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(54) IMPROVEMENTS IN OR RELATING TO FILM HANDLING APPARATUS

(71) We, KARL VOCKENHUBER, of 118 Potzleinsdorferstrasse, Vienna 18, and RAIMUND HAUSER, of 2 Goldegg-Gasse, Vienna 4, both Austria, both Austrian citizens, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement: —

This invention relates to strip handling apparatus such as a cine camera or projector, utilising a strip such as a film which is moved continuously through a gate. More particularly the invention is concerned with details of an optical system having a deflector which is driven to compensate for the motion of the strip with respect to the system when the apparatus is in use. The deflector with which the invention is concerned performs an oscillatory motion having a forward sweep motion during which it is synchronised with the strip movement through the gate, and a return or fly-back motion when the deflector is returned relatively rapidly to an initial positionin order to commence the next forward sweep.

Although the invention is primarily concerned with the photographic field, it may equally well find application in other fields, for example in the fields of data-recognition or computers.

In accordance with the present invention there is provided film handling apparatus having a film gate and a film drive for transporting the film in continuous manner through the film gate, an optical deflector having a deflecting drive for compensating the continuous movement of the film through the film gate the deflecting drive producing a forward motion of the deflector to follow movement of the film and a flyback motion which is relatively rapid compared with the forward motion, an arrangement for synchronizing the deflecting drive with the film drive, and energy transfer means effective during a terminal stage of the flyback motion to extract a quantity of energy from the moving deflector substantially equal to its dynamic energy so that the deflector is decelerated rapidly at the end of the flyback motion without bouncing and without friction braking and comes to rest at a predetermined position from which it is to commence the next forward deflecting motion.

The energy transfer means may operate in one of two ways. In the preferred arrangement cancellation of the dynamic energy of the deflector is achieved substantially instantaneously by injecting into its drive an electrical signal having an equal and opposite energy content. This may be achieved with a galvanometer type deflector drive, by injecting into the galvanometer an impulse of predetermined shape. This shape is preferably combined with an electrical impulse required to sweep the deflector forwardly in synchronism with the film or strip and the two impulses are suitably provided by a double impulse generator operated in synchronism with the drive for the film.

In an alternative arrangement the energy transfer means transfers the dynamic energy of the deflector drive to a buffer whose motion can be subsequently halted when separated by the impact from the deflector drive. In such an arrangement the mass of the buffer is matched to that of the deflector so that with impact of the latter on the former the deflector dynamic energy is transferred *in toto* to the buffer and its return motion is in this way brought to an abrupt halt. The buffer is meanwhile jolted into motion by the impact and its energy can be dissipated there-

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after in any convenient way without influencing the deflector drive.

The invention will now be described in more detail, by way of examples, with reference to the accompanying drawings, in which:—

Figure 1 illustrates in schematic form one possible arrangement of a tilt-mirror deflector in a projector;

Figure 2 shows schematically in section a drive for tilting the mirror;

Figures 3 and 4 show two different drives for tilting the mirror;

Figure 5 shows an electrical waveform resulting in an extremely quick return or fly-back motion of the mirror being achieved;

Figure 6 is an electrical block circuit showing control circuitry for a tilt-mirror drive motor;

Figure 7 is a block circuit showing another way of synchronizing electrically the control of the tilt-mirror drive;

Figure 8 shows diagrammatically a further way of electrically controlling the tilt-mirror drive;

Figure 9 shows a way of extracting a synchronizing impulse from a film perforation;

Figure 10 represents a preferred arrangement of impulse generator employing an information carrier;

Figure 11 shows diagrammatically signals obtained from respectively four tracks recorded on an information carrier;

Figure 12 shows an alternative arrangement of information carrier to that shown in Figure 10;

Figure 13 shows how an impulse may be divided between two different recording tracks;

Figure 14 shows diagrammatically a centrifugal governor for controlling variable electrical resistances employed in the arrangements shown in Figures 9 to 11;

Figure 15 shows diagrammatically a further way of producing electrical impulses for controlling movement of a tilt-mirror, or other form of optical deflector and synchronised with the movement of a film strip;

Figure 16 shows schematically a further arrangement using a telecentering device and a claw arm for maintaining synchronous movement between a film strip and a tilt-mirror;

Figure 17 shows diagrammatically an electrical waveform supplied to aballistic galvanometer drive for a tilt-mirror;

Figure 18 shows an arrangement for scanning a film strip and which instead of using telecentering as in Figure 16, uses a film gate having a zone of increased curvature;

Figure 19 shows in block diagrammatic form a circuit for triggering release of a double impulse from a magnetic field dependent resistor;

Figure 20 shows diagrammatically, and with the help of a block circuit diagram, an arrangement for synchronizing motion of a tilt-mirror deflector with the movement of a film through a film gate;

Figure 21 shows an arrangement for terminating fly-back motion of a tilt-mirror in a recoilless manner and without mechanical braking;

Figures 22 and 23 respectively show modifications of the recoilless arrangement of Figure 21;

Figures 24 and 25 show diagrammatically in respectively side and end views an arrangement for maintaining the angular movement of a tilt-mirror to half that of a claw arm by means of a torsion bar; Figure 25 being taken in the direction of the arrow XXV in Figure 24;

Figures 26 and 27 respectively show in side and plan views a cam-driven arrangement for maintaining forward tilt motion of a mirror deflector in step with movement of a film strip, Figure 27 being taken in the direction of the arrow XXVII in Figure 26;

Figure 28 is an exploded view of two cam follower levers and their associated pawl carriers, used in the arrangement of Figures 26 and 27; and

Figure 29 shows the pawl carriers of Figure 28 in end elevation, the alignment positions of certain co-operating parts being shown in broken outline.

In the apparatus of the invention, the individual film frames are projected by means of a swivel-mounted tilting mirror and a projector objective assembly. The mirror is so moved that motion of the film is compensated and a stationary picture is formed on the projector screen or framed in the camera window. A special arrangement produces electrical impulses from optical markings on the film, for example from the perforations, and these impulses control with the film movement the synchronous movements of the mirror. The electrical control of position results in such away that extremely short fly-back times for the mirror are achieved without the presence of other moving parts in the optical path, in Figures 1 to 20.

