Introduction of Talking Pictures

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In the early years of the nineteenth century, moving pictures shown in halls and theatres were silent. Around 1926, sound was first introduced using transcription discs, synchronised to pictures, printed on the celluloid film which ran through the projectors. Our article focuses on that short era prior to the introduction of sound track to the film. Sitting on that stool in the Bio-box, little did I realise that I was witnessing that short time slot in talking pictures history.

Introduction

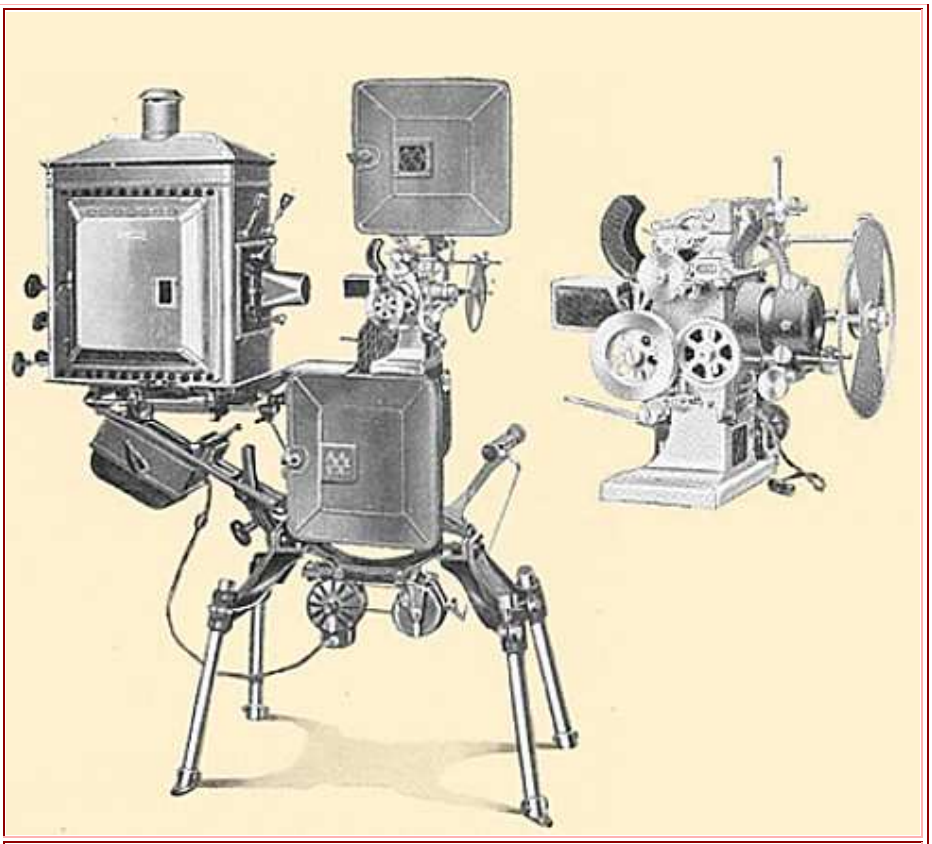
At quite an early age I became interested in motion pictures and how the operational projection system developed. Early movies were silent but synchronised sound was developed, initially using analogue techniques which lasted many decades until digital techniques were developed. Movie theatres were established, at first with flat screens, but later they developed optical techniques which led to wide curved picture displays and even stereoscopic pictures. I will not attempt to get too far into these later techniques. But as a start, I thought I would concentrate on the era when synchronised sound was initially introduced to the displayed picture. I have discussed further some early advanced sound systems including that used in the road show of Fantasia. I have included a section on common film formats including the addition of sound track to film.

The Silent Era

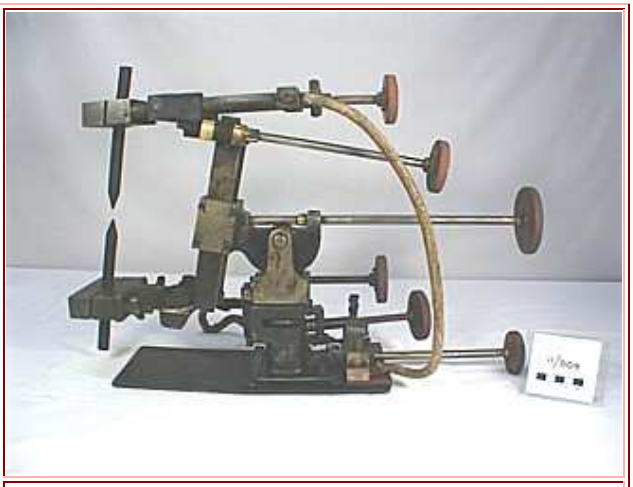
Early motion picture projectors were silent in that they projected moving pictures without synchronised sound. During the era of around 1895 to the late 1900's, they were typically located and operated within the theater auditorium itself. However by around 1909, due to increasing concerns over the inflammable characteristics of the nitrate film and the safety risks of fire, segregated projection booths were introduced and equipped with fire prevention facility. I remember the days of the movies when they always had a fireman on duty within the theatre.

To project a bright picture on to a large screen required a very high intensity light to be fed through the film frame. For many years the carbon arc was used as the light source. Apart from the high intensity light, it also emitted a high level of radiant heat through the projector aperture. If the film jammed and the heat was allowed to feed through a film frame, the inflammable film very smartly caught fire and this was always the danger requiring safety interlocks to shield the film.

In a carbon arc lamp, the electrodes are carbon rods in free air. To ignite the lamp, the rods are touched together, thus allowing a relatively low voltage to strike the arc. The rods are then slowly drawn apart, and electric current heats and maintains an arc across the gap. The tips of the carbon rods are heated and the carbon vaporizes. The carbon vapor in the arc is highly luminous, which is what produces the bright light. The rods are slowly burnt away in use, and the distance between them needed to be regularly adjusted in order to maintain the arc. In the photos of the carbon arc and the silent picture projector, the many operator adjustment knobs can seen protruding from the rear of the arc and the rear of the projector.



