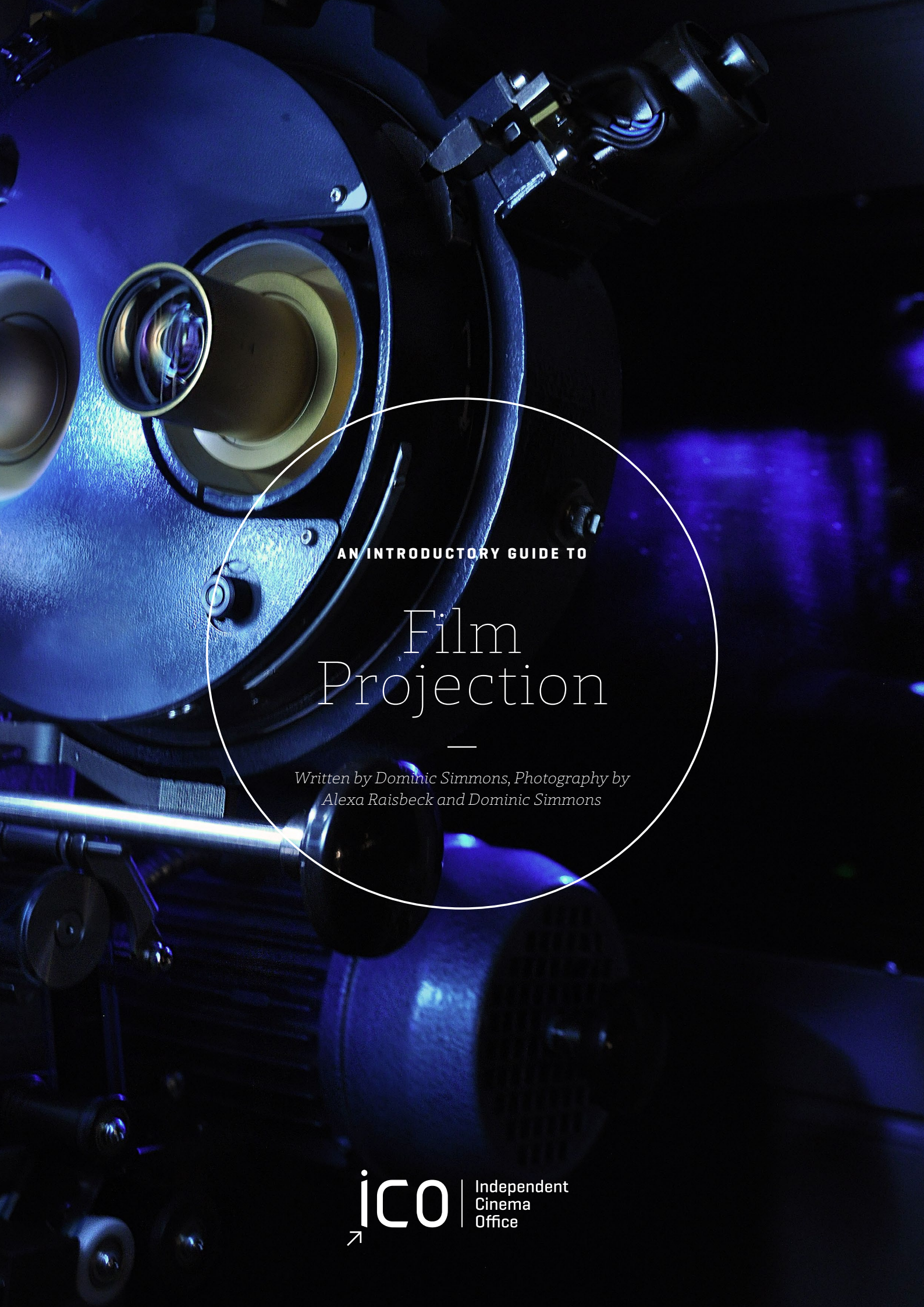

AN INTRODUCTORY GUIDE TO

Film Projection

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Written by Dominic Simmons, Photography by Alexa Raisbeck and Dominic Simmons

ICO | Independent Cinema Office

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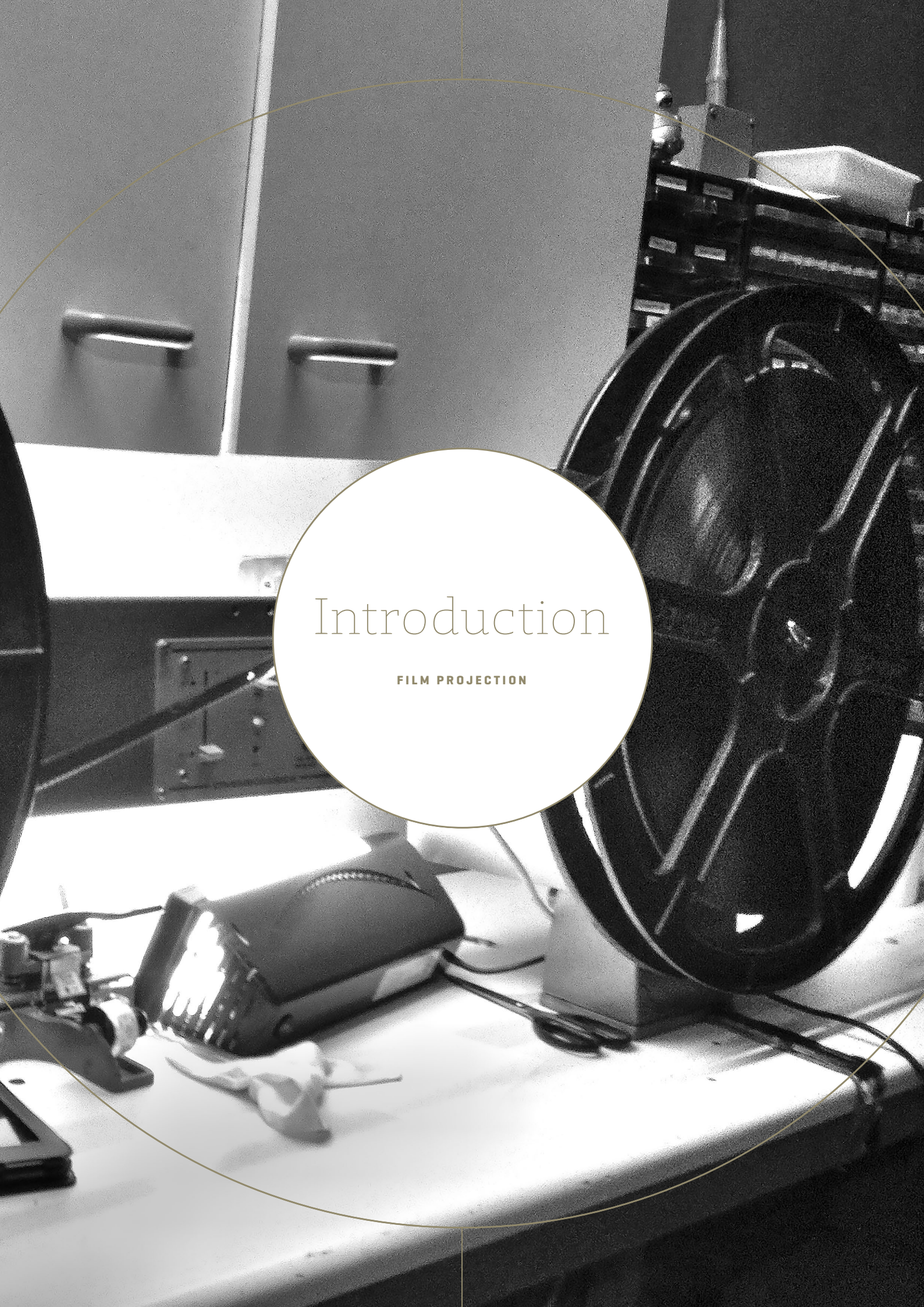


Introduction

FILM PROJECTION

Film projection has a long and storied history. There is a romance to film projection that is not shared with its contemporary replacement Digital Cinema–the idea that there is someone in a darkened booth cleaning and lacing the projector, changing reels and keeping an experienced eye on the focus and sound levels is a reassuring throwback to times gone by. Indeed, it took the cinema industry longer than most other entertainment industries to embrace digital technologies, but when, in the mid 2000s it finally did, the change from film to digital projection was rapid and in the space of five years digital cinema dominated the industry.

