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DOLBY

The Early Years

By
John F. Allen

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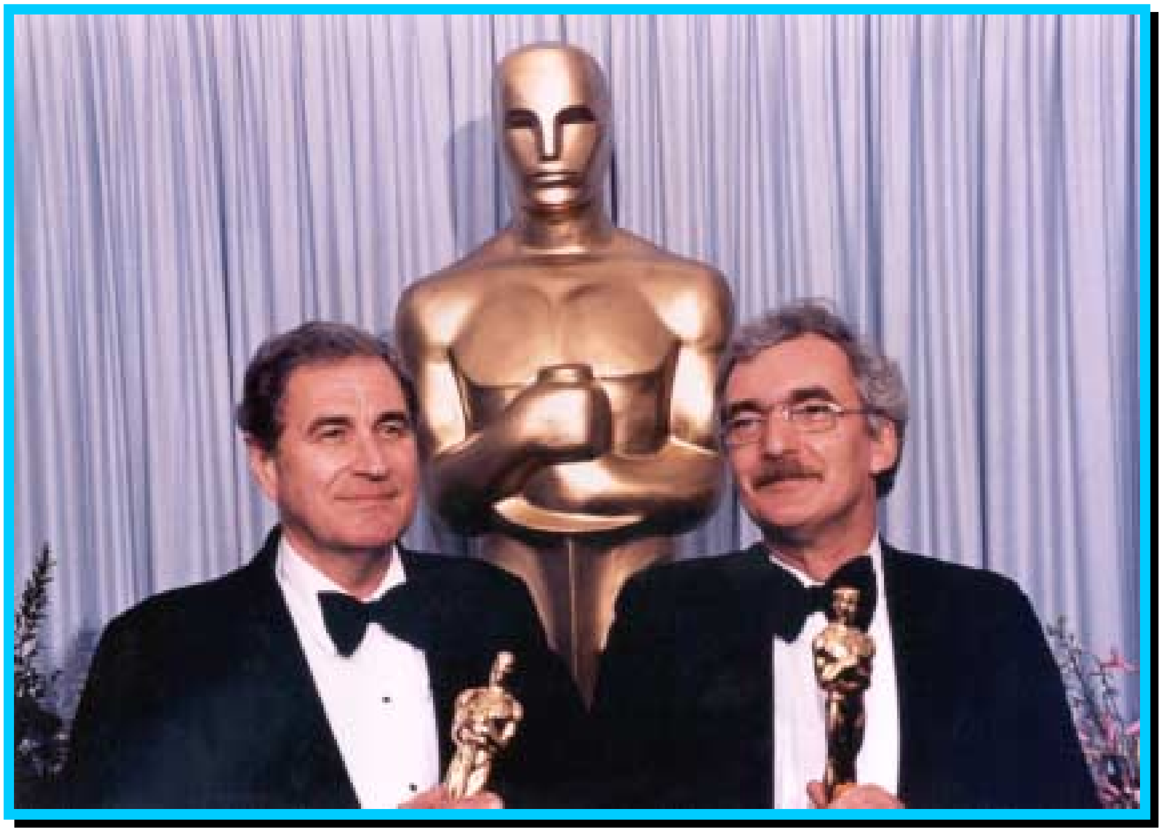


DOLBY

THE EARLY YEARS

By John F. Allen

When one thinks about modern cinema sound, one is keenly aware of the name Dolby. However, before Dolby came into existence, there was a long, and sometimes sordid, history in sound recording technologies.

Ray Dolby and his technological partner on film sound issues, Ioan Allen have helped bring audio recording, and cinema sound in particular, into the modern age. This article explores that history and pays tribute to some of those who made valuable contributions along the way.

From the earliest days of analog disc recording systems and magnetic tape recorders, the simultaneous limitations of noise and distortion have defined the record and film industries. The louder the recording, the greater the distortion. The quieter the recording, the greater the audible noise.

For tape recorders this noise was referred to as tape hiss. For program material with limited dynamic range, a news broadcast for example, the recordings were very good as hiss was not a problem with such material. However when it came to music, especially orchestral music, the limits of magnetic tape were all too audible.

