ABSTRACT

A movie projector has flickerless forward and reverse film advance at speeds determined by a Geneva intermittent drive mechanism controlled by a rotary timing disc driven at a rate proportional to the film feed rate. Independent servo-driven film supply and takeup reels are each controlled by a swinging arm which senses the length of film stored in the film supply and takeup loops allowing film buildup or excess to discharge to maintain the proper film loop length for gentle handling. Excessive arm movement is minimized by employing a reverse drive pulse of the reel drive motor to dampen oscillations. Photocell sensing of the primary film loops insures smooth film transport without damage to the film.

23 Claims, 14 Drawing Figures
MOTION PICTURE PROJECTOR

This application is a continuation of U.S. Pat. application Ser. No. 787,684, filed Dec. 30, 1968, under the title MOTION PICTURE PROJECTOR, now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

Motion picture projectors commonly employ either rectilinearly movable or rotary disc shutters. Rotary disc shutters run continuously in synchronism with the film feed rate and have an aperture which registers with each film frame to give flickerless projection of the image. The present invention pertains to a camera or projector which employs a Geneva gear intermittent drive or film pulldown mechanism which synchronizes the film advance in either forward or reverse directions with the rotation of an apertures shutter so as to achieve flickerless projection and high projected frame registration accuracy at all frame rates.

2. Description of the Prior Art

Flickerless projection at various frame rates is not uncommon in 16 mm. projectors. Speed selection is achieved usually by an escapement or braking mechanism coupled to an intermittently driven film carrier having film engaging claws which are reciprocally driven to engage series of perforations in the edges of the film and advance it frame-by-frame in synchronism with the shutter. While satisfactory for 16 mm. film, the reciprocating claw pulldown mechanism has certain mechanical limitations which prevents its effective use on larger film sizes such as 35 mm., 105 mm. and so on. While 35 mm. film is the same thickness as 16 mm. film, it has roughly four times the mass and area. Heat absorption is greater and, due to the greater mass, the larger size film is more fragile and thus more subject to being torn than the 16 mm. size requiring smoother and more gentle handling on the part of the pull-down mechanism.

Also, the fastest known pulldown mechanisms cannot operate fast enough to achieve high-speed frame rates, e.g., 30 frames per second on 35 mm. film. Roughly twice as much 35 mm. film is moved through the film gate per frame per unit time as with 16 mm. film. Presently known pulldown mechanisms have a larger movable mass that cannot be moved fast enough for handling 35 mm. film to achieve the higher frame rates.

High-speed film supply and takeup systems required for 35 mm. film are likewise of different design that is found to be adequate for handling 16 mm. film. Positive film loop sensing of both the primary and secondary feed and takeup loops is desirable in 35 mm. film, to insure minimum film tension across the film gate and at the reel whereas with 16 mm. film, such loop sensing is far less critical due to the inherent greater strength of the film.

The known projectors which employ secondary film loops in the supply and takeup systems are not designed for 35 mm. film. In one respect the storage capacity in the secondary loops is insufficient for handling 35 mm. film without damage to the film. In another respect, the 35 mm. supply and takeup reels are larger than 16 mm. reels causing a greater speed differential during operation between the pulldown rate and takeup and supply rate. Known 16 mm. systems are not equipped to handle the larger film reels.

SUMMARY OF THE INVENTION

The present invention provides an intermittent Geneva pulldown drive comprising an output shaft, a Geneva wheel on the output shaft, a continuously rotating input shaft, a rotating mass driven by the input shaft including a cylindrical locking wheel having a surface discontinuity, a locking segment axially movable to fill the discontinuity of the locking wheel to lock the Geneva wheel against rotation, a Geneva drive pin axially movable to a drive position with respect to the Geneva wheel when the locking segment is ineffective and a reciprocating key normally effective to render the locking segment ineffective and drive pin effective and being selectively operable to render the locking segment effective and the Geneva drive pin ineffective.

The Geneva locking wheel, locking segment, drive pin and key all form part of the rotating mass driven by the input shaft. The locking segment and Geneva drive pin are the only axially movable parts and these are cam driven directly. The effect is to greatly increase the responsiveness of the intermittent drive to changes in speed.

The means to impart axial movement to the locking segment and drive pin include a stationary cam ring. A cam follower on the locking segment is able to follow the surface of the cam ring only during periods when the key is selectively operated to render the locking segment effective and the Geneva drive pin ineffective and conversely the cam follower is disabled when the key is in a position to render the locking segment ineffective and the Geneva drive pin effective.

A lubrication system for the drive comprises a pump driven by the input shaft, an oil reservoir, and an oil passage connecting the pressure side of the pump to an oil outlet above the locking wheel to provide constant lubrication to the Geneva wheel.

Another aspect of the invention is an improved supply and takeup system especially designed to handle the difficulties encountered with 35 mm. and larger size film. In accordance with this aspect of the invention, a supply and takeup system includes independent servo-drives for both forward and reverse directions of the supply and takeup reels. A swinging arm is associated with each reel and carries dual film spools providing dual loop formation for maximum film storage to compensate for differentials in speed between the Geneva pulldown and either the supply or takeup reels. If the pull-down rate and reel speed are in synchronism, the arm assumes generally a mid-position. Where excess film is being introduced either because the supply reel is overspeeding relative to the pulldown or conversely, the latter is in overspeed relationship to the film takeup reel, then the respective dual loop arms move to compensate to prevent overloading the film.

The swinging arms are braked near the inner limit of movement by imparting a reverse pulse to the reel drive motor tending to reverse the direction of arm movement. This prevents excessive oscillation or cycling of the arms and has the effect of increasing the arc in which the arms can swing and still properly control loop formation.