Film 1 shows a film strip 1 which is continuously moved by known means across a film gate 2 having a window 3 and associated with two rolls or guide pins 4 provided for properly positioning the film on the film gate. A light source comprising a lamp 5, mirror 6 and condensing lens 7, illuminates as evenly as possible the window 3 which is filled by two picture frames of the film strip. The brightness information arriving from the film 1 and window 2 encounters the tilting-mirror 8 positioned by the spindle of a tilt motor 9 and is transmitted through an objective assembly 10 to the projector screen or similar surface. The synchronization of the film movement with the mirror movement

necessary for faultless presentation of the film, is achieved with a synchronizing arrangement consisting of a lamp 12, an optical system 13 and a light receiver 14. The light from the lamp 12 reflected from the film is transmitted through the optical system 13 to the receiver 14 which converts the light into electrical current. The arrival of a perforation or a non-reflecting zone of the film margin in the optical path, produces an electrical pulse in the receiver output, which is amplified by amplifiers 15 and 16 and used to control the positioning of the tilt-mirror 8. In order to make adjustment of the picture frame line possible, the entire assembly comprising parts 12, 13 and 4 is displaceable longitudinally of the film.

In Figure 2 is shown another driving system of a tilting-mirror. The light from a projector lamp (not shown) is transmitted as before through the window 3 of a film gate 2 onto a movably mounted tiltable-mirror 8 which reflects the light through the objective assembly 10 onto a screen 11. The mirror is movably mounted with the help of a woven or plastics strip 17 and is tiltable against an angle stop 18. A reciprocating pulsed system, similar to a dynamic loudspeaker, drives the free end of the mirror with the help of a lacquer stiffened woven or plastics strip 19. In this way linear motion is converted into a tilting motion of the mirror. The diaphragm arrangement necessary for centering the magnetic coil does, however, impart a dynamic couple to the surrounding air so that an oscillator drive of this design for the mirror develops more noise than a motor constructed on the principle of a galvanometer.

Figure 3 shows one possible arrangement of such a 'galvanometer' motor. Located between poles of a magnet 20 are a static iron core 21 and a spindle 22 on which a coil 23 is rotatably mounted, the spindle being held in its initial position by a spring 24. A damping liquid 25 provides damping. It can also be advantageous to utilise copper or aluminium frames to produce damping by eddy-current effect. Liquid damping has, however, the advantage that the liquid enables lower natural resonance frequencies of the oscillatory system to be damped so that a more sensitive motor can be used.

In Figure 4 is shown a motor which is provided with a known deflecting arrangement. The coil is mounted on a torsion strip 26, whose cross-section is so chosen that it readily permits torsional oscillations while preventing oscillations normal to the torsional axis. A suitable profile for the torsion spring is one of generally cruciform cross-section.

Figure 5 shows a possible current waveform through the oscillatory coil of the motor enabling an extremely short fly-back time to be achieved. During the time T_1, a reverse current impulse of magnitude U_1, is generated, the impulse being triggered from the synchronizing signal of the film and accelerating the oscillatory coil and thus the mirror very rapidly to its initial position. Were only this reverse impulse to be impressed on the oscillatory system, the oscillatory coil after its operation would move beyond the initial position and begin to execute a damped oscillation that would be useless for the intended operation. Therefore a braking pulse is applied for a suitable time T_2 to the oscillatory system as a continuation of the reverse pulse and has a magnitude U_2, the braking pulse halting the oscillatory coil at the end of the time T_2. The oscillatory coil is still when a further sawtooth waveform current begins the deflection of the mirror over a period T_3. As the current at the beginning of the sawtooth is identical with the current at the end of the braking impulse, a current build-up process is accordingly avoided and the mirror executes an exact tilting motion. With such an arrangement fly-back times in the region of half a millisecond are obtainable.

In Figure 6 is shown a block diagram of the electrical circuit of the motor. The synchronizing impulse from the film perforation enters the amplifier 15 at 28. The amplifier 15 drives a sawtooth generator 29 which has amplitude and linearity regulators 30 and 31, respectively, and also a double impulse generator 38 having controls 32 and 33 for regulating the times T_1 and T_2. The sawtooth waveform and the double impulse are added to one another in a mixing circuit 34 to obtain the waveform of the shape shown in Figure 5, which controls by way of an output stage 35 the motor 9. The frequency of the sawtooth generator 29 can be matched to different film velocities.

Figure 7, like Figure 6, shows in block diagrammatic form, a motor control circuit providing indirect synchronisation. The frequency of an oscillator 36 is compared in a phase comparator 37 with a synchronizing impulse, and a regulating voltage produced by the comparator so controls the oscillator 36 that the frequency and phase of the oscillator output and the synchronizing impulses coincides.

Figure 8 shows another possible arrangement for the mirror-tiling mechanism. The synchronizing marks on the film border are imaged by means of an optical system consisting of illuminating components 5 to 7, the tilt-mirror 8 and the objective 10, on two light detectors such as photo-cells 39 and 40. With the assistance of a differential amplifier 41, the motor 9 is now so controlled that the image of the synchronizing mark always falls evenly on both photo-cells. Departure

of the synchronizing mark from the window 3, produces in the amplifier 41 a pulse which controls the rapid return motion of the mirror to its starting position. In the case of an unbiased mirror-tilting motor 9, the existing rectangular double impulse from the generator 38, obtained as before, is fed to the mixer 34 which supplies the output stage 35 controlling the motor 9.

Figure 9 shows a possible arrangement of generating impulses from the perforations and which is also usable with a blank film. The film 1 travels between two electrodes which are constructed as a condenser. As a result of the change in dielectric strength in the presence of a perforation, the capacity of the condenser changes. As this condenser forms part of a resonant circuit of an oscillator 43, an impulse for controlling the motor 9 can be generated by a frequency discriminator connected to the oscillator 43 each time the oscillator frequency assumes a value significant of the presence of a perforation between the condenser electrodes. One can also so arrange the oscillator 43 that it only oscillates to generate a control pulse for the motor 9 when a perforation lies between the electrodes of the condenser 42.

According to Figure 10 there is provided an information carrier, constructed as a disc 45, for a synchronous production of the desired impulses. The disc is driven by a sprocket wheel 46 whose teeth 47 engages in the film perforations.

