The 6K restoration of Orson Welles' *Chimes at Midnight*

Michael Dawson

Manager, Cinedustrial, USA

Michael Dawson has been Manager of the Cinedustrial Group since 2005, prior to which he was President of Intermission Productions Ltd. He is a graduate of Southern Illinois University with a bachelor of science degree in film production and film history, theory and criticism. Michael has gained over 40 years' experience in all aspects of the motion picture industry, ranging from production to distribution and exhibition, feature films, as well as commercials, documentaries, music videos and industrials. In 1992, in partnership with Beatrice Welles and the Othello Partnership, Michael co-produced the restoration of Orson Welles' 'Othello'. In 2008, Michael restored Stanley Kubrick's first three shorts, 'The Flying Padre', 'Day of the Fight' and 'Seafarers', with the aid of Kubrick's assistant, the late Leon Vitali.

Cinedustrial, 502 North 5th Avenue, Maywood IL 60153, USA
Tel: +1 224 500 1986; E-mail: interprod1@aol.com

Scott Fritz

President, Stranded On A Planet Inc, USA

Scott Fritz has decades of experience as a sound technician and engineer. One of his primary specialisations is in the area of audio noise reduction and soundtrack enhancement. He is also a music composer and producer. In addition to composing for major Hollywood motion picture trailers, he is the co-writer and producer of 'Taste the Feeling', the current global Coca-Cola anthem, and has produced and composed dozens of global commercial spots for such companies as Schweppes, Del Valle, Hot Springs Spas, Sewell Ford, Lyft and Coca-Cola, to name but a few. He has also scored dozens of shorts and promo videos for Facebook to announce the launch of major new product features. Scott has been the president and lead producer of Stranded On A Planet for 15 years, during which time, he has composed over 800 cues for Warner/Chappell.

Stranded On A Planet Inc, 302 W Judd Street, Woodstock, IL 60098, USA
Tel: +1 646 408 6013; E-mail: scott@strandedonaplanet.com

John Beckel

Founder, Electric Brain Media, USA

John Beckel is a Chicago Columbia College graduate with a BA degree in Liberal Arts. In 2010 he founded Electric Brain Media LLC, a Cinedustrial Group Affiliate. As a filmmaker and through his studio, John has produced and post-produced hundreds of projects. He post-produced all the promotional videos for the 2015 Orson Welles Centennial Festival and the subsequent Orson Welles creative arts festivals taking place in Woodstock, Illinois. John has spent years perfecting his craft in cinematography and 3D animation.

Electric Brain Media LLC, 6104 Knoll Valley Drive Suite 303 Willowbrook, IL 60527, USA
Tel: +1 630 915 8677; E-mail: info@electricbrainmedia.com
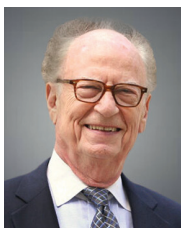
E. Leonard Rubin

Attorney, Valentine, Austriaco & Bueschel PC, USA

E. Leonard Rubin is an intellectual property rights attorney with the Chicago law firm, Valentine, Austriaco & Bueshel, specialising in defamation, trade secret, privacy and entertainment law. For decades, he has also taught entertainment law at UIC Law School (formerly The John Marshall School of Law). He has previously served as the Vice President, General Counsel and Corporate Secretary for Playboy Enterprises for more than 13 years. Len is admitted to the State of Illinois, State of New York, the United States Supreme Court, and the United States Court of Appeals for the Seventh and Fifth Circuit. He holds

a juris doctor from the University of Miami Law School, and in 2013 received Mediator Certification from DePaul University in Chicago. Len has been a member of the Copyright Society of the United States since 1978. He is a past President of the Lawyers for the Creative Arts and serves on the Board of Trustees for the Copyright Society of the United States.

Valentine, Austriaco & Bueschel PC, 105 West Adams Street, 35th Floor, Chicago, IL 60603, USA
Tel: +1 312 288 8285; E-mail: lrubin@vablawfirm.com
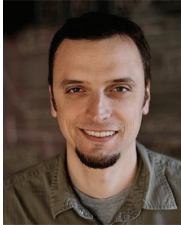
Michael Matusek

Partner, Nolo Digital Film/Sarofsky, USA

Michael Matusek is one of the founding partners of Nolo Digital Film, which was formed in 2007. He has been Head Colorist for numerous feature films, commercials and documentaries, personally grading the restoration of Orson Welles' 'Chimes at Midnight' and supervising the High Dynamic Range processing. Prior to Nolo Digital Film, Michael was Head Colorist at I-Cubed Chicago. He graduated from Southern Illinois University with a bachelor's degree in radio and television/film.

