



# **Simulation Tools in Sound Reinforcement: Multichannel Digital Audio Cinema Design**

**Athens Course UPM94  
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# A SHORT HISTORY OF CINEMA SOUND



## The Talkies Era

Early experiments with adding sound to films focused on two methods:

Recording the sound directly on the film or

Recording it on discs that were played simultaneously with the film.

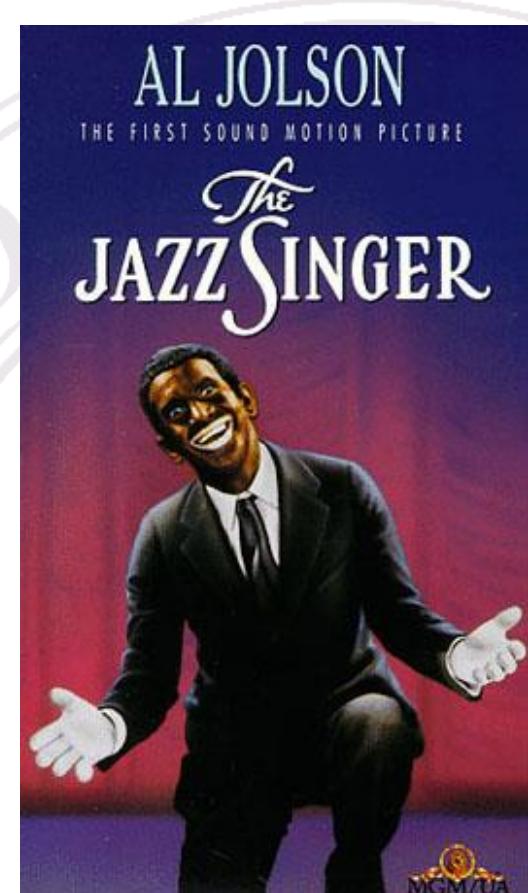
The first big hit, *The Jazz Singer*, used sound on disc, but it was sound on film that eventually won out.



# A SHORT HISTORY OF CINEMA SOUND



## The Talkies Era





# A SHORT HISTORY OF CINEMA SOUND



## ***1905: Chronophone***

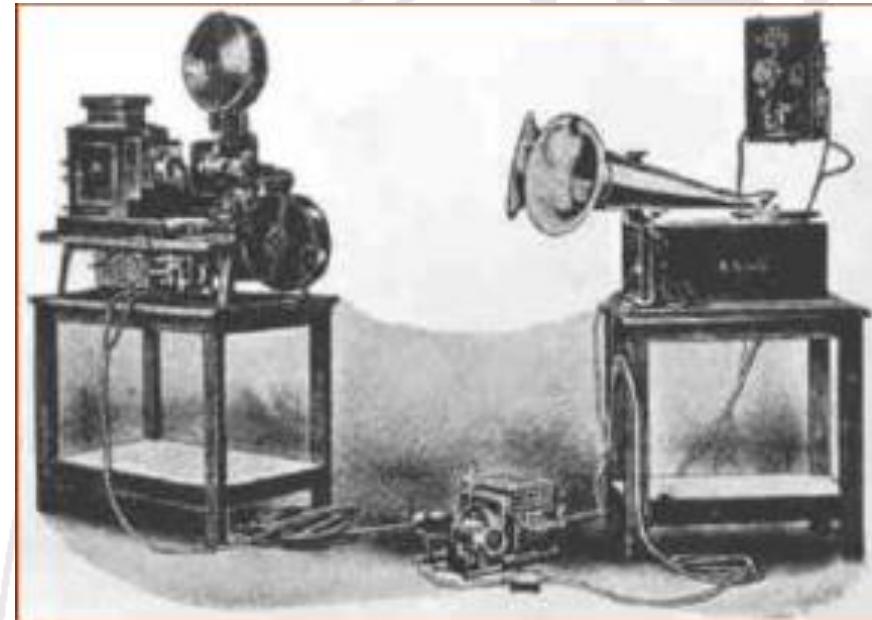
The Chronophone is an apparatus patented by Léon Gaumont in 1902 to synchronize the Cinématographe (Chrono-Bioscope) with a disc Phonograph (Cyclophone). This Sound-on-disc display was used as an experiment from 1902 to 1910.



# A SHORT HISTORY OF CINEMA SOUND



**1905: Chronophone**





# A SHORT HISTORY OF CINEMA SOUND



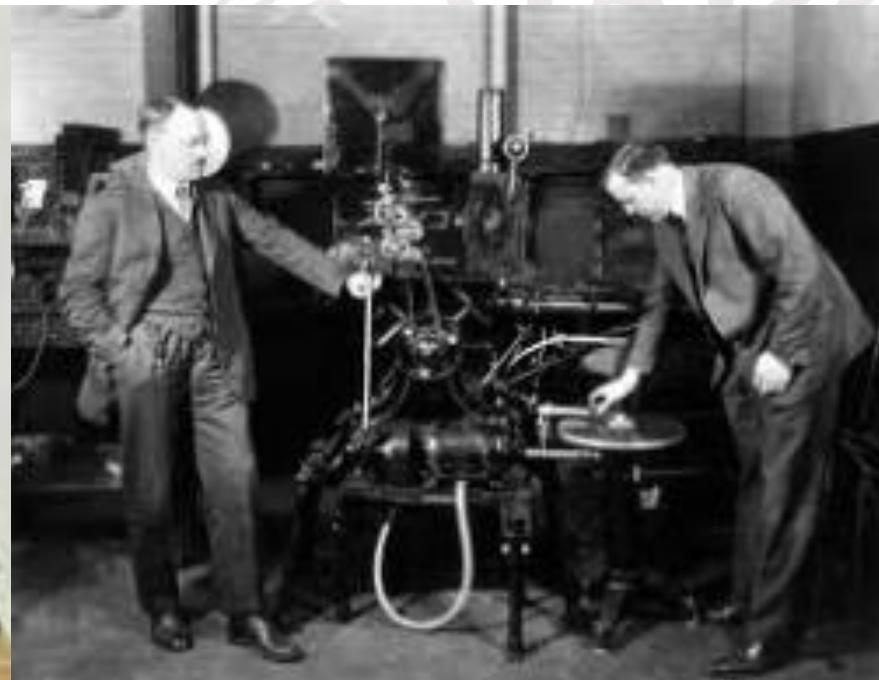
## 1921: Photokinema

The Photokinema sound-on-disc system was developed by Orlando Kellum, and was employed to add synchronized sound sequences to D. W. Griffith's failed silent film "Dream Street". In sound-on-disc technology from the era, a phonograph turntable is connected by a mechanical interlock to a specially modified film projector, allowing for synchronization. The sound discs themselves were 16-inch, optically printed phonographic records, such as used in the Vitaphone. While this system failed to win wide support in the film industry, it did pave the way for sound-on-disc music instruments, such as the Lichttonorgel and the ANS.



# A SHORT HISTORY OF CINEMA SOUND

**1921: Photokinema**





# A SHORT HISTORY OF CINEMA SOUND



## ***1922: Phonofilm***

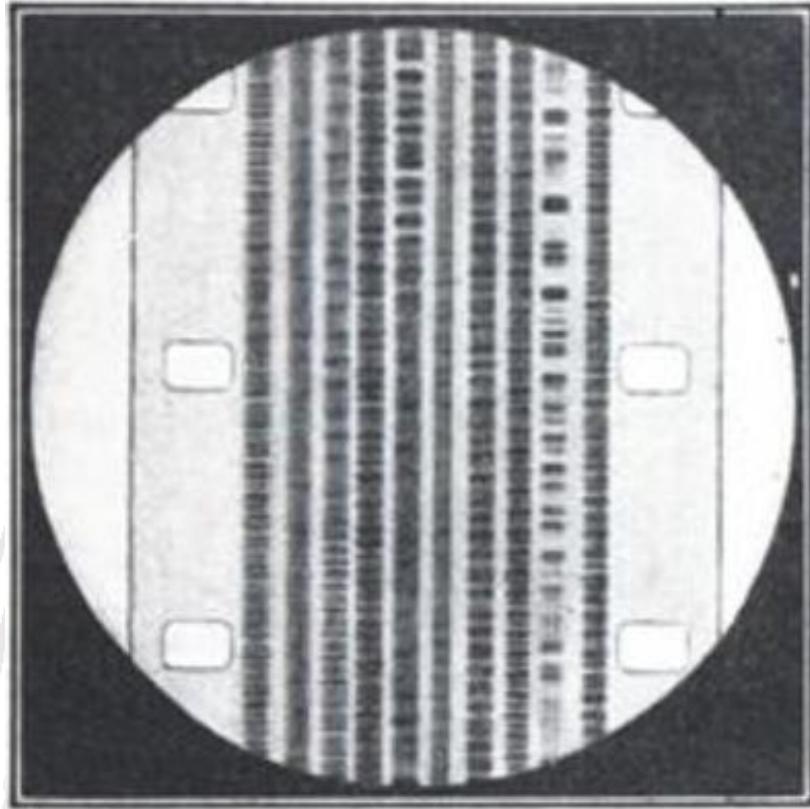
De Forest Phonofilm - Lee de Forest was already well known as the inventor of the Audion tube-a device which amplified weak radio signals-when he turned his attention to talking pictures. Building on the work of German inventors, in 1922 he developed the Phonofilm, a system for recording synchronized sound directly onto film stock.



# A SHORT HISTORY OF CINEMA SOUND



## 1922: Phonofilm



A strip of sound film, greatly magnified, with ten sound tracks side by side on a 16 mm. movie film. This substitutes for a phonograph record.



# A SHORT HISTORY OF CINEMA SOUND



## 1926: *Movietone*®

Fox used Movietone, a system that recorded sound on the film reel itself, to release several shorts films with soundtracks and add a musical score to the silent film *What Price Glory?*



# A SHORT HISTORY OF CINEMA SOUND



**1926: Movietone®**





# A SHORT HISTORY OF CINEMA SOUND



## **1926: Vitaphone**

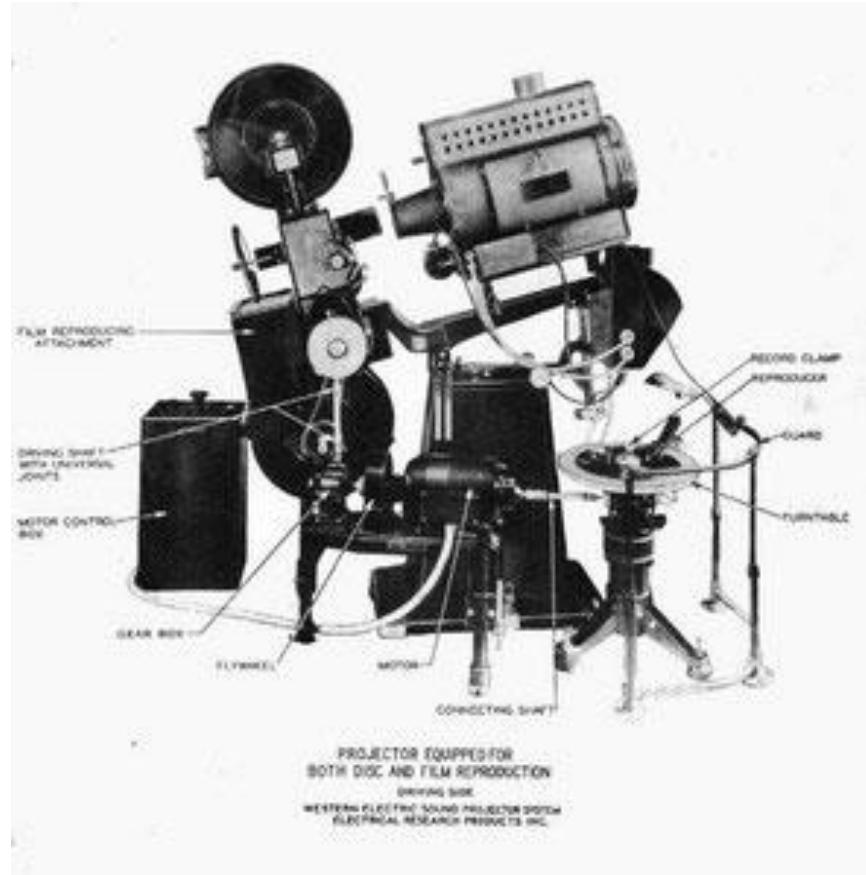
*Don Juan* was the first full-length features released with Vitaphone, though the soundtrack included only music and sound effects – no dialogue. The next year, Warner Bros used Vitaphone to release *The Jazz Singer*, a film whose wild success guaranteed the death of silent movies. Vitaphone was the last major system that recorded sound on phonograph discs.



# A SHORT HISTORY OF CINEMA SOUND



## 1926: Vitaphone





# A SHORT HISTORY OF CINEMA SOUND



## The Mono Era

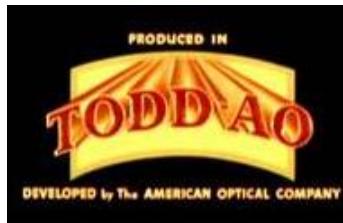
Until the 1970s, almost all movies were accompanied by optical soundtracks that represented the sound as a clear stripe of varying width along the side of the film. Optical soundtracks at that time were mono, and the audio quality was little better than a phone line. But that didn't stop studios from experimenting with both sound and image. Most of the experiments were short-lived and used on only a small number of films.



# A SHORT HISTORY OF CINEMA SOUND



## The Mono Era





# A SHORT HISTORY OF CINEMA SOUND



## **1940: Fantasound**

Walt Disney took great pains to make a faithful, multitrack recording of maestro Leopold Stokowski leading the Philadelphia Orchestra—and to create the Fantasound system to play *Fantasia*'s stereo soundtrack in theatres. But the Fantasound version of the animated classic played in only 14 U.S. theatres, a result of the system's cost and the attention and resources devoted to World War II.

Includes film soundtrack with four channels, independent from image filmtrack, synchronized in the projector.