Film projection has not disappeared, there are still projectionists showing analogue film to audiences across the country, but it is getting harder year on year to project from film in a cinema. All film projector manufacturers have either diversified away from film or gone into liquidation. This happened shortly after the tipping point in the transition from 35mm projection to digital cinema projection was reached in 2011. Knowledge is gradually leaving the industry as the skills needed are no longer required by the majority of cinemas and it is becoming harder to source good quality prints.

That being said it is not impossible, with dedication, commitment and the right advice, to continue this 120-year-old tradition and there are many reasons to do so. Not all features or shorts from the history of film production have been digitised or restored, with many only available on film, so projecting film opens up new and broader programme opportunities. Asking your audience to view a film on 16mm, 35mm or 70mm film now has a certain uniqueness due to the relative rarity of analogue film screenings. And, in a digitally dominated world there is also something magical about the mechanical process of projecting a film print – in essence, displaying captured light–that the cold steady pixels of digital cinema lack.

Starting from Scratch

FILM PROJECTION

Starting from Scratch or Revitalising Existing Equipment

There are two starting points to projecting film in a cinema. Operators will either be making the decision to install 16mm or 35/70mm projectors when opening a new cinema or will be revitalising existing equipment in a current cinema environment. Starting from scratch will be by far the hardest installation to attempt so this guide will start there. Other guides to cinema design are available so this section will focus on sourcing, installing and operating film projection equipment.

Most cinemas have stripped out and scrapped their projectors and analogue projection equipment. Of the 3500+ screens running mechanical film projectors in 2005, less than 3%–around 100–still have projectors installed today. A huge number of projectors have been removed from operation and destroyed and many of those with projection equipment remaining will not operate it for an audience. There are, however, still projectors remaining and it is still possible to get hold of working equipment.

Sourcing Equipment

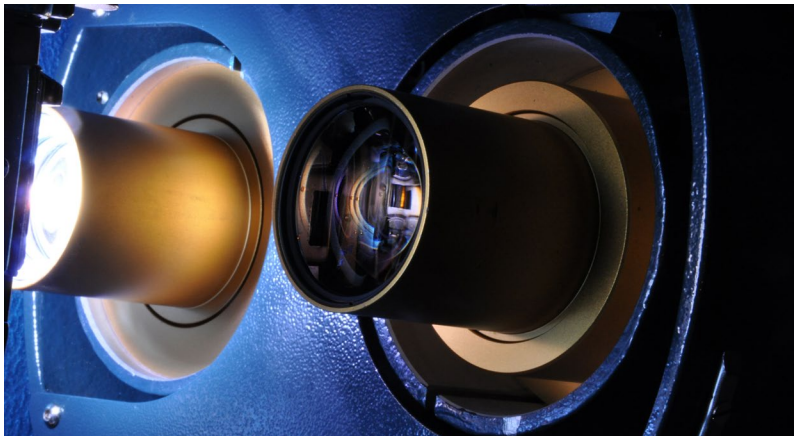
Projectors

The most critical piece of equipment is the film projector itself. A good place to start looking is with the remaining cinema engineering companies, or system integrators as they are now more widely called (Appendix 1). Most have devoted their operations to servicing digital cinema installation and maintenance and, although their stock is hugely diminished, there is a chance that they will have some projectors remaining and they will be happy to sell them on. There are other less formal routes to take, industry and heritage bodies such as the Projected Picture Trust (PPT) or the British Film Institute (BFI) will potentially be able to offer leads to follow. The internet is always a good option, websites such as film-tech.com or in70mm.com often have projectors for sale or can provide leads in their forums. eBay is also a useful place to look. There are a number of projectors remaining but unused in existing cinemas, independents are far more likely to still have equipment installed than the majors and multiplexes so will be good places to look. In short, if no luck is to be had with the integrators, finding informal networks of enthusiasts and collectors is the next place to go.

Whilst sourcing projectors you should be clear about the eventual setup in the cinema. If you wish to project archive film you will need two projectors in order to run single reels on changeover, source two of the same type to lessen the complexity of finding spares. Always check that a projector is as close to complete as possible; ensure that you have a complete gate assembly and there are no missing sprockets, also that it still has a complete sound reader, this will save time in sourcing spare parts later (see How Projectors Work section). Do not despair though, there are complete working projectors out there!

Lenses

Lenses are a critical element of film projection, again this will be covered in greater depth later in the guide, but in short, each aspect ratio will need a lens of a specific focal length and, if you are planning to screen archive film from the entire history of film-making, you will need at least 12 lenses of the correct focal length, six each for two projectors. A knowledge of the projector throw and size of screen in your cinema is essential to source the correct focal length. As with film projectors film projection lenses are no longer manufactured. It is possible to purchase bespoke lenses from a lens producer such as Schneider-Kreuznach, but they are very expensive. There are lenses out there however, and it's wise to investigate lenses at the same time as researching sources of film projectors. Be wary of overused lenses, the optical clarity will deteriorate over time due to heat, so always check second hand lenses thoroughly, a poor-quality lens will seriously impact the image clarity in the cinema.



Lenses situated within a turret

A flatbed rewind bench

Ancillary equipment

Sound processors

Projectors are vital but there is a multitude of other equipment needed to run film and of equal importance is a cinema sound processor. Dolby have traditionally dominated the field and of the remaining usable or in-use sound processors, the majority will be Dolby CP650s. Other brands such as Ultrastereo or Panastereo were well respected but did not achieve such widespread distribution, but they can still be found. Again, good sources for sound processors will be systems integrators, eBay, adverts on websites, unused equipment sitting in existing cinema projection boxes and contacts with informal networks.

Film makeup and inspection

As well as equipment needed to project film a cinema also requires film inspection and makeup equipment such as film rewind and inspection benches, splicers and film spools. There are two types of rewinders available; flat-bed inspection tables and upright film rewinders. Flatbed inspection tables are less widely seen and are more commonly used in archives and archival screening rooms or cinematheques. This type is best for detailed inspection of film reels. Upright film rewinders are a most commonly used rewind option, there are hand-cranked and belt or servo driven versions available.

Amplifiers and speakers

This is one element of the 35mm cinema operation that is not hard to source. There has been a gradual evolution in cinema sound systems away from horns and tweeters towards ribbon speakers and line arrays, but in general, today's speaker and amplification technology will happily service film projection as well as digital cinema. There are a multitude of models and suppliers who will be able to provide excellent audio quality for your cinema.

Film masking and curtains

Projecting with film requires motorised masking on the left and right and sometimes above the image. It is impossible to get a hard-edged projected frame when running film so black fabric wrapped around vertical and horizontal movable poles is necessary, known in the industry as masking. With the onset of digital cinema, where it is possible to project a hard edge, less and less cinemas use masking, but there are still engineering companies that install and service cinema masking (Appendix 1). The more discerning cinemas will still use it with digital cinema as black masking provides better contrast with the projected image, digital black is dark grey rather than black. Curtains are not an essential element of a cinema operation, but it is a great way to improve presentation and include an element of showmanship in your screenings, always appreciated by an audience. Curtains can be installed and maintained by the same companies as masking.

Consumables and Test Film

There are some specialist consumables that should be taken into consideration, critically Xenon lamps (see How Projectors Work section) and film splicing tape. 35mm lamphouses require different types of Xenon lamp to digital cinema projectors. Lamp manufacturing companies still have supplies of these types of Xenon, but as their use and commercial viability has dropped, they will become increasingly unavailable. Purchasing a good supply is advisable 16 and 35mm splicing tape is also still available from specialist suppliers, again its commercial viability is decreasing so decent supplies should be purchased. Other key consumables such as lens tissue for cleaning lenses, canned air, solvent and foam cleaners for cleaning equipment and chinagraph pencils for marking cue dots for example, have other commercial applications and should be in plentiful supply.

Revitalising Existing Equipment / Sourcing Spares

The good news is that much analogue projection equipment was built to last. Film projectors built over 60 years ago can still be in use today if they have been well serviced, this is one of the great advantages of film over digital. Digital projectors tend to have a useful life of around ten years and require a very high degree of knowledge to repair. An advantage of a film projector is that you can see how they work; a knowledge of electronics is very useful in a projectionist but not essential, many film projectors can be maintained and repaired using common sense and a manual.