Nolo Digital Film/Sarofsky, 1506 W. Fulton Street, Chicago, IL 60607, USA
Tel: +1 312 243 8650; E-mail: mike@nolodigitalfilm.com

Abstract   This paper provides a short history of the circumstances and motivational factors regarding the restoration of Orson Welles' 'Chimes at Midnight'. The paper includes a brief history of the film's picture and sound degradation and the pursuit of superior first-generation elements. It then goes on to discuss how the latest software systems were employed in the restoration process.

KEYWORDS: HDR, high dynamic range, Izotope, Arri scanner, Orson Welles, Chimes

INTRODUCTION

I first became aware of the degradation of Orson Welles' 'Chimes at Midnight' prints when I was a sales representative at Audio Brandon Films (a subsidiary of Macmillan Publishing) in the early 1980s. The company had the largest domestic and foreign non-theatrical 16-mm distribution library in the world. Working with other distribution companies, such as Peppercorn Wormser and Films Inc, made me aware of the practice of using 16-mm prints as inter-positive composites to produce expansion 35-mm negative composites of 'Chimes at Midnight'. This practice unfortunately added to the generational degradation of the visual and audio quality of this motion picture. Normally, the use of composite negatives or composite inter-positives was restricted to 'safety' backup elements only. This was in lieu of the normal method of simultaneously roll-printing picture negative and sound optical negative as separate elements in producing release prints. The use of pristine source material as previously described should be pursued as the primary starting point for improving picture and sound quality.

Four years after Welles' death in 1985, I attended the first major academic conference on Welles, held at NYU Film School. A 35-mm print of 'Chimes at Midnight' was screened at the Joseph Papp Theater. The print was the most pristine I had ever seen. When I inquired where the print had come from, the projectionist said it had been provided based on anonymity. Thus began the investigative journey.

In approaching our restoration, we pursued the best point of departure in terms of film elements. It has been rumoured that the original camera AB roll negative

was possibly damaged. Separate from being physically unavailable, the element ownership was questionable. Therefore, we felt that the best element to use would be the reversal negative made from that negative. In regard to watermarked printing stains, we did not need to utilise the duplicate negative as an insert source. This is because the basic interactive restoration tool allows for a bleed through to the next frame(s) where that artefact does not exist. Even at the 6K level, this allowed us to avoid any generational loss (the dupe neg being made from the sub inter-positive).

We also pursued the legal chain of title, which began with the original production contract, referred to as the protocol accord. This contract granted producer Harry Saltzman 50 per cent of the copyright and exhibition and distribution rights in all territories, with the exception of Spain and Portugal. From there, we obtained chain of conveyance through several Harry Saltzman owned companies to him personally. Then there was a will conveyance to his wife and subsequent widow. This allowed a legal right to accessing and obtaining numerous elements including a master negative. It should be noted that the elements included an interpositive and a duplicate negative. It was from this duplicate negative that the previously discussed release print had been made.

SOUND RESTORATION

We obtained the music synchronisation theatrical performance rights from the Italian music society unit and studio Camcine based in Rome. Some time later, we were provided eight rolls of 35-mm magnetic tape. We initially presumed this was the premix stem track of the music score. However, some time later we realised almost by accident that this was a premix stem track of the film's 'presence' track. We therefore took the opportunity to transfer at 96 GHz.

Age-related oxidisation had turned it almost orange in colour, and this caused an additional hiss factor. We therefore utilised the Premiere's Audition system. Audition is powerful standalone audio-editing software developed by Adobe, and it integrates seamlessly with Premiere.

Audition is designed to enhance the sound audio quality of soundtracks by reducing or eliminating unwanted noise and hiss, and to this end provides several powerful tools. The most effective tool for removing noise is the Noise Reduction effect. This effect uses advanced algorithms to analyse the frequency spectrum of the audio track and identify the noise components. Once identified, the Noise Reduction effect applies a filter to remove the noise components, leaving behind only the desired audio.

