Topic no. 73

35 mm Camera

Recorder and Projector

A **movie projector** is an opto-mechanical device for displaying motion picture film by projecting it onto a screen. Most of the optical and mechanical elements, except for the illumination and sound devices, are present in movie cameras.

Projection elements

As in a slide projector there are essential optical elements:

1. **Light source**

Incandescent lighting and even limelight were the first light sources used in film projection. In the early 1900s up until the late 1960s, carbon arc lamps were the source of light in almost all theaters in the world.

The Xenon arc lamp was introduced in Germany in 1957 and in the US in 1963. After film platters became commonplace in the 1970s, Xenon lamps became the most common light source, as they could stay lit for extended periods of time, whereas a carbon rod used for a carbon arc could last for an hour at the most.

Most lamp houses in a professional theatrical setting produce sufficient heat to burn the film should the film remain stationary for more than a fraction of a second. Because of this, care must be taken in inspecting a film so that it should not break in the gate and be damaged, particularly if it is flammable cellulose nitrate film stock.

2. **Reflector and condenser lens**

A curved reflector redirects light that would otherwise be wasted toward the condensing lens.

A positive curvature lens concentrates the reflected and direct light toward the film gate.

3. **Douser**

A metal or asbestos blade which cuts off light before it can get to the film. The douser is usually part of the lamphouse, and may be manually or automatically operated. Some projectors have a second, electrically controlled douser that is used for changeovers (sometimes called a "changeover douser" or "changeover shutter"). Some projectors have a third, mechanically controlled douser that automatically closes when the projector slows down (called a "fire shutter" or "fire douser"), to protect the film if the projector stops while the first douser is still open. Dousers protect the film when the lamp is on but the film is not moving, preventing the film

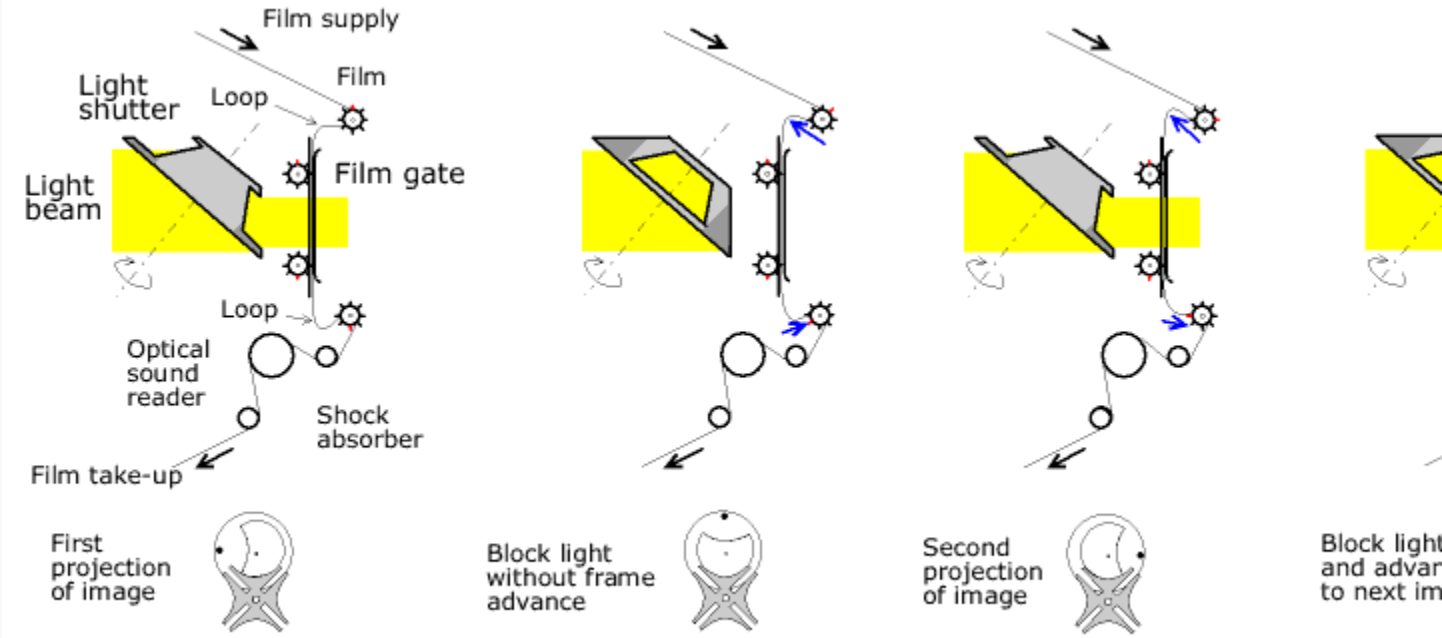
from melting from prolonged exposure to the direct heat of the lamp. It also prevents the lens from scarring or cracking from excessive heat.

