695 QUARTERLY

I.A.T.S.E. Local 695
5439 Cahuenga Blvd.
North Hollywood, CA 91601

Prsrt Std
U.S. Postage
Paid
Santa Ana, CA
Permit No. 450

224

695 QUARTERLY

THE OFFICIAL PUBLICATION OF IATSE LOCAL 695

SPRING 2013
VOLUME 5 ISSUE 2

695 QUARTERLY

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Cover: Stefan Kudelski sailing on Lake Geneva, Switzerland, with his Nagra I around 1952.

From the Editors

Welcome to the spring issue of the *695 Quarterly*. This marks the beginning of the fifth year of this publication, which is a remarkable achievement in itself.

The success of this periodical would not be possible without the determined work and support of the co-editors, the Executive Board of Local 695 and our publisher, IngleDodd Media.

When Richard Lightstone, Eric Pierce and David Waelder first met in October 2008 to formulate the mission of this publication, our mandate was to inform the entertainment industry on **everything** that the membership of this Local does.

The three of us divided up the tasks of putting this magazine together.

We also have to thank our regular contributing authors: Laurence Abrams, Scott D. Smith, Ben Betts and Jim Tanenbaum.

Thanks as well to those who have taken the time and energy to write compelling and informative articles over the last four years. They include Jay Patterson, Andy Rovins, Jeff Erdmann, Adam Blantz, Douglas Axtell, Jon Taylor, Robert Janiger, Tim Song Jones, Lee Orloff, Willie Burton, Ian Kelly, Steve Nelson, Thomas Brandau and Simon Hayes.

We will continue to bring you instructive, illuminating and entertaining articles on everything 695.

Fraternally yours,
Eric Pierce, Richard Lightstone and David Waelder

From the President

A Game Changer...

Something important has happened in this most recent cycle of films, something has dramatically altered the way we do sound for film and television. A few existing technologies were used in a bold and direct way. It was an aha moment in pre-production that has changed what is possible.

We are commonly using nonlinear, file-based systems for lightweight, multitrack field acquisition. This approach evolved from the pioneering techniques created for, and applied by, Robert Altman and his Production Sound Mixers, Jim Webb and Bob Gravenor. They muscled these innovations into the world of mechanical filmmaking, where every track existed in physical space, later to be edited by razor blade and splicers on sprocketed magnetic stock. The mechanical version of this method has long been relegated to the history of our process. But this way of applying multitrack technique has become the norm.

We have also become accustomed to the ease and economy of applying CGI techniques for creative control of images. The art of visual effects has exploded exponentially, most often applied to create visual fiction born of the imagination, or for the removal of incongruous visual elements from the frame, such as telephone poles, skylines from the wrong century, or uncooperative natural light sources.

Recently, these tools were brought together and applied with a different mindset regarding the sound work. Different in the sense that their application was premeditated. A creative premise was brought to the table by Sound Mixer Simon Hayes and embraced by Director Tom Hooper, the producers and the actors. (The multi-part article detailing his team's navigation of their journey on *Les Misérables* continues in this issue of the *Quarterly*.)

Les Mis, winner of this year's "Triple Crown" of BAFTA, CAS and Academy Award (Oscar) for sound, is a benchmark. It changes the conversation about how we do sound for film and television.

From where I sit, it seems we have arrived at the place where we can re-think the conventional notion that a great deal of our creative energy needs to be expended on hiding microphone placement to protect the image at the expense of microphone placement to optimize the quality of the sound.

I was fortunate enough to be in London for the BAFTA Awards this year and spoke at length with Simon Hayes as well as with Tom Hooper about his experience with this technique and I asked Tom several key questions. First, how did he feel about the overall approach of capturing the vocal performances live, for use in the finished film. He glowed as he happily described going for the recordings "on the day" removed the need for pre-recording all the actors as well as minimized/eliminated the need for a traditional ADR budget and schedule and most importantly, qualitatively, the performances were dynamically organic, in the moment, and filled with the genuine emotion the characters needed to move the audience. Huge collateral benefits were had from the actors' and cinematographer's and wardrobe departments' point of view, as they didn't need to worry about their wardrobe being problematic or the microphones, booms or lavalieres, being seen. It was all built in to the approach.

Wondering whether all this joy had the sour taste of rocketing the overall budget into the stratosphere, I asked Tom the key question of cost, and dear friends, here's the kicker to this creative breakthrough. Hooper, with a gleam in his eye, spit it out like a shot. Total cost for using CGI for microphone removal on *Les Mis* was, wait for it…

A mere $160,000!

…This is a nominal amount on a film of this scale. This number does not even take into consideration the enormous savings of pre-record and post production if the film had been approached traditionally. A massive win-win for all parties concerned, most significantly, the creative entity of the film itself.

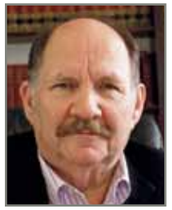
Consider the creative, logistical and financial benefits afforded to our industry if we migrate to this approach as the new normal, a game changer by any measure and certainly a dramatic underline of the great creative contribution the sound team makes to any film or television effort.

In accepting her Oscar for best supporting actress for her role in this film, Anne Hathaway made history by singling out and thanking personally, Production Sound Mixer Simon Hayes and his team for their contribution.

'Nuff said…

Fraternally,
Mark Ulano
President, IATSE Local 695

From the Business Representative



In Perspective:

I was recently phoned by a fellow Business Representative from a sister Local who requested that I refrain from telling producers of motion pictures, TV productions and commercials that Local 695 production mixers and crews are the best.

I am not making this up, that's what is out there. My immediate verbal response is unprintable for this publication.

I don't intend to amend or modify the truth. The truth of the matter is IATSE Local 695 production audio and outside-of-camera re-recording engineers and television engineers are the proven best to deliver a production perfect product.

It is to the Producer's best interest to employ IATSE Local 695 production recording crews to realize this production perfect product. After all, we have been perfecting our technical product for some 83 years. Let me make it perfectly clear, dear Producers all: that a IATSE Local 695 membership card is evidence that you employ the very best Production Mixer, Microphone Boom Operator, Video Recording Engineer/Video Assist Technician, Utility Sound Technician, Sound Service Assist and Studio Projectionist.

The internal rules set by the International Union request all members to carry their respective local union membership card. IATSE Local 695 members should always carry their membership card and proudly show it to any union representative who may request to see it.

Please remember, "If a picture is worth a thousand words, a picture with sound is worth millions." Think about it.

James A. Osburn, CAS
Business Representative, Executive Director

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I.A.T.S.E. Local 695
Production Sound Technicians,
Television Engineers,
Video Assist Technicians and
Studio Projectionists
Certified & Chartered September 15, 1930
A California Nonprofit Labor Corporation
Incorporated July 31, 1951, State of California
Affiliated with the A.F.L.-C.I.O.,
California State Federation of Labor,
and L.A. Central Labor Council

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NEWS & ANNOUNCEMENTS

L.A. TV Pilot Incentive Approved

On March 13, the Los Angeles City approved item 12-0564-S1, which waives all city fees for television pilots shot in Los Angeles.

Moved by Eric Garcetti and seconded by Paul Krekorian on June 12, 2012, the motion was referred to the Jobs and Business Development Committee, who recommended the motion for approval.

"My plan is that if you film a pilot in Los Angeles, you will not get a bill from the city," Garcetti said. "Other cities, states and countries are offering powerful incentives to lure those jobs away. We are fighting back to keep those jobs right here—where they belong."

Once all affected city departments have reported back that they have implemented procedures to implement this action, it will go back to City Council to become policy.

Fox Sports West Contract Approved

The IATSE contract with Fox Sports West was approved by the SportsNet members on April 10.

Among the gains for the members are an extra fee for mixers doing surround sound, increase in the fee for time spent traveling by car, an increase in contributions to MPIHP and Server/Tape Room staffing requirements to keep up with new technology.

Rate increases are 1.5% the first year retroactively, 3.25% the second and 3.5% the third. A-2s and utilities will get additional increases in order to bring their rates up to standards.

The IATSE represents sports television production crews in Los Angeles, San Diego, San Francisco, Seattle, Portland, Texas, Arizona, Minneapolis, Washington, New York and Chicago.

In Memoriam

JOHN ANDREW OLIVER
Production Sound Mixer
Feb. 14, 1920 – Jan. 31, 2013

J.L. Fisher's Open House and BBQ Lunch

J.L. Fisher will be conducting their 8th Annual Open House, Mixer and BBQ Lunch (excellent food ... last year, they had pizza barbecued on the grill) on Saturday, May 18, 2013, at J.L. Fisher, 1000 West Isabel Street, Burbank, CA 91506.

