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Grossetete et al.

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[54] **LIGHT-CORRECTION SYSTEM FOR PRINTERS OF COLOUR CINEMATOGRAPHIC FILMS**

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[52] **U.S. Cl.** **355/36**, 355/34, 355/83

[51] **Int. Cl.** **G03b 27/76**

[58] **Field of Search** 355/34, 35, 36, 83, 355/88

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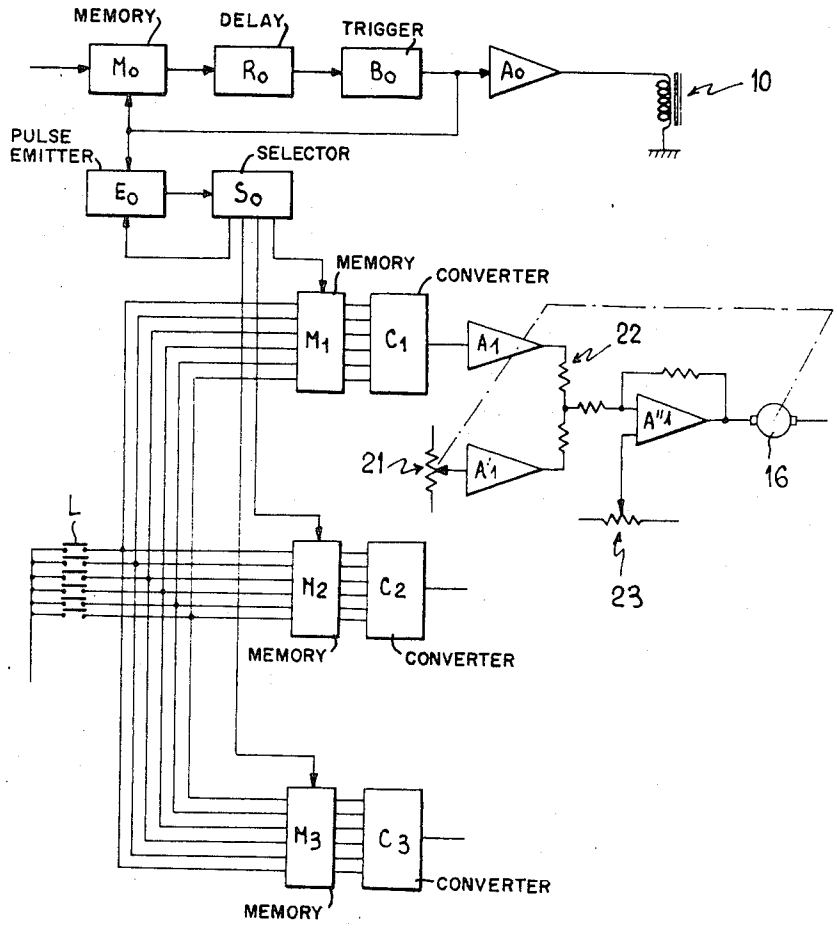
[57] **ABSTRACT**

A light-correction system for cinematographic colour film printers which operate on the additive three-colour principle. Electric pulses, originating in binary form from a reader of a perforated programming tape on which information relating to desired corrections is stored, are converted for each of the three primary colours by a digital-analogue arrangement into a representative electric voltage, and the opening of each of three corresponding flux modulators is controlled by a respective electric motor which is supplied with the respective voltage through a position-control potentiometric assembly. Each of the flux modulators includes a cam for converting rotation of the corresponding motor into angular displacement of a pivoting member mounted for rotation on an operating shaft of an aperture shutter of the respective modulator.