# A SHORT HISTORY OF CINEMA SOUND



## 1940: *Fantasound*

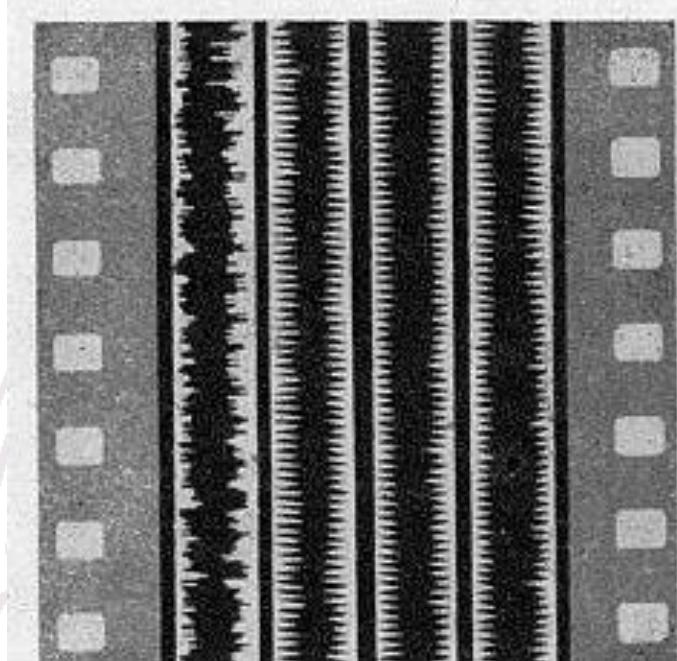
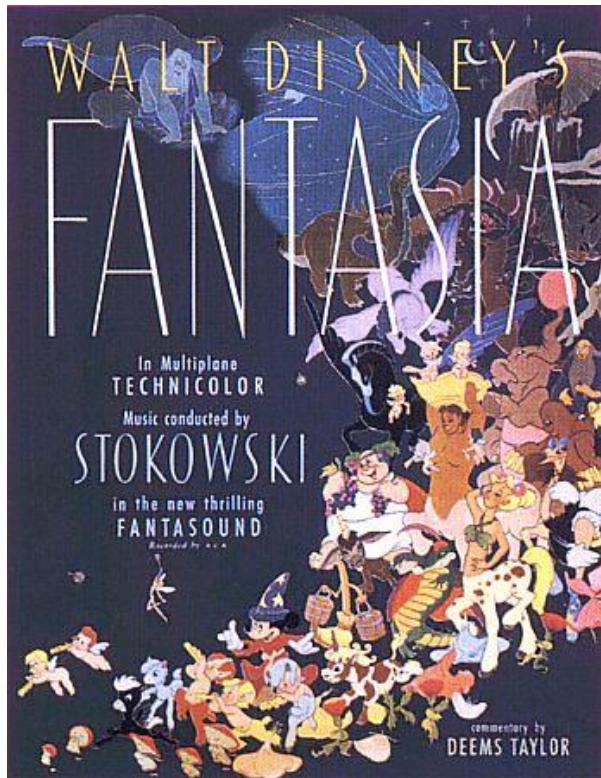


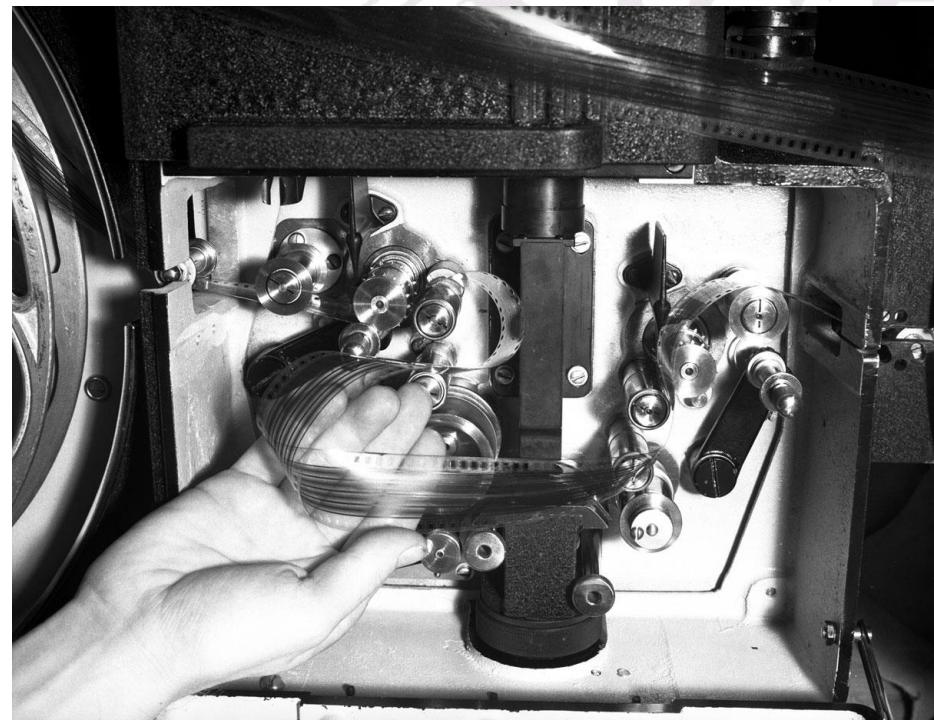
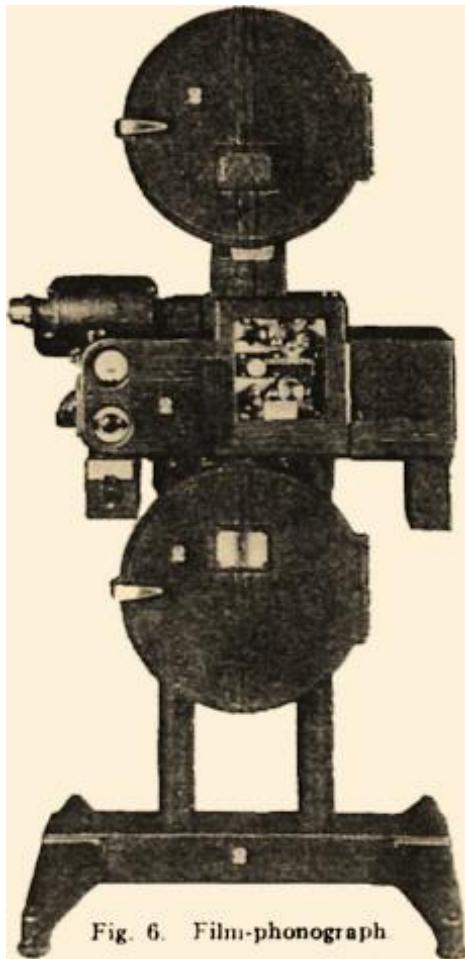
FIG 140. *Fantasound Four-Channel Film.*



# A SHORT HISTORY OF CINEMA SOUND



**1940: Fantasound**





# A SHORT HISTORY OF CINEMA SOUND



## 1940: Fantasound

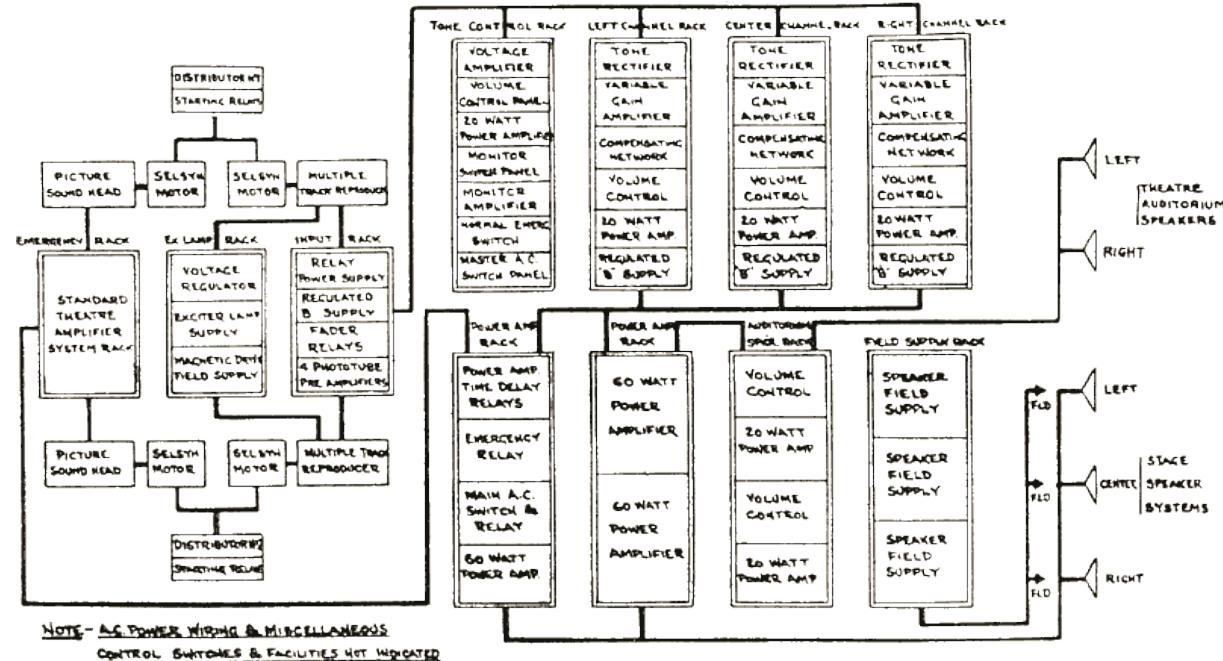


FIG. 1. Block diagram of Fantasound road-show unit.

The **Mark I** system used three widely separated horns across the stage and horns in each rear corner of the house. The **Mark II** system was a simple expansion of the Mark I system, adding three horns; one on each side-wall about halfway back from the stage, and one in the ceiling at about the center of the house.



# A SHORT HISTORY OF CINEMA SOUND



## ***1949: Perspecta / VistaVision***

This audio system, widely used in VistaVision® films, simulated stereo by selectively steering a standard optical mono signal to the left, right, or center audio channels.

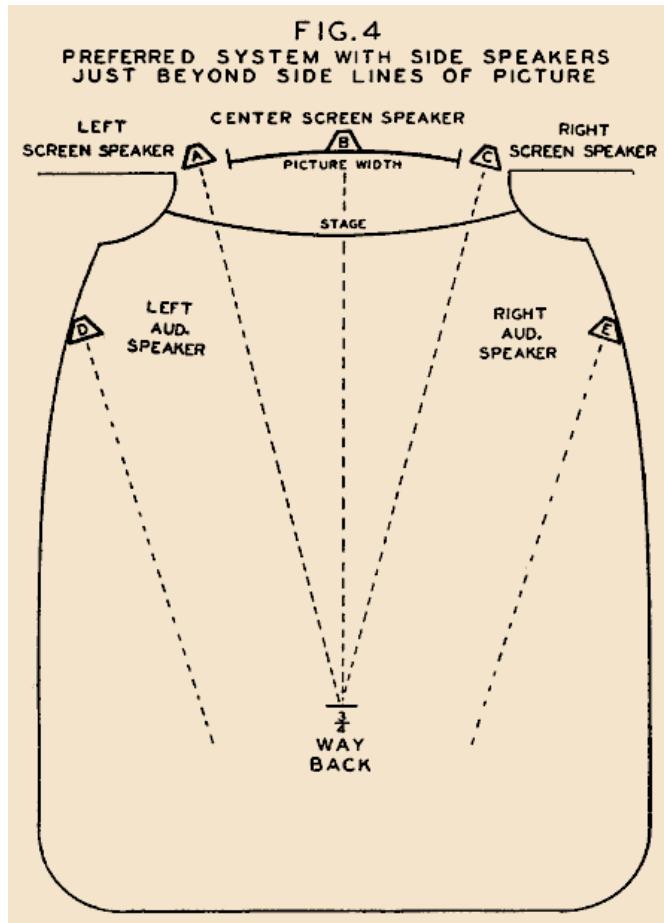
Perspect-A Stereophonic Sound and VistaVision release prints, will have a single photographic sound track located in the standard position so that they will reproduce on any standard optical sound head in any projector the world over. The sound track will also carry low frequency (below audibility) modulated control signals which will control the direction of sound reproduction in theaters that are equipped for directional sound.



# A SHORT HISTORY OF CINEMA SOUND



## 1949: Perspecta / Vistavision

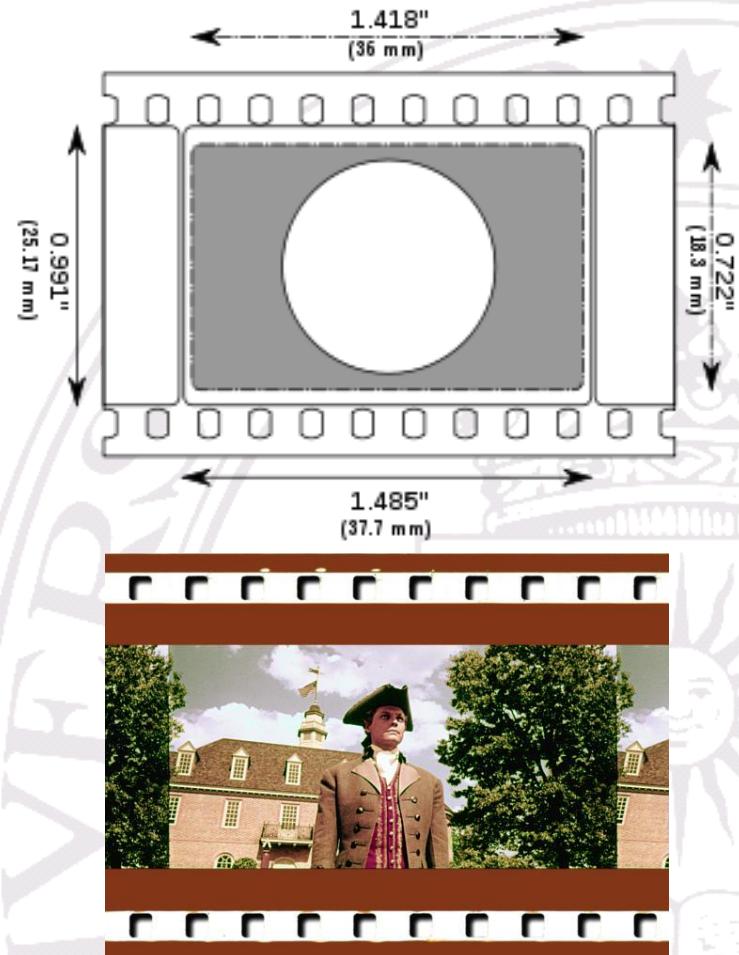
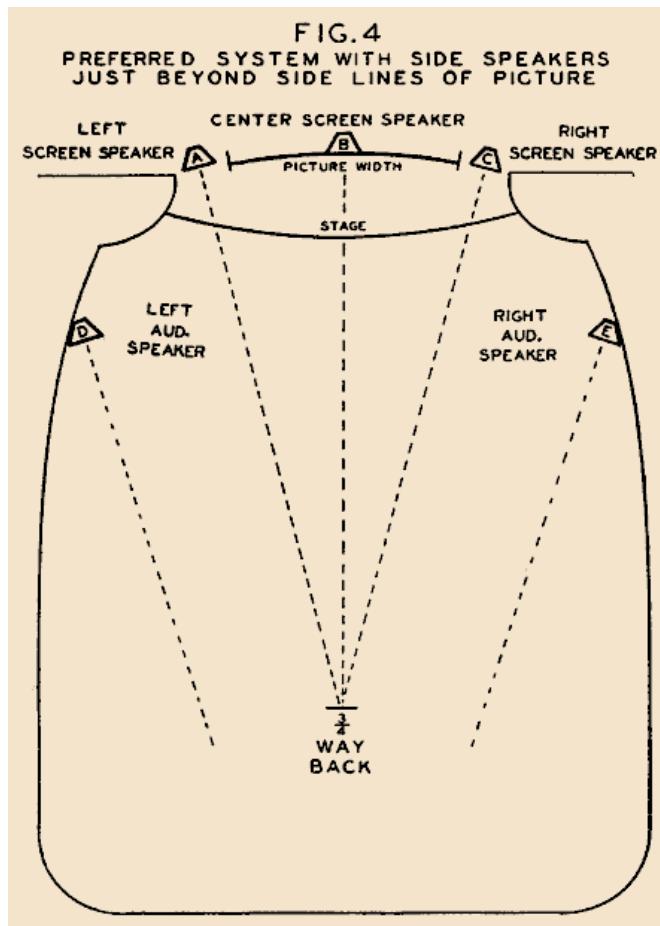