In accordance with this aspect of the invention, a separate motor control circuit for each reel motor is controlled by movement of the associated swinging arm. Rotation of the arm in one direction will set up the motor for reverse rotation. Further movement of the arm toward the inner limit of its travel energizes the motor for reverse running which tends to drive the arm back toward a midposition. A short pulse of reverse rotation is given sufficient to brake the arm and then the motor is deenergized by an interrupting switch. This switch is controlled by a novel slip-drive mechanism driven by a power takeoff shaft from the reel motor itself comprising a friction element carried on the shaft and secured against rotation, a slip ring carried on the shaft and frictionally rotated with it, adjustable means for increasing or decreasing the component of friction and spaced stops preventing rotation of the slip ring beyond a predetermined limit stop position in either the forward or reverse directions, the slip ring effective to deenergize the motor by actuating the interrupting switch upon reverse rotation.

A further feature of the invention is a primary loop control circuit which includes photocell sensing of the primary loop sizes on both the feed and takeup sides of the film gate. The loop sensing circuit overcomes the disadvantages of other types of loop sensing in that the drive clutch is only intermittently energized and once energized continues to run until proper loop formation is complete. This keeps the duty cycle of the clutch at a low level whereas in prior art projectors, the clutch is run to form the proper loop with each film advance and thus is subject to excessive wear.
Still another feature of the invention is to provide a projec-

tor having both internal and external components of the opti-
cal system. The projector cabinet houses a lens system includ-
ing a mirror fixed at an angle 45° to the axis of the lens. A
second mirror is mounted exteriorly of the projector cabinet
in the path of the reflected image. The second mirror is ad-
justable through a small angle at approximately 45° to the path
of the reflected image for projecting the final image onto a
viewing area.

In accordance with this feature of the invention, the projec-
tor cabinet has a window to permit the reflected image from
the interior mirror to be received by the exterior mirror.
Preferably, the exterior mirror is mounted on the underside of
a projector door hinged along one side. The mirror is disposed
at approximately 45° for projecting the image onto the view-
ing area when the door is locked in an open position. The door
includes a mounting plate adapted to be removably fastened
to a surface of the cabinet such that the door, mirror and
mounting plate can be unfastened, rotated and repositioned
on the cabinet so as to project an image in any one of four
directions without repositioning the projector cabinet.

Other objects and advantages of the present invention will
be apparent from the following detailed description when con-
sidered in conjunction with the accompanying drawings
wherein:

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a pictorial view of the projector and its remote
control panel;

FIG. 2 is a fragmentary, sectional view of that portion of
the projector cabinet having a projection window therein and
the projector door shown in the raised and locked in position for
projecting an image in the manner depicted in FIG. 1;

FIG. 2A is a view taken along line 2A—2A of FIG. 2 show-
ing the external mirror which is mounted on the door;

FIG. 3 is a plan view showing the interior portion of the opti-
cal system and film transport, supply and take-up systems;

FIG. 4 is a vertical, sectional view of the intermittent
Geneva pulldown drive mechanism;

FIG. 4A is a partial cross-sectional view taken along line
4A—4A of FIG. 4 showing the locking wheel assembly of the
intermittent Geneva drive;

FIG. 5 is a plan view of the Geneva drive shown in FIG. 4
with the top cover plate removed;

FIG. 5A is a fragmentary, sectional view taken along line
5A—5A of FIG. 5 showing a portion of the forced lubrication
system for the Geneva drive;

FIG. 6 shows schematically the main drive motor, shutter,
film transport, Geneva drive and timing disc therefor;

FIG. 7 is an electrical schematic of the timing circuit for
the Geneva drive;

FIG. 8 is a sectional view showing the reel motor and a frag-
mentary part of the swinging arm assembly for either the
supply or take-up reels;

FIG. 9 is a bottom view of the swinging arm cam and the
motor control switches controlled by the cam;

FIG. 10 is a plan view of the motor control circuit; and

FIG. 11 is a circuit schematic of the primary loop sensing
control.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings which are intended to merely
illustrate a preferred embodiment of the invention and not to
limit the same, FIG. 1 shows in pictorial fashion, a projector
which is completely controlled from a remote control panel
for focusing, frame speed and forward and reverse selec-
tion.

OPTICAL SYSTEM

Referring to FIGS. 2, 2A and 3, the optical system of the projec-
tor includes a lamp 14 (FIG. 3), lens system 15, 16,
dichroic mirror 17, interior mirror 18, and exterior mirror 20
(FIGS. 2–2A). The interior mirror 18 is set at an angle of
about 45° to the axis of the lens system 15, 16 so that the
reflected image is transmitted vertically through a glass win-
dow 21 (FIG. 2) in the top panel 23 of the projector cabinet.
The reflected image falls upon the exterior mirror 20 which is
mounted on a door 25 hinged along one side 26 and closeable
over the glass window 21 when the projector is not in use. The
mirror 20 is mounted on a frame 28 including a hinge 29 in
the upper edge having a tongue 30 at the lower end which is
engaged by a dog 32 positionable by lever 33. When the door 25
is raised to the position shown in FIG. 2, the frame 28 tilts out
from within the door against the dog 32 to an angle of approxi-
mate 45°. The dog 32 is adjustable by means of the lever 33
to change the mirror angle for elevating or lowering the pro-
jected image 34 as required. The door 25 is hinged to a mount-
ing plate 37 which has an aperture 38 in registry with the glass
window 21. An extensible arm 39 holds the door 25 open as
shown in FIG. 2 and locks it in position during projection.

It is a feature of the invention that the projected image may
be displayed in any one of four directions without reposition-
ing the projector. To this end, the mounting plate 37, door 25
and mirror 20 are removably attached so as to project an
image in any one of four directions of rotation without repos-
itioning the projector in a new direction. The ability to reposi-
tion the mirror 20 also permits the projection of images filmed
sides way so that the viewer sees such an image in an upright
fashion.