> The teenager that he hired was none other than a high school student by the name of Ray Dolby

Various methods to optimize tape recording were employed. One simply said that the zero dB level on the recording meter would be set when a recording level on the tape reached one percent distortion. Of course this would vary depending on the magnetic formulation. In later years, rather than a distortion level, zero dB on the meter would correspond to a specific flux level on the tape.

As with long-playing records, the technique of frequency pre-emphasis/de-emphasis was also employed with tape recorders. In recording, this technique boosted the high frequencies and reduced the lows. Reversing this in playback not only resulted in a flat playback frequency response, it also reduced the audibility of tape hiss and low frequency distortion. However, the high frequency pre-emphasis was enough to itself cause distortion. Even so, hiss would remain a problem in need of a solution, especially for music recording.

Beginning in 1947 Ampex[1] was the major manufacturer of professional tape recorders. Ampex engineers were well versed in the standards for disc based systems. What was needed was a similar set of standards for tape machines so that recordings made on any one machine could be played back on any other.

Ampex engineer Frank Lennert made the first standard test tape to be used for calibrating tape recorders. The company then decided to hire a 16 year old teenager to make the copies. The teenager that was hired was none other than a high school student by the name of Ray Dolby. Ampex founder Alex Poniatoff had met Ray as a 16 MM projectionist at a high school lecture Alex was giving and hired Ray for the job.

By the early 1950s magnetic tape recorders had become the most widely used method for recording audio. The motion picture industry began using sprocketed 35 MM stock fully coated with magnetic oxide for motion pictures such as THE TEN COMMANDMENTS and MOBY DICK. Over the next decades, as tape formulations improved so did the standard tapes.

While earning his B.S.E.E. degree at Stanford University, Ray Dolby continued his work at Ampex and contributed to the development of the first video tape recorder in 1957. This was a machine that some said could never be built. Using two inch wide tape, a round disc with four heads on it would spin perpendicular to the tape. With the tape running at 15 inches per second, the disc would spin at 1440 RPM to obtain the necessary writing speed. It all sounds pretty familiar now, but in the 1950s Ampex had to make it work without shredding every inch of tape. Even today it amazes me whenever I go near a so-called “quad” machine. I always visualize millions of pieces tape flying all over the room.

Ioan began his career at Dolby in 1969 and soon became a major innovator as well as the company’s leader in film sound

By the mid 1960s Ray had left Ampex, earned a Ph.D and worked for a while for UNESCO in India. His goal, however, was to develop a noise reduction system for audio tape recorders that would reduce hiss in music recordings to near inaudibility. After working for several years on a better way to solve the tape hiss problem, he founded Dolby Laboratories in London in 1965. The Dolby Type A-Type noise reduction system was introduced the same year, providing about 10 to 15 dB of noise reduction.

At first adding a compression/expansion process to recordings was met with concern by many audio engineers. It was feared that such a dynamic operation would produce audible artifacts. Indeed it does unless the recording and playback levels are matched throughout the entire encode/decode process. To ensure that they were, Dolby noise reduction systems included a tone oscillator at a specific level and frequency called Dolby Tone that would be used with all recordings using this system. Of course this also meant that the all important gain structure of the entire record/playback chain would be optimized. This alone would reduce the chance of noise and distortion creeping in along the way.

It wasn’t too long before classical music recording engineers learned to use the Dolby system and appreciated its benefits. Some FM radio stations also added Dolby noise reduction to their microwave studio-transmitter links. Boston’s WGBH-FM was one of them.