# A SHORT HISTORY OF CINEMA SOUND



## 1949: *Perspecta / Vistavision*





# A SHORT HISTORY OF CINEMA SOUND



## 1952: *Cinerama*

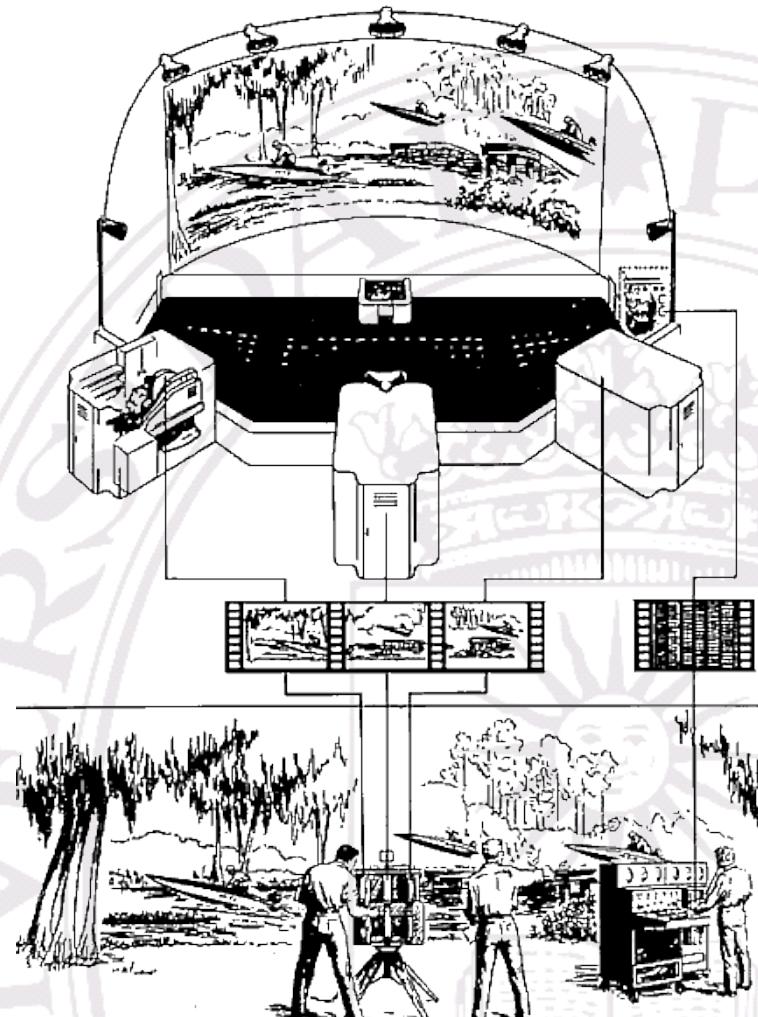
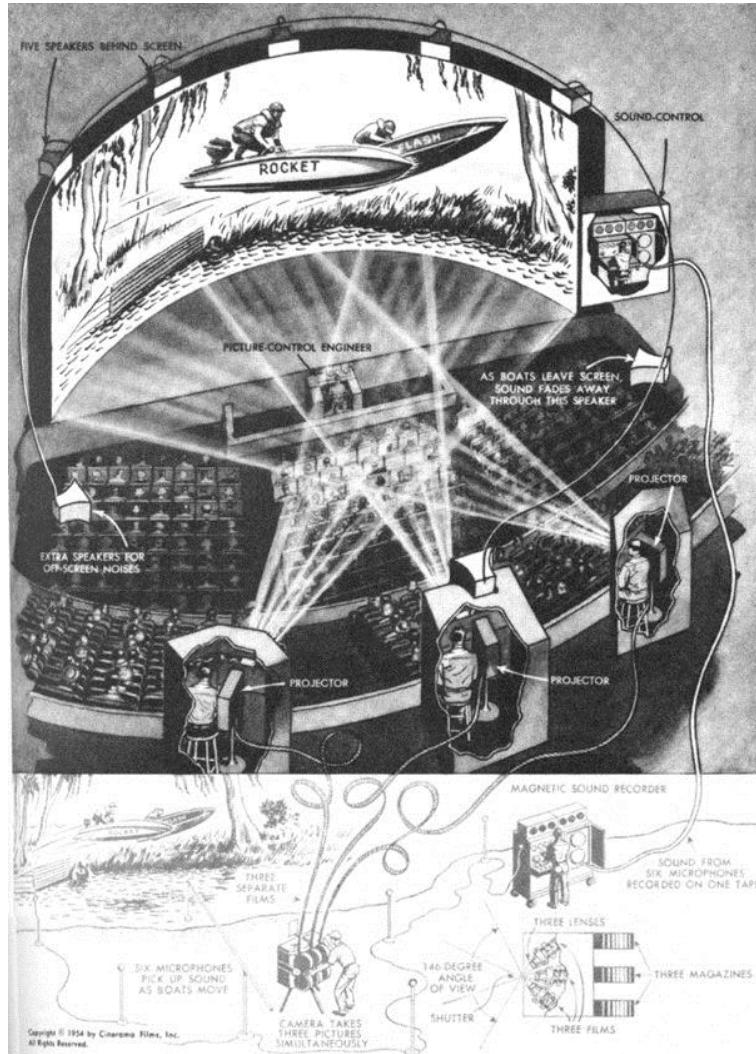
Cinerama is a widescreen process that, originally, simultaneously projected images from three synchronized 35 mm projectors onto a huge, deeply curved screen, subtending 146° of arc. The display is accompanied by a high-quality, seven-track discrete directional surround sound system.



# A SHORT HISTORY OF CINEMA SOUND



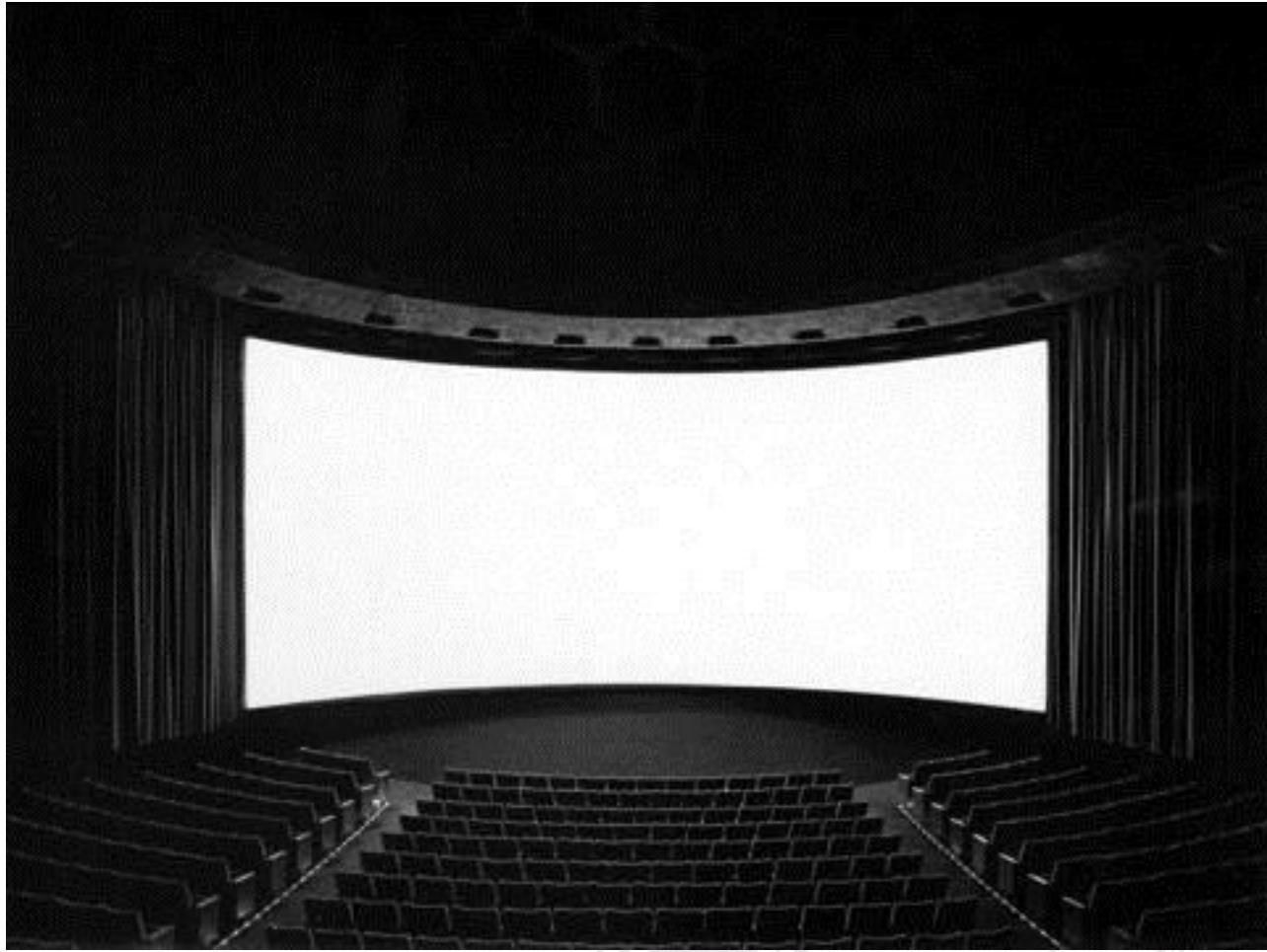
## 1952: Cinerama





# A SHORT HISTORY OF CINEMA SOUND

**1952: Cinerama**

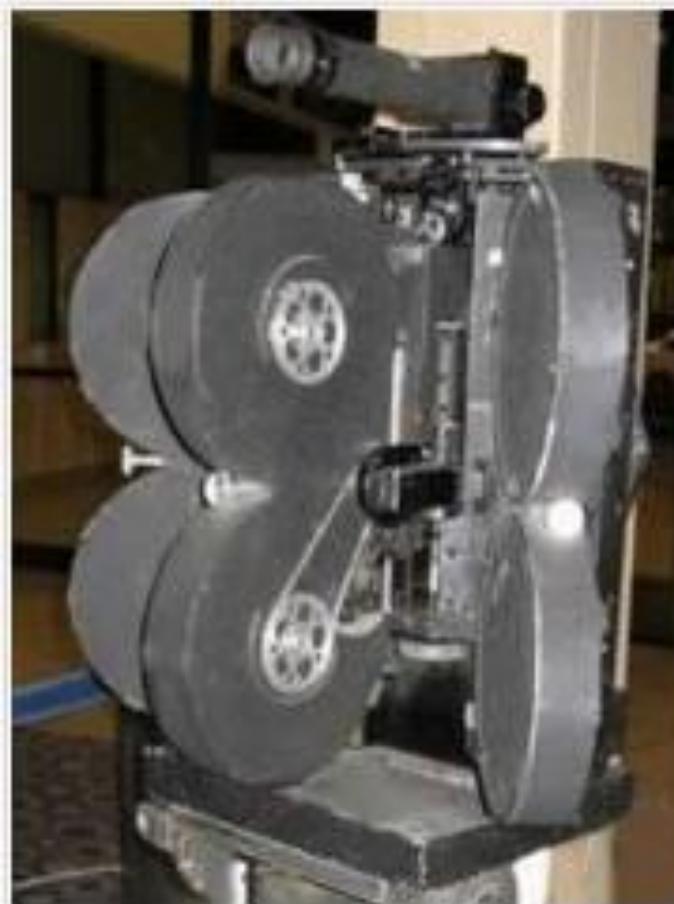




# A SHORT HISTORY OF CINEMA SOUND



**1952: Cinerama**

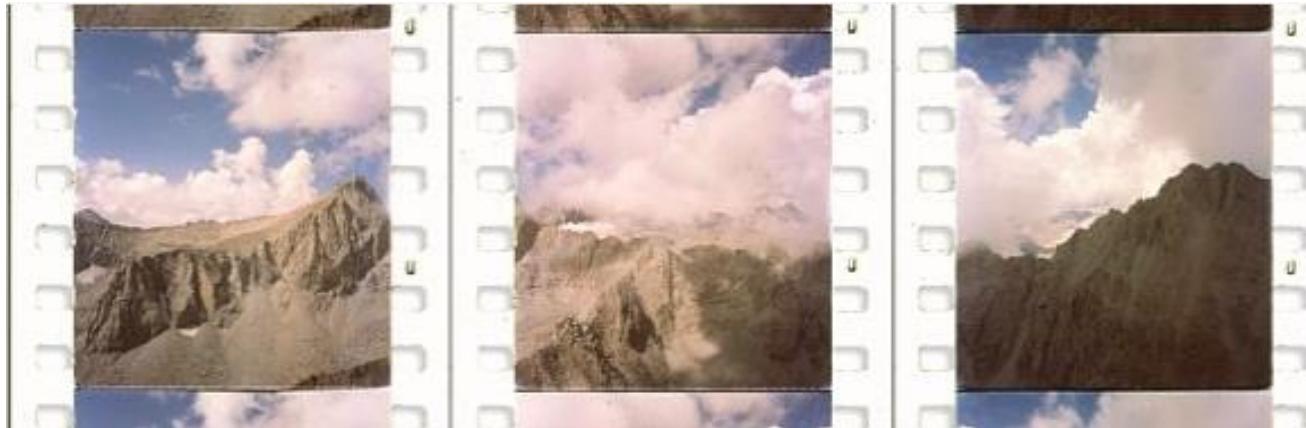




# A SHORT HISTORY OF CINEMA SOUND



**1952: Cinerama**





# A SHORT HISTORY OF CINEMA SOUND



## 1953: *CinemaScope*®

CinemaScope is mostly known for its widescreen picture, but it also featured four

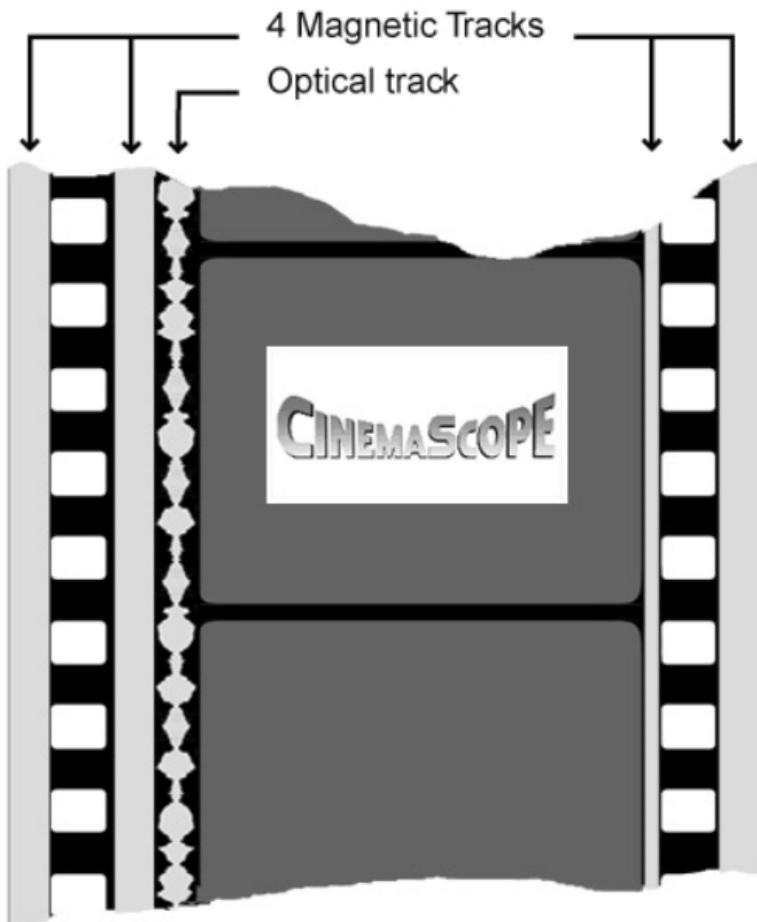
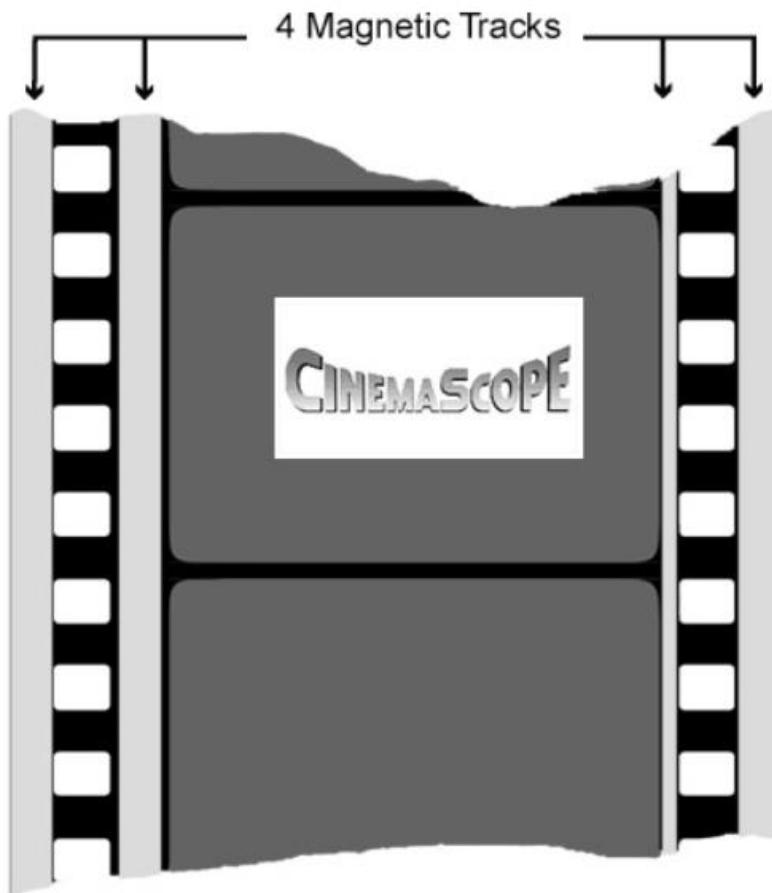
Channels of sound: left, right, and center channels, and one surround effects channel. Instead of the commonly used optical tracks, CinemaScope represented the soundtrack in magnetic stripes, at first on a separate film and then on the release print itself.