If a projector has not been used for some time it would be worthwhile stripping it down and cleaning and rebuilding it. Installing new wiring is a good idea to reduce the chance of failure later. Although projectors are mostly mechanical, there will be some electronic elements in the system, particularly in sound processors, all of which will have a multitude of sound cards that are electronic circuit boards. Old circuit boards can fail and as with everything else in analogue film projection they are obsolete and no longer manufactured. There are electronics companies who will repair old circuit boards (Appendix 1).

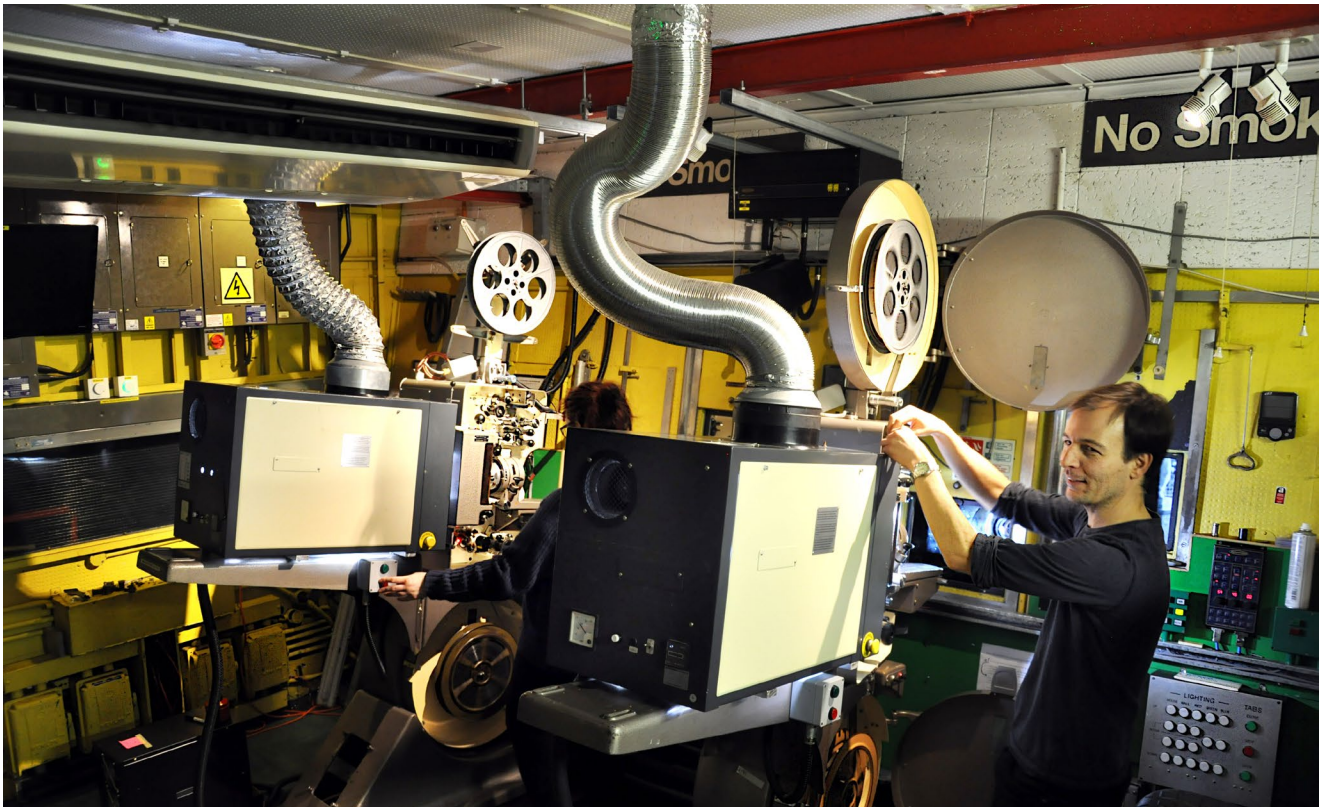
Sourcing spares is tricky. Perhaps the best way to source spares is to purchase complete projectors and strip them down. The same sources for purchasing all other equipment should be used for sourcing spares. There are engineering companies who will manufacture consumable parts such as skates for gate assemblies (see How Projectors Work section) for particular projector models but they are thin on the ground. Precision engineering companies are another potentially useful source of spares, certain parts can be copied and replicated.

Projectionists, Engineers and Technicians

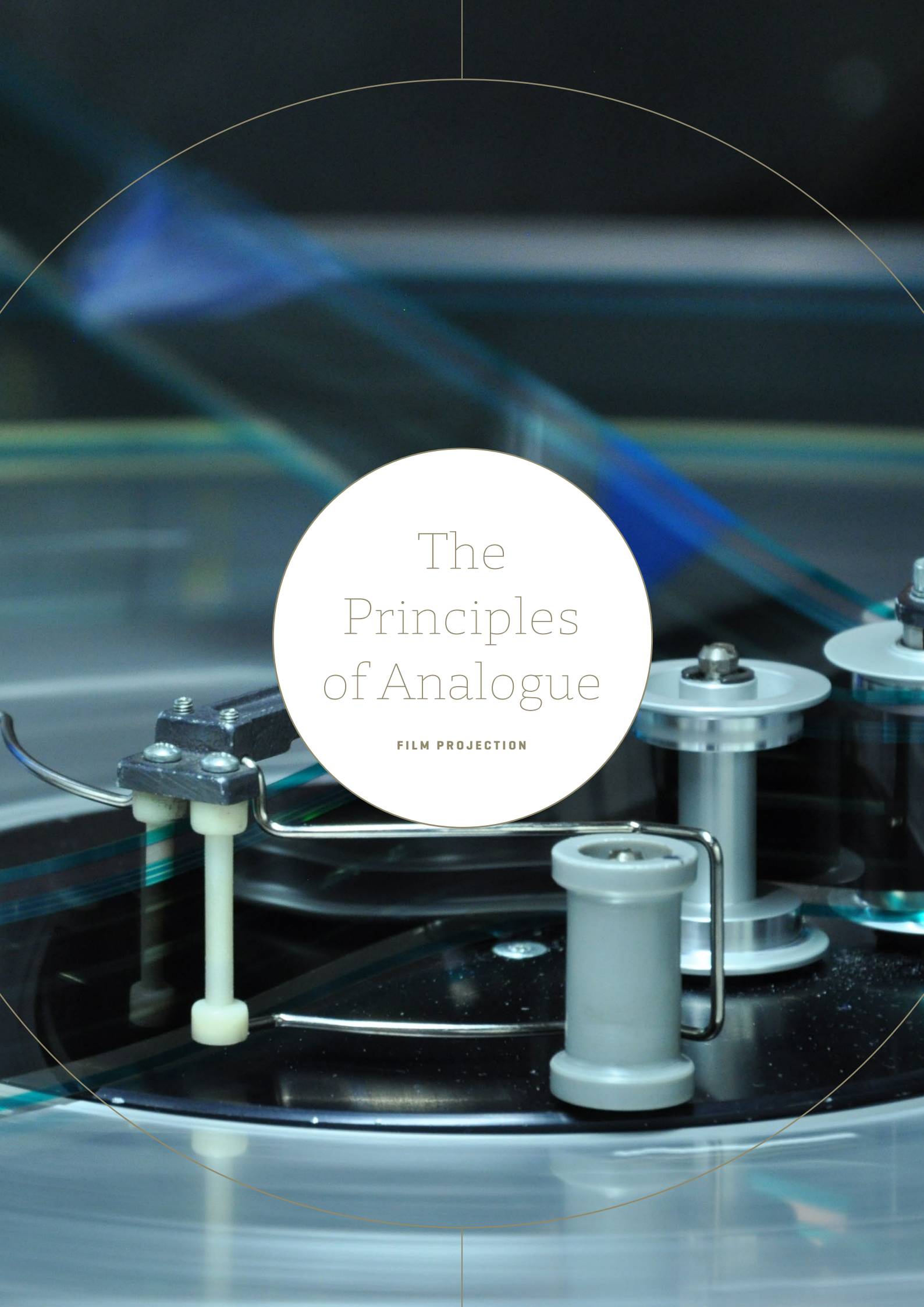
Finding working equipment is essential, but people are key to any successful analogue film operation. Projecting from film and making it sustainable is not a simple process and it is vital to find enthusiastic and knowledgeable technicians to support the process. With the industry-wide transition from film to digital, thousands of projectionists lost their jobs and left the industry and a huge amount of carefully honed expertise left with them. However many former projectionists will still be in the industry, due to a general love of film in all forms–you will likely know one yourself!

