

Recent Earmolds for Wideband OTE and ITE Hearing Aids

By MEAD C. KILLION

My talk today is organized as follows: I will begin with some demonstrations that may make some intuitive sense out of the things that happen with earmolds — for example, why changing the diameter of the last part of the sound channel will have an appreciable effect on the output of the hearing aid. Next, I will talk about earmolds for wideband hearing aids, and will describe a relatively new "6EF" earmold that has some possibility as a "universal" large-bore earmold. Partly as a result of earmold improvements, the hearing aids available today are vastly better than those available ten or twenty years ago. I'll illustrate some of those improvements, and some earmold effects, by playing recorded comparisons* so you can hear for yourself the difference. Then I will describe a new damped coupling assembly for in-the-ear hearing aids, which allows you to easily replace a clogged damper instead of sending the aid back to have a clogged receiver replaced. Finally, I will discuss a few of the pitfalls that you might run into when you start using wideband aids.

EARMOLD ACOUSTICS: SOME BASICS

First, a little bit about earmold acoustics. To begin with I'd like to talk about the acoustic horn. The acoustic horn works well under the special circumstances in which you have a relatively high-impedance source (something that has a lot of force available but does not have much motion), and you are trying to produce a lot of motion in a load that is very soft (low impedance). For example, a tiny hearing aid earphone is a very stiff source, while an ear canal filled with air is a very, very soft load. In this example, we have

an enormous impedance mismatch between the stiff diaphragm that has a very small range of motion, and the soft air in the ear canal. (The impedance difference can be 100:1 or even more!) The way you can obtain more sound under those conditions is to use the acoustic equivalent of the transmission in your car or of the gearshift on a bicycle. The acoustic equivalent of these devices is called a horn. (The best "Killion Horn," a three-foot-long contraption made of many different tubing diameters, was demonstrated: The nearly inaudible output of a tiny Knowles receiver trying to fill a room with sound can be made surprisingly loud simply by adding a properly constructed acoustic horn.)

Therefore, one thing that affects the sound delivered by the hearing aid earphone is the shape and diameter of the sound channel. By properly shaping that diameter you can get horn action. This principle can be used to control the high-frequency response of a hearing aid. I say *high-frequency* response, because there isn't enough length in the coupling system to make a very long horn, and so it is not possible to produce much horn action at low frequencies. But the length of horn we *can* use can have a large effect on the output of the hearing aid above 2 kHz to 3 kHz, with very little effect below 2 kHz (Figure 1).

Another thing that affects the sound is the existence of tubing resonances. In an over-the-ear aid the total length of tubing between receiver and earmold tip is about three inches — long enough so that several resonances are introduced into the frequency response. Figure 2 shows that even with a theoretically perfect (peak-free) receiver, feeding its output through three inches of #13 tubing to a 2-cc coupler can result in 15 dB to 20 dB peaks at those frequencies where tubing resonances occur. For three inches of tubing, these occur at roughly 1 kHz, 3 kHz, 5 kHz, 7 kHz, etc. As you probably can guess, these resonances can get you into trouble. Resonances may be fine in trumpets used for calling the troops, but in hearing aids they can create a

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peaked frequency response, which means an unnatural sound quality and a feedback problem.

However, we now have a solution for tubing resonances in the form of acoustic dampers designed to fit inside the #13 tubing (or inside the earhooks of the hearing aid). There are two things damping can do. One is obvious — to smooth the frequency response, which simply makes the aid sound better. The other, which is perhaps less obvious but can be even more important, is to increase the usable gain for the user of the hearing aid. When there is a prominent peak in the frequency response of a hearing aid, that's where the aid is liable to whistle if you turn up the gain enough.