GENEVA PULLDOWN DRIVE

Referring to FIG. 3, cinematic film depicted at 40 is guided
from a supply reel 42 through a secondary loop supply system
43, over a feed sprocket 44 to form a primary feed loop 45
passing then through a film gate assembly 46, over a pulldown
sprocket 47 forming a primary takeup loop 48, then over the
takeup sprocket 49 before entering a secondary loop takeup
system 51 finally to be wound upon a takeup reel 52. The feed
and takeup sprockets 44, 49 are each driven off of a main
drive shaft 49 (FIG. 6) at the same speed. In accordance with
the invention, the pulldown sprocket 47 is driven by an inter-
mittent Geneva pulldown drive timed to run in synchronism
with an apertured shutter 53 which is mounted on a shaft 54
driven by a pulley 55 and belt 56 from the main drive motor
52.

Referring now to FIGS. 4–4A, the Geneva drive assembly
comprises a housing 60 having an enlarged cavity 62 which is
closed by a cover plate 63. An input shaft 64 is driven by a
gear 65 which in turn is driven directly from the main drive
shaft 49 at a speed proportional to the rotational speed of the
shutter 53. Antifriction bearings 66, 67 journal the input shaft
64 axially of the housing 60 and cavity 62. An intermittently
powered output shaft 67 is offset from the input shaft 64 and
is journaled in the cover plate 63 by bearings 68, 69 and is
functionally connected to the pulldown sprocket 47.

The input shaft 64 has fixed to it intermediate bearings 66,
67, a driven mass 70 which rotates centrally within the cavity
62 and comprises a cylindrical locking wheel 71 having an in-
tegral cylindrically formed portion 72 on top provided with a
surface discontinuity 73 on one side (FIG. 4A). A bore 74
parallel to the axis of the input shaft 64 receives a locking pin
75 having a cam follower 76 on the lower end and a locking
segment 77 on the upper end adapted to fill the discontinuity
73. The locking pin 75 rotates with the locking wheel 71 and
reciprocates in the Geneva drive pin 85 secured to the bot-
tom of the cavity 62. A bore 83 parallel to the bore 74 receives a Geneva drive
pin 85 which is connected by a transverse pin 86 at the lower
end to the cam follower 76 of the locking pin 75 and thus
reciprocates in unison with the locking pin 75. A coil spring 87
axially biases the Geneva drive pin 85 and is effective for hold-
ing the cam follower 76 against the camming surface 88 dur-
ing periods when there is no output of the Geneva drive as will
be made apparent.
Also, rotating with the mass 70 is a key 90 which reciprocates transversely in a slot 92. Key 90 is normally biased laterally outwardly of the slot 92 by a spring 93 and has an arcuate face 94 which projects laterally beyond the cylindrical surface of the locking wheel 71.

Mounted in the cover plate assembly 63 is a solenoid 98 having a plunger 100 extending downwardly into the cavity 62 and provided with a contacting sleeve 102 which extends into the rotational path of the arcuate face 94 on the key 90. There are two solenoids 98, 98' (FIG. 5) only one of which is shown in FIG. 4, one being operative for controlling intermittent drive in the forward direction and the other for controlling the drive in the reverse direction as will be described hereinafter.

A Geneva wheel 105 (FIG. 5) either transmits intermittent drive to the output shaft 67 or locks it against rotation depending on whether the locking segment 77 and Geneva drive pin 85 are raised or lowered. In the raised position (FIG. 4) the locking segment 77 is elevated to clear the Geneva wheel and the drive pin 85 is raised rendering it effective to enter a Geneva drive slot 106. For each complete revolution performed by the drive pin 85, the Geneva wheel 105 and the output shaft 67 rotate a quarter of a turn. Between turns the Geneva wheel 105 has one of four semicircular mechanical ground surfaces 107 in engagement with the machined cylindrical portion 72 of the rotating locking wheel 71 preventing rotation until the surface discontinuity 73 and drive pin 85 again come around to impart rotation. When the locking segment 77 and pin 85 are lowered, the pin is rendered ineffective and the locking segment perfectly fills the discontinuity 73 locking the Geneva wheel 105 against rotation.

Smooth film advance and accurate frame registration require that the machine tolerances between the portion 72 of the locking wheel 71 and semicircular surfaces 107 of the Geneva wheel 105 are maintained fairly closely, preferably less than two-thousandths of an inch. This creates a friction problem and it is to this end that the invention provides a forced lubrication system. Referring to FIGS. 4, 5 and 5A, it will be seen that the input shaft 64 has an impeller 110 on the lower end which rotates in a cavity 111. Oil fills the cavity 111 and is maintained at a level approximately even with the cam face 80. An oil passage 112 (FIG. 5A) has a short transverse neck 113 connecting with the cavity 111 on the pressure side of the impeller 110 and with a longer transverse passage 114 extending inwardly above the cylindrical portion 72 of rotating locking wheel 71. Oil is emitted from the passage 114 through holes 115 and drops onto the rotating portion 72 where it is carried by centrifugal force into the critical area to lubricate the Geneva wheel 105. Excess oil is returned by gravity to the reservoir in the cavity 62. Oil is supplied whenever the input shaft 64 is running thus insuring adequate lubrication at all times.