The impulses are represented on the disc 45 as cut-outs 48, 49 provided in a control track on the margin of the disc. These cut-outs are illuminated by a schematically depicted projection system having a small lamp and a lens 51, in such a way that light from the projection system falls on a photoelectric transducer 52. The transducer delivers a stronger or weaker output signal which varies continuously with the strength of the light allowed through the cut-outs 48, 49. In the case of the sawtooth-signal-forming cut-out 48, the output signal of the transducer 52 will also exhibit a sawtooth development and, after the attainment of a certain level will fall suddenly again to zero so that, a galvanometer constructed as in Figure 3, for example, is returned to an initial position under the action of the force of a restoring spring 24. In order to prevent a swing of the galvanometer coil frame 23 in this case, a braking impulse is supplied subsequently to the frame by means of the cut-out 49. The described arrangement gives rise to the advantage that the control track formed by the cut-outs 48, 49 is not subjected to wear. In the case of a magnetic recording control track or the employment of a sound groove, it is preferable if several information tracks of the same kind are provided whereby the appropriate track-reading device can be switched from one track to the next, should track wear make it necessary.

Figure 11 illustrates another arrangement in which four different control tracks are provided on an information carrier not shown in detail. Sawtooth waves are recorded on the track 53, which serve as the tilt control of the mirror 8 with forward movement of the strip, whereas the track 54 contains oppositely directed sawteeth for enabling projection to occur during reverse running of the film. The double impulses which are provided in the track 55 are supplied to the electric motor oscillatory system either directly, for example by means of a second galvanometer coil winding, or indirectly, by way of a mixing stage. The sawtooth signal 56 finally serves for synchronisation of a sound recording and extends preferably over more than the illustrated impulses, for example over a span of 16 impulses.

In Figure 12 a disc 57, arranged in much the same way as the disc 45, is formed with recorded tracks 53—55, two of which are partly shown which in the illustrated embodiment are read by means of magnetic pick-up heads 58—60. This results in accordingly simple switching from the track 53 to the track 54 by reason of the fact that a control switch 61 has two contacts 62, 63 respectively arranged in the current circuits of the magnetic heads 59, 60 and which operate in reverse senses so that when one is open the other is closed. In this way mechanical displacement of the read-out arrangement from one track to another is avoided.

It is advantageous from a practical viewpoint, especially with optical scanning of a record formed on a data carrier, if there is present in the track 64 (see Figure 13) the impulse effective in one direction, that is to say to have recorded thereon the saw tooth as well as the braking impulse; whereas the fly-back impulse is in the track 65 and is effective in the reverse direction. In that case a positive impulse of combined signals is supplied by the track 64 and the track 65 supplies a negative impulse of combined signals.

In addition to the employment of frequency-modulated recordings on a carrier, there is provided for the arrengements, such are as illustrated in Figures 6—8, a regulator controlling the amplitude of the double impulse generator in accordance with the film velocity and also, if the occasion arises, the amplitude of the sawtooth generator 29 by adjustment of the resistances of the regulators 32, 33 and 30, 31, respectively. In this case these resistances can be constructed as centrifugally controlled resistors as may be visualised from the schematically shown arrangement in Figure 14 where a centrifugal governor controls the tapping

points of two resistors disposed on diametrically opposite sides beneath the governor.

A further form of control for use with the invention is illustrated in Figure 15. In this case a lamp 5 is again provided for illuminating the perforation of a film strip 1, whereby the image of the perforation is projected onto a generally rectangular photo-electric transducer 67 by means of a schematically indicated optic 10' and a screen 66 formed with a slit. A vignetting mask 68 is disposed between the screen 66 and the transducer 67 and is formed with a triangular slot 69 which limits the length of the slit image projected onto the transducer 67, in accordance with the position at which the image appears. During the movement of the film 1 over a film gate (not shown), the projected images of the slit in the screen 66 travel in corresponding manner over the vignetting mask 68, the transmitted slit images maintaining lengths corresponding to the breadths of the triangular slot 69 and producing from the transducer 67 a larger or smaller output signal that possesses a sawtooth wave shape as a consequence of the triangular slot 69. The sawtooth, so formed is led through a threshold limiting switching circuit 70, for example a Schmidt-Trigger, which triggers operation of a double impulse generator 38 on one side and extends on the other side to a mixing stage 34 in which the sawtooth waveform and the double impulse are mixed. The outgoing signal controls, again by way of an amplifier 35, a mirror-tilting electro motor 9.

Within the scope of the invention many different constructions are imaginable. For example it is possible to record an impulse, shaped as shown in Figure 5, from the outset directly onto a pilot track on the film. In a system not requiring a fly-back force, the sawtooth can also have zero gradient i.e. have the same current magnitude. Such a system is illustrated in Figure 16 where parts having the same function as corresponding parts in Figures already described, bear the same reference numerals. Here also, the film 1 is pulled across the film gate 2 containing the windows 3 at a uniform speed. The drive is obtained from a drive roll A which co-operates with a roller 4. Remote from the window 3, the film gate is additionally formed with another opening or slit 3a in which the toe of a film feed claw 73 can engage. The film feed claw 73 is supported on a claw arm 72 and is pressed by an angle spring 74 towards the film 1 and its perforations, respectively. The claw arm 72 is attached to the coil 23 of the galvanometer 9 on the pivot 22 of which the mirror 8 is fastened by means of a holder 76 and a clamping screw 71.

The galvanometer is suitably constructed without a restoring bias and its film-following motion is controlled by the claw 73. To this end it continuously receives from the double impulse generator a voltage U_3, see Figure 17. The voltage U_3 ensures that the claw 73 is not dragged from the perforation of the film momentarily engaged, as formerly commonly occurred. On the contrary, the leading end of the claw 73 lies against the leading edge of the momentarily engaged perforation, looking in the direction of movement of the film, instead of being pulled as formerly. The thrust of the claw 73 is naturally very small indeed and is only just sufficient to hold the leading end of the claw 73 in position at the forward end of the engaged perforation. It is thus assured that the side of the momentarily-engaged perforation engaged in the projector is the same side as that engaged by the film drive claw in the camera. In this way tolerances in the spacing of the perforations do not affect the positioning of the mirror.

At the end of the movement of the claw 73 and claw arm 72 synchronised with the film speed, a lug 77 formed on the arm 72 intercepts a light path extending across the direction of movement of the lug 77. In Figure 16 is shown an assembly associated with the light path comprising a lamp 78 and a photo-sensitive device 79 shown in front of, and behind the arm 72 respectively, nevertheless it is clear that these parts are arranged across the path of the lug 77. The arrangement of the light path assembly is not essential to the invention.