4 Claims, 3 Drawing Figures



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SHEET 1 OF 2

Fig.1

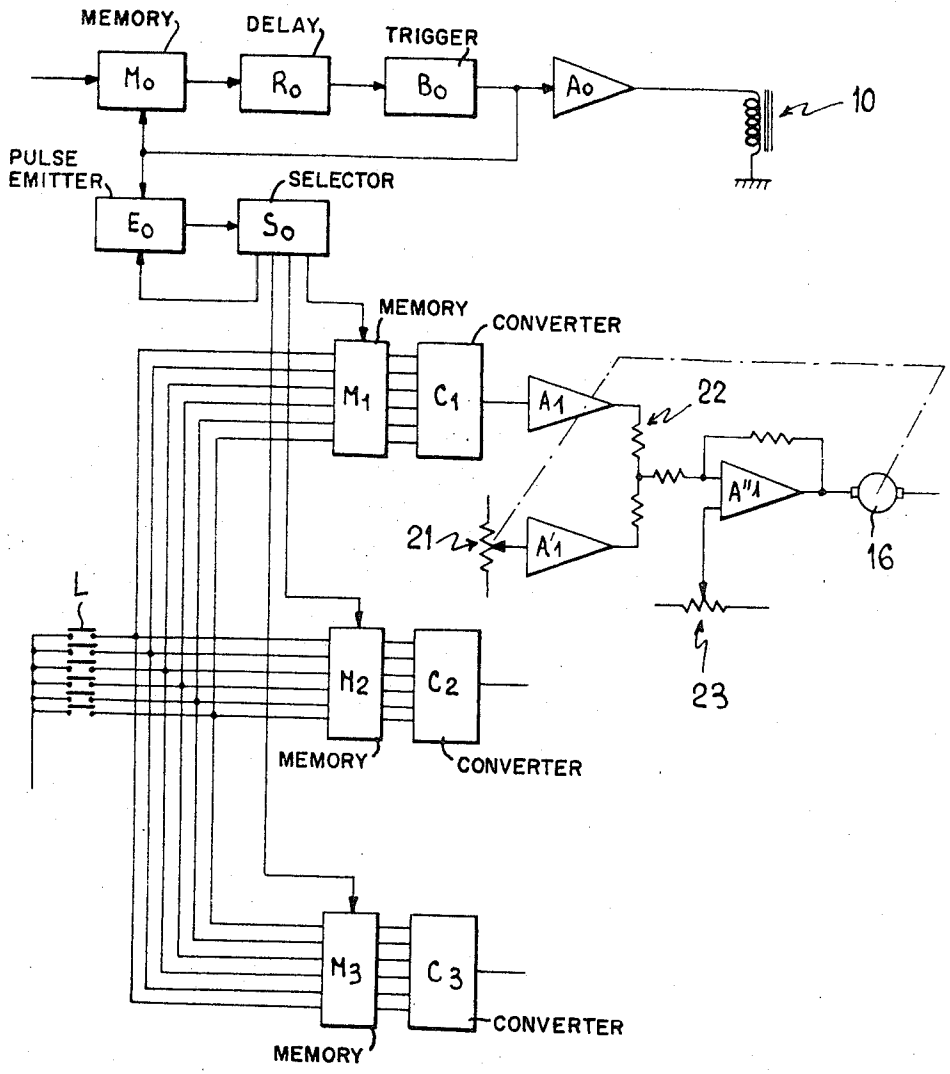

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Fig.2

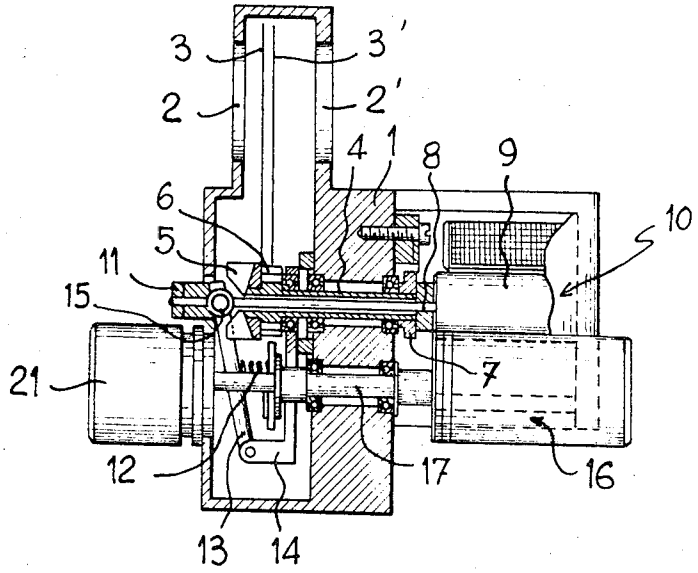
3
3'
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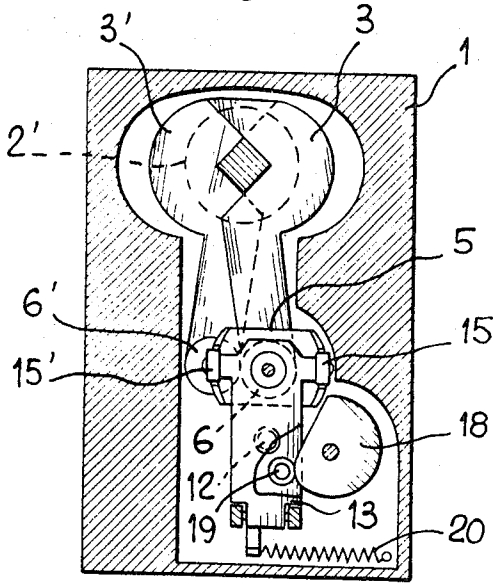
Fig.3