Local 695 will be demonstrating the Fisher boom and you're welcome to hop up and spend some time working on the boom yourself. We'll be there all day from 9 a.m. to 4 p.m. so you can stop by anytime. Jim Fisher offers tours of the Fisher facility at noon and 1:30 p.m. It's all free.

Parade of Sound Carts

Considerable ingenuity was on display at the second annual Parade of Sound Carts hosted by the Cinema Audio Society on April 20. More than 20 participants displayed their sound carts and answered questions at the Local 80 stage in Burbank.

Paul Vik Marshall, organizer of the event, showing the prizes for best cart.

Mark Ulano and Jeff Wexler take questions.

by LAURENCE B. ABRAMS

New Classes
to Keep Pace with the Technology

This year's educational programs offer more training opportunities than ever before. Some are funded by Local 695 and are completely free to 695 members and some are funded by the Contract Services Administration Training Trust Fund (CSATTF) and are either free or eligible for a two-third's reimbursement to members who qualify. This article contains an overview of some of these classes but the best way to stay in touch with all the educational opportunities available to you is by checking **www.695.com**. Also make sure that we have a good email address for you so that you'll receive updates and new class announcements as soon as they become available.

Local 695 Projectionists will see some new class options for training in digital cinema projection. We still offer the five-day **Digital Cinema CP 2000 and Solaria Series** class from Christie Digital Systems but this year we've added a new class from Barco Digital Cinema ... **Barco Certified Operator – Basic Projector Operations and Troubleshooting**. By the time you receive this publication, we hope to also have approval for **Barco Certified Operator – Projector Operations and Troubleshooting, Digital Cinema – Barco Certified Specialist – Installation and Basic Maintenance** and **Barco Certified Expert – Advanced Diagnostics and Service**. These classes are eligible for two-third's reimbursement from Contract Services if you meet their requirements. See **www.695.com/html/edu.php** for details.

Still available at no cost to all Local 695 members is the online training offered through VTC. With more than 10,000 software tutorials to choose from, this self-paced training covers a huge range of programs, including **Adobe Premiere Pro, Sony Vegas Pro, Apple Final Cut Pro, Adobe After Effects, Adobe Media Encoder, Adobe Director, LightWave 3D, Adobe Photoshop, Avid Pro Tools, Sound Forge, Adobe Audition CS6, Adobe Soundbooth, Steinberg Cubase, Steinberg Nuendo, Abelton Live, FL Studio, Apple Logic Studio, Audio Mixing Essentials, Filemaker Pro, Adobe Fireworks, Adobe Flash, Adobe Dreamweaver, Wordpress, Drupal, Joomla!, Wikis, PHP, Javascript, Networking, Programming** and literally thousands more. Each tutorial is divided up into a series of small, relatively easy-to-digest chapters. The most effective way to use these tutorials is to have the software being discussed open on your computer at the same time that you watch the tutorial so you can pause and repeat the training video as needed while you're experimenting with the operations and techniques being discussed. New VTC tutorials are being added all the time. See details about how to access this free training at **www.695.com/html/edu.php**.

Fisher boom training

Available on an appointment-only basis, our **Fisher Microphone Boom Training: One-on-One Intensive** continues to provide Local 695 members with a unique training opportunity that is not available anywhere else. In addition to training is free and available exclusively to Local 695 members. Contact us through **edu@695.com** to request a one-on-one training session. **NOTE:** On May 18, 2013, Local 695 will be giving demos on a 23-foot Fisher boom at **J.L. Fisher's 8th Annual Open House, Mixer and BBQ Lunch (free)**. See News & Announcements in this issue of the *Quarterly* for complete details.

Microphone Boom Operators and Utility Sound Technicians, we strongly encourage Production Sound Mixers to enroll in this training, as well. While a Fisher boom may not be appropriate in many shooting circumstances, it still remains a useful and powerful tool that can help you to produce superior tracks when used in the right situations ... and definitely worth a look when you expect very long shooting takes. Attendees to this training session will have hands-on time with the Model 3 and Model 6E bases and the Model 2 and Model 7 boom arms. This


Cable Clinics classroom

Studio Arts, which is located just east of Echo Park, offers training for a large list of software, including **After Effects 101, After Effects 201, After Effects 301, Avid Media Composer 1, Avid Media Composer 2, Final Cut Pro 101, Final Cut Pro 201, Final Cut Pro 350 – Color** and more. Members who attend these classes are eligible for a two-third's reimbursement of the training cost if they meet the Contract Services qualification requirements.

Also eligible for two-third's reimbursement from Contract Services is software training from a new program by an online training provider called **fxphd.com**. Most of the classes relevant to our members pertain to Video Assist Technicians and Engineers, such as **After Effects, Avid Media Composer 5.5, Advanced Color Theory and ACES Workflow, LUTs, Gamma and ACES, Intermediate Premiere Pro CS6**, and **The Craft of Color Grading II**. Additionally, for Production Sound they offer **An Audio Production Primer** and **Practical Audio Techniques with Audition**.

EVS offers two 2-day classes for EVS operators ... **LSM-XT Basic Operational Training** and **LSM-XT Advanced Operational Training**.

And Video Assist Technicians and Engineers may select from two color monitor calibration classes offered by the **Image Science Foundation**. All are eligible for two-third's reimbursement from Contract Services.

Our **Cable Clinics**, now in their fourth year, are conducted on a recurring basis by Local 695's "Master Cable Builder" James Eric. These hands-on classes are limited to just four members, providing a great opportunity to receive highly personalized training in the essential skills of cable building and repair for sound and video, including work with XLRs, BNCs, CAT-5 cables and more. Class dates are announced on our website and in email announcements.

More classes this year will expand upon our training program for **Digital Asset Management and Workflows** and, as in previous years, we continue to offer classes for **Final Cut Pro** and for **Avid Certified Pro Tools Training**.

New classes always appear on the **Announcements** page at **www.695.com** and full details for all training opportunities appear on the website's **Education & Training** page. Training updates and announcements are also sent by email. Most of you have been getting those emails periodically but if you haven't, you should check your profile at **www.695.com** and update your email address if necessary. You may also want to check the junk filters on your computer and, if necessary, "white list" our address ... **info@695.com** ... to assure that you're receiving all of our emails. As always, if you have any questions or suggestions about training or about the website, don't hesitate to contact us at **edu@695.com**.

LOCAL 695

Congratulations to the Winners

It was a triple-win hat trick for Production Sound Mixer Simon Hayes and his production sound team of Arthur Fenn, Robin Johnson, Paul Schwartz, James Gibb, Andrew Rowe and Duncan Craig, winning the Oscar, BAFTA Film Award and CAS Award for Outstanding Achievement in Sound Mixing for Motion Pictures – Live Action.

The recipients for each award are:

Oscar
Simon Hayes
Andy Nelson
Mark Paterson

BAFTA Film Award
Simon Hayes
Andy Nelson
Mark Paterson
Jonathan Allen
Lee Walpole
John Warhjurst

CAS Award
Simon Hayes
Andy Nelson
Mark Paterson
Jonathan Allen
Robert Edwards
Pete Smith

Congratulations to the Other CAS Awards Recipients

Outstanding Achievement in Sound Mixing for a Television Movie or Mini-Series
Hatfields & McCoys:
Part 1
Dragos Stanomir
Christian Cooke
Brad Zoern
Jeffrey A. Vaughn CAS
Eric Apps
Peter Persaud
Production Sound Team: Marius Cosma, Gabriel Marin, Radu Nicolae, Dan Blanaru

Outstanding Achievement in Sound Mixing for a Television Series – One Hour
Homeland
"Beirut Is Back"
Larry Long
Nello Torri CAS
Alan M. Decker CAS
Paul Drenning
Shawn Kennelly
Production Sound Team: Matt Fann, Jack Hill

Outstanding Achievement in Sound Mixing for a Television Series – Half-Hour
Modern Family
"Disneyland"
Stephen A. Tibbo CAS
Dean Okrand
Brian R. Harman CAS
Production Sound Team: **Preston Conner, Dan Lipe, Srdjan "Serge" Popovic**

Outstanding Achievement in Sound Mixing for a Television Non-Fiction, Variety or Music – Series or Specials
The 2012 Rock & Roll Hall of Fame Induction Ceremony
Brian Riordan CAS, Jamie Ledner
Production Sound Team: Richard Gizzi, Carl Glanville, Jason Gossman, John Harris, **Skip Kent,** Brian Kingman, Steve Lamphere, Bryan Leskowicz, Sean McClintock, **Billy McKarge,** Larry Reed, Joel Singer, Vinny Siniscal, Joel Tainio, **Barry Warrick,** Simon Welch

Outstanding Achievement in Sound Mixing for Motion Pictures – Animated
Brave
Bobby Johanson
Tom Johnson
Gary Rydstrom CAS
Andrew Dudman
Frank Rinella

Names in **bold** are Local 695 members.