As well as the arrangement where the lamp 78 is arranged on one side of the lug 77 and the device 79 is arranged on the other, one can also arrange for the lamp 78 and device 79 to lie on the same side of the lug 77, in this case the device 79 receiving light by way of a mirror formed, for example, by a reflecting surface on the lug 77. In each case a change in the output of the device 79 is produced by the lug 77 in the beam-interception position, whereupon fly-back impulse with a voltage U_1 and braking impulse with the voltage U_2 are released by a switching stage 80. As is obvious, when the claw 73 is constructed as a pawl with a slanting trailing surface, it does not require an additional arrangement in order to reposition the galvanometer coil 23 and the claw arm 72 and extract the claw 73 from the perforation. It is clear that the moment of the claw arm 72 on the coil pivot 23 should be compensated. Also the galvanometer 9 is correspondingly damped, for example by utilising a short-circuited coil and/or by designing the amplifier 35 with a very small output impedance. To attain an effective electrical damping a sufficiently strong magnetic excitation of the galvanometer is necessary. For example, the field strengths

in question should approach around 5000 gauss.

A further problem with utilising a claw lies in the fact that, with its angular movement, for example corresponding to one frame on the film 1, the mirror 8 although mounted on the same axis, is required to move through only half the angle of the claw arm 72 as the angle between the incident and reflected beam on the mirror is doubled. This problem may be solved in different ways.

In the example illustrated schematically in Figure 16, the mirror 8 is part of an optical system having a forward lens group 10 and a rear lens group 10a. This optical system produces a telecentering effect on the light path, whereby the mirror 8 is arranged approximately in the zone of highest concentration of the light beams from the lens 10 so that it can be made very small.

The object distance g between the forward lens group 10 and the picture window 3 corresponds in the illustrated example to the focal length of the lens group 10, so that a parallel beam of light is produced behind the lens group 10. An exceptional freedom from distortion is achieved by the utilisation of the set forth optical system, enabling the mirror 8 to be extremely small. The radius r of the claw arm 72 with the claw 73 is now dimensioned, according to a development of the invention, to be twice as large as the focal length of the lens group 10. In this way not only is the solution to the above-mentioned problem found, namely a mechanically-free ratio between the movement of the claw with the radius r and the movement of a film frame with the effective optical radius corresponding to the focal length g, but besides one also has a greater freedom regarding the disposition of the slit 3a in the film gate. The dimension of the radius r corresponding to twice the focal length g can exhibit tolerances of $\pm 10\%$. With the use of a telecentered beam paths in the illustrated manner, there is achieved in addition to negligible aberration a reduction in the importance of the tolerances to an insignificant level.

As is known, standards govern the spacing between the claw operating slit and the film gate of a camera. For example, in accordance with one of these standards the claw slit should lie between two and three perforation ahead of the picture window. These regulations can be applied in corresponding manner to the apparatus of the invention by designing the length of the claw arm 72 in the described way. It is thus a question of a projector having the advantage that the claw 73 actually occupies the same position which the claw in the camera occupied. Also, by this means, a greater precision in the guiding movement of the mirror is achieved.

As mentioned, the galvanometer is advantageously constructed without a restoring bias. It is clear from the above description, that the claw arm 72 is not required to apply any mechanical force. For this reason the claw arm 72 may be formed as a slender needle. Its mass is therefore extremely small. If desired, it is also readily possible to apply a biasing force in one or other direction. This biasing force operates, referring to the galvanometer in Figure 16—in the clockwise sense, so that it is necessary to apply to the galvanometer a sawtooth voltage in place of the constant voltage U_3. On the other hand, if the biasing force is applied in the counterclockwise direction, the voltage applied in the time t, (Figure 17) can be reduced. In circumstances when the mechanical biasing force is of the same magnitude over the entire angular range of movement of the claw it is sufficient to reduce the applied voltage in the time t_1 to zero but if the mechanical restoring bias has a varying magnitude, the voltage in the time can be correspondingly shaped, for example, as an oppositely directed sawtooth to the sawtooth illustrated in Figure 5. The time intervals t_2, t_3 shown in Figure 17 correspond to the time intervals T_1, T_2 in Figure 5.

The above-described dimensioning of the length of the claw arm 72 may be also applied to another optical system which does not employ telecentered optical paths, as is shown in Figure 18. To avoid greater distortion, it is advisable to give the film gate 2 a double curvature, namely in the region of the picture window 3 a curvature with the optical radius R', whereas in the regions adjacent to the picture window 3 and/or in the region of the slit for the claw insertion (3a in Figure 1), a curvature approximating to the radius r' of the claw arm 72. It is also evident from Figure 18 that the mirror 8' must be made substantially larger when employing an optical system without telecentered optical paths.

It is not necessary to use the light assembly shown in Figure 16 in order to trigger release of the double impulse when the claw 75 reaches its terminal position. In the case in question a solution by means of contacts is possible. A magnetic field dependent resistor 81 (Figure 19) can be provided on the movable part of the galvanometer 9 inside the magnetic field, the resistor triggering the release of the double impulses by way of a switching stage. With the circuitry shown in Figure 19 a steady voltage corresponding to the voltage U_3 is supplied to a mixing stage 34, onto which, in this case, is superimposed the double impulse from the double impulse generator.

Although it is especially useful to use a claw for synchronizing the movement of the mirror with the movement of the film, it

should not pass unnoticed that in addition to the above-mentioned possibilities other arrangements are also conceivable. It is, for example, possible also to scan the film perforations in an optical light beam. Such scanning is conceivable for copies in which, as is generally the case, the film in the region of the perforation is transparent as even a transparent film will absorb a portion of the light passing through it. Furthermore a portion of the light beam incident on the film is reflected back. By means of both of these effects, namely absorption and reflection, is the detection of the perforation possible.