Assuming that the solenoid 98 is the forward drive control solenoid, when it is energized the contact sleeve 102 will be in the downward position as shown in FIG. 4. In this position, it is within the rotational path of the arcuate face 94 of the key 90. Since the key 90 is rotating with the driven mass 70, as it comes into contact with the sleeve 102, it is depressed against the force of spring 93. At the same time the cam follower 76 on the locking pin 75 reaches the apex of the cam surface 80 lifting the locking segment 77 and Geneva drive pin 85 to their highest point of travel. In this position, the Geneva drive pin 85 extends above the surface of the locking wheel 71 and the locking segment 77 is lifted out of the discontinuity in the surface of the portion of the locking wheel 71. While thus held by the cam surface 80, it will be noted that an annular groove 116, on the locking pin 75 has been reciprocated into registration with the slot 92 which receives the key 90. Were it not for the fact that the contact sleeve 102 is holding the key 90 in the depressed position, the spring 93 would force the key into the groove 116. Disabling both the locking pin 75 and Geneva drive pin 85 causing them to remain fixed in the maximum raised position as shown in FIG. 4. In this position, the Geneva drive operates in the normal fashion with each revolution of the locking pin 85 producing a quarter turn in the Geneva wheel 105 and the cam follower 76 on the locking pin 75 remaining elevated off of the cam face 80. This would occur whenever the solenoid 98 is deenergized and the contact sleeve 102 withdrawn. So long as the contact sleeve 102 is in the position shown in FIG. 4 (solenoid energized), it forces the key 90 out of the groove 116 with each revolution and there will be no output of the Geneva drive since the cam follower 76 will be able to follow the cam surface 80. The lowest point of the cam surface 80 adjacent the Geneva wheel 105 is a half revolution from the highest point. Thus the Geneva drive pin 85 will be withdrawn into the bore 83 and rendered ineffective to drive the Geneva wheel in the case where the cam follower 76 is following the camming surface 80 and conversely, the locking segment 77 will be rendered effective to lock the Geneva wheel 105 against rotation by lowering to fill the discontinuity 73.

It is important to note that the low mass of the locking pin 75 and drive pin 85 permit them to be moved at great speed. Also, the direct mechanical drive with the cam 80 insures instant response to achieve high-speed, film pulldown and accurate frame registration required in handling 35 mm. and larger size film.

**TIMING CIRCUIT FOR THE GENEVA PULLDOWN**

The pulldown sprocket 47, which is driven by the output shaft 67 of the Geneva drive is controlled by a timing disc 120 (FIG. 6) to advance the film at several preselected speeds or provide a single frame "hold" of an indefinite period if desired. The rate of pulldown is chosen by the operator from the remote control panel 12 (FIG. 1). The speed selector is depicted by an arrow 119 in FIG. 6 which is shown energizing a lamp 121 of one cell in a bank of photocells 122, the arrangement being such that the light from the lamps 121 is interrupted by the rotating timing disc 120 in which there are four or more separate patterns of slots 123 for each speed of film advance. The particular slot pattern chosen determines the number of pulsations given the solenoid 98, 98' (forward or reverse) per revolution of the timing disc 120. The timing disc 120 is geared down to rotate at some ration of the main drive shaft 49 which is driven by a belt 126 and pulley 127 arrangement directly from the main drive motor 57. The motor output shaft 129 also directly drives the apertured shutter 53 through a belt and pulley arrangement 55, 56, 130. A second power takeoff arrangement 135 from the main drive shaft 49 drives a gear 136 meshing with gear 137 on the input shaft 64 of the Geneva pulldown drive and also a gear 138 which drives a gear 139 for rotating the timing disc 120. A clutch 140 is provided to disengage the main drive shaft 67.

It will be recalled from the previous description of the Geneva drive that when either the forward or reverse solenoids 98, 98' are deenergized the plunger 100 is withdrawn vertically out of the path of rotation of the arcuate face 94 of the transversely reciprocated key 90 which is rotating continuously with the driven mass 70. Assuming the speed selector 119 on the control panel 12 has been set for the speed corresponding with the illumination of a particular lamp 121, that cell of the cell bank 122 will "see" light through aligned slot pattern 123 of the timing disc 120. As depicted in FIG. 6, the innermost slot pattern is a single slot 123' which upon each revolution of the timing disc 120 would pulse (deenergize) the forward solenoid 98 once. The solenoid 98 then permits a pulldown or output from the Geneva drive. If the operator chose the outer slot pattern of the timing disc 120, the solenoid would be pulsed six times for each revolution of the timing disc 120. The actual film speed in frames per second thus is determined by the number of pulsations per given revolution of the disc 120 and the gear ratio of the gears 138, 139. On reverse drive, a switch 142 is moved to the opposite contact so that solenoid 98' is pulsed. The input shaft 64 is not rotating in the opposite direction to that indicated by the directional arrow in FIG. 6. The Geneva drive is coupled to the shutter 53 so that it will not drive unless the shutter is closed.
Referring now to FIG. 7, the timing circuit for controlling the Geneva drive includes the bank of photocells 122 with the timing disc 120 being depicted as a dashed line. Assuming that the circuit is set for continuous forward run, a switch S6 is closed on the lower contact 155 and the switch 142 is positioned to energize the solenoid 98. When the operator selects the speed desired, the appropriate photocell 122 is energized and the solenoid 98 will be pulsed or intermittently deenergized by the transistor switching circuit 160. Transistor Q4 is normally ON. With the voltage level at point 161 sufficient to hold the solenoid 98 in, transistor Q4 is pulsed to the OFF condition by a drop in voltage at 161. Whether Q4 is ON or OFF is determined by whether normally ON transistor Q6 and normally OFF transistor Q5 have been pulsed by the timing disc 120. If one of the cells 122 sees light through the timing disc 120, the voltage drops at point 162 turning transistor Q6 OFF which causes an increase in voltage at point 163 turning transistor Q5 ON which automatically drops the voltage at 161 below the level where transistor Q4 is ON and it momentarily goes OFF causing the solenoid 98 to drop out. By way of example, the essential components of the circuit are given in the following Table I.