Finding local contacts and local people with analogue film knowledge will be critical, it will be worthwhile getting in touch with the nearest independent cinemas that still screen 35mm film (Appendix 1) and reaching out to their networks. We at the ICO can also help put you in touch with projectionists who are skilled in both 35mm and Digital Cinema, they can use their networks to help find other technicians. Informal networks are key, there are projectionist Facebook and other social media groups to join. Systems Integrators will be useful when the more technically demanding elements of installation are needed, but initially sourcing equipment can be undertaken with less engineering knowledge. It will be expensive to rely on Systems Integration companies to fully install from scratch, although that is a service they will be able to offer.

Once equipment is installed and ready for use, regular projectionists will be needed. It is unlikely that any UK cinema's programme will screen more than a handful of 16m or 35mm films a week – BFI Southbank in London screens the most with about 400 titles a year– so sharing the skills of local projectionists is a good option and many will work on a freelance basis. Amongst the companies, technicians and people still involved in projecting analogue film, there is an understanding of the difficulties involved and a desire to keep it going as long as possible, so you will find many supportive contacts once you begin looking.



Projectionists run a show in NFT 1 at the BFI Southbank venue. Image courtesy of BFI.



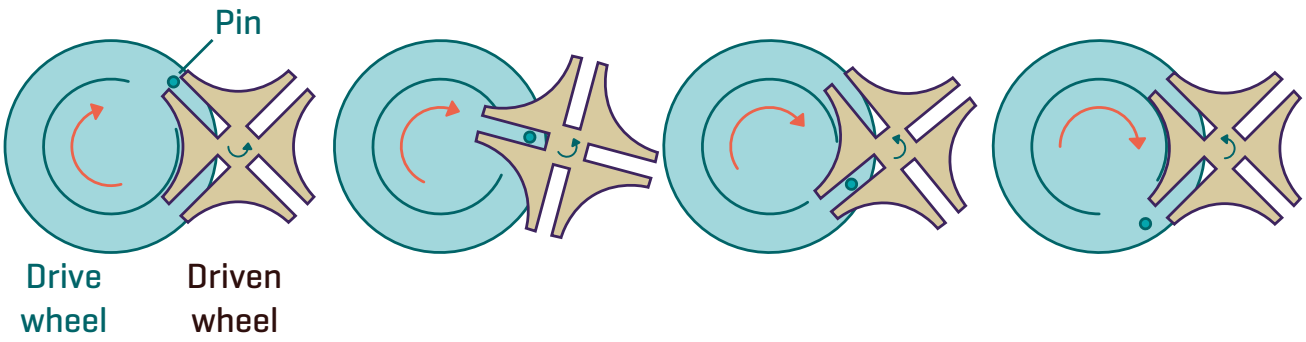
The Principles of Analogue

FILM PROJECTION

How Projectors Work

The Geneva drive or intermittent unit

A film projector is a highly specialised piece of precision engineering. The "magic of film" happens due to a sequence of still images being successively projected on to a screen, and the standard rate for sound film is 24 frames per second. This is made possible by the application of a Geneva drive whereby the continuous motion of a motor is converted into an intermittent movement of a film sprocket.



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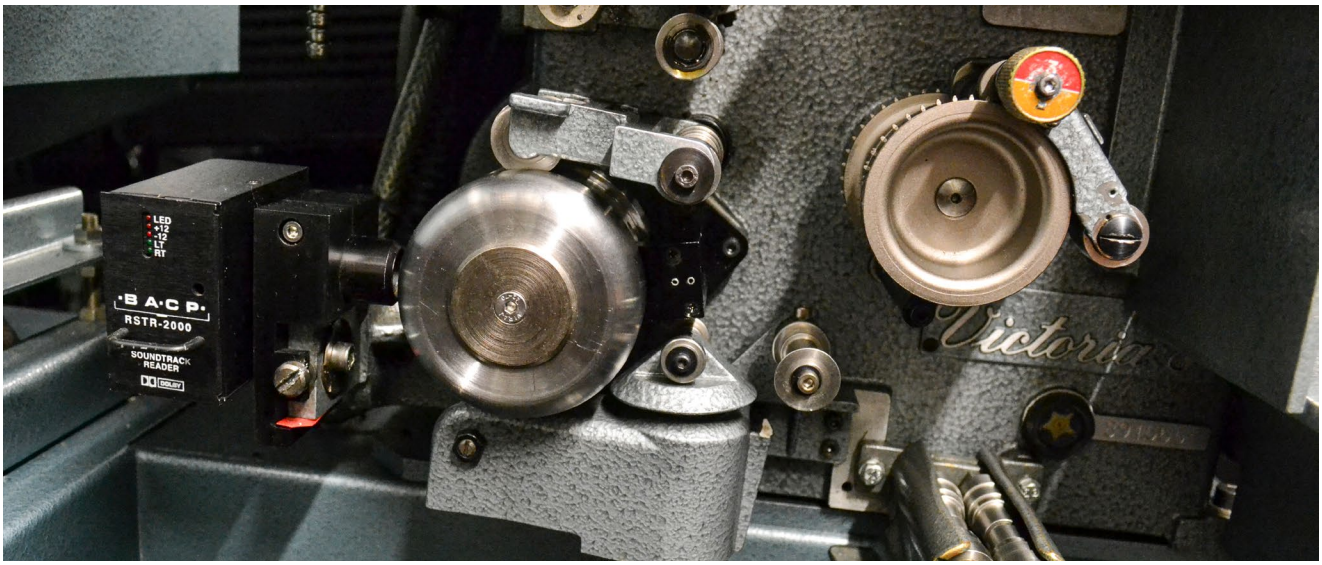
The Geneva movement working through the intermittent sprocket allows each frame to briefly rest in the projector gate, at this point a rotating shutter between the gate and the lamphouse opens to allow light through the frame. When the frames are advanced the shutter is closed stopping light from passing through the gate, maintaining the appearance of a still yet continually changing image. The shutter usually opens and closes at a rate of either 48 or 72Hz to reduce flicker, a rate of 72Hz produces less flicker and is better for projecting the slower frame rates of silent film. This requires what is known as a three bladed shutter. This process creates the phenomenon of persistence of vision and the series of still images become moving images on screen.



Component Parts of a Projector

A film projector is made up of the picture head (containing the top drive sprocket, the gate assembly, changeover zipper and the shutter assembly), the sound head, the lamphouse and power supply, a lens assembly, a top spoolbox and a bottom spoolbox. In front of the picture head is the lens assembly which enables different lenses for different aspect ratios to be placed in front of the frame. There will also be control buttons and switches. This is all visible on the operator side, on the other side of the projector can be found the motor and gearbox for oil and gear-based projectors and the drive housing for belt-based projectors.

For 35mm projectors with optical or digital audio configurations a complete reel, of any length up to an hour, is placed on a film spool in the top spoolbox, laced around the top drive sprocket, through the gate mechanism, around the intermittent sprocket, around the soundhead, over the bottom drive sprocket then into bottom spool box on to a takeup reel. In its simplest, most common iteration, all projector sprockets, the shutter and the take up reel are driven through a system of belts or gears–depending on the projector model – by a single motor. Later iterations of projectors such as the Kinoton FP30-E model use something called a stepper motor to create the intermittent movement and a series of electronically controlled servomotors to drive the film from top reel to bottom reel and control the shutter.

The Gate Mechanism

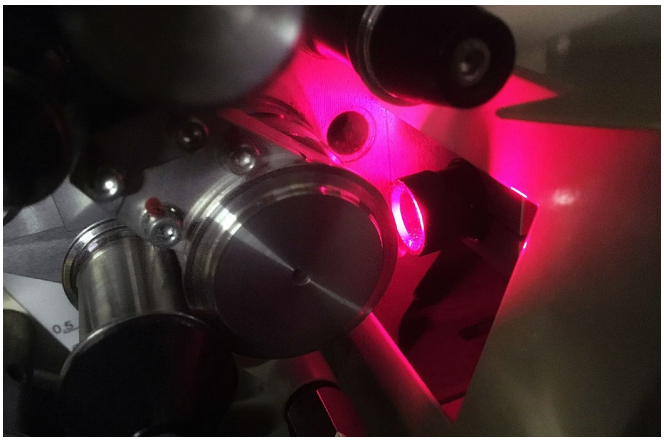
As described above, the gate is the point where the light source is directed through the frame. The print passes through the gate and is held in place by a backing plate or skate and by runners, the front of the gate is held at tension by springs and can be opened for the purpose of threading the projector. The intermittent sprocket is located just under the gate. The gate is also the point where different aperture plates are used. Aperture plates mask the amount of light hitting the frame based on the aspect ratio of the film. The intermittent sprocket can also be moved up and down with what is known as a racking handle to ensure that the print remains correctly framed in the gate.