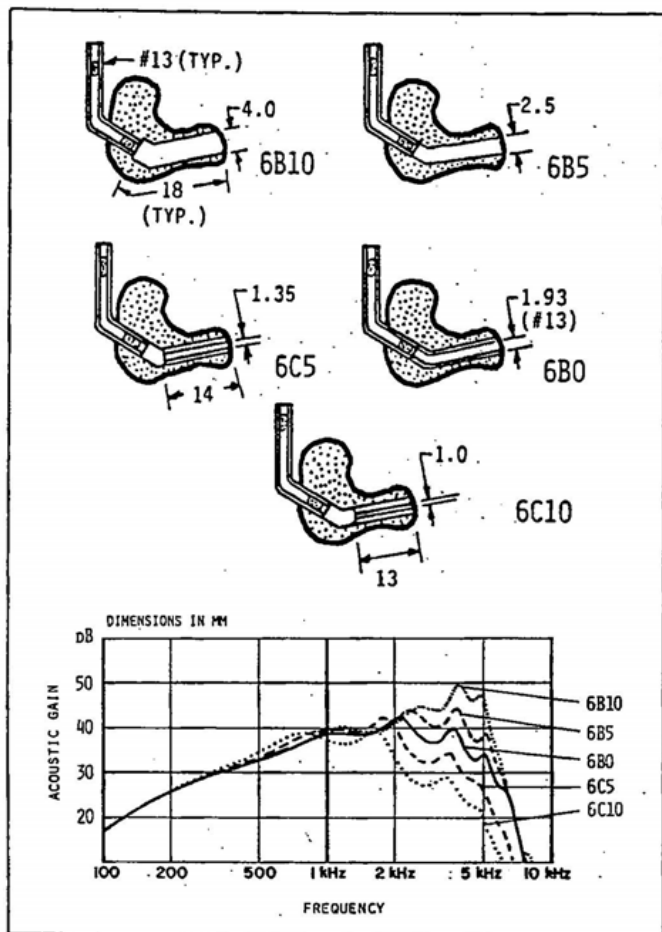


Figure 1. High-frequency response changes using "horn" and "reverse horn" earmolds from the 6BC series (from Killion, 1981a).

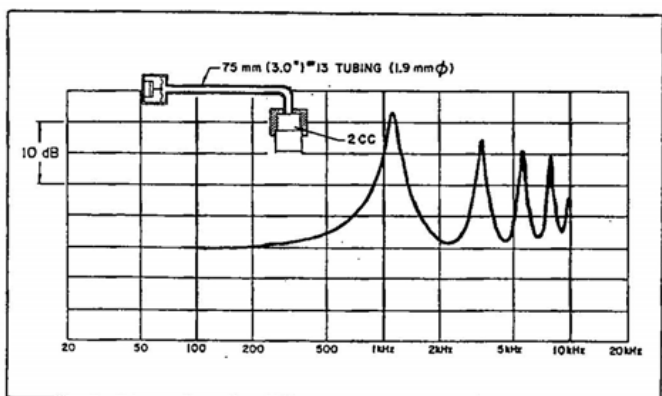


Figure 2. Undamped tubing resonances (from Knowles and Killion, 1978).

Many older aids had a strong peak near 1 kHz, and they tended to whistle at 1 kHz. If you damp that 1-kHz peak, you can turn up the gain so that the remaining frequency regions become amplified 5 to 10 dB or even 15 dB before whistling problems occur.

EARMOLDS FOR WIDEBAND HEARING AIDS

History of Earmold Design

Back in the 1960s Hugh Knowles suggested the use of stepped-diameter tubing as a means of providing a better impedance match, because of the horn effect. Sam Lybarger in the late 1960s and early 1970s began showing the construction of scientifically designed large-bore earmolds in dealer bulletins. I became interested in this approach to improving the high-frequency performance of hearing aids, and developed and named several large-bore earmolds. The most popular of those was probably the 8CR, which is shown in Figure 3. This earmold was designed at a time when most wideband hearing aids were undamped and were used with a conventional earmold (#13 tubing all the way to the tip of the earmold). The 8CR earmold was designed to do three things: (1) smooth the frequency response of such an aid, (2) extend its useful band width, and (3) provide a boost in the frequency response at about 2800 Hz.