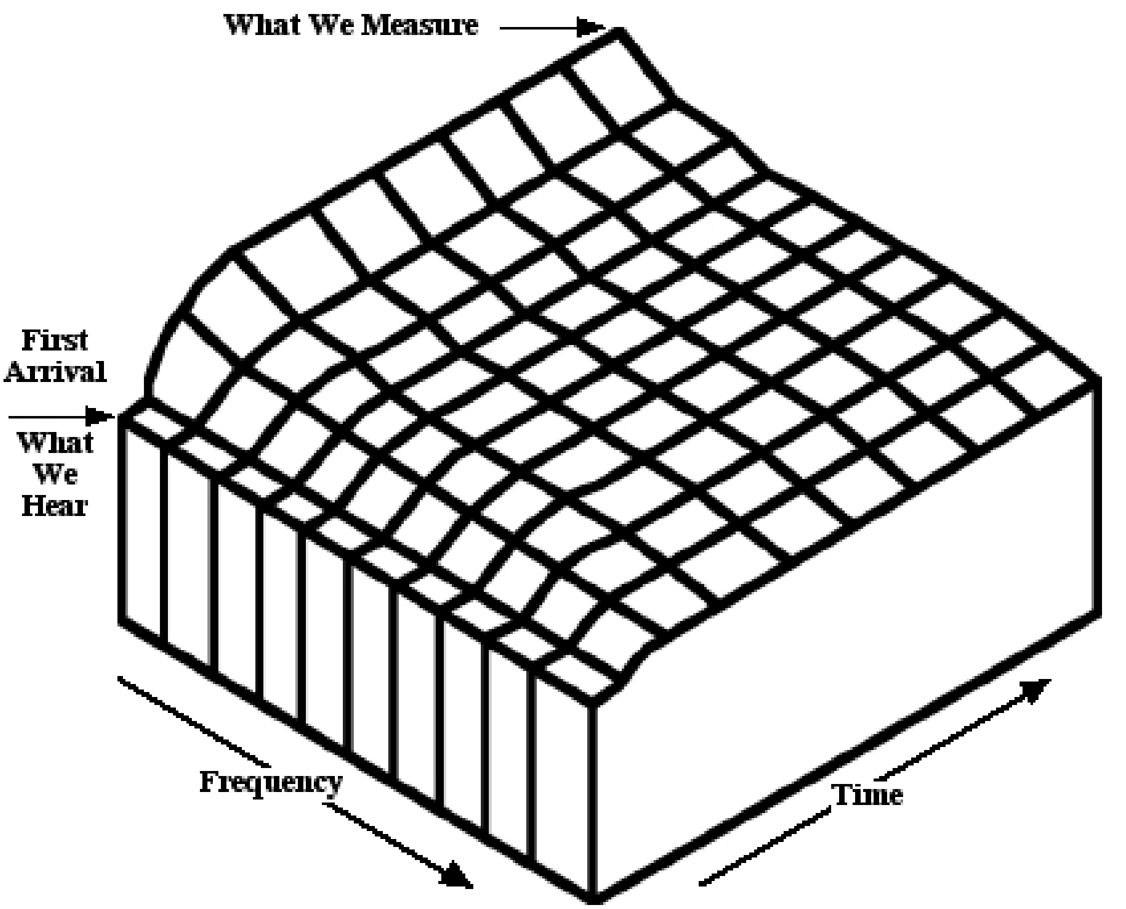
Noise reduction also allowed for mixing down multiple tracks before the added noise would become objectionable. Such a feature made Dolby A-type noise reduction a natural for motion picture sound where soundtracks derived from many tracks are the norm. Enter Ioan Allen. Ioan began his career at Dolby in 1969 and soon became a major innovator as well as the company’s leader in film sound.

While the consumer audio industry was rapidly advancing with increasingly superior home high fidelity stereo systems, the state of motion picture sound in 1969 was pretty stagnant, lacking uniform standards and going nowhere. The soundtracks for 70 MM and 35 MM magnetic films were often outstanding, but there were major sound quality issues in the theatres where films were presented. (Sadly such constraints can still be found today.) In the early 1970s 70 MM prints were becoming fewer, theatres playing 35 MM magnetic prints were also declining and the soundtracks of all the remaining 35 MM optical soundtracks were dull boring MONO! A trip to most movie theatres involved listening to two hours of "honky" distorted sound with a limited frequency bandwidth of approximately six of the ten octaves we typically hear. Dynamic range was --- well there wasn't much dynamic range. LPs and FM radio sounded better.

Figure 1. Dolby CAT-64 Equalizer

Imagine where we would be if Dolby had not made the investment to pursue the film industry? Convincing studios to employ Dolby noise reduction was a slow process. The industry was very reluctant to change anything to do with sound. But two long years later in 1971, Stanley Kubrick's A CLOCKWORK ORANGE was the first film to use Dolby noise reduction in all the premixes and masters. This was followed in 1972 by the introduction of the Model 364 cinema unit that allowed Dolby encoded mono soundtracks to be decoded for playback in theatres.