3'
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LIGHT-CORRECTION SYSTEM FOR PRINTERS OF COLOUR CINEMATOGRAPHIC FILMS

BACKGROUND OF THE INVENTION

The present invention relates to optical or contact printing machines for use with colour cinematographic films, and is concerned more particularly with a light-correction system which makes it possible to obtain copies exhibiting desired effects on projection from a given original. This system is applicable more particularly to printing machines operating by the additive three-colour principle.

The aforesaid process involves splitting up the light flux emitted by a light source, such as an incandescent or halogen lamp, into three monochromatic parallel beams each corresponding to one of the primary colours (red, green, blue). The light flux is split up by means of a system of filtering foils or reflecting mirrors. Each of these three beams passes through a flux modulator which is adapted to cause the intensity of the beam to vary as a function of a prestablished instruction programme. The three beams are then recombined into a single light beam by a system of foils and reversing mirrors, the spectral composition of which can thus be modified at will with respect to that of the initial beam. This recombined beam serves to illuminate the images of the original film in succession to provide for the production of an optical or contact copy.

The desired intensity variations are determined from a previous projection of the original with a suitable grading device which establishes the different intensity variations for the various sequences of the film in question. In practice, the information obtained by the grading device is stored in coded form on a programming tape having six perforated tracks in accordance with the binary numbering system. These six perforated tracks thus make it possible to establish a total of 50 bits of information each corresponding to one adjustment step in the aperture of the respective flux modulator for each of the three primary colours. The aperture variation causes a suitable variation in the intensity of light leaving each modulator.

The printing of the copies is effected using the information carried by the programming tape. The tape advances step-by-step with each change in film sequence in a suitable reader. The reader is provided without contacts which are closed or open depending on whether there is a perforation on the corresponding track and for the colour under consideration or not. In the systems as known at present, the use of the information thus translated into electric pulses is dependent on electromagnetic relay systems which operate as many cams as there are tracks on the programming tape, (six in the present instance). These cams are of progressively increasing height and their deviation is totalised to act mechanically on an iris or blade-type arrangement, which modulates the light beam of the primary colour in question.

These known systems have various disadvantages from the point of view of weight, size, cost inertia and reliability, and it is the purpose of the present invention to overcome these disadvantages.

SUMMARY OF THE INVENTION

According to the present invention there is provided a process for adjusting a light-correction system of a cinematographic colour film printing machine which operates on the additive three-colour principle in which the light flux emitted by a source is split up into three monochromatic beams which are each passed through the flux modulator and thereafter recombined, the process comprising the steps of, recording correction information on a perforated programming tape, advancing the tape step-by-step with the advance of the film being printed, extracting the information from the tape in the form of electric pulses with a tape reader, converting the information for each of the said monochromatic beams with a digital-analogue arrangement into a respective electrical voltage, and supplying an electric motor which is connected to an aperture controlling device on the corresponding flux moudlator with the aforesaid voltage through a position-controlling potentiometric assembly.

The present invention also provides a light-correction system for a cinematographic colour film printing machine which is adapted to operate on the additive three-colour principle in which the light flux emitted by a source is split up into three monochromatic beams which are each passed through a flux modulator and thereafter recombined, the system comprising, means for advancing a perforated programming tape on which correction information is recorded step-by-step with the advance of a film to be printed, a programming tape reading adapted to produce an output of electric pulses a digital-analogue arrangement adapted to convert the pulses relating to each of the said monochromatic beams into a representative electrical voltage, and means for separately adjusting the aperture of each of the flux modulators, and electric motor connected to each of the said adjusting means, and a position-controlling potentiometric assembly adapted to supply the motor with the said voltage.

