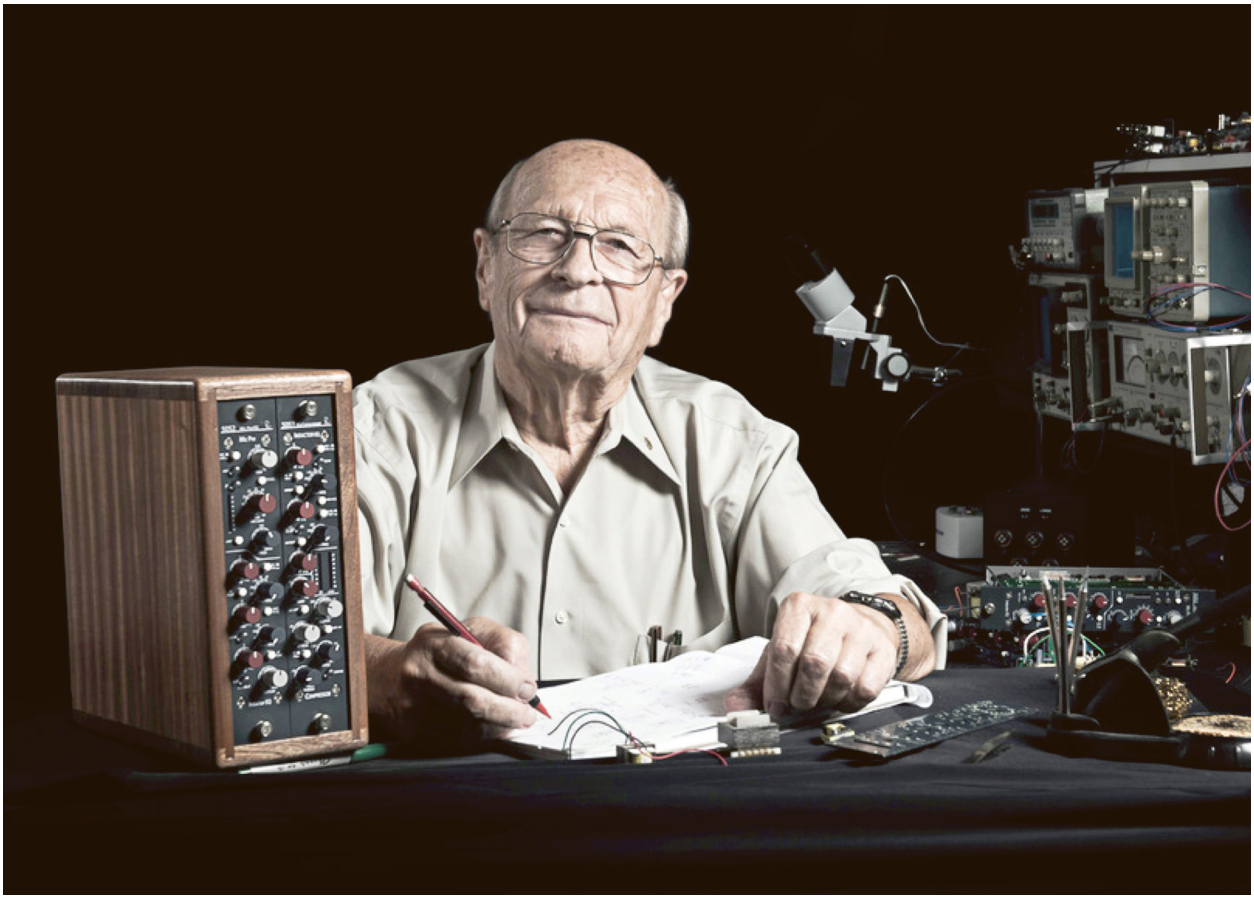
RUPERT NEVE

LIFE BEYOND MEASUREMENT



AN ESSAY BY LEWIS FRISCH

Dedication

This essay is dedicated to all my extraordinary colleagues during my ten year association with AMEK in the US and UK. Most especially, Nick Franks, Graham Langley, Greg Hogan, John Penn, Steve Harvey, Mick Brophy, Carl Reavey, Martin Arthurs, Simaen Skolfield, Melanie (nee Peter) Harrison, Bob Owinski, Sue Jones, Ray Dilfield, Dave Lewty and, of course, Josh Thomas and Mr. Rupert Neve.

About The Author

Lewis Frisch has written and lectured on the History of Audio Technology since the mid-1980s. He began selling AMEK consoles in 1985 and served as AMEK's US Press Officer from 1989 to 1994. Much of his initial historical research and lecturing was sponsored by AMEK's Nick Franks.

Introduction

Despite the overwhelming praise for Neve designs in the 1970s, many designers of audio equipment failed to appreciate exactly why these products sounded so wonderful and for several decades they continued to both accept and promulgate time-honored ideas about the limits of human auditory perception which Ruper Neve and others had discarded by the 1980s.

During those critical years beginning in 1990, Rupert Neve was instrumental in getting engineers to re-think their long-held views about the limitations of human hearing. Along with others, he led a movement over the next twenty years to examine the subtleties of perception and to create audio equipment that not only performed well on paper but which also transmitted that hard-to-define magic that we experience directly with a live performance or by way of a superbly recorded mix.

> *"We try not to stand still and as we learn more and continue to listen to the musician and producers, so we will build the sort of equipment that we think adds fullness and enjoyment to music even if we do not fully understand all the factors that make it so.:*
>
> *Rupert Neve 1993*

Lewis Frisch
The Bedford Consultancy, Nazareth, PA
June 2021

Rupert Neve:
Life Beyond Measurement

Table Of Contents

Rupert Neve: Life Beyond Measurement

I.
What I Learned from Rupert

The author's personal reflections on his association with Rupert Neve
and some things he learned from their shared experiences.

First a disclaimer: My working relationship and subsequent friendship with Rupert Neve occupied a very small band of time in our lives. It began in 1989, when Rupert entered into his consultancy with AMEK. I parted ways with AMEK in 1994, just as Rupert was moving to Texas. I wrote a letter of recommendation for him to US authorities when he applied for his permanent residency in the US. Rupert and I remained in touch for the rest of the decade. For a number of years, it seemed as if I might return to AMEK but by 2000 it was clear that would not be happening. After 2000 my contacts with Rupert were few and far between.

We were both preoccupied with establishing new companies - he with Rupert Neve Designs and I with Gotham Audio LLC. - in very different segments of the professional audio world. We rarely communicated with each other and once I stopped attending trade shows in 2009, our meetings and communications ceased altogether. That being said, those six brief years of close association (1989-1995) left an indelible mark on my life and thinking.

In that brief time, I learned that Rupert was not some god-like manifestation of genius inhabiting an elevated realm that separated him from the mere mortals that labored daily in the profession of audio. He was very much one of us, his extraordinary gifts notwithstanding. He was certainly a complicated human being with a full share of human faults and imperfections. Working with him was rewarding, but he also had those less than admirable moments and traits, just like the rest of us. That being said, he was a man of great faith, great passion and an ever-present desire and enthusiasm to communicate his ideas and beliefs to others, with grace, wisdom, wit and patience. He was always curious, ever observant, always learning. The behavior of others sometimes challenged his sensibilities but, in so many circumstances, he remained gracious under stress.

As impressive as Rupert's achievements were, his genius also relied on assembling teams of talented co-workers who could assist him in designing and producing finished, marketable products. The current, almost worshipful, appreciation of his genius tends to ignore the degree to which he was able to rely on the talents of others to help achieve the fruition of that genius. The success of these team efforts in no way diminishes his status as a Master Designer. It just serves to prove that he was indeed very human and that, like the rest of us, he benefited greatly from having supportive and gifted co-workers who understood his vision.

As AMEK's US Press Officer and Regional Sales Manager, I traveled with Rupert to various speaking engagements. His schedule at times could be grueling and a bit exhausting, but when he was presented with an audience of thoughtful audio professionals, he was thoroughly energized, and he would greatly enjoy those interactions. He had that remarkable gift of making all in attendance think he was speaking to them directly and most personally, as if it were a one-on-one conversation.

When we began our association, I knew next to nothing about his life or his designs. He patiently spent hours presenting his entire life history to me, in a most personal and intimate way, free from any trace of condescension, even as he discussed and explained technical subjects and issues that were clearly way beyond my limited knowledge and experience at the time.

I had started at radio stations as a teenager and had been an active recording engineer and studio owner from 1976 into the late 1980s, but my own studio experience was nearly all in small rooms, with limited tracks and modest equipment. Aside from a single mixing session on an AMEK Angela, I had rarely worked on anything more sophisticated than an entry level 24in/8out board, so Rupert certainly had a lot to teach me about the history and design of large consoles for multitrack recording. He tolerated my ignorance and my endless questions with his typical grace because he loved the act of sharing his life's work with young engineers and colleagues and he always seemed to appreciate the interchange as much as he enjoyed presenting his viewpoints.

His interest in people from widely different backgrounds and willingness to interact with them and perhaps learn from their experiences was ever-present. During his travels he spent a few nights at my mother's apartment in Manhattan, thoroughly enjoying the company of a first-generation American, elderly Jewish mother. She cooked him dinner the first night. He slept on a convertible sofa in her den that night and took us to dinner at her favorite neighborhood Greek diner the next evening. He visited my home in Atlanta and greatly enjoyed time with my wife and children. When he learned that my mother-in-law was an herbalist who practiced foot reflexology, he insisted on going to visit her store to discuss natural health matters and alternative medicine.

He patiently endured some odd travels with me, such as the time I persuaded him, along with Nick Franks, to dine at Tad's Steaks in San Francisco- a nationwide chain famous for steak dinners for under $5.00. Tad's was a "special treat in the dining world for those of modest means and somewhat-less-than-discerning taste palettes, decorated with red velvet walls, fake Tiffany lamps and an overall garish demeanor." Rupert ordered

his dinner from the cafeteria line, sat down at a table that had seen better days, and consumed his noticeably tough steak with a smile, pronouncing it all to have been a memorable American experience. I do think he enjoyed the evening far more than some of the meetings he endured that week with worshipful owners of old Neve consoles, in quite poor condition, who insisted that nothing he could do in the 1990s could possibly top what their old and less-than-prime Neve models were capable of. But he was always gracious.

Rupert taught me that “hearing” with our ears was only half the story. What humans do is better described as perception - a complex process by which the brain interprets auditory information from the ears and puts it into a wider context which is informed by numerous sensory inputs. So much of how and what we perceive is dictated by our mental powers of focus and concentration, not just by the physical abilities of our hearing mechanism. Rupert’s interest in the science of psychoacoustics was boundless. He observed how great recording engineers listened, he knew how he himself listened when designing equipment and he realized how much about the complex ways and means of auditory perception was still a slowly-unfolding mystery.

His hearing in the 1990s (he was 65 in 1991) had certainly deteriorated considerably according to any conventional measurements. But his ability to perceive - to focus on, identify and evaluate the smallest components of sound - was remarkable. I remember when the late David Smith was proudly showing off the new SONY recording facilities in Manhattan to Rupert. We were walking through a cavernous main recording space and listening to sounds in the room. Rupert loved the room but he said to David that he could still detect a small amount of noise coming from the lighting fixtures overhead and he assumed they were still working on eliminating that. David looked baffled. Neither he nor any of the rest of us had noticed anything. We walked around the room for another few minutes, gave it some concentrated attention, and there it was - a bit of buzz lurking just above what had initially been the noise floor. One never questioned Rupert’s “hearing” in these matters.

Another evening I took him out to a new restaurant in Atlanta. We sat down and he immediately got “that look.” I knew he was listening to the acoustics of the room. He smiled with excitement. “Do you hear that? - It’s amazing.” All I could do is say “what?” It was just a noisy restaurant room. He implored me to keep listening and after a few minutes I could distinguish a half-dozen distinct conversations in the general din. Rupert then commented that he could hear and distinguish nearly every conversation in the room. He pointed at the domed ceiling. Unbeknownst to the builders, they had created a

design that focused all those conversations down to a single point, and there we were. It was amazing. I suppose that few had ever noticed. To most it was just noisy room.