Recording *Les Misérables*

Part 2: Implementing the Plans

by Simon Hayes AMPS

Beginning my assignment on *Les Misérables*, I had some enviable, even unprecedented, advantages. I had support from the producers at Working Title Pictures and the Director, Tom Hooper, to use every resource available to achieve live recording of all the vocals without any ADR. And I had a crew of seven skilled associates to help achieve this goal, all handpicked from the best technicians I know, all excellent choices for their ability to work together as a team. But it still remained to coordinate with other departments and develop a plan for how this goal might be accomplished.

Meeting Supervising Music Editor Gerard McCann was the next step and a defining moment in the planning stage. Right away we agreed to join forces and merge his four-man department with my seven-man team. Whatever demarcation had existed, we relegated to history and agreed that the teams would share all the tasks of the daily technical grind including rigging, cabling and loading gear.

Music Supervisor Becky Bentham was also part of this first meeting. She is a legend in the UK film industry. Both Gerard and I had worked with her before and had great respect for her abilities.

The three of us discussed the project in detail and worked out a plan of attack. We would have two live pianists on set at all times. Both were part of Cameron Mackintosh's team and had years of experience with the orchestrations of *Les Mis*. One pianist would work with the shooting crew and the other would be available at all times for warm-ups and rehearsal. Whichever one was on set that day would work inside a soundproofed plywood box fitted with ventilated Perspex windows so that the mechanical sound of the Korg electric keyboard would be confined. The player would wear headphones with an IFB feed of the vocal mix in one ear. The pianist was also fitted with a radio mike for direct communication with the actors via their "earwig" feed.

The piano would then be routed both to Pro Tools Rig #1 and also to the sound cart for transmission to the actors' earpieces. Says Gerard McCann: "We had our live piano performing and three Pro Tools systems, operated by Music Editors Rob Houston, John Warhurst and myself. Simon was able to route that live piano feed into earpieces worn by the actors who were then able to sing to live accompaniment. Our Pro Tools systems had three roles: one was dedicated to playback for tracks that required a fixed tempo, like chorus material. For the larger crowd songs, we would record a rehearsal of the ensemble cast on set on the day, and use that as a playback for shooting so that the crowd could follow along singing in the correct tempo, and this live singing recorded by Simon. This was to allow Tom maximum freedom to use as much of this sometimes rough, raw, but very real sounding live chorus as he chose, together with additional layers he might record later in post. A second machine was dedicated to recording the live vocal and piano mixes from Simon, and the third was used to turn around this recorded material almost instantly for playback."

In working out the production sound methodology, I was keen to stick to a comfortable workflow; this wasn't the time to be introducing new or untested equipment into the recording chain. I needed to be using equipment that was second nature to me so my attention might be on capturing performance rather than technical issues.

I chose to gang together two Zaxcom Devas, one the Deva 16 and the other a Deva 5. This would give us 26 tracks. I would give the picture editor two mix tracks to use on his Avid timeline: **Mix-1** had the vocals and the mono piano; **Mix-2** had the vocals only, without the piano. This gave the editor the facility to adjust the blend of voice and accompaniment as needed.

We linked the two recorders together so they would have identical timecode. The Deva 16 had the two mix tracks plus isolated mikes on tracks 3–16. Machine 2's ten tracks were all assigned to ISOs.

The two linked machines gave us a total of 24 tracks. Since we might need to use radio links for the two mono booms and the stereo boom, we were limited to 20 radio mikes. I already had two fantastic Audio Developments' mixers with eight channels each. They were modified to supply either analog or digital signal on all the outputs so we were well equipped for 16 tracks. We reasoned that we would not need all available tracks recording the solo performers, only when recording the chorus, so we could connect directly to the Devas and use the front panel faders on those occasions.

I also ran a safety copy of the mix tracks on a 24-bit Nagra V in case of a hard disk failure on the primary machines. That covered us in the event of an equipment failure on a magical "perfect take."

Running 20 radio microphones without any inter-channel modulation or interference is not easy. Luckily, the UK was in the middle of switching the legal film industry channels from one band to another to make way for digital television, and we took full advantage of the temporary window available to us to use both channel 38 and channel 69. As Gerard worked out the need for five different Comtek feeds—that's right, five mixes—our special good fortune became more apparent. Our plan called for **Mix-1** to be piano and vocals while **Mix-2** would be piano only for members of the music department who needed to concentrate on that element. (Quite a few members of the music team kept two receivers on their belts so they could swap between these two mixes as they wished.)

Mix-3 would be vocal only for use by dialog coaches working on accents. The pianists also used this mix while listening to a direct feed from the electric piano in the other ear.

Mix-4 was a special mix that Tom Hooper and Danny Cohen required for themselves and the camera crew. The music was such a large part of the tempo and timing that the camera crew needed to hear the piano and voices to motivate their action. We added a talkback mike—a Shure SM58 with a transmitter—to permit Tom to communicate with camera operators and grips even during the takes.

Mix-5 was the boom operators' headphone feed, much the same as **Mix-4** but with my voice alongside the singing and piano instead of Tom's. I was, of course, using the onboard talkback mike on my mixer rather than a handheld SM58. This permitted me to talk to the three boom ops throughout takes about lens sizes, shadows, etc. With the 20 radio mikes, five wireless headphone feeds and Tom's SM58 transmitter, we would be using up to 26 separate frequencies at any time. The responsibility for wrangling all these frequencies fell to 1st Assistant Sound Robin Johnson. Without his skill and experience, I doubt we would have been able to run that many channels.

Photos by Laurie Sparham/Universal Pictures

Arthur Fenn booming Hugh Jackman on the French mountaintop.

"I'm Jean Valjean" Steadicam about to step onto crane, Arthur booming about to exit camera right, Super CMIT on radio with D/A Converter in rucksack.

All of this equipment would live on two sound carts that could be moved around on location. We were becoming technically ready. The next step was to consider the "in-the-ear" monitors for the actors.

We considered several in-ear monitors and made a decision early on to use a traditional induction loop system over the newer radio systems. To fit within the ear, all of these systems are limited to a very small driver that severely limits sound quality. None of the present designs sound very good. Since the units with a built-in radio receiver offered no audio advantage, we couldn't justify their extra expense particularly considering the number of units we would need. We concentrated our efforts into finding the best induction loop amplifiers and in optimizing the performance of the traditional design.

We confronted two problems with the available earwigs: their small driver size severely limited bandwidth and they were not very loud. An orchestra with a broad mixture of bass and high frequencies would confuse the tiny driver and the output became muddled. We found the problem was less acute using the Korg electric keyboard as its output is simpler and tends toward the midrange. The pianists were a great help with this by adjusting their play accordingly. We also adjusted the EQ settings on the keyboard to suit the earwigs.

The loudness issue was not so easily resolved. These earpieces were originally designed to assist people with hearing difficulties, not to be used as a reference while singing "Who Am I?" or "I Dreamed a Dream" at the top of one's voice. We contacted the manufacturer and they were very helpful and supplied us with louder units. We also had them come out and make ear casts of each principal actor to supply them with custom-fitted earpieces both left and right. This helped in several ways. The custom earwigs fit deeper in the ear canal and were less visible to camera. Also, a precise fit ensured that the earpiece was optimally positioned, and its tiny outlet hole unblocked, so it could deliver its maximum output. Having both left- and right-fitted earpieces also gave the option for using both if an actor were struggling to hear. This was really a last resort because it would interfere with the actors hearing their own vocals.

We decided early on not to feed vocals into the earwigs both because of the frequency response issues and also because we would forever be discussing individual preferences on the balance between vocals and piano. This would present an impossible situation because we could only provide one earwig mix on the induction loop. But there are always exceptions—on "I Dreamed a Dream," Anne came to me after the first take and asked to wear both earwigs with the piano as loud as possible and a tiny amount of her own vocal added. Since she was singing a solo, and we didn't need to provide earwigs to others, we were able to accommodate her.

