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PATENT SPECIFICATION

DRAWINGS ATTACHED

Inventors: BION WALTON McCLELLAN and
RICHARD LEWIS FABER

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Index at acceptance:—G2 E(A6A1, A11B, A12, A13)

Int. Cl.:—G 03 b 1/22

COMPLETE SPECIFICATION

Motion Picture Projector

5 We, EASTMAN KODAK COMPANY, a Company organized under the Laws of the State of New Jersey, United States of America of 343 State Street, Rochester, New York, 14650, United States of America 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:—

10 The present invention relates to a motion picture projector, and particularly to a film pull-down mechanism for motion picture projectors by the use of which different rates of projection can be achieved during operation of the projector without significant loss of light or increase in flicker.

15 In an intermittent pull-down mechanism such as is described and claimed in our co-pending application No. 29441/63 (Serial No. 1,054,105), difficulty may arise when attempting to accurately position the in-and-out follower on the face of the variable in-and-out cam because the follower is positioned by a 20 pivoted lever which cannot adjust the follower truly radially of the in-and-out cam and there is no way of accurately detenting the adjusting arm in its different positions. Minute angular misalignments have been found to cause unacceptable timing errors between the in-and-out and pull-down cams, and slight variations may cause the in-and-out follower to ride its cam at the improper skip-rate position or in a dynamically unstable operating condition.

25 The above-noted patent application shows a film feeding mechanism for projectors which can be readily reversed without stopping the drive mechanism of the projector the reversing being effected by means of a control lever separate from the control lever which changes the rate of film advance and, as a result, it is possible to damage the mechanism or film if these two operations are not properly synchronized or carried out in the right sequence. For example, in order to prevent damage of the film

and/or drive mechanism it is desirable, if not imperative, that any reversing of the film feed be accomplished only when the film claw is not in engagement with the film or, at least, when the film pull-down is operating at a slow speed. With the mechanism shown in the noted pending application this would mean that the operator would have to remember to shift the speed lever to its "still" position, or a position giving a slow rate of film pull-down, before he operates the reverse control lever.

The present invention solves the above-mentioned problem by modifying the reversing mechanism so that it can be associated with, and be operated by, the speed control member and in such a way that before the film advancing mechanism can be reversed the rate of pull-down must be slowed down, and preferably stopped, at the time a reverse of the mechanism is effected.

30 In accordance with the present invention there is provided a motion picture projector comprising an apertured film gate through which motion picture film is adapted to be intermittently advanced for the projection of successive image frames therefrom, a film claw, means for mounting the claw for up-and-down and in-and-out movements relative to said gate during which movement it intermittently engages and advances the film through the gate, drive means operating at a given frequency, an up-and-down cam connected to the drive means to drive the claw up and down relative to the gate at the given frequency, means for selectively imparting in-and-out movements to the claw in different time relations with the up-and-down movement thereof to change the rate of film advance and including an in-and-out cam driven in synchronism with the up-and-down cam and having a plurality of cam surfaces spaced along a surface thereof, certain of which cam surfaces control the rate of the in-and-out movement of the claw, a cam follower connecting the claw to the in-and-out cam to cause the claw to

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move into and out of engagement with the film in response to rotation of the cam in accordance with the particular cam surface engaged thereby, means for adjusting the cam follower along the in-and-out cam to engage selected ones of the cam surfaces, means for selectively shifting the phase relation between the up-and-down cam and the in-and-out cam by 180° to reverse the direction of movement of the film through the gate without stopping the drive means, and a common control member connected to the means for selectively changing the rate of film advance and the means for selectively reversing the direction of movement of the film so that both the rate of projection and the direction of film movement is controllable by adjustment of the common control member.

In the accompanying drawings:—

Fig. 1 is a perspective view of an intermittent pull-down mechanism for a motion picture projector constructed in accordance with a preferred embodiment of the present invention;

Fig. 2 is a front elevation of the in-and-out face cam shown in Fig. 1 which provides the in-and-out movements of the film claw;

Fig. 3 is a plan of the in-and-out cam shown in Fig. 2;

Fig. 4 is a horizontal section taken substantially through the axis of the face cam in Fig. 1 and showing parts of the drive means for the shutter shaft not shown in Fig. 1, the parts of the drive mechanism being shown in the position they assume when adjusted for a forward operation of the projector and with the rate adjusting mechanism set to a position for projecting a film at 18 frames per second, and

Fig. 5 is a view similar to Fig. 4 but with the mechanism adjusted for reverse operation at 18 frames per second.