With the introduction of Dolby A encoded soundtracks came an often under-appreciated change in the optical soundtrack itself. Noise reduction not only allowed for a considerable reduction in distortion, but it also allowed for a welcome frequency bandwidth increase to nearly nine octaves.



Reverberation build-up of Pink Noise Over Time
Figure 2.

Of course using noise reduction in soundtrack recording made perfect sense. But what about the theatres? They were still stuck with mono optical sound, poor dynamic range, limited frequency range and lots of distortion. Optical readers in the projectors were not "calibrated" with instruments. In fact, they weren't calibrated at all. In some theatres you could hear the sound change during projector changeovers. Like the monophonic soundtracks themselves, the speakers and amplifiers found in most theatres also suffered from limited bandwidth and excessive distortion. If that weren't enough, the speaker's crossovers were a mess. No amount of soundtrack preparation technology could fix any of this.

The first order of business would have to be improving the sound one could coax from theatre speakers using something called 1/3rd octave equalization. This had first been introduced by Don Davis at Altec Lansing and was intended as a means for controlling feedback in commercial sound systems. Using it for tuning a sound system to gain a smoother response and perhaps a wider bandwidth was not the original intent. But it was soon realized that 1/3rd octave equalization was a major advance in sound systems, *if employed correctly*. Unfortunately, it is still misused as often as not.

This has created a worldwide uniformity from studio to studio that has given motion pictures a remarkable consistency in sound quality that no other part of the recording industry has ever achieved

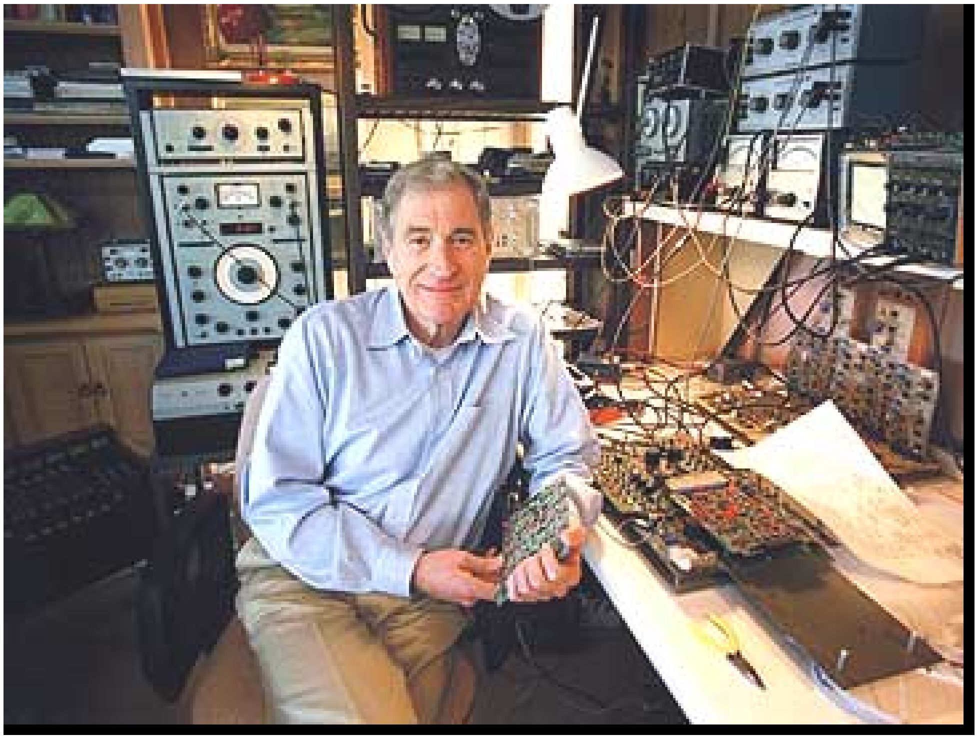
In 1973 Dolby introduced Ioan's concept of a 1/3rd octave equalizer for cinemas, the E2, including the CAT-64 equalizer module. This was an ingenious and extremely compact design done by Dolby engineer Ken Gundry. Rather than taking up two or three units of space - per channel - in an equipment rack, the CAT-64 consisted of two circuit boards sandwiched together into a package that could slide into a cinema processor. See figure 1. To minimize concern for unwanted degradation from the additional circuitry, unused 1/3rd octave controls were essentially out of the circuit. Also included were extremely useful wide-band bass and treble controls. This was a first for such equalizers and would reduce the need for using so many 1/3rd controls.