A further possibility is illustrated in Figure 20. The arrangement shown is in this case similar to that of Figures 1 and 6. Here also, light from a lamp 5 is projected by way of a condenser 7, the picture window and the tilt-mirror 8 onto a screen 11*a* of, for example, a television tube. Conforming likewise to the block diagram of Figure 6, are an amplifier 15, a sawtooth generator 29 with resistor 31 for amplitude adjustment, a mixing stage 34, output amplifier 35 and double impulse generator 38. In the illustrated example of Figure 20, however, the synchronizing control is to the same extent modified as a semi-reflecting sheet 82 is additionally provided in front of the tilt-mirror 8, the reflected beam from the sheet 82 being directed through an objective 83 and a screen 84 to a photo diode 85. In this manner the photo diode 85 receives light transmitted through the perforated margin of the film and so scans the perforations of the film in order to control the previously described circuitry. A further semi-reflecting sheet 86 is provided between the tilt-mirror 8 and the screen 11*a*, to direct light through an objective 87 and a screen 88 with a rectangular opening onto a flat sensitive surface of a photo diode 89. The screen 88 has its opening so constructed that, during projection, the picture of the perforation falls partially on the screen 88 and partially through its opening onto the photo diode 89. When the motion of the picture past the tilt-mirror 8 is correctly compensated, a constant voltage to the arrangement is provided at the output of photo diode 89. Every error in the optical compensation is detected by a decrease or increase, respectively, in the signal output voltage of the photo diode with reference to the desired voltage. The output signal from the photo diode 89 is then processed in a differential amplifier 90 which receives a reference voltage from a further photo-electric transducer 91 illuminated directly by the lamp 5. If the scanning of the picture is error-free, the differential amplifier 90 delivers a standard voltage of value 0. In either case, however, the output of the amplifier 90 becomes greater or smaller, a positive or negative control voltage is made available which is supplied to the sawtooth-generator 29 and used to control the steepness of the sawtooth. Should, therefore, the the former steepness setting of the sawtooth generator not precisely agree, such setting is brought back to the optimum value by means of the illustrated control circuit. Moreover, synchronous oscillations of the film can also be compensated by this control circuit.

In the arrangement of Figure 21 the film 1 is led along an arcuately curved path by means of a film gate (not shown). The film is continuously driven by means of a driving arrangement exemplified by a capstan A with a pressure roller 4.

The tilt-mirror 8, rockable about the axis 22, is disposed in the geometric centre of the arcuately curved path and in the path of a light beam from the light producing assembly 5, 7. A film picture is projected by the light generating assembly 5, 7 onto a conjugate flat surface 11 with the help of the tilt-mirror 8 which follows the movement of the film picture. The details of the projection arrangement not essential to the invention are only schematically depicted.

The drive for the tilt-mirror is obtained from an arm 72 connected to the mirror 8 and rockable around the axis 22, a known drag-claw 110 being carried by the arm 72. The drag claw locates in the perforation of the film and participates in its movement once for each frame of the film. The drag claw is turnable about an axis 111 and is held by a spring 112 in a position at which it engages a stop 113. At the end of the participating movement of the drag claw 110 and the arm 72, a fixed stop 114 pushes in the leading face of a limb of the drag claw 110 against the weak thrust of the spring 112, whereby the claw is extracted from the film perforation. The arm 72 then returns quickly to its original position under the action of a spring which, referring to Figure 1, gives the arm 72 a turning movement in the clockwise direction.

At the end of its returning movement the mass of the arm 72 and all the masses attached to it must be braked. This is the more critical as the fly-back time ought to be kept very short and also high velocities occur. The braking occurs, in accordance with the embodiment of the invention, through the use of a buffer 115 whose mass related to the impact point P between the arm 72 and the buffer 115 is selected to equal the magnitude of the mass of the arm 72 and the masses connected to it. Thus at the end of its motion the arm 72 strikes against the buffer so that the arm 72 is brought to a standstill and the entire energy of the arm 72 is transferred to the buffer 115 where it is absorbed by a spring 116. The buffer 115 is subsequently moved by the spring 116 back towards a cushioning stop

117. There is sufficient time with the arrangement for the return motion of the buffer 115 because the arm 72 has in the meantime recommenced its correspondingly slow forward movement.

In order to prevent unwanted turning moments occurring with the impact of both masses, it is advantageous if the impact point lies substantially on a line *b* which connects the centre of inertia M and S of the arm 72 and the buffer 115 respectively to one another. The entire mass of the arm 72 together with the masses connected to it can be through of as lumps concentrated at the centre of inertia M, and the same is valid for the centre of inertia S of the buffer 115. In the embodiment of the invention shown in Figure 21, the above advantage is realised by the buffer 115 being attached to an arm 118 which turns about the same shaft 22 as the arm 72. In such a construction it is under some circumstances advantageous for the pivot shafts of the arm 72 and the buffer 115 to be structurally separate from one another, however in axial alignment.

The invention is however in no way limited to the illustrated arrangement of buffer. It is sufficient, for instance, that the location of the impact point A is arranged where the path of movement of the buffer 115 is tangential to the arc with the radius of gyration of the arm 72.

Figures 22 and 23 expain in detail examples of such an arrangement. In Figure 22 an arcuate path *b'* is provided for the buffer 115*a* which has a centre of inertia S and which is attached to an arm 118*a* so as to be swingable about a pivot point W. On the other hand the centre of inertia of the claw arm 72 swings along an arcuate path *b''*. As is apparent, the arcuate paths meet one another tangentially.

The pivot point W need not necessarily be arranged in the illustrated manner. It could, for example, also lie in the region of the pivot shaft 22 to result in a very flat interscetion of the arcuate paths *b'* and *b''*, respectively.

In the illustrated examples of Figures 21 and 22, the masses of the buffers 115 and 115*a*, respectively, as referred to the impact point P are determined from the formula for calculation of a moment of inertia:—

$$J=mr^2$$

where J is the moment of inertia, *m* is the mass of the buffer, and *r* is the distance of the centre of inertia from its axis of rotation. As also the mass referred to the impact point P depends on the radius *r*, the mass *m* can be kept proportionaly small. As Figure 23 shows, this is however not an essential prerequisite for the invention. In accordance with Figure 23 the centre of inertia M of the arm 72 again follows an arcuate path *b''*, whereas the buffer 115*b* is guided linearly so that its centre of inertia coincides with its centre of gravity and follows a linear path *s*. The arrangement of Figure 23 could also be carried out in the reverse manner, in that the mass connected with the mirror 8 is guided linearly and the buffer 115*b* is turnable about a pivot. It is lastly also possible to have both masses guided along linear paths. In order to prevent undesirable oscillations which may arise with the impact of the buffer 115 on the cushioning stop 117, it may also be expedient to brake the buffer 115 by means of a brake and finally, by the use of a separate drive, to bring it gently against the stop 117.