In addition to utilising the Noise Reduction effect, we also made use of the DeHummer tool. This tool is specifically designed to remove the inherent low-frequency hums caused by tape oxidation. The tool applies a notch filter that will target the specific frequency of the hum or buzz and removes it from the recording.

The third Audition tool we applied was the Hiss Reduction effect. This tool is somewhat similar to the Noise Reduction effect, however, it is specifically designed to target high-frequency hiss components. This powerful tool employs a high-pass filter to remove the unwanted hiss, leaving only the pure audio.

The presence track contains the background unique to each scene — even the 'silence' of an interior has an audible component. Due to the Presence track having a variety of subtle and some less-than-subtle sounds, such as wind etc, we took advantage of Audition's Spectral Frequency display. This allowed us to visualise the frequency spectrum of the presence track, which made it possible to make more precise adjustments.

Due to the variation in audio fluctuations, the final tool utilised was the Adaptive Noise Reduction effect. This tool proved very effective during the scene where King Henry IV, played by Sir John Gielgud, is on his deathbed, lamenting to Prince Hal on how he obtained the crown. It is during the pauses that you can hear the exquisite sound of the castle's ambient silence. Not only did Audition prove to be a powerful tool for cleaning and restoring this pivotal sound element of 'Chimes at Midnight', it was also very effective in eliminating the 35-mm optical negative roll hum consistently heard in other versions of this film as well as in a number of other older films.

With some trepidation, we decided to digitally transfer the primary soundtrack at 96 Hz as opposed to 48 GHz. Our hesitation was due to the fact that while 96 GHz is broadcast quality, thus providing a superior frequency response, we were aware that, as per the presence track, any embedded noise, hiss and other audio artefacts would have equal embellishment.

The varied physical environments, high dynamic range dialogue and varying noise floor resulting from scene changes/cuts therefore presented a challenge with regards to audio restoration. Rather than try and establish a consistent noise reduction profile, we spotted scene by scene in order to determine how much noise we were able and willing to remove. When using technology as the interactive tool, the creative process of ascertaining how much is artistically appropriate is as important as what the technology can deliver. We spent quite a bit of time making sure the audio kept the viewer 'in the scene' as much as possible. In addition to noise reduction, there were quite a few distorted/clipped passages, especially during action scenes and some of Welles' more bombastic dialogue. De-clipping was necessary to soften and minimise the distortion of these moments, which we also automated to come in and out as gracefully and transparently as current state-of-the-art

technology would allow. This was especially true with the character Hotspur's dialogue at the beginning of the film. We also wanted to make sure there was no 'over-processing', such as can be detected in other restorations, notably with the sibilance in Sir John Gielgud's dialogue.

One of the primary features of iZotopes De-noise is its ability to adapt to the particular type of noise present in the recording, It can individually identify and eliminate hiss and ongoing noise, removing crackles, pops and various transient noises. We eliminated noise and hiss using RX De-noise due to its ability to preserve the character of the original audio. This was done primarily through the use of spectral shaping. This allowed the software to maintain the audio tonality and transient response of the desired audio while removing the enhanced 96-Hz noise.

We did discover some occasional clicks and pops, which again is inherent in 96-Hz transfer. We therefore utilised the iZotopes RX De-click module and a number of other tools to eliminate noise artefacts. The 35-mm roll RX De-hum proved particularly useful for eliminating other low-frequency noises. Thanks to the software's advanced spectral editing capabilities, we eliminated unwanted audio in the entire frequency domain.

In regards to the soundtrack, iZotope's RX high-level accuracy and precision in particular made it possible to remove hiss and noise without affecting the rest of the audio. Our intention was always to 'unearth' as much as we could, without altering significantly (or obviously) the creative vision of Welles, or disrupting the flow of the film in its restored state.

PICTURE RESTORATION

In the late 1990s, our company's product line was utilised to beta test a new algorithm-based system initially called Revival. This software was a result of the government of Singapore financing research
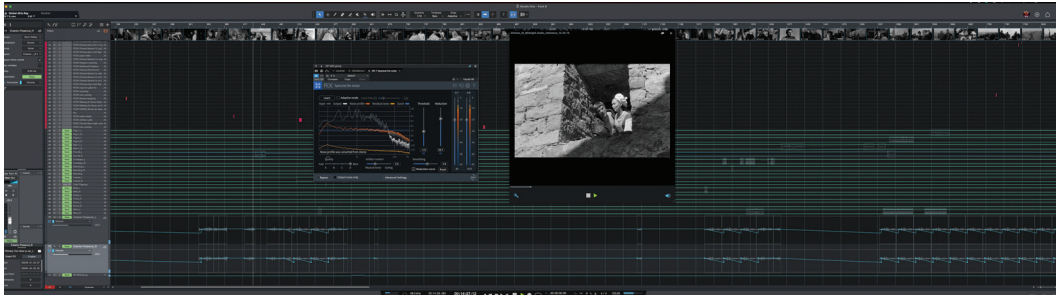
Figure 1:   Audio hiss reduction (graph demonstration)