The scene that got away, the only scene the actors mimed to. It was hard enough just finding a sound system loud enough to drown out the special FX equipment. We ended up using a 4KW JBL system with a subwoofer enhanced by 10 anchor speakers which we could get closer to the actors so there wasn't a delay factor.

For a couple of monumentally challenging sequences, Tom staged two actors at locations hundreds of yards apart, harmonizing together in real time but shot with separate cameras. In those instances, we fed their vocals to their earwigs so they could keep pace with one another. This created much hilarity on set as Hugh and Russell realized they could communicate with each other and began comparing progress on the setup and which camera crew might be ready first. There were other exceptions to our no-vocals-in-the-earwigs rule but we generally tried to keep the playback practice as simple as possible.

With recorders, track assignments, piano accompaniment and earpiece distribution worked out, Gerard McCann and I had a good plan for recording the vocals. But we needed to meet with Orchestrator and Music Producer Anne Dudley and her team to confirm that our efforts would meet her needs. We met her and Music Supervisor Becky Bentham at the famous Abbey Road Studios in London. They told us that their engineers would like to hear the mikes we intended to use so we set up some test sessions. The Neumann U87 is the standard condenser microphone in a music studio. Its accuracy is unexcelled and its large diaphragm produces a smooth response to rapid transient changes. The music studio also offers acoustic excellence and the ability to place the microphone in optimum position. No location recording plan we might devise would ever be able to equal that performance. But the live recording offers the advantage of immediacy and an emotional link to the acting so the operative question was whether the fidelity of our system would meet listening expectations.

I chose the Schoeps Super CMITs for our boom operators. These new microphones use DSP noise-canceling technology to reject off-axis background sound. This capability is a great advantage but demands a high level of skill from the boom operator.

When the Schoeps were used in testing it became clear that, if they were in an optimum position, the kind possible while shooting a close-up, they could compete on a level playing field with the music studio mikes.

We also tested the DPA lavaliers and Lectrosonics radio mikes. In my opinion, the DPA matches the Schoeps Super CMIT more closely than any lavalier I've heard. During the demo at Abbey Road, the engineers, despite initial skepticism, were suitably impressed. They felt they were getting approximately 60 percent of the quality of a Neumann U87 when I believe they were expecting much less. When you consider that the studio mike is placed on a stand in the best possible position while the DPA is rigged on the actor's chest, that is an excellent result.

Special FX over and Arthur Fenn booms the first live sung scene between Hugh Jackman and Russell Crowe.

Paco Delgado, the Costume Designer, was extremely helpful and collaborative in this process. To hide the lavalier mikes, he and his team supplied us with the necessary cuts of fabric from each costume and also allowed us to make the holes needed to hide cables. He encouraged us to take the lavalier rigging to a level that enabled us to record absolutely clean singing with no clothing rustle. As we started shooting, it became clear that the process of mic'ing the cast was far more time-consuming than on a "normal" film not just because of the need to match fabrics but also because there were so many radio mikes used.

It's always my aim to deliver as natural a dynamic range as possible so I was in full agreement with the engineers' request that we not use any compression or limiters in the recording chain. To make the full 24-bit dynamic range available, this meant not only refraining from using or tripping limiters in the equipment but also not riding gain during the take. We used the Lectrosonics transmitters at a very low-gain setting to ensure that limiters would never be engaged. Historically, the higher gain setting needed with radio mikes to stay above artifacts meant that limiters were needed to prevent overloads with louder signals. The ability of the current generation of Lectrosonics' gear to capture clean signal at lower settings, even with whispered delivery, was impressive and a key reason we were able to take on the project. By agreement between the Music Department and the Sound Department, we used no limiters or EQ anywhere while recording *Les Misérables*.

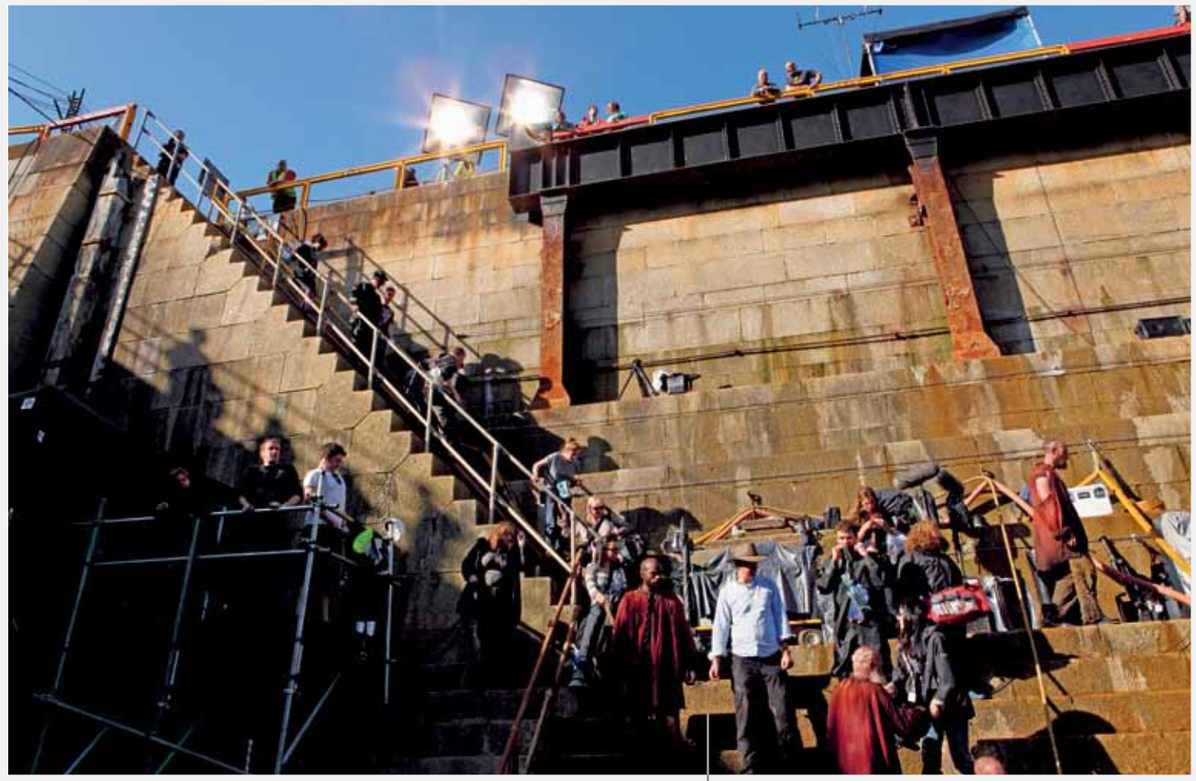
"Eve Stewart, the Production Designer, asked me about ways that set design could help with Tom's vision of a live musical. I commented that for live sound we wanted reality. If they are in shot, the cobbles should be real cobbles, the oak door frames should be real oak, so that any sounds we picked up would be as authentic as possible."

With everyone in agreement on the methodology, we turned our attention to the challenges of recording live singing on a movie set. We had to consider the scale of the Paris street scenes and how to manage them. Tom asked me if I would prefer to shoot the exteriors on a soundstage or on location. I knew that Tom wanted to shoot the scenes, some as long as 14 minutes, from start to finish without a cut. I didn't see how this would be possible outdoors in a modern, aircraft-infested environment but the only stage large enough for the planned scenes, the 007 stage at Pinewood, is not really a soundstage and has poor acoustics. Just a few weeks into preproduction, Tom contacted me to tell me about a new stage being built in Pinewood—the Richard Attenborough Stage—that would be the biggest in the UK. (After our good fortune with the transitional availability of radio frequencies, we began to think someone upstairs was smiling on our project.)

Eve Stewart, the Production Designer, asked me about ways that set design could help with Tom's vision of a live musical. I commented that for live sound we wanted reality. If they are in shot, the cobbles should be real cobbles, the oak door frames should be real oak, so that any sounds we picked up would be as authentic as possible. She took my suggestion and filled every inch of the 30,000-square-foot stage with sets built with the characteristics of permanent structures.

Our interest in solid oak and stone applied only to areas seen in the shots; outside what the cameras saw we tried to make the set and crew sonically disappear. Our efforts extended even to fitting rubber shoes on all the horses' hooves.