Time and time again, I saw those powers of concentrated perception at work in many ways. Rupert explained his design process to me and it always began with listening. Listening first to the content creators, the musician and producers and the engineers about what they were trying to do and what they were hearing. Then you take your prototypes and listen carefully - but not at high volume and not with a rushed intensity to hear and identify. You turn the volume down, put it in the background, do some other things, and let the sounds settle into your brain's processing mechanism. Then bit by bit you begin to hear things that stand out and you can begin to identify changes that need to be made. You make those changes, go back to the ears of your clients, and get their input. They tell you what they are hearing and what they are still missing. You go back and tweak again. More listening. More feedback. More tweaking. The process repeats until the client finally exclaims something like, "Rupert - It Sparkles!"1 And then for a brief moment, the Designer can rest until the next challenge to get a bit closer to perfection claims his attention.

This low level, extended listening is inevitably a slow process, so unlike the quick A/B comparisons and blind tests that many value so highly. But psychoacoustics increasingly finds that this is the way the brain processes auditory information and creates the context that we identify as perception. These revelations thrilled Rupert, confirmed his instincts and informed his work. His curiosity in the 1980s and 1990s led him down so many productive paths, turning what for others would be the "retirement years" into a time of ceaseless innovation and improvement.

Given Rupert's example, I came to realize that much of what we do as recording engineers is also a process that takes place in the brain, as opposed to one that primarily involves our skill in the use of the equipment that we have to capture, record and mix sound. Our ability to mentally analyze sound through focused concentration and then to use techniques of meditation and visualization to process the components of a mix, and find correct balances and optimum communication of emotions, is as much a part of our craft as the ability to choose and use the right equipment.

Also, much of our ability to evaluate and make the best decisions in mixing is informed by a whole range of physical reactions that give us clues to the wider context that the brain is creating with the auditory information it is receiving.

---

1 *"Rupert – It Sparkles!"* was Geoff Emerick's initial reaction when he first listened to Rupert Neve's Montserrat console at AIR studios.

Rupert Neve: Life Beyond Measurement

My time with Rupert was the inspiration for a series of college lectures I gave, beginning with the LaGrange College Electronic Music Festivals in 1998 and 2000, entitled “The Art of Engineering: Metaphysics of Mixing.” The lectures explored how engineers perceive the recording process and the “sound” of music. We are all familiar with the way engineers use equipment to get the sounds they want during mixing - what I call the mechanics of mixing. Of equal or greater importance is the way sounds are mixed and processed in the engineer’s brain - what I described as the metaphysics of mixing.

These concepts helped to explain my observations (based on personal experiences with George Massenburg and John Keane) that great engineers often exhibit identifiable gifts in their mixing at the very start of their careers, when their equipment and their experience were still very limited. Their early recordings exhibit the same footprints of talented and effective mixing as their widely acclaimed mature work, because their minds and powers of concentration were already functioning at a very elevated level when it came to understanding sound and particularly music.

Rupert was, first and foremost, a man of faith. Like Lord Kelvin, whom some believe to be the most important and influential physicist of the 19th Century, his faith supported and informed his scientific and technical work. Both were devout believers in the Christian faith who saw the hand of a loving Creator in the order and beauty of the physical world and the gifts given to his human creations. Rupert saw that man, formed in the image of God, had an inborn desire to create the good and beautiful. He believed that his work, and the work of the artists, musicians, engineers, etc. were all (when done with skill to the best of one’s abilities) a form of high praise to the Creator. As for that Creator:

> *“What may be known about God is clearly evident... for his invisible qualities are clearly seen from the world’s creation onward... because they are perceived by the things made.” (Romans 1:19, 20)*

Along with the teachings and revelations of his Christian faith - the good news of Jesus Christ - Rupert saw music as one of the Creator’s greatest gifts. To capture and communicate the fullness of music was to him a form of respectful worship. His designer’s workshop, the recording studios, the sound systems - these were all temples where he worshiped. His co-workers, musicians, engineers and producers were all fellow congregants. Even if they did not share his formal religious beliefs, they all shared his profound respect for the goodness of the gift they had been entrusted with and his determination to perfect their craft for the benefit of all who would listen to the art they helped to create.

Rupert Neve: Life Beyond Measurement

Rupert relished the Scriptures recorded in the Bible book of Hebrews:

> *"Faith is... the evident demonstration of realities that are not seen... By faith we perceive that the systems of things were put in order by God's word so that what is seen has come into existence from things that are not visible." (Hebrews 11:1, 3)*

Rupert Neve spent a life measuring the known parameters of highest quality audio recording and reproduction. But clearly, he knew there was life beyond measurement. So he chased perfection, always seeking to look beyond the obvious so as to better understand our marvelous mechanism of auditory perception and the power and beauty of sound and music. There were layers and layers of subtlety to be explored and peeled away, exposing yet even more to be discovered. Human auditory perception builds the most complex and compelling soundscapes from a seemingly endless supply of microscopic bits of information, spread across, above and under the accepted boundaries of our hearing mechanism. When it comes to capturing and reproducing those soundscapes, anything less than the best we can do is never good enough. There will always be something out there to discover, subtleties that go beyond the currently accepted models and which do make a significant difference in what we perceive and feel.

As Rupert eloquently taught, it all begins with listening and opening our minds to new ideas and possibilities, ever respectful of our perceptual capability to approach the infinite beauty and harmony of the natural world. What cannot be measured now, will be measured and understood in the future. But we should never let the limitations of the present restrict our vision to what can be clearly seen. There is so much more beyond that.

Like so many visionaries, he saw so much of our current vision as something functioning behind a veil hiding realities not yet perceived. It was those realities he diligently searched for.

> *"Therefore, we do not give up... we keep our eyes, not on the things seen but on the things unseen. For the things seen are temporary, but the things unseen are everlasting." (2 Corinthians 4: 16, 18)*

His creations were indeed the most wonderful of tools. But his greatest and most lasting legacy will be in the thinking, convictions and methods that inspired his creations and the ways that others will use the creative tools he entrusted to them, to bring forth the fullest expression of the beauty and power of the musical experience. To use George Massenburg's eloquent words, hopefully they will serve to benchmark and calibrate our hearing and thinking for generations to come.

Rupert Neve: Life Beyond Measurement

II.
The Changing Landscape of Audio Technology
1969-1994

A Career Overview: The Rupert Neve Company, ARN Consultants, Focusrite and AMEK

February 2021 was a cruel month for so many of us and for recording engineers it brought the added grief of the passing of Rupert Neve. Few have done more to advance the art and craft of recording technology, providing generations of engineers with the tools to create the most extraordinary recorded music.

He designed his first consoles with solid state electronics in 1964, and by 1970 the success of his company was assured with production moving out of the Little Shelford home facility into a purpose-built factory. Demand grew rapidly with record companies recognizing the unique quality of his equalizers and the sonic clarity of his designs. From 1969 to 1973 Mr. Neve designed a series of legendary modules with numbers that still resonate 50 years later: 1064, 1066, 1081, 2254 and perhaps the crown jewel, the 1073. Neve consoles, notably the “80-series” achieved phenomenal success in the mid-1970s as leading producers and engineers from around the world came to view Neve products as indispensable tools.

Working closely with producers and engineers such as George Martin and Geoff Emerick, Mr. Neve came to understand that our ears and minds could perceive so many things that could not easily be described with simple traditional measurements but which, when present, added life, fullness, and emotional appeal to recorded sounds and music.

Despite the overwhelming praise for Neve designs in the 1970s, many designers of audio equipment failed to appreciate exactly why these products sounded so wonderful and for several decades they continued to both accept and promulgate time-honored ideas about the limits of human auditory perception which Rupert Neve and others had discarded by the 1980s.

The Neve company became a publicly traded enterprise in 1975, and during the second half of a ten year non-compete agreement Mr. Neve (doing business as ARN Consultants) was largely occupied with a variety of audio projects not related to the design of large mixing consoles. Meanwhile, the entire music and recording landscape was undergoing a dramatic change in the 1980s and many of the cherished products from the 1970s seemed to fall by the wayside, along with the advanced notions of human perception which had guided their development to a very advanced state by 1978.

Rupert Neve: Life Beyond Measurement

The late 1980s saw professional audio rushing towards its digital future. Affordable digital recording had arrived with the R-DAT compact digital cassette in 1987 and CDs had become the dominant media for music distribution by 1988. The early 1990s promised a fully digital production chain. Digidesign's Sound Tools (1989), Pro Tools (1991) and the Alesis ADAT (1992) were just a few of the innovative products that would spark an explosion of project studios with capabilities that rivaled the midsize professional studios of the previous decade

With those dramatic changes on the horizon, many saw vacuum tubes, transformers, turntables and vinyl records as audio dinosaurs on the road to extinction. Interest in vintage gear was minimal. How shocked a young engineer from the 80s would be if they were suddenly transported to our world where so many of these "dinosaurs" have revived and are cherished by professionals and consumers alike.

What happened along the way is that many began to realize that the new technologies all too often did not quite deliver the superlative audio that digital promised. "Perfect Sound Forever" didn't quite pan out. So even as the digital tide rolled in, a good number of engineers realized that there were so many aspects of the audio quality that were not clearly understood and which often could not be easily measured. As these came to better appreciated in the 1990s, there was a simultaneous re-evaluation of older technologies and vintage equipment. Today we better understand what a magnificent and complex auditory mechanism humans are blessed with and how the most subtle factors can be perceived and influence what we call "good" sound.

In 1985, Mr. Neve's non-compete came to an end and at the same time the Neve Group was sold to the Siemens corporation of Austria. Rupert and Evelyn Neve then re-entered commercial studio supply, launching a new range of outboard equipment under the name of Focusrite Ltd. Of course, loyal Neve followers wanted nothing less than his return to the business of creating large format mixing consoles. Orders were taken for 8 new consoles with new and complex digital master control facilities. Sadly, the task exceeded the company's resources. Both time and money ran out and the company was liquidated in early 1989.

Despite this disappointment, Rupert Neve was once more about to re-shape the way many thought about audio and equipment design. Entering into a consulting agreement with the English console manufacturer AMEK, Mr. Neve immediately began to design upgraded modules for some of AMEK's most successful products, along with a new outboard equalizer. By 1993 a full range of new outboard gear was launched - the 9098 series - which would culminate in his new Super Analogue console by the decade's end. AMEK provided Mr. Neve with a unique opportunity to reach out to the international

audio community through both print advertisements and in-person appearances which highlighted the design principles that were so central to the success of his products.

AMEK was not shy about their "re-introduction" of Mr. Rupert Neve. One advertisement boldly stated:

> *"Perfection remains a dream… One man has made it his life's work to pursue this dream and more than most, he has come close to making it a reality. Time after time he has challenged the conventions and rewritten the rules. His hallmarks are an unwavering commitment to the detail of circuitry design and a lifelong dedication to improvement. His signature is a guarantee of audio excellence. Many people point to his history. Only AMEK can bring you his future."*

Though in many ways Mr. Neve shunned the spotlight, he did allow AMEK to include his picture and to quote him liberally in advertisements that proclaimed an expansive concept of auditory perception:

> *"For more than a decade leading musicians and engineers have appreciated that exceptionally wide bandwidths with very low distortion are vitally necessary in the early stages of the signal handling chain. Now academic research has endorsed our experience, finding evidence that signals as high as 100 kHz are used by the brain to add fullness and enjoyment to music… owners can rest assured that these performance parameters are an essential part of my decisions."*

Responding to criticism of these statements in 1992, Mr. Neve added

> *"We try not to stand still and as we learn more and continue to listen to the musician and producers, so we will build the sort of equipment that we think adds fullness and enjoyment to music even if we do not fully understand all the factors that make it so. We cannot 'explain' how we respond to sounds. There are many researchers who have made and are currently making extremely valuable contributions…"*

Mr. Neve then cited four papers presented at Audio Engineering Society conventions and meetings in 1991:

> *"High-frequency sound above the audible range affects brain electric activity and sound perception" (Institute of Multi-media Education, Japan)*

"Estimating the Significance of Errors In Audio Systems" and "Predicting the Audibility, Delectability and Loudness errors in Audio Systems" (J. Robert Stuart, Boothroyd Stuart Ltd, U.K)

"Understanding Noise and Distortion- A New Approach" (J. Robert Stuart, Boothroyd Stuart Ltd, U.K)

Mr. Neve had begun to test his ideas with public experiments in 1987 and once the AMEK consultancy was in place, he expanded these tests to include audiences in several countries. The audiences were always professional audio people, musicians and engineers and producers who are used to critical listening. A notable US demonstration took place in the fall of 1990 at U Mass Lowell, where the Music Department's William Moylan, a highly regarded author on sound recording technology and music theory, had established one of first Critical Listening courses.

