Chapter 2. How it works

This chapter briefly explains the mechanics of the moving image. It will also introduce you to the working parts of the projector. By the time you reach the end of this chapter you will have covered all the essentials, and be ready to move on to threading and screening a film.

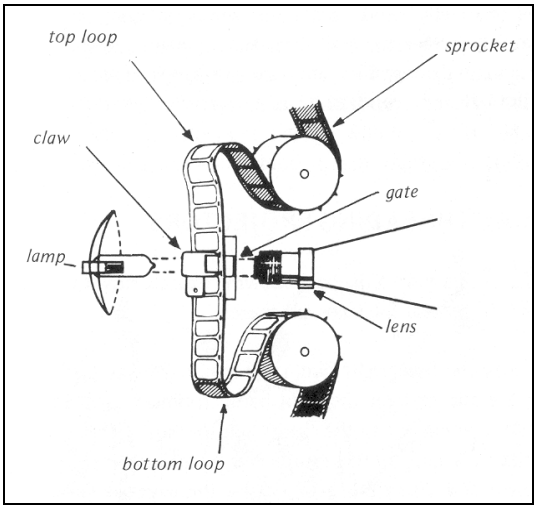
The film transport system

The film travels through the projector at a constant speed along a path called, logically enough, the film path. If you are timing a screening you need to know that film is measured in feet (not metres) and that 16 mm sound film travels through the projector at 36 feet per minute. The film is pulled from the feed reel by the feed sprocket , which engages the perforations that run along one edge of the film. It passes through a vertical channel, where its edges are pressed flat as the image passes over the lamp aperture ('the gate') between the lamp and the lens, before encountering the claw which pulls the film down one frame at a time (more on the claw shortly). It moves along to the sound drum, where it is held in close contact by a pinch roller that ensures it passes over the drum at a constant speed. It is then pulled through the take up sprocket and on to the take up reel, via a tension or 'snubber' roller.

> ***Your turn:***
> *Look at the projector and identify external parts referred to in the text: feed reel, sprockets, film path, sound drum, pressure roller, take up reel.*
> *Swing out the lens bracket (this is called 'opening the gate'); identify the lamp aperture. Rotate the inching wheel and note how the sprockets move. Note how the claw moves in and out and up and down. When the claw moves out then downwards the projector is in forward motion. Remember this for future reference.*
> *Open the lamphouse and identify the lamp. Note the type of lamp, its voltage and wattage.*

Creating the illusion of movement

The illusion of a moving picture is created only when each individual frame is absolutely still when it is viewed in sequence. This means the moving strip of film has to pause briefly to allow each frame to be viewed while it is motionless. The frame is then pulled down and replaced by the next frame, which pauses in its turn, and so on. This stop-start process is called 'intermittent motion'. In sound films the process occurs 24 times per second (in silent film, 16 frames per second). In most 16 mm projectors, the frame is pulled down by a synchronized two or three pronged claw that engages with the perforations. A few 16 mm projectors use a Geneva movement, which has a sprocket instead of a claw.



The heart of the matter: creating the illusion of movement

While the frame is being pulled down before being replaced by the next frame it is in motion, and if this is seen by the audience the illusion of movement is destroyed. This problem is solved by inserting a revolving shutter between the lamp and the film. The shutter is synchronized to pass in front of the lamp just as the frame is being pulled down, thus preventing the viewer seeing an image on screen while the frame is moving.

However, when the shutter blade passes across the lamp it creates a perception of 'flicker', which is actually the rapid variation in light intensity from brightness to darkness and back again. The problem of flicker is solved by doubling the rate at which the shutter blade interrupts the projected image. But instead of increasing the speed at which the shutter rotates, twin blades are fitted, with the result that in every rotation, each blade makes a single pass, thus exposing the still frame twice before it is pulled down and replaced by the next frame.

> ***Your turn:***
> *Open the back of the projector and identify the shutter.*
> *Rotate the inching wheel and note how the shutter moves in synchronization with the claw.*
> *Note how the spindle on the take up reel arm rotates when the inching wheel is rotated forwards.*

The lamp

The image is created by passing light through the film on to a screen. In most 16 mm projectors a small quartz iodide (QI) bulb creates a high quality white light. Most QI lamps are one piece units that incorporate reflector and bulb. Older projectors use tungsten lamps which are much larger, much less efficient and difficult to replace. Some 16 mm projectors use xenon arc lamps that produce a very pure white light. Over short distances xenon lamps have virtually no advantage over quartz iodide, but they are far superior over longer throws. They are also much more expensive to replace. All lamps operate at very high temperatures and must always be handled carefully, even when cold.

> Tip: Always use a cotton glove or soft cloth when handling lamps and their reflectors. The reason for this is that even the best washed fingers are contaminated by salts which bake to the lamp's surface. The contaminant and the lamp surface expand and contract at different rates as the lamp heats and cools. Over recurring cycles the resulting stress will weaken the surface material and ultimately cause the lamp to fail prematurely.

The lens

The most amazing thing about the lens is its ability to transform a tiny film image about the size of a finger nail into a screen picture that can measure several metres across. To produce a high quality screen image the lens must be free of dust and dirt.

> Tip: Never touch the surface of a lens. And don't clean lenses too often. They can be kept in good condition by using a puffer and soft lens brush. They rarely need cleaning with anything more. When necessary, use a special lens cleaning cloth and fluid, or lens cleaning tissues. Do not use ordinary window cleaner as it may damage the 'bloom' or optical coating on the lens. Never use ordinary household tissues or a dry cloth.
>
> Note: Funguses love the inside of lenses and lens coatings. They are very difficult to control, especially in warm, humid climates. You may need to construct a special dry cupboard, in which air is kept circulating by a low voltage light bulb, to prevent mould building up in your lenses.