Referring now to the drawings, in which for purposes of clarity and simplification are shown only those parts of a motion picture projector which are essential to an understanding of the present invention. These parts include an apertured film gate 10 the aperture 12 of which is illuminated by a lamp 14 located behind the gate. A perforated motion picture film F is moved through the gate by a pull-down mechanism which will be described hereinafter, and as each frame of the film is moved into alignment with the aperture in the gate and is illuminated by the lamp a corresponding image is projected by a lens 16 onto a screen, (not shown).

The prime mover of the projector comprises an electric motor M to the drive shaft of which is fastened a drive pulley 17. This pulley is connected by means of a belt 18 to a driven pulley 19 fixed to the end of the main drive shaft 20 which lies to one side of, and extends substantially parallel to, the optical axis of the projector. Drive shaft 20 is rotatably and slidably mounted in bearings 11 and 13 mounted in supporting walls 15 and 15' forming parts

of the projector. The reason for slidably mounting the drive shaft in bearings 11 and 13 will be pointed out below. Under normal load conditions, the motor shaft operates at approximately 3240 rpm, or 54 cycles per second, which is the operating speed of certain commercially available motors, and the pulley and belt combination is so chosen that this same frequency of rotation is transmitted to the drive shaft 20. The light beam is cut off from the projection aperture of the gate by means of a rotating sector shutter 21 drivingly connected to the drive shaft 20 in a manner hereinafter described. Since this shutter has only a single cut-off blade it will intercept the light beam at 54 cycles per second and then only at the time the film is being moved through the gate, as is well known in the art.

Coming now to the intermittent film feeding mechanism, this includes a rigid claw arm 22 extending laterally of the film to be fed and having an offset portion 23 intermediate its two ends. This claw arm is mounted to move up and down and pivot relative to the film gate by having a pair of vertically spaced ball seats 24 formed in the forward face thereof rotatably seating a pair of spaced ball bearings 25 which are in turn rotatably positioned in a vertical ball race 26 formed in one edge of the forward wall 15 of the projector. The claw arm is held in assembled relation on the ball bearings 25 by means of a spring 27, one end of which is attached to the claw arm on the side of the pivot point nearest the gate and the other end of which is attached to a pin 28 fixed to the projector. This spring, in addition to holding the claw in assembled relation with its ball mountings, also acts to bias one or more film engaging claws 29 on one end of the arm toward the gate and into a film engaging position. In addition this spring 27 also acts to force the other end 30 of the claw arm against a ball 42 which acts as a follower engaging the in-and-out cam as will be more fully described hereinafter. In known manner, the claw arm will reciprocate up and down on the ball bearings 25 to effect the film advance and will pivot about these ball bearings to move the claw teeth 29 into and out of engagement with the film, the gate being provided with an elongated slot 32 to accommodate the pull-down claws and allow the up-and-down movement of the claw while the teeth 29 are in engagement with the film.

In the arrangement shown, the up and down reciprocal movement of the claw arm edgewise for feeding the film is under the control of an up and down or pull-down cam 33 fixed to the drive shaft 20, which cam is embraced by a pair of followers 34 fixed to the claw arm and extending substantially at right angles to the vertical ball race 26. Since each revolution of the up and down cam produces one complete reciprocal stroke of the film claw, and the drive shaft is rotating at 54 rps, it

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follows that the claw will be reciprocated at a rate of 54 strokes per second.

The in-and-out movement of the pull-down claw relative to the film gate is produced by means of a skip-stroke mechanism which will now be described. Fixed to a shaft 36 rotatably mounted in the wall 15' of the projector and in substantially parallel relation with drive shaft 20 is a wheel or face cam 37 fixed to or carrying a gear 38. Gear 38 is driven by a pinion 39 which is rotatably and slidably mounted on the drive shaft 20 and is selectively clutched thereto in a manner to be fully described hereinafter. The shutter 21 is fixed to this pinion to rotate therewith.

