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Academy awards jennifer lawrence

2018 film by Francis Lawrence This article is about the film. For the novel on which the film is based, see Red Sparrow (novel). For other uses, see Red sparrow. Red SparrowTheatrical release posterDirected byFrancis LawrenceScreenplay byJustin HaytheBased onRed Sparrowby Jason MatthewsProduced by Peter Chernin David Ready Jenno Topping Steven Zaillian Starring Jennifer Lawrence Joel Edgerton Matthias Schoenaerts Jeremy Irons CinematographyJo WillemsEdited byAlan Edward BellMusic byJames Newton HowardProductioncompanies TSG Entertainment Chernin Entertainment Distributed by20th Century FoxRelease dates February 15, 2018 (2018-02-15) (Newseum) March 2, 2018 (2018-03-02) (United States[1]) Running time140 minutes[2]CountryUnited StatesLanguagesEnglish RussianBudget$69 million[3]Box office$151.6 million[3] Red Sparrow is a 2018 American spy thriller film directed by Francis Lawrence and written by Justin Haythe, based on the 2013 novel of the same name by Jason Matthews. The film stars Jennifer Lawrence, Joel Edgerton, Matthias Schoenaerts, Charlotte Rampling, Mary-Louise Parker, Jeremy Irons, and Ciarán Hinds. It tells the story of a former-ballerina-turned-Russian intelligence officer, who is sent to make contact with a CIA officer in the hope of discovering the identity of a mole. Matthews, a former member of the CIA, advised the production on the depiction of spying. Based on historic Soviet sexpionage and contemporary Russian use of kompromat, filming took place in Hungary, Slovakia and Austria. Red Sparrow premiered at the Newseum in Washington, D.C., on February 15, 2018, and was released in the United States on March 2, 2018. The film grossed $151 million worldwide, becoming a modest box-office success, and received mixed reviews from critics, who described it as having "more style than substance" and criticized the film's long runtime and over-reliance on graphic violence and sex, although Lawrence's performance was praised.[4][5] In modern-day Russia, famous ballerina Dominika Egorova who supports her infirmed mother. Her career abruptly ends after her dance partner injures her during a performance. After the Bolshoi cut her, Dominika's Uncle Ivan, the deputy director of the SVR reveals that her ex-partner, Konstantin, and a rival dancer, Sonya, who were lovers, deliberately injured her. Dominika seeks retribution by ambushing them in the Bolshoi showers and beating them with her cane, injuring both. To avoid prosecution and for financial support, she agrees to help Ivan. She is tasked with seducing Dimitry Ustinov, a Russian gangster, in exchange for her mother's continued medical care. Meeting at a bar, the two go to her private hotel room, where Dimitri attempts to rape her. During this, he is garroted by Sergei Matorin, an SVR operative authorized by Ivan. They flee to a safehouse and Ivan offers Dominika a choice: become an SVR operative, or be executed for witnessing Ustinov's assassination. Nate Nash is a CIA operative working in Moscow. While meeting with a Russian mole code-named Marble in Gorky Park, they are confronted by the police. Nash creates a diversion to ensure his contact escapes unidentified while reaching the U.S. Embassy. Nash is reassigned to the U.S. but insists he is the only person Marble will work with. Since he cannot return to Russia, he is assigned to Budapest to reestablish contact with Marble, which the SVR also deduce. Dominika is sent to State School 4, a brutal specialist training school for "Sparrows"—operatives capable of seducing their targets with sexpionage where she's given the alias, Katya, and revealing her true identity and profession is forbidden. She excels in her training, despite some friction with her trainer, 'the Matron'. Against Matron's recommendation, Ivan and General Vladimir Korchnoi, a high-ranking official, decide that Dominika is ready for an assignment in Budapest—to gain Nash's trust and expose Marble's identity. In Budapest, Dominika lives with fellow "sparrow" Marta, and is supervised by station chief Maxim Volontov. She makes contact with Nash, who quickly determines she is a Russian intelligence operative and attempts to convince her to defect. Dominika inspects Marta's room and finds she has been assigned to buy classified intelligence from Stephanie Boucher, chief of staff to a U.S. Senator. When Ivan pressures her about her slow progress with Nash, Dominika claims to be helping Marta with Boucher as well. Marta is brutally killed by Sergei Matorin after Dominika told her about the earlier incident with Ustinov. Dominika is then warned by Sergei that the same fate would befall her should she open her mouth about that again. She contacts Nash, agrees to become a double agent in exchange for protection for her and her mother, and has sex with him. Under Russian orders, Dominika travels to London with Volontov to meet Boucher and complete the trade, but covertly switches out the intelligence she supplies with CIA-supplied disinformation. After the meeting, Boucher realizes that she is being observed by American intelligence agents, panics, then backs into traffic and is killed. Russian agents observing her realize their mission has been compromised. Suspected of tipping off the Americans, Dominika and Volontov are recalled to Moscow where they are tortured and interrogated for days. Volontov is executed, but Dominika's claims of innocence are eventually believed by Ivan. She is allowed to return to Budapest to continue her mission of extracting Marble's identity from Nash. Instead, she convinces Nash to relocate her and her mother to America. After spending the night with Nash, Dominika awakes to find him being tortured by Matorin for Marble's identity. She initially assists until Matorin lowers his guard and she kills him, but is badly injured while doing so. She awakes in a hospital where Korchnoi reveals himself as Marble. He explains that he was patriotic, but became disillusioned when a bureaucrat he had once offended refused to allow an American doctor to operate on his sick wife. Korchnoi fears he will be caught soon so, instead of dying in vain, instructs Dominika to expose his identity to Ivan. Doing so would make her a national hero, and allow her to replace him as a mole passing intelligence to the CIA. When Dominika contacts her superiors, she frames Ivan as the mole, using evidence she had been fabricating since she first arrived in Hungary, and blaming him for the botched exchange in London. Ivan is killed by a sniper during a prisoner exchange while Nate goes along with her plan to confirm the mole's identity, and Dominika is honored in a military ceremony after she returns to Russia. Back in Russia, Dominika lives with her mother. She receives a phone call from an unknown person who plays Grieg's piano concerto, which she had told Nash was the piece for her first solo performance. The film ends with her watching a ballet performance at the Bolshoi from the balcony and leaving mid-performance. Jennifer Lawrence as Dominika Egorova, a former prima ballerina who is now a "Sparrow"[6] Joel Edgerton as Nate Nash, a CIA operative[6] Matthias Schoenaerts as Ivan Vladimirovich Egorov,[7][6] Dominika's uncle and Deputy Director of the SVR Charlotte Rampling as Matron, the Headmistress of Sparrow School[8] Mary-Louise Parker as Stephanie Boucher, a US Senator's Chief of Staff Ciarán Hinds as Colonel Zakharov, Director of the SVR Joely Richardson as Nina Egorova, Dominika's ailing mother Bill Camp as Marty Gable, Nash's supervisor Jeremy Irons as General Vladimir Andreievich Korchnoi, a high-ranking SVR officer who was revealed to be the CIA mole codenamed "Marble"[6] Thekla Reuten as Marta Yelenova, a veteran Sparrow Douglas Hodge as Colonel Maxim Volontov, SVR Budapest Section Chief Sakina Jaffrey as Trish Forsyth, CIA Station Commander[9] Sergei Polunin as Konstantin, Dominika's former dance partner Nicole O'Neal as Sonya, a rival ballerina and Konstantin's lover Sasha Frolova as Anya, friend of Dominika[7] and classmate at the Sparrow school Sebastian Hülk as Sergei Matorin, a Russian operative and torture expert Kristof Konrad as Dimitri Ustinov, a Russian gangster[10] who presents himself as a patron of arts Hugh Quarshie as Simon Benford, CIA officer After Jason Matthews' book Red Sparrow was published in 2013, 20th Century Fox purchased the film rights, and signed Francis Lawrence to direct.[11] Matthews said the idea of "sparrows" and a "sparrow school" was based on State School 4 in the Soviet Union, though Russian "sexpionage" is now done by women contracted outside of spy agencies.[12][13] The Russian concept of kompromat was also influential.[12] Francis worked on adapting Matthews' book in 2015, and has said that at the time, he had reservations about the timelines of a Cold War story.[14] Screenwriter Justin Haythe reduced the number of narrators and shifting perspectives in the novel, concentrating on Dominika.[11] Russian President Vladimir Putin, who appears in the novel, was also cut from the adaptation, due to Francis Lawrence's belief that it would be a distraction to have an actor play the highly public figure.[15] Matthews, who said he based his book on his experiences in the CIA,[16] was also hired as technical advisor, to supervise the accuracy of the depiction of espionage.[11] He had the Gorky Park scene rewritten to depict espionage methods more accurately.[13] Francis Lawrence presented the screenplay to Jennifer Lawrence, who accepted the part.[17] She stated she admired the character and his direction, with her sole point of hesitation being the "really sexual" nature of the character.[14] They met to discuss the nude scenes.[16] In 2014, Jennifer Lawrence had private nude photos stolen in the iCloud leaks. However, she drew a distinction between the film and the leak based on her consent to the film, as opposed to the leak.[17] Lawrence explained: "The insecurity and fear of being judged for getting nude, what I went through, should that dictate decisions I make for the rest of my life?"[16][18] Matthews advised Lawrence that double agents from Russia feel "a dread of discovery, a dread of being arrested, a dread of going to prison."[13] Lawrence also studied ballet for four months.[19] Kurt Froman of the New York City Ballet coached her, as she had never studied ballet before, and spent four hours with her each day for five days per week.[20] American Ballet Theatre principal dancer Isabella Boylston acted as Lawrence's dance double.[21] As a former member of the CIA, Matthews coached actor Joel Edgerton. Edgerton said it was difficult to consider having "an interpersonal dating-style relationship ... [and] That fact that you would have to report any of those kinds of interactions with your bosses."[16] Matthias Schoenaerts and Jeremy Irons joined the cast by December 2016.[6] Festetics Mansion in Dég Principal photography started in Budapest and Dunaújváros in Hungary on January 5, 2017.[22][23][24] Other filming locations include Festetics Mansion in Dég, Hungary;[25] Bratislava, Slovakia and Vienna, Austria.[26] In post-production, Francis Lawrence offered Jennifer Lawrence the opportunity to view a cut of the film ahead of the studio and producers, so that she might request the deletion of any nude or sexual scenes. She declined to request any deletions.[17] However, the film was edited for the United Kingdom release to remove a garroting and secure a 15 certificate from the British Board of Film Classification.[27] 2. Adagio Grieg's piano concerto Problems playing this file? See media help. Main article: Red Sparrow (soundtrack) For the soundtrack, the 1868 Piano Concerto by Edvard Grieg was used.[28] James Newton Howard wrote the score, recorded in October 2017, citing Wolfgang Amadeus Mozart's Requiem and Igor Stravinsky's The Firebird as influences. He commenced work before seeing a cut of the film.[29] The film was originally scheduled to be released by 20th Century Fox on November 10, 2017, but in April 2017 it was announced that the film's release would be pushed back to March 2, 2018, because it was seen as a less competitive one.[1][30] The studio's adaptation of Murder on the Orient Express was moved into Red Sparrow's November slot. The first trailer for the film was released on September 14, 2017.[31] The film premiered on February 15, 2018, at the Newseum,[32] and began a U.S. theatrical release on March 2.[20] Red Sparrow screened at FEST in Belgrade on February 28, 2018.[33] It was released in the United Kingdom on March 1, 2018.[15][34] Red Sparrow was released on digital streaming platforms on May 15, 2018.[35] It was released on 4K UHD Blu-ray, [36] Blu-ray and DVD on May 22, 2018.[37] Red Sparrow grossed $46.8 million in the United States and Canada, and $104.7 million in other territories, for a worldwide total of $151.5 million, against a production budget of $69 million.[3] In the United States and Canada, Red Sparrow was released alongside Death Wish, and was projected to gross $20–24 million from 3,056 theaters in its opening weekend.[38] It made $6 million on its first day (including $1.2 million from Thursday night previews) and $17 million over the weekend, finishing second, behind holdover Black Panther. Deadline Hollywood noted the opening was underwhelming given the film's $69 million budget, and that Lawrence's salary of $15–20 million was too much to spend on one star.[39] It fell 51% in its second weekend to $8.15 million, finishing fourth.[40] In the United Kingdom, the film was second at the box office in its opening weekend after Black Panther,[41] and went on to gross £6.4 million.[42] Jennifer Lawrence's performance was praised by critics.[43][44] On review aggregator website Rotten Tomatoes, the film has an approval rating of 45%, based on 300 reviews, and an average rating of 5.5/10. The website's critical consensus reads, "Red Sparrow aims for smart, sexy spy thriller territory, but Jennifer Lawrence's committed performance isn't enough to compensate for thin characters and a convoluted story."[45] On Metacritic, the film has a weighted average score of 53 out of 100, based on 51 critics, indicating "mixed or average reviews".[46] Audiences polled by CinemaScore gave the film an average grade of "B" on an A+ to F scale.[39] Manohla Dargis of The New York Times found the film to be "preposterously entertaining" and credited its success to Lawrence's performance, writing that "like all great stars, [Lawrence] can slip into a role as if sliding into another skin, unburdened by hesitation or self-doubt."[43] IndieWire's Eric Kohn, who graded the film a B, noted the performances of Lawrence and Rampling, stating that "the considerable talent on display is [the film's] constant saving grace." However, he also found that the film "doesn't know when to stop, sagging into bland torture scenes and an underwhelming final showdown."[44] Giving the film a B−, The A.V. Club's Jesse Hassenger noted its methodical nature, with its minimal action and character exploration, and remarked that Francis Lawrence "brings to this material what he brought to The Hunger Games: a sense of style that feels constrained by obligations to hit a certain number of plot points."[47] Alonso Duralde of TheWrap criticized the derivative story and the lack of chemistry between Lawrence and Edgerton, calling the film "neither intelligent enough to be involving nor fun enough to be trashy."[48] Michael Phillips of the Chicago Tribune gave the film 1.5 out of 4 stars and said, "Half of the Red Sparrow audience will spend at least part of the running time fighting off memories of Salt and Atomic Blonde and the Black Widow storyline from The Avengers. The other half, meantime, will wonder when spy movies became quite so punishing."[49] Simran Hans of The Guardian found the film to be sexist, writing that "it busies itself with the grim surface pleasures of ogling its central character as she is degraded in every way possible."[50] Emily Gaudette of Newsweek called the film a "sadistic torture porn" and went on to ask "how many naked women need to be assaulted in a film before a director has made his point? ... for Francis Lawrence, the answer is a pile so big it's impossible to tell the victims apart."[51] The estimation reported by Russian publications was lower than the global average. According to Megacritic, the average score was 4.7 out of 10 based on more than 30 reviews.[52] Award Date of ceremony Category Recipient(s) Result Ref. Alliance of Women Film Journalists January 10, 2019 Actress Most in Need of a New Agent Jennifer Lawrence Won [53][54] Most Egregious Age Difference Between the Leading Man and the Love Interest Jennifer Lawrence, Joel Edgerton Nominated Hall of Shame Nominated Costume Designers Guild February 19, 2019 Excellence in Contemporary Film Trish Summerville Nominated [55] Golden Trailer Awards May 31, 2018 Best Teaser "Program", 20th Century Fox, Wild Card Nominated [56] Hollywood Post Alliance November 15, 2018 Outstanding Color Grading – Feature Film Dave Hussey Nominated [57] People's Choice Awards November 11, 2018 Drama Movie of 2018 Nominated [58] Drama Movie Star of 2018 Jennifer Lawrence Nominated [58] According to The Daily Telegraph, "The espionage historian Nigel West — whose Historical Dictionary of Sexspionage (Scarecrow Press) was originally written as a handbook for the intelligence community — questions the existence of such training schools".[59] As of 2018, director Francis Lawrence has expressed interest in a sequel based on either Palace of Treason or The Kremlin's Candidate.[60] ^ a b Lang, Brent (April 22, 2017). 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Here's what its director told us". Metro. Archived from the original on May 26, 2019. Retrieved May 26, 2019. Official website Red Sparrow at IMDb Retrieved from " 24K and 8K digital video formats "Ultra HD" redirects here. For the video disc format, see Ultra HD Blu-ray. For the resolution commonly referred to as "Ultra HD", see 4K resolution. Comparison of 8K UHDTV, 4K UHDTV, HDTV and SDTV resolution Diagram of the CIE 1931 color space that shows the Rec. 2020 (UHDTV) color space in the outer triangle and Rec. 709 (HDTV) color space in the inner triangle. Both Rec. 2020 and Rec. 709 use Illuminant D65 for the white point. Ultra-high-definition television (also known as Ultra HD television, Ultra HD, UHDTV, UHD and Super Hi-Vision) today includes 4K UHD and 8K UHD, which are two digital video formats with an aspect ratio of 16:9. These were first proposed by NHK Science & Technology Research Laboratories and later defined and approved by the International Telecommunication Union (ITU).[a] The Consumer Electronics Association announced on October 17, 2012, that "Ultra High Definition", or "Ultra HD", would be used for displays that have an aspect ratio of 16:9 or wider and at least one digital input capable of carrying and presenting native video at a minimum resolution of 3840 × 2160.