The Lens Assembly

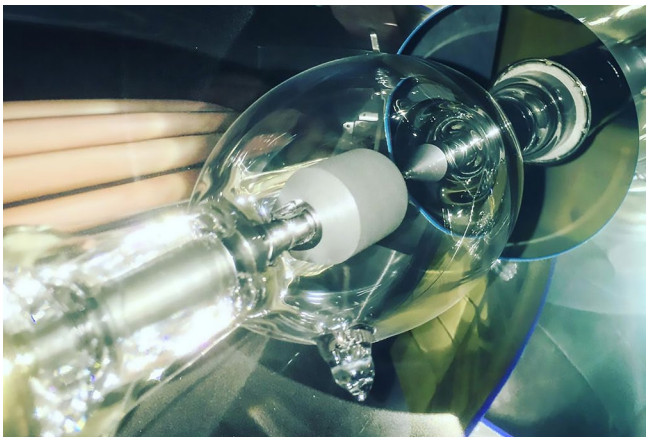
There are two types of lens assembly, turret and single lens barrel. Turret systems were more commonly used in multiplexes and held more than one lens, usually two or three. They were often motorised and could be automated to shift between widescreen and cinemascope ratios which was all that was necessary in contemporary multiplex cinema operations. Single lens barrels are more commonly found in cinematheques and independent cinemas. Up to six different lenses are needed to project film from the whole history of cinema and it is not possible to have this many lenses on a turret. Lenses are changed for each screening depending on the aspect ratio required. The primary purpose of the lens assembly is to hold the lens in front of the frame. This is where focussing takes place, with a focus knob that moves the whole assembly in relation to the frame in the gate.

The Sound Head

The optical sound head is always located below the gate assembly. Unlike the picture head, the print must move through the sound head in a smooth motion, therefore there is always a loop of film between it and the gate to allow the intermittent motion in the gate to take place without snapping the film. Beneath the sound head is a constant drive sprocket to pull the film through the head. A flywheel and dampers are employed to ensure constant smooth movement of the print, any changes to the speed can cause a “wow” sound on the soundtrack. This is most noticeable on music.



An optical sound head reader



An xenon lamp inside the light collecting mirror

Different soundtracks will be covered later in the guide, but optical soundtracks are printed on all 35mm film prints and take the form of analogue variable area, variable density tracks or digital tracks. The principal component of the sound head is the solar cell. A tightly focussed slit of light shining from an exciter lamp on one side of the print passes through the soundtrack area on the print onto the solar cell. Variations in the amount of light pulsing through the print are converted to a weak electrical signal by the solar cell, pre-amplified then processed into analogue audio by the cinema sound processor before being sent to the amplifiers and speakers.

The Lamphouse

The lamphouse primarily consists of the Xenon lamp, a light-collecting mirror behind the lamp, a heat shield, an extract vent, the housing and an internal mechanism called a douser which is opened to allow light into the projector head and closed to prevent light from escaping when the projector is not in motion. Power supplies called rectifiers are commonly situated next to the lamphouse. Direct current (DC) is required for Xenon lamps and rectifiers convert mains alternating current (AC) to DC current. Xenon lamps are the most common source of light for film projection, they consist of positive and negative electrodes (anode + and cathode -) and ionised Xenon gas under pressure. Direct current (DC) arcs across the gap between the electrodes, ionises the Xenon gas and creates bright white light. This light is focussed by the collecting mirror and directed though the shutter and on to the frame, projecting the image on to a screen. Xenon lamps come in all sizes from 500W to 7kW, the largest screens needing the most powerful lamps. This process creates an incredible amount of heat so all lamphouses will have a fan for heat extraction, usually situated on the top of the lamphouse.

The Spoolboxes

After film inspection and makeup, complete reels of film are placed on film spools and slotted on to spindles in the top spool box. Standard sizes for film spools are 2000, 5000 and 6000 feet. A full 2000-foot reel lasts approx. 18 mins depending on the type of film stock. After the print has been threaded through the projector and projected, it is collected by the take up spool. It is essential to use the same size or bigger take up spool or the result will be film all over the floor, a projectionist's worst nightmare. The bottom spool is powered from the motor and uses a clutch mechanism to ensure that power increases as the amount of film on the spool increases.

Long-play operation

Projectors being used in cake stand or platter (non-rewind) operation do not have need of spools. Platter or long-play operation was the standard for all multiplexes and requires additional equipment, namely a separate film platter usually consisting of three large rotating, horizontal plates each capable of containing a complete feature. In operation film is taken from the centre of the large reel and run through a film pay-out unit which controls the speed of rotation of the plate based on how much film it contains. After moving through the projector, the film is taken up on a free plate and when the film is over there is no need to rewind the print and it can be taken from the centre of the reel again. Although very convenient for repeat screenings, film platter systems had a reputation for being more likely to damage prints and archive film cannot be run on them.

A print sat on a platter - The platters make up the 'Cakestand'

A Dolby CP650 sound processor wihtin an equipment rack

Additional Elements

Sound processor

Mounted in an equipment rack away from the projector there will need to be a cinema sound processor. The processor is used to decode the information sent from the sound head and output it to amplifiers as analogue audio. The sound processor is also used to control the volume of the audio and switch between different inputs such as, non-sync (play-in music), in-auditorium microphones, auxiliary inputs like video sound and, of course, film sound. It is also used to switch between different types of inputs from the projectors such as mono, stereo and surround sound formats. Contained within the housing will be a set of sound cards that are used to calibrate the output of the audio and add noise reduction to ensure the highest quality audio is heard in the auditorium. An engineer will use high quality microphones set up in the auditorium to do this.

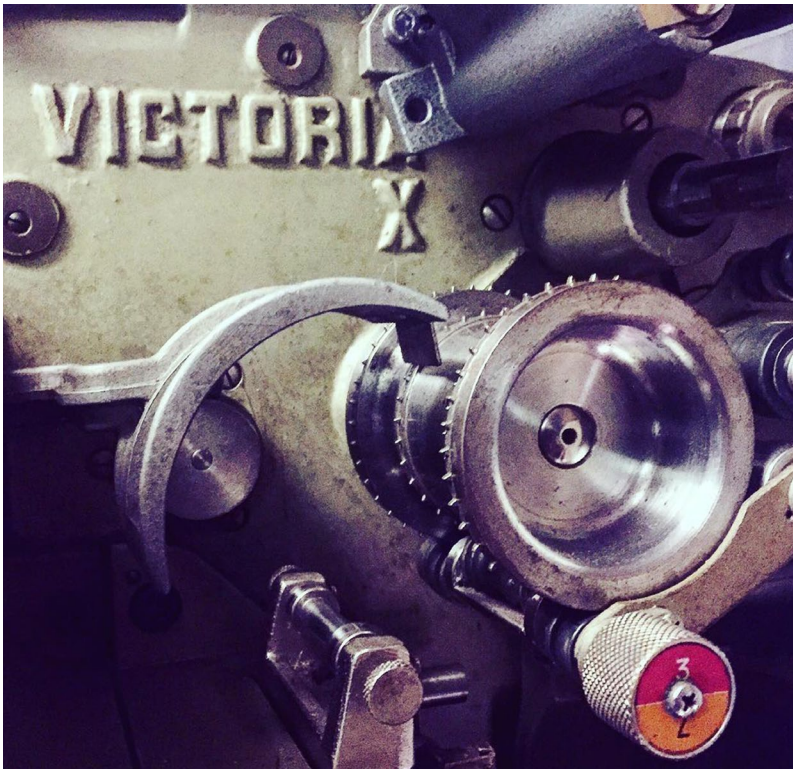
Button consoles

All projection boxes will have wall or projector mounted control consoles for manual operation of house and stage lighting, curtains and masking, and projector controls. All should be mounted within easy reach of the projector location.

70mm Projection

Certain projector models can screen both 35mm and 70mm. The first of these projectors was the Philips DP70 which entered production in the mid 1950s, a period of great technical innovation. Other notable models are the Philips DP75 and the Cinemeccanica Victoria 8. 70mm projection was achieved by using dual gauge drive sprockets, either a swappable or dual gauge intermittent sprocket and adapters for the larger spools required.