When the film passes across the lamp aperture it is actually upside down, but the lens rotates the image through 180°, so the audience sees it the right way up.

Ideally, the whole of the screen should be in sharp focus at all times. However, this can be difficult to achieve given the magnification of the original tiny film image and the many variables (eg screen angle, warped or curled film, etc) involved. So it is important to get sharp focus on the centre of the screen, which is where most of the audience will be looking most of the time.

> ***Your turn***
> *Unroll some film until you can see some images. Note the top of each frame faces the head (start) of the film. This is important if you have no other way of knowing which end of the film is the head and which is the tail (end).*

Focal length
The focal length of a lens determines how large the focused image will be over different distances. This is discussed further in the *Procedures* chapter, under *Setting Up*.

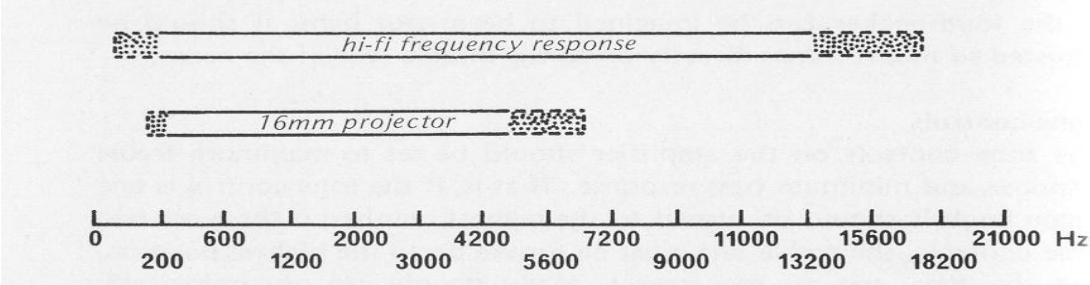
Zoom lenses and tele converters
A zoom lens or tele converter can be adjusted to provide variable image size with clear focus over a range of distances. However, in both instances the image has to travel though extra glass elements that can have an adverse effect on light intensity and picture quality.

Anamorphic lenses
Cinemascope (known also as 'scope') films can only be projected using an anamorphic lens, which expands the film image sideways, restoring it to its correct proportions. The anamorphic lens is fitted to the projector in front to the normal lens, usually with a special bracket that swings out of the way when it is not being used.

Sound
The soundtrack
The sound that comes through the speaker is recorded on the film as an optical soundtrack. This is the wavy line that runs along one edge of the film. As the film passes over the sound drum an exciter lamp directs a beam of light through the soundtrack, causing the light's intensity to vary. These variations in intensity are sensed by a photoelectric (or 'solar') cell, which converts the varying light patterns into electrical signals that are amplified and fed into a speaker to produce sound in the form of music, dialogue and special effects.

> ***Your turn***
> *Find the optical soundtrack on a piece of film.*
> *Note the soundtrack runs along one edge of the film and the perforations run along the other edge.*

Optical soundtracks do not cover the entire frequency range. The following simplified diagram illustrates the comparison between the frequency response of a normal stereo system and a 16 mm optical soundtrack.



You can see how much of the frequency range is missing. You can never replace the missing frequencies, but you can partly compensate when you are setting your amplifier outputs. You don't need much bass. But you

need plenty of treble. If you are stuck for conversation with another projectionist sometime, just raise the topic of how to get better sound out of 16 mm film. You won't have to say anything for at least half an hour. Everyone has a better way to do it. The fact remains that the original signal from the soundtrack is limited, so it doesn't matter how many amplifiers and speakers you hook up, the sound is not going to match that of a multi channel surround sound system. Despite all of this, a 16 mm optical soundtrack in good condition can produce very satisfactory results.

The exciter lamp

The exciter lamp should strike the soundtrack exactly 26 frames ahead of the lamp aperture. The actual distance is determined by the size of the bottom loop that is set when you are threading up. If the bottom loop is too large the sound will be out of synchronization ('out of sync') with the action on screen, and it will be especially noticeable during dialogue scenes.

Magnetic soundtracks

A few 16 mm films have a magnetic soundtrack. This is a narrow band of brown material that runs along the edge where the optical soundtrack would otherwise be. Films with magnetic sound tracks can be screened only on projectors that are fitted with magnetic track readers.

> ***Your turn***
> *Identify the sound drum, pressure roller, exciter lamp, noting its type, voltage and wattage, and photoelectric cell. Note if your projector is capable of reading a magnetic sound track.*

Amplifiers

All sound projectors are fitted with amplifiers. Until about the late 1950s amplifiers were powered by valves, known in the USA as tubes. These still work well, if you can find replacement valves. More recent amplifiers are either solid state or have integrated circuits.

> Note: Fitting a line out
> A shortcoming with most projector amplifiers is that they have only a single external speaker connection and do not have a line out if you want to connect to an external amplifier. This can be overcome in two ways. 1. Have an audio specialist fit a line out and jack. 2. Connect the projector's amplifier output to the input of a normal stereo amplifier via a device that reduces the projector amplifier's output to a level that will not damage either amplifier. The device, called an 'attenuator', is obtainable from any audio or electronics store. This method is effective, safe, simple, inexpensive and requires no modifications to the projector. It is a little more fiddly to operate, but works well.

The right image and sound

While the film is running adjustments can be made to the focus, the frame and the sound, to make the experience as enjoyable as possible for the audience. These are discussed in the *Procedures* chapter.

Summary

The projector incorporates four systems that all work together. They are:

- The film transport system
- The intermittent motion mechanism
- The light source and lens
- The sound system

> ***Your turn***
> *Prepare to screen a film: Go to Procedures chapter.*