and development at the University of Singapore. It introduced an artefact removal system with an auto–pass that could be completed in no more than 24 hours, depending on the artefact density. Following the auto–pass, only the more egregious visual anomalies would remain for manual removal. Prior to that time, systems like Discreet Logic would use a manual bleed–through or clone of that portion of the frame from a clean adjacent frame. However, with five or six artefacts per frame, it would take literally months to manually restore a film, based on spending just a few minutes per frame for interactive removal. So, for lack of a better metaphor, the post beta Revival system brought digital restoration from the horse and buggy to the automobile. Since then, a number of improved derivative-based systems have been developed for restoration. The one we used was Pixel Farms PF Clean. This work began after the 6K scan. The 6K transfer of the assembled AB roll Saltzman negative was done on an Arri XT scanner.

Pixel Farms is a very good system and has a number of excellent tools for restoration. This system has new tools specifically designed for eliminating all of the various types of film artefacts, including scratches, emulsion chipping, base abrasions and other types of damage. This proved quite advantageous for the negative 6K transfer. At the 6K level, the entire spectrum of embedded dirt, abrasions and any emulsion chipping become extremely articulated. With regard to the negative's general condition, however, it should be noted that at 24 frames per second, the totality of frames that remained behind (post auto-pass) constituted approximately 15–18 minutes out of a 1 hour 55 minute motion picture.

There were some base abrasions and base scratch marks during the Battle of Shrewsbury scene that could be detected in the sky. Additional artefacts such as emulsion chipping were intermittently found in some exterior and interior scenes. This was particularly true of interior scenes of the Boars Head Inn. This occurs when tiny pieces of the emulsion — the light-sensitive layer that captures the image — breaks from off the film base, leaving a damaged area. We used the PF Clean tool, which uses advanced algorithms to detect emulsion chipping. Once the system identifies the damage it uses imprinting or cloning. This in turn fills in the missing image, restoring the film to its original appearance.

There was a chemical stain anomaly that appeared at the heads and tails of the AB rolls, appearing almost exclusively during the castle scenes midway through the film. These were euphemistically referred to as watermarks on our logs for manual interactive removal. These stain marks are somewhat consistent and can occur when there is negative-to-negative contact printing.

For removal, we used the same tool and method we applied to the emulsion chipping issue during the Battle of Shrewsbury scene. During the Battle of Shrewsbury, we encountered intermittent scratch clusters that would appear in the sky backdrop and were quite mobile and would move around, unlike

the normal release print base or emulsion scratches that are steady and long lasting. The PF Clean tool for removing these cluster marks analyses the film frame by frame and identifies the scratches by comparing the appearance of the damaged area with the surrounding frames. Once identified, the system uses advanced restoration techniques, such as imprinting, to fill in the scratches and restore the image to its original appearance.

Another issue was grain movement in the background sky shots during the exterior scenes prior to the Battle of Shrewsbury. It is essential to understand how PF Clean removes grain from motion picture footage. We used the Temporal Filter, which takes into account the motion of the camera and the scene. The algorithm calculates a motion vector field that maps the motion of each pixel in the image. This allows the software to distinguish between noise and the actual details of the image. This capability is acutely critical in black-and-white motion picture footage, where grain dance can distract or obscure subtle nuances of the image.

Once the software has created a motion vector field, it applies a temporal filter to the image. This filter uses the motion vector field to identify areas of the image that have moved, such as the grain particles, and separates them from the static elements of the image. This filter then applies a smoothing effect to the moving elements, creating a cleaner, more pristine image while retaining the original character of the footage. This process is an example of what is called 'motion-compensated noise reduction' and is a standard approach to removing grain movement from film footage. After said application was applied, the issue was resolved.

Figures 2–6 provide examples of the restoration work.