It may be here once again observed that the arcuate construction of the film path and the location of the mirror 8 in the centre of its curvature require special measures in order to ensure that, with progression of the film through one film frame, the deviation of the mirror 8 corresponds solely to a half film frame. These requirements stem from the known doubling of the angle defined between the incident and reflected light rays and referred to the tiling angle of the mirror. It is also apparent from Figures 24 and 25 that one can forego a special spring for the fly-back of the claw arm 72 if the shaft 22 is formed by a torsion bar which has one end fixed and the arm 72 clamped to the other end while the mirror 8 is attached to the centre. In this case the torsional movements at the centre of the torsion bar amounts to precisely half the torsional movement at the clamping point of the arm 72. Possible inaccuracies can be adjusted out by displacement of one of the fixtures, preferably the claw arm clamping fixture.

Figure 25 expains how the individual parts are connected to the torsion bar 22. The torsion bar 22 is fixed by means of a grub screw 215 in a pedestal 216. The pedestal is slidable lengthwise of the axis of the torsion bar 22 inside a slot provided in a base plate 217 and is positionally fixed by means of a bolt 218. The attachment point for the grub screw 215 can be displaced along the axis of the torsion bar 22 by sliding the pedestal 216 after the screw 215 and bolt 218 have been slackened.

The claw arm 72 is attached to the other end of the torsion bar. The arm 72 can also be displaced along the axis of the torsion bar 22 to make adjustments, after loosening of its clamping screw 119.

As is shown, the spacing between the attachment points of the screws 215 and 119 is 2*a*. In the illustrated example, the mirror is fixed a distance *a* from the attachment

points of the screws 215 and 119, respectively, by means of a clamp 120 having a clamping screw 121 so that the mirror is also fixed in the middle of the torsion bar 22. As the torsion bar 22 is fixedly held at one end in the pedestal 216 whereas its end to which the claw arm 72 is attached participates in a torsional movement corresponding to the turning movement of the arm 72, the torsional movement in the middle of the torsion bar 22 is exactly half. In this way an angular movement of the arm 72 amounting to an angle α is transmitted to the mirror in the ratio $\alpha/2$. In this manner not only is the desired reduction of the arms movement achieved, but also beyond that one is saved the provision of special spring for the return motion of the arm 72 and the mirror 8, respectively.

Numerous variations within the scope of the invention are conceivable. In particular, other proportionate reductions of the arm-to-mirror movement can also be obtained in suitable ways. An adjustment can be achieved equally well through shifting the pedestal 216 as through shifting the mirror 8 together with its attachment, and also, if the occasion arises, by shifting the arm 72 lengthwise of the axis of the torsion bar 22.

Referring to Figure 26 and 27 a shaft 301 is provided on a small film projector whose individual parts are not illustrated, the shaft carrying a sprocket wheel 302 constructed in conventional manner. Furthermore a tilt-mirror 303 is pivoted for swinging movement about axle pins 304, 305. The tilt-mirror 303 is biased in a counterclockwise direction (see Figure 26) by an angle spring 306 shown in Figure 27. The axle pins 304, 305 project into support bores provided in support cheeks 307, 308. In this way the mirror is lightly pivotably turnable and possesses a small mass.

Two sensing levers 309, 319 are pivotted on the axle pin 304, which by means of cam followers 311, 312 ride on respective cams 313, 314 attached to the shaft 301. Consequently the sensing levers 309, 310 perform oscillatory movements around the axle pin 304 while following the camming profiles of the cams 313, 314. Figure 28 shows the arrangement of the sensing levers 309, 310 in exploded form. It is apparent that the camming profiles of the cams 213, 314 are angularly displaced about half a cam projection with respect to one another.

Two pawl carriers 315, 316 are pivoted to the axle pin 303 and operate between the tilt-mirror 303 and the sensing levers 309, 310. As is clearly shown in Figures 26 and 28 the axle pin 304 passes in this case through elongated slots 317, 318 formed in both pawl carriers. The pawl carriers 315, 316 are biased on the one hand by tension springs 319, 320 and are braced on the other hand by extensions 321, 322 which rest on studs 323 and 324, respectively, provided on the sensing levers 309, 310. In this way the force of the bias springs 319, 320 is not only exerted by way of the extensions 321, 322 and the studs 323, 324 on the sensing levers 309, 310 whereby it is assured that the cam followers 311, 312 follow the cams 313, 314, but also the pawl carriers 315, 316, which slide easily within limited ranges of movement determined by the elongation of the slots 317, 318, are pulled downwards with reference to the positions shown in Figure 26.

The pawl carriers 315, 316 are provided with pawls 325, 326 which are arranged alternately to engage the tilt-mirror 303. In this way it becomes possible for one of the sensing levers to execute a slow movement in the clockwise direction during which it slowly turns the tilt-mirror 303 by way of the associated pawl. At the end of this movement the pawl becomes disengaged to allow the mirror 303 to return quickly to its initial position under the action of the angle spring 306, the other sensing lever having meanwhile arrived at the initial position. The latter sensing lever then engages the mirror whereas the former sensing lever turns slowly back to the initial position. Large inertial forces are thus avoided in connection with which the fact that the cams 313, 314 are arranged on the shaft 301 of the sprocket wheel 302, which is driven in synchronism with the film, ensures synchronous motion of the camming profiles and the film.

In order to ensure the alternate engagement of the pawls 325, 326 on the mirror, the pawl carriers 315, 316 are respectively provided with control levers 327, 328. The control levers 327, 328 are turnable about a pivot shaft 329. Control cams 330, 331 are provided to control the movements of the control levers 327, 328 which ride on such control cam profile, respectively, as shown in Figure 26. The control cams 330, 331 are displaced a half division from one another in similar manner to the cams 313, 314.

At one side of the control levers 327, 328 lie on the control cams 330, 331 and on the other side on the pawl carriers 315, 316. Projecting camming surfaces on the control cam 330, 331 respectively produce an angular lar movement of respective control levers in the counterclockwise direction to displace the associated pawl carriers 315, 316 together with their respective elongated slots 317 318 in relation to the axle pin 304.

With the counterclockwise movement of one or other of the control levers 327, 328, displacement of the associated pawl carrier 315, 316 occurs upwardly (as shown with pawl carrier 315 in Figure 26) against the force of its respective tension spring 319, 320 thereby advancing the time of disengage-

ment of the respective pawls 325, 326 with the mirror 303. The mirror 303 is then turned in the counterclockwise direction under the action of the angle spring 306 and brought back to its original position in which it is operatively engaged by the pawl of the other pawl carrier. The tilt-mirror 303 then executes a fresh pivoting motion under the action of this latter pawl.