### Table I

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C10</td>
<td>1000 MF 50 v.</td>
<td>capacitor</td>
<td></td>
</tr>
<tr>
<td>C11</td>
<td>300 PF</td>
<td>capacitor</td>
<td></td>
</tr>
<tr>
<td>C12</td>
<td>Claire C704 L</td>
<td>capacitor</td>
<td></td>
</tr>
<tr>
<td>D4</td>
<td>1 A 50 VPVT</td>
<td>diode</td>
<td></td>
</tr>
<tr>
<td>Q4</td>
<td>2 N 3054</td>
<td>Transistor</td>
<td></td>
</tr>
<tr>
<td>Q5, Q6</td>
<td>2 N 1893</td>
<td>Transistor</td>
<td></td>
</tr>
<tr>
<td>R10</td>
<td>ADJ. 50025 W</td>
<td>Resistor</td>
<td></td>
</tr>
<tr>
<td>R11</td>
<td>2.2K W</td>
<td>Resistor</td>
<td></td>
</tr>
<tr>
<td>R12</td>
<td>2710W</td>
<td>Resistor</td>
<td></td>
</tr>
<tr>
<td>R13</td>
<td>6800W</td>
<td>Resistor</td>
<td></td>
</tr>
<tr>
<td>R14</td>
<td>1.5K W</td>
<td>Resistor</td>
<td></td>
</tr>
<tr>
<td>R15</td>
<td>6.8K W</td>
<td>Resistor</td>
<td></td>
</tr>
<tr>
<td>R16</td>
<td>2.2K W</td>
<td>Resistor</td>
<td></td>
</tr>
<tr>
<td>R17</td>
<td>ADJ. 100 K</td>
<td>Resistor</td>
<td></td>
</tr>
<tr>
<td>R98, 98'</td>
<td>5.121</td>
<td>Solenoid</td>
<td></td>
</tr>
</tbody>
</table>

### REEL MOTOR CONTROL

Referring again to FIG. 3, the film 40 is unwound from a supply reel 42 and is coiled upon a takeup reel 52. A secondary loop supply and takeup system 43, 51 is associated with each reel 42, 52 comprising a swinging arm 170, 171 carrying a pair of film spools 172, 173 which in cooperation with fixed spools 174, 175 form secondary film loops 179, 180. The reels 42, 52 are driven independently of the feed and takeup sprockets 44, 50, which are driven by the main drive motor 57 (FIG. 6), thus the secondary loops 179, 180 compensate for an differentials in speed between the two drives to prevent film damage. With 35 mm. film a larger reel capacity is required than with 16 mm. film and as the storage capacity of the reel goes up, so also does the magnitude of the speed differential. Furthermore, the speed differential is constantly varying as a function of the changing diameter of the film as it is coiled or uncoiled in ever-increasing or decreasing convolutions upon the reels. This problem particularly manifests itself with 35 mm. and larger size film where 1,000 -foot reels are not uncommon.

For the present purposes a motor control for the takeup reel 52 only will be described, but an independent and identical control for the supply reel 42 is provided. In FIG. 8, a sectional view of a takeup reel deck 52 illustrates a fragmentary portion of the swinging arm 171. The reel deck 52' is driven by a reel motor 181' which is servo-controlled by the swinging arm 171. The arm 171 is mounted on a shaft 182 which carries a control cam 183 for actuating a series of microswitches (FIG. 9) forming part of the motor control circuit (FIG. 10). A coil spring 184 urges the arm 171 toward the outer limit of its arc.

Referring now to FIGS. 9 and 10, the control cam 183 oscillates with the arm 171 through an arc of perhaps 45°. Positioned around the cam 183 are microswitches S11, S15 and S14, which have cam followers FS11, FS14 and FS15, which run on the surface of the cam 183 for actuating the switches. In accordance with the invention, a switch S17 is controlled by a slip drive arrangement 189 which comprises a power takeoff shaft 190 (FIG. 8) driven by the motor 181. Rotating with the shaft 190 is a sleeve 192 which carries a pair of slip rings 193, 194 between which is sandwiched a wavy steel washer 195. Slip ring 193 forms a bearing with a steel washer 196 resting upon a shoulder 197 of the sleeve 192. A second steel washer 198 is held against the slip ring 194 by a nut 199 threaded on the end of the sleeve 192 which may be tightened to vary the frictional component of the slip rings 193, 194. Slip ring 194 carries a pin 200 (FIG. 9), which is anchored against rotation at 201. The slip ring 193 also carries a pin 202 but it is permitted to swing between limit stops 285, 286. In the direction of rotation of the motor 181 for winding in film (clockwise), the pin 202 will swing into engagement with the forward limit stop 203 and conversely upon reverse rotation of the motor 181 the pin 201 will swing in the opposite direction until contacting reverse limit stop 204. A switch arm 205 of the switch S17 is disposed within the path of the pin 202 and will be triggered by the pin 202 when it moves toward the reverse limit stop 204.

Let it be assumed that film is being fed through the projector but that motor 181 is stopped and that the arm 171 is therefore moving toward the outer limit of its arc as depicted in FIG. 3 under the influence of spring 184. In this condition, the switch S17 is making contact at 210 (FIG. 10), and switch S14 is open. When the movement of the arm 171 has reached the point where the control cam 183 closes switch S15, the motor 181 commences to run receiving power through gate Q9 which is rendered conductive by a predetermined voltage at point 212 intermediate resistors R8, R9. As the motor 181 commences to run, it takes film out of the dual loop takeup system 51 at a rate greater than it is being fed to the system by the takeup sprocket 50, thus the arm 171 now starts back toward its midposition. As it reaches the control cam 183 now actuates switch S11 to make contacts 215, 216 which sets up the motor 181 to run in reverse direction. As the arm 171 continues through the midposition, it reaches a point near its inner limit of travel where the control cam 183 closes switch S14 and opens switch S15. With switch S11 now in the position to run the motor in reverse, the motor receives power tending to dump film into the takeup system 51 which has the effect of braking the movement of the arm 171. It will be noted that while the motor 181 is running in the forward direction, pin 202 on the slip ring 193 is in engagement with the forward limit stop 203. As soon as the motor commences to run in the reverse direction, the pin 202 swings back toward the reverse limit stop 204 and as it does it triggers switch arm 205 of switch S17 interrupting the circuit to the motor since switch S15 is now open. With the motor 181 stopped and the takeup sprocket 50 continuing to run, the arm 171 will move back toward its midposition while the spring 184 maintains the required tension on the film. The motor 181 resumes its normal operation taking up film in the conventional manner once arm 171 has reestablished itself in the midposition. The identification and values of the essential components in the circuit in FIG. 10 are given in the following table:

### Table II

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q9</td>
<td>RCA 40430</td>
<td>Transistor</td>
<td></td>
</tr>
<tr>
<td>C9</td>
<td>0.1 MF 400 v.</td>
<td>Capacitor</td>
<td></td>
</tr>
<tr>
<td>R1</td>
<td>100 ohm</td>
<td>Resistor</td>
<td></td>
</tr>
<tr>
<td>R8</td>
<td>470 ohm</td>
<td>Resistor</td>
<td></td>
</tr>
<tr>
<td>R9</td>
<td>4.7K ohm</td>
<td>Resistor</td>
<td></td>
</tr>
<tr>
<td>181</td>
<td>B.C. 12653</td>
<td>Motor</td>
<td></td>
</tr>
</tbody>
</table>

Thus, in accordance with the invention, a motor control circuit is provided in which a reverse pulse of the motor is used as
3,642,357

brake on the arm 171 near the inner limit of its travel which dampens excessive arm oscillations and increases the effective arc through which the arm can be controlled. This has the effect of increasing the range in speed differential which the dual loop systems 43, 51 can accommodate. Clearly, the slip drive arrangement 189 has other applications and may be used equally well wherever the reverse drive of a motor can be used as sort of a brake or retarding force for another mechanism or for some other control function.

PHOTOELECTRIC SENSING OF THE PRIMARY FEED AND TAKEUP LOOPS

It is common to provide feed and takeup loops 45, 48 so that the film is solely under control of the pulldown sprocket 47 in passing through the film gate 46 (Fig. 3). Adequate loop size is required to protect the film from excess tension. To this end, a photoelectric sensing system is provided in which light sensing systems 230, 232 are energized when light is reflected by either of the primary loops 45, 48. Referring again to FIG. 6, it will be seen that the main drive shaft 49 which powers the Geneva pulldown input shaft 64 also provides input to the clutch 140 which is engaged to drive the feed and takeup sprockets 44, 50. If the loop 48 overlays the sensor system 232, light from the lamp 233 falls on the film at the critical angle and is reflected onto the light activated SCR Q11 which starts the drive through the clutch 140 causing both the feed and takeup sprockets 44, 50 to rotate. SCR Q11 is the trigger cell and when turned ON, it remains ON until shut off by SCR Q10 coming ON and vice versa. SCR Q10 is turned OFF by the SCR Q11 coming ON. Schematically, this is shown by the circuit diagram in FIG. 11. Light-sensitive Q11 is turned ON by the reflection of light off of the primary loop 48 on the takeup side energizing the coil of clutch 140. Once energized, Q11 stays ON while the excess film in the takeup loop 48 is no discharged into the secondary dual loop takeup system 51. Since the clutch is driving both the takeup sprocket 50 and the feed sprocket 44, the primary loop 45 ON the feed side continues to increase in size until the light from lamp 234 is reflected from the film and energizes the SCR Q10 turning it ON. When Q10 becomes conductive, Q11 goes OFF at which point the clutch 140 is deenergized until again triggered by the primary loop 48 on the takeup side. The identification and value of each component of the switching circuit in FIG. 11 is given in the following Table III.

| Q10 GE L0F | SCR | Q11 GE L0F | SCR | R18 k ohm. 1W. | Resistor | R19 k ohm. 1W. | Resistor | R20 IM ohm. 5W. | Resistor | R21 IM ohm. 5W. | Capacitor | C120.0 mf. 30v. | Capacitor | C130.0 mf. 30v. | Capacitor | C14 1.5 mf. 100v. | Capacitor |
|-------------|-----|------------|-----|--------------|----------|--------------|----------|--------------|----------|--------------|---------|---------------|---------|---------------|---------|------------|

Although only certain specific embodiments have been described, it is apparent that those skilled in the art can well understand the principle of operation of the invention and possibly envision modifications to the specific embodiments, although departing from the invention as defined in the appended claims.

What is claimed is:

1. A motion picture projector having a cinematic film supply and takeup means, an apertured shutter, and means for framing the film in synchronism with the shutter comprising:

a. a pulldown sprocket engageable with the film for transporting it intermittently in timed relationship to the shutter,

b. an output shaft drivingly connected to the pulldown sprocket for imparting intermittent rotation to it, and

c. intermittent drive means selectively operable to drive the output shaft at various frame rates comprising:

da. a Geneva gear mounted on the output shaft,

e. a locking wheel rotatably engageable with the Geneva gear for imparting intermittent rotation to it and alternately locking it between rotations, and

f. means movable relative to the locking wheel to render it ineffective for a portion of a revolution to lock and effective to rotate said Geneva gear.

2. A motion picture projector according to claim 1 wherein the means movable relative to the locking wheel comprises:

a. a locking segment movable to create a discontinuity in the surface of the locking wheel to render it ineffective for locking said Geneva gear for a complete revolution, and

b. a drive element movable relative to the locking wheel to render it effective for intermittently driving the Geneva gear.