70mm projection also ushered in stereo and surround sound, this was achieved with a magnetic sound head located above the gate assembly and up to six magnetic tracks on the print. Using a similar technology to cassette tapes, the print is run over a magnetic sound head and can output five screen channels and a mono surround channel. Later prints dispensed with the magnetic track and used the DTS digital audio system (described later in the guide). 70mm prints have five perforations per frame and also run at 24 frames per second – apart from the original 70mm incarnation, Todd-AO, which ran at 30 frames per second.



A dual 35mm/70mm sprocket with selectable lay-off roller

Film Prints and Formats

FILM PROJECTION

Film Gauges

There are three common gauges of film used in analogue film projection, specified based on the width of the frame, 16mm, 35mm and 70mm. By far the most used and the standard for cinema projection for over a hundred years, is 35mm. Based on an Edison Company patent, the 35mm, four perforation gauge was standardised in 1909 and this allowed a quick spread of the technology across the world with the promise that a 35mm print could be screened in any international cinema.

The smallest gauge commonly screened in cinemas is 16mm, this gauge is often associated with artists' films and previous to that was a very common presentation format for TV companies. Cinemas that still project film will often have one 16mm projector for experimental film programmes and occasional archive TV programmes. The pinnacle of film projection gauges is 70mm, the larger frame allows for greater depth of focus and far superior projection standards, but the number of screenable 70mm prints is very low in comparison to 35mm.

35mm Film

Although film has moved through various iterations over the years, film projection in its most basic form has not changed greatly since pre-First World War. Sound film arrived in the late 1920s, with stereo sound in the 70s, and 5.1 audio fully arrived in the early 90s. Colour in film arrived early but wasn't widely used until the 1930s and wide screen ratios were all developed post WWII in an attempt to see off competition from television. But at its simplest, a 35mm film screening still relies on the same use of the Geneva drive and the same 24 frames per second advancing through the gate. That is what still makes an analogue film screening compelling; it has a connection to a hundred years of celluloid history and the human involvement in the process.

Film Stock

Analogue film stock is made up of a clear base material with a layer of light sensitive emulsion that carries the image on one side. Standard 35mm has four perforations on either side of the frame. This is what the drive and intermittent sprockets grip to pull the print through the projector.

Over the course of motion picture history there have been three dominant film stocks; cellulose nitrate, commonly abbreviated to nitrate, diacetate and triacetate, referred to as acetate or safety film and finally polyester. Nitrate was used from pre-1890 to 1951, acetate was used from pre-WWI but only came to dominate in the post WWII period, polyester arrived on the scene in the early 1990s, each has its good and bad points but the superior strength and ability of polyester to retain colour has resulted in it being the contemporary film stock of choice.

Nitrate, popular for so long due to its rich contrast and colour, is famously dangerous; being highly flammable and capable of producing its own oxygen once alight. The cause of many devastating cinema fires over the years, nitrate should never be projected without exhaustive safety procedures, and there are only a handful of international cinemas still capable of doing so.

Safety or acetate stock has the advantage of being hard to burn, but can become brittle and is prone to lose colour, suffering from the dreaded vinegar syndrome, or acetate base degradation–a breakup or deterioration in the stock typified by a pungent vinegar odour. Polyester is now preferred due to its strength and stability, but it is prone to collecting dust due to static and is so strong that can destroy projection equipment if there is a mechanical failure.

An example of Nitrate and Safety edge markings indicating the type of film stock

A close up of film frames with a: optical variable area track, a Dolby Digital track (situated between the perforations) and a DTS track (intermittent line next to film image)

Film Soundtracks

There are many flavours of 35mm soundtrack, the image above from a relatively recent release shows how crowded the frame has become, with four different ways of playing out audio on this particular print, one analogue audio and three digital.

Analogue Optical Track

The track on the inside of the perforations is a variable area Dolby SR (Spectral Recording) analogue optical track. The analogue optical track was the principal way to play back film sound from the 1920s to the 1990s. As described in the sound head section, variations in light from the analogue optical track are picked up and converted to signal by the solar cell. There have been many varieties of analogue optical soundtrack but they can all be narrowed down to two different types, variable area and variable density. Variable density tracks appear a bit like a bar code and are mono, usually appearing on older prints from the 30s. Variable area tracks are far more common and have the appearance of a soundwave, they can be mono, stereo or multichannel. Stereo versions will always have two tracks (bilateral) and each track will have detectable differences when viewed on a bench. In the later years of 35mm releases analogue optical tracks were mainly used as a backup to the digital track, but every 35mm print still has them printed.

DTS (Digital Theatre Systems)

The series of dots and dashes next to the image are timecode markers for DTS (Digital Theatre Systems) audio. This digital system uses a remote media player to output the audio to the sound processing equipment, soundtracks are received with the print reels on a CD-ROM which, in the latest versions, is uploaded to the media player. A timecode reader is attached to the projector, usually above the picture head, and this reads the timecode which keeps the audio in sync during the screening. DTS was accepted as one of the best options for digital audio. The audio is usually relatively uncompressed and high quality, reliable and able to play out up to 8 tracks. A downside is the separate disc required to upload the audio, many prints no longer have a disc available so it is not possible to use DTS very often.

Dolby SRD (Spectral Recording–Digital)

Situated between the perforations is the Dolby SRD track. SRD is a series of printed sequential data blocks that are picked up by a digital soundhead mounted to the projector, commonly above the picture head. Some projector manufacturers also mounted red light readers in the sound head that could scan and read SRD tracks as well as analogue optical tracks. A separate unit mounted in the sound track called a DA20 is required to decode the data and output digital audio to the sound processor. Dolby SRD is currently the most commonly used digital soundtrack, although the sound is more compressed than DTS audio, the fact that the data is printed on the print reels means it is more available for projection. It is also only capable of outputting 6 channels of audio.

Sony SDDS (Sony Dynamic Digital Sound)

The least successful of the three digital soundtracks available to cinemas, it arrived on the scene later than DTS and SRD and was more expensive to install, consequentially it had less penetration internationally despite Sony owning a Studio and chain of multiplexes. The SDDS track is printed on the edge of the print and is capable of up to 8 channels, although less than 100 releases made use of all 8. As with SRD a digital sound head is mounted to the projector above the picture head and a decoder is mounted near the sound equipment.

Film Aspect Ratios

If you get a bunch of projectionists in a room, before long talk will get around to film aspect ratios, there are so many grey areas and opportunities for debate. It is generally fairly straightforward to determine the correct aspect ratio for most prints, but there are always exceptions to every rule.

There are seven different ratios regularly used in 35mm film projection, they are defined by the ratio of the width to height of the frame, and are as follows; 1.33:1 Silent, 1.19:1 Movietone, 1.375:1 or Academy, 1.66:1, 1.75:1, 1.85:1 or Widescreen and 2.39:1 or CinemaScope, with the most common being 1.33 Silent, 1.37, 1.66, 1.85 and 2.39.

Widescreen and Cinemascope projection has a complex history with various competing systems, a subject too detailed and controversial to enter into here! As a taste of the confusion around Cinemascope, the 20th Century Fox originated system of CinemaScope ceased to be used from 1967 onwards, as most anamorphic films were shot with the Panavision system, but CinemaScope had become a catch-all term and although CinemaScope is generally a 2.39:1 ratio in projection, the term is used interchangeably with 2.35:1 in the industry.

Projecting each ratio requires a different lens and aperture plate as different percentages of the frame are used, although a single focal length lens can be used for 1.19:1 and 1.375:1, and also 1.66:1 and 1.75:1. The aperture plate for the projection ratio is cut to the same shape as the ratio the film is shot in. 1.85:1 and 1.66:1 prints often have a black matte printed on each frame to ensure the print is correctly framed in the projector, but can also be unmatted, so careful attention to framing must be made by the projectionist to avoid accidental projection of sound booms or the top of scenery.

Standard ratios including 1.37, 1.66, 1.85 and 2.35 - Courtesy Brian Pritchard.

1.33:1 Silent

The earliest standardised ratio, this uses the full width of the frame with very thin frame lines. This was the most common ratio up until the late 1920s when sound films began appearing.

1.19:1 or Movietone

This is the earliest sound ratio, and it is very close to being square. The ratio, colloquially named Movietone, had the addition of an optical soundtrack printed on one side of the frame but still used the full height, it can be projected today using a 1.375:1 lens but with aperture plates cut higher to expose the full height of the frame. Prints with a 1.19:1 ratio were produced from around 1928 -1932 when the Academy standard was widely adopted, a famous example being Fritz Lang's M.