In a preferred embodiment of the present invention, the adjustment of the aperture of the flux modulator is deferred with respect to the information stored on the programming tape and is triggered by a reference notch or index carried by the film so as to be produced in the interval of a change in sequence. To this end, the rotation of the controlling electric motor is converted into an angular displacement of a pivoting member mounted for rotation on the operating shaft of the closure shutter or shutters of the flux modulator, and this operating shaft is only made fast angularly with the one said pivoting member during a short time period which is within the interval of the change in sequence.

According to another feature of the invention, the angular interlocking of the said pivoting member with the operating shaft of the closure shutter or shutters is controlled, against the action of a return spring, by an electromagnet receiving an electric pulse indicative of a change in sequence. The use of the information output of the reader of the programming tape is thus to some degree prepared for by the electric motor and the associated position control system, while the effective use thereof is deferred until the precise instant of a change in sequence of the film.

Other features and advantages of the invention will be apparent from reading the following description of one embodiment, with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a simplified electric circuit diagram of a

light-correction system according to the invention, only one of the three light flux modulators being shown;

FIG. 2 and 3 are longitudinal and transverse sections, respectively of a flux modulator.

DESCRIPTION OF AN EMBODIMENT OF THE INVENTION

The system for electrically controlling the flux modulators, as shown diagrammatically in the form of a block diagram in FIG. 1, comprises firstly a regulated electric supply system (not shown), and a means for controlling the advance of the programming tape and the deferred use of the information stored by it, said means comprising an order-initiating memory M_o operated by a reference index or notch carried by the original film at the location of each change in sequence, a delay arrangement R_o designed to take into account the distance between the index-sensing device of the preceding memory and the projection aperture, a monostable triggering device B_o controlled by the signal as thus deferred, a pulse emitter E_o initiated by the said triggering device, and a step selector S_o switching the pulses received from the preceding emitter in succession towards each of the three circuits associated with the flux modulators.

The control system additionally comprises three individual control circuits, each associated with one of the flux modulators corresponding to the three primary colours. Each of these circuits comprises a memory M_1, M_2 or M_3 of convention design, the inputs of which are directly connected to the track contacts of the programming tape reader L, as well as a digital-analogue converter C_1, C_2, or C_3, which is adapted to translate the information received in the form of a binary signal from the associated memory into a proportional continuous electric voltage. The three memories M_1 M_2 and M_3 are controlled by the step or spacing selector S_o which sequentially controls their opening, and also by a clearing circuit (not shown). The essential purpose of these memories is to record the information received from the programming tape reader L with each advance of this latter and to keep the information available at the input of the associated converters as long as is necessary for use of the recured information.

The information established in analogue form by the converters C_1, C_2 and C_3 is translated into intensity variations of the monochromatic fluxes by flux modulators the position of which are servo-controlled. A flux modulator is illustrated diagrammatically in FIG. 1.

The light flux modulator comprises a rigid housing 1 into the upper portion of which two aligned circular windows 2 and 2' are drilled. Two symmetrical opaque shutter members 3 and 3' are disposed between the windows keyed on two parallel and spaced rotating shafts. The displacements of the two shutters are synchronised and take place in opposite directions, so that they offer an aperture of variable surface area to the passage of light beams (shown shaded in FIG. 3). Consequently, they intercept a larger or smaller fraction of the light flux admitted through the windows 2 and 2'. The closure shutter 3 is more specifically fixed to the end of a hollow shaft 4 journalling by means of ball-bearings in a reinforced wall of the housing 1. The hollow shaft 4 also carries at the same end a member 5 machined in the form of a cam having re-entrant surfaces, and also a toothed wheel 6 adapted to mesh with as little play as possible with an identical toothed wheel 6' keyed on the shaft of the other shutter 3', the shaft wheels thus making the rotational movements of these two shutters synchronised as already mentioned above. At its opposite end, the hollow shaft 4 carries a circular plate 7 forming a brake element. Arranged coaxially with the hollow shaft 4 is a sliding rod 8 which is rigidly attached to a plunger 9 of an electromagnet 10. In the absence of energisation of the control winding, the plunger is biased by the action of a spring out of the coil, in which position it comes into contact with the circular plate 7 and thus by friction immobilises the hollow shaft 4 in the angular position which it has reached when the plunger contacts the plate 7. The rod 8 carries a stop or abutment collar 11 at its free end. The end of a pivoting blade 13 is held against the stop 11 by the action of a compression spring 12. The pivoting blade 13 is connected at its other end by a fork joint to the cranked end of a lever 14 which is mounted for pivotal movement by means of a roller bearing on the hollow shaft 4. The blade 13 is provided at its upper end with a pair of aligned lateral projections which support rollers 15 and 15' which are adapted to engage the re-entrant surfaces of the cam 5, but which are normally held spaced from these surfaces by the action a blade return spring 12. The displacements of the pivoting lever 14 are controlled by a direct current electric motor 16 via a speed reduction gear by means of a rotatable cam 18 keyed on the motor shaft 17 and a roller 19 mounted on the pivoting lever and held in contact with the cam by a tension spring 20. A slide member of a position control potentiometer 21 is keyed on the shaft 17.