3. A motion picture projector according to claim 2 comprising:

a. a stationary cam mounted adjacent the locking wheel,

b. a cam follower operatively connected to the locking segment and drive element,

c. key means normally effective to disable said cam follower and render said locking wheel ineffective for locking and effective for driving said Geneva gear during a portion of a revolution, and

d. means to selectively render said key means ineffective.

4. A motion picture projector according to claim 3 comprising:

a. a locking pin reciprocally mounted on the locking wheel and carrying the locking segment on one end, and

b. means connecting the locking pin, drive element and cam follower to reciprocate in unison relative to the locking wheel when the cam follower rides on said cam ring.

5. A motion picture projector according to claim 4 wherein said locking pin includes:

a. an annular groove,

b. a transverse slot in said locking wheel receiving said key means, and

c. a spring normally biasing said key means into said groove when brought into registration with the slot by reciprocation of the locking pin.

6. A motion picture projector according to claim 4 wherein said key means is selectively tendered said key means ineffective comprises:

a. a timing disc driven at a speed proportional to the speed of said shutter,

b. a plurality of concentric timing paths on the timing disc each corresponding to a predetermined film frame rate,

c. means for selecting one of said timing paths to accomplish a timed function and

d. means responsive to the timed function for operating said key means.

7. A motion picture projector according to claim 6 wherein each said timing path comprises:

a. a multiple of a unit timing slot and said means for selecting one of said timing paths comprising,

b. a photosensitive means for each timing path energized by the passage of light through a unit timing slot.

8. A motion picture projector according to claim 7 comprising:

a. a control switch remote from said projector to select only the desired timing path,

b. a solenoid operative to render said key means ineffective, and

c. a switching circuit connecting the photosensitive means to said solenoid.

9. A motion picture projector according to claim 1 comprising:

a. a housing having a cavity within which the locking wheel and Geneva gear are situated,

b. said cavity defining an oil reservoir,
c. an impeller driven whenever the locking wheel is rotating,
d. an impeller chamber supplied with oil from the oil reservoir,
e. passage means connecting the pressure side of the impeller to lubricate the locking wheel and Geneva gear.

10. In a motion picture projector having a rotatable shutter, film supply and takeup systems, a film transport sprocket in each system, each driven from the same power source at the same speed to advance the film with respect to the supply and takeup systems at the same rate, and a pulldown sprocket driven at a speed proportional to the speed of the shutter to advance the film in synchronism with the shutter, an excess of film being disposed in primary feed and takeup loops respectively between the pulldown sprocket and transport sprockets, the improvement comprising:

a. first detector means spaced from the pulldown sprocket a distance at which it is desired to have the film loop extend on the feed side,
b. second detector means positioned at the maximum distance from the pulldown sprocket at which the film loop can extend on the takeup side, and
c. normally OFF photosensitive switching means in the second detector turned ON by the presence of the film loop on the takeup side to actuate said feed and takeup sprockets for decreasing the size of the takeup loop and increasing the size of the feed loop and
d. other switching means on said first detector turned ON by the presence of the film loop on the feed side effective to turn OFF said normally OFF photosensitive switching means, stopping film advance.

11. In a motion picture apparatus having an apertured shutter, a shutter drive and a film receiving mechanism, the improvement comprising:

a film transport mechanism including
an input shaft drivable at a speed proportional to shutter speed,
an output shaft intermittently coupled to the input shaft to produce intermittent-rotary motion for advancing the film by the shutter and framing it in synchronism with the shutter aperture, and
a transmission between said shafts including
an intermittent-rotary driven element on the output shaft and
a rotary driving element on the input shaft, the latter being capable of intermittent driving and non-driving engagement with said driven element, the driving engagement being regulated at a frequency to establish a predetermined rate of film advance and means effective to initiate said driving engagement having a low mass in relationship to the mass of said input shaft to permit rapid operation of said means.

12. In a motion picture apparatus according to claim 11 wherein said intermittent-rotary driven element has a plurality of equally spaced drive slots oriented with each having its open end extending radially and having a semicircular surface intermediate each said drive slot, and said driving element having a cylindrical surface portion engageable with said semicircular portions of the driven element and having a surface discontinuity at one circumferential location to permit relative movement of the driven element and said means effective to initiate driving engagement comprising
a pin carried by the driving element eccentric to the axis of rotation of the input shaft and opposite the surface discontinuity of said cylindrical portion, said pin being extensible so as to successively enter the drive slots on said driven element to effect said intermittent-rotary driving engagement and retractable to avoid entering said drive slots in the nondriving position.

13. The motion picture apparatus according to claim 12 wherein said driving element comprises in addition
a locking segment moveable axially with said pin to fill said surface discontinuity when the pin is in a retracted position positively locking said driven element against rotation during the nondriving engagement between said elements, the axially moveable mass of said pin and locking segment being only a fraction of the total rotary mass of said driving element.

14. The motion picture apparatus according to claim 13 wherein said driving element comprises a locking key movable transversely of the axis of the input shaft to prevent retraction of said pin in the driving position and timing means operable at a frequency proportional to shutter speed to selectively cause movement of said locking key out of the locking position to thereby permit retraction of said pin at a frequency establishing said predetermined rate of film advance, and
cumming means stationary relative to the input shaft engageable with said pin for moving it from the retracted to the extended position.

15. A motion picture projector for cinematic film comprising:

an apertured shutter,
a shutter drive,
a power takeoff from the shutter drive, and
flickerless film transport means for framing the film in synchronism with the shutter aperture including
a rotary input member driven by said power takeoff at a speed proportional to shutter speed, an intermittent-rotary output member drivingly connected to said rotary input member and engageable with the film for framing it in timed relationship with the shutter aperture,
a driven element carried by said intermittent-rotary output member, and
a driving element carried by said rotary input member being selectively movable between driving and idle positions relative to the driven element for imparting intermittent rotation to the driven element when in the driving position and interrupting the drive relationship when in the idle position whereby said rotary input member may be continuously rotated at a speed sufficiently high to provide flickerless film advance.