4. Film gate and single image

A single image of the series of images comprising the movie is positioned and held flat within an aperture called the gate. The gate also provides a slight amount of friction so that the film does not advance or retreat except when driven to advance the film to the next image.

5. Shutter

A commonly held misconception is that film projection is simply a series of individual frames dragged very quickly past the projector's intense light source. This is not the case; if a roll of film were merely passed between the light source and the lens of the projector, all that would be visible on screen would be a continuous blurred series of images sliding from one edge to the other. It is the shutter that gives the illusion of one full frame being replaced exactly on top of another full frame. A rotating petal or gated cylindrical shutter interrupts the emitted light during the time the film is advanced to the next frame. The viewer does not see the transition, thus tricking the brain into believing a moving image is on screen. Modern shutters are designed with a flicker-rate of two times (48 Hz) or even sometimes three times (72 Hz) the frame rate of the film, so as to reduce the perception of screen flickering. Higher rate shutters are less light efficient, requiring more powerful light sources for the same light on screen.



Mechanical sequence when image is shown twice and then advanced.
Outer sprockets rotate continuously while the frame advance sprockets are controlled by the mechanism shown - a Geneva drive.

6. **Imaging lens and aperture plate**

Imaging lens *Diastar* of an Askania 35mm movie projector (focal length: 400 mm)

A projection objective with multiple optical elements directs the image of the film to a viewing screen (imaging lens). Imaging lenses also differ in aperture and focal length. Different lenses are used for different aspect ratios.

Aspect ratios are controlled by the lens with the appropriate aperture plate, a piece of metal with a precisely cut rectangular hole in the middle of equivalent aspect ratio. The aperture plate is placed just behind the gate, and masks off any light from hitting the image outside of the area intended to be shown. All films, even those in the standard Academy ratio, have extra image on the frame that is meant to be masked off in the projection.

7. **Viewing screen**

In most cases this is a reflective surface which may be either aluminized (for high contrast in moderate ambient light) or a white surface with small glass beads (for high brilliance under dark conditions). Switchable projection screen can be switched between opaque and clear by a safe voltage under 36V AC and is viewable from both sides. In a commercial theater, the screen also has millions of very small, evenly spaced holes in order to allow the passage of sound from the speakers and subwoofer which often are directly behind it.

Film transport elements

Film supply and take up

Two-reel system

In the two-reel system the projector has two reels–one is the feed reel, which holds the part of the film that has not been shown, the other is the takeup reel, which winds the film that has been shown. In a two-reel projector the feed reel has a slight drag to maintain tension on the film, while the takeup reel is constantly driven with a mechanism that has mechanical 'slip,' to allow the film to be wound under constant tension so the film is wound in a smooth manner.

The film being wound on the takeup reel is being wound "head in, tails out." This means that the beginning (or "head") of the reel is in the center, where it is inaccessible. As each reel is taken off of the projector, it must be re-wound onto another empty reel. In a theater setting there is often a separate machine for rewinding reels. For the 16 mm projectors that were often used in schools and churches, the projector could be re-configured to rewind films.

The size of the reels can vary based on the projectors, but generally films are divided and distributed in reels of up to 2000 feet (610 m, about 22 minutes at 24 frames/sec). Some projectors can even accommodate up to 6000 feet (1,830 m), which minimizes the number of changeovers (see below) in a showing. Certain countries also divide their film reels up differently; Russian films, for example, often come on 1000-foot (305 m) reels, although it's likely that most projectionists working with changeovers would combine them into longer reels of at least 2000 feet (610 m), to minimize changeovers and also give sufficient time for threading and any possibly needed troubleshooting time.

Films are identified as "short subjects," taking one reel or less of film, "two-reelers," requiring two reels of film (such as some of the early Laurel & Hardy, 3 Stooges, and other comedies), and "features," which can take any number of reels (although most are limited to 1½ to 2 hours in length, enabling the theater to have multiple showings throughout the day and evening, each showing with a feature, commercials, and intermission to allow the audiences to change). In the "old days" (i.e., ca. 1930–1960), "going to the movies" meant seeing a short subject (a newsreel, short documentary, a "2-reeler," etc.), a cartoon, and the feature. Some theaters would have movie-based commercials for local businesses, and the state of New Jersey required showing a diagram of the theater showing all of the exits.