The repeated conclusion from these experiments was that although traditional measurements limited human hearing to an audio bandwidth of 20 Hz to 20 kHz, human perception can be aware of frequencies that are well above this and that when these frequencies are eliminated from the audio chain during the recording process, the results are a loss of quality in music reproduction and a perceptible reduction in listener enjoyment. While many subjects were discussed in Mr. Neve's extensive talks to audio engineering professionals and students after 1989, this concept of wideband high fidelity was to be an essential component in all his lectures.

During those critical years beginning in 1990, Rupert Neve was instrumental in getting engineers to re-think their long-held views about the limitations of human hearing. Along with others, he led a movement over the next twenty years to examine the subtleties of perception and to create audio equipment that not only performed well on paper but which also transmitted that hard-to-define magic that we experience directly with a live performance or by way of a superbly recorded mix.

When he reclaimed full use of his name and launched Rupert Neve Designs in 2005, his newest designs received immediate acclaim and achieved astounding success. While some would continue to argue against his ideas regarding how we perceive sound, few could question that once again his designs had given audio engineers the most extraordinary tools to elevate their craft to true art.

Josh Thomas, who had been working with Rupert Neve since their days with AMEK,

summed up the twin goals of Rupert Neve Designs:

> *"The first was to set a new standard in the quality of recorded sound, drawing upon his unparalleled depth of experience to create high-end solutions for the modern recording engineer, musician, and listener alike. The second was to pass on his philosophies, techniques, and methodologies to a new generation of designers to carry his life's work and passion into the future."*

The recording industry responded with unprecedented accolades including a Lifetime Achievement Technical GRAMMY Award in 1997, Studio Sound Magazine's Audio Person of the Century Award in 1999, an Audio Engineering Society Fellowship Award in 2006, and 16 TEC (Technical Excellence and Creativity) Awards for Rupert Neve Designs.

III.
Can You "Hear" This?
Re-Examining the Limits of Auditory Perception

Beginning in the late 1950s leading designers of consumer and professional audio equipment begin to search for a better understanding of the factors that infuence the "sound" of their products and the way that listeners respond to their sonic attributes.

To better understand why the designs of Rupert Neve have had such a profound impact on the world of recorded music, it will be helpful to look more closely at some of the ideas which he, and a handful of others, took as the basis for their work in the 1990s.

These ideas were not exactly new. Audio enthusiasts had recognized their validity as far back as the late 1950s but widespread acceptance and application was slow in coming. Mr. Neve began incorporating them into his designs in the 1970s and by the 1990s he was able to combine his own experiences with newer scientific research, becoming a leading participant in a movement that demanded a critical re-examination of the limits of human perception.

By the turn of the century a chorus of leading audio engineers and equipment designers had taken up the catchy slogan that "life beyond 20 kHz" was indeed a musical and perceptual reality.

This re-examination of auditory perception met with considerable opposition in both consumer and professional publications. Those who insisted on the need for bandwidth out to 40 kHz and beyond were all too often characterized as misguided purveyors of audio mythology. One writer exclaimed after reading Mr. Neve's statement that there is evidence that signals as high as 100 kHz are used by the brain to add fullness and enjoyment to music:

> *"Perhaps AMEK should explain whose brain can be so addled with fullness from signals that are at least an octave higher than the average ultrasonic garage door transmitter! Come off it. Who are you kidding! It's this sort of codswallop that keeps alive the myths and legends of the hi-fi brigade!"*

A much more technical columnist wrote in a 2000 issue of TV Technology regarding a

discussion at an Audio Engineering Society meeting on psychoacoustics, concerning a proposal for a new ultra-wide bandwidth digital format:

> *"Does anyone here know of any studies that convincingly show that humans hear above 20 kHz? And we all just sat there. Not one of us knew of anything like that. So much for what the people who are really interested in what, and how, we can hear tell us. Above 20 kHz? No evidence, zero, zippo, zilch."*

Battle lines were clearly drawn. One of the most respected columnists in the Pro Audio press, with an impeccable background (then and now) in academic recording engineering programs carefully reviewed Mr. Neve's experiments and the articles that were being widely cited by proponents of life beyond 20 kHz. He concluded in a May 2002 column:

> *"So, it seems like the audio world above 20 kHz… will probably not turn out to be very important. As I said, there may be other reasons why high sampling rates are helpful… but not because your old technology and mine, is missing anything."*

David Blackmer, the developer of the DBX voltage controlled amplifier, began his own research into the capabilities of human hearing in the late 1980's. In 1998 he published a groundbreaking article *"Life Beyond 20 kHz"* which summed up the obstacles that he, Rupert Neve and others faced when presenting the case for an expanded concept of human auditory perception:

> *"Many engineers have been trained to believe that human hearing receives no meaningful input from frequency components above 20 kHz. I have read many irate letters from such engineers who insist that information above 20 kHz is clearly useless, and any attempt to include such information in studio signals is deceptive, wasteful and foolish. They assert further that any right-minded engineer should know that 20 kHz has been acknowledged as an absolute limitation for decades. Those of us who are convinced that there is critically important audio information to at least 40 kHz are viewed as misguided."*

Practical evidence for an expanded understanding of human auditory perception had been accumulating for 40 years, as Mr. Neve knew all too well. His designs in the 21st Century would prove the validity of this approach beyond question

Yet even today, hundreds of reference books and articles will inform readers that the commonly stated range of human hearing is 20 to 20,000 Hz. Most of them refer back to the Fletcher and Munson graphs of human hearing experimentally developed in the

late 1920s and early 1930s. More recent research allows that under the best laboratory conditions some laboratory conditions, some humans can hear sound as low as 12 Hz and as high as 28 kHz. But as far back as the 1860s the renowned physicist Helmholtz defined the musical spectrum as extending up to 40,000 cycles.

He acknowledged that people don't "hear" that high but insisted that they do respond to sensations involving those frequencies. Designers of the circuitry for audio equipment have always grappled with the fact that in listening tests amplifiers with similar specifications for noise, harmonic distortion and frequency response within that 20-20K range of human hearing often sounded very different from one another. As high fidelity equipment became increasingly sophisticated in the 1950s, some designers realized that extending linear response above and beyond the 20-20K absolutes seemed to elicit a positive response from listeners. Along with this came the realization that there were subtle distortion factors, not easily measured at that time, which impacted the true and pleasing reproduction of music

Shortly after stereo LPs were introduced in 1958, the pioneering record label, Audio Fidelity, claimed a total frequency range of 16 to 25,000 cps on their vinyl records stating that while this "may not be within the range of ordinary human hearing… it is the opinion of the manufacturer that if these frequencies were omitted from this record a certain warmth of tone that is felt and sensed rather than heard would be lost." Likely they were influenced by published interviews with the American designer of amplifiers and loudspeakers, Stewart Hegeman. who in the late 1950s developed a radical theory of amplifier design based on ultra-wide frequency response.

He argued that an amplifier's frequency response should extend far above and below the commonly accepted 20 to 20,000 kHz range. and he proved the validity of this approach with his acclaimed Citation designs for Harman-Kardon. The Citation I preamplifier boasted a frequency response from 5 Hz to 80 kHz. His Citation II stereo amplifier, introduced in 1959, is one of the most highly prized vintage tube amplifiers, with restored models selling for as high as $3500. Among other things the Citation II boasted a full power bandwidth of 18 Hz to 60,000 Hz and output transformers that were capable of high frequency response out to an astonishing 270,000 cycles.

Almost 60 years after its introduction, amplifier designer Bob Carver described the Citation II with the same sort of superlatives that audio engineers use when describing vintage Neve consoles:

> *"The Citation II was Stu Hegeman's penultimate masterpiece, inspired by his unwavering desire to build a power amplifier equal to his stunningly great Citation*

> *I preamplifier. I consider the Citation II power amplifier to be one of the most original designs in audio history, introducing technology that had never before been seen in an audio product. The Citation II's high-gain, wide-bandwidth video-pentode design yielded performance that was difficult to believe. Stu Hegeman's circuits produced a sound that had a life and a breadth and image depth that were stunning. They were the ultimate in sound staging and sense of immersion. The Citation II's circuit was most elaborate, the thinking behind it exceptionally advanced, the sound spectacular!"*

Sheldon Stokes, a design engineer wrote:

> *"When the passive components in this amp are updated, this amp sounds just amazing. It produces music with an authority and an ease that is unequaled in the audio world. It tends to have a dry and "correct" sound rather than a "tube amp" sound. …If you want your music served up honestly with a bare minimum of distortion this may be the amp for you."*

Hegeman responded to questions about his wide-bandwidth approach in a 1961 interview:

> *"A rigorous approach to sound reproduction should include two octaves below and two octaves above those 20 to 20,000 cycles limits, that is about 2 to 80,000 cycles. The extreme bass contributes what you might call the "sound' of the hall, the aura or the ambience of the environment of live music. The extreme highs contribute to the space and the air of the sounds produced in that environment."*

Hegeman believed that tones which could not be heard in isolation still could influence what was perceived by listeners - that there were factors when limiting bandwidth and excluding these signals which created distortions in the listening experience, much in the way a seawall throws back the surf and creates interference with the oncoming waves. He also believed in the critical importance of minimum phase shift or time displacement within the elements of complex signals. When the relationship between overtones at the frequency extremes and fundamentals was changed the result was a sound perceived by most as less lifelike and pleasing.

Stewart Hegeman recognized that reproduction of complex musical information required amplifiers with extremely wide-band response and phase shift reduced to a bare minimum. He focused on both wide response and eliminating the un-measurable (in the 1950s) forms of transient distortion which imparted an unnatural, brittle quality to sound that he described as canned or electronic-sounding, lacking both clarity and sweetness. As

acclaimed as his products were, a NY Times article in 1990 noted:

> *"It took nearly two decades for Hegeman's wide band principle to be recognized as essential for low distortion amplifiers… Much later, as suitable measurement methods became available, controlled experiments at the State Technical Research in Oulu, Finland and at the University of Osaka, Japan bore out Hegeman's findings."*

In Finland and the Netherlands researchers began extensive research in the late 1960s which focused on those transient intermodulation distortions that Hegeman had worked hard to eliminate in his designs. Finnish designer Matti Otala's research culminated in a landmark technical paper published by the Audio Engineering Society in 1972. His views were highly controversial at the time but within a few years other noted amplifier designers such as John Curl had joined him in the quest to describe and measure what came to be known as slew induced distortion.

The results could be clearly be seen in better sounding amplifiers by the end of the decade. Harman-Kardon, the company whose Hegeman designs had revolutionized tube amplifiers, collaborated with Matti Otala on a solid-state amplifier that would achieve similar fame. 1980 brought the introduction of the Citation XX high current amplifier which boasted stunningly quick transient response and a lifelike, open sound. The Citation XX amplifier was called "the world's best-sounding power amplifier" by the editors of The Audio Critic magazine.

We cannot state with any certainty the degree to which Mr. Neve was familiar with developments in American high-fidelity equipment during the 1950s. But his work in the 1970s,1980s and 1990s certainly echoed and expanded those earlier concepts. From the earliest days of the Neve company, Mr. Neve had also learned from listening tests that his customers responded well to circuitry with flat frequency response that extended far beyond the 20-20 kHz absolutes. Early Neve consoles were designed with bandwidth and linearity well in excess of the figures considered necessary at the time.