In order to avoid vibration of the mirror with engagement of the pawls 325, 326, the pawls are suitably provided with a springy portion of the same mass as the tilt-mirror 303. At the moment of impact of the tilt-mirror 303 on this springy portion, the movement is transferred from the mirror 303 to the springy portion in accordance with the laws of elastic impact in such a way as to enable the mirror to be moved by the individual pawls without further oscillatory movement. To attain this result, namely absorbing the kinetic energy of the mirror in such a way that there is no 'bounce' when it strikes the pawl, it may be expeditious to arrange for controllable adjustment of the pawls 325, 326 and/or the abutment of the control levers 327, 328 on the control cams 330, 331 and/or on the pawl carriers 315, 316.

WHAT WE CLAIM IS:—

1. Film handling apparatus having a film gate and a film drive for transporting the film in a continuous manner through the film gate; an optical deflector having a deflecting drive for compensating the continuous movement of the film through the film gate, the deflecting drive producing a forward motion of the deflector to follow movement of the film and a flyback motion which is relatively rapid compared with the forward motion; an arrangement for synchronizing the deflecting drive with the film drive; and energy transfer means effective during a terminal stage of the flyback motion to extract a quantity of energy from the moving deflector substantially equal to its dynamic energy so that the deflector is decelerated rapidly at the end of the flyback motion without bouncing and without friction braking and comes to rest at a predetermined position from which it is to commence the next forward deflecting motion.

2. Apparatus as claimed in claim 1, in which electrical impulses control the drive for the deflector whose forward motion is controlled by synchronizing markers on the film scanned by a sensing device, and whose return motion is controlled by a second pulse part which is in the opposite sense to a first pulse part producing the forward motion.

3. Apparatus as claimed in claim 2, in which the markers comprise perforation holes of the film.

4. Apparatus as claimed in claim 2 or 3, in which the deflecting drive is an electrically operated motor to which are applied sawtooth shaped first pulse parts which are respectively followed by the second pulse parts.

5. Apparatus as claimed in claim 4, in which the second pulse parts are followed by a third pulse part which provides said energy.

6. Apparatus as claimed in Claim 4 or Claim 5, in which the second and third pulse parts are provided by a double impulse generator and are supplied to the deflector drive through a mixing stage which also receives the sawtooth shaped first pulse parts.

7. Apparatus as claimed in any one of Claims 2 to 6, in which the sensing device initiating generation of the pulse parts is continuously dependent on the velocity of the film.

8. Apparatus as claimed in Claim 7, in which the sensing device comprises a rotary information carrier driven by a sprocket wheel over which the film passes, and travelling past a read-out position where information is read from the carrier.

9. Apparatus as claimed in Claim 8, in which the three pulse parts are provided on one and the same information carrier.

10. Apparatus as claimed in Claim 9, in which the information carrier is a disc.

11. Apparatus as claimed in Claim 9 or Claim 10, in which the information carrier is formed with at least two tracks.

12. Apparatus as claimed in Claim 11, in which at least a portion of the tracks provided on the information carrier contain similar data.

13. Apparatus as claimed in Claim 11, in which at least one track provides an oppositely directed sawtooth waveform to a second track, for use during projection of the film during reverse running and a selector arrangement is provided and is operable to select which of the tracks is to be used at the read-out position, in accordance with the running direction of the film.

14. Apparatus as claimed in Claim 13, in which two similar pick-ups are provided at the read-out position and are associated with respective tracks, the selector arrangement selecting the pick-up which is to be used.

15. Apparatus as claimed in Claim 14, in which the selector arrangement comprises a change-over switching circuit controllable by the running direction of the film and connected to both pick-ups, operation of the switching circuit determining which of the tracks is to be read.

16. Apparatus as claimed in Claim 11, in which one tracks provides a first impulse for operating the deflector drive in one direction, and the other track provides a second impulse for operating the deflector drive in the opposite direction.

17. Apparatus as claimed in Claim 16, including separate electrical connections

through which the first and second impulses are respectively supplied, as desired, to the deflector drive.

18. Apparatus as claimed in Claim 17, in which the deflector drive comprises a ballistic galvanometer having a moving coil frame provided with separate windings connected respectively to receive said first and second impulses.

19. Apparatus as claimed in any one of Claims 11 to 18, including a further track on the information carrier formed with a track synchronizing signal for a sound recording.

20. Apparatus as claimed in any one of Claims 2 to 19, in which the amplitudes of the pulse parts are a function of the film velocity and a control arrangement enables adjustment of such amplitudes.

21. Apparatus as claimed in Claim 20, in which the control arrangement includes a centrifugally controlled circuit dependent on the film velocity.

22. Apparatus as claimed in any one of Claims 9 to 21, in which the information carrier provides the pulse parts as a frequency modulated signal which is read by a pick-up arrangement and supplied to a frequency discriminating circuit providing an output which varies with the input frequency.

23. Apparatus as claimed in Claim 22, in which the pick-up arrangement includes a magnetic pick-up head for reading a magnetic track recorded on the information carrier.

24. Apparatus as claimed in any one of Claims 2 to 23, including a sawtooth generating assembly providing an output to a threshold trigger circuit controlling a double-impulse generating circuit.

25. Apparatus as claimed in Claim 24, in which the threshold trigger circuit is a Schmidt trigger circuit.

26. Apparatus as claimed in any one of Claims 2 to 25, having a projection assembly for directing light through perforations of the film towards a photo-electric receiver which provides an output signal of different magnitudes in accordance with the incidence on different surface portions of light of the same intensity.

27. Apparatus as claimed in Claim 26, in which the receiver is provided with a triangular or trapezoidal light-sensitive surface to be illuminated by way of a screen having a slit extending parallel to the base of the triangle or the parallel sides of the trapezium, whereby the motion of the perforations through the light produce s sawtooth output waveform from the receiver.

28. Apparatus as claimed in Claim 27, in which the light-sensitive surface of the receiver to be illuminated has the triangular or trapezoidal shape imparted to it by way of a vignetting mask having a slot of triangular or trapezoidal shape through which passes the light incident on the receiver.

29. Apparatus as claimed in Claim 26, in which the receiver is provided with two photo-electric detectors lying adjacent one another and between which the light transmitted through a perforation is incident by way of the deflector, both detectors being operatively connected to the deflector drive motor to control its movement.