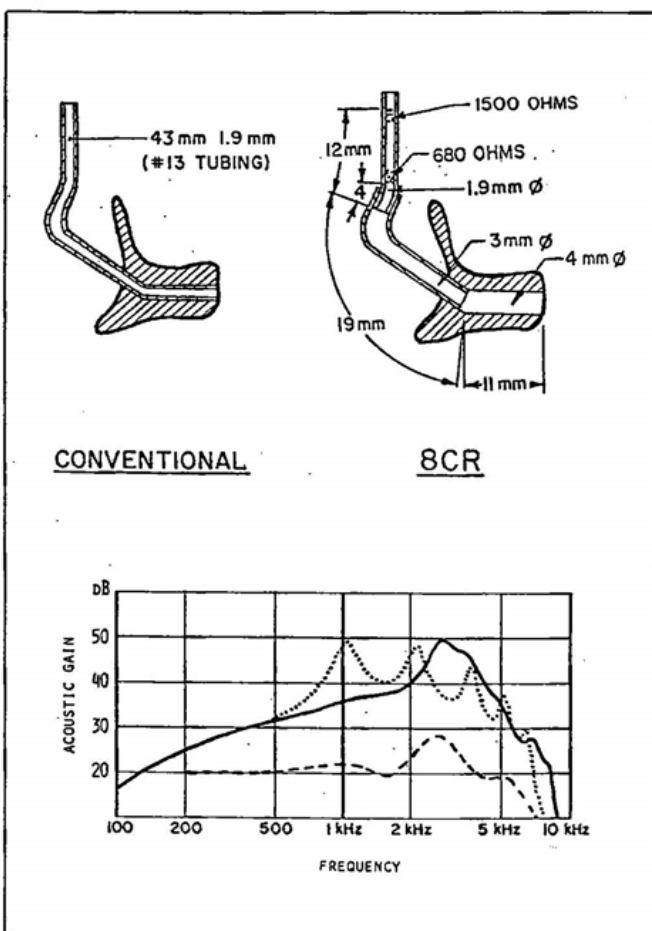


Figure 3. Frequency response of wideband aid with conventional (.....) and 8CR (————) earmolds, measured with a 2-cc coupler. Note: Shape of 2-cc coupler response for BTE aid required to provide typical wearer with flat insertion gain (-----) is shown, plotted arbitrarily at 20-dB gain level for ease of visual comparison (from Killion, 1981a).

Why a boost at 2800 Hz? Because when you block the canal with an earmold, you lose the external-ear resonances we've heard three speakers talk about today: "Nature's own amplifier" produces a 15-dB to 20-dB boost in eardrum pressure in the open ear at approximately 2800 Hz. The 8CR earmold was intended to provide a boost at the same frequency even after Nature's own amplifier had been plugged up with an earmold.

The 8CR earmold design became very popular, especially after Cy Libby tooled it in a one-piece plastic molding to form the Libby Horn, a much simpler construction than the glued-together-tubing constructions I had originally shown for the 8CR. There were two problems with the 8CR earmold. One was that it required a 4-mm (0.158-inch) diameter sound channel at the tip of the earmold. Many dispensers who wanted to use the 8CR discovered that children (and even some adults) simply didn't have ears big enough to accommodate a 4-mm channel.

A second problem became apparent as people began using these new large-bore earmolds: Because of the presence of the dampers, and perhaps partly because of the presence of the larger bores, we began to see more moisture problems in the tubing. It's the same phenomenon that can be seen when you take a can of soda pop out of the refrigerator on a moist day and condensation forms on the cold can. In the case of an earmold worn by someone who tends to produce a lot of moisture, there is almost 100% humidity down in the ear canal combined with a piece of outer plastic tubing that is exposed to whatever breezes come by. If those breezes happen to be at less than body temperature, which they usually are, there is a good chance that condensation will form.

The moisture problem is as old as hearing aids that use tubing; it goes back to the 1950s. One solution is just about as old; you use a small air syringe (which Hal Hen introduced in 1955 and still supplies) with which to force air through the tubing. Generally, three or four squeezes gets the moisture out. But the problem was much more severe with the new earmolds, so many hearing aid dispensers and designers started putting dampers in the earhooks themselves. (The earhook generally nestles above the ear and stays warm, so that moisture-condensation problems are greatly reduced.) Today almost every manufacturer will supply a damped earhook with at least one of his hearing aid models. Thus, we have come full circle back to what the dean of hearing aid engineers, Sam Lybarger, was doing regularly 20 years ago: designing hearing aids that were internally damped in order to produce a smooth frequency response.

There is a problem with those damped earhooks that I should mention. The manufacturer loses points on the data sheet when he damps out the peaks. Damping a large peak at 1 kHz decreases the maximum-gain rating he can publish, and it also decreases the SSPL-90 rating for the hearing aid. A dispenser who was used to looking for 115 dB, for example, might suddenly see the same hearing aid rated at only 108 dB and conclude that it doesn't have enough gain and output (even though the *usable* gain for most hearing aid wearers had been increased). What many manufacturers have done to solve that problem is to supply the hearing aid with two earhooks. One of the earhooks is the traditional undamped earhook. The manufacturer uses it during "Final Test," producing the large numbers with which everyone is familiar. That earhook you should throw away, or feed to your dog, or something. The other earhook is a damped earhook, which will provide a smooth frequency response.

I said you should throw away the undamped earhook. There's an exception to that rule. You may have an experienced hearing aid wearer who has become accustomed to a peaked frequency response, and if you smooth out the

frequency response for him you may find that he doesn't think it's loud enough anymore. He may not like the change at all. Even if it's a change for the better, or you're convinced it is, in such cases you may want to use the undamped earhook rather than have your patient go through a new accommodation period.

The 6EF Earmold

While I was still at Industrial Research Products (a Knowles Company), I was assigned to design a new earmold that met two requirements: (1) there should be no dampers in the earmold (all the damping had to be in the hearing aid or earhook), and (2) the earmold should have a maximum 3-mm sound channel. The resulting "6EF earmold" is shown in Figure 4. As usual, I described the basic construction in terms of telescoping tubes. Instead of #13 tubing going all the way to the tip of the earmold, which would make it a conventional earmold, the #13 tubing is cemented inside a piece of #9 tubing that goes to the end of the mold. The tubing has a 3-mm inside diameter, providing a 3-mm-diameter sound channel. The crucial dimension is the 22-mm length of that large-diameter sound channel.