X CURVE

With the introduction of cinema sound system equalization, the parallel needs for a measurement system and, equally important, a target measured response were also required. The use of pink noise and real-time analyzers had become a popular measurement approach in the early 1970s. It was also more affordable, especially when compared to the Time-Delayed Spectrometry systems that could cost two or three times as much.

To see what a measured response of a loudspeaker with a flat frequency response might be in a room as large as a cinema, Ioan went to the Elstree Studios outside London. In one of the large rerecording studios, he placed three large studio monitors in front of the mixing console that was some 40 feet from the speakers behind the screen. Being so close, the flat response of the studio monitors delivered their flat sound directly to the ears of someone sitting a few feet away at the console. Then (most importantly) by ear, Ioan, assisted by of group of engineers and mixers, adjusted the equalizers for the screen speakers so that

their tone matched the near-field monitors. Trust me, this required talent and was not easy to do. With the distant screen speakers now delivering the same tone as the monitors, Ioan played pink noise through the screen speakers and used a real-time analyzer to measure the result.



Contrary to what one might expect, the measured frequency response did not appear to be flat even though it was. A look at the chart in figure 2 shows why. The response of the direct first arrival sound shows a flat frequency response. It is also the flat response that would be measured if the speaker was in a small room such as a typical living room. Our ears and brains use the direct sound to determine the tone of the sound. A cinema is a much larger space. The additional volume of the room introduces acoustic differences, some of which our brains ignore. Nonetheless, the larger room's acoustics, including greater reverberation, corrupts the measurements seen with pink noise and real time analyzers by showing a pronounced high frequency roll off. This finding also correlated with similar work done earlier by Boston pioneer-acoustician Leo Beranek and became known as the X curve.

The X curve was one of the most important introductions in cinema sound. But it has also been one of the most misunderstood. Since it looks almost identical to the playback part of the pre-emphasis/de-emphasis scheme, many technicians mistakenly assumed that it was. For that matter, many still do. But by looking at the chart in figure 2, we see that the X curve is nothing more than the result of the combined measured response of a flat loudspeaker playing pink noise in a large room along with the added effects of the room's acoustics thrown in to confuse us. In other words, we hear the flat direct sound, but we are forced to measure something else. The X curve, including its tolerances, attempts to

provide a target response for such a challenging measurement approach. Because there is no system that measures what something sounds like, it is also recognized that, as with the use of any measurement system, trained ears must be the final judge. Or as Don Davis often said, "It's the analyzer between the ears that's the most important."

For the first time, the pink-noise/real-time analyzer alignment procedure along with the X curve provided a method of achieving a reasonably similar tone in cinema sound systems no matter the loudspeakers installed. Unfortunately this approach has often been poorly implemented in most cinemas, resulting in over-equalization that ignores the tolerances, distorting the tone and diminishing dialog intelligibility.

That being said, it must also be recognized and appreciated that unlike in cinemas, the X curve has been very carefully and intelligently implemented in the studios. This has created a worldwide uniformity from studio to studio that has given motion pictures a remarkable consistency in sound quality that no other part of the recording industry has ever achieved.

STEREO OPTICAL

Next Ioan would tackle changing the 35 MM release print optical soundtrack from mono to stereo. Back in the 1930s, German engineers had developed a stereo optical recorder. Unfortunately there was no reader that would fit in a projector. I happened to see this recorder sitting in a hallway at the Babelsberg Studios in Potsdam-Babelsberg, Germany.

In 1974 Dolby and Kodak commissioned a modern stereo optical recorder and installed it at Elstree Studios. To read a Stereo Variable Area (SVA) soundtrack in a projector, Ioan Allen used the now familiar split solar cell. Originally invented by Kodak's Ron Uhlig for use with 16 MM films, this could not only read the stereo track, it could also fit in the projector's sound head.