[5][6] In 2015, the Ultra HD Forum was created to bring together the end-to-end video production ecosystem to ensure interoperability and produce industry guidelines so that adoption of ultra-high-definition television could accelerate. From just 30 in Q3 2015, the forum published a list up to 55 commercial services available around the world offering 4K resolution.[7] The "UHD Alliance", an industry consortium of content creators, distributors, and hardware manufacturers, announced during a Consumer Electronics Show (CES) 2016 press conference its "Ultra HD Premium" specification, which defines resolution, bit depth, color gamut, high dynamic range (HDR) performance required for Ultra HD (UHDTV) content and displays to carry their Ultra HD Premium logo.[b] Ultra-high-definition television is also known as Ultra HD, UHD, UHDTV, and 4K.[13][14][15][16][17] In Japan, 8K UHDTV will be known as Super Hi-Vision since Hi-Vision was the term used in Japan for HDTV.[18][19] In the consumer electronics market companies had previously only used the term 4K at the 2012 CES but that had changed to "Ultra HD" during CES 2013.[16][17] "Ultra HD" was selected by the Consumer Electronics Association after extensive consumer research, as the term has also been established with the introduction of "Ultra HD Blu-ray".[20] Super Hi-Vision/8K Specifications [18][19][21][22]Number of pixels7680×4320Aspect ratio16:9Viewing distance0.75 HViewing angle100°ColorimetryRec. 2020Frame rate120 Hz progressiveBit depth12 bits per channel (RGB)Audio system22.2 surround soundSampling rate48/96 kHzAudio bit depth16/20/24 bitsNumber of audio channels24 chUpper layer9 chMiddle layer10 chLower layer3 chLFE2 chUncompressed video bit rate144 Gbit/s See also: Rec. 2020 and DisplayPort: DisplayID Two resolutions are defined as UHDTV:[13][14][15] UHDTV-1 is 3840 pixels wide by 2160 pixels tall (8.3 megapixels), which is four times as many pixels as the 1920 × 1080 (2.07 megapixels) of current 1080p HDTV (full HDTV). Also known as 2160p, and 4K UHD. Although roughly similar in resolution to 4K digital cinema formats, it should not be confused with other 4K resolutions such as the 4096 × 2160 DCI 4K/Cinema 4K. The total number of pixels of RGB stripe type is 8.3 megapixels. UHDTV-2 is 7680 pixels wide by 4320 pixels tall (33.18 megapixels), also referred to as 4320p and 8K UHD, which is sixteen times as many pixels as current 1080p HDTV, which brings it closer to the detail level of 15/70 mm IMAX.[14][23][24] NHK advertises the 8K UHDTV format with 22.2 surround sound as Super Hi-Vision, which can be broadcast with H.264 codecs.[25] The human visual system has a limited ability to discern improvements in resolution when picture elements are already small enough or distant enough from the viewer. At some home viewing distances and current TV sizes, HD resolution is near the limits of resolution for the eye and increasing resolution to 4K has little perceptual impact, if consumers are beyond the critical distance (Lechner distance) to appreciate the differences in pixel count between 4K and HD. One exception is that even if resolution surpasses the resolving ability of the human eye, there is still an improvement in the way the image appears due to higher resolutions reducing spatial aliasing. UHDTV provides other image enhancements in addition to pixel density. Specifically, dynamic range and color are greatly enhanced, and these impact saturation and contrast differences that are readily resolved greatly improve the experience of 4KTV compared to HDTV. UHDTV allows the future use of the new Rec. 2020 (UHDTV) color space which can reproduce colors that cannot be shown with the current Rec. 709 (HDTV) color space.[18] In terms of CIE 1931 color space, the Rec. 2020 color space covers 75.8%, compared to coverage by the DCI-P3 digital cinema reference projector color space of just 53.6%, 52.1% by Adobe RGB color space, while the Rec. 709 color space covers only 35.9%.[18] UHDTV's increases in dynamic range allow not only brighter highlights but also increased detail in the greyscale. UHDTV also allows for frame rates up to 120 frames per second (fps).[15][26] UHDTV potentially allows Rec. 2020, higher dynamic range, and higher frame rates to work on HD services without increasing resolution to 4K, providing improved quality without as high of an increase in bandwidth demand. Prototype camera head (2006) Prototype camera head (2009) The first displays capable of displaying 4K content appeared in 2001, as the IBM T220/T221 LCD monitors. NHK researchers built a UHDTV prototype which they demonstrated in 2003.[27] They used an array of 16 HDTV recorders with a total capacity of almost 3.5 TB that could capture up to 18 minutes of test footage.[27] The camera itself was built with four 2.5-inch (64 mm) CCDs, each with a resolution of only 3840 × 2048.[27] Using two CCDs for green and one each for red and blue, they then used a spatial pixel offset method to bring it to 7680 × 4320.[27][c] Subsequently, an improved and more compact system was built using CMOS image sensor technology[28] and the CMOS image sensor system was demonstrated at Expo 2005, Aichi, Japan, the NAB 2006 and NAB 2007 conferences, Las Vegas, at IBC 2006 and IBC 2008,[29] Amsterdam, Netherlands, and CES 2009. A review of the NAB 2006 demo was published in a broadcast engineering e-newsletter.[30] Individuals at NHK and elsewhere projected that the timeframe for UHDTV to be available in domestic homes varied between 2015 and 2020 but Japan was to get it in the 2016 time frame.[31] On November 2, 2006, NHK demonstrated a live relay of a UHDTV program over a 260 kilometer distance by a fiber-optic network.[32] Using dense wavelength division multiplex (DWDM), 24 Gbit/s speed was achieved with a total of 16 different wavelength signals.[32] On December 31, 2006, NHK demonstrated a live relay of their annual Kōhaku Uta Gassen over IP from Tokyo to a 450 in (11 m) screen in Osaka. Using a codec developed by NHK, the video was compressed from 24 Gbit/s to 180–600 Mbit/s and the audio was compressed from 28 Mbit/s to 7–28 Mbit/s.[33] Uncompressed, a 20-minute broadcast would require roughly 4 TB of storage. The SMPTE first released Standard 2036 for UHDTV in 2007.[34] UHDTV was defined as having two levels, called UHDTV1 (3840 × 2160) and UHDTV2 (7680 × 4320).[34][35] In May 2007, the NHK did an indoor demonstration at the NHK Open House in which a UHDTV signal (7680 × 4320 at 60 fps) was compressed to a 250 Mbit/s MPEG2 stream.[36] The signal was input to a 300 MHz wide band modulator and broadcast using a 500 MHz QPSK modulation.[36] This "on the air" transmission had a very limited range (less than 2 meters), but shows the feasibility of a satellite transmission in the 36,000 km orbit.[36] In 2008, Aptina Imaging announced the introduction of a new CMOS image sensor specifically designed for the NHK UHDTV project.[37] During IBC 2008 Japan's NHK, Italy's RAI, BSkyB, Sony, Samsung, Panasonic Corporation, Sharp Corporation, and Toshiba (with various partners) demonstrated the first ever public live transmission of UHDTV, from London to the conference site in Amsterdam.[38][39] On June 9, 2010, Panasonic announced that its professional plasma display lineup would include an 152-inch (3.9 m) plasma display with 4K resolution. At the time of announcement, it was the largest 4K display and the largest television.[40] On September 29, 2010, the NHK partnered up and recorded The Charlatans live in the UK in the UHDTV format, before broadcasting over the internet to Japan.[41] On May 19, 2011, Sharp in collaboration with NHK demonstrated a direct-view 85 in (220 cm) LCD display capable of 7680 × 4320 pixels at 10 bits per channel.[42] It was the first direct-view Super Hi-Vision-compatible display released.[43] Before 2011, UHDTV allowed for frame rates of 24, 25, 50, and 60 fps.[35] In an ITU-R meeting during 2011, an additional frame rate was added to UHDTV of 120 fps.[44] On February 23, 2012, NHK announced that with Shizuoka University they had developed an 8K sensor that can shoot video at 120 fps.[45][46][47] In April 2012, Panasonic, in collaboration with NHK announced a 145 in (370 cm) display (7680 × 4320 at 60 fps), which has 33.2 million 0.417 mm square pixels.[48] In April 2012, the four major South Korean terrestrial broadcasters (KBS, MBC, SBS, and EBS) announced that in the future, they would begin test broadcasts of UHDTV on channel 66 in Seoul.[49][50] At the time of the announcement, the UHDTV technical details had not yet been decided.[49][50] LG Electronics and Samsung are also involved in UHDTV test broadcasts.[50] In May 2012, NHK showed the world's first ultra-high-definition shoulder-mount camera.[51] By reducing the size and weight of the camera, the portability had been improved, making it more maneuverable than previous prototypes, so it could be used in a wide variety of shooting situations.[51] The single-chip sensor uses a Bayer color-filter array, where only one color component is acquired per pixel.[51] Researchers at NHK also developed a high-quality up-converter, which estimates the other two color components to convert the output into full resolution video.[51] Also in May 2012, NHK showed the

with sales expected to reach five million by the end of the year. GfK also forecasts that Ultra HD screens in 2020 will represent more than 70% of total sales across Europe and almost 60% in the Middle East and North Africa.[177] On 2 September 2015, Sony unveiled the Xperia Z5 Premium; the first smartphone with a 4K display.[178] On 9 September 2015, Apple Inc. announced that their new smartphone the iPhone 6S could record video in 4K.[179] On 6 October 2015, Microsoft unveiled the latest version of their Microsoft Surface Book laptop with a display of "over 6 million pixels" and their new phones the Microsoft Lumia 950 and 950 XL, which, aside from 4K video recording that their predecessors included, feature a display of "over 5 million pixels".[180] On 8 December 2015, the ceremony of the opening of the Holy Door in Vatican City, which marked the beginning of the Jubilee Year of Mercy in the Roman Catholic church, was the first worldwide Ultra HD broadcast via satellite.[181] The event was produced by the Vatican Television Center with the support of Eutelsat, Sony, Globecast and DBW Communication. The team did some advanced experimentation with 4K/High Dynamic Range live images and in particular using technology developed by the BBC's R&D division and Japan's public broadcaster NHK in terms of Hybrid Log Gamma (HLG) signals.[182] The "UHD Alliance", an industry consortium of content creators, distributors, and hardware manufacturers, announced Monday on January 11, 2016 during CES 2016 press conference its "Ultra HD Premium" specification, which defines resolution, bit depth, color gamut, high dynamic range (HDR) performance required for Ultra HD (UHDTV) content and displays to carry their Ultra HD Premium logo.[8][9][10][11][12] On April 2, 2016, Ultra-high-definition television demo channel UHD1 broadcast the Le Corsaire ballet in Ultra HD live from the Vienna State Opera. The programme was produced by Astra satellite owner, SES in collaboration with European culture channel ARTE, and transmitted free-to-air, available to anyone with reception of the Astra 19.2°E satellites and an ultra HD screen equipped with an HEVC decoder.[183] As of April 2016, The NPD Group reported that 6 million 4K UHD televisions had been sold.[184] In May 2016, Modern Times Group, owner of the Viasat DTH platform announced the launch of Viasat Ultra HD, the first UHD channel for the Nordic region. The channel features selected live sport events especially produced in Ultra HD and launch in the autumn via the SES-5 satellite at 5°E. Viasat is also launching an Ultra HD set-top box from Samsung and a TV-module that enables existing UHD TVs to display the channel.[185] Satellite operator, SES said that the launch of Viasat Ultra HD brings the number of UHD channels (including test channels and regional versions) carried on SES satellites to 24, or 46% of all UHD channels broadcast via satellite worldwide.[186] In August 2016, Sky announced that 4K broadcasts would begin via their new Sky Q 2TB box. The opening match of the 2016–17 Premier League between Hull City and Leicester City on Sky Sports was the first 4K transmission.[187] On 29 September 2017, BSAT-4a, dedicated for UHDTV programming and was also claimed "the world's first 8K satellite", was launched from the Guiana Space Centre aboard Ariane 5 rocket. BSAT-4a would be used for 2020 Summer Olympics held in Japan.[188] Additionally, in September 2017, Kaleidescape, a manufacturer of home-theater movie players and servers made 4K UHD movies compatible with their movie store, and with their movie players.[189] In December 2017, Qualcomm announced that their Snapdragon 845 chipset and Spectra 280 Image Signal Processor would be the first phone SoC to record video in UHD Premium.[190] In April 2018, RTL started broadcasting its own UHD channel in Germany. First available at Astra 19.2°E, the Channel shows UHD productions, Formula 1, Football and Deutschland sucht den Superstar. Satellite operator SES broadcast an 8K television signal via its satellite system for the first time in May 2018. The 8K demonstration content, with a resolution of 7680 × 4320 pixels, a frame rate of 60 fps, and 10 bpc color depth, was encoded in HEVC and transmitted at a rate of 80 Mbit/s via the Astra 3B satellite during SES's Industry Days conference in Luxembourg.[191] In June 2018, fuboTV broadcast the 2018 FIFA World Cup live in 4K and HDR10 becoming the first OTT streaming service to do so.[192] Quarter, Semi and Final matches were available on many popular streaming devices including Apple TV, Chromecast Ultra, Fire TV, Roku and Android TVs. Content was streamed at 60 frames per second using HLS and DASH. Video was sent in fragmented MP4 containers delivering HEVC encoded video. On December 1, 2018, NHK launched BS8K, a broadcast channel transmitting at 8K resolution.[193][194][195] In February 25, 2019 at the event of 2019 Mobile World Congress, Sony announced the Xperia 1, the first smartphone featuring a ultrawide 21:9 aspect ratio 4K HDR OLED display (with a resolution of 3840 × 1644), which would be released on May 30, 2019.[196] In May 2019, for the first time in Europe, 8K demonstration content was received via satellite without the need for a separate external receiver or decoder. At the 2019 SES Industry Days conference at Betzdorf, Luxembourg broadcast quality 8K content (with a resolution of 7680 × 4320 pixels at 50 fps) was encoded using a Spin Digital HEVC encoder (at a bit rate of 70 Mbit/s), uplinked to a single 33 MHz transponder on SES' Astra 28.2°E satellites and the downlink received and displayed on a Samsung 82 in (210 cm) Q950RB production model TV.[197] Fashion 4K Festival 4K High 4K TV 4K Heritage 4K UltraHD FunBox[198] 4K Universe Astra Promo beIN Sports 4K (Spain) Canal+[199] Canal+ 4K Ultra HD (Poland) Digi 4K (Romania) Digiturk UHD[200] Discovery Eurosport 4K Fashion One 4K Fashion TV 4K Festival 4K Insight[201] UHD M3.hu UHD (online only) M6 4K Movistar Fórmula 1 UHD[202] Movistar Partidazo UHD[203] NASA TV NPO 1 Pearl TV[204] ProsiebenSat.1 UHD QVC Deutschland QVC Zwei Rai 4K[205] RMC Sport 1 RTL UHD[199] RTVS UltraHD SES Ultra HD Demo Channel SFR Sport 4K Sky Sport 4K (Italy) Sky UHD1 (UK) Sky UHD2 (UK) Sky Sport UHD (Germany) Sky Sport Bundesliga UHD (Germany) Sky Sports Main Event UK Sky Sports F1 UHD UK Sportklub 4K Sport TV 4K UHD[206][207] Travelxp Tricolor Ultra HD[208] TF1 4K TNT Sports Ultimate TRT 4K TVE La 1 UHD (Spain)[209] TVP 4K (Poland) UHD-1 V Sport Ultra HD Virgin TV Ultra HD Wow! 4K BTV (Botswana) EBS 4K (Ethiopia) Nahoo sports+ UHD (Ethiopia) Nahoo sports+2 UHD (Ethiopia) ETV sports UHD (Ethiopia) Kana TV 4K (Ethiopia) on Time sports HD (Egypt) NASA TV UHD Sportsnet 4K and Sportsnet One 4K (Canada) TSN 4K and TSN 2 4K (Canada) Hispasat TV 4K (Latin America) Fashion One 4K Fox Sports 4K and Fox Sports 1 4K (USA) DirecTV 4K and DirecTV Cinema 4K (USA) ESPN (USA) 4KUNIVERSE Insight UHD The Country Network SporTV 4K (Brazil) UHD-1 CCTV-4K (Chinese: 中央广播电视总台4K超高清频道) CCTV-16 4K (Chinese: 中央广播电视总台奥林匹克频道) BRTV Satellite 4K UHD Channel (Beijing TV 4K UHD) (Chinese: 北京卫视4K超高清频道) Guangdong Radio and Television 4K Variety Channel (Chinese: 广东广播电视台4K综艺频道) Guangzhou Television Ultra HD (Chinese: 广州南国都市频道) SiTV Joy UHD (Chinese: 欢笑剧场4K频道) Wasu-Discovery UHD (Chinese: 求索纪录频道) First Media 4K (Indonesia) IndiHome 4K (Indonesia) Cable 4K (South Korea)[210] KBS1 UHD (South Korea)[211] KBS2 UHD (South Korea) MBC UHD (South Korea)[211] SBS UHD (South Korea)[211] KNN UHD (South Korea)[211] KBC UHD (South Korea)[211] TBC UHD (South Korea)[211] TJB UHD (South Korea)[211] UBC UHD (South Korea)[211] G1 UHD (South Korea)[211] Asia UHD (South Korea) Insight UHD[place missing] Life U (South Korea)[212] SBS F!L UHD (South Korea)[213] IRIB UHD (Iran) Sky UHD[place missing] UHD Dream TV[place missing] UMAX (South Korea)[214] UXN[place missing] 4K-Sat[place missing] Tata Play 4K (India) Now Sports 4K (Hong Kong) TVB Jade UHD (Chinese: 翡翠台) Bol Network (Pakistan) Hum News (Pakistan) Kan11 4K (Israel) NHK BS 4K (Japan) BS Nittele 4K (Japan) BS Asahi 4K (Japan) BS TV Tokyo 4K (Japan) BS-TBS 4K (Japan) BS Fuji 4K (Japan) SHOP CHANNEL 4K (Japan) 4K QVC (Japan) THE CINEMA 4K (Japan) J Sports (Japan) Star Channel 4K (Japan) Sukachan 4K (Japan) Japanese movie + Jidaigeki 4K (Japan) Wowow 4K (Japan) Astro Super Sport UHD (Malaysia) True 4K (Thailand) VTVcab 4K (Vietnam) SCTV 4K (Vietnam) Foxtel Movies Ultra HD (Australia) Fox Sports Ultra HD (Australia)[215] NHK BS8K (Japan) CCTV-8K (China)[216] BRTV Documentary, Science & Education 8K UHD Experimental Channel (Chinese: 北京广播电视台纪实科教8K超高清试验频道), formerly BRTV Winter Olympic & Documentary 8K UHD Experimental Channel (Chinese: 北京广播电视台冬奥纪实8K超高清试验频道)[217][218] Field trials using existing digital terrestrial television (DTT) transmitters have included the following.