For Eponine's number, "A Little Fall of Rain," we faced the additional challenge of recording the entire number in the rain. We worked with the Special Effects Department to get the best possible rain that would show on camera without drowning the mikes or making too much noise. We covered every part of the set not seen by the camera, every rooftop and every piece of floor, with rubberized horsehair to deaden the raindrops. We had an entire truckload of horsehair delivered to Pinewood. We also had a horsehair cover to provide quiet protection for the camera and asked the camera technicians to wear black "Bolton" cloth (Duvateen) ponchos over their Gore-Tex to soak up the sound of the water hitting. We even had a second boom operator shadow the primary boom with a horsehair roof on the end of his boom



Looking out over the massive dry dock with Shark Fin and Yagi antennas.

> **“Guys, I know you aren’t going to like this and I know we are in freezing temperatures up a mountain but, if this is going to work, I need you all to take off your Gore-Tex trousers and, if you are tracking with the action, just wear your jeans. Otherwise, all I am going to record is the swooshing of Gore-Tex.”**

pole to shield the primary mike. That was the attention to detail that we exercised and it was possible because of an outstanding seven-man team. With a truck full of rubber-backed carpet, this team padded every dolly track and every walk-and-talk to keep the set as quiet as possible and recovered the carpets as soon as the shot was completed so they never held up the shooting. These efforts paid off not just by reducing noise from footfalls but they helped to deaden sound reflections throughout the set and augmented the many sound blankets we hung for that purpose.

Wind to flutter hair and costumes is a necessary element to create the illusion that players are outside and not on a set. Traditionally, large fans or wind machines provide this but they are quite noisy and compel ADR whenever they’re used. We coordinated with the FX Department to place the wind machines outside the stage and pipe-in the wind through flexible air-conditioning hose. The mikes didn’t pick up the sound of the electric motors at all, just the sound of moving air that mimicked the sound of actual wind. And, since its frequency fell outside of normal voices, it could be effectively removed in post.

After all the technical planning, we were ready to put our methodology to the test. The film had engaged the actors for an eight-week rehearsal period directly prior to shooting. Such a lengthy rehearsal period isn’t the norm but *Les Mis* was a complex project. I felt it important for the whole sound crew to be involved from the beginning but there was a move to exclude us. I can certainly understand the budget implications of adding a large sound crew for an extra eight weeks. And, the performers can be self-conscious as they develop their performances. Working with playback or with a piano accompaniment will mask errors in pitch or delivery but singing a cappella leaves every performance mercilessly exposed. I could understand the reluctance but I felt it important that everyone become committed to the live recording protocols from the beginning. I worried that, after eight weeks of rehearsal with the blanket of protection afforded by an amplified piano, the cast might balk at the introduction of the earwigs on the first day of shooting. If they felt they couldn’t work without the live piano, the whole plan of live recording would founder. We needed the collaboration between Cast and Sound to begin on the first day of rehearsals.

I also felt that the long rehearsal period was important to more than just the cast. I wanted to use earwigs and radio mikes on every rehearsal so that the Pianists, Roger Davison and Jennifer Whyte, could become comfortable with the process of working within a sound booth and following the pace of the singers from their own headphones. And, I wanted the practice time for the Sound Department so that we might become familiar with the songs, the staging, the head turns, the extremes in dynamics, and work out solutions to the challenges in advance. Sometimes a single performer would need two mikes, one on each side or one close to the mouth and one lower, to handle these variables.

Even more important than the technical issues was the opportunity to become acquainted with the cast and earn their trust that we would deliver quality recordings of their live performances. I pressed these points with the producers and with Tom and eventually we were invited to participate.

By the end of the rehearsal period, the cast was completely unfazed by using the earwigs and having direct communication with the pianists through their lavaliers. They would arrive at our sound carts upon entering the rehearsal stage to ask for their mikes and earwigs before proceeding to the set and enjoyed being able to communicate directly with the pianists without raising their voices to draw the pianists’ attention.

It was going well but we were developing a new process and everyone, Tom Hooper, the Producers, the Music Department and our own Sound Department, wanted a test to confirm that it would all work through editing and mixing to a final product. The “Red and Black” number performed by the students in the café was a good selection for our test. With multiple solo lines from the cast and an ensemble of about 20 students, it provided a taste of most of the circumstances we would encounter throughout the film. From the beginning, I had requested that rehearsals take place in the proper acoustic environment so that we might make test recordings and check the results later through studio monitors. Consequently, our rehearsal space was a proper soundstage at Pinewood that was suitable for a film test. Tom decided to shoot the test with a full camera crew and three 35mm cameras.

The test shoot proved challenging, exciting and interesting. Although Tom had discussed the visual style he had worked out with DP Danny Cohen, nothing quite prepared me for his single-minded enthusiasm for shooting every take all the way through from beginning to end. For the sake of performance and energy, Tom would shoot numbers in their entirety so I needed to be ready at all times. For me this meant multi-tracking and mixing 20 mikes on every take from 8 a.m. to 8 p.m. It was mentally demanding; I had to find a zone and stay focused. My own mixing improved with the constant practice but that was a small benefit as we always intended to remix from the ISO tracks in post. More importantly, the boom operators thoroughly learned the intricacies of every move by both cameras and cast members and became adept at following the singers exactly. Since the long takes forced a camera reload for nearly every take, my crew had an opportunity to act on every little problem revealed by the previous take. Carpet placement could be optimized, a cast member standing on a squeaky floorboard could be shifted slightly and chorus or extras that were whispering when they should have been miming, could be advised. (Many members of the chorus ensemble came from a theater background where ad-libs would enhance the performance. It took awhile before they became comfortable with the understanding that film editing needed consistent, i.e. silent, backgrounds.)

Silencing the ad-libs and background action was a huge undertaking that continued throughout the movie and was a constant negotiation with Tom. He liked the way the ad-libs tended to increase energy in the performances and used them to motivate the soloists to project their singing to rise above the clutter. But I maintained that working this way would force ADR when the ad-libs and chatter didn’t match in the cuts. Tom understood; while he encouraged active participation in the rehearsals, he recorded the takes with mimed background action.

We finished the test shoot and I was mentally and physically wiped out. It had been the most challenging day I had ever recorded and it dawned on me that we had 70 days of this in front of us, many without the comfort and acoustic security of a soundstage. Every single day would require immense focus and energy from all of us. We got word very quickly as the test was edited and orchestrated that the vocal recordings were a complete success. Everyone was incredibly euphoric that our workflow had been proved not just possible but hugely successful. There were lots of extremely happy producers after the test.

I’m glad I experienced the test before we started shooting because it gave me a chance to prepare myself for an incredibly demanding shoot. The first part of the shoot was a reduced unit in the French Alps shooting Valjean (Hugh Jackman) traveling on foot from the port to the Bishop’s chapel. We arrived and the 1st Assistant Director told me Tom had chosen a location on the highest mountain peak and it was impossible to access it in vehicles. He asked me to go ‘handheld’ because carrying the kit up the mountain would be impossible. I told him that I wasn’t prepared to compromise sound quality in any way and we set about carrying my 180-pound sound cart up the mountain. It took four men nearly an hour to make a 20-minute trip across the boulder-strewn pass. It was a Herculean effort but we arrived at the summit with all the equipment—the proper D/A converters, the big mixing panel, the high-gain antennas—we needed to do a first-class job. It was just this kind of single-minded purpose and resistance to compromise that got us great production tracks.

Arthur Fenn and Simon Hayes discuss tactics; 24 radio mikes and a look at how they applied carpeting to reduce footstep noise and creaks from the track.

Quickly, we learned from Tom and the 1st AD exactly where Hugh would be walking and singing and we set about running a battery-powered induction loop under the rocks. With Tom and Hugh's permission, we had prerecorded the piano track in rehearsals. If Hugh was comfortable setting a pace in rehearsal, we could run playback from a Mac laptop using Audacity rather than take a piano and Pro Tools up the mountain. Valjean was to walk across the summit covered by a single handheld camera. Arthur, my Key 1st Assistant Sound, asked if he could work with a radio boom to help with the uneven surface at the summit. I asked that he remain on a cable for every shot apart from a 360-degree pan so we might minimize radio electronics in the boom signal chain and maximize sound quality. We fitted Hugh with two radio mikes, one tight and one slightly wider. Tom asked us to shoot the rehearsal so I had no idea of the volume to expect. As Tom, Arthur and the camera crew tracked with Hugh and he began to sing, it became clear we were capturing something magical. I quickly listened to the ISO tracks and decided that Arthur's boom with the Super CMIT was the best sounding track. Due to the tight headroom Tom was maintaining, it was in a perfect position 10 inches above Hugh's head. I concentrated my attention on Arthur's boom track in subsequent takes. There was no background noise apart from Hugh's wooden clogs and his walking stick tapping the granite. They were not compromising the vocal performance and I decided not to bother Hugh about them so he might get on with his acting.