Early Silent Picture Projector of around 1926



Early Carbon Arc 1920-1930 era
Removed from the Projector

Projectors beamed the light image through lenses onto the screen and provided the mechanism to roll the film and switch the changing picture frames through the projector aperture. Properly equipped movie theatres were normally fitted with two projectors so that picture presentation was continuous through changes of film reels. They also had a slide projector to display fixed scene pictures before the start of films and during intermission. I

But the silent movies weren't always quiet. Musicians were often engaged to add background music and somtimes their instruments provided synthesised sound to add life to the action being displayed on the screen.

The selection of music depended on who did the choosing. Some musicians tried to incorporate music suitable to the film's setting. For example: Authentic sea shanties for a shipboard picture, a bit of Mussorgsky or Rimsky-Korsokov for a Russian setting, or red hot Jazz for a flapper film.

The need for orchestral instrument and their musician players led to the development of electric organs, such as the Wurlitzer, which electrically operated different instruments all controlled from a single console by a single operator.

Electric Organ Control Console
with Chris McFee in Control
(From Capri website)

In Adelaide, the Regent theatre in Rundle Street was equipped with a Wurlitzer organ. It was a treat to visit the theatre just to listen to the organ at intermission. The magnificent theatre was demolished in 1961 and the organ was moved to St Peter's College where it remains.

The Grand Regent Theatre in Adelaide had the Wurlitzer Organ
Photo 1940's

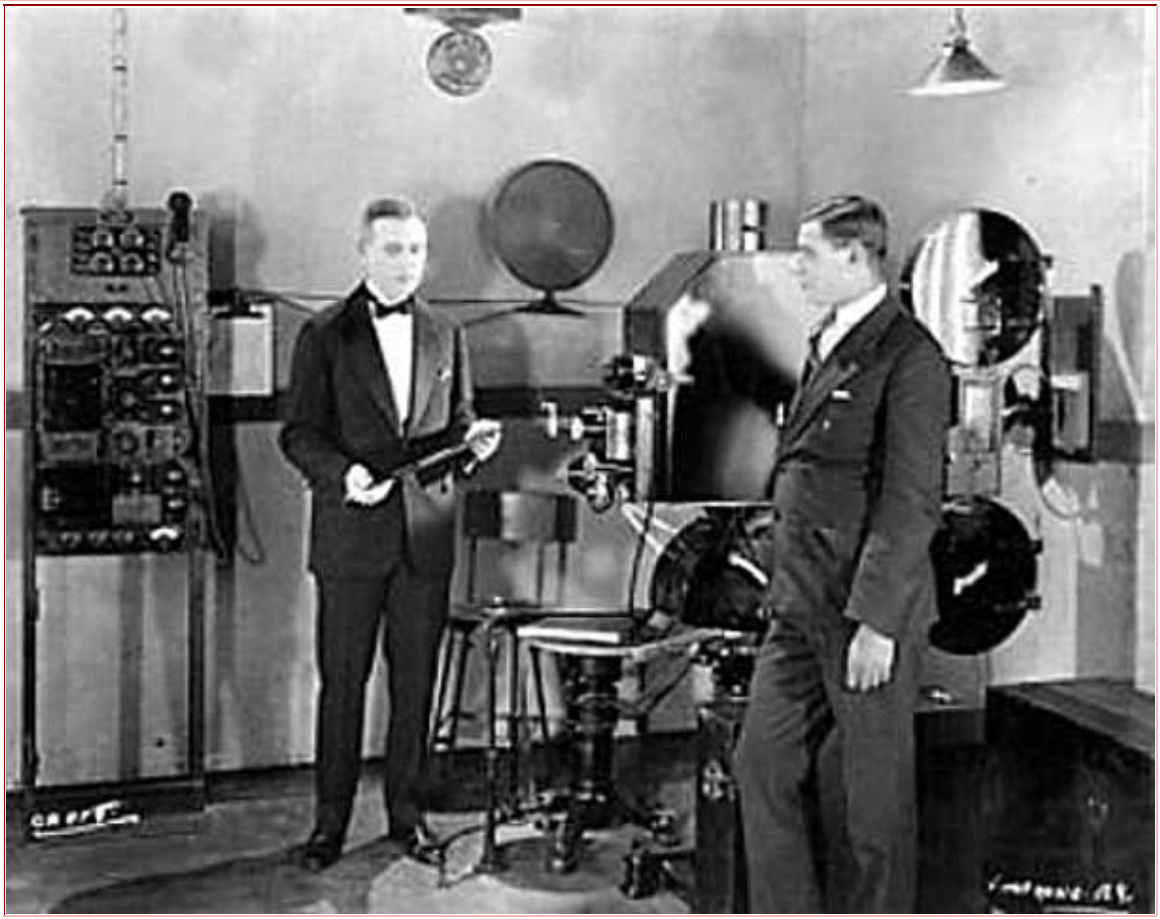
But the electric organ is not lost to Adelaide. The Organ Society of Australia in Adelaide revived what is now the Capri Theatre in Goodwood and retrieved (via Darwin actually) the Wurlitzer Organ which had previously been in the Plaza Theatre Melbourne. The Capri has the remote controlled instruments fitted in the side wings of the auditorium. Covers are normally in place for general use of the theatre but sometimes they remove those covers so the instruments can be seen. It is an intrigue to watch these instruments being played with no human hand in sight.

Capri Theatre Wurlitzer Controlled Instruments
(Normally concealed from the theatre audience)

<u>Synchronised Sound on Disc</u>

Around 1926, Western Electric introduced sound to the theatres called Vitaphone using recording on disc which was synchronised to the moving picture. The system operated until about 1931 when was it finally phased right out by the sound track on film. Vitaphone was initially very successful in replacing the earlier silent films and in particular with the introduction of "The Jazz Singer" with Al Jolson.

The discs running at 33 & 1/3 rpm on a 16 inch turntable were synchronised with the speed of the film running through the projector. The operator had to ensure that disc start was initiated to correspond with start of the film on the projector as indicated by cue marks flashed on the screen.