GRADING

In regard to grading the film, one must understand that when producing an answer print for a black-and-white motion picture, the original film laboratory colourist was (and remains) somewhat limited to timing and exposure settings. The basic guideline for black-and-white film is to make the best timings for grey tonality and producing rich blacks. While grading can be used for creative purposes, such efforts in pre-digital cinema were usually employed at the time of shooting. The camera operator would use various filters and exposures to capture what the lighting crew had established for any particular scene. Today's digital grading software has improved exponentially. While grading based on those technical advancements can be used to add or fix something on an aesthetic creative level, our philosophy was to stick to the basic guidelines of producing the best black-and-white image possible. We also had a 35-mm AP print made at the LTC labs, which we used as a reference for improvement.

We used Baselight Two software for grading this motion picture. It has a number of tools to restore and bring about stunning black-and-white images. 'Chimes at Midnight' has ample examples of deep-rich blacks. These can be found in all of the castle scenes, the Boars Head Inn scenes and even in the attire of black tunics. The most useful tool for improving the image is the colour temperature tool. Due to the effect of having such high 6K resolution, we needed this tool to lower temperature. As an example, it was most helpful during the opening scenes of King Henry IV on his throne. It was also used as a tool for enriching all the dark hallway shots.

The contrast tool is the most important tool for grading black-and-white film in Baselight Two. This tool allows users to adjust the overall contrast of the image. In 'Chimes', this was used to enrich the existing more dramatic look. Being in 6K, this tool definitely allows images more depth and dimensionality. This was very apparent in all
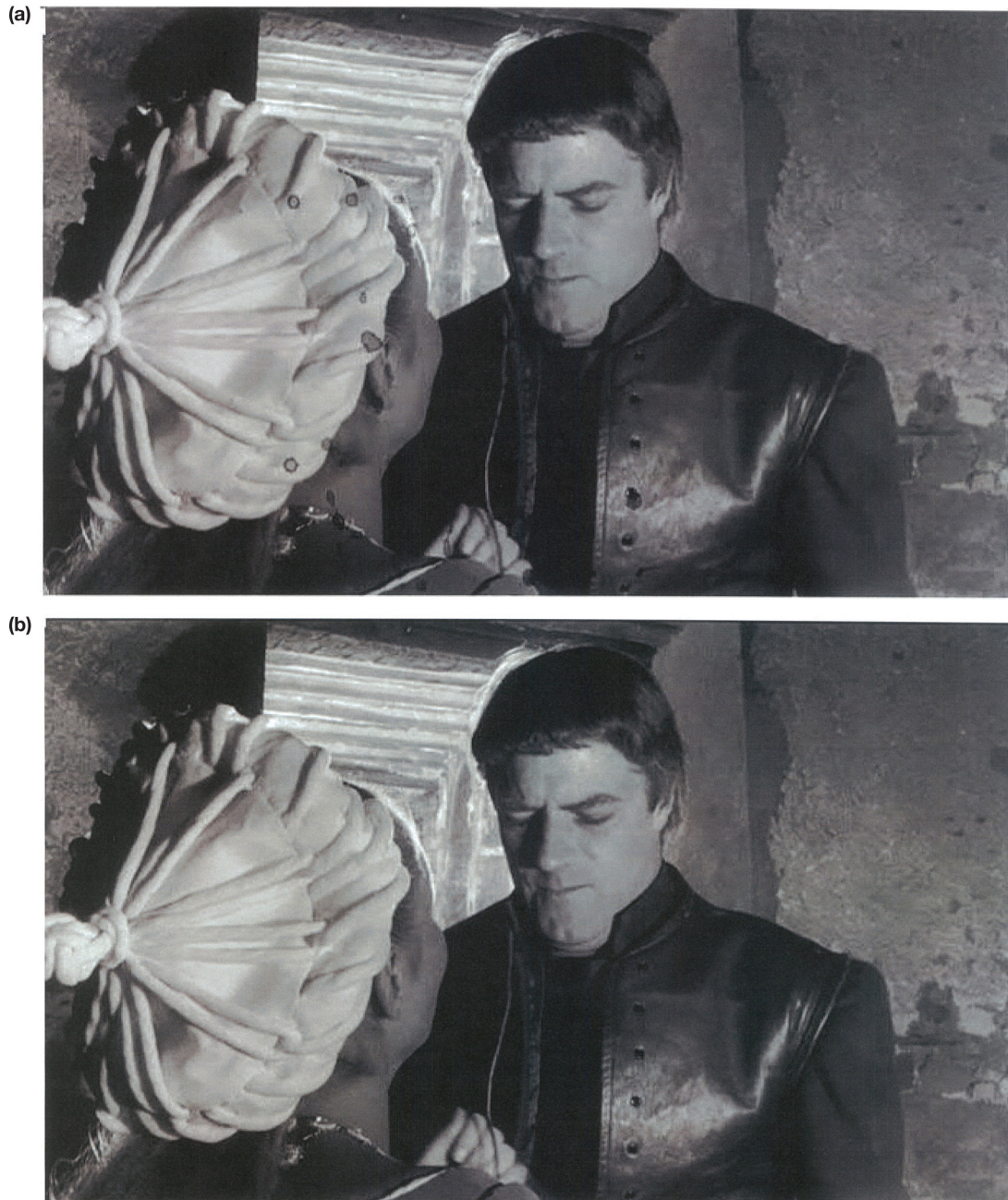
Figure 2: Negative chemical spotting on bonnet — (a) before and (b) after