The other, or forwardly directed, face of the face cam 37 is provided with a plurality of depressions 40, 40' and 40'' which are spaced circumferentially about the face of cam 37 and have their leading and trailing edges tapered into the surface of the cam so that a follower pressed against the face of the cam can move into and out of the depressions as the cam rotates. These depressions, therefore, constitute cam surfaces which in combination with the face of the cam 37 form a series of concentric in-and-out cams whose profiles control the in-and-out movement of the claw. Depressions 40' are twice as wide in a radial direction of the face cam as depressions 40, while depression 40'' is three times as wide as depression 40 in the same sense. Accordingly, starting at the outside of the face cam, and moving radially inwardly thereof, we have a series of concentrically arranged in-and-out cams comprising first an outer group of nine depressions separated by nine high areas of substantially the same arcuate length as the depressions, then a group of three depressions separated by three high areas having an arcuate length substantially three times that of the depressions, then a group consisting of one depression, and finally a concentric circle in which there are no depressions. This arrangement of cam surfaces provides a multiple in-and-out cam by means of which the skip rate of the in-and-out movement of the claw can be changed relative to the pull-down stroke to vary the rate by which the film is advanced through the gate by merely moving the ball follower 42 radially of the face cam and into alignment with different ones of said concentric, and circular cam surfaces. In-and-out movement is transmitted to the claw from the in-and-out cams by the ball follower 42 which is pressed against the face of the in-and-out cam 37 by the follower end 30 of the claw arm which is loaded in this direction by the action of spring 27 biasing the claw into engagement with the film. It will thus be seen that spring 27 in addition to forcing the ball follower into engagement with the in-and-out cam also serves to hold the ball follower in assembled relation. The depression cam surfaces 40, 40' and 40'' are of such depth that when the ball follower drops into

one of the same the spring 27 can pivot the claw arm far enough to engage the claw teeth 29 with the film perforations. On the other hand, when the ball follower 42 rides out of a depression and onto the surface of the face cam between depressions the claw arm will be pivoted against the action of spring 27 by a sufficient amount to withdraw the claw teeth from the film path. Accordingly, each circular series of depressed cam surfaces in combination with the face surface of the cam therebetween will constitute a circular in-and-out cam for controlling the movement of the claw teeth 29 to and from the film path of the gate. The innermost circle of the in-and-out cam described has no depressed cam surfaces, but the face surface of the cam causes the claw to be held out of engagement with the film for the projection of "stills" and can be considered as another in-and-out cam surface. Should it be found desirable or necessary to maintain the extent of the in-and-out movement of the claw teeth the same in each position of the ball follower 42 radially of the in-and-out cam 37, then the depth of the depressed cam surfaces of each circular group can be different from those of the other groups to account for the change in the throw of the claw arm occasioned by altering the length of the lever arm as the ball follower is shifted radially of the in-and-out cam relative to the pivot point of the arm when the projection rates are changed.

The reduction ration between pinion 39 and gear 38 on the face cam is nine to one (9 : 1). Since there are nine depressed cam surfaces on the outer circular group of the face cam, when the ball follower is positioned radially of the face cam to engage this group it will produce an in-and-out stroke of the claw for each revolution of the up-and-down cam 33. This means that the film F will be pulled down one frame per revolution of the cam 33 or at a rate of 54 frames per second. When the ball follower 42 is moved radially inward of the face cam to engage the next circular group of depressed cam surfaces, or that circle containing the three depressed cam surfaces 40', the claw will be moved in-and-out once for every three revolutions of the up and down cam 33 and the film will be advanced at a rate of 18 frames per second. When the follower ball is moved inwardly to the circle containing the one cam surface 40'' it produces one in-and-out stroke of the claw for every nine revolutions of the up and down cam 33 and advances the film at a rate of six frames per second.