An early demonstration of projection with the Vitaphone sound on disc in 1926

Vitaphone Disc

Projection Room with sound turntables around 1928

It was during this period of sound on disc that I was first introduced to the world of moving pictures. My eldest big brother Hurtle was twelve years older than myself and was working as an assistant to the Operator Jack Brook in the Projection Room of the Lyric Theatre at Murray Bridge. Considering the period, I must have been around six or seven years old. One day Hurtle took me up into the projection room and sat me on the operators stool so I could watch the pictures through the viewing window adjacent to one of the two film projectors. I identify the period because the sound on disc turntables were in operation. Apart from fear that I might fall from what to me was a high stool, I was all eyes and ears to lead me into a new phase of interest in movie pictures. I now realise that I had been shown something of movie sound on disc which embraced quite a short time slot in the history of sound in motion pictures. .

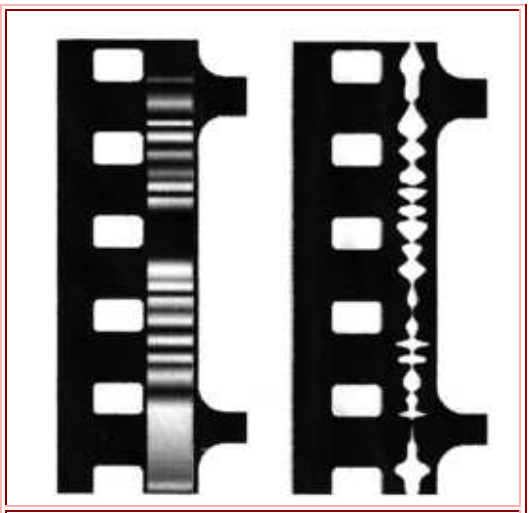
The Lyric Theatre at Murray Bridge
(From Ref. 6)

Sound on film and the Sound Track

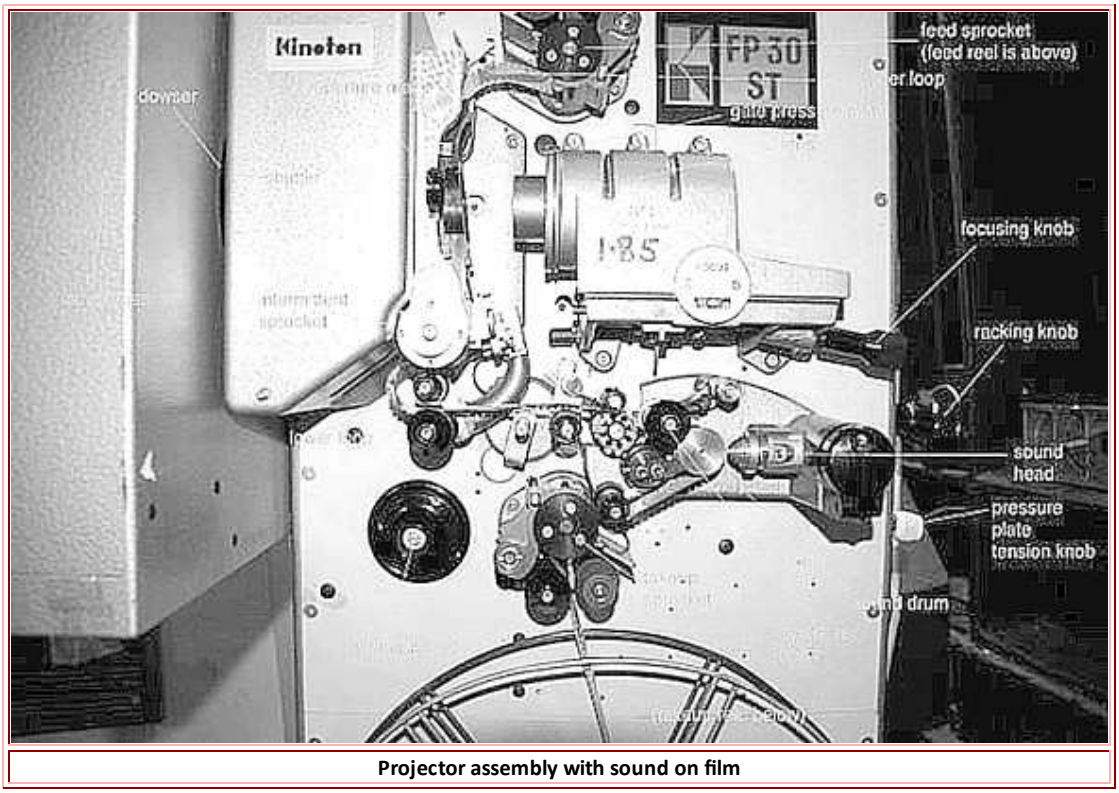
Sound from disc was not to last long. There was always the problem of starting the separate disc so that the sound (and particularly speech) was in precise phase with the moving lips of the performer in the picture. If the film broke and had to be rejoined, the sound would no longer be synchronised beyond the joint. So this led to the sound track printed on the film which automatically synchonised the sound to the pictures framed on the film.

Around 1928, RCA introduced Photophone which provided a photographically formed sound track on the film. In this system, the print density of the narrow sound track was varied in proportion to the instantaneous amplitude of the electrical sound wave. By comparison in later systems, the sound track width was varied in proportion to the instantaneous amplitude of the electrical sound wave.

In Australia in 1929, Ray Allsop introduced the Raycophone sound head to provide sound on film at a fraction of the cost of imported equipment. Following this development, in 1938 at the Regent and Plaza theatres in Sydney, he demonstrated stereo sound from 35mm film sound tracks.