There are several ways of producing the 6EF earmold. One is to use #13 and #9 tubing as shown in Figure 4. Another is to use the "3-mm Libby Horn," which Cy Libby has tooled to provide the 6EF sound channel. Mas Harada has tooled a very pretty little plastic elbow with a 3-mm inside diameter. You can glue the #13 tubing up inside the top of the elbow, and then cement the elbow into a properly bored earmold, forming a continuous 3-mm-diameter sound channel (partly in the elbow and partly in the earmold) that is the required 22 mm long. Most recently, Vern Morgan has tooled a somewhat different plastic elbow that has a nipple for #13 tubing on one end — much like the European elbows or the "CFA adapter" here in the United States — except that like Harada's elbow, Morgan's elbow has a 3-mm inside diameter. With this elbow, replacing the tubing requires only that a new tube is slipped over the earhook at one end and over the nipple of the elbow at the other. All of these constructions can be assembled to yield identical 22-mm by 3-mm sound channels and, thus, identical acoustic performance.

One more historical note: When the 6EF earmold design was finished, I discovered that it was remarkably similar to an earmold that Sam Lybarger described back in 1970. Indeed, the 6EF is not much different from the 18 mm × 3 mm diameter sound channel of the HA2 coupler. (In my experiments, the additional 4 mm of length in the 6EF resulted in smoother response curves.) Once again, we've come full circle.

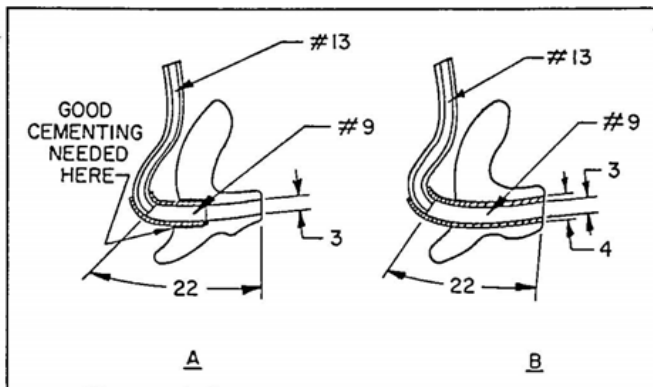


Figure 4. Alternate (A) and "standard" (B) construction for 6EF earmold. The alternate construction can be used even with small ear canals (from Killion, 1981b).

TWO DECADES OF DESIGN PROGRESS

A couple of years ago, I had a chance to set up the KEMAR manikin in the listening room at Industrial Research Products, Inc. IRPI's listening room is set up like a living room with a high-fidelity loudspeaker system, so I was able to make realistic recordings of music played through commercial 1982 hearing aids. I also made recordings through some hearing aids that I have collected over the years since the 1960s. I'd like to play some of those recordings,* not only to show the effect of using the new 6EF earmold compared to a conventional one, but also to illustrate just how far we have come since the 1960s (or even since the 1970s) in terms of what hearing aids can do.

During the last decade, hearing aid designers have produced excellent new designs: hearing aids with the peaks smoothed, an intentional boost in response at 2700 Hz, and wider band widths. In some cases this has been accomplished even with a conventional earmold! If you measure insertion gains on KEMAR — i.e., measure what the hearing aid actually does for the hearing aid wearer — you find that there are now hearing aids with a smooth, wideband frequency response even *without* a large-bore earmold.

A 1980s Design Example

The first tape-recorded demonstration I have is a comparison between that type of modern hearing aid used with a conventional earmold, and a hearing aid from the 1970s (one of the better designs of the 1970s). The insertion-gain response curves of these aids are shown in Figure 5. I will play an ABA comparison, using the Oscar Peterson Trio music. *[Plays]* The improvement is dramatic.

But what happens if we take that same hearing aid and use it with a 6EF earmold (or Libby's 3-mm horn, Harada's elbow, or Morgan's elbow used to provide the acoustically equivalent 6EF sound channel)? Not surprisingly, above approximately 3 kHz we get a substantial boost, approaching 10 dB of high-frequency emphasis (Figure 6).

A Second 1980s Design Example

The solid curve in Figure 7 shows the response of a second 1982-design wideband hearing aid used with a 6EF earmold. This is a *substantially* better high-frequency response than you could have found a decade ago. In fact, this is an excellent hearing aid. The electronics are excellent, and the input compression is very nice.

Let's compare this 1982 hearing aid with an aid from the 1960s. The dotted line in Figure 7 shows the response of one of the "high-frequency-emphasis" hearing aids from the 1960s, used with a conventional earmold. Notice that above 2 kHz it rolls off sharply. There is no way you can get any true high-frequency emphasis from this aid. The only thing you can do is what everyone learned to do: Use as much earmold venting as possible to get rid of the lows so that it appeared to have some high-frequency emphasis.