Mr. Neve noted that "the old text books would always tell you never to provide a bandwidth in excess of that which was strictly needed." But based on listening tests, he started to extend the bandwidth of some of his circuits and by 1970 Neve consoles had response out to 35 or 40 kHz. Some accused Neve of over-engineering, but Neve felt that listening supported the idea that the wider bandwidth circuitry "sounded" better.

The Neve designs garnered great praise in the early 1970s from leading engineers and producers, but there were some recording engineers in the USA who were not overly

enthusiastic about the sound of Neve consoles. Initially Rupert believed that response out to 40 kHz would prove "*more than adequate*." He was therefore puzzled when he received comments from American engineers that a newly delivered console sounded muffled. Rather than dismissing the criticism, as many would have, Rupert began an intensive round of listening to various circuits, with and without transformers, and he began to further extend the bandwidth of some of the circuits in his designs.

Rupert Neve's epiphany came in 1977, not long after he had sold the NEVE company. AIR Studios had taken delivery of a new NEVE console and during its installation and testing engineer Geoff Emerick wasn't at all happy with it although he could not be very specific about that the problem was. A team of NEVE engineers was sent to check it out but they found nothing out of the ordinary. They wrote it off to Emerick's personality and concluded it would be best to just do nothing and eventually the "problem" would go away. Sir George Martin intervened and pleaded with Rupert, "Please come and make Geoff happy, while he's unhappy we can't do any work." So, Rupert Neve himself sat down with Emerick at the console, set up a tape playback and compared the signal directly from the source with the signal emerging from the console's signal path. At first Mr. Neve couldn't hear any problem and Emerick could only say it seemed that the console path sounded "brighter." With additional listening, Mr. Neve, too, could perceive a difference.

The testing continued on a channel by channel basis and Emerick was able to identify a channel module had that slightly brighter sound. Upon examination it was found that the channel had an improperly terminated transformer which was producing a 3dB rise at 54 kHz. Geoff Emerick was able to correctly identify two more modules that had a similar mis-wiring. Rupert Neve commented in a number of interviews in the 1990s:

> *"Theoretically that should be outside the range of human hearing, but we both perceived it in the same way, even if we didn't "hear" it in the traditional sense. Did the brightness exist? Absolutely, although a team of engineers was unable to determine the cause for Emerick's displeasure and therefore said it didn't exist… This started me wondering how so many people could hear something that was out of band when conventional wisdom stated that anything above 20 kHz should be inaudible."*

The following year NEVE began work on a new console (A4792) for Sir George Martin's new AIR Studios on the Caribbean island of Montserrat. The AIR Montserrat studio opened in July 1979. Three "Montserrat" consoles were eventually produced for AIR and Rupert Neve believed that these consoles represented a "substantial step forward" in terms of bandwidth, noise and distortion. The bandwidth was well in excess of 100 kHz. Rupert recalled with great pride Geoff Emerick's reaction when he first recorded and

mixed on the “Montserrat”: “Rupert - It sparkles!” So many famous names would echo these sentiments in years to come and these consoles have achieved an iconic status. When Rupert Neve returned to designing modules and consoles after 1985, the extended bandwidth of the Montserrat design was the foundation upon which these were built. He was determined to know more about the seemingly un-measurable aspects of human perception and to confirm whether harmonics falling outside the audio band could make a difference to the audible sound. He was not content just to design better sounding equipment for creative artists and their engineers. He was fond of quoting the great physicist, Lord Kelvin, “To Measure is To Know.”

His initial tests were deceptively simple, requiring little in the way of specialized equipment. With an oscillator he would switch between sine waves (the simplest of all waveforms containing a single fundamental frequency with no harmonics or overtones) and square waves (the fundamental frequency and its odd harmonics). Conventional wisdom is that as the frequency rises sine waves and square waves begin to sound more and more identical, as the third harmonics begin to move “outside” the range of human hearing.

So with a 4 kHz tone the third harmonic at 12 kHz is getting hard for many to hear and by the time you get to an 8 kHz tone that third harmonic is at 24 kHz and almost no one should be able to “hear” it. But Rupert found that if you go on raising the frequency, listeners could still tell the difference between a sine wave and a square wave, even though you have exceeded the accepted limit of hearing.

Rupert began to conduct public experiments in 1987 starting with an audience at the Institute of Broadcast Sound. Being broadcasters, most present would have an ingrained skepticism about the ability to hear signals above 15 kHz. Yet 30 to 40 percent of those present could still hear a difference between sine and square waves when the fundamental was around 12-14 kHz. Rupert repeated the public experiments many times in the years that followed, in different venues around the world and often using other peoples’ equipment. The results were consistent from demonstration to demonstration.

These experiments were especially impressive when the audiences consisted of younger professionals who had been trained in critical listening. Some 60% of those present in those younger audiences were able to distinguish a difference between sine and square waves when the fundamental was as high as 10 kHz. Some in that age group could hear fundamentals out to 18-19 kHz. and they could still detect differences between the sine and square waves indicating an ability to perceive harmonics up to almost 60 kHz!

IV.
Can You "Hear" This?
High Resolution Audio in the 1990s

Rupert Neve and other leading equipment designers spearhead a movement for High Resolution Audio which would challenge the audio industry to accept an expanded concept of human auditory perception, leading to new standards for audio quality in the 21st century.

During 1991-1992, as Rupert's new designs for AMEK were achieving considerable success, he became increasingly aware of research around the world on the ways in which harmonics present outside the conventional audio bandwidth can affect what we hear. One paper by Robert Stuart suggested that when noise is pushed "out" of the conventional bandwidth by noise-shaping techniques, it is still perceived by human ears. Rupert told one interviewer:

> *"If there is musically useful information out of band, the human system makes positive use of it - on the other hand if it's just dirt, it reflects somehow back into the wanted signal within the 20 kHz bandwidth and affects the way you hear the sound."*

As he developed the new 9098 console, he corresponded with these researchers discussing the positive aspects of out of bandwidth sound and what valuable nuanced sonic formation can be lost when bandwidth is cut at 26 kHz. All getting back to that question from the 1950s - why do amplifiers that measure identically minuscule harmonic distortion and flat response, in the frequency response 20-20 kHz bandwidth, sound so strikingly different? Rupert noted in a 1993 interview:

> *"It's all very subjective. It would seem that the human system is able to take the most microscopic bits of information and build on them - not that you perceive them as sound but you can say "This makes it sound good" or "this doesn't."*

This viewpoint resonates so strongly with Stewart Hegeman's credo way back in 1959 that the characteristics of an amplifier in the non-audible range strongly influence the quality of sound in the audible frequency range.

The crowning achievement of Rupert's work as a consultant to AMEK in the 1990s was the 9098 Super Analogue console. With a bandwidth that was flat from 10 to 200 kHz and a near total lack of crossover distortion, the console was a modern day "Montserrat,"

again proving the real-world viability of the Rupert Neve design philosophy. AMEK's publicity boasted in 2001:

> *"The 9098i's technical specification is impressive to say the least… it attains a performance level, which pushes back the boundaries of known theoretical limits. Featuring an extended audio bandwidth of 200 kHz (-3dB), 9098i maintains a sense of transparency that is absent from inferior bandwidth-limited systems. An incredible dynamic range and remarkable phase linearity provide accurate imaging across the entire bandwidth… a sense of realism other consoles simply cannot produce… achieved by reducing distortion to a barely measurable level".*

Rupert and other leading designers were inspired by a slew of new academic research which informed their quest for higher resolution equipment that facilitated more realistic and lifelike sound reproduction. Rupert's years as a consultant to AMEK were marked by a great deal of cross-communication between him and other leading designers and researchers in the US, Japan and the UK. Working closely on new console designs with AMEK's own distinguished console designer, Graham Langley, Rupert began a lasting and fruitful relationship with George Massenburg, who had previously collaborated with Graham on AMEK's flagship APC-1000 console.

In a 1993 interview Massenburg noted:

> *"I like the kind of tools that Rupert Neve builds, no matter who he's working for. He is a man who truly understands audio. I'm always inspired and always learning something when I talk with him. He's built a great equalizer every time he set out to do so. He's working with a man at AMEK who has also built great equalizers for many years, Graham Langley."*

Massenburg's life has been a relentless search for both technical and emotional perfection in his recording engineering and his technical designs. In the 1990s he knew we could do much better in all aspects of the recording arts. In an article written for Studio Sound in 1992 entitled "Analogue's Future," Massenburg proclaimed:

> *"If we have learned anything, it is that given enough money and resources there are improvements to be made almost everywhere. In the 1970s amplifiers improved with the knowledge about tertiary disturbances like transient intermodulation distortion... even the lunatic fringe in consumer audio occasionally comes up with breakthroughs that contribute to the body of knowledge regarding artifice. In the domain of extremely high resolution analogue audio there is a world of*

> *data, increasingly ambiguous data as one approaches, even moves below, the noise floor. And ambiguity notwithstanding, these signals are meaningful to the ear... hopefully there will still be those who will be willing to use their own ears in evaluating equipment, and more, have the courage to describe the rather subtle differences that are heard..”*

A year later he told an English interviewer:

> *“The ability of recorded music to reach out and touch many hearts has not in and of itself improved. Some of the techniques have expanded greatly - the ability to synthesize - but the ability to make it touch people and make it viscerally effective - and to reflect some cultural references has not grown significantly.”*

Like Rupert Neve, Massenburg’s lengthy career in professional audio would culminate in the 1990s with fast-growing influence as an educator and proponent of the need for high resolution audio, in addition to revitalized activity as an equipment designer. His impressive achievements were recognized with a TEC Award for Producer and Engineer in 1989, a TEC Hall of Fame Award in 1990, a TEC Award for Engineer of the Year in 1992 and Grammy awards in 1989 and 1996.

Massenburg, Neve and others who saw a great need for higher resolution audio technology were all greatly influenced by the aforementioned AES publication in 1991 of the research by Oohashi et al. from the Japanese Institute for Multimedia Education. Entitled “High-Frequency Sound Above the Audible Range Affects Brain Electric Activity and Sound Perception,” the paper reported on a novel technique to measure brain electric activity which allowed the researchers to determine if high frequency components above the audible range can influence sound perception in ways not discerned by the method of paired comparisons.

They concluded that high frequency sound induces activation of electroencephalogram rhythms that persist in the absence of high frequency stimulation, and can affect perception of sound quality. Subjects in these experiments were responding to ultrasonic frequencies as high as 60 kHz.

Rupert Neve visited Professor Oohashi in Tokyo and was treated to an impressive series of demonstrations comparing music recorded and reproduced in several formats: one with very wide bandwidth, also a standard Compact Disc with bandwidth restricted to 20 kHz, and a wide-band one bit JVC digital CD system. He concluded:

> *“There is no doubt that wide bandwidth is more enjoyable. Music actually sounds sweeter and warmer when high frequencies are extended (distortion and noise*

> *free) beyond audibility, No obvious sensation of a stronger or more aggressive high frequency response. I was able to relax and stop "listening" - just letting the magnificent sound flow over me. This accords with opinions from many well-known 'golden' ears of the industry. For example, George Massenburg…"*

In his 1999 column for *AudioTechnology*, Rupert expanded this a bit, highlighting the noise components whose elimination would become a cornerstone of his designs in the coming decade:

> *"But it seems to me that there is more than frequency response, as demonstrated by Professor Oohashi, which plagues the standard CD. The digital process is always badly flawed by non-harmonically-related switching transients which are dumped in the critical area above 20 kHz, resulting in a substantial increase in noise beyond audibility (where it has been thought, it does not matter)."*

Another influential paper, "Ultrasonic Speech Perception" by Martin Lenhart was published in Science that same year and it concluded that "bone-conducted ultrasonic hearing has been found capable of supporting frequency discrimination and speech detection in normal, older hearing-impaired, and profoundly deaf human subjects."