Sound Tracks
Left: Variable Density
Right: Variable Width

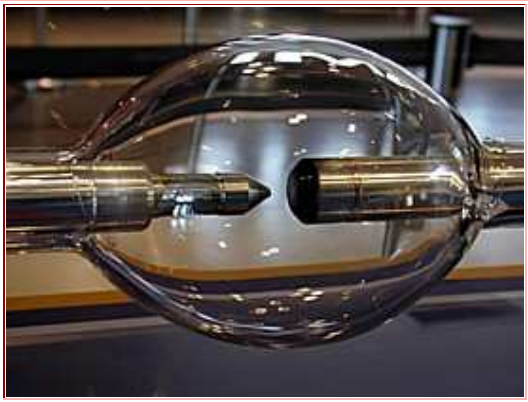


Projector assembly with sound on film

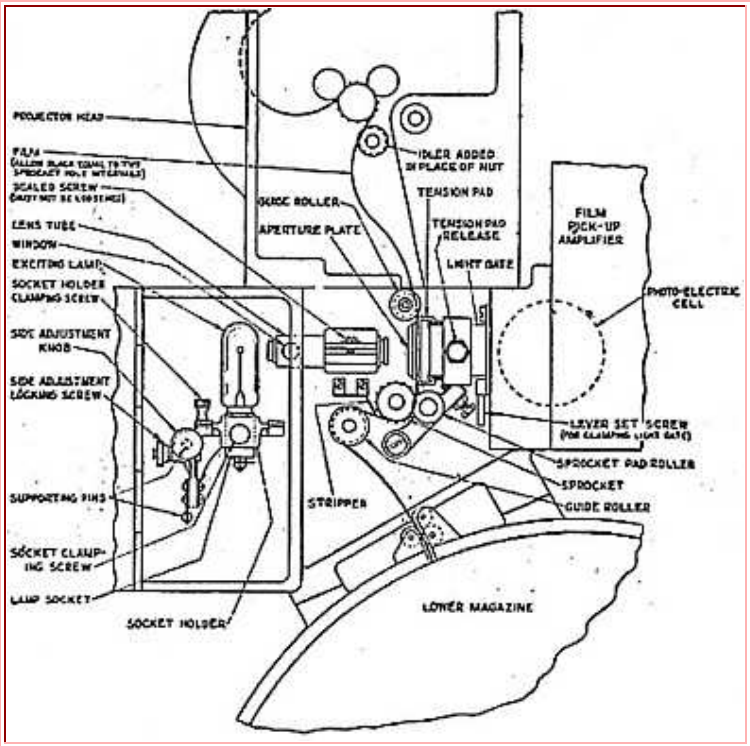
As the years advanced, projection systems changed. Early projector light sources were open carbon arc lamps which dissipated a lot of heat to obtain the light intensity required. I tried to get some idea of of the power involved. I recorded some figures given for the Grauman's Chinese

Theatre (Ref. 10): - 63 to 70 volts DC at 100 to 120 amps (that is around 6000 to 8000 watts). During operation, these open arcs had to be continuously monitored and adjusted. Not surprisingly, by around the 1960's, sealed Xenon projection lamps became the normal light source.

Today, almost all movie projectors in theaters employ these lamps, with power ratings ranging from 900 watts up to 12 kW. A xenon arc lamp is a specialized type of gas discharge lamp, that produces light by passing electricity through ionized xenon gas at high pressure. They operate continuously without adjustment for lifetimes, typically in the region of 500 to 1000 hours.