We live in a totally different world today, because we have available hearing aids with true high-frequency emphasis. This has an unexpected bonus: You can now leave the lows in! There is a fair amount of recent research that adds up to these conclusions: (1) leaving the lows in sounds better, and (2) leaving the lows in gives better speech-discrimination scores *as long as* the hearing aid has good highs (i.e., has a wide band width and true high-frequency emphasis above 1-kHz).

Now let's take the 1982 hearing aid and the 1960s hearing aid to a symphony concert. *[Demonstration plays]*. The resemblance between the sound of the narrow-band hearing aid and the sound of a cheap transistor radio is not coincidental. If you measure the frequency response of a \$5.95

pocket radio as heard by KEMAR, the result is a response that's not very far from that of the typical hearing aid in the 1960s.

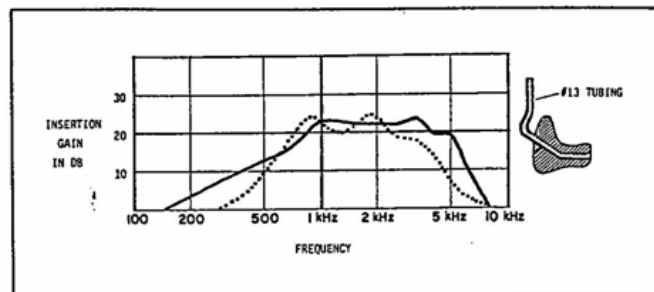


Figure 5. Insertion response obtained with 1970s hearing aid (.....) and modern wideband hearing aid #1 (———), as received, using a conventional earmold.

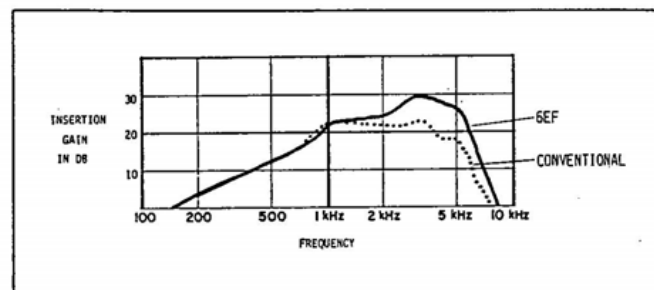


Figure 6. Comparison between responses of modern wideband hearing aid #1 using conventional and 6EF earmolds.

Too Many Highs?: "Treble Response Selector" Inserts For the 6EF Earmold

There's another thing that makes me enthusiastic about the 6EF earmold. If you're afraid of jumping into wide-bore earmolds, you can order a 6EF earmold and insert a piece of #13 tubing to change the sound channel back to the same dimension as in a conventional earmold. (That may seem like the hard way of doing things, but bear with me for a moment.) The *sound* doesn't care about the earmold construction on the outside: all it cares about is the air that it can feel and the walls that it can feel. So if you put a piece of #13 tubing back up into that large-diameter hole of a 6EF earmold, you end up with a conventional 1.93-mm-diameter sound channel. And you will get the same response that you would have had if you had ordered a standard earmold in the first place.

But now you have many options. If you want more highs, all you have to do is to take the piece of #13 tubing out and you have the large-bore 6EF earmold again, with 5 dB to 10 dB greater high-frequency boost (Figure 8). If you want *fewer* highs, for whatever reason (perhaps the subject is not used to them), you don't need to buy an old 1960s version hearing aid for him. You simply put in a piece of smaller-diameter tubing, using the "reverse-horn" effect, and roll those highs off. If you use a piece of #19 tubing as an insert, for example, you can roll off the frequency response of this wideband hearing aid to make it almost identical in the highs to the best we could do in 1960. (The lower curve of Figure 8 shows almost exactly the same high-frequency response as the dotted curve of Figure 7.)

Therefore, if you have hearing aid wearers whose initial reaction to wideband frequency response is negative, but you know that in order to communicate effectively they need more high frequencies, you can do the same thing that dispensers have been doing for years with venting: You can begin with this small insert, giving the patients

the same narrow-band response they are used to, then bring them back in about two weeks, change to a slightly larger insert, and send them out again. If that goes well, bring them back in a couple of weeks and change to the next larger insert. At each stage they know and you know that you can always back up if it isn't successful, and you might find that at the end of that adaptation period you have a happier hearing aid user who likes the sound quality, and who is functioning much, much better.