# A SHORT HISTORY OF CINEMA SOUND



**1953: CinemaScope®**

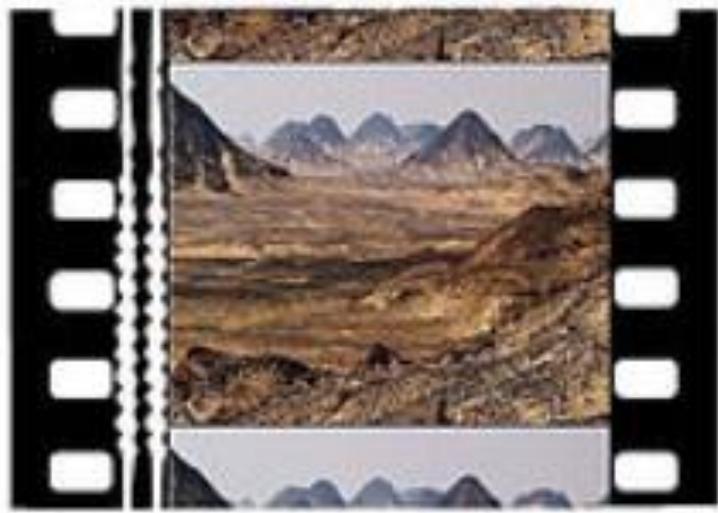
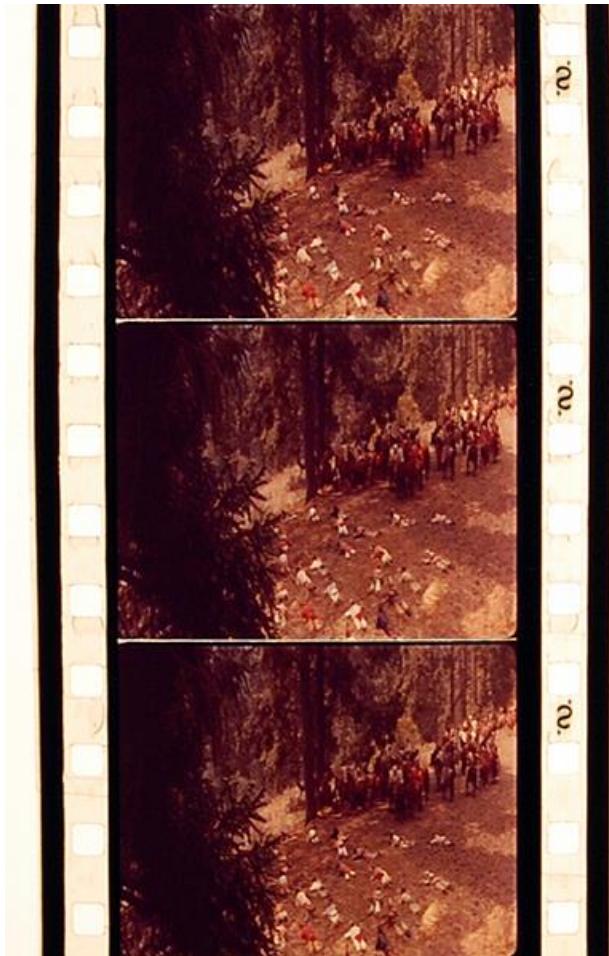




# A SHORT HISTORY OF CINEMA SOUND



**1953: CinemaScope®**





# A SHORT HISTORY OF CINEMA SOUND



1953: *CinemaScope®*



As seen on a  
standard 4:3  
TV



As seen on a  
16:9 widescreen  
TV



# A SHORT HISTORY OF CINEMA SOUND



## **1955: Todd-AO**

TODD-AO was conceived as a 65mm system, both for photography and projection. The sound, like Cinerama's was to be reproduced from a 35mm multi-track magnetic film and it was intended to have at least seven channels, and perhaps more.

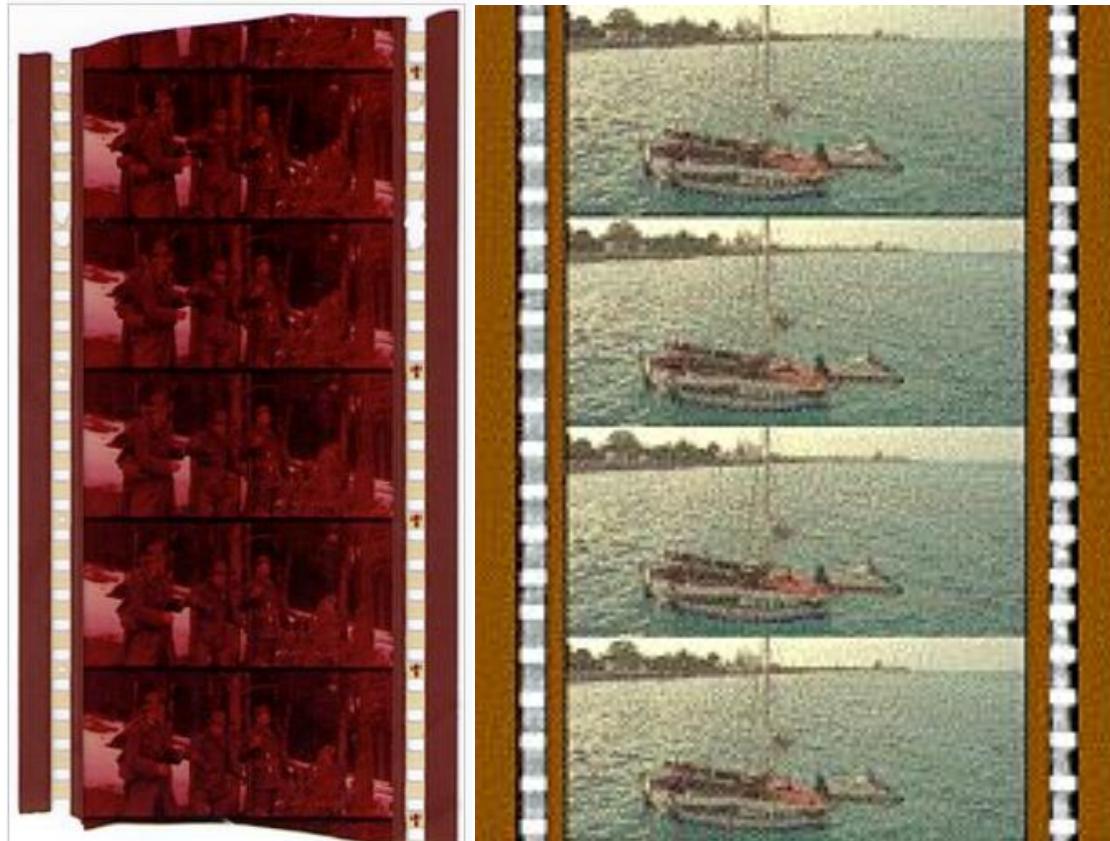
TODD-AO quickly evolved into the familiar 65mm negative and 70mm positive print. Todd-AO added 2.5mm to each side of the film allowing two magnetic tracks to be recorded on the each side of the film outside the sprocket holes and one track on each side was recorded inside the sprocket holes on tracks that laid on top of the edges of the picture.



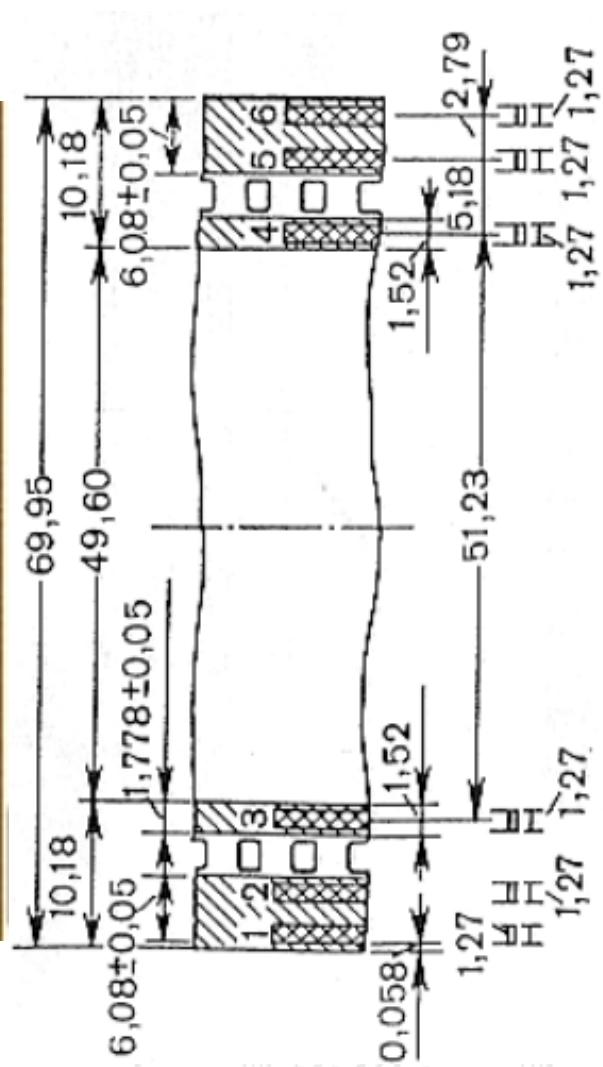
# A SHORT HISTORY OF CINEMA SOUND



## 1955: Todd-AO



Faded vintage 70 mm positive film with  
4 magnetic strips containing 6-channel  
stereo sound





# A SHORT HISTORY OF CINEMA SOUND



**1955: Todd-AO**





# A SHORT HISTORY OF CINEMA SOUND



## **1955: 70mm-6 tracks**

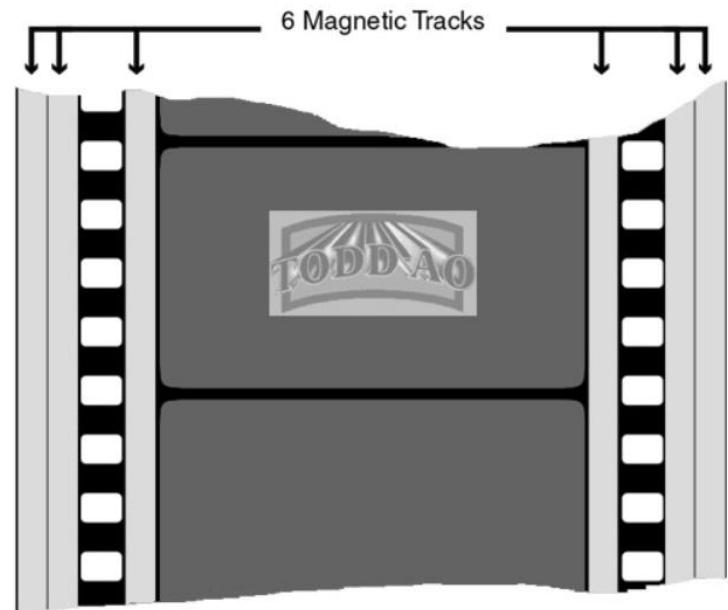
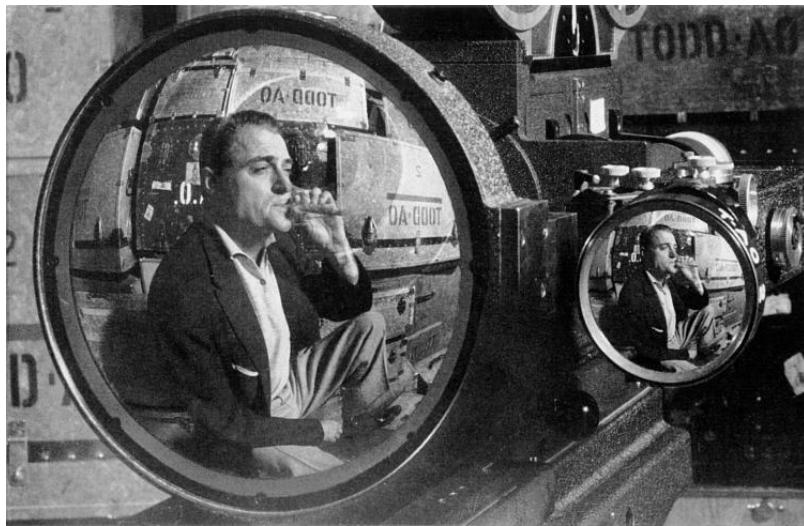
70 mm film (or 65 mm film) is a wide high-resolution film, with higher resolution than the standard 35 mm motion picture film format. As used in cameras, the film is 65 mm (2.6 in) wide. For projection, the original 65 mm film is printed on 70 mm (2.8 in) film. The additional 5 mm are for 4 magnetic strips holding six tracks of sound. Each frame is five perforations tall, with an aspect ratio of 2.20:1. The vast majority of cinemas are unable to handle 70 mm film, and so original 70 mm films are shown using either 35 mm prints in the regular CinemaScope/Panavision aspect ratio of 2.35:1.