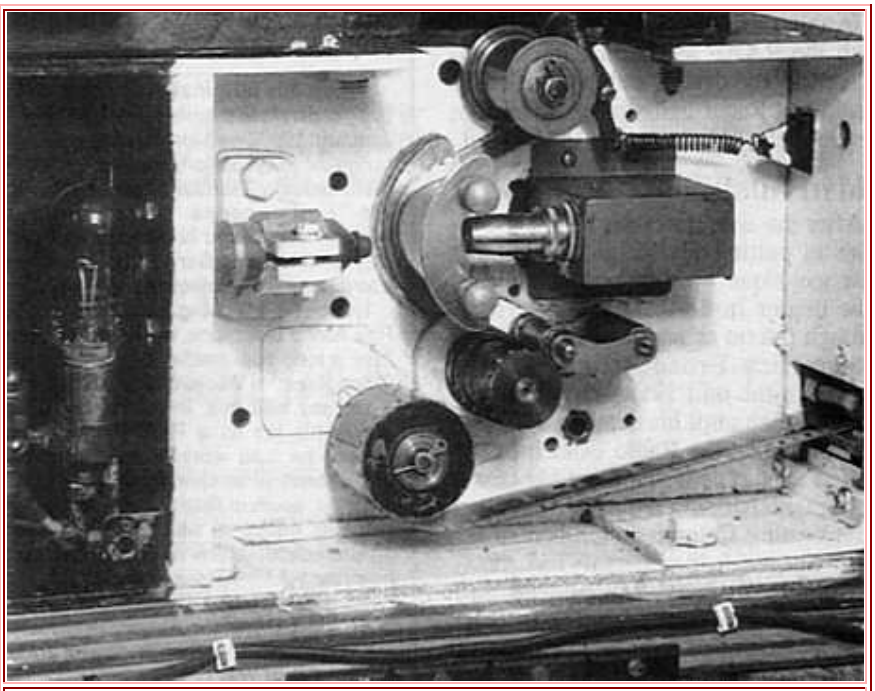


Sealed Xenon Lamp

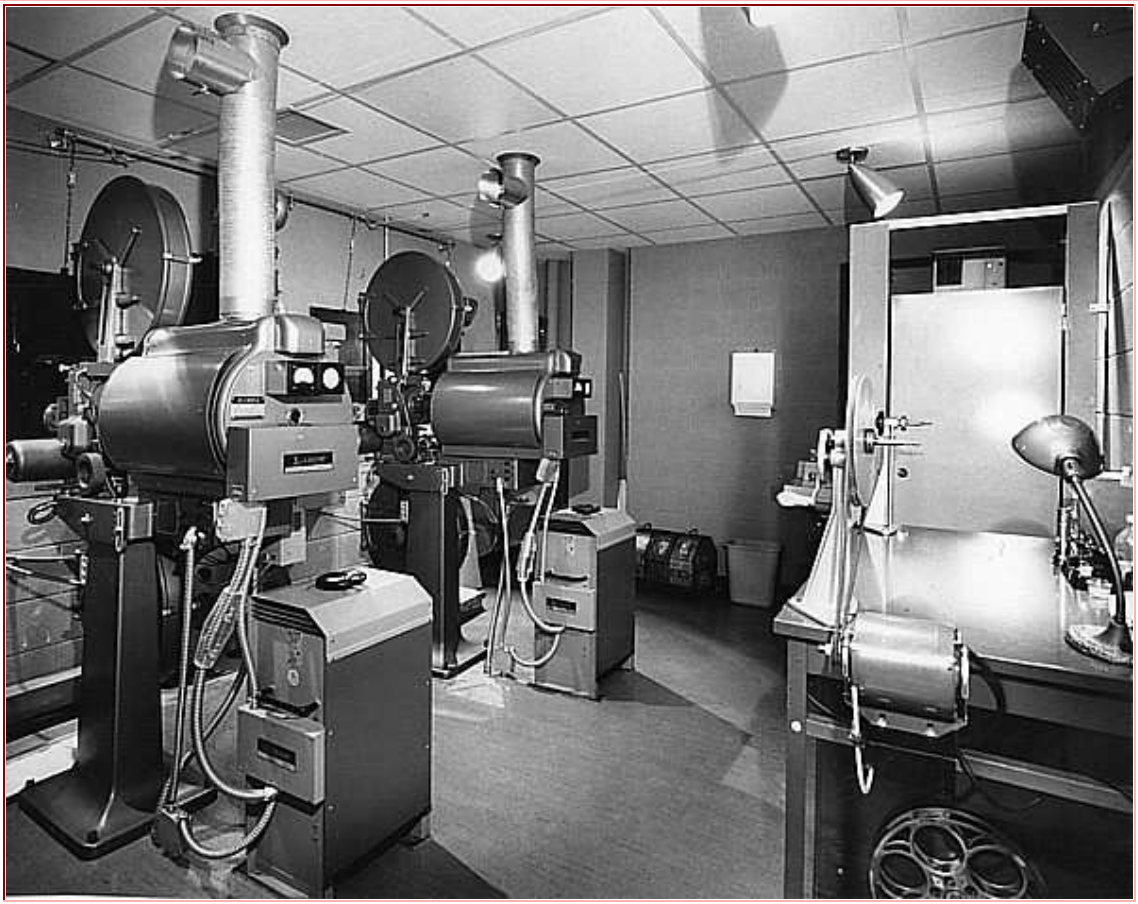


Schematic Diagram showing Sound on Film
(From Ref. 7)

Early power amplifiers to drive the auditorium speakers were electron tubes and triode tubes (such as the 2A3) seemed to be the order of the day. It was always aimed to produce high quality sound in the theatre. Triodes generated predominately even harmonic distortion and this was easily cancelled out by connecting the triodes in push pull configuration. Around the 1960's and 1970's, transistor and general solid state circuitry was replacing earlier electron tube circuitry and one might assume that by now, most electron tube amplifiers in theatres would have been phased out.



The Ray Allsop Raycophone Sound Head



Projection Room - often called the Bio-Box

Film Formats

Most of the common film formats are described in the text together with a number of diagrams. Some of the diagrams have mixed metric and imperial measurements. My apologies for that but the text on the diagrams was carried through from the original sources. Also for the 9.5mm film, I was unable to find a diagram with dimensions printed.

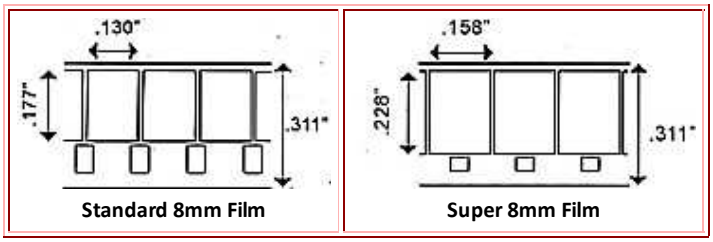
The 8 mm film is a film format in which the film strip is eight millimeters wide. It exists in two main versions: The original standard 8 mm film,

(also known as regular 8 mm), and the Super 8. Although both standard 8 mm and Super 8 are 8 mm wide, Super 8 has a larger image area because of its smaller and more widely spaced sprocket perforations.

The standard 8 mm was released by the Eastman Kodak company to the market in 1932 to create a home movie format that was less expensive than 16 mm. The film spools actually contain a 16 mm film with twice as many perforations along each edge as normal 16 mm film. On its first pass through the camera, the film is exposed only along half of its width. When the first pass is complete, the operator opens the camera and the film spool is flipped over. The film is then exposed on a second pass along the other half of its width. After the film is developed, the processor splits it down the middle, resulting in two lengths of 8 mm film, each with a single row of perforations along one edge.

As can be seen from the diagrams, the standard 8 mm film uses a single perforation (or sprocket hole) along one edge centred between each pair of frames, as opposed to the super 8 mm film which has perforations also along one edge but centred on each frame. The single hole allowed more of the film to be used for the actual image, and in fact the image area is almost the same size as the 16 mm film. Of course, picture resolution displayed on the screen is dependent on the resolution of the image on the film and hence dependent on the size of the film image. Any gain on the image area is a gain on the resolution of the display on the screen.

Super 8mm film was released in 1965 by Eastman Kodak as an improvement over the older "Double" or "Regular" 8 mm home movie format. The film is nominally 8mm wide, the same as older formatted 8mm film, but the dimensions of the rectangular perforations along one edge are smaller, which allows for a greater exposed area. The Super 8 standard also allocates the border opposite the perforations for an oxide stripe upon which sound can be magnetically recorded.