If the ball follower 42 is moved in on the face cam to a position where there are no depressed cam surfaces there will be no in-and-out movement of the claw but the claw teeth will be held out of engagement with the film by the face surface of the cam. This position of the ball follower will produce a desirable

condition for still projection in which the shutter continues to run at 54 frames per second. It is also pointed out that for all three film speeds described, as well as during still projection, the rate at which the light beam is interrupted by the shutter, and hence the flicker effect, remains constant at 54 interruptions per second. Furthermore, the amount of light transmitted remains constant and independent of the rate of projection.

As will be noted in Figs. 2 and 3, the arcuate wall 44 of each of the depressed surfaces 40, 40¹ and 40¹¹ is inclined to allow the ball follower 42 to be shifted radially of the face cam from one group of cam surfaces to the next concentric group without stopping the mechanism even if the shift is undertaken at the time the ball follower 42 is in engagement with one of the depressed cam surfaces. This allows an instant change of frame rate which is highly desirable. In addition, there is little difference in mechanism noise between the fast and slow film speeds.

It is necessary to position the ball follower 42 accurately at the different radial positions on the face of the in-and-out cam in order to avoid minute angular misalignments which will cause unacceptable timing errors between the in-and-out and pull-down cams and in order to avoid slight radial variations which may cause the in-and-out follower to ride on the in-and-out cam at the improper skip-rate position or in a dynamically unstable operating condition. This is achieved by positioning the detenting the lever which controls the position of the ball follower directly on the in-and-out cam assembly. In this manner all variations and tolerances can be made to have the minimum possible effect on the follower timing and location.

To this end, the ball follower 42 is confined in an aperture 50 in the end of a shift lever 51 which extends in parallel spaced relation to the face cam 37 and is suspended at one end by an elongated slot 52 therein engaging a pin 53 fixed to the projector and is suspended at the other end by an elongated slot 54 therein engaging the hub of the face cam 37. The shift lever 51 is held flat against the face of the in-and-out cam 37 by the presence of a spring washer 35 which is backed up by a retaining ring (not shown) fastened to the cam shaft 36. The lever is thus held parallel to the plane of rotation of the in-and-out cam. The shift lever 51 is offset as shown clearly in Fig. 1 to pass below the optical axis of the projector, and the ball follower 42 is located in line with the axis of the face cam so that as the shift lever is adjusted back and forth as indicated by the double ended arrow in Fig. 1 for varying the rate of film advance the ball follower will be moved accurately radially of the face cam. It is pointed out that while the width of the aperture 50 capturing the ball follower is slightly larger than the dia-

meter of said ball so to allow the ball to move freely transversely of the lever in response to the in-and-out cam 37, the width of the aperture should be maintained as small as possible so that there will be no lost motion between the shift lever 51 and the ball follower 42 when the shift lever is adjusted to change the rate of projection. Instead of the in-and-out follower being a ball, it could be a pin with a rounded end engaging the face cam and with a flat or rounded end engaging the follower end 30 of the claw arm 22.

The shift lever 51 may be pushed back and forth in the direction of the double arrow shown in Fig. 1 by the eccentric pin 55 on the control knob 56 engaging an elongated slot 57 in a turned-over end 58 on the end of the shift lever 51. The control knob 56 will be mounted on a control panel (not shown) of the projector and a pointer 59 thereon can co-operate with a speed scale calibrated in rates of 54, 18, 6, 0, 6, 18, and 54 frames per second. In the position of the control knob shown in the drawings, the shift lever 51 positions the ball follower 42 in the position shown in solid lines and in which position it engages the second group of three cam surfaces 40¹ on the face cam so that the claw teeth will be moved into and out of engagement with the film at the rate of 18 frames per second. If the control knob 56 were rotated in a counterclockwise direction from the position shown, it would first move the shift lever 51 inwardly of the face cam to a position giving a rate of film advance of six frames per second and then to the innermost position on the face cam in which the ball follower 52 would engage that circular portion of the cam having no depressed cam surfaces and in which position the claw would be held out of engagement with the film and "still" projection would result. The different positions the ball follower 42 can occupy are illustrated in Figs. 4 and 5 by dotted lines. The control knob 56 is capable of movement slightly greater than 180° and in going from one limit of this movement to the other shifts the ball follower 42 from the position where it engages the outermost group of cam surfaces on the face cam (54 frames per second) to its innermost position on the face cam (still projection) and then out again on the cam surface to the 54 frame per second position.