[219] Type Country / Region Transmitter site Covering ERP DTT system Channel bandwidth Transmission mode Multiplex capacity Signal bit rate Video encoding standard Picture standard Audio encoding standard Center frequency 8K-UHD Japan[220] NHK Hitoyoshi Station Hitoyoshi Area, Kumamoto Prefecture 140 W (H)135 W (V) ISDB-T 6 MHz 32kGI=1/32, 4096QAMFEC 3/4dual-polarized MIMO 91.8 Mbit/s 91.0 Mbit/s MPEG-4AVC/H.264 7680 × 4320p59.94 frame/s8 bit/px MPEG-4 AAC384 kbit/s 671 MHz(Ch 46) NHK Mizukami Station 25 W (H)25 W (V) 671 MHz(Ch 46) NHK STRL Building Tokyo 93 W (H)93 W (V) 581 MHz(Ch 31) 8K-UHD South Korea Technical Research Institute Building of Korean Broadcasting System (KBS) Yeoeuido, Seoul 10 W (H)10 W (V) – 6 MHz 2kGI=1/16, 256QAMFEC 3/4dual-polarized MIMO 50.475 Mbit/s(Single band) 50.0 Mbit/s(Single band) HEVC – – 605 MHz & 623 MHz(Ch 36 & Ch 39) 4K-UHD Australia[221] Gore Hill Sydney 50 kW DVB-T2 7 MHz 16k extended modeGI=1/32, 256QAM32kFEC 3/4, PP7 38.63 Mbit/s Variable(some trials at 35 Mbit/s) HEVC 3840 × 2160p MPEG-4 AAC 212.5 MHz(Ch 10) Kings Cross 650 W 536.5 MHz(Ch 29) North Head 1 kW 536.5 MHz(Ch 29) 4K-UHD Brazil Mt. Sumaré Parts of Rio de Janeiro metropolitan area 660 W (H)660 W (V) ISDB-T 8 MHz 32k extended modeGI=1/128, 64QAMFEC5/6, PP7 36.72 Mbit/s 35.0 Mbit/s HEVC 3840 × 2160p50 frame/s8 bit/px E-AC-3 5.1 754 MHz(Ch 56 in Region 1) 4K-UHD South Korea Gwanaksan South Metropolitan area of Seoul 36.7 kW DVB-T2 6 MHz 32k extended modeGI=1/16, PP4, 256 QAMFEC 3/4, 4/5, 5/6 < 35.0 Mbit/s Variable(some trials at 25~34 Mbit/s) HEVC Main10Level 5.1Max 28 Mbit/s 3840 × 2160p60 frame/s8 or 10 bit/px MPEG-H 3D Audio[222] 761 MHz(Ch 62) 12.9 kW 701 MHz(Ch 52) 40.0 kW 707 MHz(Ch 53) Namsan Central area of Seoul 2.2 kW 761 MHz(Ch 62) Yongmunsan West Metropolitan area of Seoul 8.3 kW 707 MHz(Ch 53) 4K-UHD France Eiffel Tower City of Paris 1 kW DVB-T2 8 MHz 32k extended modeGI=1/128, 256QAMFEC2/3, PP7 40.2 Mbit/s Two programmes carried:one at 22.5 Mbit/s,one at 17.5 Mbit/s HEVC 3840 × 2160p50 frame/s8 bit/px HE-AAC 192 kbit/s 514 MHz(Ch 26 in Region 1) 4K-UHD Spain ETSI Tele-comunicación Ciudad Universitaria Madrid 125 W DVB-T2 8 MHz 32k extended modeGI=1/128, 64QAMFEC5/6, PP7 36.72 Mbit/s 35 Mbit/s(other bit rates also tested) HEVC 3840 × 2160p50 frame/s8 bit/px E-AC-3 5.1 754 MHz(Ch 56 in Region 1) 4K-UHD Sweden Stockholm Nacka City of Stockholm 35 kW DVB-T2 8 MHz 32k extended modeGI=19/256, 256QAMFEC3/5, PP4 31.7 Mbit/s 24 Mbit/s HEVC 3840 × 2160p29.97 frame/s8 bit/px 618 MHz(Ch 39 in Region 1) 4K-UHD United Kingdom[223] Crystal Palace Greater London(serving over 4.5 million households) 39.8 kW DVB-T2 8 MHz 32k extended modeGI=1/128, 256QAMFEC 2/3, PP7 40.2 Mbit/s Variable(some trials at 35 Mbit/s) HEVC 3840 × 2160p50 or 59.94 frame/s8 bit/px (most) or 10 bit/px 586 MHz(Ch 35 in Region 1) Winter Hill North-west England, including Manchester and Liverpool(serving 2.7 million households) 22.5 kW 602 MHz(Ch 37 in Region 1) Black Hill Central Scotland, including Glasgow and Edinburgh(serving 1 million households) 39 kW 586 MHz(Ch 35 in Region 1) 4K-UHD Czech Republic[224] Žižkov Television Tower Prague – DVB-T2 8 MHz – – HEVC 3840 × 2160p – 706 MHz(Ch 50 in Region 1) 4K-UHD Slovakia Kamzík Bratislava 5 kW DVB-T2 32k256QAM, FEC 3/4 36 Mbit/s HEVC 3840 × 2160p 184.5 MHz(Ch 6) 4K-UHD China(P. R. of)[225] Jiaxing TV Tower Jiaxing, Zhejiang 1 kWSignal radius: 39 km DTMB-A 8 MHz 32k2PN1024, 256APSKFEC 2/3 Unknown Unknown HEVC 3840 × 2160p50 frame/s MPEG-4 AAC 562 MHz(Ch 24) 4K-UHD China(P. R. of)[226] Taishan Parts of Luzhong areaSignal radius: 130 km Unknown(TPO: 1kW) DTMB-A 8 MHz Unknown Unknown Unknown(some trials at 33.53 Mbit/s for one program) AVS2 3840 × 2160p50 frame/s Unknown 778 MHz(Ch 46) 4K-UHD Hong Kong SAR[227] Temple Hill Kowloon and northern part of Hong Kong Island 1 kW DVB-T2 8 MHz 32kGI=1/32, PP4, 256QAMFEC 2/3 Unknown 25.8 Mbit/s HEVC 3840 × 2160p50 frame/s Unknown 602 MHz(Ch 37) Kowloon Peak 320 W Golden Hill Tsuen Wan and Kwai Chung 320 W 4K-UHD Hong Kong SAR Temple Hill Kowloon and northern part of Hong Kong Island 1 kW DTMB-A 8 MHz 32k2PN1024, 256APSKFEC 2/3 37.89 Mbit/s 25.5 Mbit/s HEVC 3840 × 2160p50 frame/s Unknown 602 MHz(Ch 37) Kowloon Peak 320 W Golden Hill Tsuen Wan and Kwai Chung 320 W Standards that deal with UHDTV include: Standards approved in ITU-R: Rec. ITU-R BT.1201-1 (2004)[228] Rec. ITU-R BT.1769 (2006)[229] Rec. ITU-R BT.2020 (2012, revised 2014)[26][230] Rec. ITU-R BT.2035-0 (07/13) A reference viewing environment for evaluation of HDTV program material or completed programmes Rec. ITU-R BS.2051-0 (02/14) Advanced sound system for programme production Rec. ITU-R BT.2100 (2016) Other documents prepared or being prepared by ITU-R: Report ITU-R BT.2246-3 (2014) The present state of ultra-high definition television Draft New Report ITU-R BT.[UHDTV-DTT TRIALS] (Sub-Working Group 6A-1) Collection of field trials of UHDTV over DTT networks[219] Standards developed in ITU-T's VCEG and ISO/IEC JTC 1's MPEG that support Ultra-HD include: H.265/MPEG-H HEVC High Efficiency Video Coding (2013, revised 2014) H.264/MPEG-4 AVC Advanced Video Coding (support for Ultra-HD added circa 2013) SMPTE 2036-1 (2009)[231] SMPTE 2036-2 (2008)[232] SMPTE 2036-3 (2010)[233] DVB approved the Standard TS 101 154 V2.1.1, published (07/2014) in the DVB Blue Book A157 Specification for the use of Video and Audio Coding in Broadcasting Applications based on the MPEG-2 Transport Stream, which was published by ETSI in the following months. Standards for UHDTV in South Korea have been developed by its Telecommunications Technology Association. On August 30, 2013, the scenarios for 4K-UHDTV service were described in the Report "TTAR 07.0011: A Study on the UHDTV Service Scenarios and its Considerations". On May 22, 2014, the technical report "TTAR-07.0013: Terrestrial 4K UHDTV Broadcasting Service" was published. On October 13, 2014, an interim standard – "TTAI.KO-07.0123: Transmission and Reception for Terrestrial UHDTV Broadcasting Service" – was published based on HEVC encoding, with MPEG 2 TS, and DVB-T2 serving as the standards. On June 24, 2016, a standard – "TTAK.KO-07.0127: Transmission and Reception for Terrestrial UHDTV Broadcasting Service" – was published based on HEVC encoding, with MMTP/ROUTE IP, and ATSC 3.0 serving as the standards. Rec. 2020 – ITU-R Recommendation for UHDTV 4K resolution – Resolutions of common 4K formats and list of 4K-monitors, TVs, projectors 8K resolution – Specifications for ~8x4K UHD and 8Kx8K fulldome Ultra HD Blu-ray – 2160p / 4K (3840 × 2160 resolution) format Blu-ray Disc as specified by Blu-ray Disc Association IMAX – A film theater format that historically has been innovative in creating a more realistic viewing experience High Efficiency Video Coding (HEVC) VP9 / WebM 22.2 surround sound – The audio component of Super Hi-Vision ^ Attributed to multiple sources:[1][2][3][4] ^ Attributed to multiple sources:[8][9][10][11][12] ^ The resulting lines in the image alternate between pixels from the green-1 and red CCDs, and pixels from the blue and green-2 CCDs. ^ Thomas, Alexander. "Just how useful is 2160p aka 4K?". ^ "Defining the Future of Television". BBC. June 19, 2013. ^ "Leading Television Industry Players Line Up To Support '4K Ultra HD'". 2014 Press Releases. 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"3Gb/s SDI for Transport of 1080p50/60, 3D, UHDTV1 / 4k and Beyond" (PDF). Archived from the original (PDF) on 2016-03-03. Retrieved 2017-03-17. Society of Motion Picture and Television Engineers: SMPTE 274M-2005: Image Sample Structure, Digital Representation and Digital Timing Reference Sequences for Multiple Picture Rates Society of Motion Picture and Television Engineers: SMPTE 292M-1998: Bit-Serial Digital Interface for High Definition Television Society of Motion Picture and Television Engineers: SMPTE 291M-1998: Ancillary Data Packet and Space Formatting Society of Motion Picture and Television Engineers: SMPTE 372M-2002: Dual Link 292M Interface for 1920 x 1080 Picture Raster Standards of SMPTE HDcctv Alliance (Security organization supporting SDI for security surveillance) Retrieved from " 4Film that gives an illusion of three-dimensional depth This article is about motion pictures that give an illusion of depth. For 2D motion pictures created using 3D modeling software, see Computer-generated imagery. For motion pictures created using stereophotogrammetry, see Volumetric video. 3D films are motion pictures made to give an illusion of three-dimensional solidity, usually with the help of special glasses worn by viewers. They have existed in some form since 1915[citation needed], but had been largely relegated to a niche in the motion picture industry because of the costly hardware and processes required to produce and display a 3D film, and the lack of a standardized format for all segments of the entertainment business. Nonetheless, 3D films were prominently featured in the 1950s in American cinema and later experienced a worldwide resurgence in the 1980s and 1990s driven by IMAX high-end theaters and Disney-themed venues. 3D films became increasingly successful throughout the 2000s, peaking with the success of 3D presentations of Avatar in December 2009, after which 3D films again decreased in popularity.[1] Certain directors have also taken more experimental approaches to 3D filmmaking, most notably celebrated auteur Jean-Luc Godard in his film Goodbye to Language. This section needs additional citations for verification. Please help improve this article by adding citations to reliable sources in this section. Unsourced material may be challenged and removed. (December 2009) (Learn how and when to remove this message) The basic components of 3D film were introduced separately between 1833 and 1839. Stroboscopic animation was developed by Joseph Plateau in 1832 and published in 1833 in the form of a stroboscopic disc,[2] which he later called the fantascope and became better known as the phénakisticope. Around the very same time (1832/1833), Charles Wheatstone developed the stereoscope, but he did not really make it public before June 1838.[3] The first practical forms of photography were introduced in January 1839 by Louis Daguerre and Henry Fox Talbot. A combination of these elements into animated stereoscopic photography may have been conceived early on, but for decades it did not become possible to capture motion in real-time photographic recordings due to the long exposure times necessary for the light-sensitive emulsions that were used. Charles Wheatstone got inventor Henry Fox Talbot to produce some calotype pairs for the stereoscope and received the first results in October 1840.[3] Only a few more experimental stereoscopic photographs were made before David Brewster introduced his stereoscope with lenses in 1849. Wheatstone also approached Joseph Plateau with the suggestion to combine the stereoscope with the fantascope. In 1849, Plateau published about this concept in an article about several improvements made to his fantascope and suggested a stop-motion technique that would involve a series of photographs of purpose-made plaster statuettes in different poses.[4] The idea reached Jules Duboscq, an instrument maker who already marketed Plateau's Fantascope as well as the stereoscopes of Wheatstone and Brewster. In November 1852, Duboscq added the concept of his "Stéréoscope-fantascope, ou Bïoscope" to his stereoscope patent. Production of images proved very difficult, since the photographic sequence had to be carefully constructed from separate still images. The bioscope was no success, and the only extant disc, without apparatus, is found in the Joseph Plateau collection of the University of Ghent. The disc contains 12 albumen image pairs of a machine in motion.[5] Most of the other early attempts to create motion pictures also aimed to include the stereoscopic effect. In November 1851, Antoine Claudet claimed to have created a stereoscope that showed people in motion.[6] The device initially only showed two phases, but during the next two years, Claudet worked on a camera that would record stereoscopic pairs for four different poses (patented in 1853).[7] Claudet found that the stereoscopic effect did not work properly in this device, but believed the illusion of motion was successful.[8] In 1855, Johann Nepomuk Czermak published an article about his Stereophoroskop. His first idea to create 3D animation involved sticking pins in a stroboscopic disc to create a sequence that would show one pin moving further into the cardboard and back. He also designed a device that would feed the image pairs from two stroboscopic discs into one lenticular stereoscope and a vertical predecessor of the zoetrope.[9] On February 27, 1860, Peter Hubert Desvignes received British patent no. 537 for 28 monocular and stereoscopic variations of cylindrical stroboscopic devices. This included a version that used an endless band of pictures running between two spools that was intermittently lit by an electric spark.[10] Desvignes' Mimoscope, received an Honourable Mention "for ingenuity of construction" at the 1862 International Exhibition in London.[11] It could "exhibit drawings, models, single or stereoscopic photographs, so as to animate animal movements, or that of machinery, showing various other illusions."[12] Desvignes "employed models, insects and other objects, instead of pictures, with perfect success." The horizontal slits (like in Czermak's Stereophoroskop) allowed a much improved view, with both eyes, of the opposite pictures.[13] In 1861, American engineer Coleman Sellers II received US patent No. 35,317 for the kinematoscope, a device that exhibited "stereoscopic pictures as to make them represent objects in motion". In his application he stated: "This has frequently been done with plane pictures but has never been, with stereoscopic pictures". He used three sets of stereoscopic photographs in a sequence with some duplicates to regulate the flow of a simple repetitive motion, but also described a system for very large series of pictures of complicated motion.[14][15] On August 11, 1877, the Daily Alta newspaper announced a project by Eadward Muybridge and Leland Stanford to produce sequences of photographs of a running horse with 12 stereoscopic cameras. Muybridge had much experience with stereo photography and had already made instantaneous pictures of Stanford's horse Occident running at full speed. He eventually managed to shoot the proposed sequences of running horses in June 1878 with stereoscopic cameras. The published result and animated versions for his zoopraxiscope were not stereoscopic, but in 1898 Muybridge claimed that he had (privately) viewed the pictures in two synchronized zoetropes with Wheatstone's reflecting stereoscope as a "very satisfactory reproduction of an apparently solid miniature horse trotting and of another galloping".[16] Thomas Edison demonstrated his phonograph on November 29, 1877, after previous announcements of the device for recording and replaying sound had been published earlier in the year. An article in Scientific American concluded, "It is already possible, by ingenious optical contrivances, to throw stereoscopic photographs of people on screens in full view of an audience. Add the talking phonograph to counterfeit their voices, and it would be difficult to carry the illusion of real presence much further". Wordsworth Donisthorpe announced in the January 24, 1878, edition of Nature that he would advance that conception: "By combining the phonograph with the kinesigraph, I will undertake not only to produce a talking picture of Mr. Gladstone, which, with motionless lips and unchanged expression, shall positively recite his latest anti-Turkish speech in his own voice and tone. Not only this, but the life size photograph itself shall move and gesticulate precisely as he did when making the speech, the words and gestures corresponding as in real life."[17] Dr. Phipson, a correspondent for British news in a French photography magazine, relayed the concept but renamed the device "Kinétiscope" to reflect the viewing purpose rather than the recording option. This was picked up in the United States and discussed in an interview with Edison later in the year.[18] Neither Donisthorpe's or Edison's later moving picture results were stereoscopic. In the late 1890s, British film pioneer William Friese-Greene filed a patent for a 3D film process. In his patent, two films were projected side by side on screen. The viewer looked through a stereoscope to converge the two images. Because of the obtrusive mechanics behind this method, theatrical use was not practical.[19] Frederic Eugene Ives patented his stereo camera rig in 1900. The camera had two lenses coupled together 1+3⁄4 inches (4.45 centimeters) apart.[20] On June 10, 1915, Edwin S. Porter and William E. Waddell presented tests to an audience at the Astor Theater in New York City.[21] In red-green anaglyph, the audience was presented three reels of tests, which included rural scenes, test shots of Marie Doro, a segment of John Mason playing a number of passages from Jim the Penman (a film released by Famous Players–Lasky that year, but not in 3D), Oriental dancers, and a reel of footage of Niagara Falls.[22] However, according to Adolph Zukor in his 1953 autobiography The Public Is Never Wrong: My 50 Years in the Motion Picture Industry, nothing was produced in this process after these tests. By 1909, the German film market suffered much from overproduction and too much competition. German film tycoon Oskar Messter had initially gained much financial success with the Tonbild synchronized sound films of his Biophon system since 1903, but the films were losing money by the end of the decade and Messter would stop Tonbild production in 1913. Producers and exhibitors were looking into new film attractions and invested for instance in colorful imagery. The development of stereoscopic cinema seemed a logical step to lure visitors back into the movie theatres. In 1909, German civil engineer August Engelsmann patented a process that projected filmed performances within a physical decor on an actual stage. Soon after, Messter obtained patents for a very similar process, probably by agreement with Engelsmann, and started marketing it as "Alabastra". Performers were brightly dressed and brightly lit while filmed against a black background, mostly miming their singing or musical skills or dancing to the circa four-minute pre-recorded phonographs. The film recordings would be projected from below, to appear as circa 30 inch figures on a glass pane in front of a small stage, in a setup very similar to the Pepper's ghost illusion that offered a popular stage trick technique since the 1860s. The glass pane was not visible to the audience and the projected figures seemed able to move around freely across the stage in their virtual tangible and lifelike appearance. The brightness of the figures was necessary to avoid see-through spots and made them resemble alabaster sculptures. To adapt to this appearance, several films featured Pierrot or other white clowns, while some films were probably hand-coloured. Although Alabastra was well received by the press, Messter produced few titles, hardly promoted them and abandoned it altogether a few years later. He believed the system to be uneconomical due to its need for special theatres instead of the widely available movie screens, and he did not like that it seemed only suitable for stage productions and not for "natural" films. Nonetheless, there were numerous imitators in Germany and Messter and Engelsmann still teamed with American businessman Frank Joseph Godsol (Goldsoll) set up a short-lived variant named "Fantomo" in 1914.