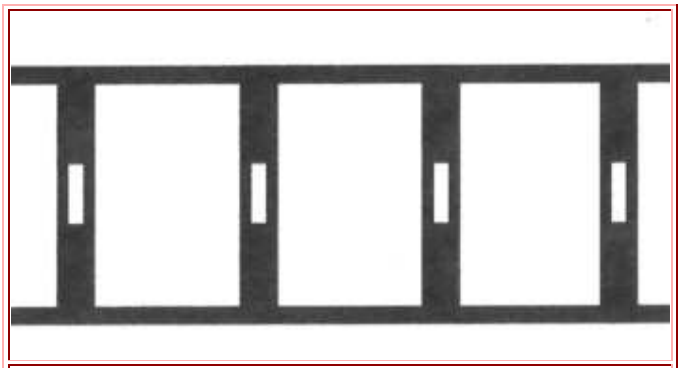


Standard 8mm Film

Super 8mm Film

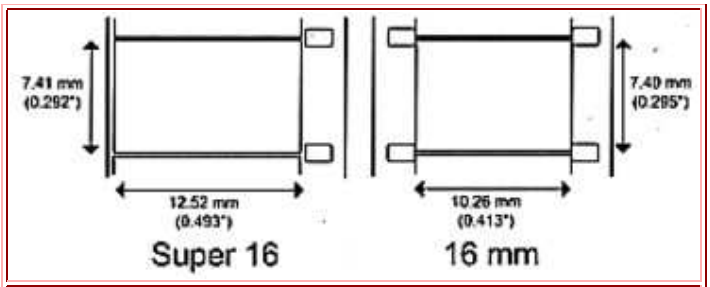
The 9.5 mm film is an amateur film format introduced by Pathé Frères in 1922 as part of the Pathé Baby amateur film system. It was conceived initially as an inexpensive format to provide copies of commercially made films for home users. As can be seen from the 9.5 mm diagram, the sprocket holes are in the centre of the film between each of the picture frames allowing the frames to take up maximum width of the film dimension and achieve maximum resolution for the film size.

The movie film became very popular in Europe over the next few decades and is still used by a small number of enthusiasts today. During the years leading up to the Second World War, and for some years after the war, the gauge was used by enthusiasts who wanted to make home movies and to show commercially made films at home.



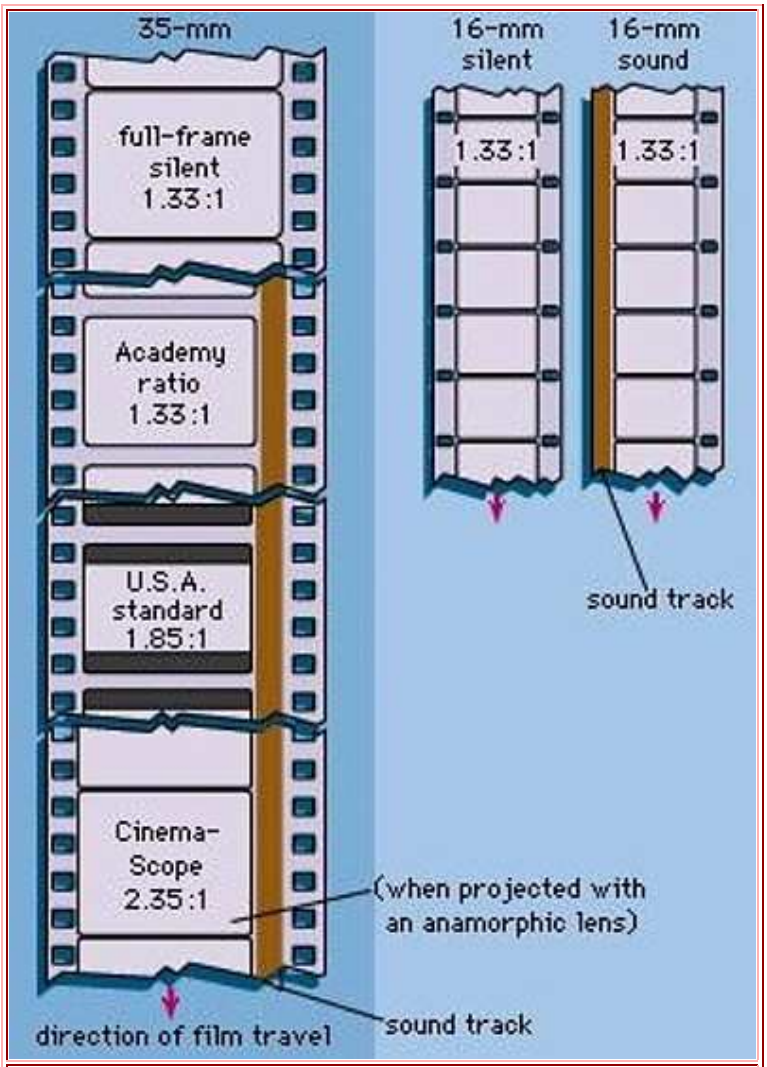
Format of 9.5mm Film (Sprocket Holes at Centre)

The 16 mm film is a popular and economical gauge of film which is used for non-theatrical film making, such as industrial, educational, or low-budget motion pictures. It also existed as a popular amateur or home movie-making format for several decades. Eastman Kodak released the first silent 16 mm film and associated equipment in1923. RCA-Victor introduced a 16 mm sound format using optical sound track in the years 1932-1935.