# A SHORT HISTORY OF CINEMA SOUND



**1955: 70mm-6 tracks**





# A SHORT HISTORY OF CINEMA SOUND

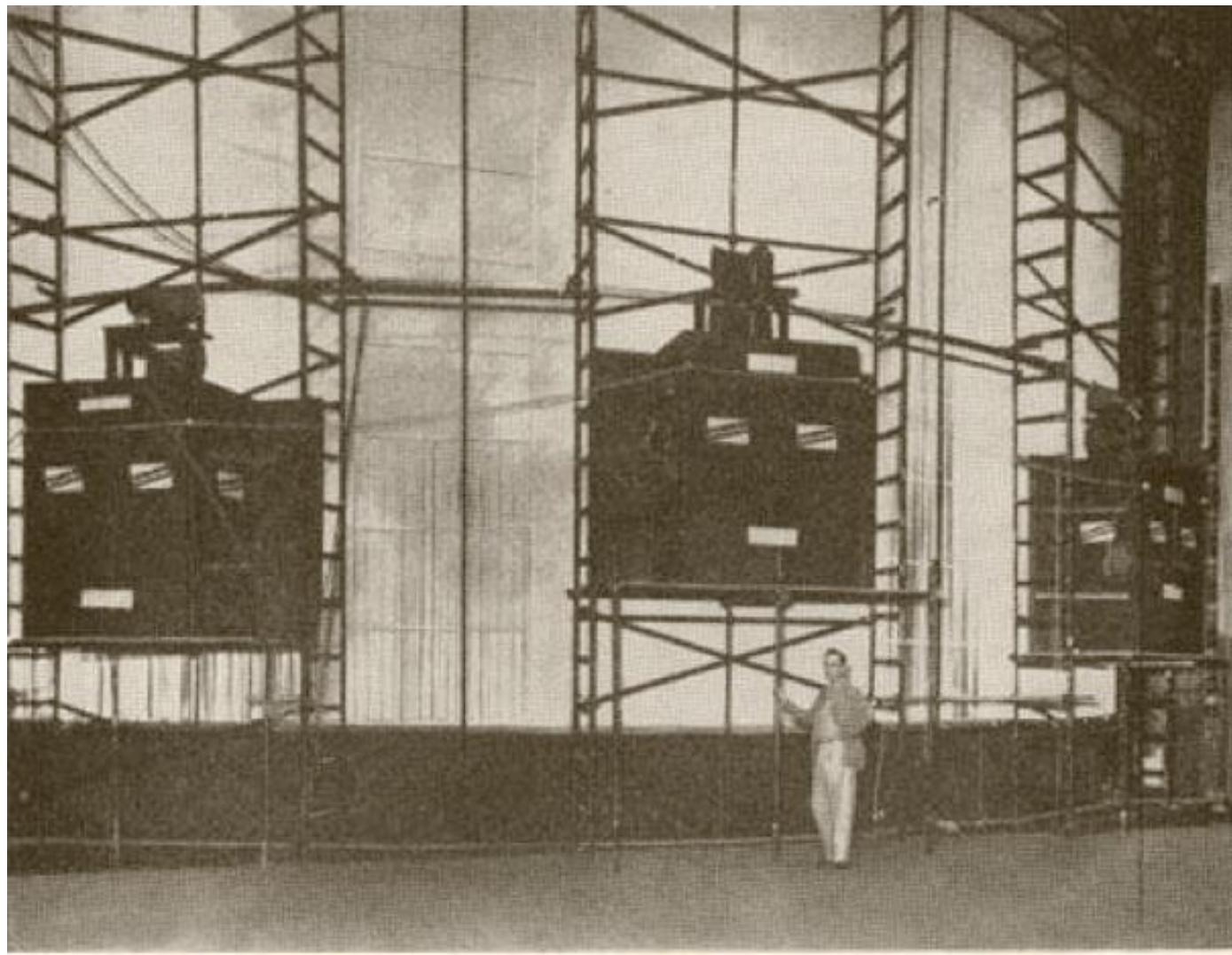


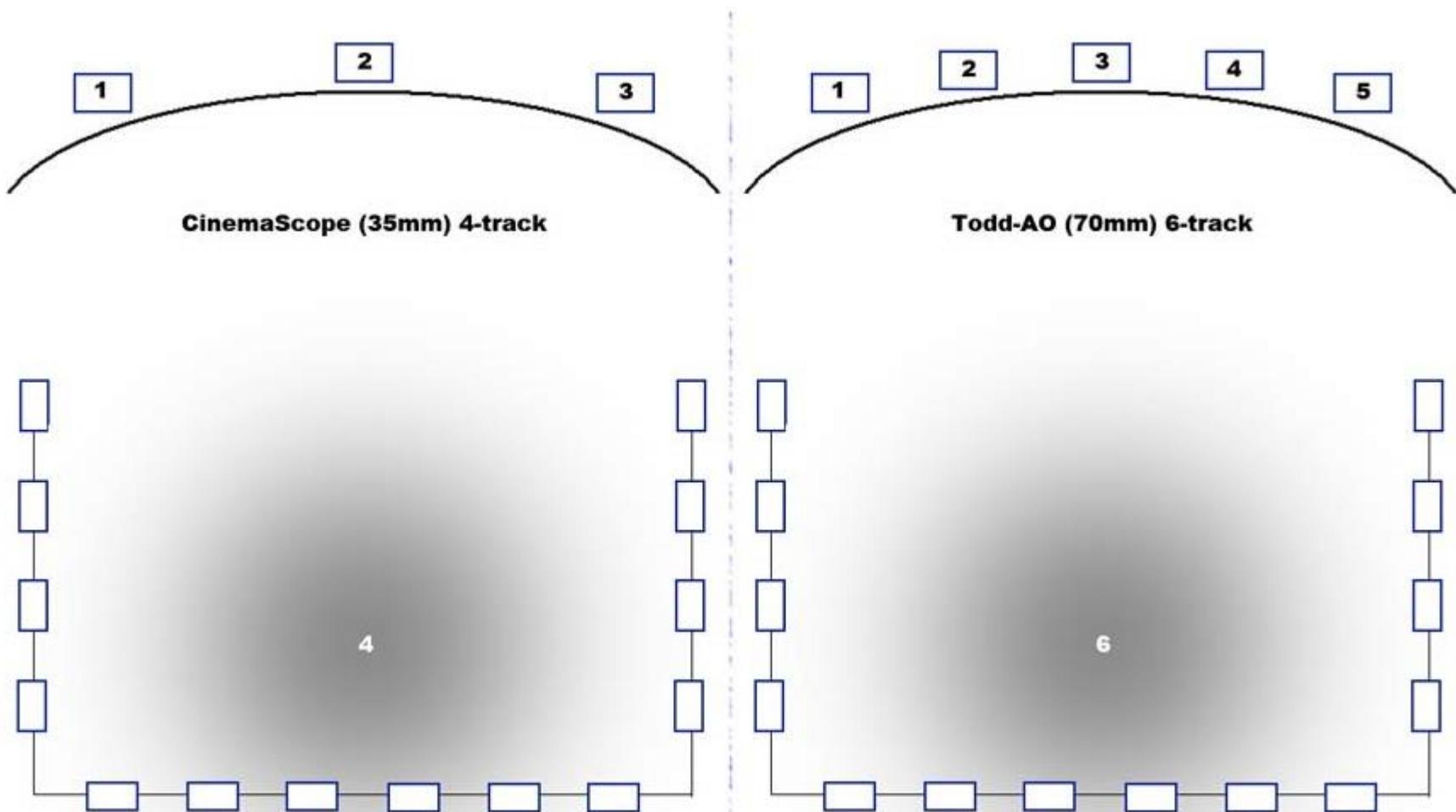
Fig. 10. Arrangement of loudspeakers behind screen.



# A SHORT HISTORY OF CINEMA SOUND



**1955: 70mm-6 tracks**





# A SHORT HISTORY OF CINEMA SOUND



## 1974: *Sensurround*

Sensurround is the brand name for a process developed by Cerwin-Vega in conjunction with Universal Studios to enhance the audio experience during film screenings, specifically for the 1974 film *Earthquake*. Sensurround worked by adding extended-range bass for sound effects.

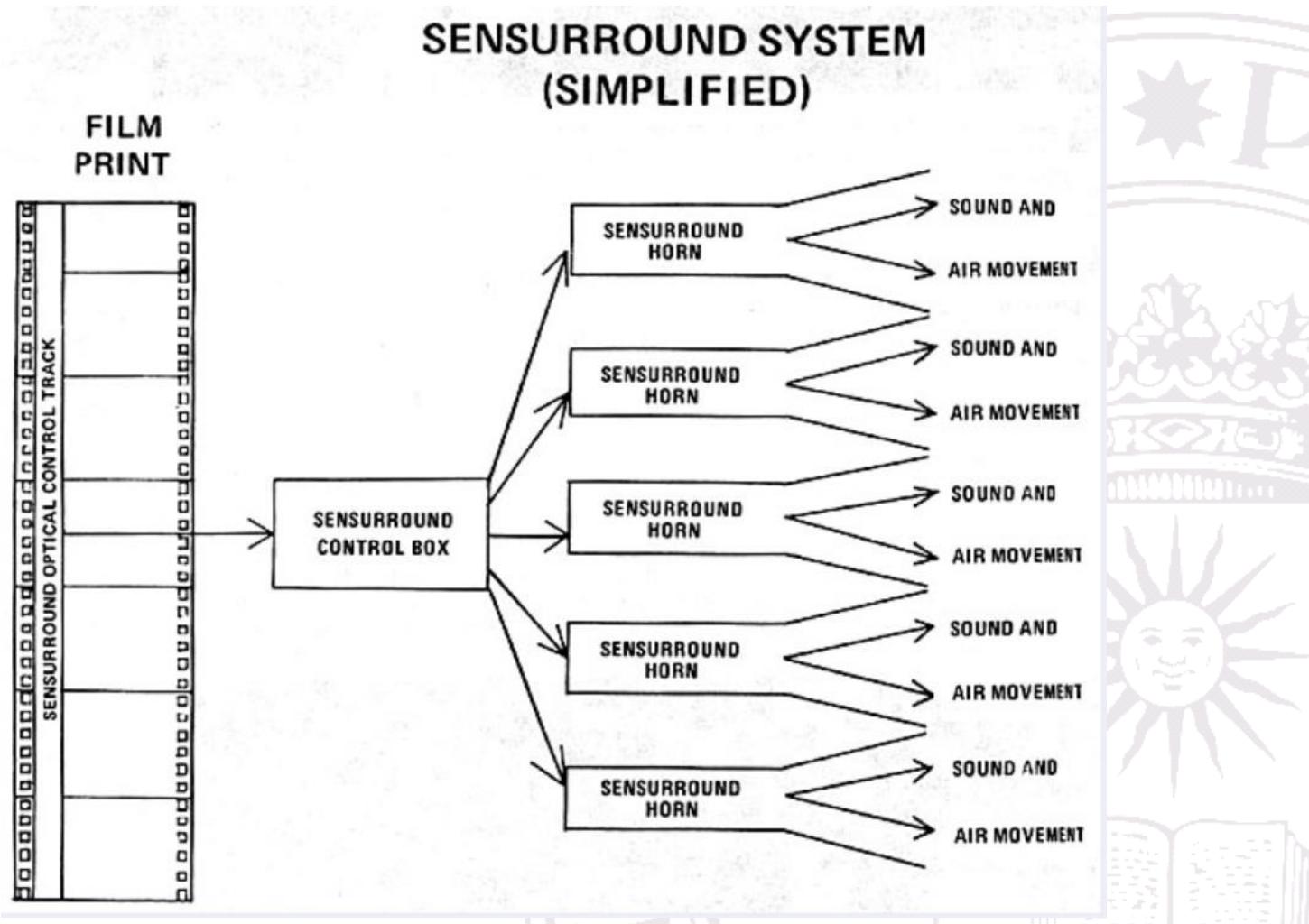
Sensurround involved the installation of large, low frequency, horn-loaded speakers which contained specially designed 18-inch Cerwin-Vega Model 189 E drivers in custom black wood cabinets. Three horn configurations were available, Model-C (Corner), Model-W (Folded Bass Bin) and Model-M (Modular).



# A SHORT HISTORY OF CINEMA SOUND



## 1974: Sensurround

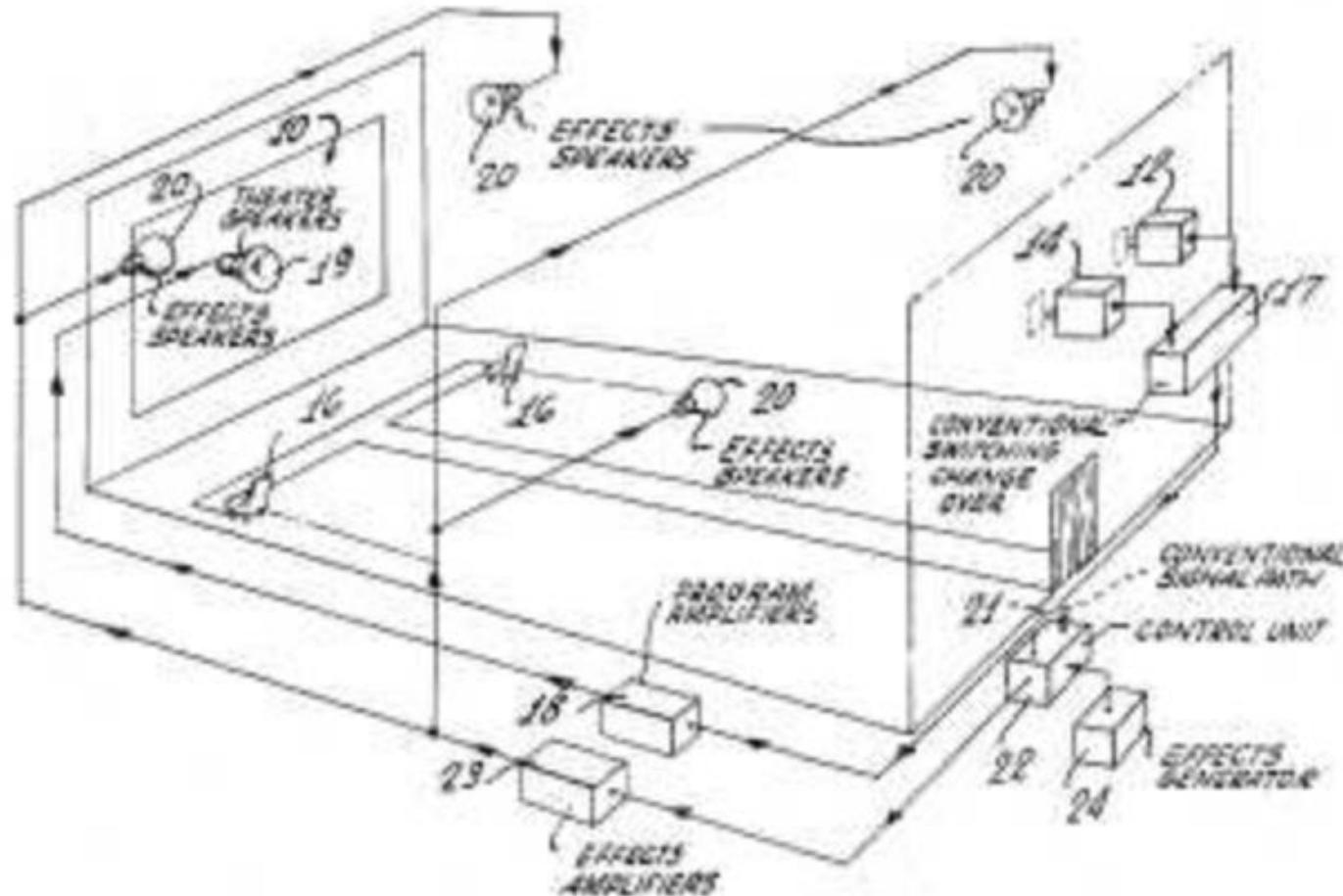




# A SHORT HISTORY OF CINEMA SOUND



## 1974: Sensurround





# A SHORT HISTORY OF CINEMA SOUND



## The Stereo Era

When audience in 1977 “heard” the massive spaceships passing over their head in *Star Wars* (recorded in Dolby Stereo), the experience forever changed their expectations for cinema sound.



# A SHORT HISTORY OF CINEMA SOUND



## The Stereo Era





# A SHORT HISTORY OF CINEMA SOUND



## 1975: *Dolby Stereo*®

One significant problem with adding stereo sound to film with an optical soundtrack was fitting the tracks on the limited real estate of the film stock itself. Dolby Stereo solved the problem by encoding four channels of sound (left, right, center and surround) down to two channels to record on the film, and then decoding them back to four channels when replayed in the cinema.