When the shift lever 51 is moved in the direction of the double arrow shown in Fig. 1, the radial position of the ball follower 42 on the in-and-out cam is determined by the radial position of four concentric skip-frame detent grooves 60 in the face of the cam 37 into which a detent ball 61 captured in an aperture 62 in the shift lever is forced to drop by a detent spring 63. Thus the radial position of the ball follower 42 is determined as accurately as it is possible to mould, or otherwise form, the relative positions of the detent

grooves 60 tracks on of the circular faces making circular tracks on the cam disc groove 60 to the co detent ball.

The mechanism described at rates of with substitution to another movement of the film 8.1, 2.7, sprocket e.g. when film supplied by the difference the take-up tendency friction of the system will however alter the mechanism with down motion the film claw.

The subject of the application 1,107,719.

While projection be applicable beyond

In one of this variation having motor of part up-and relative is done obviously just provided of the into the of the film position of the the rate is operated direct projector speed might be provided be reversed

grooves 60 to the skip-rate in-and-out cam tracks on the face of the in-and-out cam. Each of the circular grooves of in-and-out cam surfaces making up a cam track, as well as the circular track on the face of a cam which has no cam depressions, has a corresponding detent groove 60. A positive detent action is imparted to the control knob 56 by the action of the detent ball 61.

The variable in-and-out pull-down mechanism described up to this part can feed film at rates of 54, 18, 6 or 0 frames per second with substantially instant shift from one rate to another without stopping the up and down movement of the film claw. This means that the film is travelling through the projector at 8.1, 2.7, 0.9 or 0 inches per second. With a sprocketless projector of the well known type, e.g. where the film is pulled directly from the film supply reel and fed to the take-up reel by the action of the pull-down claw, this difference in film rate is absorbed easily by the take-up and supply reels which are generally tendency driven, i.e. driven through a light friction clutch or the like. If this pull-down system were used in a sprocket-type projector, however, means would have to be provided to alter the sprocket feed rate in exact synchronism with the change in rate of the claw pull-down mechanism in order to avoid a loss of the film loop ahead of and/or beyond the film claw.

The mechanism described above forms the subject of the Claims of copending Patent Application No. 23451/65 (Serial No. 1,107,718).

While we have mentioned certain rates of projection in describing our invention, it will be appreciated that more or fewer speed changes could be provided without going beyond the scope of the present invention.

In order to achieve reverse projection with this variable rate pull-down system without having to stop or reverse the direction of the motor of the drive shaft 20, an arrangement of parts has been devised for reorienting the up-and-down cam 33 from its original position relative to the in-and-out cam 37. When this is done, the in-and-out cam which has previously been forcing the claw into the film path just prior to the start of the down stroke and withdrawing it from the film path at the end of the down stroke, will now force the claw into the film path just prior to the beginning of the up stroke and will draw it out of the film path at the completion of the up stroke of the claw. While it is desirable to change the rate of film advance when the projector is operating in reverse as well as in a forward direction, it should not be possible for the projector to be reversed while operating at high speed because the mechanism and/or film might be damaged. Accordingly, we have devised a mechanism by which the projector may be reversed and which mechanism is combined

with the rate changing knob so that the projector can only be reversed when the film claw is disengaged from the film.

To this end, and referring to Figs. 4 and 5, the drive shaft 20, which is always driven in the direction indicated by the arrow, is slidably mounted in bearings 11 and 13, pull-down cam 33 is fixed thereto, and pinion 39 is rotatably and slidably mounted thereon as previously described herein. When the projector is operating in a forward direction, see Fig. 4, a driving dog 70 on the pull-down cam 33 drives a forward driving dog 71 on the pinion 39. The pinion in turn drives the in-and-out cam 37 which controls the axial movement of the ball follower 42 as described above. The single bladed shutter is fixed to the pinion 39 and is so timed relative to the forward dog 71 that it covers the gate aperture during the forward indexing stroke of the claw. A retaining ring 72 fixed to the drive shaft 20 is forced against the bearing 11 by a shifting spring 73, thus establishing the axial position of the pull-down cam 33 and the driving dog 70 fixed thereto. A light coil spring 75 encircling the drive shaft 20 ensures the pinion 13 and the shutter 21 fixed thereto always being located against the face of the other bearing 13. The spring 75 may be made heavy enough for the spring 73 to be omitted. A shifting lever 76 which pivots about a stationary pivot 77 on the projector is normally biased in a clockwise direction by means of a spring 78 so that the end of a finger 79 integral therewith does not contact the face of the pulley 19 when the mechanism is set for forward projection, see Fig. 4.