[23] Rather in agreement with Messter or not, Karl Juhasz and Franz Haushofer opened a Kinoplastikon theatre in Vienna in 1911. Their patented system was very similar to Alabaster, but projected life-size figures from the wings of the stage. With much higher ticket prices than standard cinema, it was targeted at middle-class audiences to fill the gap between low-brow films and high-class theatre. Audiences reacted enthusiastically and by 1913 there reportedly were 250 theatres outside Austria, in France, Italy, United Kingdom, Russia and North America. However, the first Kinoplastikon in Paris started in January 1914 and the premiere in New York took place in the Hippodrome in March 1915. In 1913, Walter R. Booth directed 10 films for the U.K. Kinoplastikon, presumably in collaboration with Cecil Hepworth. Theodore Brown, the licensee in the U.K. also patented a variant with front and back projection and reflected decor, and Goldsoll applied for a very similar patent only 10 days later.[23] Further development and exploitation was probably haltered by World War I. Alabastra and Kinoplastikon were often advertised as stereoscopic and screenless. Although in reality the effect was heavily dependent on glass screen projection and the films were not stereoscopic, the shows seemed truly three-dimensional as the figures were clearly separate from the background and virtually appeared inside the real, three-dimensional stage area without any visible screen. Eventually, longer (multi-reel) films with story arcs proved to be the way out of the crisis in the movie market and supplanted the previously popular short films that mostly aimed to amuse people with tricks, gags or other brief variety and novelty attractions. Sound film, stereoscopic film and other novel techniques were relatively cumbersome to combine with multiple reels and were abandoned for a while. Fairall in 1922 Fairall's 3D camera Audience wearing special glasses watch a 3D "stereoscopic film" at the Telekinema on the South Bank in London during the Festival of Britain 1951. The earliest confirmed 3D film shown to an out-of-house audience was The Power of Love, which premiered at the Ambassador Hotel Theater in Los Angeles on September 27, 1922.[24][25][26] The camera rig was a product of the film's producer, Harry K. Fairall, and cinematographer Robert F. Elder.[19] It was filmed dual-strip in black and white, and single strip color anaglyphic release prints were produced using a color film invented and patented by Harry K. Fairall. A single projector could be used to display the movie but anaglyph glasses were used for viewing. The camera system and special color release print film all received U.S Patent No. 1,784,515 on December 9, 1930.[27][28] After a preview for exhibitors and press in New York City, the film dropped out of sight, apparently not booked by exhibitors, and is now considered lost. Early in December 1922, William Van Doren Kelley, inventor of the Prizma color system, cashed in on the growing interest in 3D films started by Fairall's demonstration and shot footage with a camera system of his own design. Kelley then struck a deal with Samuel "Roxy" Rothafel to premiere the first in his series of "Plasticon" shorts entitled Movies of the Future at the Rivoli Theater in New York City. Also in December 1922, Laurens Hammond (later inventor of the Hammond organ) premiered his Teleview system, which had been shown to the trade and press in October. Teleview was the first alternating-frame 3D system seen by the public. Using left-eye and right-eye prints and two interlocked projectors, left and right frames were alternately projected, each pair being shown three times to suppress flicker. Viewing devices attached to the armrests of the theater seats had rotary shutters that operated synchronously with the projector shutters, producing a clean and clear stereoscopic result. The only theater known to have installed Teleview was the Selwyn Theater in New York City, and only one show was ever presented with it: a group of short films, an exhibition of live 3D shadows, and M.A.R.S., the only Teleview feature. The show ran for several weeks, apparently doing good business as a novelty (M.A.R.S. itself got poor reviews), but Teleview was never seen again.[29] In 1922, Frederic Eugene Ives and Jacob Leventhal began releasing their first stereoscopic shorts made over a three-year period. The first film, entitled Plastigrams, was distributed nationally by Educational Pictures in the red-and-blue anaglyph format. Ives and Leventhal then went on to produce the following stereoscopic shorts in the "Stereoscopiks Series" released by Pathé Films in 1925: Zowie (April 10), Luna-cy! (May 18), The Run-Away Taxi (December 17) and Ouch (December 17).[30] On September 22, 1924, Luna-cy! was re-released in the De Forest Phonofilm sound-on-film system.[31] The late 1920s to early 1930s saw little interest in stereoscopic pictures. In Paris, Louis Lumiere shot footage with his stereoscopic camera in September 1933. The following March he exhibited a remake of his 1895 short film L'Arrivée du Train, this time in anaglyphic 3D, at a meeting of the French Academy of Science.[26] In 1936, Leventhal and John Norling were hired based on their test footage to film MGM's Audioscopiks series. The prints were by Technicolor in the red-and-green anaglyph format, and were narrated by Pete Smith. The first film, Audioscopiks, premiered January 11, 1936, and The New Audioscopiks premiered January 15, 1938. Audioscopiks was nominated for the Academy Award in the category Best Short Subject, Novelty in 1936. With the success of the two Audioscopiks films, MGM produced one more short in anaglyph 3D, another Pete Smith Specialty called Third Dimensional Murder (1941). Unlike its predecessors, this short was shot with a studio-built camera rig. Prints were by Technicolor in red-and-blue anaglyph. The short is notable for being one of the few live-action appearances of the Frankenstein Monster as conceived by Jack Pierce for Universal Studios outside of their company. While many of these films were printed by color systems, none of them was actually in color, and the use of the color printing was only to achieve an anaglyph effect.[32] While attending Harvard University, Edwin H. Land conceived the idea of reducing glare by polarizing light. He took a leave of absence from Harvard to set up a lab and by 1929 had invented and patented a polarizing sheet.[33] In 1932, he introduced Polaroid J Sheet as a commercial product.[34] While his original intention was to create a filter for reducing glare from car headlights, Land did not underestimate the utility of his newly dubbed Polaroid filters in stereoscopic presentations. In February 1936, Land gave the first public demonstration of Polaroid filters in conjunction with 3D photography at the Waldorf-Astoria Hotel.[35] The reaction was enthusiastic, and he followed it up with an installation at the New York Museum of Science.[26] It is unknown what film was run for audiences at this exhibition. Using Polaroid filters meant an entirely new form of projection, however. Two prints, each carrying either the right or left eye view, had to be synced up in projection using an external selsyn motor. Furthermore, polarized light would be largely depolarized by a matte white screen, and only a silver screen or screen made of other reflective material would correctly reflect the separate images. Later that year, the feature, Nozze Vagabonde appeared in Italy, followed in Germany by Zum Greifen nah (You Can Nearly Touch It), and again in 1939 with Germany's Sechs Mädel rollen ins Wochenend (Six Girls Drive Into the Weekend). The Italian film was made with the Gualtierotti camera; the two German productions with the Zeiss camera and the Vierling shooting system. All of these films were the first exhibited using Polaroid filters. The Zeiss Company in Germany manufactured glasses on a commercial basis commencing in 1936; they were also independently made around the same time in Germany by E. Käsemann and by J. Mahler.[36] In 1939, John Norling shot In Tune With Tomorrow, the first commercial 3D film using Polaroid in the US[citation needed]. This short premiered at the 1939 New York World's Fair and was created specifically for the Chrysler Motors Pavilion. In it, a full 1939 Chrysler Plymouth is magically put together, set to music. Originally in black and white, the film was so popular that it was re-shot in color for the following year at the fair, under the title New Dimensions.[citation needed] In 1953, it was reissued by RKO as Motor Rhythm. Another early short that utilized the Polaroid 3D process was 1940's Magic Movies: Thrills For You produced by the Pennsylvania Railroad Co. for the Golden Gate International Exposition.[citation needed] Produced by John Norling, it was filmed by Jacob Leventhal using his own rig. It consisted of shots of various views that could be seen from the Pennsylvania Railroad's trains. In the 1940s, World War II prioritized military applications of stereoscopic photography and it once again went on the back burner in most producers' minds. What aficionados consider the "golden era" of 3D began in late 1952 with the release of the first color stereoscopic feature, Bwana Devil, produced, written and directed by Arch Oboler. The film was shot in "Natural Vision", a process that was co-created and controlled by M. L. Gunzberg. Gunzberg, who built the rig with his brother Julian, Friend Baker and Lothrop Worth, shopped it without success to various studios before Oboler used it for this feature, which went into production with the title, The Lions of Gulu.[37] The critically panned film was nevertheless highly successful with audiences due to the novelty of 3D, which increased Hollywood interest in 3D during a period that had seen declining box-office admissions.[38] As with practically all of the features made during this boom, Bwana Devil was projected dual-strip, with Polaroid filters. During the 1950s, the familiar disposable anaglyph glasses made of cardboard were mainly used for comic books, two shorts by exploitation specialist Dan Sonney, and three shorts produced by Lippert Productions. However, even the Lippert shorts were available in the dual-strip format alternatively. Because the features utilized two projectors, the capacity limit of film being loaded onto each projector (about 6,000 feet (1,800 m), or an hour's worth of film) meant that an intermission was necessary for every feature-length film. Quite often, intermission points were written into the script at a major plot point. During Christmas of 1952, producer Sol Lesser quickly premiered the dual-strip showcase called Stereo Techniques in Chicago.[39] Lesser acquired the rights to five dual-strip shorts. Two of them, Now is the Time (to Put On Your Glasses) and Around is Around, were directed by Norman McLaren in 1951 for the National Film Board of Canada. The other three films were produced in Britain for The Festival of Britain in 1951 by Raymond Spottiswoode. These were A Solid Explanation, Royal River, and The Black Swan. James Mage was also an early pioneer in the 3D craze. Using his 16 mm 3D Bolex system, he premiered his Triorama program on February 10, 1953, with his four shorts: Sunday In Stereo, Indian Summer, American Life, and This is Bolex Stereo.[40] This show is considered lost. Another early 3D film during the boom was the Lippert Productions short A Day in the Country, narrated by Joe Besser, which was composed mostly of test footage. Unlike all of the other Lippert shorts, which were available in both dual-strip and anaglyph, this production was released in anaglyph only. April 1953 saw two groundbreaking features in 3D: Columbia's Man in the Dark and Warner Bros.' House of Wax, the first 3D feature with stereophonic sound. House of Wax was (outside of Cinerama) the first time many American audiences heard recorded stereophonic sound; it was also the film that typecast Vincent Price as a horror star as well as the "King of 3-D" after he became the actor to star in the most 3D features (the others were The Mad Magician, Dangerous Mission, and Son of Sinbad). The success of these two films proved that major studios now had a method of getting filmgoers back into theaters and away from television sets, which were causing a steady decline in attendance. Universal-International released its first 3D feature, It Came from Outer Space, on May 27, 1953, with stereophonic sound. That was followed by Paramount's first 3D feature, Sangaree with Fernando Lamas and Arlene Dahl. The Walt Disney Studios entered 3D with its May 28, 1953, release of Melody, which accompanied the first 3D western, Columbia's Fort Ti at its Los Angeles opening. It was later shown at Disneyland's Fantasyland Theater in 1957 as part of a program with Disney's other short Working for Peanuts, entitled, 3-D Jamboree. The show was hosted by the Mousketeers and was in color. Columbia released several 3D westerns produced by Sam Katzman and directed by William Castle. Castle would later specialize in various technical in-theater gimmicks for such Columbia and Allied Artists features as 13 Ghosts, House on Haunted Hill, and The Tingler. Columbia also produced the only slapstick comedies conceived for 3D. The Three Stooges starred in Spooks and Pardon My Backfire; dialect comic Harry Mimmo starred in Down the Hatch. Producer Jules White was optimistic about the possibilities of 3D as applied to slapstick (with pies and other projectiles aimed at the audience), but only two of his stereoscopic shorts were shown in 3D. Down the Hatch was released as a conventional, "flat" motion picture. (Columbia has since printed Down the Hatch in 3D for film festivals.) John Ireland, Joanne Dru and Macdonald Carey starred in the Jack Broder color production Hannah Lee, which premiered on June 19, 1953. The film was directed by Ireland, who sued Broder for his salary. Broder counter-sued, claiming that Ireland went over production costs with the film.[citation needed] Another famous entry in the golden era of 3D was the 3 Dimensional Pictures production of Robot Monster. The film was allegedly scribed in an hour by screenwriter Wyott Ordung and filmed in a period of two weeks on a shoestring budget.[citation needed] Despite these shortcomings and the fact that the crew had no previous experience with the newly built camera rig, luck was on the cinematographer's side, as many find the 3D photography in the film is well shot and aligned. Robot Monster also has a notable score by then up-and-coming composer Elmer Bernstein. The film was released June 24, 1953, and went out with the short Stardust in Your Eyes, which starred nightclub comedian, Slick Slavin.[citation needed] 20th Century Fox produced its only 3D feature, Inferno, in 1953, starring Rhonda Fleming. Fleming, who also starred in Those Redheads From Seattle, and Jivaro, shares the spot for being the actress to appear in the most 3D features with Patricia Medina, who starred in Sangaree, Phantom of the Rue Morgue and Drums of Tahiti. Darryl F. Zanuck expressed little interest in stereoscopic systems, and at that point was preparing to premiere the new widescreen film system, CinemaScope. The first decline in the theatrical 3D craze started in August and September 1953. The factors causing this decline were: Two prints had to be projected simultaneously.[citation needed] The prints had to remain exactly alike after repair, or synchronization would be lost.[citation needed] It sometimes required two projectionists to keep sync working properly.[citation needed] When either prints or shutters became out of sync, even for a single frame, the picture became virtually unwatchable and accounted for headaches and eyestrain.[citation needed] The necessary silver projection screen was very directional and caused sideline seating to be unusable with both 3D and regular films, due to the angular darkening of these screens. Later films that opened in wider-seated venues often premiered flat for that reason (such as Kiss Me Kate at the Radio City Music Hall).[citation needed] A mandatory intermission was needed to properly prepare the theater's projectors for the showing of the second half of the film.[citation needed] Because projection booth operators were at many times careless, even at preview screenings of 3D films, trade and newspaper critics claimed that certain films were "hard on the eyes."[citation needed] Sol Lesser attempted to follow up Stereo Techniques with a new showcase, this time five shorts that he himself produced.[citation needed] The project was to be called The 3-D Follies and was to be distributed by RKO.[citation needed] Unfortunately, because of financial difficulties and the general loss of interest in 3D, Lesser canceled the project during the summer of 1953, making it the first 3D film to be aborted in production.[citation needed] Two of the three shorts were shot: Carmenesque, a burlesque number starring exotic dancer Lili St. Cyr, and Fun in the Sun, a sports short directed by famed set designer/director William Cameron Menzies, who also directed the 3D feature The Maze for Allied Artists. Although it was more expensive to install, the major competing realism process was wide-screen, but two-dimensional, anamorphic, first utilized by Fox with CinemaScope and its September premiere in The Robe. Anamorphic films needed only a single print, so synchronization was not an issue. Cinerama was also a competitor from the start and had better quality control than 3D because it was owned by one company that focused on quality control. However, most of the 3D features past the summer of 1953 were released in the flat widescreen formats ranging from 1.66:1 to 1.85:1. In early studio advertisements and articles about widescreen and 3D formats, widescreen systems were referred to as "3D", causing some confusion among scholars.[citation needed] There was no single instance of combining CinemaScope with 3D until 1960, with a film called September Storm, and even then, that was a blow-up from a non-anamorphic negative.[citation needed] September Storm also went out with the last dual-strip short, Space Attack, which was actually shot in 1954 under the title The Adventures of Sam Space. In December 1953, 3D made a comeback with the release of several important 3D films, including MGM's musical Kiss Me, Kate. Kate was the hill over which 3D had to pass to survive. MGM tested it in six theaters: three in 3D and three-flat.[citation needed] According to trade ads of the time, the 3D version was so well-received that the film quickly went into a wide stereoscopic release.