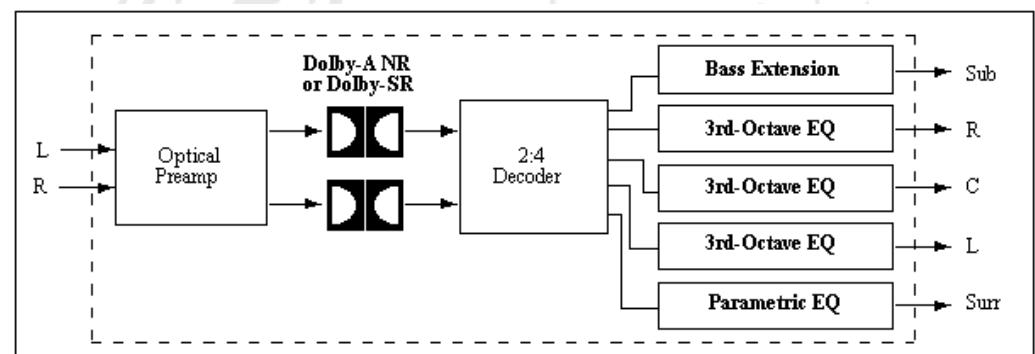
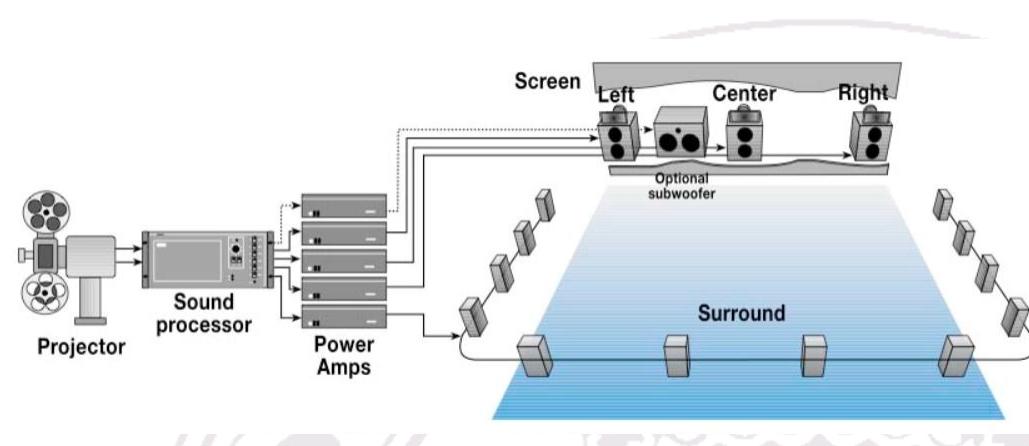
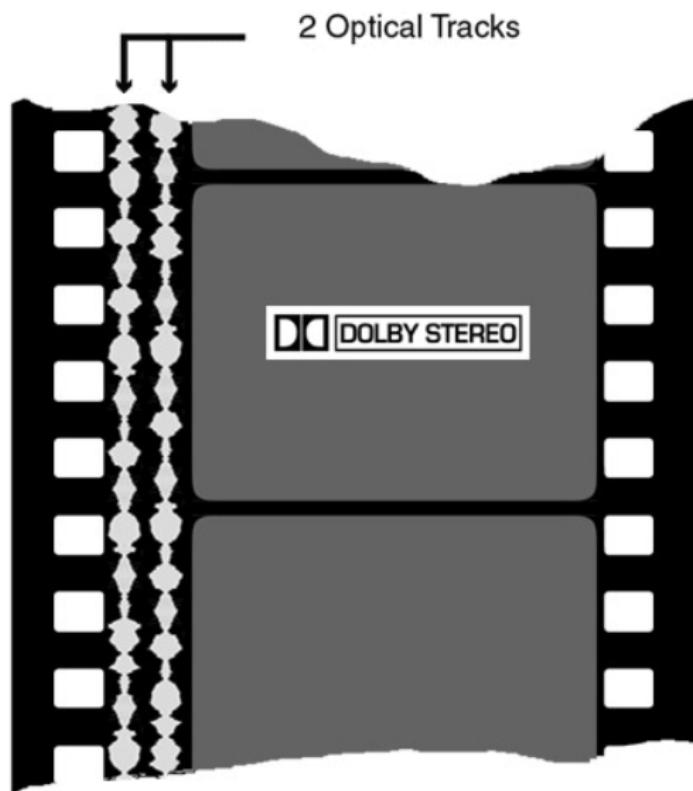
This yielded a total of four sound channels, as in the 4-track magnetic system, in the track space formerly allocated for one mono optical channel. Dolby also incorporated its A-Type noise reduction into the Dolby Stereo system.



# A SHORT HISTORY OF CINEMA SOUND



**1975: Dolby Stereo®**





# A SHORT HISTORY OF CINEMA SOUND



## The Multichannel Era

The advent of six channels of audio, known as 5.1 sound, allowed for true surround sound. Over the years, new technologies added additional channels, culminating in the Barco Auro format, which uses 11.1 channel arrangement.



# A SHORT HISTORY OF CINEMA SOUND



## The Multichannel Era





# A SHORT HISTORY OF CINEMA SOUND



## 1978: Dolby Stereo 70mm

Applying Dolby noise reduction techniques to the magnetic soundtrack on 70mm film allowed for the first full 5.1 surround sound (left, right, center left surround, right surround and subwoofer channels). The technology debuted in *Superman* and used next year in *Apocalypse Now*.

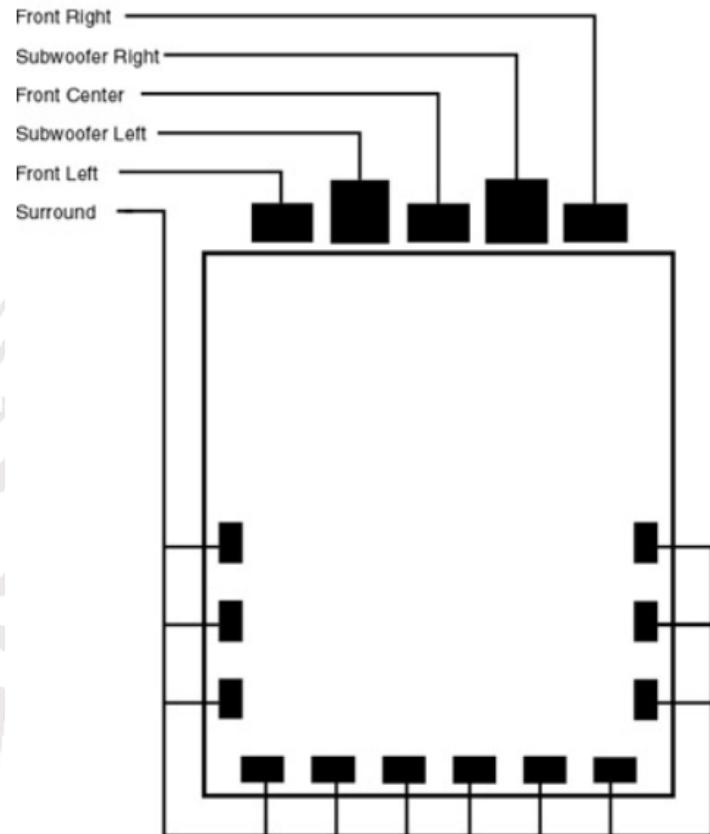
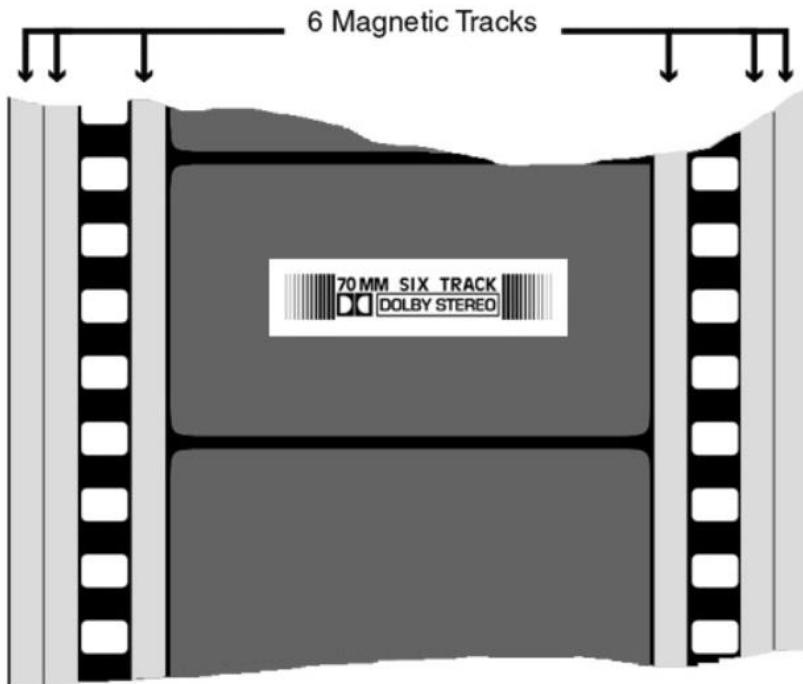
The original layout was for 5 front channels and one surround. But by the 1970s the use of the intermediate (left-center and right-center) tracks had been largely abandoned. Dolby instead used these channels for LFE (low-frequency enhancement) utilizing the bass units of the otherwise redundant intermediate front speakers. Later the unused HF capacity of these channels was used to provide for stereo surround in place of the mono giving the modern 5.1 channel allocation retained today by Dolby Digital.



# A SHORT HISTORY OF CINEMA SOUND



1978: Dolby Stereo 70mm

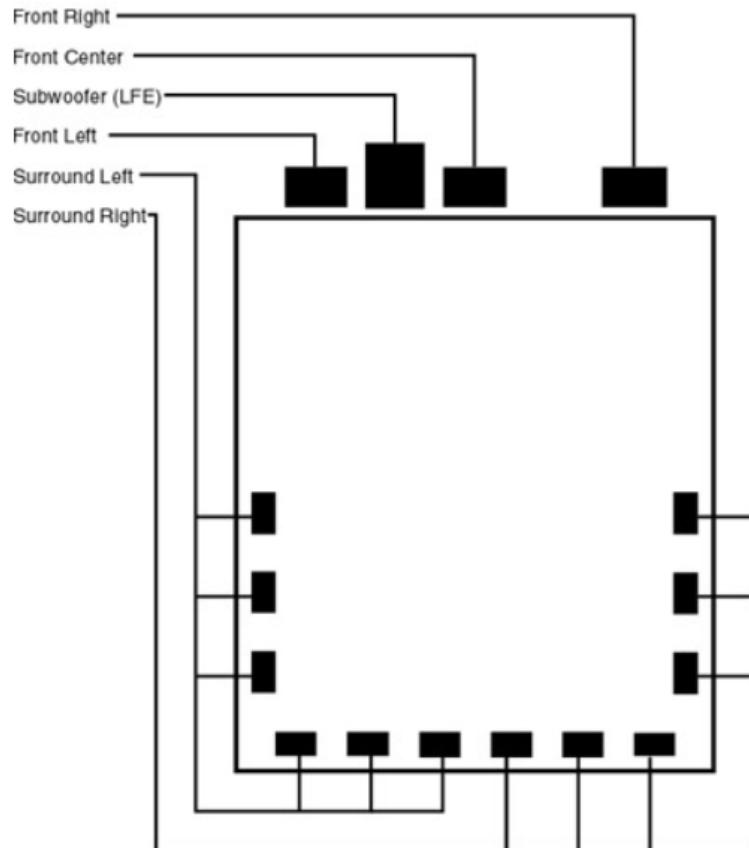
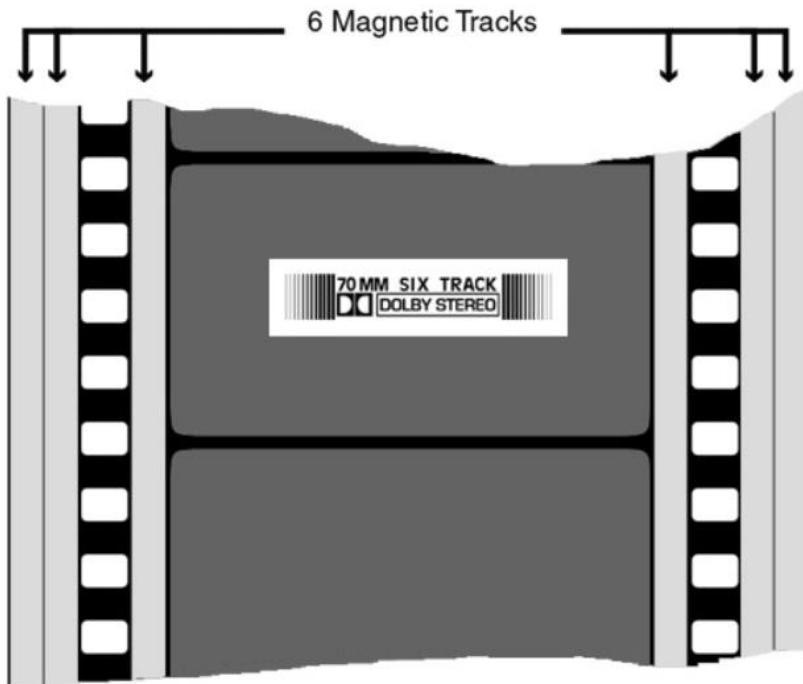




# A SHORT HISTORY OF CINEMA SOUND



1978: Dolby Stereo 70mm





# A SHORT HISTORY OF CINEMA SOUND



## 1983: THX®

The THX system is not a recording technology, and it does not specify a sound recording format: THX is mainly a quality assurance system. THX-certified theaters provide a high-quality, predictable playback environment to ensure that any film soundtrack mixed in THX will sound as near as possible to the intentions of the mixing engineer. THX also provides certified theaters with a special crossover circuit whose use is part of the standard.



# A SHORT HISTORY OF CINEMA SOUND



## 1983: THX®

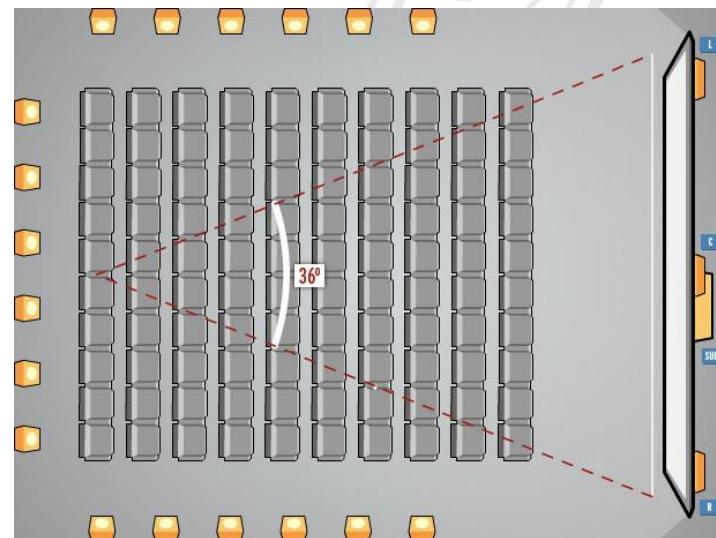
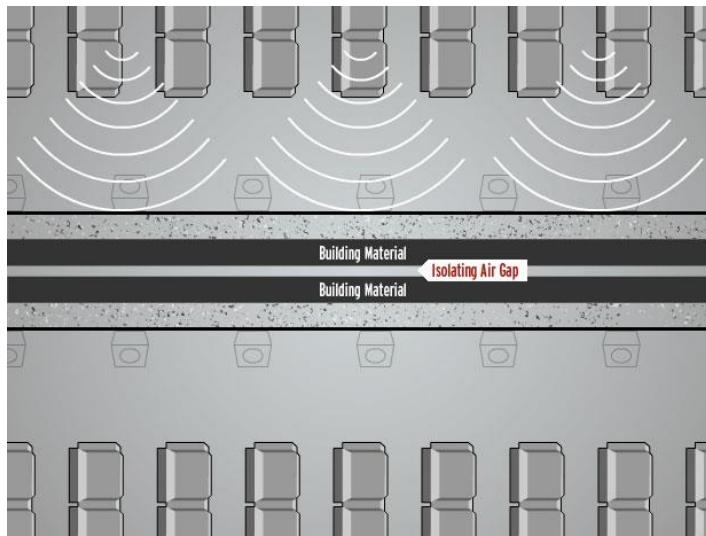
Certification of an auditorium entails specific acoustic and other technical requirements; architectural requirements include a floating floor, baffled and acoustically treated walls, non-parallel walls (to reduce standing waves), a perforated screen (to allow center channel continuity), and NC30 rating for background noise ("ensures noise from air conditioning units and projection equipment does not mask the subtle effects in a movie's soundtrack").