To reverse the projector, the shift lever 76 is pivoted in a counterclockwise direction about its pivot 77 to cause the end of finger 79 to engage the face of the pulley 19 and shift the drive shaft 20 axially to the left and into the position shown in Fig. 5. In this position of the drive shaft 20 the driving dog 70 on the pull-down cam 33 slips off the forward driving dog 71 on the pinion 39. As a result pinion 39 slips back precisely 180° until its reverse driving dog 80 comes into engagement with the driving dog 70 on the pull-down cam 33 and continues to operate in this position. Shifting spring 73 and coil spring 75, if both are used, are deflected or compressed by the axial movement of the drive shaft 20 to this reverse position.

In order to link the reversing of the projector with the change of speed thereof so that the rate of projection can be varied during both directions of operation but the mechanism cannot be reversed except when the film claw is disengaged from the film, the reversing of the projector is made dependent upon rotation of the control knob 56 as will be described. The end 85 of shift lever 76 has fixed thereto a follower 86 which is held by spring 78 against the periphery of a cam 87 fixed to

the control knob 56 for rotation thereby. The cam 87 includes an arcuate lobe 88 which has a rise which will cause the shift lever 76 to be pivoted in a counterclockwise direction to reverse the projector when the lobe is moved into engagement with the follower 86. The lobe 88 is so positioned on the control knob 56 relative to the eccentric pin 55 thereon that it will not engage follower 86 to reverse the projector except when the control knob is in a position to have shifted the ball follower 42 radially of the in-and-out cam to a position where the claw is held out of the film and the film speed is stopped. In other words the projector can be reversed only when the rate control knob is in a position to give a "still" projection. The lobe 88 is of such arcuate length that after the control knob is moved in a counterclockwise direction from the position shown in Fig. 4 and through the "still" position it will hold the mechanism in the reversed condition while the control knob is rotated further in a counterclockwise direction to produce the full range of rate variations of which the mechanism is possible, see Fig. 5, therefore, both the direction and speed of projection will be determined by the setting of the control knob 56 in such a way as to insure that these two operations can occur in only the proper sequence.

While we have shown this reversing mechanism in combination with our new variable rate pull-down system it is pointed out, and it will be appreciated by those skilled in the art, that this reversing mechanism could be used in combination with any conventional pull-down mechanism capable of only one rate of projection or a mechanism having no provision for projecting "stills".

WHAT WE CLAIM IS:—

1. A motion picture projector comprising an apertured film gate through which a motion picture film is adapted to be intermittently advanced for the projection of successive image frames therefrom, a film claw, means for mounting the claw for up-and-down and in-and-out movements relative to said gate during which movements it intermittently engages and advances the film through the gate, drive means operating at a given frequency, an up-and-down cam connected to the drive means to drive the claw up-and-down relative to the gate at the given frequency, means for selectively imparting in-and-out movements to the claw in different time relations with the up-and-down movement thereof to change the rate of film advance and including an in-and-out cam driven in synchronism with the up-and-down cam and having a plurality of cam surfaces spaced along a surface thereof, certain of which cam surfaces control the rate of the in-and-out movement of the claw, a cam follower connecting the claw to the in-and-out cam to cause the claw to move into and out of engagement with the film in response to

rotation of the cam in accordance with the particular cam surface engaged thereby, means for adjusting the cam follower along the in-and-out cam to engage selected ones of the cam surfaces, means for selectively shifting the phase relation between the up-and-down cam and the in-and-out cam by 180° to reverse the direction of movement of the film through the gate without stopping the drive means, and a common control member connected to the means for selectively changing the rate of film advance and the means for selectively reversing the direction of movement of the film so that both the rate of projection and the direction of film movement is controllable by adjustment of the common control member.