[citation needed] However, most publications, including Kenneth Macgowan's classic film reference book Behind the Screen, state that the film did much better as a "regular" release. The film, adapted from the popular Cole Porter Broadway musical, starred the MGM songbird team of Howard Keel and Kathryn Grayson as the leads, supported by Ann Miller, Keenan Wynn, Bobby Van, James Whitmore, Kurt Kasznar and Tommy Rall. The film also prominently promoted its use of stereophonic sound. Several other features that helped put 3D back on the map that month were the John Wayne feature Hondo (distributed by Warner Bros.), Columbia's Miss Sadie Thompson with Rita Hayworth, and Paramount's Money From Home with Dean Martin and Jerry Lewis. Paramount also released the cartoon shorts Boo Moon with Casper, the Friendly Ghost and Popeye, Ace of Space with Popeye the Sailor. Paramount Pictures released a 3D Korean War film Cease Fire filmed on actual Korean locations in 1953.[41] Top Banana, based on the popular stage musical with Phil Silvers, was brought to the screen with the original cast. Although it was merely a filmed stage production, the idea was that every audience member would feel they would have the best seat in the house through color photography and 3D.[citation needed] Although the film was shot and edited in 3D, United Artists, the distributor, felt the production was uneconomical in stereoscopic form and released the film flat on January 27, 1954.[citation needed] It remains one of two "Golden era" 3D features, along with another United Artists feature, Southwest Passage (with John Ireland and Joanne Dru), that are currently considered lost (although flat versions survive). A string of successful films filmed in 3D followed the second wave, but many were widely or exclusively shown flat. Some highlights are: The French Line, starring Jane Russell and Gilbert Roland, a Howard Hughes/RKO production. The film became notorious for being released without an MPAA seal of approval after several suggestive lyrics were included, as well as one of Ms. Russell's particularly revealing costumes.[citation needed] Playing up her sex appeal, one tagline for the film was, "It'll knock both of your eyes out!" The film was later cut and approved by the MPAA for a general flat release, despite having a wide and profitable 3D release.[citation needed] Taza, Son of Cochise, a sequel to 1950s Broken Arrow, which starred Rock Hudson in the title role, Barbara Rush as the love interest, and Rex Reason (billed as Bart Roberts) as his renegade brother. Originally released flat through Universal-International. It was directed by the great stylist Douglas Sirk, and his striking visual sense made the film a huge success when it was "re-premiered" in 3D in 2006 at the Second 3D Expo in Hollywood. Two ape films: Phantom of the Rue Morgue, featuring Karl Malden and Patricia Medina, produced by Warner Bros. and based on Edgar Allan Poe's "The Murders in the Rue Morgue", and Gorilla at Large, a Panoramic Production starring Cameron Mitchell, distributed flat and 3D through Fox. Creature from the Black Lagoon, starring Richard Carlson and Julie Adams, directed by Jack Arnold. Although arguably the most famous 3D film, it was typically seen in 3D only in large urban theaters and shown flat in the many smaller neighborhood theaters.[42] It was the only 3D feature that spawned a 3D sequel, Revenge of the Creature, which was in turn followed by The Creature Walks Among Us, shot flat. Dial M for Murder, directed by Alfred Hitchcock and starring Ray Milland, Robert Cummings, and Grace Kelly, is considered by aficionados of 3D to be one of the best examples of the process. Although available in 3D in 1954, there are no known playdates in 3D,[citation needed] since Warner Bros. had just instated a simultaneous 3D/2D release policy. The film's screening in 3D in February 1980 at the York Theater in San Francisco did so well that Warner Bros. re-released the film in 3D in February 1982. The film is now available on 3D Blu-ray, marking the first time it was released on home video in its 3D presentation. Gog, the last episode in Ivan Tors' Office of Scientific Investigation (OSI) trilogy dealing with realistic science fiction (following The Magnetic Monster and Riders to the Stars). Most theaters showed it flat. The Diamond (released in the United States as The Diamond Wizard), a 1954 British crime film starring Dennis O'Keefe. The only stereoscopic feature shot in Britain, released flat in both the UK and US. Irwin Allen's Dangerous Mission released by RKO in 1954 featuring Allen's trademarks of an all-star cast facing a disaster (a forest fire). Bosley Crowther's New York Times review mentions that it was shown flat. Son of Sinbad, another RKO/Howard Hughes production, starring Dale Robertson, Lili St. Cyr, and Vincent Price. The film was shelved after Hughes ran into difficulty with The French Line, and was not released until 1955, at which time it went out flat, converted to the SuperScope process. 3D's final decline was in the late spring of 1954, for the same reasons as the previous lull, as well as the further success of widescreen formats with theater operators. Even though Polaroid had created a well-designed "Tell-Tale Filter Kit" for the purpose of recognizing and adjusting out of sync and phase 3D,[43] exhibitors still felt uncomfortable with the system and turned their focus instead to processes such as CinemaScope. The last 3D feature to be released in that format during the "Golden era" was Revenge of the Creature, on February 23, 1955. Ironically, the film had a wide release in 3D and was well received at the box office.[44] Stereoscopic films largely remained dormant for the first part of the 1960s, with those that were released usually being anaglyph exploitation films. One film of notoriety was the Beaver-Champion/Warner Bros. production, The Mask (1961). The film was shot in 2-D, but to enhance the bizarre qualities of the dream-world that is induced when the main character puts on a cursed tribal mask, these scenes went to anaglyph 3D. These scenes were printed by Technicolor on their first run in red/green anaglyph. Although 3D films appeared sparsely during the early 1960s, the true second wave of 3D cinema was set into motion by Arch Oboler, the producer who had started the craze of the 1950s. Using a new technology called Space-Vision 3D. The origin of "Space-Vision 3D" goes back to Colonel Robert Vincent Bernier, a forgotten innovator in the history of stereoscopic motion pictures. His Trioptiscope Space-Vision lens was the gold standard for the production and exhibition of 3-D films for nearly 30 years.[45] "Space-Vision 3D" stereoscopic films were printed with two images, one above the other, in a single academy ratio frame, on a single strip, and needed only one projector fitted with a special lens. This so-called "over and under" technique eliminated the need for dual projector set-ups, and produced widescreen, but darker, less vivid, polarized 3D images. Unlike earlier dual system, it could stay in perfect synchronization, unless improperly spliced in repair. Arch Oboler once again had the vision for the system that no one else would touch, and put it to use on his film entitled The Bubble, which starred Michael Cole, Deborah Walley, and Johnny Desmond. As with Bwana Devil, the critics panned The Bubble, but audiences flocked to see it, and it became financially sound enough to promote the use of the system to other studios, particularly independents, who did not have the money for expensive dual-strip prints of their productions. In 1970, Stereovision, a new entity founded by director/inventor Allan Silliphant and optical designer Chris Condon, developed a different 35 mm single-strip format, which printed two images squeezed side by side and used an anamorphic lens to widen the pictures through Polaroid filters. Louis K. Sher (Sherpix) and Stereovision released the softcore sex comedy The Stewardesses (self-rated X, but later re-rated R by the MPAA). The film cost US$100,000 to produce, and ran for months in several markets.[citation needed] eventually earning $27 million in North America, alone ($140 million in constant-2010 dollars) in fewer than 800 theaters, becoming the most profitable 3-Dimensional film to date, and in purely relative terms, one of the most profitable films ever. It was later released in 70 mm 3D. Some 36 films worldwide were made with Stereovision over 25 years, using either a widescreen (above-below), anamorphic (side by side) or 70 mm 3D formats.[citation needed] In 2009 The Stewardesses was remastered by Chris Condon and director Ed Meyer, releasing it in XpanD 3D, RealD Cinema and Dolby 3D. The quality of the 1970s 3D films was not much more inventive, as many were either softcore and even hardcore adult films, horror films, or a combination of both. Paul Morrisey's Flesh For Frankenstein (aka Andy Warhol's Frankenstein) was a superlative example of such a combination. Between 1981 and 1983 there was a new Hollywood 3D craze started by the spaghetti western Comin' at Ya!. When Parasite was released it was billed as the first horror film to come out in 3D in over 20 years. Horror films and reissues of 1950s 3D classics (such as Hitchcock's Dial M for Murder) dominated the 3D releases that followed. The second sequel in the Friday the 13th series, Friday the 13th Part III, was released very successfully. Apparently saying "part 3 in 3D" was considered too cumbersome so it was shortened in the titles of Jaws 3-D and Amityville 3-D, which emphasized the screen effects to the point of being annoying at times, especially when flashlights were shone into the eyes of the audience. The science fiction film Spacehunter: Adventures in the Forbidden Zone was the most expensive 3D film made up to that point with production costs about the same as Star Wars but not nearly the same box office success, causing the craze to fade quickly through spring 1983. Other sci-fi/fantasy films were released as well including Metalstorm: The Destruction of Jared-Syn and Treasure of the Four Crowns, which was widely criticized for poor editing and plot holes, but did feature some truly spectacular closeups. 3D releases after the second craze included The Man Who Wasn't There (1983), Silent Madness and the 1985 animated film Starchaser: The Legend of Orin, whose plot seemed to borrow heavily from Star Wars. Only Comin' At Ya!, Parasite, and Friday the 13th Part III have been officially released on VHS and/or DVD in 3D in the United States (although Amityville 3D has seen a 3D DVD release in the United Kingdom). Most of the 1980s 3D films and some of the classic 1950s films such as House of Wax were released on the now defunct Video Disc (VHD) format in Japan as part of a system that used shutter glasses. Most of these have been unofficially transferred to DVD and are available on the grey market through sites such as eBay. Stereoscopic movies were also popular in other parts of the world, such as My Dear Kuttichathan, a Malayalam film which was shot with stereoscopic 3D and released in 1984. In the mid-1980s, IMAX began producing non-fiction films for its nascent 3D business, starting with We Are Born of Stars (Roman Kroitor, 1985). A key point was that this production, as with all subsequent IMAX productions, emphasized mathematical correctness of the 3D rendition and thus largely eliminated the eye fatigue and pain that resulted from the approximate geometries of previous 3D incarnations. In addition, and in contrast to previous 35mm-based 3D presentations, the very large field of view provided by IMAX allowed a much broader 3D "stage", arguably as important in 3D film as it is theatre. The Walt Disney Company also began more prominent use of 3D films in special venues to impress audiences with Magic Journeys (1982) and Captain EO (Francis Ford Coppola, 1986, starring Michael Jackson) being notable examples. In the same year, the National Film Board of Canada production Transitions (Colin Low), created for Expo 86 in Vancouver, was the first IMAX presentation using polarized glasses. Echoes of the Sun (Roman Kroitor, 1990) was the first IMAX film to be presented using alternate-eye shutterglass technology, a development required because the dome screen precluded the use of polarized technology. From 1990 onward, numerous films were produced by all three parties to satisfy the demands of their various high-profile special attractions and IMAX's expanding 3D network. Films of special note during this period include the extremely successful Into the Deep (Graeme Ferguson, 1995) and the first IMAX 3D fiction film Wings of Courage (1996), by director Jean-Jacques

and blue for the left eye. Glasses which filter out the very specific wavelengths allow the wearer to see a 3D image. This technology eliminates the expensive silver screens required for polarized systems such as RealD, which is the most common 3D display system in theaters. It does, however, require much more expensive glasses than the polarized systems. It is also known as spectral comb filtering or wavelength multiplex visualization The recently introduced Omega 3D/Panavision 3D system also uses this technology, though with a wider spectrum and more "teeth" to the "comb" (5 for each eye in the Omega/Panavision system). The use of more spectral bands per eye eliminates the need to color process the image, required by the Dolby system. Evenly dividing the visible spectrum between the eyes gives the viewer a more relaxed "feel" as the light energy and color balance is nearly 50-50. Like the Dolby system, the Omega system can be used with white or silver screens. But it can be used with either film or digital projectors, unlike the Dolby filters that are only used on a digital system with a color correcting processor provided by Dolby. The Omega/Panavision system also claims that their glasses are cheaper to manufacture than those used by Dolby.[86] In June 2012 the Omega 3D/Panavision 3D system was discontinued by DPVO Theatrical, who marketed it on behalf of Panavision, citing "challenging global economic and 3D market conditions".[87] Although DPVO dissolved its business operations, Omega Optical continues promoting and selling 3D systems to non-theatrical markets. Omega Optical's 3D system contains projection filters and 3D glasses. In addition to the passive stereoscopic 3D system, Omega Optical has produced enhanced anaglyph 3D glasses. The Omega's red/cyan anaglyph glasses use complex metal oxide thin film coatings and high quality annealed glass optics. Main article: Autostereoscopy In this method, glasses are not necessary to see the stereoscopic image. Lenticular lens and parallax barrier technologies involve imposing two (or more) images on the same sheet, in narrow, alternating strips, and using a screen that either blocks one of the two images' strips (in the case of parallax barriers) or uses equally narrow lenses to bend the strips of image and make it appear to fill the entire image (in the case of lenticular prints). To produce the stereoscopic effect, the person must be positioned so that one eye sees one of the two images and the other sees the other. Both images are projected onto a high-gain, corrugated screen which reflects light at acute angles. In order to see the stereoscopic image, the viewer must sit within a very narrow angle that is nearly perpendicular to the screen, limiting the size of the audience. Lenticular was used for theatrical presentation of numerous shorts in Russia from 1940 to 1948[76] and in 1946 for the feature-length film Robinson Crusoe.[88] Though its use in theatrical presentations has been rather limited, lenticular has been widely used for a variety of novelty items and has even been used in amateur 3D photography.[89][90] Recent use includes the Fujifilm FinePix Real 3D with an autostereoscopic display that was released in 2009. Other examples for this technology include autostereoscopic LCD displays on monitors, notebooks, TVs, mobile phones and gaming devices, such as the Nintendo 3DS. Main article: Health effects of 3D Some viewers have complained of headaches and eyestrain after watching 3D films.[91] Motion sickness, in addition to other health concerns,[92] are more easily induced by 3D presentations. One published study shows that of those who watch 3D films, nearly 55% experience varying levels of headaches, nausea and disorientation.[93] Glasses designed to eliminate eyestrain by converting 3D images back into 2D have been developed.[94] There are two primary effects of 3D film that are unnatural for human vision: crosstalk between the eyes, caused by imperfect image separation, and the mismatch between convergence and accommodation, caused by the difference between an object's perceived position in front of, or behind the screen and the real origin of that light on the screen. It is believed that approximately 12% of people are unable to properly see 3D images, due to a variety of medical conditions.[95][96] According to another experiment up to 30% of people have very weak stereoscopic vision preventing them from depth perception based on stereo disparity. This nullifies or greatly decreases immersion effects of digital stereo to them.[97] It has recently been discovered that each of the rods and cones in animal eyes can measure the distance to the point on the object that is in focus at the particular rod or cone. Each rod or cone can act as a passive LIDAR (Light Detection And Ranging). The lens selects the point on the object for each pixel to which the distance is measured; that is, humans can see in 3D separately with each eye.[98] If the brain uses this ability in addition to the stereoscopic effect and other cues no stereoscopic system can present a true 3D picture to the brain. The French National Research Agency (ANR) has sponsored multidisciplinary research in order to understand the effects of 3D film viewing, its grammar[clarification needed], and its acceptance.[99] After Toy Story, there were 10 really bad CG movies because everybody thought the success of that film was CG and not great characters that were beautifully designed and heartwarming. Now, you've got people quickly converting movies from 2D to 3D, which is not what we did. They're expecting the same result, when in fact they will probably work against the adoption of 3D because they'll be putting out an inferior product.—Avatar director James Cameron[100] Most of the cues required to provide humans with relative depth information are already present in traditional 2D films. For example, closer objects occlude further ones, distant objects are desaturated and hazy relative to near ones, and the brain subconsciously "knows" the distance of many objects when the height is known (e.g. a human figure subtending only a small amount of the screen is more likely to be 2 m tall and far away than 10 cm tall and close). In fact, only two of these depth cues are not already present in 2D films: stereopsis (or parallax) and the focus of the eyeball (accommodation). 3D film-making addresses accurate presentation of stereopsis but not of accommodation, and therefore is insufficient in providing a complete 3D illusion. However, promising results from research aimed at overcoming this shortcoming were presented at the 2010 Stereoscopic Displays and Applications conference in San Jose, U.S.