I should add that before shooting, I spoke with Tom, the DP and the camera crew and told them, "Guys, I know you aren't going to like this and I know we are in freezing temperatures up a mountain but, if this is going to work, I need you all to take off your Gore-Tex trousers and, if you are tracking with the action, just wear your jeans. Otherwise, all I am going to record is the swooshing of Gore-Tex." This was one of those moments where all the talking about the importance of sound quality and performance was truly put to the test and it was time to see if the crew really understood what that meant. One by one they duly removed their Gore-Tex trousers.

When we arrived home from France and started setting up to shoot in Pinewood Studios, I went to watch dailies at Editorial. I viewed on an Avid machine through near field studio monitors. It was just the raw mix track which in this case was the boom only. As I saw Valjean walk wearily across the mountain range and into a close-up, I could hear his breathlessness due to the altitude and see the fog from his breath on screen. As he started to sing with such fragility from the effect of the altitude, it sounded so real. I was completely spellbound and I knew in that moment that we were creating something special. Never before had I experienced such a connection while watching a musical.

As we shot, it became clear to us that we needed to be flexible and use the best method available to record each scene. Scenes like the factory women singing "At the End of the Day" were staged with multiple solos and hard light that made swinging booms to each player difficult. Those scenes were best recorded on radio mikes with the booms playing a secondary role and the stereo boom serving to add dimension to the radio mikes used on the chorus. That was also the technique used for "Lovely Ladies" but for Hugh Jackman's "Who Am I?" and Anne Hathaway's "I Dreamed a Dream" and Eddie Redmayne's "Empty Tables and Empty Chairs," the boom was the primary recording device.

On "I Dreamed a Dream," we were shooting with three cameras and, from the first take it became clear that Anne was going to clutch her chest during the emotive parts of the performance. Of course, that was right where the lavalier was placed. To ask her not to do this action, a part of her instinctive body language during the scene, would have been to stifle the truth and honesty in the performance. After the first take, I told Tom that we couldn't rely on the radio mike any longer and had to get the boom closer. The "A" camera was shooting a close-up, "B" camera was shooting a wider close-up with the same top-line but "C" camera was shooting a classic wide with three feet of headroom. I reasoned that it was unlikely the wide shot would be used for long and the boom could be painted out if necessary, so I asked Tom if he would permit us to bring the boom into the wide shot. The VFX supervisor was present and instantly said, "The shot is static. If you just keep the boom out while the clapper board is going on before the performance starts, we will get a clear piece of the background needed to matte the boom out." It was this kind of instant answer and collaborative teamwork that enabled Tom to make quick decisions and keep shooting.

The boom was also invaluable on all the sewer scenes where the radios would have become waterlogged. One of my favorite songs in the movie, "Empty Tables and Empty Chairs," sounds beautiful on the boom and that was possible because all three cameras were shooting close-ups from different angles so the headroom was the same.

Recording singing differs from recording dialog in that the acoustics on singing need to be the same throughout. It would be wrong to have the wide shots sounding "wide" and the close-ups sounding "close"

At the back of the music truck with the electric piano, Claude-Michel Schönberg (folded arms blue jumper) and Alain Boublil (pink jumper), the writers of *Les Mis*. As Hayes speaks with Gerard McCann (back to camera), Robin Johnson wrangles frequencies on the sound cart.

because when the orchestral music is added, the balance of music and vocal would change shot by shot. This would draw attention to the shifts in camera angle. Yet while recording dialog, it is generally accepted that an acoustic change matching shots of differing sizes actually helps a scene to sound real to the audience. For singing, whatever mikes are used must be in a close and uniform position throughout the song.

It is possible to use slightly different widths of mike placement as long as there isn't a noticeable acoustic shift. We often used two radio mikes on an actor if their performance required extreme dynamic range and I would rig one lavalier close to the mouth to get a very closely mic'd performance on the whispers, but another lavalier five or six inches further away to pick up the louder pieces while sounding a little more open. Of course, the mikes were recorded on separate tracks so the dialog editor had a choice depending on what sounded better in the final context of the scene, once orchestration had been added.

Another break in filmmaking tradition was bringing a dialog editor, the extremely skilled Tim Hands, aboard just a few weeks into shooting. He was based at Pinewood while we were shooting and I was in constant contact with him daily explaining how we covered scenes, which tracks I thought were best and pointing out any issues I thought he needs to know. It was his job to clean and edit the vocals on Pro Tools. He was extremely subtle in his work and mindful of Tom's admonition to not remove anything that would diminish the audience connection to the actor. He concentrated on removing background noises that had nothing to do with the on-screen performance. When a scene was starting to take shape in the Avid, the Picture Editing Department would give Tim the EDL and he would give them a bounce back of the edited audio from my ISO tracks. This meant that Tim was often working on a scene many times as the picture editor and Tom made changes but it also had the valuable 'knock on' effect of immersing Tim in the material so that he became completely familiar with all of it. When Alastair Sirkett joined him in the post-production process, this intimate familiarity helped him get the best from the recordings and the pair of them delivered an outstanding finished product.

After the film techniques clean up, the tracks pass to John Warhurst, the Music and Sound Editor. He went through them using music industry technique to make them sound their best going into the final mix. This process exemplifies the special collaborative workflow for this movie. Supervising Music Editor Gerard McCann pointed out at the beginning of our planning that the skills and objectives of a film dialog editor and those of a music vocal editor are very different. For instance, a music editor would be working out of his usual skill set if presented with generator noise or lighting hum while a dialog editor would not be at home adding reverb to enhance vocals. An oversimplification but because the vocals on *Les Mis* were essentially a crossover of both mediums, we needed to make sure they benefited fully from each methodology.

Although Re-recording Mixer Andy Nelson's main contribution comes at the very end of the process, his involvement began at the conception. He has extensive experience in musicals including work on *Evita* and *Phantom of the Opera*. Tom Hooper was familiar with his work on Alan Parker's *The Commitments*, a project that featured some live recording to a prerecorded backing track, so he sought out Andy when he was first considering live recording for *Les Mis*. Andy confirmed the success of the live recording on *The Commitments* and encouraged Tom to take on the larger challenge of *Les Misérables*.

Tom encouraged me to contact Andy Nelson when I was first hired. Gerard McCann and I had a long conference call with him to discuss workflow and methodology, check that he agreed with our plans and receive any advice he might offer. We kept in contact thereafter and he regularly listened to and commented on material as we worked.

Andy was particularly keen on not using EQ or compressors and limiters in the recording chain. He also asked that processing done by the dialog and music editors be "virtual" so that changes could be reversed and the material returned to a raw state at the touch of a button. He wanted to have complete control at the final mix where all the elements of score, sound effects, Foley and vocals could be evaluated together and judged as a whole.

For instance, he wanted us to avoid using plug-ins to clean up camera noise because they often have a slight effect on the vocal tone and he thought that the orchestration might effectively hide the camera noise.

Jonathan Allen, a Re-recording Mixer from Abbey Road Studios, was also generous with help and advice throughout the project. He worked on the orchestrations in Post but also joined me on days with big chorus ensembles and assisted both with advice and mike placement.

The whole project was a collaborative project from the outset. It set out to bring to the audience the in-the-moment emotions and the live singing of the cast. The success of that endeavor demonstrates what can be accomplished with everyone working together.

Cameron Mackintosh offered daily support and input for the project. He commented that "Music, if used correctly, should pull the heartstrings." I believe that the filming of *Les Misérables*, as envisioned by Tom Hooper and with the support of Producers Eric Fellner, Tim Bevan, Debra Hayward and Sir Cameron Mackintosh, and each and every crew and cast member, really does "pull the heartstrings." It was a fantastic piece of work.

A Tribute to Stefan Kudelski and the Nagra Recorder

1983, Stefan Kudelski posing with the VPR-5 video recorder developed with the Ampex Corporation

by Scott D. Smith, CAS

INTRODUCTION

Few pieces of equipment have attained the iconic status of the Nagra recorder. Used and revered by production sound crews around the globe, Nagra recorders have been used in the recording of production soundtracks for an untold number of feature films, documentaries, commercials, industrial films and TV productions. Similarly, it has seen extensive use by radio stations for location origination, as well as by engineers engaged in music recording.