1.375:1 or Academy

The height to width ratio of 1.19:1 was not popular with film-makers and audiences alike and Studios all had attempts to return the frame aspect ratio to 1.33:1. In 1930 a reduction in image size in the frame size was agreed upon by the Studios as recommended by the Society of Motion Picture Engineers (SMPE) and, after some modification by the Academy of Motion Pictures Arts and Sciences, the ratio settled upon was 1.375:1. This retained the striped optical track and increased the size of the frame lines to compensate. Academy was the dominant ratio from 1932 to the mid-1950s when it was superseded by wider ratios. It was used for longer in certain territories such as Russia, and is still occasionally used today by certain arthouse directors such as Pawel Pawlikowski and Andrea Arnold.

1.66:1

The first feature released in 1.66:1 was George Steven's Shane by Paramount in 1954. The feature was printed in the same way as a 1.37:1 film, but in projection a shorter focal length lens was used to project a wider image, with the top and bottom cropped off the image by the projector aperture plate, a process that is still used today for all wide screen ratios except CinemaScope. The cinematographer would also have framed each shot to allow more space at the top and bottom of the frame. Various Studios used 1.66:1 through the late 50s and into the 60s although the wider ratio is 1.85:1 was also adopted and eventually became the standard US widescreen ratio. European Studios were slower to adopt 1.85:1 as a standard and 1.66:1 was more commonly used across the continent for a longer period than the US, still being regularly used in France into the 1990s and beyond. As with everything to do with ratios, there are some exceptions, such as 1.85:1 being far more common in Italy than 1.66:1 from the outset of the widescreen era.

If the ratio of a print is unclear from looking at the frame, the print is unmatted and information online is inconclusive, the best bet with ratios is to put a reel on screen and make a judgement. Arguments around 1.66:1 and 1.85:1 are the most common in projectionist circles.

1.75:1

This is a relatively uncommon ratio, it was used intermittently by European and US Studios, predominantly MGM – who called it Metroscope–and Disney, although they soon adopted the wider 1.85:1 ratio. Many cinemas would not have had the lenses or aperture plates for this ratio and would have chosen either 1.66:1 or 1.85:1 if a 1.75:1 print turned up.

1.85:1 Widescreen

As noted above wider screen ratios were adopted by most international studios from the mid-50s onwards. US Studios such as Columbia and Universal adopted the slightly wider ratio of 1.85:1 over 1.66:1 from the outset and gradually it became the standard for non-anamorphic widescreen screenings. In the later years of 35mm film projection the majority of cinemas would only use 1.85:1 and CinemaScope ratios for all contemporary releases.

A key issue for cinemas after the evolution to wider screen ratios, and this still has a bearing today, was the loss of light due to the use of a smaller percentage of the frame in projection. Quite a large percentage of available light is matted out by the smaller aperture plates used for widescreen, resulting in a darker image on screen.

2.39:1 CinemaScope

CinemaScope was originally a trademark of 20th Century Fox's first anamorphic widescreen releases, but in the preceding years became shorthand for all anamorphic widescreen projection, these days it has been shortened to 'Scope' for D-Cinema. As noted above there have been many different versions of "CinemaScope" with many tradenames and different ratios, from 2.35:1 up to 2.66:1.

The anamorphic process of using specialised lenses to squeeze the image during filming, then reversing the effect by unsqueezing the image in projection was first patented by a French Professor named Henri Chrétien in the 1920s, a process he called Anamorphoscope. This enabled the 1.33:1 35mm frame to be unsqueezed to a ratio up to 2:66:1. Various soundtrack iterations including four tracks of magnetic sound either side of the perforations changed the ratio over time. A striped optical track plus a magnetic track eventually led to a ratio of 2.35:1. The CinemaScope aspect ratio quickly proved popular with film-makers and audiences alike and became regularly used, particularly on high budget action films. A CinemaScope print is easy to determine during print inspection and makeup due to its obviously squeezed images.

Sourcing Prints

FILM PROJECTION

The domination of digital cinema over analogue film projection is almost complete and fewer film prints are struck year on year. Therefore, the large majority of available prints must be sourced from film archives, studios, and print repositories. There are good sources of 35mm prints–the British Film Institute's Distribution arm has a large selection of prints and can offer advice about where to find prints they don't have available in their catalogue. Park Circus also has a very large catalogue of 35mm and recently an increasing catalogue of 70mm. FTS Bonded Services keep a large selection of film prints and it also worthwhile contacting international sales agents such MK2, The Match Factory or Playtime.

Many archives and some studios will only loan prints to members of International Federation of Film Archives (FIAF) and cinemas that they have dealt with before. Film Archives tend to require a high degree of assurances about loaning prints, all will expect their prints to be shown on dual projector systems and changeovers and detailed print condition reports filled out prior and post screenings. If these standards can be met then it will be possible to book archive film prints and there are many national and international archives with large catalogues. In the UK, the BFI National Film and TV Archive has the largest collection and internationally there are many others such as the Library of Congress or George Eastman House. FIAF is a good source of information on international archives.

In the contemporary film landscape, all prints, irrespective of where they have been sourced, should be regarded as precious and irreplaceable and as such, treated with great care during projection.

Print Inspection and Makeup

Careful print makeup and inspection is a vital part of the process of screening from film. Whether it is 16mm, 35mm or 70mm, a print must be thoroughly inspected to ensure that there will be no issues with projecting it. An average length 35mm feature film will arrive on five to seven reels, each 35mm reel usually holds up to 20 minutes of screen time. It is the responsibility of the projectionist to "makeup" the reels onto spools in order to project the film. Depending on the source of the print, this can be one 2000-foot spool per reel for archive film, up to three reels per 6000-foot spool for non-archive or 'release' prints projected using changeovers, or all reels on to one large plate for long play systems. Today's prints will most likely not be brand-new direct from the laboratory and will have been screened before, potentially many times.

Make up can be a long and involved process which we'll touch on here only briefly. Initially, the projectionist must check all the reels have arrived and they are all from the correct film. This can be done by looking at the film cans, but really should be confirmed by looking at the print itself, the leaders and tails in particular. The projectionist must also ascertain the aspect ratio and the sound format. Any film splices or joins must be checked to ensure they are sound and have the correct number of perforations on the frames either side of the join. All the perforations must be sound and not torn and if the film is running on changeovers then cue dots must be checked to ensure they are visible and in the right place–a missed changeover is embarrassing for the projectionist and annoying for the audience. Any issues not picked up during the inspection cause problems during screening–bad joins and torn perforation are the principal cause of stoppages during a screening.

At all times during makeup great care must be taken to avoid any unnecessary damage to the print. Makeup areas should be kept clean and free from coffee cups. When lifting reels out of cans, care should be taken not to allow centres to drop out of the reel. Rewinding should always be done without losing control and gloves should be worn on at least one hand to avoid any additional dirt build up. If a projectionist is conscientious, a print can often leave the projection box in a better condition than when it arrived, slap dash make up and print handling will damage irreplaceable prints.

Projectionists handling and inspecting film prints on a flatbed rewind bench

Operation

FILM PROJECTION

The efficient automated playlist of the contemporary multiplex has meant the loss of some of the performative elements of a night at the cinema. An analogue film screening should be viewed as a performance and the projectionist's role is to ease the audience into the film with as little friction as possible. This human involvement also allows extra details to be considered, such as carefully selecting play-in music ahead of the screening and the addition of theatrical elements such as curtains and specific lighting to add showmanship to a screening.

Pre-show checks

During operation the projectionist is responsible for everything that hits the screen or takes place in the auditorium. Ahead of the house opening to the audience everything should be double checked to ensure there will be no errors. All equipment needs to be switched on, the projector and portholes fully cleaned, the spools (of the correct film!) placed on the projector, the correct lens and aperture plate should be in place and the masking set for the correct aspect ratio. The lamp should be on and running at the correct brightness. Before a screening, if there is time, it is wise to put a reel on screen to check that the focus is correct.

For most cinemas running 35mm, lining up a show will also include running digital adverts and trailers, so this should also take place in advance. It's useful to rehearse the transition from digital to analogue presentation to make sure it's as smooth as possible.