30. Apparatus as claimed in Claim 29, in which correct synchronism of the movements of the film and deflector is accompanied by the illumination of both detectors whereas a phase difference between the movements its accompanied by preferential illumination of one detector with respect to the other and the transmission of an error-connecting signal to an appropriate winding of the deflector drive to reduce the error to zero.

31. Apparatus as claimed in Claim 2, in which an electrical supply circuit to the deflector motor is controlled by the output frequency of an oscillator which is controlled by a capacitor having its two electrodes disposed, respectively, on opposite sides of a path of movement of perforations on the film.

32. Apparatus as claimed in Claim 29 or Claim 30, in which the sawtooth electrical waveform controls the motion of the deflector in the running direction of the film, and the instantaneous magnitude of the sawtooth is controlled by the receiver.

33. Apparatus as claimed in Claim 31, in which a sawtooth waveform generator controls with its sawtooth output the motion of the deflector in the running direction of the film, and the instantaneous magnitude of the sawtooth is controlled by the electrical capacitance of the capacitor.

34. Apparatus as claimed in any one of Claims 2 to 32, in which the movement of the deflector drive is liquid-damped.

35. Apparatus as claimed in any one of Claims 2 to 32, in which the deflector drive is formed as a galvanometer having a moving coil assembly which is supported by a torsion spring of generally cruciform cross-section.

36. Apparatus as claimed in any one of Claims 2 to 35, in which the deflector drive has effectively no restorfing bias and a mechanical scanning mechanism connected to the drive is provided to scan the film perforations, the electrical drive to operate the deflector in the scanning direction comprising a pulse part having substantially zero gradient.

37. Apparatus as claimed in Claim 36, in which the scanning mechanism comprises a sensing arm rotated by the drive and having a claw to locate in the film perforations to maintain the motion of the deflector in synchronism with the motion of the film.

38. Apparatus as claimed in Claim 36 or Claim 37, in which the scanning mechanism forms part of switching circuitry for triggering operation of a double impulse generator and which responds to the position of the scanning mechanism.

39. Apparatus as claimed in Claim 38, in which the switching circuit is triggered electronically when the scanning mechanism is in a position corresponding to termination of the scan.

40. Apparatus as claimed in Claim 38 or Claim 39, in which the scanning mechanism position is sensed by it intercepting an optical path of a light beam.

41. Apparatus as claimed in Claim 38 or Claim 39, in which the scanning mechanism position is sensed by its influence on the capacitance of an electrical capacitor.

42. Apparatus as claimed in Claim 38 or Claim 39, in which the scanning mechanism position is sensed magnetically.

43. Apparatus as claimed in Claim 42, in which said position is signalled by a magnetic-field-sensitive element arranged in a magnetic field and the deflector drive motor and moved with the scanning mechanism.

44. Apparatus as claimed in Claim 43, in which the element is a magnetic-field-sensitive resistor.

45. Apparatus as claimed in Claim 1, in which the deflector is braked by a buffer and their masses, referred to their impact point, are chosen to be the same.

46. Apparatus as claimed in claim 45, in which the impact point lies substantially on the line passing through the centres of inertia of both masses at the moment of impact.

47. Apparatus as claimed in claim 46, in which one mass swings around an arc centred at a first point, the other mass follows an arcuate path of movement which is tangential to the arc at the impact point of the two masses and which has a radius equal to the radius of gyration of the swinging mass.

48. Apparatus as claimed in claim 47, in which both masses move around the same axis and have the same radius of gyration.

49. Film handling apparatus as claimed in claim 1, in which the optical deflector is provided by a tilt-mirror to compensate optically for movement of the image picture of a perforated strip guided around an optically smooth part-cylindrical surface, the tilt-mirror being driven to turn about an axis provided by a torsion bar having at one end a first fixture holding the torsion bar end stationary, intermediate its ends a second attachment fixture on which the tilt-mirror is mounted, and at its second end the torsion bar is provided with a third fixture to which is attached a mechanism which arcuately moves the mirror by engaging a perforation of the film strip while travelling around the cylindrical surface which is centered on the axis of the torsion bar.

50. Apparatus as claimed in claim 49, in which at least one of three attachment fixtures is slidable axially relative to the torsion bar for adjusting the angular movement of the tilt-mirror with respect to the mechanism.

51. Film handling apparatus as claimed in claim 1, the optical deflector tiltable to follow motion of a moving strip and driven through a drive coupling having two couplers which operate in succession to each produce a relatively slow forward follow motion of the deflector, each coupler being decoupled from the mirror on completion of the slow forward motion and a further drive then returning the deflector rapidly to its initial position where it is engaged by the second coupler to execute a second forward motion during which the first coupler returns to its initial position, said energy transfer means comprising a springy pawl portion formed on each coupler and struck by the deflector at the end of the return movement.

52. Apparatus as claimed in claim 51, in which the deflector is a tiltable mirror, the couplers comprise cam-following levers, and the second drive for the rapid return of the mirror is provided by a spring.

53. Apparatus as claimed in claim 51 or claim 52, in which the couplers are positionally controlled by respective coaxially arranged cams driven by the same drive and of identical profiles although offset angularly, with respect to one another, by the angle

$$\frac{360}{N}$$

where N=the number of cams having associated couplers for producing forward motion of the deflector.

54. Apparatus as claimed in claim 53, in which each coupler is independently movable tangentially of its cam against the bias of a spring and is provided with a slot through which passes a fulcrum around which the coupler turns and which moves relatively along the slot during such tangential movement, the position of the fulcrum in the slot being determined by a control lever which is borns on at one end by a control cam driven in synchronism with the coupler cams and bears at its other end on the coupler.

55. Apparatus as claimed in claim 52, in which the axis about which the deflector turns is eccentric with respect to the axes of the couplers.

56. Apparatus as claimed in claim 55, in which the pawls are independently adjustable to alter their radii of rotation with respect to the deflector.

57. Apparatus as claimed in claim 55 or

claim 56, in which the pawls are respectively mounted on two arms which operate alternately and have claws to engage with perforations of the strip.

58. Apparatus as claimed in claim 1, arranged and adapted to operate substantially as described with reference to any one of the embodiments shown in the accompanying drawings.

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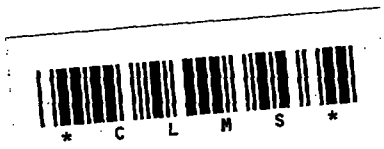
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