of the interior castle scenes, but it was also used to give more luminescence or pop to the battle scene. Additionally, the Contrast tool was used to bring about more nuanced visuals by adjusting the contrast in certain areas of the image, specifically as it regards highlights and shadows.

This tool was invaluable in adding balance to court shots where the contrast ratio was uneven. This also occurred occasionally during the Boars Head table conversation scenes. We also used it in the famous Boars Head Inn banquet hall party and dance scene.
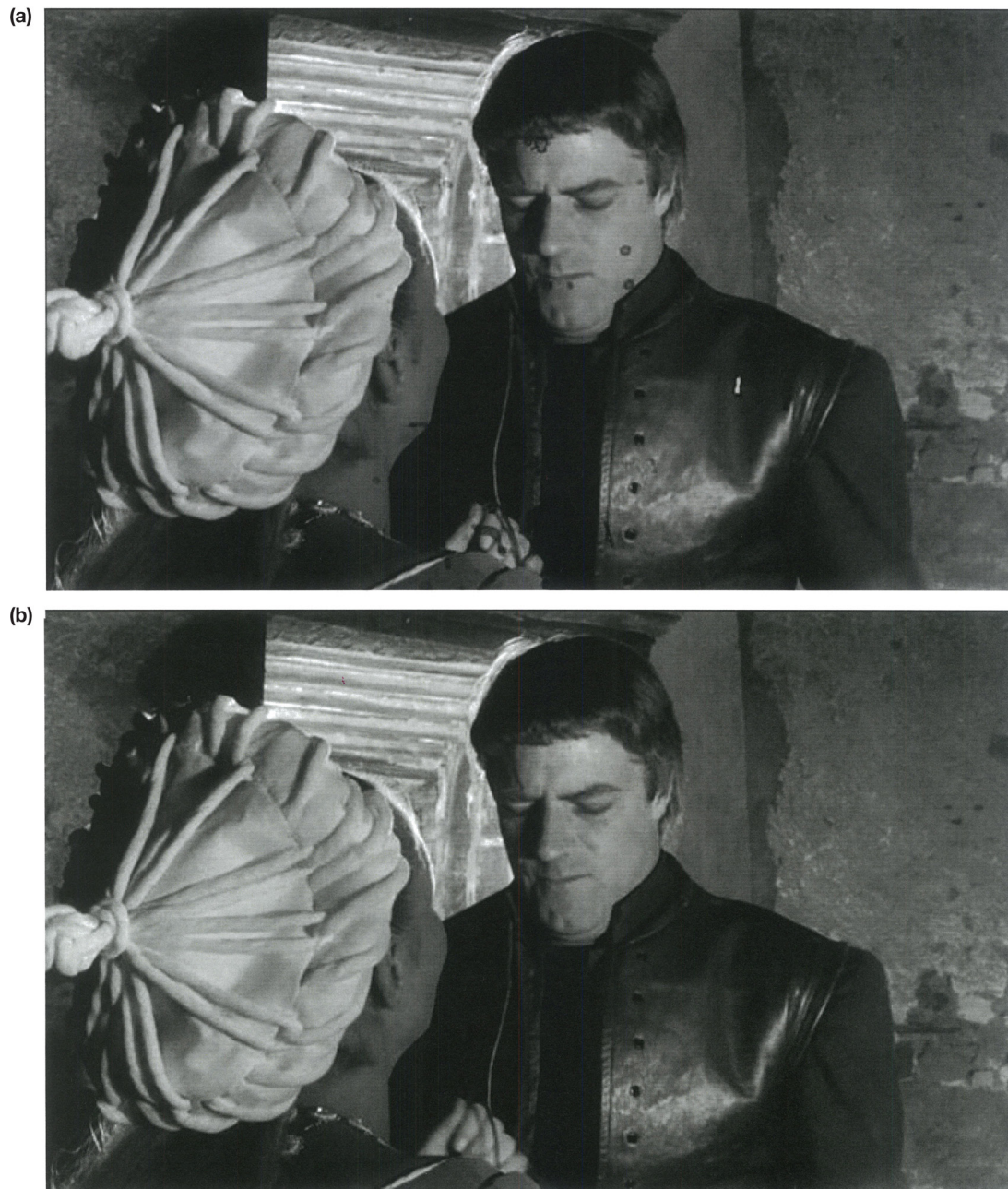
Figure 3: Negative chemical spotting on face — (a) before and (b) after