Long considered the "gold standard" for location sound, the Nagra recorders established a level of technical superiority and reliability that to this day is unmatched by almost any other audio recorder (with the possible exception of the Stellavox recorders, designed by former Nagra engineer Georges Quellet).

With the death of Stefan Kudelski in January of this year, this is an appropriate time to look at the history of the Nagra recorders and the man responsible for their huge success.

The Early Years

It should probably come as no surprise that Stefan Kudelski would be destined for great works. Born in Warsaw, Poland, on February 27 of 1929 to Tadeusz and Ewa Kudelski, it was clear early on that he possessed a level of intelligence and ambition exhibited by few other young men his age. His father had studied architecture at Lviv Polytechnics, but later went into chemical engineering. His mother was an anthropologist. Despite this, his childhood years were far from idyllic. With the Nazi invasion of Poland in September of 1939, his family fled Warsaw, first to Romania, then to Hungary, and finally to France and Switzerland. He resumed his high school education at the Collège Florimont in Geneva, and later studied electrical engineering at the École Polytechnique (now known as the Swiss Federal Institute of Technology) in Lausanne, Switzerland.

The Nagra I

Kudelski did not set out to create a portable tape recorder. His initial interest was sparked by the terribly inefficient work he saw being done at a machine shop in Geneva, where each piece was turned by hand. Realizing that much of this repeatable work could be done by automation, he set about designing what would have been one of the first CNC machine tools. However, he lacked a method to record and store the data necessary to control the motors and began to look at magnetic recording as a possible medium for data storage.

After dismantling an old recorder to study its design, Kudelski designed a new recorder from scratch. This recorder was the genesis of the Nagra I. However, as the son of a poor refugee family, he was unable to interest anyone in his CNC machine tool project, so he turned his focus to designing a recorder suitable for broadcast use.

Working from his apartment in Prilly, he managed to scrape together enough money to design a prototype machine. It was an instant success, and he sold his first machine for the sum of 1000 CHF. (While this only amounted to about $228 USD in 1952, it was still a significant amount of money for the young Kudelski.) This initial sale was followed by orders from both Radio Lausanne and Radio Geneva. In May of 1952, on the heels of interest from some well-respected European reporters, he received an order for six Nagra 1's from Radio Luxembourg. That convinced Kudelski that he was on the right path.

Kudelski left the École Polytechnique, and pursued development of the Nagra full time. Years later, he would receive an "honoris causa" degree from the École Polytechnique, in recognition of his work in developing the Nagra recorder.

By the end of 1953, Kudelski had established manufacturing operations at a house in Prilly (west of Lausanne), and employed a staff of 11. Toward the end of 1954, he refined the design, now called the Nagra II, and implemented printed circuit boards for the audio electronics.

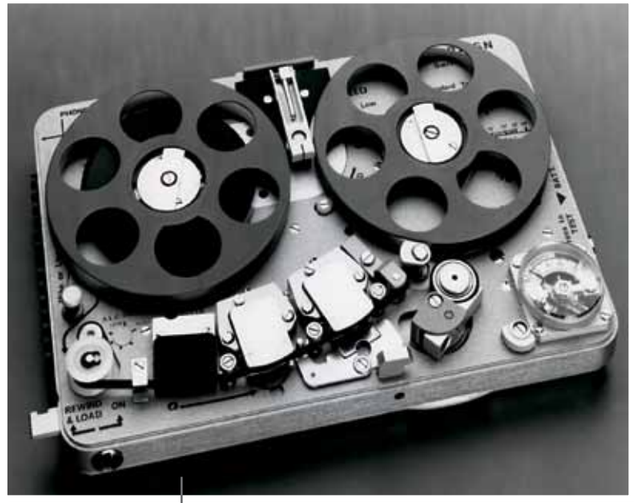
The orders continued to roll in, virtually all from word of mouth, and by the end of 1956, the staff numbered 17. Despite this success, Kudelski recognized that there were still improvements needed, especially in the area of the drive mechanism. He continued development of the machine, but opted for a ground up redesign, as opposed to the incremental changes between the Nagra I and II. The result was the Nagra III, introduced in 1958.

The Nagra III Makes Its Debut

The design of the Nagra III marked a significant departure from the Nagra II. Gone was the spring wound drive mechanism, replaced by an extremely sophisticated servo-drive DC motor. Also absent was the tube-based amplifier circuitry. In its place was series of modules, each encased in metal, which contained the individual components of the machine. The attention to detail could only be described as obsessive. Even the meter (called the "Modulometer") was designed from scratch, and contained luminous needle and scale markings, so as to be read in the dark. This kind of attention to detail set the Nagra apart from most of the other recording equipment of the period, which still relied on VU meters and bulky electronics. It was designed for rugged operational conditions, and could be powered from 12 standard "D" cell batteries.

Acceptance of the Nagra III was almost instantaneous. The factory built 250 machines in 1958. In 1959, the Italian radio network RAI (Radio Audizioni Italiane) ordered 100 machines to cover the Olympic Games in Rome, paying cash in advance. To meet the challenge of this large order, the company acquired larger premises in Paudex near Lausanne. Since the Nagra III relied heavily on custom machined parts, a significant investment in machine tooling, along with skilled machinists to run them, was required to keep pace with orders that were now coming in from networks around the world, including the BBC, ABC, CBS, NBC and others. By 1960, there were more than 50 employees working in Switzerland, and a network of worldwide sales agents was established to support the sale and service of the machines. By 1960, the Nagra factory was turning out approximately 480 recorders annually.

1960 also marked the debut of the Nagra SN recorder, an extremely small recorder utilizing 1/8" tape in a reel-to-reel configuration.



The exotic Nagra SNN miniature recorder introduced in 1971

Nagra Enters the Film Business

The application of portable sound recording to the film industry was not lost on Kudelski or his agents. In 1959, French director Marcel Camus had used a Nagra II to record part of the sound on the feature production of *Black Orpheus*, shot on location in Brazil. Sensing that this could be a burgeoning market, Kudelski quickly set about designing a version of the Nagra III that could utilize a pilot system for synchronous filming.

This early version of this system, known as PILOTTON, was based on technology initially developed in 1952 by Telefunken and German Television, which consisted of a single center channel pilot track about 0.5mm wide. However, it did not have a HF bias signal applied to it, which caused distortion which bled into the audio track. Realizing that a better solution was needed, Kudelski invented the Neopilot system to replace the PILOTTON system. This design consisted of two narrow tracks at the center of the tape, recorded out of phase with each other, so the signal was cancelled out when reproduced by a full-track head. The addition of HF bias helped reduce distortion, which resulted in minimal interference to the program audio.

A companion synchronizer (the SLP), developed about the same time, provided a method to resolve synchronous recordings on the Nagra III. The design of the DC servo-motor system provided an elegant approach to this task, making the AC motor-drive systems of the day look archaic in comparison.

The first of the Nagra III's equipped with the new Neopilot system were delivered in 1962, and led to a huge increase in sales. Lead times for the Nagra III now grew to 68 months, requiring yet more space for production. The Swiss government also placed restrictions on how many workers could be hired, causing further delays and hampering growth of the company.

In 1964, additional office and production space was rented in Renens, with further premises acquired in 1965 in Malley. By the end of 1965, the decision was made to purchase a factory in Neuchâtel. Later, a huge tract of land was purchased in Cheseaux-sur-Lausanne, which allowed for the construction of a dedicated factory. In 1968, the company was registered as Kudelski S.A. (essentially a public limited company, as opposed to the previously privately held firm).

Nagra IV Debuts

The company celebrated the sale of the 10,000th Nagra in 1969 and moved into their new facilities in Cheseaux-sur-Lausanne. The introduction of the Nagra IV that same year marked another significant improvement in analog recording technology. While the basic transport design mimicked that of the Nagra III, the new machine now used much more reliable silicon transistors, and sported two mic inputs. The pilot system was also improved, with the flux level on tape being standardized, regardless of the voltage present at the pilot input. Filtering added to the pilot signal significantly reduced the amount of noise that could bleed through into the audio track. Approximately 2,510 new machines were built in 1969.

Not content to leave well enough alone, one year later, Kudelski introduced the Nagra 4.2L recorder. While the 4.2L offered a few improvements over the IV, they were not as significant as the changes seen between the model III and IV. If some industry observers were of the opinion that Kudelski had begun to slow down further development of analog recorders, they were significantly underestimating his ambitions…

If One Channel Is Good, Why Not Two?