Harvey Fletcher, who was the "father of psychoacoustics" at Bell Telephone Laboratories and author of *Speech and Hearing* in 1929, used to tell a marvelous story back in the 1940s when he first bought a high-fidelity phonograph. In the 1940s the records were very scratchy, so that high-fidelity also meant high-scratch. As I heard the story later, Dr. Fletcher bought his first true high-fidelity phonograph and brought it home, only to hear his wife say, "I can't put up with that, it shrieks." So he purchased 20 one-microfarad capacitors and soldered all 20 of them across the loudspeaker terminals to roll off the highs. This solved the problem; his wife was happy. Once a week for 20 weeks he quietly went in and clipped one capacitor. At the end of 20 weeks they were both happy!

EARMOLDS FOR WIDEBAND ITE AIDS

Now I will talk a little bit about in-the-ear aids. They have been around for quite a while, but now there are things you can do as a dispenser to control the frequency response of in-the-ear aids.

An Aside on Response Peaks And Deafness

Once more, I emphasize the importance of avoiding peaks in the frequency response. I talked earlier about the reason for not having peaks in the frequency response in terms of sound quality and acoustic feedback. But there's more to it than that. If you have someone who has an abnormal growth of loudness — typically someone with a sensorineural loss who may have lost many of his outer hair cells — that patient may have lost his ability to hear quiet sounds, although intense sounds may be just as loud to him as they are to you. He has what is called *recruitment*. This is the person who says: "I can't hear you . . . I can't hear you . . . stop shouting!" All of a sudden the sound reaches a level that is just as loud for him as it is for everyone else, but below that it was too quiet to be heard properly.

If you fit this person with a peaky hearing aid you give him, in addition to his own internal recruitment, the equivalent of a hearing aid with recruitment — thus, doubling his problem. I will play a tape for you that illustrates this phenomenon; but first, let me describe how the tape came about.

There have been various simulations of hearing loss. The one in which I have the most confidence is one that's been done by Edgar Villchur. When he was a visiting scientist at the Massachusetts Institute of Technology he used a 16-channel, computer-controlled bank of expanders to simulate the accelerated loudness growth of hearing-impaired subjects with recruitment. He subsequently had an analog version built (by me) for his own laboratory. He took four persons with unilateral deafness, and had them compare the sound of his processed simulation in their good ears with the way they actually heard amplified speech in their bad ears (Villchur, 1974). Two of the persons described the sounds as similar; two described them as very similar. Based on those experiments, this electronic processing is probably the closest we are likely to come, at least within the next few years, to hearing what it would be like to hear if you had moderate-severe deafness. I will play a recording made through an

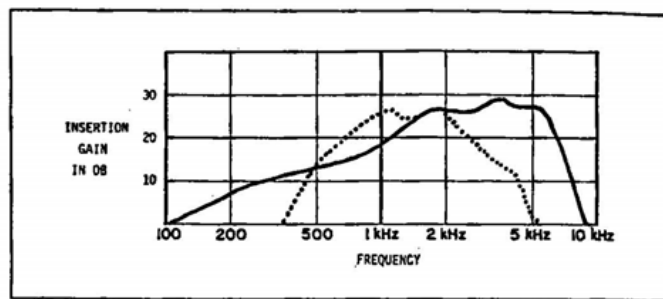


Figure 7. Response of 1960s-design hearing aid with conventional earmold (.....) and modern wideband hearing aid #2 with 6EF earmold (——).

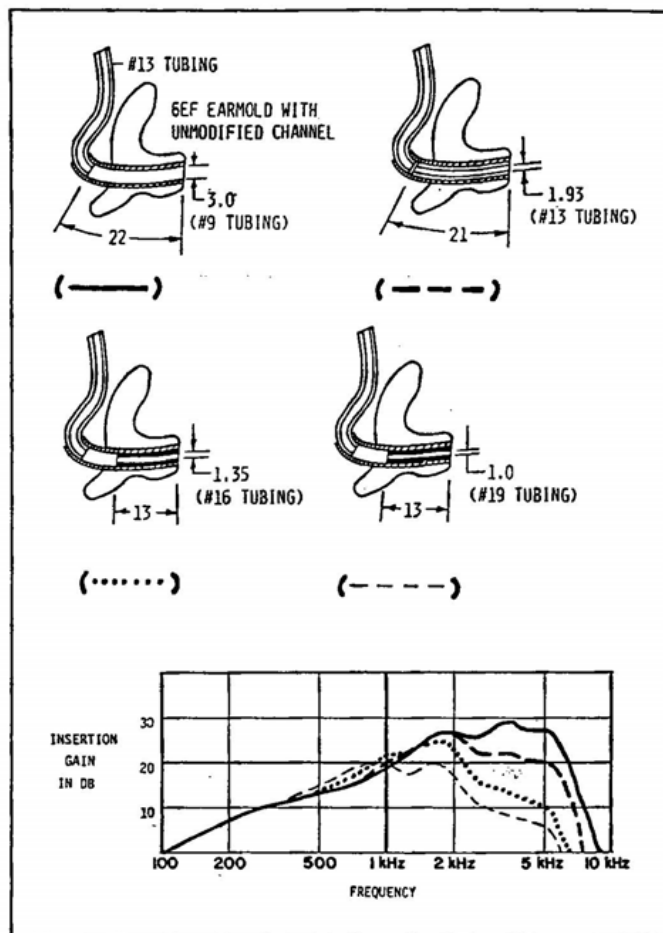


Figure 8. High-frequency response control obtained with "Treble Response Selector" inserts in 6EF earmold, using modern wideband hearing aid #2.