[101] Film critic Mark Kermode[102] argued that 3D adds "not that much" value to a film, and said that, while he liked Avatar, the many impressive things he saw in the film had nothing to do with 3D. Kermode has been an outspoken critic of 3D film describing the effect as a "nonsense" and recommends using two right or left lenses from the 3D glasses to cut out the "pointy, pointy 3D stereoscopic vision", although this technique still does not improve the huge brightness loss from a 3D film.[103] Versions of these "2-D glasses" are being marketed.[104] As pointed out in the article "Virtual Space – the movies of the future"[105][failed verification] in real life the 3D effect, or stereoscopic vision, depends on the distance between the eyes, which is only about 2+1⁄2 inches. The depth perception this affords is only noticeable near to the head – at about arms length. It is only useful for such tasks as threading a needle. It follows that in films portraying real life, where nothing is ever shown so close to the camera, the 3D effect is not noticeable and is soon forgotten as the film proceeds. Director Christopher Nolan has criticised the notion that traditional film does not allow depth perception, saying "I think it's a misnomer to call it 3D versus 2D. The whole point of cinematic imagery is it's three dimensional... You know 95% of our depth cues come from occlusion, resolution, color and so forth, so the idea of calling a 2D movie a '2D movie' is a little misleading."[106] Nolan also criticised that shooting on the required digital video does not offer a high enough quality image[107] and that 3D cameras cannot be equipped with prime (non-zoom) lenses.[106] Late film critic Roger Ebert repeatedly criticized 3D film as being "too dim", sometimes distracting or even nausea-inducing, and argued that it is an expensive technology that adds nothing of value to the film-going experience (since 2-D films already provide a sufficient illusion of 3D).[108] While Ebert was "not opposed to 3-D as an option", he opposed it as a replacement for traditional film, and preferred 2-D technologies such as MaxiVision48 that improve image area/resolution and frames per second.[108] Most 3D systems will cut down the brightness of the picture considerably – the light loss can be as high as 88%. Some of this loss may be compensated by running the projector's bulb at higher power or using more powerful bulbs.[109] The 2D brightness cinema standard is 14 foot-lamberts (48 candela per square metre), as set by the SMPTE standard 196M. As of 2012[update], there is no official standard for 3D brightness. According to the industry de facto standard, however, the "acceptable brightness range" goes as low as 3.5 fL (12 cd/m2) – just 25% of the standard 2D brightness.[110] Among others, Christopher Nolan has criticized the huge brightness loss: "You're not that aware of it because once you're 'in that world,' your eye compensates, but having struggled for years to get theaters up to the proper brightness, we're not sticking polarized filters in everything."[111] In September 2012, the DCI standards body issued a "recommended practice" calling for a 3D projection brightness of 7 fL (24 cd/m2), with an acceptable range of 5–9 fL (17–31 cd/m2).[2] It is not known how many theaters actually achieve such light levels with current technology. Prototype laser projection systems have reached 14 fL (48 cd/m2) for 3D on a cinema screen.[3] Main article: 2D to 3D conversion Another major criticism is that many of the films in the 21st century to date were not filmed in 3D, but converted into 3-D after filming. Filmmakers who have criticized the quality of this process include James Cameron (whose film Avatar was created mostly in 3D from the ground up, with some portions of the film created in 2D,[112] and is largely credited with the revival of 3D) and Michael Bay.[100] However, Cameron has said that quality 2D to 3D conversions can be done if they take the time they need and the director is involved.[113] Cameron's Titanic was converted into 3D in 2012, taking 60 weeks and costing $18 million. In contrast, computer-animated films for which the original computer models are still available can be rendered in 3D easily, as the depth information is still available and does not need to be inferred or approximated. This has been done with Toy Story, among others.[114] Film portal Cinematography Digital cinema List of 3D films (1914–2004) List of 3D films (2005–present) 2D to 3D conversion Depth perception Stereoscopy Autostereoscopy 3D display 3D television 4D film Volumetric display 3-D Film Preservation Fund Motion capture Stereoscopic video game Surround sound Digital 3D Disney Digital 3-D RealD 3D Dolby 3D XpanD 3D MasterImage 3D IMAX 3D 4DX ^ Goldberg, Matt (April 6, 2018). "3D Is Dead (Again)". Collider. ^ "animation | History, Movies, Television, & Facts". Britannica. Retrieved April 18, 2022. ^ a b Mills, Virginia (August 13, 2018). "180 years of 3D". Royal Society. Retrieved January 16, 2023. ^ Bulletins de l'Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique (in French). Hayez. 1849. ^ Pellerin, Denis (October 13, 2017). "The Quest for Stereoscopic Movement: Was the First Film ever in 3-D?". International Journal on Stereo & Immersive Media. 1 (1). 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For motion pictures created using stereophotogrammetry, see Volumetric video. 3D films are motion pictures made to give an illusion of three-dimensional solidity, usually with the help of special glasses worn by viewers. They have existed in some form since 1915[citation needed], but had been largely relegated to a niche in the motion picture industry because of the costly hardware and processes required to produce and display a 3D film, and the lack of a standardized format for all segments of the entertainment business. Nonetheless, 3D films were prominently featured in the 1950s in American cinema and later experienced a worldwide resurgence in the 1980s and 1990s driven by IMAX high-end theaters and Disney-themed venues. 3D films became increasingly successful throughout the 2000s, peaking with the success of 3D presentations of Avatar in December 2009, after which 3D films again decreased in popularity.[1] Certain directors have also taken more experimental approaches to 3D filmmaking, most notably celebrated auteur Jean-Luc Godard in his film Goodbye to Language. This section needs additional citations for verification. Please help improve this article by adding citations to reliable sources in this section. Unsourced material may be challenged and removed. (December 2009) (Learn how and when to remove this message) The basic components of 3D film were introduced separately between 1833 and 1839. Stroboscopic animation was developed by Joseph Plateau in 1832 and published in 1833 in the form of a stroboscopic disc,[2] which he later called the fantascope and became better known as the phénakisticope. Around the very same time (1832/1833), Charles Wheatstone developed the stereoscope, but he did not really make it public before June 1838.[3] The first practical forms of photography were introduced in January 1839 by Louis Daguerre and Henry Fox Talbot. A combination of these elements into animated stereoscopic photography may have been conceived early on, but for decades it did not become possible to capture motion in real-time photographic recordings due to the long exposure times necessary for the light-sensitive emulsions that were used. Charles Wheatstone got inventor Henry Fox Talbot to produce some calotype pairs for the stereoscope and received the first results in October 1840.[3] Only a few more experimental stereoscopic photographs were made before David Brewster introduced his stereoscope with lenses in 1849. Wheatstone also approached Joseph Plateau with the suggestion to combine the stereoscope with the fantascope. In 1849, Plateau published about this concept in an article about several improvements made to his fantascope and suggested a stop-motion technique that would involve a series of photographs of purpose-made plaster statuettes in different poses.[4] The idea reached Jules Duboscq, an instrument maker who already marketed Plateau's Fantascope as well as the stereoscopes of Wheatstone and Brewster. In November 1852, Duboscq added the concept of his "Stéréoscope-fantascope, ou Bioscope" to his stereoscope patent. Production of images proved very difficult, since the photographic sequence had to be carefully constructed from separate still images. The bioscope was no success, and the only extant disc, without apparatus, is found in the Joseph Plateau collection of the University of Ghent. The disc contains 12 albumen image pairs of a machine in motion.[5] Most of the other early attempts to create motion pictures also aimed to include the stereoscopic effect. In November 1851, Antoine Claudet claimed to have created a stereoscope that showed people in motion.[6] The device initially only showed two phases, but during the next two years, Claudet worked on a camera that would record stereoscopic pairs for four different poses (patented in 1853).[7] Claudet found that the stereoscopic effect did not work properly in this device, but believed the illusion of motion was successful.[8] In 1855, Johann Nepomuk Czermak published an article about his Stereophoroskop. His first idea to create 3D animation involved sticking pins in a stroboscopic disc to create a sequence that would show one pin moving further into the cardboard and back. He also designed a device that would feed the image pairs from two stroboscopic discs into one lenticular stereoscope and a vertical predecessor of the zoetrope.[9] On February 27, 1860, Peter Hubert Desvignes received British patent no. 537 for 28 monocular and stereoscopic variations of cylindrical stroboscopic devices. This included a version that used an endless band of pictures running between two spools that was intermittently lit by an electric spark.[10] Desvignes' Mimoscope, received an Honourable Mention "for ingenuity of construction" at the 1862 International Exhibition in London.[11] It could "exhibit drawings, models, single or stereoscopic photographs, so as to animate animal movements, or that of machinery, showing various other illusions."[12] Desvignes "employed models, insects and other objects, instead of pictures, with perfect success." The horizontal slits (like in Czermak's Stereophoroskop) allowed a much improved view, with both eyes, of the opposite pictures.[13] In 1861, American engineer Coleman Sellers II received US patent No. 35,317 for the kinematoscope, a device that exhibited "stereoscopic pictures as to make them represent objects in motion". In his application he stated: "This has frequently been done with plane pictures but has never been, with stereoscopic pictures". He used three sets of stereoscopic photographs in a sequence with some duplicates to regulate the flow of a simple repetitive motion, but also described a system for very large series of pictures of complicated motion.[14][15] On August 11, 1877, the Daily Alta newspaper announced a project by Eadward Muybridge and Leland Stanford to produce sequences of photographs of a running horse with 12 stereoscopic cameras. Muybridge had much experience with stereo photography and had already made instantaneous pictures of Stanford's horse Occident running at full speed. He eventually managed to shoot the proposed sequences of running horses in June 1878 with stereoscopic cameras. The published result and animated versions for his zoopraxiscope were not stereoscopic, but in 1898 Muybridge claimed that he had (privately) viewed the pictures in two synchronized zoetropes with Wheatstone's reflecting stereoscope as a "very satisfactory reproduction of an apparently solid miniature horse trotting and of another galloping".[16] Thomas Edison demonstrated his phonograph on November 29, 1877, after previous announcements of the device for recording and replaying sound had been published earlier in the year. An article in Scientific American concluded, "It is already possible, by ingenious optical contrivances, to throw stereoscopic photographs of people on screens in full view of an audience. Add the talking phonograph to counterfeit their voices, and it would be difficult to carry the illusion of real presence much further". Wordsworth Donisthorpe announced in the January 24, 1878, edition of Nature that he would advance that conception: "By combining the phonograph with the kinesigraph, I will undertake not only to produce a talking picture of Mr. Gladstone, which, with motionless lips and unchanged expression, shall positively recite his latest anti-Turkish speech in his own voice and tone. Not only this, but the life size photograph itself shall move and gesticulate precisely as he did when making the speech, the words and gestures corresponding as in real life."[17] Dr. Phipson, a correspondent for British news in a French photography magazine, relayed the concept but renamed the device "Kinétiscope" to reflect the viewing purpose rather than the recording option. This was picked up in the United States and discussed in an interview with Edison later in the year.[18] Neither Donisthorpe's or Edison's later moving picture results were stereoscopic. In the late 1890s, British film pioneer William Friese-Greene filed a patent for a 3D film process. In his patent, two films were projected side by side on screen. The viewer looked through a stereoscope to converge the two images. Because of the obtrusive mechanics behind this method, theatrical use was not practical.[19] Frederic Eugene Ives patented his stereo camera rig in 1900. The camera had two lenses coupled together 1+3⁄4 inches (4.45 centimeters) apart.[20] On June 10, 1915, Edwin S. Porter and William E. Waddell presented tests to an audience at the Astor Theater in New York City.[21] In red-green anaglyph, the audience was presented three reels of tests, which included rural scenes, test shots of Marie Doro, a segment of John Mason playing a number of passages from Jim the Penman (a film released by Famous Players–Lasky that year, but not in 3D), Oriental dancers, and a reel of footage of Niagara Falls.[22] However, according to Adolph Zukor in his 1953 autobiography The Public Is Never Wrong: My 50 Years in the Motion Picture Industry, nothing was produced in this process after these tests. By 1909, the German film market suffered much from overproduction and too much competition. German film tycoon Oskar Messter had initially gained much financial success with the Tonbild synchronized sound films of his Biophon system since 1903, but the films were losing money by the end of the decade and Messter would stop Tonbild production in 1913. Producers and exhibitors were looking into new film attractions and invested for instance in colorful imagery. The development of stereoscopic cinema seemed a logical step to lure visitors back into the movie theatres. In 1909, German civil engineer August Engelsmann patented a process that projected filmed performances within a physical decor on an actual stage. Soon after, Messter obtained patents for a very similar process, probably by agreement with Engelsmann, and started marketing it as "Alabastra". Performers were brightly dressed and brightly lit while filmed against a black background, mostly miming their singing or musical skills or dancing to the circa four-minute pre-recorded phonographs. The film recordings would be projected from below, to appear as circa 30 inch figures on a glass pane in front of a small stage, in a setup very similar to the Pepper's ghost illusion that offered a popular stage trick technique since the 1860s. The glass pane was not visible to the audience and the projected figures seemed able to move around freely across the stage in their virtual tangible and lifelike appearance. The brightness of the figures was necessary to avoid see-through spots and made them resemble alabaster sculptures. To adapt to this appearance, several films featured Pierrot or other white clowns, while some films were probably hand-coloured. Although Alabastra was well received by the press, Messter produced few titles, hardly promoted them and abandoned it altogether a few years later. He believed the system to be uneconomical due to its need for special theatres instead of the widely available movie screens, and he did not like that it seemed only suitable for stage productions and not for "natural" films. Nonetheless, there were numerous imitators in Germany and Messter and Engelsmann still teamed with American businessman Frank Joseph Godsol (Goldsoll) set up a short-lived variant named "Fantomo" in 1914.[23] Rather in agreement with Messter or not, Karl Juhasz and Franz Haushofer opened a Kinoplastikon theatre in Vienna in 1911. Their patented system was very similar to Alabaster, but projected life-size figures from the wings of the stage. With much higher ticket prices than standard cinema, it was targeted at middle-class audiences to fill the gap between low-brow films and high-class theatre. Audiences reacted enthusiastically and by 1913 there reportedly were 250 theatres outside Austria, in France, Italy, United Kingdom, Russia and North America. However, the first Kinoplastikon in Paris started in January 1914 and the premiere in New York took place in the Hippodrome in March 1915. In 1913, Walter R. Booth directed 10 films for the U.K. Kinoplastikon, presumably in collaboration with Cecil Hepworth. Theodore Brown, the licensee in the U.K. also patented a variant with front and back projection and reflected decor, and Goldsoll applied for a very similar patent only 10 days later.[23] Further development and exploitation was probably haltered by World War I. Alabastra and Kinoplastikon were often advertised as stereoscopic and screenless. Although in reality the effect was heavily dependent on glass screen projection and the films were not stereoscopic, the shows seemed truly three-dimensional as the figures were clearly separate from the background and virtually appeared inside the real, three-dimensional stage area without any visible screen. Eventually, longer (multi-reel) films with story arcs proved to be the way out of the crisis in the movie market and supplanted the previously popular short films that mostly aimed to amuse people with tricks, gags or other brief variety and novelty attractions. Sound film, stereoscopic film and other novel techniques were relatively cumbersome to combine with multiple reels and were abandoned for a while. Fairall in 1922 Fairall's 3D camera Audience wearing special glasses watch a 3D "stereoscopic film" at the Telekinema on the South Bank in London during the Festival of Britain 1951. The earliest confirmed 3D film shown to an out-of-house audience was The Power of Love, which premiered at the Ambassador Hotel Theater in Los Angeles on September 27, 1922.