16. A motion picture projector for cinematic film comprising:

an apertured shutter,
a shutter drive,
a power takeoff from the shutter drive, and
flickerless film transport means for framing the film in synchronism with the shutter aperture including
a rotary input shaft driven by said power takeoff at a speed proportional to shutter speed, an intermittent-rotary output shaft drivingly connected to said rotary input shaft,
a pulldown sprocket drivingly coupled to the intermittent-rotary output shaft and engageable with the film for framing it in timed relationship with the shutter aperture,
a drive element carried by said intermittent-rotary output shaft having a plurality of circumferentially and equally spaced drive slots oriented with the open end extending generally radially outwardly of said output shaft,
a locking wheel carried by said input shaft and rotatably engaging said driven element between said drive slots and having a surface discontinuity at one circumferential point thereon, and
a drive pin opposite said surface discontinuity being selectively movable on an axis parallel to the input shaft between driving and idle positions relative to the driven element, said drive pin successively entering said driving slots for imparting intermittent-rotation to the output shaft when in the driving position and interrupting the drive relationship when in the idle position during which the locking wheel is effective to lock the driven element against rotation whereby said input shaft may be continuously rotated at a speed sufficiently high to provide flickerless film advance.
17. A motion picture projector for 35 mm. cinematic film comprising
an apertured shutter,
a shutter drive,
a power takeoff from the shutter drive, and
flickerless film transport means for framing the film in
synchronism with the shutter aperture including
a rotary input shaft driven by said power takeoff at a speed
proportional to shutter speed,
an intermittent-rotary output shaft drivingly connected to
said rotary input shaft and engageable with the film for
framing it in timed relationship with the shutter aperture,
a Geneva wheel carried by said intermittent-rotary output
shaft,
a rotating mass driven by the input shaft including a cylin-
dricallocking wheel having a surface discontinuity,
a locking segment axially movable to fill the discontinuity of
the locking wheel to lock the Geneva wheel against rota-
tion,
a Geneva drive pin axially movable to a drive position with
respect to the Geneva wheel when the locking segment is
ineffective, and
a reciprocating key normally effective to render the locking
segment ineffective and drive pin effective and being
selectively operable to render the locking segment effec-
tive and the drive pin ineffective whereby the rotary input
member may be continuously rotated at a given speed
and selectively driven said output shaft at different
frequencies of intermittent-rotation.

18. In a motion picture projector for cinematic film com-
prising
an apertured shutter and
a shutter drive, the improvement comprising
film transport means for high-speed film advance of large-
size film including
a rotary input shaft driven at a speed proportional to a
shutter speed,
an intermittent-rotary output shaft drivably connected to
the input shaft and operable to advance the film in
synchronism with the shutter aperture,
a driven means carried by said output shaft,
a driving means carried by the input shaft, the latter means
having an element rotatable therewith but also movable
axially relative to the driven element to effect an intermit-
tent drive engagement therewith and said element com-
prising a small fraction of the total rotating mass of said
driving means so as to be rapidly movable to effect said
intermittent drive engagement whereby said input shaft
may be rotated at speeds sufficiently high to provide
flickerless film advance for large film sizes.

19. The improvement according to claim 18 wherein a
means stationary relative to the input shaft is operable to
cause positive axial movement of said element from a non-
driving to the intermittent driving engagement position in
response to rotation of said input shaft.

20. The improvement according to claim 19 providing in
addition timing means selectively operable to cause movement of
said element between the intermittent driving and non-
intermittent driving positions at varying frequencies in timed relationship with the shutter speed.

21. A motion picture projector for cinematic film compris-
ing
an apertured shutter,
a shutter drive,
flickerless film transport means for advancing the film in timed rela-
tionship with the shutter aperture including
a rotary input member driven at a speed proportional to
shutter speed,
an intermittent-rotary output member drivably connected to
said rotary input member and engageable with the film for
framing it in synchronism with the shutter aperture
and
timing means for effecting the rotary to intermittent-
rotary drive between said members including
driving and driven means operable to effect an intermittent
coupling between said members, one of said means in-
cluding a coupling element having a low mass in relation-
ship to the rotating masses so as to be rapidly movable
into coupling engagement for imparting intermittent-
rotation to the output member when in a driving position
and interrupting the drive relationship when in the idle
position, and
stationary means operable to cause positive movement of
said coupling element from the idle to the driving position
involving a direct mechanical action whereby rapid film
advance and positive framing may be obtained for large-
size film at speeds sufficiently high to prevent flicker.

22. A motion picture projector according to claim 21
wherein
said driven means has a plurality of equally spaced drive lo-
cations and
said driving means is arranged to cooperate with said drive
locations for imparting intermittent-rotation to the output
member and
timing means operable to vary the frequency of cooperation
between said driving means and drive locations for
establishing a predetermined rate of film advance.

23. A motion picture projector according to claim 22
wherein
said driven means is a Geneva wheel having a plurality of
equally spaced, radially extending drive slots and inter-
mEDIATE semicylindrical surface portions, and
said driving means comprises a locking wheel having a
cylindrical surface portion engageable with the semicyl-
drical surface portions of the Geneva wheel, said surface
portion having a discontinuity at one location and
a drive pin rotated with said locking wheel and axially
movable on an axis eccentric to the axis of rotation of said
input member and opposite said discontinuity so as to
enter said drive slots to effect intermittent-rotation of the
Geneva wheel and
said timing means operable to establish the frequency of in-
termittent-rotation of the Geneva wheel by controlling
the axial movement of the drive pin.