in-the-ear hearing aid to this simulated sensorineural-loss subject, but first I'll play a recording made with a hearing aid that has a smooth frequency response. Listen to what it would be like to have this hearing impairment, even if the hearing aid has a *smooth* response. Now I will play exactly the same tape-recorded passage — this time through a hearing aid with a peak in it — again through the deafness simulator. The subject's abnormal loudness growth greatly exaggerates the nastiness of the peak. (Tape plays).

In-the-ear hearing aids are being *regularly* produced today with smooth frequency responses. What has not been available in the past has been the ability to do anything at the dispenser level about smooth frequency response with ITE hearing aids, because it was all built into the hearing aid.

The Replaceable Damper

The following is, quite frankly, a commercial for something in which I believe very strongly (but in which I have no commercial interest). This is the Knowles BF-1743 replaceable damper assembly, in which a small metal tube is cemented inside the in-the-ear hearing aid as shown in Figure 9. Inside this tube a small silicone-rubber tube holds a damper in place. The damper itself is the damper that many in-the-ear manufacturers are using now: the same Knowles BF-series fused-mesh damper that was originally designed for use with over-the-ear hearing aids. This is important, because it means that you don't have to stock a new type of damper.

Knowles Electronics also manufactures a little tool to go with this assembly, the BF-1778 inserting tool illustrated in Figure 10. (Even if you don't use them to play with ITE hearing aids, these tools are very handy for handling damping plugs.) The BF-1778 tool fits just inside the tip of the damper, grabs the damper, and allows you to remove and re-insert the damper in an ITE hearing aid. The curves in Figure 11 show that by changing the value of the damper you can have a substantial effect on the high-frequency response of an ITE hearing aid. It also shows that ITE aids with a bandwidth of 40 Hz to 18 kHz are now possible. (Indeed, most ITE manufacturers can make one for you if you wish.)

Even if you think you don't want a smooth frequency response in your ITE hearing aid, if you order the aid with one of the BF-1743 replaceable damper couplings, you can always take the damper out and give the hearing aid wearer all the peaks he wants!

PITFALLS WITH WIDEBAND HEARING AIDS

It is sometimes said that persons with mild-to-moderate hearing loss won't want wideband sound. It is my firm

belief that in most cases what they don't want is peaky sound, they don't want *excessive* high-frequency amplification (they don't want you to blow their heads off with highs), they don't want *distorted* highs, and they don't want the squealing that results from a carelessly taken earmold impression. But I believe there is almost no case (except when the cochlea is very badly damaged) in which you can make an argument for cutting back a *properly fitted*, full-bandwidth frequency response. Full band width sounds better and makes speech more intelligible. Of course, you *can* make many good arguments for cutting back a *misapplied* wideband response.

More Bandwidth, More Peaks?

Therefore, let's talk about some of the pitfalls of going to wideband hearing aids — and there are some. One of the pitfalls occurs when you combine wideband with peaky frequency response. As you increase the band width you expose the aid to more and more frequency regions in which feedback is likely to occur, so that you certainly are going to have to watch out about *response smoothness*. (Remember that squealback almost always occurs at a response peak.)

Feedback

The second pitfall is that you may end up needing a better earmold fit and less venting. But this may not be as great a problem as it first appears; in many cases you can use much less venting than you thought you needed, because now you have true high-frequency emphasis, and you can now leave the lows in. Several university studies, in addition to anecdotal dispenser reports, say that the satisfaction of the hearing aid wearer is substantially higher when the lows are left in, if you provide true high-frequency emphasis.