[24][25][26] The camera rig was a product of the film's producer, Harry K. Fairall, and cinematographer Robert F. Elder.[19] It was filmed dual-strip in black and white, and single strip color anaglyphic release prints were produced using a color film invented and patented by Harry K. Fairall. A single projector could be used to display the movie but anaglyph glasses were used for viewing. The camera system and special color release print film all received U.S Patent No. 1,784,515 on December 9, 1930.[27][28] After a preview for exhibitors and press in New York City, the film dropped out of sight, apparently not booked by exhibitors, and is now considered lost. Early in December 1922, William Van Doren Kelley, inventor of the Prizma color system, cashed in on the growing interest in 3D films started by Fairall's demonstration and shot footage with a camera system of his own design. Kelley then struck a deal with Samuel "Roxy" Rothafel to premiere the first in his series of "Plasticon" shorts entitled Movies of the Future at the Rivoli Theater in New York City. Also in December 1922, Laurens Hammond (later inventor of the Hammond organ) premiered his Teleview system, which had been shown to the trade and press in October. Teleview was the first alternating-frame 3D system seen by the public. Using left-eye and right-eye prints and two interlocked projectors, left and right frames were alternately projected, each pair being shown three times to suppress flicker. Viewing devices attached to the armrests of the theater seats had rotary shutters that operated synchronously with the projector shutters, producing a clean and clear stereoscopic result. The only theater known to have installed Teleview was the Selwyn Theater in New York City, and only one show was ever presented with it: a group of short films, an exhibition of live 3D shadows, and M.A.R.S., the only Teleview feature. The show ran for several weeks, apparently doing good business as a novelty (M.A.R.S. itself got poor reviews), but Teleview was never seen again.[29] In 1922, Frederic Eugene Ives and Jacob Leventhal began releasing their first stereoscopic shorts made over a three-year period. The first film, entitled Plastigrams, was distributed nationally by Educational Pictures in the red-and-blue anaglyph format. Ives and Leventhal then went on to produce the following stereoscopic shorts in the "Stereoscopiks Series" released by Pathé Films in 1925: Zowie (April 10), Luna-cy! (May 18), The Run-Away Taxi (December 17) and Ouch (December 17).[30] On September 22, 1924, Luna-cy! was re-released in the De Forest Phonofilm sound-on-film system.[31] The late 1920s to early 1930s saw little interest in stereoscopic pictures. In Paris, Louis Lumiere shot footage with his stereoscopic camera in September 1933. The following March he exhibited a remake of his 1895 short film L'Arrivée du Train, this time in anaglyphic 3D, at a meeting of the French Academy of Science.[26] In 1936, Leventhal and John Norling were hired based on their test footage to film MGM's Audioscopiks series. The prints were by Technicolor in the red-and-green anaglyph format, and were narrated by Pete Smith. The first film, Audioscopiks, premiered January 11, 1936, and The New Audioscopiks premiered January 15, 1938. Audioscopiks was nominated for the Academy Award in the category Best Short Subject, Novelty in 1936. With the success of the two Audioscopiks films, MGM produced one more short in anaglyph 3D, another Pete Smith Specialty called Third Dimensional Murder (1941). Unlike its predecessors, this short was shot with a studio-built camera rig. Prints were by Technicolor in red-and-blue anaglyph. The short is notable for being one of the few live-action appearances of the Frankenstein Monster as conceived by Jack Pierce for Universal Studios outside of their company. While many of these films were printed by color systems, none of them was actually in color, and the use of the color printing was only

Avatar has gone on to be one of the most expensive films of all time, with a budget at $237 million; it is also the highest-grossing film of all time. The main technologies used to exhibit these films, and many others released around the time and up to the present, are RealD 3D, Dolby 3D, XpanD 3D, MasterImage 3D, and IMAX 3D. The success of the film also led to electronics manufacturers releasing 3D televisions[56] and caused 3D films[57] to increase in popularity. March and April 2010 saw three major 3D releases clustered together, with Alice in Wonderland hitting US theaters on March 5, 2010, How to Train Your Dragon on March 26, 2010, and Clash of the Titans on April 2, 2010. On May 13 of the same year, China's first IMAX 3D film started shooting. The pre-production of the first 3D film shot in France, Derrière les murs, began in May 2010 and was released in mid-2011. On October 1, 2010 Scar3D was the first-ever stereoscopic 3D Video-on-demand film released through major cable broadcasters for 3D televisions in the United States. Released in the United States on May 21, 2010, Shrek Forever After by DreamWorks Animation (Paramount Pictures) used the Real D 3D system, also released in IMAX 3D. In September 2003, Sabucat Productions organized the first World 3-D Exposition, celebrating the 50th anniversary of the original craze. The Expo was held at Grauman's Egyptian Theatre. During the two-week festival, over 30 of the 50 "golden era" stereoscopic features (as well as shorts) were screened, many coming from the collection of film historian and archivist Robert Furmanek, who had spent the previous 15 years painstakingly tracking down and preserving each film to its original glory. In attendance were many stars from each film, respectively, and some were moved to tears by the sold-out seating with audiences of film buffs from all over the world who came to remember their previous glories. In May 2006, the second World 3-D Exposition was announced for September of that year, presented by the 3-D Film Preservation Fund. Along with the favorites of the previous exposition were newly discovered features and shorts, and like the previous Expo, guests from each film. Expo II was announced as being the locale for the world premiere of several films never before seen in 3D, including The Diamond Wizard and the Universal short, Hawaiian Nights with Mamie Van Doren and Pinky Lee. Other "re-premieres" of films not seen since their original release in stereoscopic form included Cease Fire!, Taza, Son of Cochise, Wings of the Hawk, and Those Redheads From Seattle. Also shown were the long-lost shorts Carmenesque and A Day in the Country (both 1953) and William Van Doren Kelley's two Plasticon shorts (1922 and 1923). In the wake of its initial popularity and corresponding increase in the number of screens, more films were being released in the 3D format, yet fewer people were choosing to see them in such a way. For instance, only 45% of the premiere weekend box office earnings of Kung Fu Panda 2 in 2011 came from 3D screenings as opposed to 60% for Shrek Forever After in 2010.[58] In addition, the premiere of Cars 2 opening weekend gross consisted of only 37% from 3D theatres.[59] Harry Potter and the Deathly Hallows – Part 2 and Captain America: The First Avenger were major releases that achieved similar percentages: 43% and 40% respectively.[60] In view of this trend, there has been box office analysis concluding the implementation of 3D presentation is apparently backfiring by discouraging people from going to film theatres at all. As Brandon Gray of Box Office Mojo notes, "In each case, 3D's more-money-from-fewer-people approach has simply led to less money from even fewer people."[61] Parallel, the number of televisions sold with support for 3D television has dropped, let alone those sold with actual 3D goggles. According to the Motion Picture Association of America, despite a record total of 47 3D films being released in 2011, the overall domestic box office receipts were down 18% to $1.8 billion from $2.2 billion in 2010.[62] Although revenues as a whole increased during 2012, the bulk has so far come from 2D presentations as exemplified by little over 50% of filmgoers opting to see the likes of The Avengers and 32% choosing Brave in their 3D versions. Conflicting reasons are respectively offered by studios and exhibitors: whereas the former blame more expensive 3D ticket prices, the latter argue that the quality of films in general is at fault. However, despite the perceived decline of 3D in the U.S. market, studio chiefs in 2012 were optimistic of better receipts internationally, where there still appeared to be a strong appetite for the format.[63][64][needs update] Studios are also using 3D to generate additional income from films that are already commercially successful. Such re-releases usually involve a conversion from 2D. For example, Disney has reissued both The Lion King and Beauty and the Beast, with plans to add some of its other well-known titles.[65] Titanic has also been modified for 3D,[66] and there are also plans to similarly present all six Star Wars films.[67] Jeffrey Katzenberg, a producer of 3D films and one of the leading proponents of the format, blames oversaturation of the market with inferior films, especially ones photographed conventionally and then digitally processed in post-production. He claims that such films have led audiences to conclude that the format is not worth the often much higher ticket price.[68] Daniel Engber, a columnist for Slate, comes to a similar conclusion: "What happened to 3-D? It may have died from a case of acute septicemia—too much crap in the system."[69] Film critic Mark Kermode, a noted detractor of 3D, has surmised that there is an emerging policy of distributors to limit the availability of 2D versions, thus "railroading" the 3D format into cinemas whether the paying filmgoer likes it or not. This was especially prevalent during the release of Prometheus in 2012, where only 30% of prints for theatrical exhibition (at least in the UK) were in 2D.[70] His suspicions were later reinforced by a substantial number of complaints about Dredd from those who wished to see it in 2D but were denied the opportunity.[71] In July 2017, IMAX announced that they would begin to focus on screening more Hollywood tentpole movies in 2D (even if there's a 3D version) and have fewer 3D screenings of movies in North America, citing that moviegoers in North America prefer 2D films over 3D films.[72] In 2024, 3D films in 4K HDR became available to home media for the first time, with the launch of the visionOS operating system offering two services to access movies in such formats: Apple TV and Disney+. Some films were also offered in high frame rate (48fps), such as Avatar: The Way of Water. Other 3D media shot in 8K with a 180-degree view was also made available under the moniker "Apple Immersive Video."[73][74] Further information: Stereoscopy Stereoscopic motion pictures can be produced through a variety of different methods. Over the years the popularity of systems being widely employed in film theaters has waxed and waned. Though anaglyph was sometimes used prior to 1948, during the early "Golden Era" of 3D cinematography of the 1950s the polarization system was used for every single feature-length film in the United States, and all but one short film.[75] In the 21st century, polarization 3D systems have continued to dominate the scene, though during the 1960s and 1970s some classic films which were converted to anaglyph for theaters not equipped for polarization, and were even shown in 3D on television.[76] In the years following the mid-1980s, some films were made with short segments in anaglyph 3D. The following are some of the technical details and methodologies employed in some of the more notable 3D film systems that have been developed. Main article: Stereo photography techniques The standard for shooting live-action films in 3D involves using two cameras mounted so that their lenses are about as far apart from each other as the average pair of human eyes, recording two separate images for both the left eye and the right eye. In principle, two normal 2D cameras could be put side-to-side but this is problematic in many ways. The only real option is to invest in new stereoscopic cameras. Moreover, some cinematographic tricks that are simple with a 2D camera become impossible when filming in 3D. This means those otherwise cheap tricks need to be replaced by expensive CGI.[77] In 2008, Journey to the Center of the Earth became the first live-action feature film to be shot with the earliest Fusion Camera System released in Digital 3D and was later followed by several others. Avatar (2009) was shot in a 3D process that is based on how the human eye looks at an image. It was an improvement to the existing 3D camera system. Many 3D camera rigs still in use simply pair two cameras side by side, while newer rigs are paired with a beam splitter or both camera lenses built into one unit. While Digital Cinema cameras are not a requirement for 3D they are the predominant medium for most of what is photographed. Film options include IMAX 3D and Cine 160. In the 1930s and 1940s, the Fleischer Studios made several cartoons with extensive stereoscopic 3D backgrounds, including several Popeye the Sailor, Betty Boop, and Superman cartoons. In the early to mid-1950s, only half of the major Animation film studios operation experimented with creating traditional 3D animated short subjects. Walt Disney Studio produced two traditional animation short for stereoscopic 3D, for cinemas. Adventures in Music: Melody (1953), and the Donald Duck cartoon Working for Peanuts (1953). Warner Bros. only produced a single cartoon in 3D: Lumber Jack-Rabbit (1953) starring Bugs Bunny. Famous Studios produced two cartoons in 3D, the Popeye cartoon Popeye, the Ace of Space (1953), and the Casper the Friendly Ghost cartoon Boo Moon (1954). Walter Lantz Studio produced the Woody Woodpecker cartoon Hypnotic Hick (1953), which was distributed by Universal. From the late 1950s until the mid-2000s almost no animation was produced for 3D display in theaters. Although several films used 3D backgrounds. One exception is Starchaser: The Legend of Orin. CGI animated films can be rendered as stereoscopic 3D version by using two virtual cameras. Stop-motion animated 3D films are photographed with two cameras similar to live action 3D films. In 2004 The Polar Express was the first stereoscopic 3D CGI-animated feature film. The 3D version was solely released in IMAX theaters. In November 2005, Walt Disney Studio Entertainment released Chicken Little in digital 3D format, being Disney's first CGI-animated film in 3D. The film was converted from 2D into 3D in post production. nWave Pictures' Fly Me to the Moon (2008) was actually the first animated film created for 3D and released exclusively in 3D in digital theaters around the world. No other animation films have released solely in 3D since. The first 3D feature by DreamWorks Animation, Monsters vs Aliens, followed in 2009 and used a new digital rendering process called InTru3D, which was developed by Intel to create more realistic animated 3D images. InTru3D is not used to exhibit 3D films in theaters; they are shown in either RealD 3D or IMAX 3D. Main article: 2D to 3D conversion In the case of 2D CGI animated films that were generated from 3D models, it is possible to return to the models to generate a 3D version. For all other 2D films, different techniques must be employed. For example, for the 3D re-release of the 1993 film The Nightmare Before Christmas, Walt Disney Pictures scanned each original frame and manipulated them to produce left-eye and right-eye versions. Dozens of films have now been converted from 2D to 3D. There are several approaches used for 2D to 3D conversion, most notably depth-based methods.[78] However, conversion to 3D has problems. Information is unavailable as 2D does not have information for a perspective view. Some TVs have a 3D engine to convert 2D content to 3D. Usually, on high frame rate content (and on some slower processors even normal frame rate) the processor is not fast enough and lag is possible. This can lead to strange visual effects.[79] Further information: 3D television and 3D display Main article: Anaglyph 3D The traditional 3D glasses, with modern red and cyan color filters, similar to the red/green and red/blue lenses used to view early anaglyph films. Anaglyph images were the earliest method of presenting theatrical 3D, and the one most commonly associated with stereoscopy by the public at large, mostly because of non-theatrical 3D media such as comic books and 3D television broadcasts, where polarization is not practical. They were made popular because of the ease of their production and exhibition. The first anaglyph film was invented in 1915 by Edwin S Porter. Though the earliest theatrical presentations were done with this system, most 3D films from the 1950s and 1980s were originally shown polarized.[80] In an anaglyph, the two images are superimposed in an additive light setting through two filters, one red and one cyan. In a subtractive light setting, the two images are printed in the same complementary colors on white paper. Glasses with colored filters in each eye separate the appropriate images by canceling the filter color out and rendering the complementary color black. Anaglyph images are much easier to view than either parallel sighting or crossed eye stereograms, although the latter types offer bright and accurate color rendering, particularly in the red component, which is muted, or desaturated with even the best color anaglyphs. A compensating technique, commonly known as Anachrome, uses a slightly more transparent cyan filter in the patented glasses associated with the technique. Process reconfigures the typical anaglyph image to have less parallax. An alternative to the usual red and cyan filter system of anaglyph is ColorCode 3-D, a patented anaglyph system which was invented in order to present an anaglyph image in conjunction with the NTSC television standard, in which the red channel is often compromised. ColorCode uses the complementary colors of yellow and dark blue on-screen, and the colors of the glasses' lenses are amber and dark blue. The polarization 3D system has been the standard for theatrical presentations since it was used for Bwana Devil in 1952,[80] though early Imax presentations were done using the eclipse system and in the 1960s and 1970s classic 3D films were sometimes converted to anaglyph for special presentations. The polarization system has better color fidelity and less ghosting than the anaglyph system. In the post-'50s era, anaglyph has been used instead of polarization in feature presentations where only part of the film is in 3D such as in the 3D segment of Freddy's Dead: The Final Nightmare and the 3D segments of Spy Kids 3-D: Game Over. Anaglyph is also used in printed materials and in 3D television broadcasts where polarization is not practical. 