2. A motion picture projector according to claim 1, wherein one of the cam surfaces on the up-and-down cam is adapted to hold the claw out of engagement with the film for the still projection of a given frame of film.

3. A motion picture projector according to claim 1, in which the connection between the said common control member, the rate changing means and the reversing means necessitates the rate changing means assuming a position effecting still projection, thereby removing the claw from the gate, each time a reversal of the film is effected.

4. A motion picture projector according to claim 1 or 3, in which the rate changing means and the phase shifting means, and the connection between each of these means and the said common control member, is such that a movement of the said common control member between two limits first reduces the rate of projection from a maximum equal to the frequency of drive means in predetermined stages until the film is motionless when the said common control member reaches an intermediate position of adjustment and after which further movement of the said common control member increases the rate of projection in predetermined stages until the maximum rate is again achieved when the said common control member reaches the other limit, the said common control member effecting reversal of the film movement as it moves through the intermediate position, whereby the reversal of the film can be accomplished only when the film in the gate is motionless and the rate of projection can be changed during both the forward and reverse operation of the projector.

5. A motion picture projector according to claim 4, in which the means for shifting the phase relation between said up-and-down and in-and-out cams by 180° to reverse the direction of film movement includes an axially slidably mounted drive shaft forming a part of the said drive means and adapted to move between a first position and a second position in one of which it causes the film to move forwardly and in the other of which it causes the film to move in reverse, a shiftable lever connected to the drive shaft to move it between

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the control knob 56 for rotation thereby. The cam 87 includes an arcuate lobe 88 which has a rise which will cause the shift lever 76 to be pivoted in a counterclockwise direction to reverse the projector when the lobe is moved into engagement with the follower 86. The lobe 88 is so positioned on the control knob 56 relative to the eccentric pin 55 thereon that it will not engage follower 86 to reverse the projector except when the control knob is in a position to have shifted the ball follower 42 radially of the in-and-out cam to a position where the claw is held out of the film and the film speed is stopped. In other words the projector can be reversed only when the rate control knob is in a position to give a "still" projection. The lobe 88 is of such arcuate length that after the control knob is moved in a counterclockwise direction from the position shown in Fig. 4 and through the "still" position it will hold the mechanism in the reversed condition while the control knob is rotated further in a counterclockwise direction to produce the full range of rate variations of which the mechanism is possible, see Fig. 5, therefore, both the direction and speed of projection will be determined by the setting of the control knob 56 in such a way as to insure that these two operations can occur in only the proper sequence.

While we have shown this reversing mechanism in combination with our new variable rate pull-down system it is pointed out, and it will be appreciated by those skilled in the art, that this reversing mechanism could be used in combination with any conventional pull-down mechanism capable of only one rate of projection or a mechanism having no provision for projecting "stills".

WHAT WE CLAIM IS:—

1. A motion picture projector comprising an apertured film gate through which a motion picture film is adapted to be intermittently advanced for the projection of successive image frames therefrom, a film claw, means for mounting the claw for up-and-down and in-and-out movements relative to said gate during which movements it intermittently engages and advances the film through the gate, drive means operating at a given frequency, an up-and-down cam connected to the drive means to drive the claw up-and-down relative to the gate at the given frequency, means for selectively imparting in-and-out movements to the claw in different time relations with the up-and-down movement thereof to change the rate of film advance and including an in-and-out cam driven in synchronism with the up-and-down cam and having a plurality of cam surfaces spaced along a surface thereof, certain of which cam surfaces control the rate of the in-and-out movement of the claw, a cam follower connecting the claw to the in-and-out cam to cause the claw to move into and out of engagement with the film in response to

rotation of the cam in accordance with the particular cam surface engaged thereby, means for adjusting the cam follower along the in-and-out cam to engage selected ones of the cam surfaces, means for selectively shifting the phase relation between the up-and-down cam and the in-and-out cam by 180° to reverse the direction of movement of the film through the gate without stopping the drive means, and a common control member connected to the means for selectively changing the rate of film advance and the means for selectively reversing the direction of movement of the film so that both the rate of projection and the direction of film movement is controllable by adjustment of the common control member.