At Cal Tech's Music Lab, James Boyk, a pianist, educator and sound recordist familiar with these papers, published his own research on ultrasonic sound. Using the latest HP FFT Analyzer and advanced measurement microphones, he analyzed the spectra of musical instruments. His 1992 paper, *"There's Life Above 20 Kilohertz! - A Survey of Musical Instrument Spectra to 102.4 kHz"* confirmed his long-held ideas that the unique sound characteristics of musical instruments were influenced by harmonics or overtones found in frequencies far beyond the instrument's perceived frequency range.

Each major musical instrument family had a least one member which produced energy to 40 kHz or above. Harmonics of the French horn could extend to above 90 kHz, trumpet to above 80 kHz, violin and oboe to above 40 kHz and a cymbal crash showed no signs of running out of energy at 100 kHz. Boyk called for further research to determine whether these ultrasonic sound components did indeed matter to human musical perception and pleasure. His work caught the attention of leading recording engineers such as Doug Sax and George Massenburg.

Massenburg wrote:

> *"I would like to point out that the future will undoubtedly bring a widened view of the "audible" band. More than ever before, 20 kHz has become a severe*

> *limitation. I was deeply impressed when Jim Boyk, from Cal Tech, showed me some spectral analyses made on a new HP analyzer of trumpet with a Harmon mute, and its harmonic at 50 kHz was at least as loud as its fundamental. Its harmonics went out to 100 kHz - you could count them! There is something to extended high-end response, and sooner or later, we're going to have to take this seriously. Life doesn't end at 20 kHz."*

When Massenburg presented his first paper on parametric EQ, all the way back in 1971, he had the opportunity to meet David Blackmer, the developer of the DBX voltage controlled amplifier. They talked at length. Massenburg was greatly impressed by the genius and elegance of Blackmer's designs. Years later he stated concerning Blackmer: *"He knew how to make a VCA that no one had envisioned up to then. And of all the inventions in audio in the last 30 years, none is as elegant and simple as the David Blackmer VCA."*

It was not coincidental that Blackmer came to join that group of extraordinarily talented engineers calling for a reexamination of audio perception in the 1990s. After selling dbx, Inc. he began basic research in the 1980s, initially focusing on loudspeaker design and analyzing why different high frequency drivers, which had identical frequency response out to 20 kHz, sounded very different. He traced the only measurable differences to resonances in the 27-30 kHz range, a realm supposedly beyond the capability of human hearing.

To better understand why there was a night and day difference in the sound of the drivers, Blackmer began developing his own microphones to aid in testing his speaker designs, leading to his acclaimed line of Earthworks microphones in the early 1990s. In his research David Blackmer focused on the hair cells of the inner ear and the way their pulse vibrations seemed to help the auditory system to map impulse information embedded in tones. Blackmer believed that sound quality information delivered to the brain included waveform, embedded transient identification and high frequency component identification to at least 40 kHz, and perhaps 80 kHz. By the middle of the decade, he was granting interviews that contained statements like:

> *"We are looking at better ways to understand the sense of human perception and the full range of its incredible capacity - a respect for the subtleties of that and especially the subtleties that go beyond the models that are normally accepted. Apparently, there is very good evidence that there is information beyond the current model for human hearing that is necessary to make good recordings... human senses have a much greater range than the models we make of them have."*

Rupert Neve: Life Beyond Measurement

Blackmer's Earthworks microphones received across the board recognition and praise in late 1990s for their wide bandwidth and ultra-fast transient response. With Blackmer's original research and design philosophy as its foundation, the brand has enjoyed durable success for over 25 years.

Rupert Neve and many others made frequent reference to the papers published between 1991 and 2000 by Robert Stuart and his co-workers at Meridian Electronics. In 1996, Robert Stuart was made a Fellow of the Audio Engineering Society for his important insights into the models of auditory perception and their applications to audio technology. Meridian's development of Lossless Packing was a landmark in the development of high resolution digital audio as exemplified in such products as DVD Audio and Dolby TrueHD.

Combining 20+ years of experience in high-end product design with a formal education and academic work in psychoacoustics, Stuart's work in the 1990s bridged the often separated worlds of the audiophile, academics and professional audio researchers and engineers. Stuart's ideas as to how we go about perceiving the most subtle differences in systems and his insistence that the smallest details in both the signal and the context of the signal can make a step change in what we perceive, helped provide others with new levels of understanding about the importance of wide bandwidth, high resolution audio and the way humans perceive sound. In a 2005 interview he noted:

> *"What I think is outrageous is to say we understand everything about how the human hearing system works, because what we do know is that it's incredibly sensitive to certain kinds of differences and very tolerant of others. So you can measure something objectively, but you know as well as I do that's its possible to design a system that measures well but is not satisfactory. That's why we inform everything we do not only with psychoacoustics, but with critical listening... Listening is multi-dimensional… You have to listen to everything.*
>
> *It's really important to understand how a human being responds to sounds. We don't hear sine waves and noises and clicks and ticks, which are the vectors that electronics and acoustic engineers use to measure systems. When we hear a waveform there a very complex cognitive process that follows - we immediately externalize that sound as an object. If you design on an electrical engineering basis, you'd say that an amplifier only has to be flat from 20 Hz to 20 kHz and with distortion below "x." You're immediately starting out with a model that says I believe I understand completely how this all works, and I'm not giving any value to the subjective mapping or the interpretive mapping or the cognitive mapping of what's going on.*

Rupert Neve: Life Beyond Measurement

> *It's terribly important not only to know the value of each change you make but also how the way each component of the error the system makes is going to be interpreted. What we're trying to do with any system is not just to minimize the errors it makes, but to understand how each error operates in the context of others… We're working with all sorts of things ranging from thresholds, to loudness, to how one thing sounds in the presence of another. We work with timing, distortion and - how much you can get away with, how much you can't get away with - and whether you're creating an error that is spatially disconnected from the thing that caused it in the first place. All these are very important. So yes, I approach audio design fundamentally from the way we hear."*

Robert Stuart's pioneering work as co-founder, chairman and technical director of the Meridian Group, included the launch of the first digital surround-sound processor - the Meridian Digital Theatre - in 1994 and continued through the 1990s, reaching a crescendo with the development in 1999-2000 of Meridian Lossless Packing (MLP). His papers were recognized with the AES Fellowship in 1996 and over the next 20 years Meridian consumer audio products received well over 300 awards culminating in a Lifetime Achievement Award from CEDIA in 2015 recognizing his "quest to capture the excitement and raw emotion of live music in digital recordings, bringing us ever closer to what we experience in a concert hall and what musicians hear in the recording studio."

This growing chorus of voices in the 1990s calling for a new understanding of human auditory perception finally began to impact the mainstream audio press. Even publications that usually addressed nuts-and-bolts design and systems integration took notice and reported on ideas that had previously been dismissed as golden ears mythology. In 1998 *"Sound and Video Contractor"* printed David Blackmer's extensive discussion *"Life Beyond 20 kHz."* The same publication, edited by Nat Hecht, summed up a good bit of academic research in a 2001 editorial entitled *"On the Threshold of Discovery"* accompanied by with a boldly printed headline which read, *"Humans can respond to ultrasonic frequencies up to 60 kHz!"*

Hecht was citing the Oohashi et al. AES paper that had so influenced Rupert Neve some ten years earlier. He also cited the work being done at Cal Tech by James Boyk in the early and mid-1990s, the Lenhart paper on Ultrasonics and the Blackmer article. It was becoming increasingly difficult to dismiss the opinions of those seeking a new understanding of perception as their careers, and the products they developed, achieved such a high level of recognition and acclaim during the 1990s.

Neve and Massenburg, along with other designers were all corresponding with one

another as *"Life Beyond 20 kHz"* became a rallying cry for both academics and some of the leading audio equipment designers of our era. Over the next five years the proponents of extended bandwidth finally received a real hearing and in-depth attention from the professional audio community.

Massenburg's career as both an engineer and designer was reaching new heights between 1988-1992, the same years in which Rupert Neve began his remarkable work with AMEK. Massenburg received his Technical Grammy award in 1998, a year after Rupert received his Technical Grammy and the same year as Rupert was launching the 9098 designs.

Literally dozens of interviews with Neve, Massenburg, Stuart, and Blackmer populated all the major professional audio trade publications. This time around the advocates of extended bandwidth would find a much wider audience and their ideas would come to have real staying power. They would not have a twenty year wait for recognition, as Stewart Hegeman had experienced. The proponents were too deeply embedded in the mainstream of professional audio and too widely respected to ignore or ridicule.

Even as the entire audio press flocked to interview them, there were still plenty of skeptics to be found. The theoretical background that many engineers inherited from their training strongly shaped the beliefs of many. So, until everything could be measured and explained in technical terms, they would continue to resist these ideas that seemed so "provocative" to use Rupert's own words. Provocative they were - here is a typical slice of vintage Rupert Neve which appeared in a 1998 interview:

> *"The Japanese showed some time ago that the brain produces electric radiations in the presence of different emotions and emotional stimuli. If you listen to an analogue music signal that is good quality, with no crossover distortion and no digital sampling, it can be a very satisfying experience…but the Japanese have shown, and in fact a lot of us are accepting quite happily, that {referring to distortion present in CD's and cheaply designed amplifier circuitry} that these distortions - first of all the lack of music-related frequencies above 20 kHz and secondly the presence of switching transient noises above 20 kHz - actually produce a different from of brain radiation. They produce the kind associated with discomfort, frustration, even anger."*

The interviewer undoubtedly seemed taken aback by this. So, Rupert added:

> *"You can talk to others. It's not just me. Talk to George Massenburg for instance, and he will tell you exactly the same thing."*

Rupert Neve: Life Beyond Measurement

Perhaps the most remarkable and widely read expression of Rupert Neve's design philosophy in the 1990s appeared in a series of interviews conducted by the Australian publication *AudioTechnology* beginning in 1998.

AudioTechnology was a brand new publication in 1997 preparing to launch their first issue in 1998. AMEK's Australian representative wanted them to include a piece on Rupert Neve's PurePath series of outboard gear. The magazine was less than enthusiastic because they had planned to fill the first issue with really exciting previews of some digital audio workstations that had a real "buzz" going at the time. They didn't think the Neve products were particularly newsworthy and as for Rupert he seemed to be old news, a "recurring echo from a warm and distant past."

Nonetheless, he still was Rupert Neve, idolized by many old school guys, so the magazine's founding editor, Greg Simmons, resolved to do the interview and squeeze in a review of the gear and maybe a half page of interview. Just six questions, all related to the PurePath product review. A "six question, twenty minute interview" went on for two hours, back in the day when international phone calls between Australia and Texas were still a considerable expense. Simmons transcribed some 12,000 words which he described as "priceless." Rather than edit them down, he elected to run the interview across the first three issues of the magazine.

They were a resounding success. Simmons noted that he immediately gained a loyal audience with "cynical and hardened professional engineers who were expecting yet another ill-informed, over-hyped and ad-driven piece of garbage aimed squarely at the home studio market." Instead of fluff, Rupert provided them with a new understanding of what humans could perceive and a persuasive argument for the necessity to critically re-examine their opinions and standards as regards high resolution audio reproduction.

The prestigious Audio Media magazine bought the interview, assuring wide distribution in US and UK and "rekindling worldwide interest in Rupert's uncompromising philosophies and audio designs." Demand for more was such that Rupert went on to write a regular column for the Australian magazine, providing in-depth discussions of noise, distortion, bandwidth and tonality in audio equipment along with a healthy dose of anecdotal wit and wisdom. Characteristically, he refused to accept any payment for the articles.

By the end of 1999, Rupert Neve was far too busy with the 9098 console, and new things to come, to allow for time to continue writing the column. Both Neve and Massenburg entered the new century as renowned for their recent efforts to expand the horizons of audio, as they were for their enormous successes in the 70s and 80s. Audio technology advanced at an extraordinary pace in the new millennium to meet the explosive demand for a mind-boggling array of media and content.

