensor 45 and amplifier 192. The operation of the photosensor 360 of FIG. 11 with limiter 207 of FIG. 5 proceeds substantially in the manner shown in FIG. 7d for opaque-margin film, and in the manner shown in FIG. 7h for transparent-margin film.

Considering the principles of operation of the methods and apparatus herein disclosed, it will be appreciated that the subject invention is also applicable to the sensing of fiducial markings other than sprocket holes in motion picture film or other information carriers. By way of example, the subject invention may be employed for sensing transparent fiducial markings in opaque-margin film, or sensing opaque fiducial markings in transparent-margin film. Moreover, the subject invention may be employed for sensing fiducial markings of high opacity in film margins having a somewhat lower opacity as well as in transparent film margins. All these alternatives are possible because the methods and apparatus of the subject invention are capable of providing sensing signals which are insensitive to contrast variations of various fiducial markings, though being sensitive to the fiducial markings as such.

A modification of the apparatus of FIG. 5 is shown by the circuit diagram of FIG. 12. The previously described photocells 47 and 48 of the sensor 45 are connected in parallel with opposite polarities. The parallel-connected photocells 47 and 48 are connected between the inverting and non-inverting inputs 193 and 194 of the amplifier 192. The feedback resistor 224 is connected between the amplifier output 191 and the inverting input as before. The non-inverting input 194 is grounded.

A shunt resistor 700, which is similar to the above mentioned resistors 200 and 201, is connected in parallel to the photocells 47 and 48 in order to shunt out the

photocell capacitances and to force the photocells to operate in the preferred short circuit mode. The resistance of the resistor 700 is small compared to that of the illuminated photocells.

I claim:

1. In a method of controlling a film motion compensator in a continuous film feed motion picture apparatus with the aid of fiducial markings provided on motion picture film bases having different optical characteristics, the improvement comprising in combination:

electrooptically sensing said fiducial markings and generating first electric signals having different amplitude values in accordance with said different optical characteristics;

converting said first electric signals into corresponding second electric signals having substantially equal amplitude values substantially independent of said different optical characteristics; and controlling said film motion compensator with the aid of said second electric signals.

2. A method as claimed in claim 1, wherein: said different optical characteristics of said film bases are different transparency values; and said fiducial markings are sensed by projecting light through said fiducial markings and adjacent film bases and electrooptically generating said first electric signals in response to said projected light.

3. A method as claimed in claim 2, wherein: said fiducial markings are sprocket holes; and said film bases are substantially transparent film bases and relatively opaque film bases.

4. In apparatus for controlling a film motion compensator in a continuous film feed motion picture apparatus with the aid of fiducial markings provided on motion picture film bases having different optical characteristics, the improvement comprising in combination:

electrooptical sensing means for generating first electric signals having different amplitude values in accordance with said different optical characteristics;

means connected to said sensing means for converting said first electric signals into corresponding second electric signals having substantially equal amplitude values substantially independent of said different optical characteristics; and

means connected to said converting means for controlling said film motion compensator with the aid of said second electric signals.

5. An apparatus as claimed in claim 4, wherein: said different optical characteristics of said film bases are different transparency values; and said sensing means include means for projecting light through said fiducial markings and adjacent film bases, and electrooptical signal generating means for generating said first electric signals in response to said projected light.

6. An apparatus as claimed in claim 5, wherein: said electrooptical signal generating means include differential photocell means.

7. An apparatus as claimed in claim 5, wherein: said electrooptical signal generating means include

differential phototransistor means.

8. An apparatus as claimed in claim 7, wherein: said differential phototransistor means include a PNP phototransistor, an NPN phototransistor and means for differentially interconnecting said PNP and NPN phototransistors.

9. An apparatus as claimed in claim 5, wherein: said electrooptical signal generating means include a differential amplifier including a PNP transistor, an NPN transistor and means for differentially interconnecting said PNP and NPN transistors, and first photoelectric means connected to said PNP transistor and second photoelectric means connected to said NPN transistor.

10. An apparatus as claimed in claim 5, wherein: said electrooptical signal generating means include operational amplifier means having an inverted input, a non-inverting input, and an output, and first photoelectric means connected to said inverting input and second photoelectric means connected to said non-inverting input.

11. In apparatus for controlling a film motion compensator in a continuous film feed motion picture apparatus with the aid of projected images of fiducial markings, comprising:

electrooptical signal generating means including two spaced photocell means for generating two output signals in response to said projected images of fiducial markings and means connected to said two photocell means for providing a third signal corresponding to the difference between said two output signals;

signal amplitude limiter means connected to said electrooptical signal generating means for amplitude limiting said third signal; and

means connected to said limiter means for controlling said compensator in response to said amplitude limited third signal.

12. An electrooptical sensor as claimed in claim 11, wherein:

said two photocell means are two phototransistor means.

13. An electrooptical sensor as claimed in claim 11, wherein:

said two photocell means include a PNP phototransistor, and an NPN phototransistor.

14. An electrooptical sensor as claimed in claim 11, wherein:

said means for providing a third signal include a differential amplifier including a PNP transistor, an NPN transistor and means for differentially interconnecting said PNP and NPN transistors; and said two photocell means include first photoelectric means connected to said PNP transistor and second photoelectric means connected to said NPN transistor.

15. An electrooptical sensor as claimed in claim 11, wherein:

said means for providing a third signal include operational amplifier means having an inverting input, a non-inverting input, and an output; and

said two photocell means include first photoelectric means connected to said non-inverting input.

* * * * *