It is apparent from the foregoing description that the shutters 3 and 3' remain locked in the position because of the braking action exerted by the plunger 9 of the electromagnet 10 on the circular plate 7 which is rigidly mounted on the hollow shaft 4. However, this does not prevent the motor 16 from responding to information received by a rotational movement which causes a pivoting in one direction or the other of the lever 14 and of the blade 13 which is associated with it. The angular position of the rollers 15 and 15' ceases for this reason to be in coincidence with that of the re-entrant surfaces of the cam 5. The motor 16 is thus prepared to act on the information received, under the control of the position-control potentiometer 21, but it will only do so when the coil of the electromagnet 10 is placed under voltage. Actually, at this particular moment, the pull of the plunger 9 will simultaneously have the effect of freeing the circular plate 7 from the braking pressure exerted on it and of causing, by means of the rod 8 and the stop collar 11 acting on the free end of the blade 13, the engagement of the rollers 15 and 15' carried by this latter with the re-entrant surfaces of the cam 5. The cam 5 will then itself pivot in such a way as to re-align its angular position with that of the rollers, thus driving with it the shutters 3 and 3'. The resultant change in shutter spacing will thus be dependant on the information received from the programming tape for the primary colour in question. It will be appreciated that the inertia of the movable equipment formed by the hollow shaft 4, the cam 5, the shutter blades 3 and 3' and their toothed wheels 6 and 6', can be made very small and this makes it possible for the mechanism as described to respond to information received from the programming tape in a very short time.

Referring for the time being to FIG. 1 of the accompanying drawings, the electrical control means of the flux modulator comprises essentially two circuits. The first, which controls the operation of the electromagnet **10**, transmits to the latter, through an amplifier A_o, a suitable deferred electric control pulse having a sufficiently short duration (for example, 10 mS), so that the execution of the desired correction takes place in the interval separating the first image of the sequence in question of the film from the last image of the preceding sequence. The second circuit, which is associated with the motor **16**, comprises a potentiometric assembly **22** which is acted upon by the digital-analogue converter C_1 through an amplifier A_1, an amplifier A'_1 of similar form but having a gain equal to the unit being introduced for the purpose of correction of thermal deviation in the opposite branch of the assembly connected to the position-control potentiometer **21**. A third amplifier A_1'', having a reaction loop, in its turn acts on the motor **16** from the potentiometric assembly **22**, this amplifier being in addition influenced by the position of an auxiliary potentiometer **23**, called the correction threshold, which is regulated as a function of the characteristics of the film emulsion being used.

