AUDIO UPDATE

Progress in hi-fi hearing-aid design.

LARRY KLEIN,
AUDIO EDITOR

IT IS AN UNFORTUNATE FACT OF LIFE that weaknesses and disabilities begin to appear and multiply as we get older. Or as someone once said, "Time marches on—and leaves its heelprints on our bodies." Particularly troubling to those of us involved, professionally or otherwise, in audio pursuits is the gradual impairment of our hearing. In general, it takes three main forms: (1) an overall loss of sensitivity, which means that most sounds have to be louder to be heard at a satisfactory level, (2) a loss of relative high-frequency sensitivity, and (3) a loss of dynamic range, which audiologists refer to as "recruitment." (A persistent ringing in the ears called tinnitus is also a major hearing problem, but the present state of our knowledge and technology doesn't seem to offer much hope to its sufferers.)

As we get older, we frequently have problems in all three areas. For example, if you need to have the sound of your bedroom TV turned up slightly higher than your wife's preferred setting, then problem (1) is at work. If records or tapes that once bothered you because they had too much background hiss sound relatively hiss-free these days, problem (2) is the probable cause. (Assuming, that is, that you haven't upgraded to quieter audio equipment.) An early warning of problem (3) is an increased sensitivity to—and annoyance with—loud noises produced by motorcycles, lawnmowers, subway screeching, politicians, and so forth. Its proverbial manifestation is the old lady who demands that you speak up because she can't hear you—and then complains that you are shouting at her when you do.

Obviously, the main emphasis in hearing-aid design has always been to restore or enhance speech intelligibility. That is certainly a laudable goal, but anyone with a hearing loss who was interested in listening to music through an aid was inevitably left frustrated by distortions in the input and output transducers and inadequacies in signal bandwidth, noise, overload, and so forth.

Hi-fi hearing aid

With that once-over-lightly discussion as background, let's look at a hi-fi hearing-aid design approach used by the Swiss authors of a recent Audio Engineering Society paper ("High Fidelity Multiband Hearing Aid," Preprint 2793 B-4).

Oddly enough, the authors list as their first design objective the widening of frequency bandwidth downward to around 40 Hz. That strikes me as strange given the relative lack of music fundamentals down there and the fact that few people complain about—or are even aware of—the almost universal lack of 40-Hz capabilities in their home speaker systems. The author's choice of low-end cutoff frequency may have been influenced by the fact that their test subject for the aid design was a professional violoncello player.

The next step involved evaluating the "equal-loudness contours" of the potential hearing-aid user. In other words, at each level, how much gain had to be applied to equivalent strength frequencies for each to be heard as equivalently loud? When you think about it, it becomes obvious that the key to enhancing the audio quality of a hearing aid is to tailor its response to the specific needs of the user. Merely adding amplification as was done in the earliest aids simply results in ear overload at some frequencies and inadequate boost at others.

Today's conventional aids are all frequency-contoured to conform to the user's specific needs, but the hi-fi aid designers went a step further: They split the right- and left-ear channels each into three bands (40–400 Hz, 400 Hz–4 kHz, 4–8 kHz), each band having its own adjustable compression ratios and levels. The compression ratios can be adjusted from 1:1 (no compression) to 4:1 for each of the six bands. In addition, each channel has its own external Baxandall bass and treble tone controls and level controls to allow user adjustment of the aid's response within the basic parameters set by the internal calibrations.

Standard miniature input and output transducers were, of course, not up to the requirements of the hi-fi aid. The authors chose a somewhat bulky electrodynamic omnidirectional microphone (which feeds both channels) over the smaller, but noisier, electret type. Conventional sealed electrodynamic headphones intended for high-quality Walkman use served nicely as output transducers. Since, according to its picture, the prototype hi-fi aid and its phones

could easily be mistaken for a Walkman, I expect that anyone wearing it to a live event will receive some strange glances from other concertgoers.

The digital future

As might be supposed, digital redesign is high on the agenda for hearing-aid design. In general, digitalization offers little for low-gain, straight-forward aids meant to correct minor hearing deficits. But when the demands are for multiple wide bandwidth, compressible channels, and simplified, but precise, tailoring to the specific needs of the user, then digital comes into its own. Although there was no attempt to incorporate digital circuitry in the hi-fi aid, the designers stated strongly that digital technology should ultimately be introduced into the equalization and compression stages. Altering the parameters of their existing prototype analog aid is a laborious and delicate task that digitalization will vastly simplify.

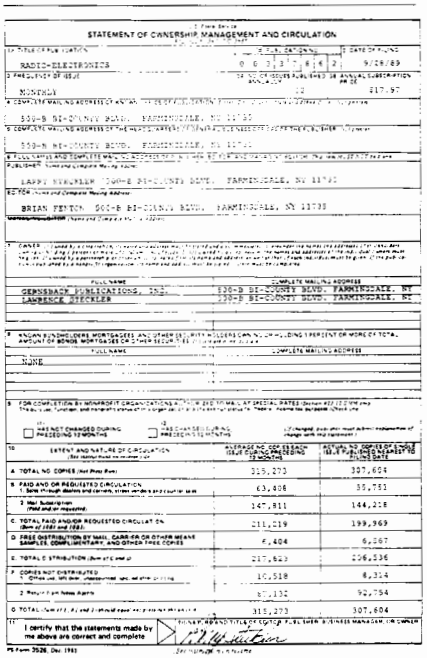
At least one U.S. company (Maico Hearing Instruments 612/832-4400) makes a "digital hybrid" aid whose parameters are programmable over a wide range. The manufacturer claims the availability of a million and a half settings, any of which can be stored by a built-in digital memory programmed by an external computer. That enables fairly rapid and precise conformation to the hearing needs of the user—and simplified readjustment as those needs change over time. Another U.S. company (Nicolet Instruments 800/843-1055) is the first company to have available a fully digital unit, but details were not available at press time.

It seems safe to say that in the next year or two we should see the introduction of a variety of fully digital aids. That implies that there's an A/D converter after the input microphone and fully digital signal processing from that point on. For those who can afford such devices—and I expect them to be very expensive—the sound that they deliver will be a cut above what is presently available. But no one ever said that good hi-fi equipment comes cheap!

System imbalance

Q. After a long struggle to find the reason for my having to operate the balance control on my preamplifier at the 3-o'clock position, I traced the difficulty to my speakers rather than my amplifier or preamp. It turned out that a readjustment of the midrange control on one of my speakers cured the problem. What would account for that?

A. The frequencies that contribute to the ear's perception of "loudness" are mostly in the midrange. (You can confirm that for yourself by noting the small effect on the overall loudness of music produced by boosting or cutting the highs and lows with the outermost sliders of a ten-band graphic equalizer.) Hence, any control intended to boost or cut the mid-frequencies in a speaker system will also necessarily influence its relative "efficiency." **R-E**



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