3D polarized televisions and other displays only became available from several manufacturers in 2008; these generate polarization on the receiving end. cardboard 3D linear polarized glasses from the 1980s similar to those used in the 1950s. Though some were plain white, they often had the name of the theatre and/or graphics from the film Main article: Polarized 3D system To present a stereoscopic motion picture, two images are projected superimposed onto the same screen through different polarizing filters. The viewer wears low-cost glasses which also contain a pair of polarizing filters oriented differently (clockwise/counterclockwise with circular polarization or at 90 degree angles, usually 45 and 135 degrees,[81] with linear polarization). As each filter passes only that light which is similarly polarized and blocks the light polarized differently, each eye sees a different image. This is used to produce a three-dimensional effect by projecting the same scene into both eyes, but depicted from slightly different perspectives. Since no head tracking is involved, the entire audience can view the stereoscopic images at the same time. Resembling sunglasses, RealD circular polarized glasses are now the standard for theatrical releases and theme park attractions. Circular polarization has an advantage over linear polarization, in that the viewer does not need to have their head upright and aligned with the screen for the polarization to work properly. With linear polarization, turning the glasses sideways causes the filters to go out of alignment with the screen filters causing the image to fade and for each eye to see the opposite frame more easily. For circular polarization, the polarizing effect works regardless of how the viewer's head is aligned with the screen such as tilted sideways, or even upside down. The left eye will still only see the image intended for it, and vice versa, without fading or crosstalk. Nonetheless, 3D cinema films are made to be viewed without head tilt, and any significant head tilt will result in incorrect parallax and prevent binocular fusion. In the case of RealD a circularly polarizing liquid crystal filter which can switch polarity 144 times per second is placed in front of the projector lens. Only one projector is needed, as the left and right eye images are displayed alternately. Sony features a new system called RealD XLS, which shows both circular polarized images simultaneously: A single 4K projector (4096×2160 resolution) displays both 2K images (2048×1080 resolution) on top of each other at the same time, a special lens attachment polarizes and projects the images.[82] Optical attachments can be added to traditional 35mm projectors to adapt them for projecting film in the "over-and-under" format, in which each pair of images is stacked within one frame of film. The two images are projected through different polarizers and superimposed on the screen. This is a very cost-effective way to convert a theater for 3-D as all that is needed are the attachments and a non-depolarizing screen surface, rather than a conversion to digital 3-D projection. Thomson Technicolor currently produces an adapter of this type.[83] A metallic screen is necessary for these systems as reflection from non-metallic surfaces destroys the polarization of the light. Polarized stereoscopic pictures have been around since 1936, when Edwin H. Land first applied it to motion pictures. The so-called "3-D movie craze" in the years 1952 through 1955 was almost entirely offered in theaters using linear polarizing projection and glasses. Only a minute amount of the total 3D films shown in the period used the anaglyph color filter method. Linear polarization was likewise used with consumer level stereo projectors. Polarization was also used during the 3D revival of the 1980s. In the 2000s, computer animation, competition from DVDs and other media, digital projection, and the use of sophisticated IMAX 70mm film projectors, have created an opportunity for a new wave of polarized 3D films.[47][48] All types of polarization will result in a darkening of the displayed image and poorer contrast compared to non-3D images. Light from lamps is normally emitted as a random collection of polarizations, while a polarization filter only passes a fraction of the light. As a result, the screen image is darker. This darkening can be compensated by increasing the brightness of the projector light source. If the initial polarization filter is inserted between the lamp and the image generation element, the light intensity striking the image element is not any higher than normal without the polarizing filter, and overall image contrast transmitted to the screen is not affected. A pair of LCD shutter glasses used to view XpanD 3D films. The thick frames conceal the electronics and batteries. Main article: Active shutter 3D system In this technology, a mechanism is used to block light from each appropriate eye when the converse eye's image is projected on the screen. The technology originated with the Eclipse Method, in which the projector alternates between left and right images, and opens and closes the shutters in the glasses or viewer in synchronization with the images on the screen. [citation needed] This was the basis of the Teleview system which was used briefly in 1922.[29][84] A newer implementation of the Eclipse Method came with LCD shutter glasses. Glasses containing liquid crystal that will let light through in synchronization with the images on the cinema, television or computer screen, using the concept of alternate-frame sequencing. This is the method used by nVidia, XpanD 3D, and earlier IMAX systems. A drawback of this method is the need for each person viewing to wear expensive, electronic glasses that must be synchronized with the display system using a wireless signal or attached wire. The shutter-glasses are heavier than most polarized glasses, though lighter models are no heavier than some sunglasses or deluxe polarized glasses.[85] However these systems do not require a silver screen for projected images. Liquid crystal light valves work by rotating light between two polarizing filters. Due to these internal polarizers, LCD shutter-glasses darken the display image of any LCD, plasma, or projector image source, which has the result that images appear dimmer and contrast is lower than for normal non-3D viewing. This is not necessarily a usage problem; for some types of displays which are already very bright with poor grayish black levels, LCD shutter glasses may actually improve the image quality. Main article: Anaglyph 3D § Interference filter systems Dolby 3D uses specific wavelengths of red, green, and blue for the right eye, and different wavelengths of red, green, and blue for the left eye. Glasses which filter out the very specific wavelengths allow the wearer to see a 3D image. This technology eliminates the expensive silver screens required for polarized systems such as RealD, which is the most common 3D display system in theaters. It does, however, require much more expensive glasses than the polarized systems. It is also known as spectral comb filtering or wavelength multiplex visualization The recently introduced Omega 3D/Panavision 3D system also uses this technology, though with a wider spectrum and more "teeth" to the "comb" (5 for each eye in the Omega/Panavision system). The use of more spectral bands per eye eliminates the need to color process the image, required by the Dolby system. Evenly dividing the visible spectrum between the eyes gives the viewer a more relaxed "feel" as the light energy and color balance is nearly 50-50. Like the Dolby system, the Omega system can be used with white or silver screens. But it can be used with either film or digital projectors, unlike the Dolby filters that are only used on a digital system with a color correcting processor provided by Dolby. The Omega/Panavision system also claims that their glasses are cheaper to manufacture than those used by Dolby.[86] In June 2012 the Omega 3D/Panavision 3D system was discontinued by DPVO Theatrical, who marketed it on behalf of Panavision, citing "challenging global economic and 3D market conditions".[87] Although DPVO dissolved its business operations, Omega Optical continues promoting and selling 3D systems to non-theatrical markets. Omega Optical's 3D system contains projection filters and 3D glasses. In addition to the passive stereoscopic 3D system, Omega Optical has produced enhanced anaglyph 3D glasses. The Omega's red/cyan anaglyph glasses use complex metal oxide thin film coatings and high quality annealed glass optics. Main article: Autostereoscopy In this method, glasses are not necessary to see the stereoscopic image. Lenticular lens and parallax barrier technologies involve imposing two (or more) images on the same sheet, in narrow, alternating strips, and using a screen that either blocks one of the two images' strips (in the case of parallax barriers) or uses equally narrow lenses to bend the strips of image and make it appear to fill the entire image (in the case of lenticular prints). To produce the stereoscopic effect, the person must be positioned so that one eye sees one of the two images and the other sees the other. Both images are projected onto a high-gain, corrugated screen which reflects light at acute angles. In order to see the stereoscopic image, the viewer must sit within a very narrow angle that is nearly perpendicular to the screen, limiting the size of the audience. Lenticular was used for theatrical presentation of numerous shorts in Russia from 1940 to 1948[76] and in 1946 for the feature-length film Robinson Crusoe.[88] Though its use in theatrical presentations has been rather limited, lenticular has been widely used for a variety of novelty items and has even been used in amateur 3D photography.[89][90] Recent use includes the Fujifilm FinePix Real 3D with an autostereoscopic display that was released in 2009. Other examples for this technology include autostereoscopic LCD displays on monitors, notebooks, TVs, mobile phones and gaming devices, such as the Nintendo 3DS. Main article: Health effects of 3D Some viewers have complained of headaches and eyestrain after watching 3D films.[91] Motion sickness, in addition to other health concerns,[92] are more easily induced by 3D presentations. One published study shows that of those who watch 3D films, nearly 55% experience varying levels of headaches, nausea and disorientation.[93] Glasses designed to eliminate eyestrain by converting 3D images back into 2D have been developed.[94] There are two primary effects of 3D film that are unnatural for human vision: crosstalk between the eyes, caused by imperfect image separation, and the mismatch between convergence and accommodation, caused by the difference between an object's perceived position in front of, or behind the screen and the real origin of that light on the screen. It is believed that approximately 12% of people are unable to properly see 3D images, due to a variety of medical conditions.[95][96] According to another experiment up to 30% of people have very weak stereoscopic vision preventing them from depth perception based on stereo disparity. This nullifies or greatly decreases immersion effects of digital stereo to them.[97] It has recently been discovered that each of the rods and cones in animal eyes can measure the distance to the point on the object that is in focus at the particular rod or cone. Each rod or cone can act as a passive LIDAR (Light Detection And Ranging). The lens selects the point on the object for each pixel to which the distance is measured; that is, humans can see in 3D separately with each eye.[98] If the brain uses this ability in addition to the stereoscopic effect and other cues no stereoscopic system can present a true 3D picture to the brain. The French National Research Agency (ANR) has sponsored multidisciplinary research in order to understand the effects of 3D film viewing, its grammar[clarification needed], and its acceptance.[99] After Toy Story, there were 10 really bad CG movies because everybody thought the success of that film was CG and not great characters that were beautifully designed and heartwarming. Now, you've got people quickly converting movies from 2D to 3D, which is not what we did. They're expecting the same result, when in fact they will probably work against the adoption of 3D because they'll be putting out an inferior product.— Avatar director James Cameron[100] Most of the cues required to provide humans with relative depth information are already present in traditional 2D films. For example, closer objects occlude further ones, distant objects are desaturated and hazy relative to near ones, and the brain subconsciously "knows" the distance of many objects when the height is known (e.g. a human figure subtending only a small amount of the screen is more likely to be 2 m tall and far away than 10 cm tall and close). In fact, only two of these depth cues are not already present in 2D films: stereopsis (or parallax) and the focus of the eyeball (accommodation). 3D film-making addresses accurate presentation of stereopsis but not of accommodation, and therefore is insufficient in providing a complete 3D illusion. However, promising results from research aimed at overcoming this shortcoming were presented at the 2010 Stereoscopic Displays and Applications conference in San Jose, U.S.[101] Film critic Mark Kermode[102] argued that 3D adds "not that much" value to a film, and said that, while he liked Avatar, the many impressive things he saw in the film had nothing to do with 3D. Kermode has been an outspoken critic of 3D film describing the effect as a "nonsense" and recommends using two right or left lenses from the 3D glasses to cut out the "pointy, pointy 3D stereoscopic vision", although this technique still does not improve the huge brightness loss from a 3D film.[103] Versions of these "2-D glasses" are being marketed.[104] As pointed out in the article "Virtual Space – the movies of the future"[105][failed verification] in real life the 3D effect, or stereoscopic vision, depends on the distance between the eyes, which is only about 2+1⁄2 inches. The depth perception this affords is only noticeable near to the head – at about arms length. It is only useful for such tasks as threading a needle. It follows that in films portraying real life, where nothing is ever shown so close to the camera, the 3D effect is not noticeable and is soon forgotten as the film proceeds. Director Christopher Nolan has criticised the notion that traditional film does not allow depth perception, saying "I think it's a misnomer to call it 3D versus 2D. The whole point of cinematic imagery is it's three dimensional... You know 95% of our depth cues come from occlusion, resolution, color and so forth, so the idea of calling a 2D movie a '2D movie' is a little misleading."[106] Nolan also criticised that shooting on the required digital video does not offer a high enough quality image[107] and that 3D cameras cannot be equipped with prime (non-zoom) lenses.[106] Late film critic Roger Ebert repeatedly criticized 3D film as being "too dim", sometimes distracting or even nausea-inducing, and argued that it is an expensive technology that adds nothing of value to the film-going experience (since 2-D films already provide a sufficient illusion of 3D).[108] While Ebert was "not opposed to 3-D as an option", he opposed it as a replacement for traditional film, and preferred 2-D technologies such as MaxiVision48 that improve image area/resolution and frames per second.[108] Most 3D systems will cut down the brightness of the picture considerably – the light loss can be as high as 88%. Some of this loss may be compensated by running the projector's bulb at higher power or using more powerful bulbs.[109] The 2D brightness cinema standard is 14 foot-lamberts (48 candela per square metre), as set by the SMPTE standard 196M. As of 2012[update], there is no official standard for 3D brightness. According to the industry de facto standard, however, the "acceptable brightness range" goes as low as 3.5 fL (12 cd/m2) – just 25% of the standard 2D brightness.[110] Among others, Christopher Nolan has criticized the huge brightness loss: "You're not that aware of it because once you're 'in that world,' your eye compensates, but having struggled for years to get theaters up to the proper brightness, we're not sticking polarized filters in everything."[111] In September 2012, the DCI standards body issued a "recommended practice" calling for a 3D projection brightness of 7 fL (24 cd/m2), with an acceptable range of 5–9 fL (17–31 cd/m2).[2] It is not known how many theaters actually achieve such light levels with current technology. Prototype laser projection systems have reached 14 fL (48 cd/m2) for 3D on a cinema screen.[3] Main article: 2D to 3D conversion Another major criticism is that many of the films in the 21st century to date were not filmed in 3D, but converted into 3-D after filming. Filmmakers who have criticized the quality of this process include James Cameron (whose film Avatar was created mostly in 3D from the ground up, with some portions of the film created in 2D,[112] and is largely credited with the revival of 3D) and Michael Bay.[100] However, Cameron has said that quality 2D to 3D conversions can be done if they take the time they need and the director is involved.[113] Cameron's Titanic was converted into 3D in 2012, taking 60 weeks and costing $18 million. In contrast, computer-animated films for which the original computer models are still available can be rendered in 3D easily, as the depth information is still available and does not need to be inferred or approximated. This has been done with Toy Story, among others.[114] Film portal Cinematography Digital cinema List of 3D films (1914–2004) List of 3D films (2005–present) 2D to 3D conversion Depth perception Stereoscopy Autostereoscopy 3D display 3D television 4D film Volumetric display 3-D Film Preservation Fund Motion capture Stereoscopic video game Surround sound Digital 3D Disney Digital 3-D RealD 3D Dolby 3D XpanD 3D MasterImage 3D IMAX 3D 4DX ^ Goldberg, Matt (April 6, 2018). "3D Is Dead (Again)". Collider. ^ "animation | History, Movies, Television, & Facts". Britannica. Retrieved April 18, 2022. ^ a b Mills, Virginia (August 13, 2018). "180 years of 3D". Royal Society. Retrieved January 16, 2023. ^ Bulletins de l'Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique (in French). Hayez. 1849. ^ Pellerin, Denis (October 13, 2017). "The Quest for Stereoscopic Movement: Was the First Film ever in 3-D?". International Journal on Stereo & Immersive Media. 1 (1). 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