Changeover

Because a single film reel does not contain enough film to show an entire feature, the film is distributed on multiple reels. To prevent having to interrupt the show when one reel ends and the next is mounted, two projectors are used in what is known as a "changeover system," after the switching mechanism that operates between the end of one reel on the first projector and the beginning of the next reel on the second projector. The two-reel system was used almost

universally for movie theaters before the advent of the single-reel system in order to be able to show feature-length films. Although one-reel long-play systems tend to be more popular with the newer multiplexes, the two reel system is still in significant use to this day.

The projector operator operates two projectors, starting the first reel of the show on projector "A." While this reel is being shown, the projectionist threads the second reel on projector "B."

As the reel being shown approaches its end, the projectionist looks for cue marks at the upper-right corner of the picture. Usually these are dots or circles, although they can also be slashes. Some older films occasionally used squares or triangles, and sometimes positioned the cues in the middle of the right edge of the picture.

The first cue appears twelve feet (3.7 m) before the end of the program on the reel, equivalent to eight seconds at 24 frames/sec. This cue signals the projectionist to start the motor of the projector containing the next reel. After another ten and a half feet (3.2 m) of film is shown (seven seconds at 24 frames/sec), the changeover cue should appear, which signals the projectionist to actually make the changeover. When this second cue appears, the projectionist has one and a half feet (457 mm), or one second at 24 frame/s, to make the changeover. If it doesn't occur within one second, the tail leader of the reel coming to an end will be projected on the screen.

Twelve feet before the "first frame of action," Academy leaders have a "START" frame. The projectionist positions the "START" in the gate of the projector. When the first cue is seen, the motor of the starting projector is started. Seven seconds later the end of the leader and start of program material on the new reel should just reach the gate of the projector when the changeover cue is seen.

On some projectors, the operator would be alerted to the time for a change by a bell that operated when the feed reel rotation exceeded a certain speed (the feed reel rotates faster as the film is exhausted), or based on the diameter of the remaining film (Premier Changeover Indicator Pat. No. 411992), although many projectors do not have such an auditory system.

During the actual operation of a changeover, the two projectors use an interconnected electrical control connected to the changeover button so that as soon as the button is pressed, the changeover douser on the outgoing projector is closed in sync with the changeover douser on the incoming projector opening. If done properly, a changeover should be virtually unnoticeable to an audience. In older theaters, there may be manually operated, sliding covers in front of the projection booth's windows. A changeover with this system is often clearly visible as a wipe on the screen.

Once the changeover has been made, the projectionist unloads the full takeup reel from projector "A," moves the now-empty reel (that used to hold the film just unloaded) from the feed spindle

to the takeup spindle, and loads reel #3 of the presentation on projector "A." When reel 2 on projector "B" is finished, the changeover switches the live show from projector "B" back to projector "A," and so on for the rest of the show.

When the projectionist removes a finished reel from the projector it is "tails out," and needs to be rewound before the next show. The projectionist usually uses a separate rewind machine and a spare empty reel, and rewinds the film so it is "head out," ready to project again for the next show.

One advantage of this system (at least for the theatre management) was that if a programme was running a few minutes late for any reason, the projectionist would simply omit one (or more) reels of film to recover the time.

Single-reel system

Christie AW3 platter, BIG SKY Industries console, and Century SA projector.

There are two largely used single-reel systems (also known as long-play systems) today: the tower system (vertical feed and take up) and the platter system (non-rewinding; horizontal feed and take up).

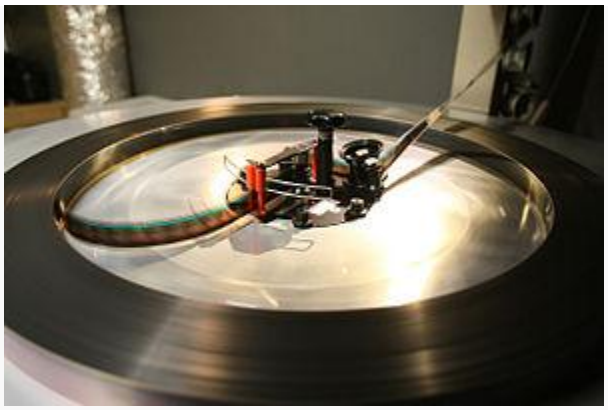
The tower system largely resembles the two reel system, except in that the tower itself is generally a separate piece of equipment used with a slightly modified standard projector. The feed and take up reels are held vertically on the axis, except behind the projector, on oversized spools with 12,000 foot (3,660 m) capacity or about 133 minutes at 24 frame/s. This large capacity alleviates the need for a changeover on an average-length feature; all of the reels are spliced together into one giant one. The tower is designed with four spools, two on each side, each with its own motor. This allows the whole spool to be immediately rewound after a showing; the extra two spools on the other side allow for a film to be shown while another is being rewound or even made up directly onto the tower. Each spool requires its own motor in

order to set proper tensioning for the film, since it has to travel (relatively) much further between the projector film transport and the spools. As each spool gains or loses film, the tension must be periodically checked and adjusted so that the film can be transported on and off the spools without either sagging or snapping.