2. A motion picture projector according to claim 1, wherein one of the cam surfaces on the up-and-down cam is adapted to hold the claw out of engagement with the film for the still projection of a given frame of film.

3. A motion picture projector according to claim 1, in which the connection between the said common control member, the rate changing means and the reversing means necessitates the rate changing means assuming a position effecting still projection, thereby removing the claw from the gate, each time a reversal of the film is effected.

4. A motion picture projector according to claim 1 or 3, in which the rate changing means and the phase shifting means, and the connection between each of these means and the said common control member, is such that a movement of the said common control member between two limits first reduces the rate of projection from a maximum equal to the frequency of drive means in predetermined stages until the film is motionless when the said common control member reaches an intermediate position of adjustment and after which further movement of the said common control member increases the rate of projection in predetermined stages until the maximum rate is again achieved when the said common control member reaches the other limit, the said common control member effecting reversal of the film movement as it moves through the intermediate position, whereby the reversal of the film can be accomplished only when the film in the gate is motionless and the rate of projection can be changed during both the forward and reverse operation of the projector.

5. A motion picture projector according to claim 4, in which the means for shifting the phase relation between said up-and-down and in-and-out cams by 180° to reverse the direction of film movement includes an axially slidably mounted drive shaft forming a part of the said drive means and adapted to move between a first position and a second position in one of which it causes the film to move forwardly and in the other of which it causes the film to move in reverse, a shiftable lever connected to the drive shaft to move it between

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the said two positions, and in which means for adjusting the cam follower along the in-and-out cam to engage selected ones of the cam surfaces thereon to change the rate and characteristic of the in-and-out movement of the claw includes a follower shifting bar oscillatable between two limits in one of which the follower engages a cam surface which causes the claw to move in and out of engagement with the film at a frequency equal to the given frequency at which the drive means is operating, and in the other of which the follower engages a cam surface which holds the claw out of engagement with the film for the projection of stills, and in which the said common control member and its connection with the means for selectively changing the rate of film advance and the means for selectively reversing the direction of movement of the film includes a control member oscillatable between two positions during which it passes through an intermediate position, and means connecting the said control member and the follower shifting bar for shifting the bar from its one limit to its other limit and back to the said one limit as the said control member moves from one of its two positions to the intermediate position and then onto its other position, and means for connecting the said control member and the said shiftable lever for shifting this lever to move the drive shaft from one of its two positions to the other at the time the said control member is moved to its intermediate position, whereby the film movement is reversed during the time the claw is disengaged from the film.

6. A motion picture projector according to claim 4, wherein the drive shaft is mounted to move axially between a first position, in which the pull down cam is connected to the in-and out cam in a phase relationship such that the claw moves into engagement with the

film at the top of the up and down stroke of the claw, and a second position, in which the phase relationship between the in-and-out cam and the pull down cam is shifted 180° relative to their relationship when the drive shaft is in the first position and wherein the claw enters the film at the bottom of the pull down stroke, and means for shifting the drive shaft axially between the first and second positions includes an indexed control knob movable between two positions on a scale which designate a forward and a reverse projection condition, respectively.

7. A motion picture projector according to claim 6, in which the drive shaft is spring biased to the said first position for forward projection of the film.

8. A motion picture projector according to claim 7, wherein the drive means for rotating the pull down and in-and-out cams in timed relation and the means for selectively reversing the direction in which the claw moves the film through the gate includes a drive shaft axially movable between a first and a second position, the pull down cam being fixed to the drive shaft to rotate therewith, means for driving the in-and-out cam, a clutch means for connecting the drive shaft to the means for driving the in-and-out cam and shiftable between first and second positions in which the phase relation between said pull down and in-and-out cams is shifted by 180°, and means for selectively moving the drive shaft axially while it is rotating in order to shift the clutch between the said first and second positions and reverse the direction of the film advance through the projector.

L. A. TRANGMAR, B.S.c., C.P.A.
Agent for the Applicants.

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