The Show

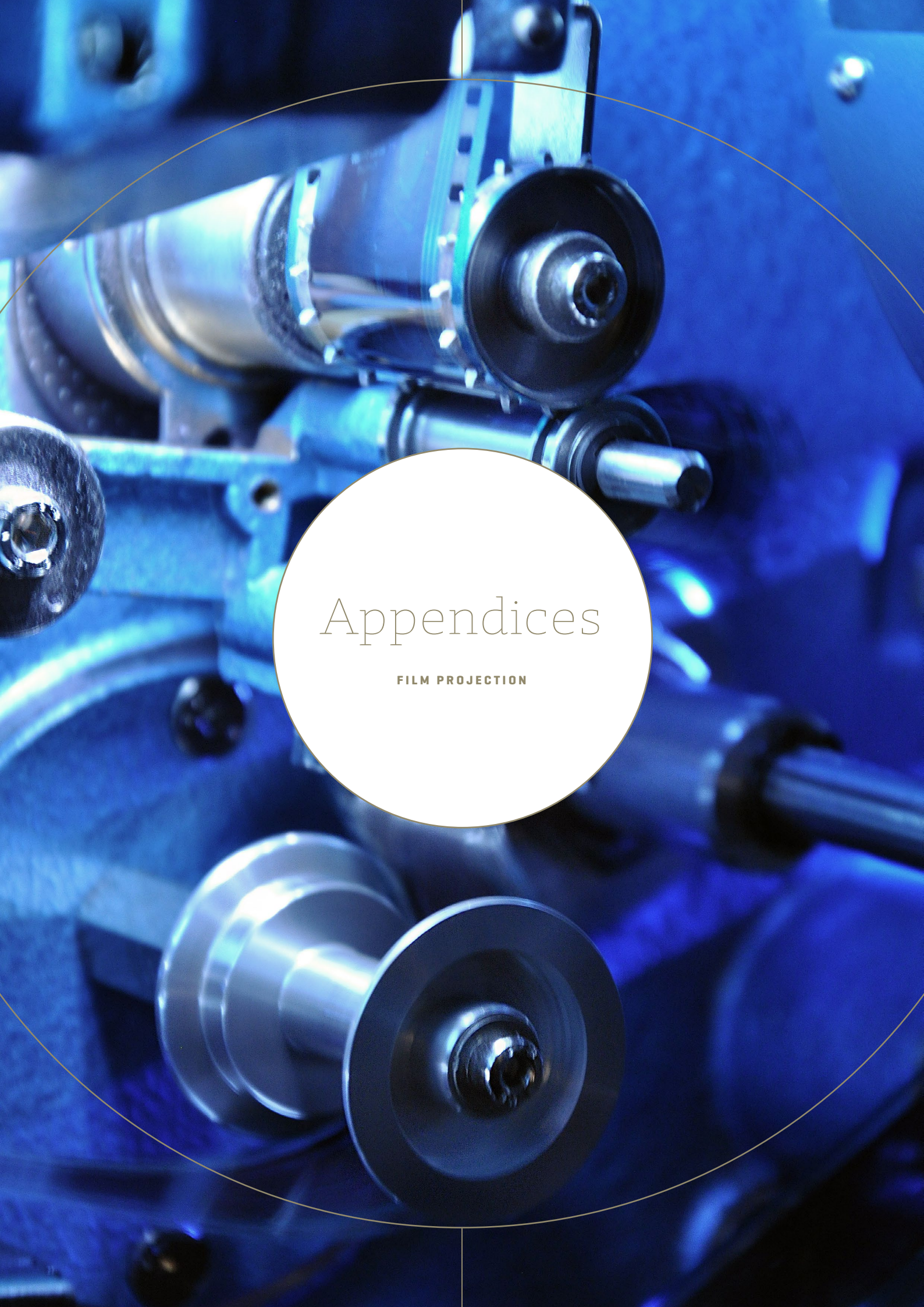
There is a repeatable chain of actions at the start of a film screening and this is the point where the projectionist needs to be fully focused on what needs to happen. Music must be faded, house lights dropped, curtains opened, the projector started, sound format selected, projector douser opened and sound unmuted, all in a fluid sequence. Once the film is on screen, the gate tension, framing and focus should be checked, followed by a quick trip to the auditorium to make sure the volume is correct for the audience. It's always best to check the volume is correct on a scene of dialogue. Volume is very subjective and is one of the most complained about aspects of film projection. There's a balance to be found between ensuring a film soundtrack has impact but does not overwhelm or become painful for audiences with a wide range of auditory sensitivity, and this is not always easy to get right.

Apart from the volume check, if possible a projectionist should remain in the projection box for the duration of the film, this can seem less essential when running a long play system, but with prints becoming more precious, projectionists need to keep an eye out for any issues. Focus, or framing can change over the course of a film and equipment can fail, so someone on hand to keep the image looking good on screen or prevent excess damage is important. If two projectors are used, changeovers will need to be undertaken.

A changeover should allow a seamless transition from one reel to the next and excellent timing and concentration is needed to make it a smooth one. Whilst the outgoing reel is running, the incoming reel should be laced and ready to go. Timings can vary from projector to projector but the incoming reel can often be laced with eight feet of leader ahead of the start of the actual picture. With a minute or so to go before the end of the outgoing reel the projectionist should ready themselves at the porthole next to the inactive projector and look at the top right corner of the screen. When they spot the first set of four cue dots–these are on screen for a sixth of a second–the start button is pressed on the projector and a short pause the lamphouse douser is opened and the second cue dots are awaited. Just over seven seconds after the first set of dots the second set of four will appear. At this point the projectionist will press two buttons, one to shut the changeover shutter on the outgoing projector and open the shutter on the incoming projector, the other button changes over the sound. After seven seconds, the leader will have run through the projector and the shutter and sound will open on the picture section of the incoming reel. Repeat until all the reels have finished.

The final act of a film screening is to bring the lights up and close the curtains at the end of the film, as the douser is closed and the sound is muted.

For both audience and projectionist, there is much pleasure to be had from an incident free show and the less the former recognises the hard work of the latter during the screening, the better.



Appendices

FILM PROJECTION

Appendix 1 - Cinema Engineers and Systems Integrators

Projection Equipment Sales and Installation

Bell Theatre Services

Unit 9B Chester Road
Borehamwood
Hertfordshire
WD6 1LT

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020 8238 6000
admin@bell-theatre.com
sales@bell-theatre.com

LINK
BELL THEATRE

CinemaNext UK

An Ymagis Group Company
Eskdale Road, Riverside House
Middlesex
UB8 2RT–Uxbridge
United Kingdom

—

0203 6958473
contact.uk@cinemanext.com

LINK
CINEMANEXT UK

Sound Associates Ltd

Keeble House,
81 Island Farm Road
West Molesey,
Surrey KT8 2SA

—

020 8939 5900
info@soundassociates.co.uk

LINK
SOUND ASSOCIATES LTD

Omnex Pro Film

Mission Hall,
9-11 North End Rd,
London W14 8ST, UK

—

0161 477 7633
info@omnex.co.uk

LINK
OMNEX PRO FILM

Rosbeektechniek

LINK
ROSBEEKTECHNIEK

Sir Winston Churchilllaan 309
2287 AA Rijswijk ZH
Netherlands
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Tel: +31 70 319 40 71
Mob: +31 653 334 165
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Masking, Curtains and Screen Installation Engineers

Powell Cinema Engineers

LINK
POWELL CINEMA ENGINEERS

Unit 8 & 9, Leighton Industrial Park,
Billington Road,
Leighton Buzzard,
Beds, LU7 4AJ
—
01525 383054
Info@powellled.com

Camstage

LINK
CAMSTAGE

Batford Mill Industrial Estate,
Lower Luton Rd,
Harpenden AL5 5BZ
—
01727 830151
camstage.com/contact-us

Appendix 2 - Links & Resources

Links

Useful and interesting links:

http://www.film-tech.com/vbb/–great forum for useful advice and equipment information, equipment sales and requests

https://in70mm.com/–focus on 70mm but useful for all film information and occasional equipment sales

http://www.widescreenmuseum.com/–good information on aspect ratios and film history

https://www.fiafnet.org/–home page of International Federation of Film Archives

Resources

The Art of Film Projection: A Beginner's Guide

Rochester, NY: George Eastman Museum, 2019
ISBN 9780935398311

Great accessible book on all things film projection.

The Advanced Projection Manual

Torkell Sætervadet, FIAF/Norsk Filminstitutt, 2005,
ISBN: 9782960029611

Thorough and authoritative book on film projection.

BKSTS CTC Projectionists' Handbook