TO HDR OR NOT TO HDR

Due to a lack of full technical understanding on our part, we hesitated to make use of HDR processing for motion pictures. The issue being, would it in fact visually enhance a 57-year-old black-and-white motion picture? Following the screening of a documentary regarding the black-and-white still photography of European caves we decided to run some tests.

When applied to a motion picture, the HDR software captures images at different exposures. One of the misconceptions about the HDR process is that it adds visual

(a)

(b)

Figure 4: Emulsion abrasion, centre frame — (a) before and (b) after

elements or components to the image. In fact, it is quite the opposite. Due to wavelength penetration, it allows the viewer to see visual nuance that has always been present. While visible to the human eye, it simply could not be recorded on film or subsequent digital format. Because 'Chimes' had so many scenes with strong photographic contrasts, especially in the Boars Head Inn and in King Henry IV's castle, we used a Baselight Two contrast application. Due to the lack of colour information, black-and-white motion pictures simplify the HDR process. Based on the test demonstration, because of the increased visual dexterity and various visual effects, we decided to go forward. One such test was

(a)

(b)

Figure 5: Emulsion chip on chin — (a) before and (b) after

watching the 4K spec monitor of Welles as Falstaff giving his famous Shakespearean ode to the virtues of drinking sack (sherry). As we watched the simply beautiful 4K image on one monitor I turned my head to see the HDR monitor. As Welles is giving his speech, he turns slightly and then, all of a sudden, brilliant glistening rays of sunlight reflect off his armour, yet this did not exist on the regular 4K monitor. After HDR processing, however, numerous visual delights became evident throughout the film — delights that were always there but impossible to perceive until now. Examples include the smoke-laden HDR 'extended' beams of light cascading into the castle's throne room, and the beams
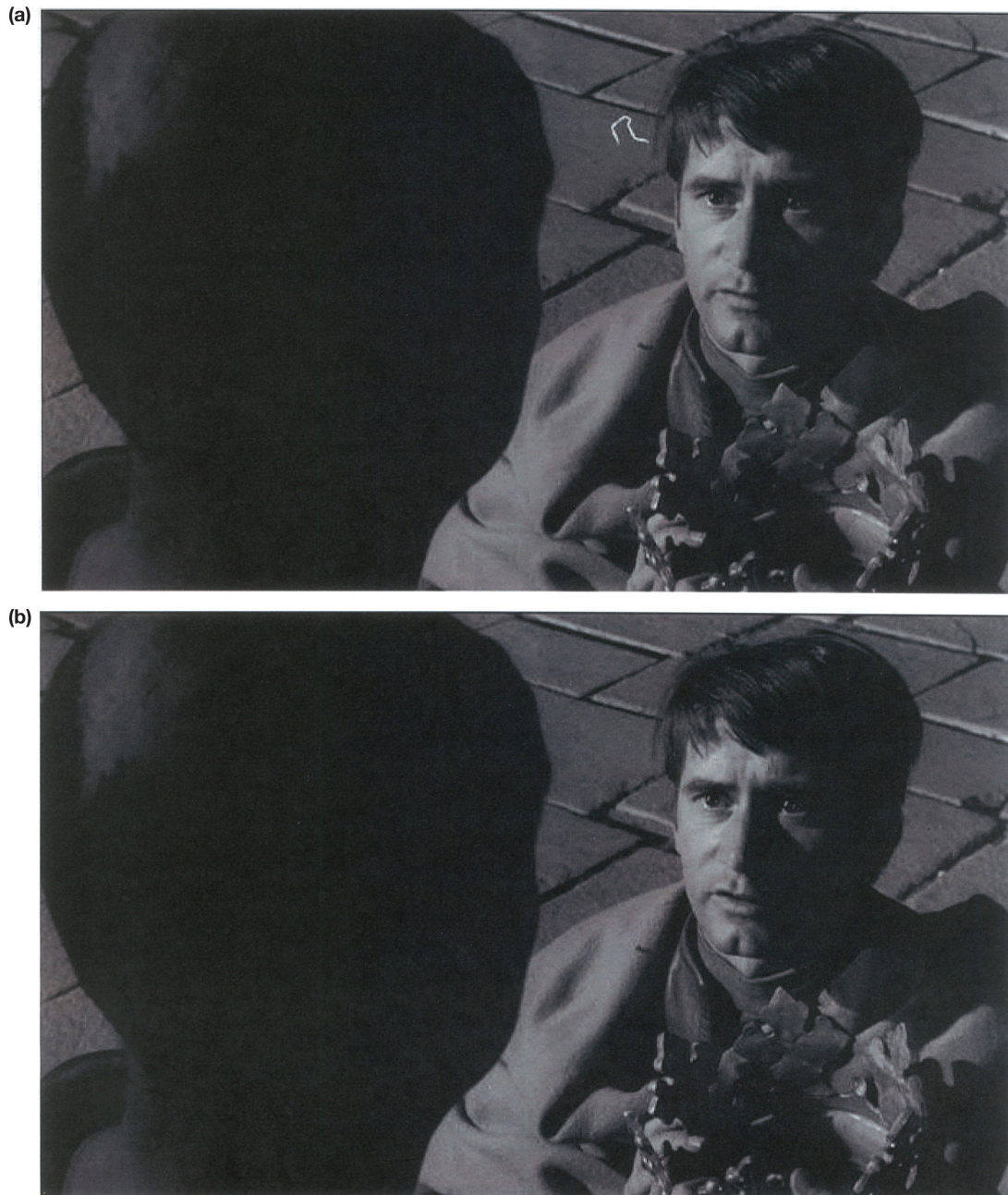
(a)

(b)