At the November, 1974 Toronto convention of the Society of Motion Pictures and Television Engineers, Dolby presented a ground-breaking demonstration of the stereo optical soundtrack with a special remixed section of STARDUST. One year later, Dolby's first cinema sound processor was introduced, the CP-100, capable of playing both 70 MM magnetic and 35 MM stereo optical soundtracks. The first units were installed for the London premiere of TOMMY in March, 1975. LISZTOMAINIA was the first film released in three channel (left, center, right) Dolby encoded optical stereo later that year.

The CP-100 was something new in audio. For the first time noise reduction, equalization

stereo decoding, changeover control, a six channel ganged fader, non sync and microphone inputs as well as eight channels of metering, were all available in single unit. Today we remember the CP-100 as the prototype of a new generation of comprehensive sound system

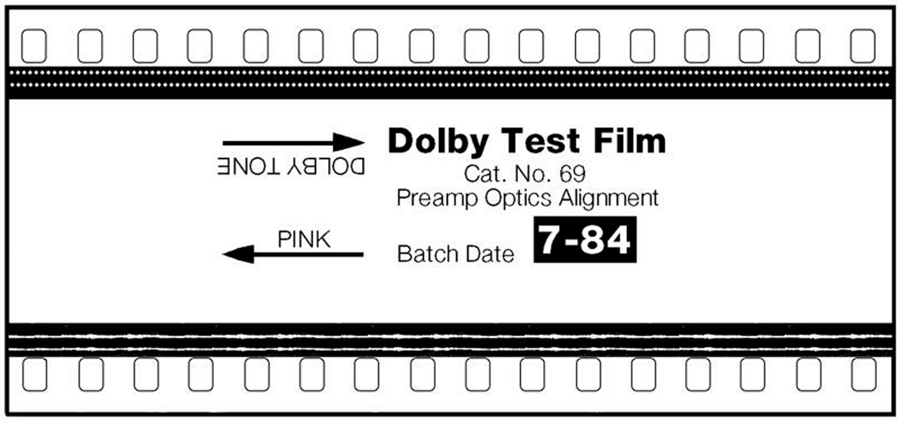


Figure 3. Dolby CAT-69 test film

design and management, the cinema sound processor. In the decades that followed the CP-100, Dolby's analog cinema processors evolved. Michael Karagosian and Brad Teague led the design of the remarkable CP-200. Other processors included the CP-50, the CP-55 and CP-65. Dolby's digital processors have included the CP-500, CP-650 and CP-750. The ATMOS processors, CP-850 and CP-950 came later.

A-CHAIN ALIGNMENT

Ioan realized that conventional alignment method for the sound-heads in projectors was not only outdated, but, frankly, ridiculous. To assure an accurate A-chain alignment and calibration, Ioan created a package of test films and procedures. The test films included signals for level calibration (see figure 3), slit lens loss correction and minimizing crosstalk between the left and right channels. Beginning with the SMPTE Buzz Track film to align the film path, these Dolby test films standardized the calibration and operation of the optical sound readers throughout the world for the first time.

In October, 1976, after 11 years of painstaking and expensive research following the introduction of Dolby A-type noise reduction, A STAR IS BORN was released with the first stereo optical soundtrack with an encoded surround track. Left, center, right, surround four channel sound was now possible with 35 MM release prints without the need for the costly and time-consuming magnetic striping. Theatres could now play four channel stereo without the need of high-priced and maintenance-heavy magnetic sound readers.

For the first time Dolby's calibration tone was used to calibrate the optical A-chain consisting of the soundtrack reader and the Dolby encoded playback processing. The Dolby calibration level for optical soundtracks was set at 50 percent modulation. This brought the newly optimized gain structure of the motion picture sound process into the theatre and right into the cinema processor itself.

Ray and Ioan also insisted that each Dolby encoded soundtrack was to be prepared with a Dolby staff member present to make sure that the studio engineers got the most out of this new technology. Throughout the world, this team of dedicated consultants worked, often with little sleep, to make sure that the Dolby equipment was always calibrated and working properly. They were also on hand for reviewing answer prints, checking release print quality and checking playback quality for test screenings, premiers as well as some first run theatres.