A new generation of educators, researchers and students broadened and deepened the study of the art and craft of audio engineering. Vinyl revived, tubes and transformers once again became worthy of study and application, every form of vintage gear was re-explored and re-created. All the while digital technology continued to progress and move ever closer to that goal of perfect utility and perfect sound.

Amidst all this backward and forward motion, Rupert Neve, through his final company, Rupert Neve Designs, continued to provide engineers and musicians with a steady stream of new designs and new products which became instant classics. They, more than anything written, were the proof of the pudding - the ultimate validation of the designer and his philosophy of human perception and audio design.

So much of the present state of the art in audio rests on the foundations that Rupert and others laid in the 1990s. The concepts of wideband audio, and associated concepts of noise and distortion struggled for recognition for decades. Progress came in fits and starts and skepticism about these concepts remained deeply entrenched right into the 21st century. But this time around they would not be sidelined, buried or dismissed as just one more manifestation of consumer audio's "lunatic fringe."

After 1995 many leading recording engineers and producers came to agree with Robert Stuart that *"it's incredibly important that you capture the content and archive at the highest possible resolution. Even if its going to be delivered on a storage channel like CD, you absolutely should capture it with all the information that we can hear."* Enthusiastic consumers joined with the content producers in demanding higher resolution delivery systems that could transparently deliver everything heard in the studio or concert hall to human listeners.

David Blackmer discussed his motivation at Earthworks noting:

> *"Many listeners hear a great difference when 20 kHz band limited audio signals are compared to wideband signals… what we're trying to do is get that 'golden halo" around each sound that you hear live - especially with the higher frequency instruments - which you never get on a recording. We're trying to find a way to get that on a recording… The point of all this is that there seems to be a lot of room for improvement in audio and we're determined to do our part in helping it happen."*

Pioneer introduced a 96 kHz High-Sampling Professional DAT Recorder in 1995, claiming that its expanded bandwidth delivered "a more natural sound, improved sound localization and clearer resolution of sounds with sharp attacks." High Resolution formats began to

appear in the consumer market in 1996 and by 2000 they had proliferated to such a degree that format wars greatly decreased their chances for widespread acceptance. The explosion of online music retailing and portable music players using highly compressed audio also blunted the acceptance of new formats.

Opposition to the basic premise that humans can respond to frequencies above 20 kHz and below the noise floor was deeply entrenched in the technical community with numerous highly respected authors such as Paul Lehrman and David Moulton writing persuasively in the early 2000s that the science to verify the claims of high resolution was flawed and lacking in substance. Many early papers using blind listening tests concluded that differences were not audible and that even musicians were unable to distinguish higher resolution formats from 16 bit audio at 48 kHz sampling rates. The reliance on the standard method of real-time A/B evaluation, despite psychoacoustic models that indicated we don't actually perceive audio in this manner, did cause many to dismiss the idea that we were missing something with the standard sampling rates and bit depths.

Few had the courage to take on Rupert Neve directly as Paul Lehrman did in several 2002 articles where he both dismissed the 1991 Japanese paper and challenged the validity of Rupert Neve's sine wave/square wave experiments. His opposition was widely supported at the time by many academicians and scientist in the New England audio community. Lehrman concluded:

> *"Maybe I'm missing something but I think it's a bit much for the entire audio industry to reinvent itself based on this one light-years -from-definitive study... There are less-formal experiments that purport to show that we can hear above 20 kHz, and perhaps the best known of these is the one that Rupert Neve - whom I have a tremendous amount of admiration for, although I think he's completely wrong on this - does… So it seems like the audio world above 20 kHz… will probably not turn out to be very important. As I said, there may be other reasons why high sampling rates are helpful, and they are very much worth discussing, but not because your old technology and mine, is missing something."*

Yet despite this opposition, influential audio engineers continued to insist that the old technology was indeed missing a great deal and, in time, further A/B testing did begin to show that trained listeners could distinguish high resolution formats from CD under formal scientific test conditions. In the digital studio environment, acceptance of high resolution sampling and bit rates by content creators and their engineers was widespread.

As all of this intense discussion of technology played out in the audio industry's press, the music content creators took notice and the integration of audio technology persons and

issues into the National Academy of Recording Arts and Science began to accelerate. In 1994 the Recording Academy's National Trustees began to present

Special Merit Awards to individuals and/or companies who have made contributions of outstanding technical significance to the recording field. The first Technical GRAMMY awards went to Thomas Stockham (pioneering work in digital recordings) and Ray Dolby (various licensed DOLBY technologies). These were followed by awards to Rupert Neve in 1997 and George Massenburg in 1998.

In 2001, the Recording Academy initiated a technical division, The Producer & Engineers Wing, which currently boasts over 6000 members. Over the next 20 years the Wing became a major force in the movement to raise the quality of the audio product available to consumers and to promote the use and standardization of high-resolution audio in the creative audio process.

In 2005, George Massenburg and other preeminent recording engineers formed the Music Engineering and Technology Alliance (META) to promote the highest standards of sound quality in both recordings and playback. Co-founder Frank Fillipetti noted at their first press conference:

> *"The highest quality audio to have ever been produced for mass consumption s currently available to all music lovers, and yet most channels of current delivery fall well short of what's possible. We intend to change that. We are trying to bring back to listeners the unbridled passion that comes from listening to a beautifully recorded work played back on a high quality sound system."*

However, the future of high definition consumer audio remained in doubt despite the fact that so many leading producers and engineers were choosing to create studio master recordings using increasing sample rates and bit depths, insisting that these do make a difference.

High Resolution downloads became available between 2008 and 2012, along with new high-resolution optical disc formats such as Pure Audio Blu-ray and High Fidelity Pure Audio. Consumers clamored for portable high resolution delivery systems and in 2012 musician Neil Young proposed to rescue music from mediocre quality portable music players with his high resolution Pono player.

The Pono audio system would deliver music as it first sounded in the studio with 24 bit,192 kHz audio instead of compressed files. The success of Pono's initial crowd-sourced fundraising and its claimed backing from major record labels, validated a powerful rising

tide of consumer interest in high definition audio, even though Pono itself would quickly fail as a commercial venture.

Pono's claim of superior reproduction was not enough to assure its success given a consumer climate that favored moving to smartphones and music streaming. There was also the usual chorus of critics. Some questioned whether the high-resolution files were really the key to improved audio quality and they proposed that other less radical methods could better contribute to the needed improvements. Others said that the most of the public clearly couldn't hear the difference and that past experience showed that barely anyone would be willing to pay for high-quality digital audio. Many articles concluded with brutal put-downs such as *"it's highly unlikely you could hear the difference" and "Pono offers you a feature that you can't actually perceive."*

Neve, Massenburg and others would cringe at this concept of audio that basically boiled down to "less than the best is certainly good enough." Fortunately, the alliance of producers, engineers, major record labels and industry behemoths, such as Sony, would continue to demand delivery formats capable of bringing studio master quality to consumers. High Resolution Audio would live on to fight another day.

In 2014, the Digital Entertainment Group, the Consumer Electronics Association, and the Producers & Engineers Wing of the Recording Academy came together, along with record labels to formulate a branding definition of high resolution audio as *"lossless audio capable of reproducing the full spectrum of sound from recordings which have been mastered from better than CD quality music sources which represent what the artists, producers and engineers originally intended."* This branding made it clear that the producers and suppliers of musical content had cast their votes and accepted the groundwork laid in the 1990s. That same year the influential Japan Electronics and Information Technology Industries Association (JEITA) announced a specification and "Hi-Res Audio" logo for consumer audio products.

Music professionals with access to high resolution, first generation material reported clearly audible differences and subjectively better sound compared to CD quality audio, critical skepticism notwithstanding. In 2017-2018 the Producers & Engineers Wing issued its landmark *"Recommendations for Hi-Resolution Music Production,"* a 41-page set of basic technical guidelines and best practices for producers and engineers.

This happened at a time when the technology to handle large files was developing to the point where the vision of those pioneers from the 1990s was becoming feasible at the mass market level. The Recording Academy could report that:

> *"Sales of H-Resolution Audio downloads from companies such as HD Tracks and Pro Studio Masters have become a healthy business with many subscription services focusing on the delivery of higher quality audio, whether CD-quality or true Hi-resolution using MQA. And now, most major record companies require the delivery of hi-res masters because they recognize new opportunities to monetize better sounding music."*

The consumer demand for High Resolution Audio continued to grow but a good number of critics in the technical and scientific community continued to challenge the many music technology professionals who had adopted the ideas that flourished in the 1990s. Many of these critics were now willing to admit that there is a clear, though small, audible difference, especially if the listeners have had some background in critical listening. But even as recently as 2020, a Japanese technical paper re-examined earlier tests and concluded that the ability to distinguish high resolution audio from CD audio was "only slightly better than chance."

A widely quoted AES Paper in 2019, *"High Resolution Audio: A History and Perspective"* by Vicki Melchior examined the continuing debate about whether high resolution audio was audibly superior and what might explain the differences. She adopts a popular view in the scientific community that filtering chains are the most likely contributors to the distinctive sound of digital formats. She reported little scientific evidence to confirm the audibility of ultrasonic frequencies asserting that their role in normal audio listening has been rejected since the late 1990s due to this lack of evidence. Melchior concluded that *"The reasons for greater transparency ascribed to higher sample rates have been debated without consistent evidence."* This seems to be a viewpoint repeatedly expressed by respected professionals in the technically rich Boston audio community for over 20 years.

The high frequency sound components of high resolution audio have been studied extensively in Japan by Oohashi and others for close to 30 years. The so-called "hypersonic effects" on brain activity have been observed and documented. A 2020 paper by Hiroshi Nittono, a professor of experimental psychology at Osaka University, has been taken by some as further proof that adding frequencies above the human audible range does not produce a better listening experience than standard quality CD audio.

The paper's title *"High-frequency Sound Components of High-resolution Audio Are Not Detected in Auditory Sensory Memory"* sums up his experiments as to whether sounds with high frequency components are processed differently in the auditory cortex than sounds without those components. His conclusion was that *"even if high-resolution audio is superior to the standard format, the difference is apparently not detectable at the cortical level."* Indeed, Nittono comments in his discussion of the results that *"at least for*

people with regular hearing ability, the broad playback bandwidth of high resolution audio does not seem to have an advantage over the traditional standard audio's bandwidth at a conscious level."

Has this question of whether the extended bandwidth of High Resolution Audio results in audibly superior recording and reproduction finally been settled in favor of the naysayers? Nittono himself admits that *"the mechanism of how the brain detects sound differences remains unknown."*

Certainly, audio professionals who share a deep desire to do the best work possible are not willing to write off extended bandwidth and the still to be explained "hypersonic effect." The 2018 Recording Academy Recommendations for Hi-Resolution Music Production Summary stated:

> *"Virtually every person who contributed to the creation of these recommendations has performed detailed listening tests, comparing different equipment, file types, and audio resolutions. Some of our interviewees recorded complete sessions at different resolutions and then compared the sounds between those sessions. Many also upsampled and downsampled sessions to hear how each conversion effected the resulting sound quality. In the end, everyone felt that hi- resolution audio most accurately reflected what they heard in the studio, whether recording, mixing or mastering… Recording hi-resolution audio makes a difference for anyone recording, producing or listening to music. It raises the bar. We're on the verge of advancement - a new era of excitement about music and the way it sounds "*

The history of audio technology in the 20th Century teaches us to accept the pronouncements of the academic and scientific establishment, and even the accepted wisdom of of the manufacturers they design for, with a healthy dose of skepticism. Time and time again the engine of technological change has been driven by the content creators- the musicians and their producers and engineers who heard what others could not hear, who experienced what others overlooked or dismissed, who sought an emotional connection and level of perfection in their art that those with more conventional vision could not fully understand. In this they have reflected the extraordinary role of music in our lives and its unique place in the design of things which drove them to seek new means of expression that challenged conventional boundaries, technologies, and established ideas about how we perceive, compose and create.