# A SHORT HISTORY OF CINEMA SOUND



## 1983: THX®





# A SHORT HISTORY OF CINEMA SOUND



**1983: THX®**





# A SHORT HISTORY OF CINEMA SOUND

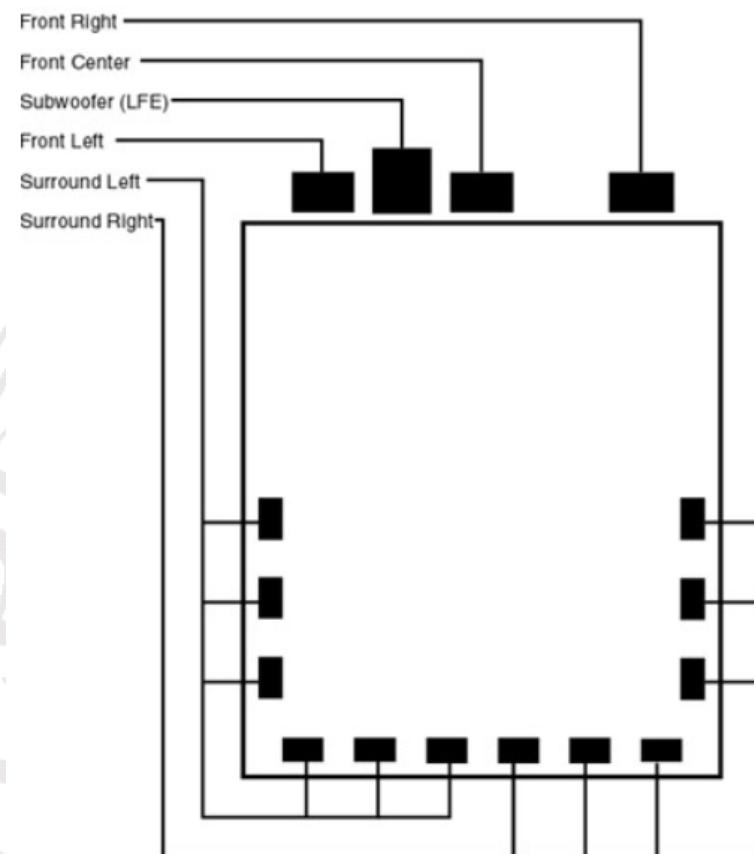
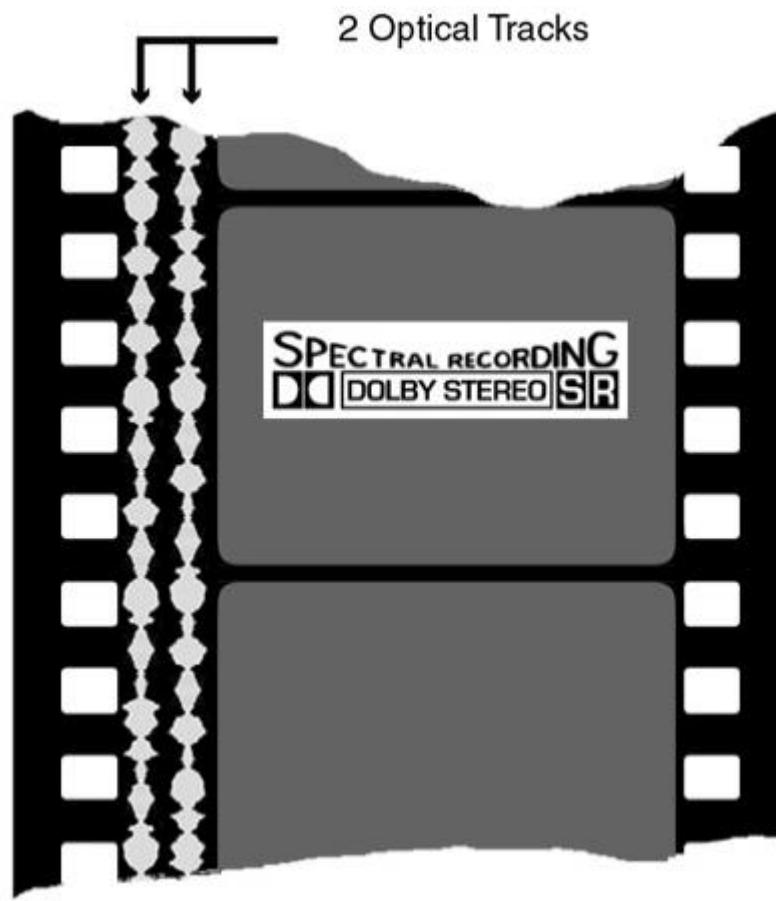
## 1986: Dolby Stereo SR

Dolby presented in 1986 a new recording system: Dolby SR (Spectral Recording). Dolby SR had twice as much noise reduction as Dolby A did and provided a wider dynamic range, higher frequency response and lower distortion. The 35mm optical preview Dolby Stereo SR print soundtracks treated with Spectral Recording provided not only better sound in theaters equipped with new SR-processors but in all cinemas. Dolby Stereo SR used the same setup as regular Dolby Stereo, so it was completely compatible with existing Dolby equipment.



# A SHORT HISTORY OF CINEMA SOUND

## 1986: Dolby Stereo SR





# A SHORT HISTORY OF CINEMA SOUND

## ***1990: Cinema Digital Sound (CDS)***

In the late 1980's Eastman Kodak Corporation joined forces with Optical Radiation Corporation to develop what would become the first commercially available digital sound format.

It was a sound-on-film system for 35mm and 70mm film formats with the digital information placed between the sprockets and the film frame, thus replacing the analog optical tracks on 35mm and the magnetic stripes on 70mm releases. CDS featured 6 discrete audio channels: 5 of them with full bandwidth (Left, Center, Right, Left and Right Surround) and one low frequency only channel (LFE).



# A SHORT HISTORY OF CINEMA SOUND



## 1990: Cinema Digital Sound (CDS)





# A SHORT HISTORY OF CINEMA SOUND



## ***1991: Dolby Digital***

Dolby Digital not only provided a 5.1 digital soundtrack, but through an ingenious use of type limited space on the film track- provided an analog backup. Dolby placed the digital sound track in between the film's sprocket holes, leaving in place an analog optical soundtrack that would play if the digital track was damaged or if the theatre was not equipped yet for digital sound.

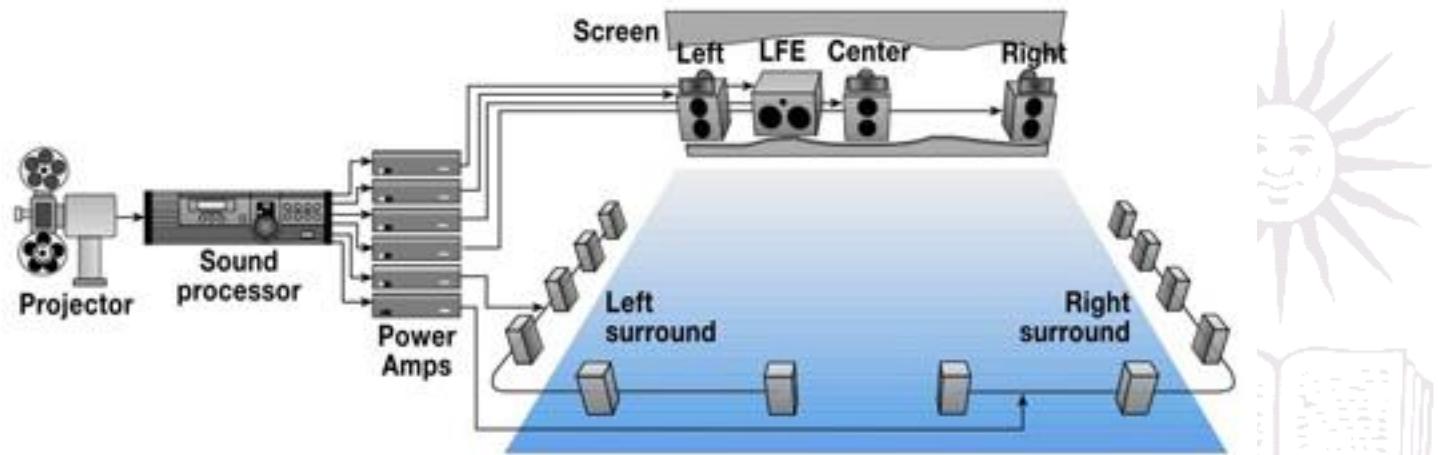
Dolby Digital is the common version containing up to six discrete channels of sound. The most elaborate mode in common use involves five channels for full-range speakers (20 Hz-20,000 Hz) (right, center, left, right surround, left surround) and one channel (20 Hz-120 Hz) for the subwoofer driven low-frequency effects. Mono and stereo modes are also supported. AC-3 supports audio sample-rates up to 48 kHz.



# A SHORT HISTORY OF CINEMA SOUND



**1991: Dolby Digital**





# A SHORT HISTORY OF CINEMA SOUND

## ***1993: Digital Theatre System® (DTS)***

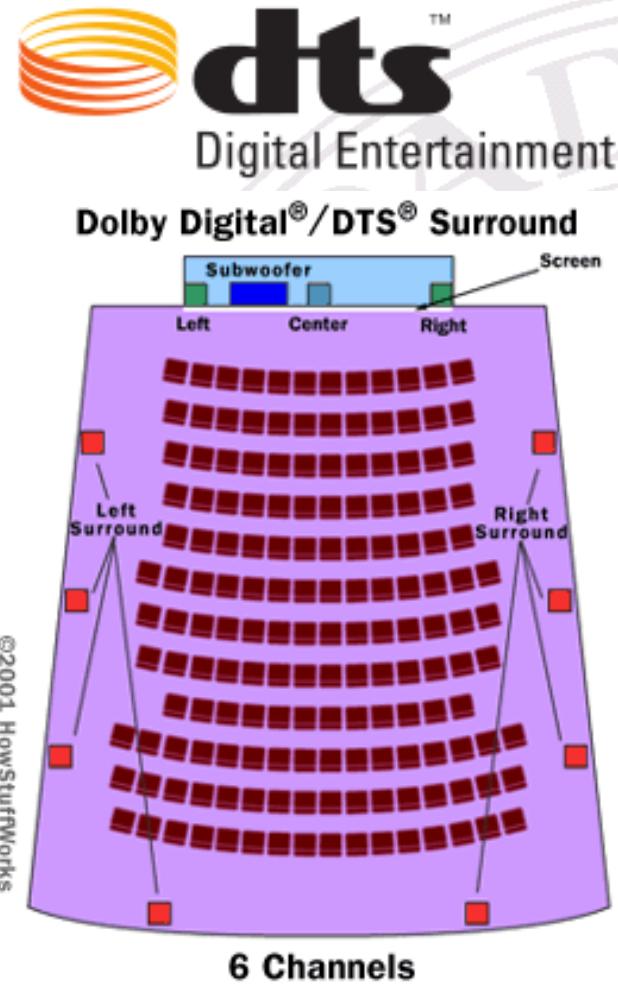
The surround sound system from DTS harked back to the sound-on-disc formats of the early days of talkies. The DTS digital sound for motion pictures is designed for the digital sound released in 6 track theatres. It is a dual system in that the audio data is recorded on a CD-ROM disc. CD-ROM disc are produced by DTS that hold the feature's 6-track sound mix. A special DTS timecode is printed on the motion picture print along conventional stereo optical soundtrack. The timecode is used by the DTS system to synchronize the sound and picture. The timecode lies between the picture and the optical track and is printed onto the release print from the soundtrack negative.



# A SHORT HISTORY OF CINEMA SOUND



**1993: Digital Theatre System® (DTS)**





# A SHORT HISTORY OF CINEMA SOUND



## ***1993: Sony Dynamic Digital System™ (SDDS)***

The latest entry in cinema digital sound, Sony Dynamic Digital Sound® (SDDS), boasts five separate channels at the front of the theater as well as left and right surround channels, for a total of eight available channels including the subwoofer.

Like Dolby Digital, SDDS encodes digital information with a distinct pattern of light and dark areas on film. In this case, the reader includes a laser on one side of the film and an array of photocells on the other side. Unlike the other digital formats, SDDS uses two identical digital tracks to allow for better error correction.

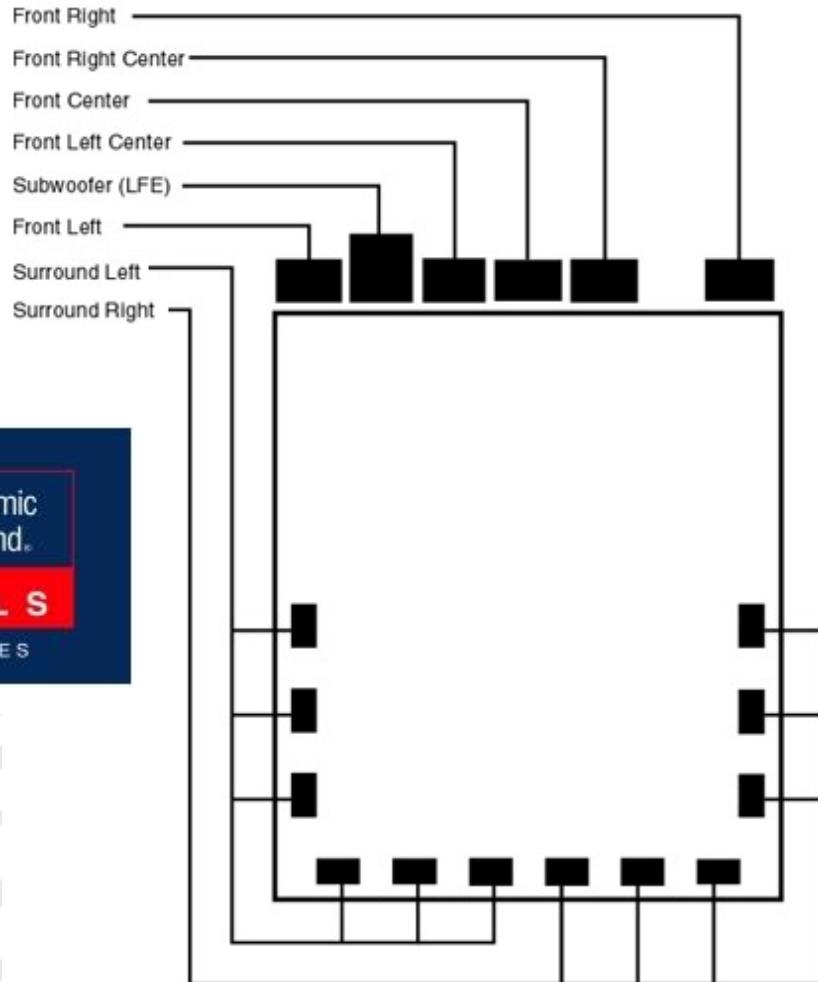
The system is able to reproduce sound-mixes with 7.1, 5.1 or 4.0 discrete channels.



# A SHORT HISTORY OF CINEMA SOUND



## 1993: Sony Dynamic Digital System™ (SDDS)





# A SHORT HISTORY OF CINEMA SOUND



**1993: Sony Dynamic Digital System™ (SDDS)**





# A SHORT HISTORY OF CINEMA SOUND



## 1999: *Dolby Digital Surround EX™*

Dolby Digital Surround EX allowed moviemakers to add a new rear channel to the 5.1 arrangement of standard Dolby Digital audio. First used in *Star Wars: Episode 1 - The Phantom Menace*, the back channel lets filmmakers bring to life sounds behind the audience.