1977 saw the release of both STAR WARS and CLOSE ENCOUNTERS of the THIRD KIND. With the release of these two monster hits coming so close together, the public became aware of Dolby Stereo. Nothing has been the same since.

For the release of SUPERMAN in 1978, Ioan teamed up with Dolby engineers Max Bell and David Watts. Together they developed a 70 MM soundtrack format with stereo surrounds. By necessity, this format had to be backwards compatible with 70 MM six-track prints of the past as well as the majority of cinemas wired for mono surrounds. So only the left and right surround high frequencies were recorded and placed on the left-center and right-center tracks 2 and 4 that were now being used for the new Low Frequency Effects (LFE) or subwoofer track. These higher frequencies were then combined with the lower frequencies of the monophonic surround channel on track 6. This format was later refined by myself and Showscan with totally discrete left and right surround tracks into what we now know as 5.1.

Ray Dolby introduced Spectral Recording, or Dolby SR, in 1986, after more years in development than the A-Type noise reduction system. This was a dramatic increase in noise reduction, up to 25 dB. But SR was much more than noise reduction. Multiple techniques like Anti Saturation and Spectral Skewing were included to make Dolby SR a new low-distortion recording process as well. Dolby Spectral Recording made it possible to fit the widest possible dynamic range into the more restricted range available with magnetic tape.

Applying Dolby SR to release prints would have to wait a while. Once Dolby's Douglas

Greenfield was able to figure a way to squeeze all the parts into a module that would fit in the cinema processors, Dolby and film mixers needed to eliminate the possibility of any compatibility issues as well as optimizing its use with optical soundtracks.

Ray gave Ioan a free hand in working with the worldwide organizations (ISO and SMPTE) responsible for creating and maintaining motion picture standards. Though not always related to Dolby technologies, many of the standards that have resulted from this work had not existed before and often helped to correct some oversights of the past.

I will leave the story of the progression from analog motion picture sound to digital for another time. The purpose of this article has been to remember and pay tribute to the seminal work of Ray Dolby and Ioan Allen who along with a dedicated group of Dolby's engineers as well as countless mixers and studio engineers helped to bring the sound quality of movies to where it is today.

A few years ago at the annual ICTA Los Angeles seminar, we took the opportunity to stand in extended applause to express to Ioan our sincere and heartfelt thanks. It was a moving moment for all of us.

It's again worth noting that within the audio and recording industry, motion picture sound is by far the most consistent in its quality and beauty. For their historic contributions, both Ray and Ioan were awarded well deserved Oscar statuettes at the 1989 Academy Awards.

A personal note: 2020 marks the fortieth anniversary of my first article published in BOXOFFICE in 1980. In the years that followed, it was my honor to work with outstanding editors, Alexander Auerbach, Harley Lond, Ray Greene, Kim Williamson and now Lisa Silver. I also enjoyed getting to know Bob Dietmeier, the magazine's owner for most of those years. I am grateful to Daniel Loria for this opportunity to bring this story to the readers of BOXOFFICE.

1. Much of the history of Ampex was drawn from a paper entitled, "Standard Alignment Tapes, A History At and After Ampex," presented by Jay McKnight at the Association for Recorded Sound Collections' Annual Conference in March 2008.

Ioan Allen's paper on the X curve is available at:
hps4000.com/pages/special/Dolby_The_X-Curve.pdf

Additional articles about Dolby can be found at hps4000.com/pages/dolby_.html

John F. Allen is the founder and president of High Performance Stereo (hps4000.com) in Las Vegas, Nevada. In addition, he has served as the sound director of the Boston Ballet and has mixed live concerts of the Boston Symphony, the Boston Pops orchestras, military bands, jazz ensembles as well as other orchestras. He is also the inventor of the HPS-4000® motion picture sound system and in 1984 was the first to bring digital sound to the cinema. A frequent presenter at technical seminars, his in-depth articles on the subject of sound have appeared in industry publications for the past 40 years. John Allen can be reached by E-mail at johnfallen@hps4000.com.