The staff of *HR* would like to welcome Marshall Chasin, AuD, as a regular columnist on our pages. Not that he wasn't before; Dr Chasin has written for this magazine since the early 1990s and is greatly valued for both his articles and his guidance as part of the *HR* Editorial Advisory Board. In his new "Back to Basics" column, he will explore a broad body of literature and knowledge related to acoustics, hearing aid fittings, hearing conservation, music, and much more.

—Karl Strom, HR Editor-in-chief

Did We Throw Out the Baby with the Bathwater? The Limitations and Benefits of Flared Tubing

BY MARSHALL CHASIN, AuD

The science of flared or belled tubing is something many of us were more aware of in the 1980s than we are today. In the 1980s, with the limitations of the Class A amplifier stages commonly used in the hearing aid industry, whenever possible, it was always better to amplify the higher frequencies acoustically than electronically. This was directly related to the high distortion with Class A amplifiers with more intense (and high frequency) signals.

While this is no longer a concern with the ubiquitous use of the cleaner sounding Class D output stage that now has been in use for about a quarter of a century, there *were* some other benefits of a flared or belled tubing; we may have thrown the baby out with the bathwater. And, with the advent of slim-tube hearing aids (with the receiver in the hearing aid), the Libby horn which flared from an inner diameter (ID) of 2 mm to 3 or 4 mm, is no longer widely used as well.

Marshall Chasin, AuD, is an audiologist and director of research at the Musicians' Clinics of Canada, Toronto. He has authored five books, including *Hearing Loss in Musicians, The CIC Handbook,* and *Noise Control—A Primer*, and serves on the editorial advisory board of *HR*. Dr Chasin has guest-edited two special editions of *HR* on music and hearing loss (March 2006 and February 2009), the latter with Larry Revit, as well as a special edition on hearing conservation (March 2008) with Lee Hager. He has been presented several awards over the years including the 2003 Professional Leadership Award for clinical and research work with musicians and performing artists from the Audiology Foundation of America, the Eve Kassirer Award for outstanding professional achievement from CASLPA in 1991, the Honours of the Association from OSLA in 1999, the 2012 Queen Elizabeth II Diamond Jubilee Medal, and the 2013 Jos Millar Shield from the British Society of Audiology.

However let's return to the scientific basis of the Libby horn or any flared length of tubing. There are two equations governing their acoustic behavior, and these are the same two equations we can use in speech acoustics, musical acoustics, or the design of loud speaker systems.

1) $F = v/2L$, where v is the speed of sound (340,000 mm/sec)
2) Amplification factor = 20 log (inner diameter [ID] of wider portion/ID of narrower portion)

The first equation ($F=v/2L$) tells us at which frequency a flare/horn will begin to have its effect, and the second equation (amplification factor) tells us the maximum amount of improvement (increase) in transmission in dB.

Equation #1 says that the increase in gain and output will not be realized until the higher frequency region. Specifically, for a 75 mm length of tubing—still found in modern behind the ear hearing aids—a flare will begin to have its effect at 2266 Hz (or F = 340,000 mm/sec / [2 x 75 mm]), and the acoustic amplification effect will gradually increase with frequency. For shorter-eared individuals, such as small children (a shorter L), the effect may not be seen until closer to 3000 Hz.

> Using flared tubing allows our clients to have sufficient gain and sufficient output (for that gain) almost free of charge and may also allow them to continue on with their current amplification.

Equation #2 tells us how much of a benefit we can obtain. In the case of the 4 mm Libby horn that flared from ID of 2 mm to 4 mm, we have 20 log 2, which is 6 dB. That is, for a doubling from 2 mm ID to 4 mm ID, we can obtain up to 6 dB of "free amplification."

Notice that we can obtain this benefit for *any* doubling and this includes from 1 mm ID to 2 mm ID tubing. This is the same formula that speech scientists use to determine how much we can increase our vocal intensity when we open our mouths wider, or musical instrument designers use to determine how large the trumpet flare should be.

Some of the benefits that can still be recognized with a flared tubing (even for slim tube fittings) is an additional 6 dB of increase for both the gain and the output for sounds above about 2200 Hz. Using an acoustic flare will improve battery life since the amplification occurs *after* the hearing aid circuitry.

Another benefit is that *both* the hearing aid gain and the hearing aid output will be increased by the flare. This is a much more desirable situation than if we simply turned up the high frequency gain using software. It may be that our clients require more high frequency gain and output than their hearing aid can provide. Using flared tubing allows our clients to have sufficient gain and sufficient output (for that gain) almost free of charge and may also allow them to continue on with their current amplification.

This can be accomplished by trimming off the last 20-22 mm of the slim tube and gluing on a piece of #13 tubing (which has an ID of about 2 mm). I typically use a receiver-in-the-ear tip which fits snuggly over the piece of #13 tubing.

This sounds "low tech," and indeed it is—but there is still a place for basic acoustic science in our modern day hearing aid fittings!

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