Seeing further opportunities in the sale of machines to the broadcast and film markets, in 1971, Kudelski introduced a stereo version of the Nagra 4.2, called the IVS. Built on the same platform as the 4.2, the machines offered many of the same features, but with two channels of recording in the same footprint as the mono recorder. It also marked the introduction of a new pilot system, called NagraSync FM, which recorded a FM modulated pilot signal at 13.5 kHz between the two audio tracks. This allowed for synchronous recordings, without having to reduce the width of audio tracks, and neatly solved the

Stefan Kudelski conducting an interview with the Nagra II

Nagra II courtesy of David Panfili, Location Sound Corporation

problem faced by trying to use the older Neopilot system for two-channel recording. It also allowed for a limited bandwidth commentary track to be recorded on the same channel, which aided in slating for production situations where a standard "clapper" slate couldn't be used, without interfering with the program being recorded. While stereo recorders were certainly nothing new at this point, all the commercially available machines were bulky AC-operated recorders, giving Kudelski yet another significant entry into the audio recorder market.

1971 also saw the introduction of the unique SNN recorder, a miniature recorder using 1/8" wide tape, but in a reel-to-reel configuration as opposed to a cassette. Like its predecessors, it also had the ability to do synchronous recording. Although Kudelski had begun development work on the SNN about a decade earlier, he waited until 1971 to bring it to market. This year would also mark the introduction of equipment destined for applications outside of the traditional film and broadcast arena.

Diversification

Whether driven by the need to invent or recognizing that the market for portable audio recorders would eventually become saturated, Kudelski began to design and manufacture equipment for applications outside of the traditional film and broadcast market. While he had designed a recorder for military applications as early as 1967 (called the "Crevette"), 1971 would mark a significant departure in the direction of the company.

Fresh off the heels of the Nagra SNN and IVS recorders, in 1972, Kudelski introduced the Nagra IV-SJ, a two-channel instrumentation recorder aimed at scientific and industrial markets. Recognizing the application of the SNN recorder for law enforcement use, Kudelski also introduced the SNS, which was a half-track version of the SNN recorder that could record at slower speeds.

Kudelski then introduced the Nagra IS in 1974 as a lightweight recorder for use by broadcast reporters. This single-speed machine, with a footprint and weight almost half that of that of the 4-series recorders, rapidly gained acceptance by broadcasters looking for a high-quality, economical ¼-inch recorder. Like other Nagra products, variations of the basic recorder soon appeared, which could provide Neopilot sync for film use, as well as two-speed operation. Two years later, the Nagra E was introduced, which was a further simplification of the IS recorder.

Despite the simplification of these products, both maintained the unique trademark characteristics of Kudelski's design approach, and would never be mistaken for some mass market cassette recorder.

Just the FAX Ma'am

While Kudelski was recognized worldwide for his unique audio design talents, somewhat less well known was his keen interest as both a sailor and aviation buff. In fact, Kudelski established "Air Nagra" in the 1960s, which operated a few Cessna twin-engine planes, used primarily to transport businessmen in the local area. Ever aware of the opportunity to bring a new product to market, in 1977, Kudelski introduced the "NAGRAFAX," a unique portable weather facsimile machine aimed at the maritime market. While the military had a similar system in use, the NAGRAFAX was aimed at the commercial and private yacht market, and also saw use in airports, ski resorts and coast guard stations. This product marked Kudelski's first departure from recording equipment.

1977 saw the introduction of yet another instrumentation recorder, the Nagra TI, which offered four channels of recording (as opposed to the two channels of the Nagra IV-SJ).

It also boasted a unique dual-capstan transport, which minimized disturbances in the tape path, a critical design component when the recorders were employed in military operations. This transport

Stefan with the Nagra III. Introduced in 1958, becoming the standard for motion picture sound recording. Nagra III courtesy of David Panfili, Location Sound Corporation

would become the basis for the Nagra TA recorder introduced in 1981. Essentially a two-channel analog version of the TI recorder, the Nagra TA had the unique ability to chase timecode in forward and reverse, and was specifically aimed at the telecine post market.

While the T-Audio recorder boasted the most sophisticated transport design of any of the Nagra analog audio recorders, its complex logic circuits caused many users to shy away from it, except for telecine applications, where it had no rival. Despite this, it is still highly prized among audiophiles for its stellar tape-handling features.

Nagra and Ampex—Strange Bedfellows

Nagra and Ampex, in an unlikely alliance, embarked on a joint venture in 1983 to introduce a portable one-inch Type C video recorder aimed at the broadcast market. While Sony already had a small one-inch video recorder on the market, the design efforts of Kudelski predictably raised the bar significantly. Employing lightweight transport and surface mount devices, the new recorder (dubbed the VPR-5) brought a level of sophistication to the broadcast video recorder market that has never been seen since. While the VPR-5 enjoyed a brief period of popularity (with 100 machines ordered for use at the 1986 Mexico World Cup), the ever-changing "format wars" brought a premature end to its use.

Nagra and the Cold War

In yet another unlikely alliance, soon after the introduction of the VPR-5, Nagra joined with the Honeywell Corporation with the intent to produce a highly specialized recorder designed expressly for military use. However, this venture, which utilized all of Nagra's R&D operations, never brought a product to market. The project was quickly abandoned after the fall of the Berlin Wall in 1989. The only remnant of the effort is a prototype recorder called the "RTU." This would be the last project that Stefan Kudelski would be engaged with directly in an engineering capacity.

Despite this misstep, much was learned during the development of the RTU, and in 1992, Nagra introduced the Nagra D, a unique (and proprietary) four-channel digital recorder aimed at the film and music recording market. While the Nagra D gained some adherents, by this time Nagra had unfortunately begun to lose its dominance in film sound to DAT technology, which had made inroads into the market while Nagra was distracted by the Honeywell venture. (In fact, Nagra never did produce a DAT recorder, moving directly from the Nagra D open-reel digital recorder to the introduction of the ARESC tapeless digital recorder in 1995.)

Despite losing some market share in traditional film sound recording to new players, Kudelski continued to design and innovate. In 1997, they introduced a line of high-end audiophile components, starting with the PL-P vacuum tube preamplifier, and later incorporating the VP-A mono-block tube power amplifier, as well as the MPA 250-watt MOSFET power amplifier.

Even further afield from the original focus of the company was the establishment of a division devoted to pay TV set-top boxes for CANAL+ in 1989. This would turn into a very successful growth operation for the company, and continues to be the main business of the firm.

Nagra Today

In 2002, Nagra introduced the Nagra V hard drive recorder, which was intended as the replacement for the Nagra 4-series analog recorders. However, despite the excellent design, by this time Nagra had lost some of its footing in the film recording market, overshadowed by the development of DAT recording in the 1980s, and the introduction of the DEVA hard drive recorder in 1997. Nonetheless, Nagra still enjoys a significant share of the broadcast journalism market, with products such as the ARES series solid-state recorders. Currently operated as a separate entity located in Romanel under

T-Audio Nagra courtesy of Chinhda Khommarath

the moniker of Audio Technology Switzerland, the firm continues to pursue the film recording market, with the introduction of the Nagra VI hard drive/CF card recorder in 2008. Stefan Kudelski's son, André Kudelski, continues as CEO and Chairman of the firm.

Despite the changes in technology that have taken place in the intervening years since the introduction of the first Nagra recorder, every sound mixer "of a certain age" I've spoken with can still recall the first time they used a Nagra recorder. Likewise, the stylistic contributions made to the film business by Kudelski's introduction of the Nagra are immeasurable. Films such as D.A. Pennebaker's *Don't Look Back* would have simply been impossible to do without the aid of lightweight cameras and recorders. The entire French New Wave movement, led by directors such as Francois Truffaut and Jean Luc Godard would arguably not even have existed without the aid of the Nagra recorder and Éclair camera. Thank you Mr. Kudelski for your marvelous invention.

The author wishes to thank Omar Milano for generously sharing the transcript of an interview he conducted with Mr. Kudelski. I am also grateful for the opportunity to have accepted the Wings Award on behalf of Mr. Kudelski at the Polish Film Festival in America in 2008. It was an honor.

Editors: We will present other articles in coming issues to explore the accomplishments of Stefan Kudelski. We invite members to submit stories and anecdotes of their experiences with the man and his recorders. Please send your anecdotes to: ***nagra@695.com***