These individuals have always found an audience who responded to their vision and that has led to new musical forms, new technologies and ever higher levels of fidelity.

It goes without saying that in many cases, this audience became obsessively devoted to spending vast sums of money in a never-ending quest for the status and rewards of sound systems that bequeathed to their owners the dubious satisfaction of outdoing their peers. But even amidst the worst excesses of competitive golden-ear audio, sincere lovers of the art unearthed new and very real performance parameters which eventually could be understood, measured and incorporated into designs that brought us ever closer to the complex beauty of the live musical experience.

And so, from Stuart Hegeman to Neve, Massenburg and the other visionaries of the 1990s, the sixty-year quest to give musicians and engineers the best tools to bring forth their art in the fullest beauty and power continues. Ignoring the skeptics who have dismissed their ideas of an expanded concept of human auditory perception, these pioneers continue to delight both creators and consumers with equipment that brings us ever closer to that most elevated and meaningful form of communication. Just as it was sixty years ago, the proof is in the pudding. The equipment they design is, in a word, incomparable, and the reception these designs receive validates the thoughts, intentions and design philosophies that underlie the remarkable performance of the final products.

George Massenburg wrote in 1992, *"The physical universe is exceedingly detailed. Ornate beyond comprehension - infinite - and almost never thought to be bounded at larger than molecular proportions… sound in nature is both subtle and eloquent." He looked forward to audio systems that "exemplify the purest form of high resolution technology, systems whose performance will serve to benchmark and calibrate our hearing and thinking for generations to come."*

Sadly, in our time, too many ears have been calibrated to sound that is very far from the eloquence of nature. One could use dozens of adjectives to describe what so many have become accustomed to. All too often that list does NOT include "lifelike," "natural," or "musical." In a 1993 NY Times article *"Music Takes A Back Seat,"* music writer Edward Rothstein described the sound as *"embalmed."* He feared that digital formats would *"codify an artificial and astringent sonic style"* and he worried that *"if listeners became too used to the embalmed quality of these innovations, eventually even concert halls and instruments will suffer."*

To some degree we see this prophecy fulfilled in what one producer described as "the Bad Sound we usually get now: it's loud, it's sort of crunchy and it's sort of dirty. Initially it's sort of exciting but you just know it's a sound that will wear thin very quickly." Flat, two-dimensional, lifeless, and unsettling are a few other adjectives frequently used to describe that sound.

Rupert Neve: Life Beyond Measurement

Science fiction writer Arthur C. Clark wrote that *"any sufficiently advanced technology is indistinguishable from magic."* Rupert Neve understood so well that whereas *"to measure is to know,"* there is indeed life beyond measurement. He understood that in our world of technology, artists, especially musicians, are purveyors of the things unseen. His technology was a means to bring the fullness of those realities - the subtle eloquence of sound - to listeners. Many an engineer, recording and mixing on a Rupert Neve designed console, has sensed the "magic" in his designs.

Rupert Neve and the others mentioned did not just seek to design products that were commercially successful. Rather they hoped to elevate our respect for the extraordinary gift of perception that allows us to fully experience the beauty and power of music. They understood how our perceptual systems can take the most microscopic bits of auditory information and build on them to create an experience that at best is transcendent, moving our minds and bodies in ways that surpass data, logic and reason. When fully realized, this experience brings us into harmony with each other, our environment and for those who choose to believe, our Creator, the author of beauty.

That extraordinary listening experience is something that those of us who share the sheer love of sound and music, are familiar with. It informs us that in all the chaos of unwanted noise and distortion, deep inside there is the stuff we want - the stuff that isn't dryly and clinically perfect - the stuff that is living and full in a way that makes the experience organically realistic and emotionally satisfying. It is the stuff that creates context, harmony and pure pleasure even though at first it may be recognized only subliminally. And yes, some of it lives beyond 20-20 kHz and under the so-called "noise floor."

An expanded concept of human auditory perception will eventually be sorted out and fully validated. Rupert Neve spent a lifetime doing the hard work of understanding these experiences. He knew that we have not yet perfected the means of measuring every parameter that contributes to sound quality. He realized "there is abundant evidence which suggests there is a great deal we don't yet understand." Nonetheless, he was determined to be fulfill his creative mission:

> *"Capturing recording and reproducing sound is not merely a matter of devouring equipment specifications. We have to know and understand the technology we are harnessing and be skillful in its use. But far more important is the vision for what we want to do and the perspective we bring to the feast, which frees the creator in us to produce a sound of beauty which is a joy forever."*

He never stopped listening. He never stopped learning. He never rested on past laurels. He never failed to listen to and respect the opinions of the musicians, producers and engineers that he served. Countless creators, engineers and consumers have reaped the

benefits of his lifelong quest. Rupert Neve's 1998 philosophical comment about equipment design bears repeating:

> *"One must do the best one can. Philosophically, people need to keep in mind why they do what they do. We are all creative people… As a designer I simply do the best that I can, the best my Creator enabled me to do, and then hand it on to you guys and say 'now it is up to you to do something really positive with this beautiful piece of equipment.'"*

V.
In their Own Words

Quotations from Rupert Neve and other leading equipment designers which illuminate their design philosophies and the expanded concepts of human auditory perception.

STEWART HEGEMAN (1961)

"My experience in audio has taught me that the fullest, most natural sound demands appreciable power not only within the generally accepted limits of 20 to 20,000 cycles, but below and above these frequencies… in the 10 to 20-cycle region and in the 30,000 to 40,000-cycle area of frequency response.

Extensive tests with amplifiers of different high frequency cutoff points showed that the greater the undistorted bandwidth, the better the sound. The widest response always sounded best. There was greater instrumental separation and clarity, more air around the sound, more spaciousness in the tone. The interesting things here is that the average listen can perceive these effects even though his hearing of individual tones may fall rapidly above a given point. A person may not be able to hear specific tones but still be aware of their absence or presence as part of a total listening experience. It seems clear that when you step from pure test tones to the realm of music, people can hear more then they think they can."

GEORGE MASSENBURG (1997)

"...lastly I would like to point out that the future will undoubtedly bring a widened view of the audible band."

"Based on my experience, digital recordings do not sound the same as analog. Part of it has to do with the extraordinary high excess response of the analog chain; we have (or

had) analog consoles that are flat out to 200 kHz. James Boyk [LA-based piano artist, writer and teacher at Cal Tech] has shown frequency response plots of a harmonic series of trumpets with Harmon mutes that show really extended frequency response. We know that violins have excess high-frequency response; we know we can't record violin to the point where it can fool us - we can almost always tell the real from the recorded violin. Whether it's frequency response or phase coherency or minimizing the time-granularity, we don't know.

And I've been looking at it a little differently. Hearing data is processed so differently from visual data - a large portion of the cortex is allocated to image processing/visual data, and a rather smaller part is for processing perceived sounds. It's possible from what I've

read that we may process what we hear a little differently than what we see. The subconscious or unconscious may come into play. We may process sounds other than with a direct, immediate response to, say, "Yes, I hear an 18 kHz sine wave."

We have timing cues that allow us to identify and separate images in space that let us determine where a sound is located in a room, for example. And these cues have very fine gradations - perhaps far finer than the approximately 20 microseconds available in current digital conversion techniques. Maybe we need finer resolutions - maybe down to 5 microseconds, maybe further. I can't really find any hard research numbers on this.
What I need to do is make recordings and have them be a part of my life for a time. It's the texture-lace-filigree delicacy of a performance, ambiguities in playback - that, over time, will fill in a sound picture. But, so far, [with digital at CD sampling rates], I cannot achieve that integration of music into my life the way I used to with my favorite records. Audio has sunk to a great low with the takeover of the CD. We came from a great, warm and safe medium that made us want to go home and put on a record; I don't love to put on CDs. With the CD, another style of recording has emerged. It's extremely clear and dimensionless, but it doesn't have any depth. I'm looking for a step forward in resolution. I respectfully submit that we need a very much better mastering format. Ninety-six kHz may not even be high enough! I just know that it's got to be better… It's not black magic anymore… Maybe we'll look at 192 kHz rates, and then five years from now, when somebody wants to release this on one of the new enhanced DVD formats, we'll have a master recording that can do justice to future listeners."

"If engineering is the science of compromise, then the art of engineering is the search for increasingly subtle factors that further the ostensible state of the art." (1992)

DAVID BLACKMER:

Question: Why do you make microphones that exceed 20kHz?

"Earthworks does not make microphones that go up to 50 kHz because of a belief that you can hear tones at these frequencies. Due to research conducted over a long period of time, it has been determined that sound in an echoic environment has multiple pressure waves which converge on the listener nearly simultaneously. Its these wave fronts, which may only have a low kHz center frequency and bandwidth, but when they are spaced very closely in time, the human ear is sensitive to time relationships between the wavefront arrival times down to a resolution of around 20 microseconds. This time relationship corresponds to a frequency of 50 kHz. It's not the pure tonal sounds you look for with a 50 kHz microphone, it's an accurate representation of the space the sounds you are capturing occurred in. This will result in a vastly improved, more true to life sound than traditional 20 kHz band limited microphones. You really have to hear it to believe it.

We believe there is more to human hearing than the range of frequencies which can be heard as tones. Most sound recordings don't live up to the sonic experience of being there with the live music. We are convinced that audio equipment with extended frequency response and faster, cleaner time-domain performance will yield more life-like results than the slower more colored equipment of yesteryear.

The time resolution of human hearing is 10 microseconds or better. This corresponds to frequencies beyond 80kHz. Most microphones smear frequencies in relation to time to such a degree that the time relationships which existed in the air are audibly degraded. When you choose a microphone, you get its time domain imprint on the track. Mics with poor time resolution will distort the signal beyond any practical recovery of the original."

J. ROBERT STUART as interviewed by Robert Harley in The Absolute Sound (2009)

Question: The Audio Engineering Society tends to reject the individual listening experience and the high end often relies on less-than rigorous science… that brings to mind a conversation we had about why blind listening tests may not be reliable. You said that when exposed to sound, our brain builds a model over time of what's creating that sound. The rapid switching in blind testing doesn't allow that natural process to occur…

"That's right. Perception happens on lots of different time scales. There's something called the conscious present, which is a period of time over which some of this integration into

an object would happen. If you were dropped into a concert hall, how long would it take you to really understand what it is you're hearing? It can take several seconds, or even minutes before you're listening fully into the space.

Sometimes when you're looking for the difference between A and B, you can hear it quickly. Other times the difference between A and B can come on a time scale of minutes or even longer where you find that you've changed something and you don't notice a change but find that you have a very different connection to the music. But if you are doing quick switching that mechanism gets broken.

The problem with A/B switching, or blind listening tests, is that it doesn't always eliminate things that we find to be important on a lot of time scales. Obviously, you can do blind

listening on long time scales and that's good. I don't tend to do a lot of that, because typically what we're trying to do is work out whether something we're doing has made a difference rather than to prove you can hear it. Listening is so multi-dimensional… What we're looking for is not only that we can hear a difference, but also that it is more musically satisfying. Did it take me closer to the artist? Does it inform me more of what the composer intended? Am I able to tell better what the instruments are?... That's why we inform everything we do not only with psychoacoustics, but with critical listening. You have to listen to everything."

FROM THE RECORDING ACADEMY'S RECOMMENDATIONS FOR HI-RESOLUTION MUSIC PRODUCTION (2018):

"THE REAL DIFFERENCE BETWEEN 44.1/16, 48/24, 96/24, 192/24 AND BEYOND"

Is there a truly noticeable difference between MP3s and 192/24 files? Absolutely, but everyone owes it to themselves to listen and compare. In most cases the differences between CD-quality and 192/24 are at least noticeable, and frequently, they are stark. Skillfully mixed and mastered music with a wide dynamic range benefits dramatically from a hi-res workflow. For recordings such as symphonic film scores, classical music or other recordings that feature acoustic instruments, hi-res audio is a perfect fit - the increased audio quality can be appreciated by virtually anyone who hears it. In the experience of this committee and the audio professionals we interviewed (including numerous rock, pop and urban producers and engineers whose work is aggressive and powerful), recording, mixing and mastering at resolutions 96/24 or better results in a final product that is both sonicallyy superior and faithful to the sound of the final mastered mix."