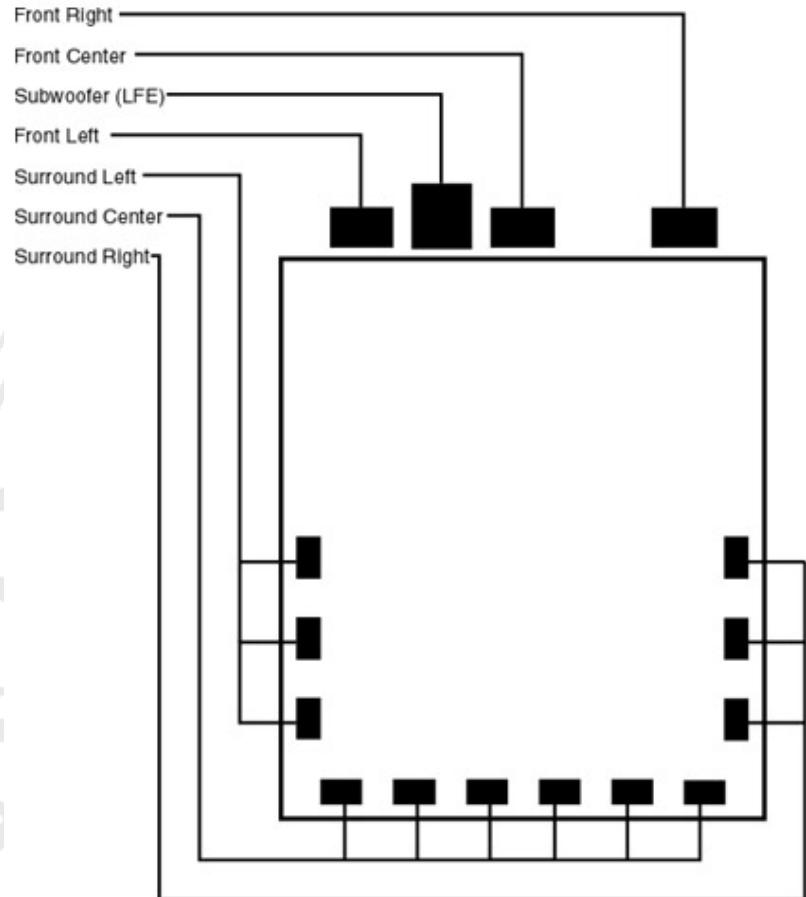
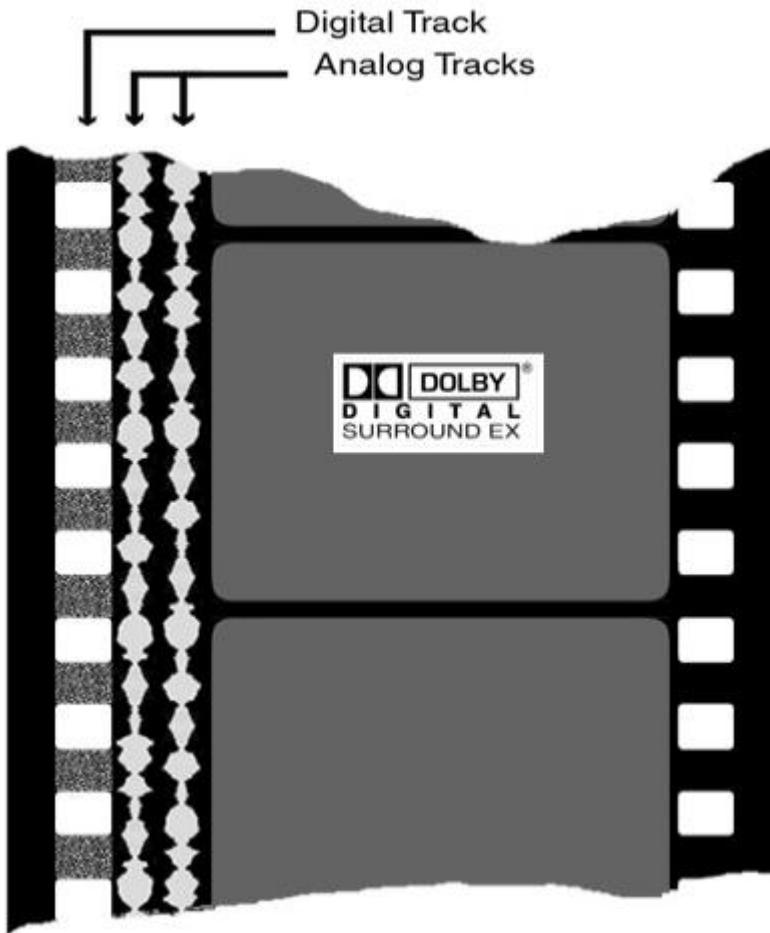
Dolby Digital Surround EX's center surround-channel was encoded in the existing 2 surround channels by applying the same techniques as on with Dolby Stereo. By adding an adapter (and some additional wiring) any Dolby Digital-theatre could be easily upgraded.



# A SHORT HISTORY OF CINEMA SOUND



## 1999: Dolby Digital Surround EX™





# A SHORT HISTORY OF CINEMA SOUND

## **2010: Dolby Surround 7.1**

The transition to digital cinema-projecting films through digital technology rather than using 35mm film-added almost limitless capacity for storing audio information.

Dolby used the bandwidth to add two separate surround channels in the back of the theatre, making four surround zones in all. Dolby Surround 7.1 creates a much more enveloping sound experience than previous surround technologies.



# A SHORT HISTORY OF CINEMA SOUND

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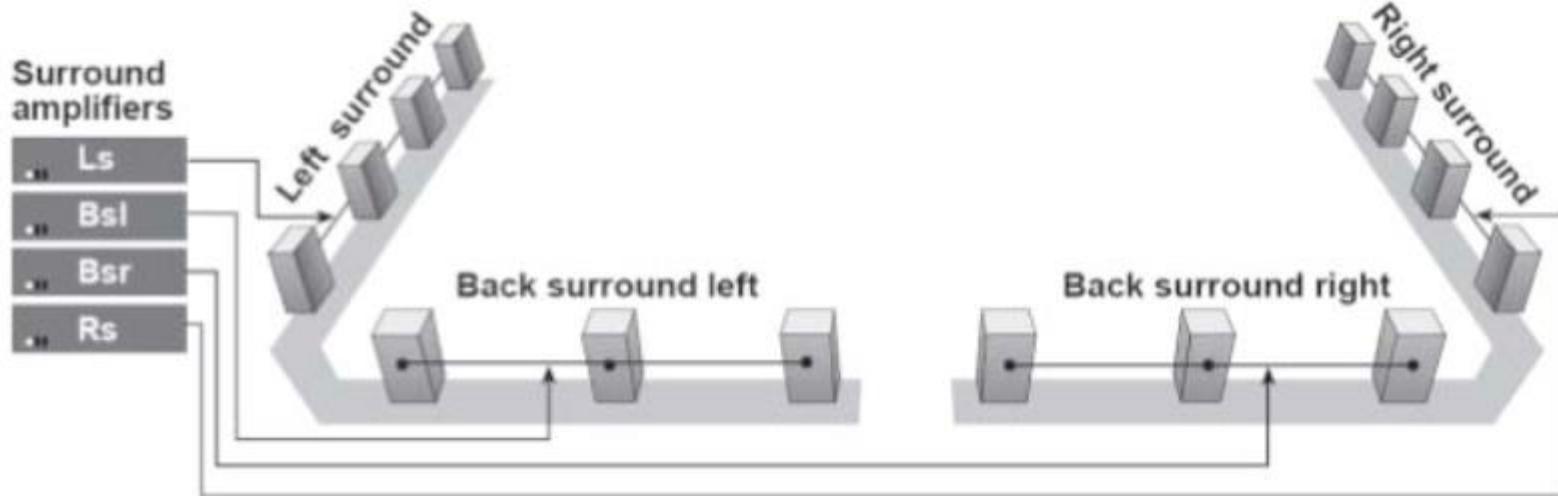


# A SHORT HISTORY OF CINEMA SOUND



**2010: Dolby Surround 7.1**

**DOLBY®  
SURROUND 7.1**





# A SHORT HISTORY OF CINEMA SOUND

## **2012: Barco Auro 11.1**

Developed by Galaxy Studios and exclusively licensed by Barco-a company best known its projection system-the Auro 11.1 system expands channel-based surround sound. It debuted in January 2012 with *Red Tails*. Eighteen films had been mixed with Auro 11.1 through October 2013.

The audio format creates immersive 3D sound by using a three dimensional (x,y,z) 11.1 channel /speaker layout. The Auro 11.1 system is designed along three layers of sound (ear-level, height and overhead). Based on the existing 5.1 surround sound configuration, the technology adds a height and top layer for an immersive sound experience. With this audio format, natural sound comes from all around and above the listener.



# A SHORT HISTORY OF CINEMA SOUND

2012: Barco Auro 11.1



**Auro 3D: 11.1 channels**

Main Layer	Upper Layer
Left	Left
Center	Center
Right	Right
Surround Left	Surround Left
Surround Right	Surround Right
LFE	Voice of God (VOG)



# A SHORT HISTORY OF CINEMA SOUND



## The Object-Based Audio Era

The newest cinema technology allows creators to precisely place or move individual sounds anywhere within the theatre, including overhead, creating a virtual reality of sound that makes moviegoers feel as if they are in the middle of the movie action. Audience members hear an arrow as it flies from the screen past their left shoulder or a helicopter flying from side-to-side above them.



# A SHORT HISTORY OF CINEMA SOUND



## The Object-Based Audio Era

**iosono** )))

the future of spatial audio

**iSens**<sup>®</sup>

**imsound**

**DOLBY.ATMOS**



# A SHORT HISTORY OF CINEMA SOUND

## ***2010: imm Sound / iSens***

imm sound's technology breaks complexity at its root (adding more and more audio channels 7.1, 9.1, 10.1, 11.1, 13.1 layouts), by eliminating the concept of audio channel. The technology allows film production, post-production and delivery to be 100% independent of the loudspeaker layouts where content is to be exhibited. imm sound's 3D soundtracks are always reproduced fully adapted to every cinema's specific layout, thus tackling all present and future configurations at once.

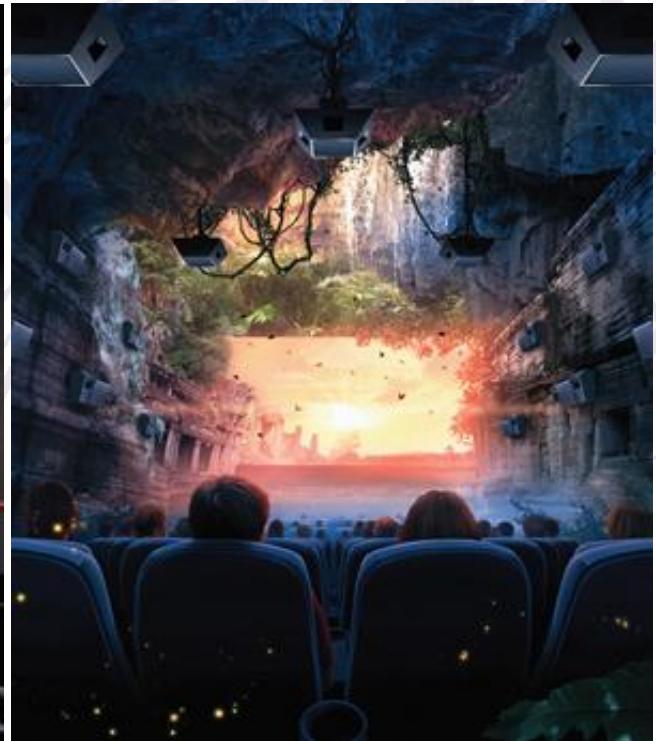
imm sound certified cinemas enjoy imm 3D soundtracks reproduction in a variety of layouts which are tailored based on the exhibitor specific needs; examples include the minimum recommended 14.1 or the typical 23.1 premium layout.



# A SHORT HISTORY OF CINEMA SOUND



**2010: imm Sound / iSens**





# A SHORT HISTORY OF CINEMA SOUND



## 2010: IOSONO 3D

IOSONO 3D that was developed by Fraunhofer. Audio objects and rendering through multiple speakers to cover the spherical space is approached to realize the sound localization based on a totally new theory: Wave Field Synthesis that captures the sound source through an array of multiple microphones and reproduces it with the same kind of speaker array around the space.

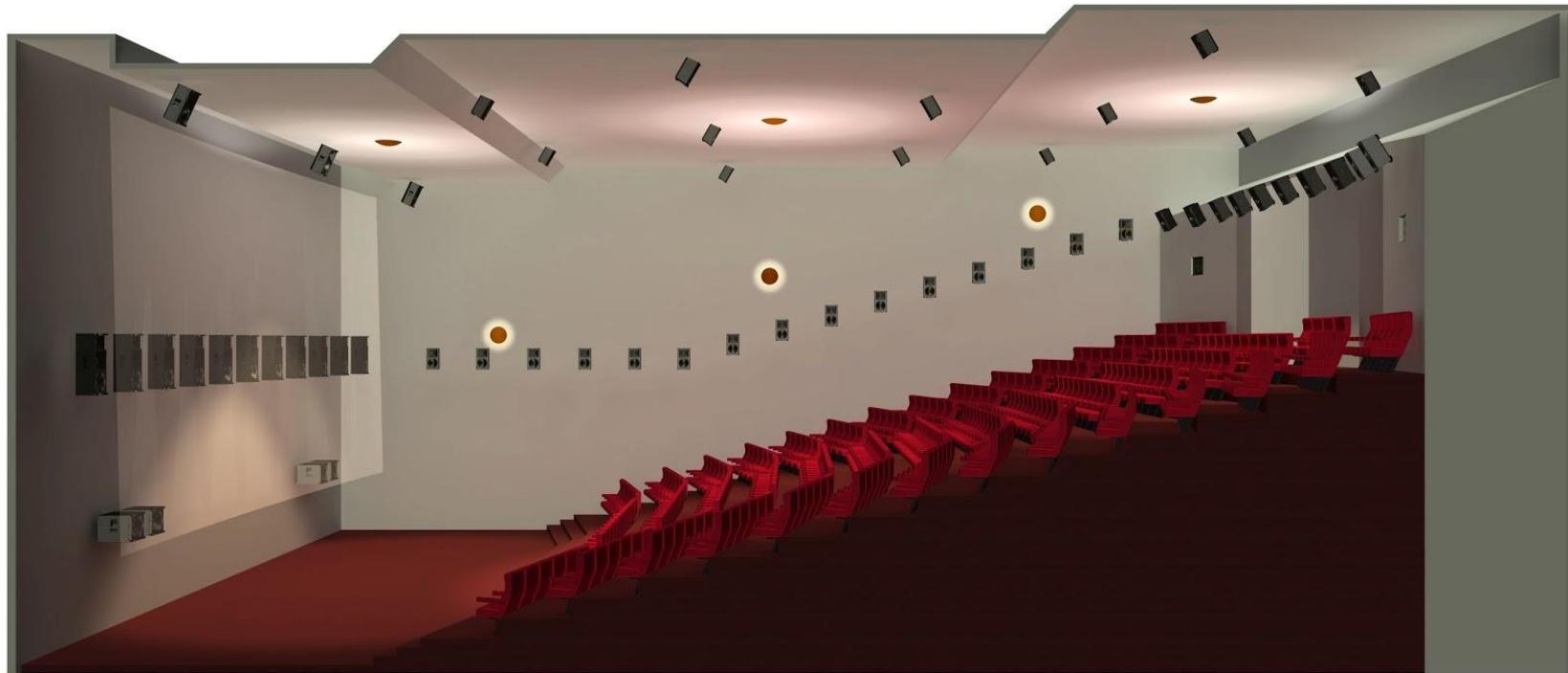
According to IOSONO, a typical 1:2 box auditorium would need 9 speakers in front behind the screen and also 9 in the back to yield total 54 speakers to form a single-layer horizontal ring. In addition, recent installations have 15 to 18 ceiling speaker channels by using triangulated array for the ceiling zone.



# A SHORT HISTORY OF CINEMA SOUND



**2010: IOSONO 3D**





# A SHORT HISTORY OF CINEMA SOUND

## ***2012: Dolby Atmos***

By allowing filmmakers to specify exactly where in the theatre an individual sound should be heard, Dolby Atmos films create a 3D sound experience so realistic. Dolby Atmos features the pinpoint accuracy of object-based audio, while still allowing filmmakers to use the more traditional multichannel approach when that better suits their needs.

The first generation cinema hardware, the "Dolby Atmos Cinema Processor" supports up to 128 discrete audio tracks and up to 64 unique speaker feeds, the technology will initially be geared towards commercial cinema applications only, but may later be adapted to home cinema. In addition to playing back a standard 5.1 or 7.1 mix using arrays, the system will give each loudspeaker its own unique feed, thereby enabling many new front, surround, and even ceiling-mounted height channels for the precise panning of select sounds.



# A SHORT HISTORY OF CINEMA SOUND



**2012: Dolby Atmos**