The operation of the light-correction system as described above is explained below, taking as the initial instant that when a correction has just been effected in the interval of a change in film sequence. The order for executing this correction was initiated from the input memory M_o and the delay arrangement R_o by an electric pulse of 10 mS emitted by the trigger B_o, which pulse, as explained above, operated the control electromagnets **10** of the three flux modulators, corresponding respectively to the three primary colours. This same pulse simultaneously initiates the functioning of the pulse emitter E_o and the advance of the programming tape in the tape reader L. During this advance of the programming tape, the coded information relating to the sequence following that which is undergoing printing travel in succession, for each of the primary colours, beneath the contacts of the tape reader L; by the co-ordinating action of the step selector S_o, the three memories M_1, M_2 and M_3 are successively opened to the pulses originating from the tape reader, each of these memories only retaining the instructions relating to the fundamental colour with which it is associated. The advance of the programming tape is ended by a fourth step corresponding to a stopping position. Each of the three memories M_1, M_2 and M_3 thus records the correction information relating to the colour in question and transmits it to the associated digital-analogue converter C_1, C_2, C_3, throughout the time necessary for the preparation of the execution by the motor **16** and by the associated position control of the corresponding flux modulator. Allowing for the inertia of the moving parts, this time can be in the region of 10 mS, and this, with the lag given by R_o, corresponds to the movement of about eight images in front of the projection aperture. When this time has elapsed, the three memories M_1, M_2, M_3 are automatically cleared by a control circuit which is not shown in FIG. 1. At this stage of the operating cycle, the correction information carried by the programming tape and relating to the sequence to come is thus prepared by the respective flux modulators and stored. The information will be acted upon automatically with a change in sequence by the control electromagnets **10** being placed under voltage in accordance with the procedure already described, this being initiated by the passage of the corresponding index mark of the film in front of the index feeler of the input memory M_o.

It will be appreciated that the control system shown diagrammatically in FIG. 1 of the accompanying drawings is able, despite its relative complexity, to be kept within the limits of acceptable size, this being particularly due to the use of miniaturised elements and integrated circuits. The flux modulators in FIGS. 2 and 3 can in their turn be easily made in the form of units of small dimensions and reduced weight, these advantages moreover being concurrent with a desirable reduction in the inertia of the movable components, and consequently of the response times The present invention thus permits the development of a light correction system which is lighter, more compact and responds more rapidly than the mechanical control systems as known at the present time.

It is naturally understodd that the scope of the invention is not limited to the preferred constructional form as described above, which is only given by way of example, but that on the contrary it covers all modifications in construction which make use of the same principles.

We claim:

1. A light-correction system for a cinematographic color film printing machine which is adapted to operate on the additive three-color principle in which the light flux emitted by a source is split up into three monochromatic beams which are each passed through a flux modulator and thereafter recombined, the system comprising, means for advancing a perforated programming tape on which correcting information is recorded step-by-step with the advance of a film to be printed, a programming tape reader for producing an output of electric pulses, a digital-analogue arrangement for converting the electric pulses into representative electrical voltages; means for separately adjusting the aperture of each of the flux modulators, said adjusting means including an aperture shutter and corresponding operating shaft for each flux modulator a separate electric motor for driving each of said adjusting means; separate position-controlling potentiometric assemblies for coupling each of the motors with one of the representative voltages; means for storing correction information supplied by the reader; means for sensing an index mark carried by the film; means for extracting the stored information when an index mark is sensed; a cam mounted in each of the flux modulators, for converting rotation of each corresponding motor into an angular displacement of a pivoting member mounted for rotation on an operating shaft of an aperture shutter of the respective flux modulator; means for making the operating shaft fast with the said pivoting member during a short time interval initiated by the index mark sensing means; the pivoting member comprising a lever journalled at one of the ends on the operating shaft of the corresponding aperture shutter and a blade articulated on the other end of the lever and provided at its free end with aligned lateral projections for engaging in corresponding recesses of the cam, said cam being keyed on the operating shaft, a spring for controlling the spacing between the cam and the blade and an electromagnet for engaging the blade with the cam when the latter receives an electric pulse indicative of a sensed index mark.

2. A light-correction system according to claim 1, wherein the operating shaft of the aperture shutter is hollow and in that the pivot means for the engagement of the blade with the cam is controlled by means of a sliding rod disposed coaxially of the said shaft and operated by the plunger of the electromagnet.

3. A light-correction system according to claim 2, wherein a friction connection is established by the action of said spring on the blade between the sliding rod and the hollow shaft so as to immobilise the latter in the last angular position which was communicated to it by the blade.

4. A light-correction system according to claim 1, wherein each digital-analogue converter has associated with it a memory for storing information extracted from the programming tape corresponding to the respective monochromatic beam, and including single selector mechanism to switch said information to each memory with each advancing movement of the programming, the operation of the selector mechanism being initiated by the sensing of said index mark.

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