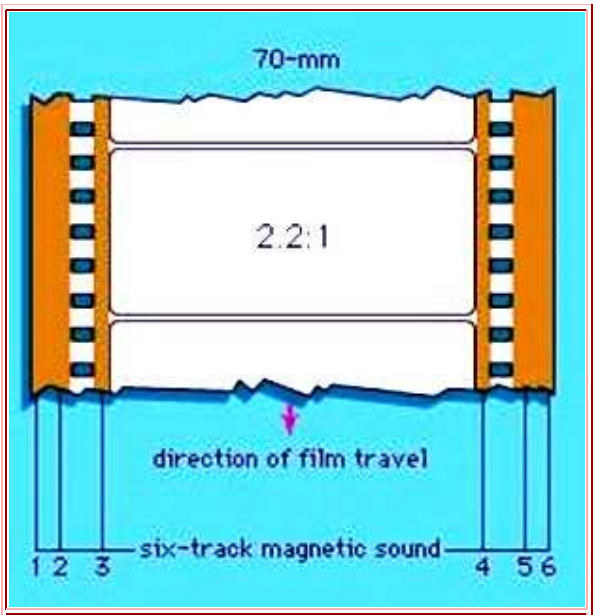


Formats of Silent Super 16mm & Silent Standard 16mm film

The formats for 16 mm film can be a little confusing. The original silent version has sprocket holes down both sides of the film (similar to that for 35 mm film). However, Super 16 mm film has only one side with the sprocket holes, leaving the other side with space to fit an optical (or magnetic} sound track on the other side, or a 20% wider picture frame without room for a sound track.

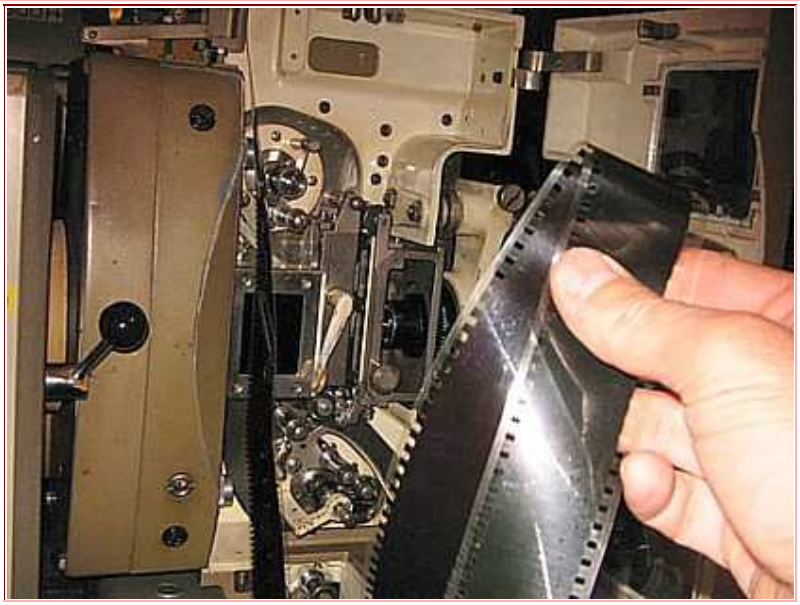


Formats for 35mm & 16mm



70mm Film with Magnetic Sound Tracks

Forms of 35mm wide film were introduced as early as 1892 but the 35 mm width film and four perforations per frame became accepted as the international standard gauge in 1909. It remained by far the dominant film gauge for image origination and projection in picture theatres until the advent of digital photography and cinematography. This was despite challenges from smaller and larger gauges. Its size allowed for a relatively good trade-off between the cost of the film stock and the quality of the images captured.



35mm Film

The normal sound track on 35mm film is photographic (as shown on the diagram). However, special presentations of sound on 35 mm film have been recorded magnetically on ferric oxide tracks bonded to the film print, outside of the sprocket holes. 16 mm and Super 8 formats have also been used with a similar magnetic track bonded to the side of the film on which the sprocket holes had not been punched.

Several digital sound sound track systems for 35 mm cinema were introduced during the 1990s. Dolby Digital is stored between the perforations on the sound side. Sony Dynamic Digital Sound (SDDS) is recorded on both outer edges of the 35 mm film. Here we get into a complex system useful for a very large cinema auditorium, The system supports up to eight independent channels of sound: five front channels, two surround channels and a single sub-bass channel. DTS (formerly known as Digital Theater Systems) is a five channel primary (full-range) system, similar to a Dolby Digital setup, plus a special low-frequency effects channel for the subwoofer sound speaker. For DTS, the sound data is stored on separate compact discs synchronized by a timecode track on the film just to the right of the analog soundtrack and left of the frame.

Films formatted with a width of 70 mm have existed in the motion picture industry since the 1890's. It is used for still and motion picture photography, with higher resolution than the standard 35 mm motion picture film format. As used in cameras, the film is 65 mm (2.6 in) wide. For projection, the original 65 mm film is printed on 70 mm (2.8 in) film. The additional 5 mm is used for 4 magnetic strips holding six tracks of sound.

The 70mm film has been used on many of the modern wide screen versions of the movie theatre, making use of the higher resolution of the wider film format.

Moving Pictures, Frame rate & the Projection Shutter

Moving pictures, as seen by the human eye, are created by displaying alternate fixed frames of pictures, each one slightly changed from its previous one. If the rate of change is fast enough, the eye interprets the changes as movement. The earliest cameras and projectors needed to be hand-cranked to advance the film through the gate. This lead to varying frame rates. Early silent films had frame rates from 14 to 26 frames per second, which was enough to provide a sense of motion, but the motion was often jerky or uneven. Eventually cameras and projectors were motor driven and standard frame rates were established.

A rate of 16 frames per second was set in some early projectors but the general rate of 24 frames per second eventually established as the standard. However this is not fast enough to prevent flicker as seen by the eye. So each frame is cut in twice by a shutter rotating at 24 times per second so that 48 fixed frames per second are displayed to the screen. The shutter also blanks out projected light each time the projector moves the film from the displayed frame to its next one.

When the current frame has been is displayed in the light beam beam twice, and the operation is complete, the mechanism of the projector moves the film to the next frame. That frame remains stationary whilst the operation of frame display is repeated twice. In observing the film running through the projector gate, one might get the impression that it it runs through in a steady continuous state. But through the gate, it is a start--stop operation at a repetition rate of 24 per second.

Diagram of the rotating Shutter

The Shutter Rotates at 24 frames per second. It opens twice per rotation for 90 degrees to allow passage of the light beam. The film moves one frame during every second shutter closure.

