The Motion Picture Projector (part 2)

– Andrew Irvine

People have been enjoying motion pictures for more than 100 years. Decades of innovation over that time have produced impressive breakthroughs in light, sound, image and film transport. The intermittent movement, however, has remained unchanged since its inception. It is this mechanism, and its integration with the shutter, that is the most critical component of any motion picture projector, for without it we would never be able to experience the illusion of cinema.

The film begins its journey on the top spool, often called the "pay out". This is a free-wheeling mechanism held back by a clutch which can be adjusted to set the tension on the film as it feeds into the top of the projector. From here the film passes over a series of sprocketed rollers. These sprocketed rollers pull the film through the projector by locking small teeth into the perforations on either side of the picture frame area of the film. There are usually at least three of these rollers, one to draw the film into the machine from the pay out spool, one to pull the film through the gate and a third just before it enters the lower take up spool. This final roller is usually called a "hold back" sprocket, referring to its function of keeping the film from being drawn too quickly onto the lower spool.

The film then ends its journey on the lower "take up" spool. This spool is mounted on a motor-driven spindle. The motor pulls the film faster than it is being fed through the machine, but as on the pay out there is a clutch mechanism which allows the spool to slip and can be adjusted to supply tension so the film is not taken up either too tightly or too loosely.

35mm film stock, the standard of motion picture film, thus moves through the projector at a rate of 24 frames per second or 90 feet per minute. Each frame is held upright before the light source by a mechanism called a gate or film trap. The gate ensures the film is held flat so that it can be accurately focused when the image is projected. The gate sits between the light source and the lens.

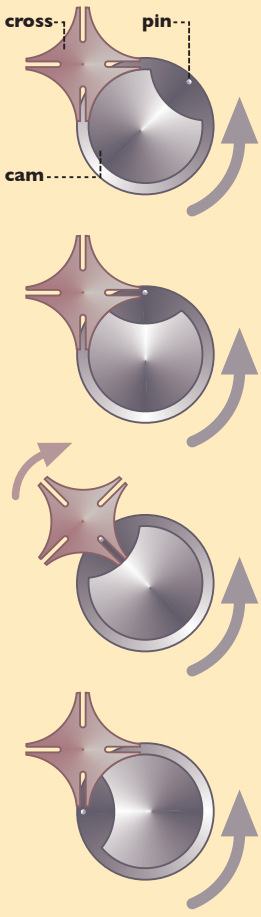
With the film moving so rapidly through the projector, one would expect little more than a blur to appear on screen as the image is projected. To counter this each frame is held firmly in place and perfectly stationary while light is passed through it and the lens, before being pulled down to the next frame. This frame-by-frame stop-start motion is provided by the Geneva movement (see sidebar), an invention without which motion pictures would not exist.

The intermittent motion of the film through the gate is perfectly synchronized

The Geneva Movement

The Geneva movement, also called the cam and cross, maltese cross or intermittent movement, is at the heart of motion picture projector operation. This mechanism drives the intermittent sprocket, pulling the film rapidly through the gate then stopping it to ensure a rock-steady image while the shutter is open.

The mechanism consists of two parts, a maltese cross-like wheel which interlocks with another wheel containing a cam and a pin. The cam locks the cross in place during its stationary phase, while the pin drives the cross during its motion phase. Illustrated below are the stages in the operation of the movement.



1 *As the wheel rotates, the cross is locked in place by its position against the rotating cam. The curve of the cross fits flushly with the outer circle of the cam ensuring it is unable to move.*

2 *When the pin reaches the top of the arc, it locks into the slot on the cross. At the same time, the depression in the cam opens up, allowing the cross freedom to turn around it.*

3 *With the pin now locked into the slot, the wheel continues to turn and the cross is pulled rapidly around through ninety degrees. The cross is given free movement by the open depression in the cam.*

4 *As the pin leaves the cross, the cam once again engages with the curve of the cross, locking it into its new position. The cross remains locked until the wheel rotates the pin once again to the top of its arc.*

with the opening and closing of the shutter. This ensures no light passes through the film while it is in motion, which would introduce "ghosting".

The shutter consists usually of a circular plate into which is cut an opening of between one quarter and one half of the plate's area. This plate spins just behind the gate, shutting off and opening up the light source in synchronization with the motion of the film. While the shutter is closed the film can move forward, advancing to the next frame. The film must be perfectly stationary in the gate before the opening in the shutter once again reaches the gate, and must not move again until the shutter is closed.

The rate at which the shutter-plate spins is normally twice that of the advancement of frames of film. This means the shutter usually spins at a rate of 48 revolutions per second. This helps to reduce visible flicker on screen, as the human eye can normally perceive the alternation of light and dark at lower speeds.

With a steady progression of still images now projected onto the screen, the human brain takes over. Persistence of vision creates an illusion of motion—the illusion of cinema. ■