MR. RUPERT NEVE:

Question: So someone could hear the effect of a 3dB boost at 54 kHz? I would imagine that gave you some food for thought…? (1998)

"This gets back to my original point that the educated ear will hear it, even if it is out of band. This is the thing Geoff Emerick did years ago... the danger is that if you are not sensitive to people like Geoff Emerick, and you don't respect them for what they have done, then you are not going to listen to them… Geoff finally managed to show me what it was that he could hear, and then I began to hear it, too… He was perceiving something that I wasn't looking for. And it wasn't until I had spent some time with him, as it were, being led by him through the sounds, that I began to pick up what he was listening to. And once I'd heard it, oh yes, then I knew what he was talking about…

I found that I could do new circuitry, with a much wider bandwidth, relatively easily. So I redesigned all my transformers and output circuitry and the general electronics… The danger here is that the more qualified you are, the more you 'know' that something can't be done so you don't try it. Ignorant idiots like me don't know it can't be done, so we have a go and it works. I am not academically qualified. I am what I call QBE- that's my degree- 'Qualified by Experience.'

What is more important to an audio person is that you understand what you are listening to and listening for. You may be listening to a particular type of sound and you're listening for the artifacts that characterize that sound. So you are much better educated. The more you listen, the more you become aware of things and the easier it becomes to do."

"One final point, I have never been able to give a quick A/B assessment in paired comparison tests. I find that 'straining' to hear something is counter-productive. I like to leave something playing in the background while I do something else and after a while something starts to irritate me and I have to find out what it is." (1992)

Question: What are your thoughts on 24 bit, 96 kHz digital technology? (1998)

"Well, the number of bits is OK, but the sampling rate isn't. It has to go twice that. We have to do 192 kHz because we need a reliable audio frequency range, free of distortion and noise, up to about 75 kHz. I can't prove that, but there's a lot of evidence from people who have done a lot of listening and we think that if we could get a really good pass band up to about 75 kHz we would lose absolutely nothing from the state of the art as we know it. Sampling at 96 kHz would give barely a 50 kHz pass band which is not quite enough - the resolution in the time domain is still not quite what it should be."

Rupert Neve: Life Beyond Measurement

"Having said that, there are systems coming along now which do give us the frequency response, quite adequate dynamic range, and actual harmonic distortion. The interesting thing is if you start with sound quality which is very good, that will reflect right through the digital system, you can hear it, even through radio transmission." (2001)

"There is evidence that the presence of incredibly small quantities of the 'wanted' signal (e.g. the true harmonics of musical instruments) enhance the listening experience whilst incredibly small quantities of unwanted signals (noise, high order harmonic distortion, non-harmonic switching 'splat' or clicks) have the opposite effect - producing a puzzled and tired brain response that is trying to relate this unnatural sound to its built-in data bank of real sound acquired from the natural world around us." (1999)

A NOTE ON DISTORTION - From the Portico 5017 Operations Guide (2010):

"The human hearing system is a remarkably complex mechanism and we seem to be learning more details about its workings all the time. For example, Oohashi demonstrated that arbitrarily filtering out ultrasonic information that is generally considered above our hearing range had a measurable effect on listener's electroencephalograms. Kunchur [2008] describes several demonstrations that have shown that our hearing is capable of approximately twice the timing resolution that our limit of 20 kHz might imply (F=1/T or T=1/F). His peer reviewed papers demonstrated that we can hear timing resolution at approximately with 5 microsecond resolution (20 kHz implies a 9 microsecond temporal resolution, while a CD at 44.1k sample rate has a best-case temporal resolution of 23 microseconds).

It is also well understood that we can perceive steady tones even when buried under 20 to 30 dB of noise. And we know that most gain stages exhibit rising distortion at higher frequencies, including more IM distortion. One common IM test is to mix 19 kHz and 20 kHz sine waves, send through a device and then measure how much 1 kHz is generated (20-19=1). All this hints at the importance of maintaining a sufficient bandwidth with minimal phase shift, while at the same time minimizing high frequency artifacts and distortion. All of the above and our experience listening and designing suggest that there are many subtle aspects to hearing that are beyond the realm of simple traditional measurement characterizations…

In a traditional console, large bi-polar regulated supplies were used, necessarily having a shared common 0 'ground' wire. Crosstalk between modules resulted, often accompanied by R.F. interference due to the unbalanced loop 'antennas' that were inevitably present.

This interference, in some cases, could actually be heard but even at low levels below audibility there was a potential intermodulation with the desired signal. Of course, this represented both a quantitative and subjective intrusion affecting sound quality…

One needs to be very careful when one hears traces of distortion prior to re-cording because some flavors of distortion that might seem acceptable (or even stylish) initially, may later prove to cause irreparable damage to parts of the sound (for example, 'warm lows' but 'harsh sibilance') or in louder or quieter sections of the recording... beware that usually deviations from linearity carry at least as much long-term penalty as initial appeal, and that one should always be listening critically when recording and generally 'playing it safe' when introduc-ing effects that cannot be removed."

FROM THE 9098i PRODUCT REFERENCE (1999):

"A photograph taken on a cheap disposable camera can never be enhanced to produce high quality artwork. In the same way, the audio quality at the beginning of the chain determines the final result…

The way in which an analog amplifier handles very small signals is as important as the way it behaves at high levels… Signal levels of -60 dBu need to be treated more kindly than high level signals, with more attention to noise and distortion performance. Yet it is this crucial area of input stage design that many con-soles let themselves and their users down.

It is noteworthy that most equipment manufacturers quote distortion figures at maximum output levels, the implication being that if a device is able to exhibit low percentage THD when working hard, it must be 'even better' at low levels. This is a fallacy. All amplifier stages, no matter how expensive the active devices, or carefully designed circuitry, exhibit some non-linearity. Class A, the classical linear amplification mode, has traditionally been employed to obtain the lowest possible distortion... providing transparency and realism…

The fine subtleties of circuit design relating to sonic performance are gradually becoming more clearly understood. For example, research has shown that frequencies above 20 kHz affect the way in which humans perceive sound quality. But long before such scientific evidence emerged, a substantial body of musicians and engineers knew that equipment with apparently the same technical specifications nevertheless sounded different

Obviously, there must have been parameters which were not being measured - or were considered to be unimportant. For example, a figure of 0.1% harmonic distortion was

thought to imply excellence, or at least 'as good as you can get' but without qualifying the harmonic order of distortion such a figure cannot identify the sonic quality. Very small amounts of high order distortion producing musically dissonant odd harmonics have a disastrous effect on the sound quality whereas if the 0.1% is all composed of second harmonic it will be totally inaudible.

Odd order harmonics above the 3rd, i.e. 5th, 7th, etc must be reduced by more than fifty times below the old '0.1%' standardization. The crossover point needs very careful attention from the designer. Very small discontinuities or imperfections in the crossover result in disastrous high order harmonics Blind listening tests have repeatedly shown that permitting the bandwidth of the audio chain to extend way beyond the audible spectrum [to 200 kHz (-3dB) in the 9098i] maintains a sense of transparency and realism that is absent in band-limited systems. Although we are unable to directly hear these upper harmonics that are indubitably produced by almost all natural instruments, they nevertheless have an effect on that part of the spectrum which we can hear. The 9098i ensures that these harmonics are maintained not only in their correct amplitude but also in their correct phase relationships with other components."

STATEMENT FROM RUPERT NEVE DESIGNS:

"The sound of a specific piece of gear is much more than just the schematic, or the individual components used. Rupert understood this better than anyone, and spent a vast amount of time listening to his equipment - not just measuring it - to ensure that every element of the design worked in harmony to create the most lifelike sonic reproduction possible" (2021)

SOME CONCLUDING WORDS FROM RUPERT NEVE REGARDING THE IMPORTANCE OF LISTENING:

"What is happening now is that we have some pretty wonderful designers around who are also prepared to listen. The trouble with a lot of designers, you know, is that they don't listen. They think their math books will give them all the answers. You do absolutely need to listen, and to be prepared to listen to what other people are saying, too. And then you will be able to come up with some really first class designs." (1998)

"I'm reflecting on what we're really looking for: satisfaction in a listening experience. To attain satisfaction, part of the process is to discard the noise! Beneath that noise there may be stuff that we are only recognizing subliminally... deep down, embedded in the discord, is the stuff we want. It just has to be sorted out, which is often hard work.

Having a frequency response way out there to dog-land means more bandwidth and, therefore, more noise. It opens the window to more of those minuscule high order harmonics and switching 'splats' generated by all but the best equipment. Is it important? Yes, it is, because it also opens the window to those minuscule music harmonics which are a true part of music." (1998)

"But you've got more than a generation of people who've grown up with compact discs and do not know what real sound is like. They don't go to concerts. So, they have no basis of comparison. They've grown up with digital and so digital sounds okay. But the resolution just isn't there. You cannot get proper separation from a stereo channel, digital just won't do it. Just try and envision what happens with a 10 kHz wave form with some harmonics in it - you can't resolve anything above the second harmonic anyway, and now if you slip that between two channels what's it going to tell you? Nothing. There is no separation. So, the limitations of the current systems are well known but they represent a quantum step forward in usability compared with the LP, the cartridge and the messy noisy disc.

There have been recent tests on frequency response well in excess of the audio path. They show the brain actually reacts against the restriction of frequency response with the electromagnetic brain-waves that are associated with frustration and anger if it doesn't get the frequency response associated with the signal it's supposed to hear. Now it doesn't happen with everybody because it's working against a data bank. If you have a stored data bank of knowledge of what a concert in the best hall sounds like, you're comparing it. Your decoding mechanism is taking care of that and it is saying it is not the real thing, it's got stuff missing. Now you couldn't listen, then sit down and write, "I think that the frequency response is 3 dB down at 35 kHz," but the brain actually knows that and compares against the data bank of experience. It simply reacts, knowing it isn't right, it doesn't fit." (2001)

"Inevitably, our data bank of 'natural' sound is built up on the basis of our personal experience and this must surely emphasize the importance of listening to 'natural' sound, and high-quality musical instruments within acoustic environments that are subjectively pleasing so as develop keen awareness that will contribute to a reliable data bank. Humans who have not experienced enough 'natural' sound may well have a flawed data bank! Quality recording equipment should be capable of retaining 'natural' sound and this is indeed the traditional measuring stick. And 'creative' musical equipment should provide the tools to manipulate the sound to enhance the emotional appeal of the music without destroying it. Memory and knowledge of real acoustic and musical events may be the biggest tool and advantage any recording engineer may possess..." (2011)

Rupert Neve: Life Beyond Measurement

"We've got frequency response, which is sometimes regarded as not that important, but a 1/10 of a dB deviation in frequency response in the 20 Hz-20 kHz range can make a very subtle difference to the sound. We have to make sure that it's either dead flat (quite beyond those limits) or we have to know why it's not flat. You take most present-day equipment and they don't work to those limits. They say it's flat, yes flat within a dB, even half a dB, sometimes better, but when you really get down to it those little differences - the golden eared people can hear it - they might not know that it's a frequency response but they know that it's different. They either like it or don't like it. The greatest satisfaction that I get is when I have a new piece of equipment and somebody who really knows, a really golden eared person, is playing with it. Occasionally it happens. You find that the EQ, which might have a range of +/-18 dB, and he's moving it just a fraction off flat. I've had this happen, I suppose, three times. Once, way back at AIR Studios with Geoff Emerick, I was doing just that, checking out the EQ. Other people had already checked it out and they were winding controls back and forth saying,"Oh listen to that, listen to that bass", but Geoff had everything flat, then started moving just a tiny fraction and he'd say, 'Ohhh, would you listen to that!'" (2001)

"The infinite search for perfection is life's greatest privilege."
Rupert Neve (1995)