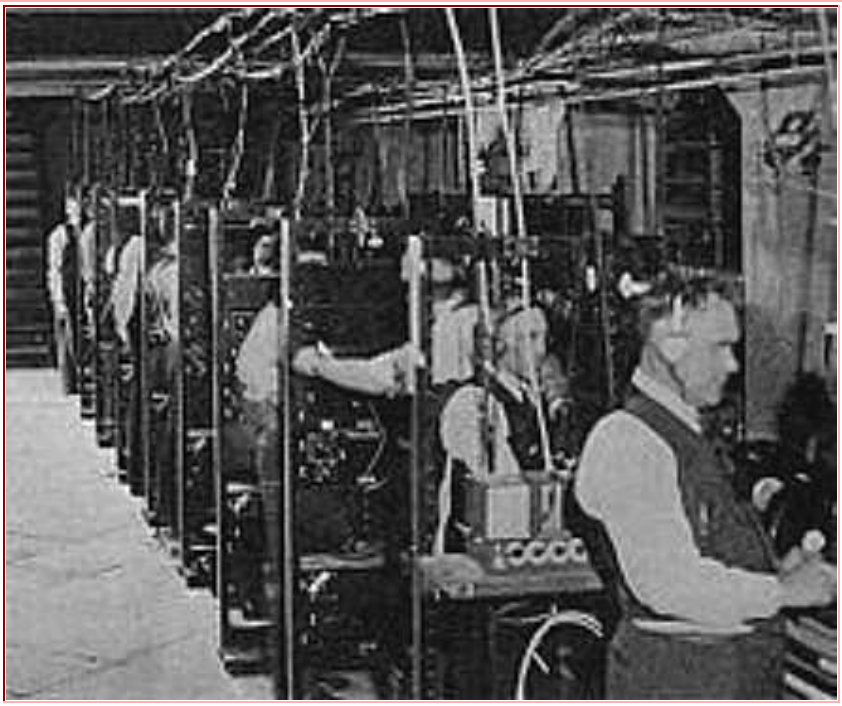
But here is an interesting point of discussion. Our (now superseded) analogue television frame rate was 25 frames per second, locked at half our power line frequency of 50 Hertz (for a number of very good technical reasons). If they displayed a movie film, originally photographed at 24 frames per second, and transmitted frame for frame, did it display on our TV screens 4% quicker?

Fantasia & Fantasound

Over the years there has been a multitude of different advanced screen displays, different sound systems and different ways in which the sound is supported by, and synchronised with, the picture information carrier. But even in the mature 1940's there were some quite advanced developments. One such development was the animated film "Fantasia", produced by Walt Disney and released by Walt Disney Productions in 1940. Fantasia was first released in theatrical roadshow engagements held in thirteen U.S. cities commencing on November 13, 1940. Unfortunately, World War 2 prevented further circulation throughout Europe.

The SA motion picture theatre group Ozone took over the running of what had been the Lyric Theatre at Murray Bridge in the 1940's. It was around then, in my teenage years, that I met up with a young chap who Ozone sent to the town to run the theatre and its projectors. We talked about motion pictures and the eight track Fantasia sound. He was a member of IRE and he loaned me a copy of Fantasia as written up in a current issue of the Proceedings of the IRE Australia. So my interest started right then.

Fantasound, developed for Fantasia in part by Disney engineer William Garity, employed two 35mm projectors, running at the same time and synchronised. One contained the picture film with a mono soundtrack for backup purposes, and the other contained a sound film that contained eight recorded tracks. These were rearranged into four channels, three of which contained the audio for the left, center, and right stage speakers respectively, whilst the fourth was a control track of amplitude and frequency tones that drove variable-gain amplifiers to control the volume of the three audio tracks. The system was clearly stereo and probably an early introduction to what we now know as surround sound. In making the movie, eight operators were used to manually control different levels of the eight tracks.



Eight operators are shown controlling the eight sound tracks in the making of Fantasound for the movie "Fantasia"

The combination of each pair of tracks is interesting in that they run in push-pull and a push pull light image is fed via a lens and photo cell to feed the input of a push pull amplifier. One can guess that they were aiming to cancel out even harmonic distortion generated in the optical sound tracks

The roadshows did not continue beyond USA as costs involved did not deliver profit and fantasound ended in 1941. RKO aquired the film rights in 1941 and replaced fantasound with monosound. Disney engineer Terry Porter set up the original s sound again in 1990 but the Fantasia system was only shown in New York and Los Angeles theatres. A report, in the Melbourne Argus of 9-9-41, stated that Fantasia was arriving in Australia the following week. Another report listed the start of a roadshow here on 15-9-41. However, it must be assumed that this was now a monosound version.

The standard picture display in early theatres was in an aspect ratio of 4:3 (or 1.33:1). Some later versions of Fantasia were reproduced in a widescreen version called Superscope with aspect ratio of 2.35:1. The 35mm film frame was still 1.33:1, but on filming, a special lens (called an anamorphic lens) in the camera, compressed the picture in the horizontal axis to the 1.33:1 width. On projection, a special lens (the inversion of the camera lens) in the projector, expanded the displayed picture to the original picture aspect seen by the camera. I understand that this is the basis of many wide screen systems, such as CinemaScope, which followed further down the track.

Today's Movie Theatre Complexes

Up to the most recent few decades, individual movie theatre projection rooms were required to be staffed by a certified qualified projection operator, usually accompanied by at least one projection assistant. However things have now changed with many newer multiple auditoriums and projection rooms in a single large theatre complex. Using the more recent developments of digital systems with computer control technology, digital memory storage, and improved projection safety, these newer theatre systems are staffed with a minimal number of projection operators who control the whole unattended projector operation.

Today we sit in the auditorium, partly surrounded by a massive, almost overpowering realistic picture and listen to high quality surround sound. One hundred years ago, it was a black and white picture, of limited size and limited resolution, and no synchronised sound. Our motion picture entertainment has come a long way.

If you are interested further in the history of projection and sound reproduction, I suggest you might download the story of the Grauman Chinese Theatre in Hollywood California (Ref.10), who have documented much of the range of motion picture technologies.

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