In a platter system the individual 20-minute reels of film are also spliced together as one large reel, but the film is then wound onto a horizontal rotating table called a platter. Three or more platters are stacked together to create a platter system. Most of the platters in a platter system will be occupied by film prints; whichever platter happens to be empty serves as the "take-up reel" to receive the film that is playing from another platter.

The way the film is fed from the platter to the projector is not unlike an eight-track audio cartridge. Film is unwound from the center of the platter through a mechanism called a payout unit which controls the speed of the platter's rotation so that it matches the speed of the film as it is fed to the projector. The film winds through a series of rollers from the platter stack to the projector, through the projector, through another series of rollers back to the platter stack, and then onto the platter serving as the take-up reel.

This system makes it possible to project a film multiple times without needing to rewind it. As the projectionist threads the projector for each showing, he transfers the payout unit from the empty platter to the full platter and the film then plays back onto the platter it came from. In the case of a double feature, each film plays from a full platter onto an empty platter, swapping positions on the platter stack throughout the day.



nonrewind in Royal - Malmo, Sweden.

The advantage of a platter is that the film need not be rewound after each show, which can save labor. Rewinding risks rubbing the film against itself, which can cause scratching of the film and smearing of the emulsion which carries the pictures. The disadvantages of the platter system are that the film can acquire diagonal scratches on it if proper care is not taken while threading film from platter to projector, and the film has more opportunity to collect dust and dirt as long

lengths of film are exposed to the air. A clean projection booth kept at the proper humidity is of great importance, as are cleaning devices that can remove dirt from the film print as it plays.

Automation and the rise of the multiplex

The single reel system can allow for the complete automation of the projection booth operations, given the proper auxiliary equipment. Since films are still transported in multiple reels they must be joined together when placed on the projector reel and taken apart when the film is to be returned to the distributor. It is the complete automation of projection that has enabled the modern "multiplex" cinema - a single site typically containing from 8 to 24 theaters with only a few projection and sound technicians, rather than a platoon of projectionists. The multiplex also offers a great amount of flexibility to a theater operator, enabling theaters to exhibit the same popular production in more than one auditorium with staggered starting times. It is also possible, with the proper equipment installed, to "interlock", i.e. thread a single length of film through multiple projectors. This is very useful when dealing with the mass crowds that an extremely popular film may generate in the first few days of showing, as it allows for a single print to serve more patrons.

Feed and extraction sprockets

Smooth wheels with triangular pins called sprockets engage perforations punched into one or both edges of the film stock. These serve to set the pace of film movement through the projector and any associated sound playback system.

Film loop

As with motion picture cameras, the intermittent motion of the gate requires that there be loops above and below the gate in order to serve as a buffer between the constant speed enforced by the sprockets above and below the gate and the intermittent motion enforced at the gate. Some projectors also have a sensitive trip pin above the gate to guard against the upper loop becoming too big. If the loop hits the pin, it will close the dousers and stop the motor to prevent an excessively large loop from jamming the projector.

Film gate pressure plate

A spring-loaded pressure plate functions to align the film in a consistent image plane, both flat and perpendicular to the optical axis. It also provides sufficient drag to prevent film motion during the frame display, while still allowing free motion under control of the intermittent mechanism. The plate also has spring-loaded runners to help hold film while in place and advance it during motion.

Intermittent mechanism

The intermittent mechanism can be constructed in different ways. For smaller gauge projectors (8 mm and 16 mm), a pawl mechanism engages the film's sprocket hole one side, or holes on each side. This pawl advances only when the film is to be moved to the next image. As the pawl retreats for the next cycle it is drawn back and does not engage the film. This is similar to the claw mechanism in a motion picture camera.

In 35 mm and 70 mm projectors, there usually is a special sprocket immediately underneath the pressure plate, known as the intermittent sprocket. Unlike all the other sprockets in the projector, which run continuously, the intermittent sprocket operates in tandem with the shutter, and only moves while the shutter is blocking the lamp, so that the motion of the film cannot be seen. It also moves in a discrete amount at a time, equal to the number of perforations that make up a frame (4 for 35 mm, 5 for 70 mm). The intermittent movement in these projectors is usually provided by a Geneva drive, also known as the Maltese Cross mechanism.

IMAX projectors use what is known as the rolling loop method, in which each frame is sucked into the gate by a vacuum, and positioned by registration pins in the perforations corresponding to that frame.