Figure 6: Emulsion curl scratch — (a) before and (b) after

of light fully enhanced and extended at the end of dark castle hallways.

CONCLUSION

We conducted a very thorough legal chain of title and subsequently obtained the best elements and applied the latest digital technology to a restoration based on a 6K scan. In regard to other vintage motion picture masterpieces, we would recommend such an endeavour if in possession of quality elements. It should be noted that movie theatres only project in 4K and most only in 2K. While our digital cinema packages contain a 4K file program, when inserting a 4K digital

cinema package into a 2K projector, it is automatically compressed to 2K. However, that compression from 4K to 2K will have a better image quality than a film scanned at 2K, hence the decision to begin at 6K.

We did our first technical test of the restored 'Chimes at Midnight' at Chicago's famous historic Pickwick Theater in June 2022. This location was chosen due its new Christie Laser 4K projection system, new sound system and new 18 × 12 metre screen. We did observe a few minor issues, but we were able to take care of these. In January 2023, we went back to the Pickwick and had a special advanced sneak preview benefit screening. Our improvements were manifested and the audience was very positive in applauding twice with follow-up praise: "Master Shallow we have heard the Chimes at Midnight."

AUTHORS' NOTE

The 6K restoration of Orson Welles' 'Chimes at Midnight' was produced in partnership with producer Harry Saltzman's widow Adriana and C.A.M. LLC.

Under US copyright law, the percentage of copyright ownership, not withstanding an extenuating contractual circumstance, is irrelevant in regard to dissemination and exhibition. In regards to 'Chimes at Midnight', however, there was a separate right granted. While our contractual relation is proprietorial, lengthy due diligence allowed us to acquire complete chain of title.

Separate from cloud storage, the 6K restored 'Chimes at Midnight' has been stored on standard DCPs, Linux DCP backup, with Raw scans and assorted masters on Lacie Rugged 5TB USB-C external drives.