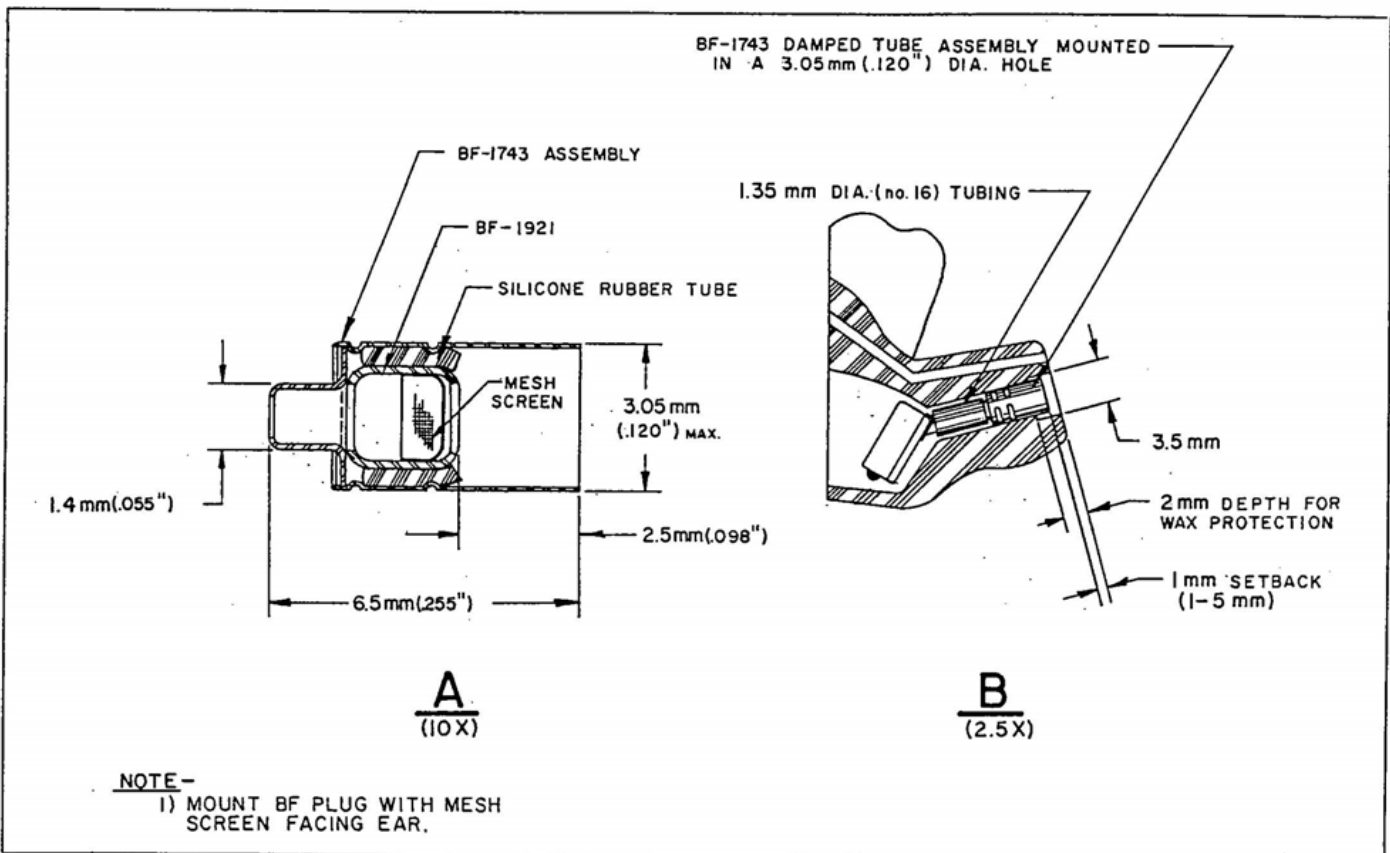


Figure 9. Knowles BF-1743 damped coupling assembly (A), and shown mounted in ITE hearing aid earmold (B) (from Killion and Murphy, 1982).

Distortion

The third and most subtle pitfall has to do with high-level distortion; it is related to limiting the maximum output of the hearing aid. What happens when you deliver increasingly intense sound to the input of the hearing aid? Unless the hearing aid is going to cause ear discomfort or damage, sooner or later the output of the hearing aid must stop going up. The question is, *how* does it stop going up? Does it stop going up by peak clipping with the accompanying very high distortion, or does it stop going up because internally, electronically, a little electronic elf turns down the volume control? Obviously the latter gives a much better sound than peak clipping. That's been known for decades. Even so, you still hear people saying, "Don't use AGC or compression unless the client has a very narrow dynamic range. If they have more than a 30-dB dynamic range, just give them traditional peak clipping." You may save a few dollars if you do that, but when you go to wideband hearing aids you're going to run into real trouble. You can get away with peak clipping with a hearing aid that doesn't have any highs, because the harsh high-frequency distortion products simply aren't reproduced. Once you go wide band, however, you will find that all of those distortion products are very audible.

Let me demonstrate to you the sound of two peak-clipping hearing aids: A 1960s narrow-band aid and a 1982 wideband aid. The 1982 hearing aid actually has a better amplifier, but listen to how much worse peak clipping sounds with

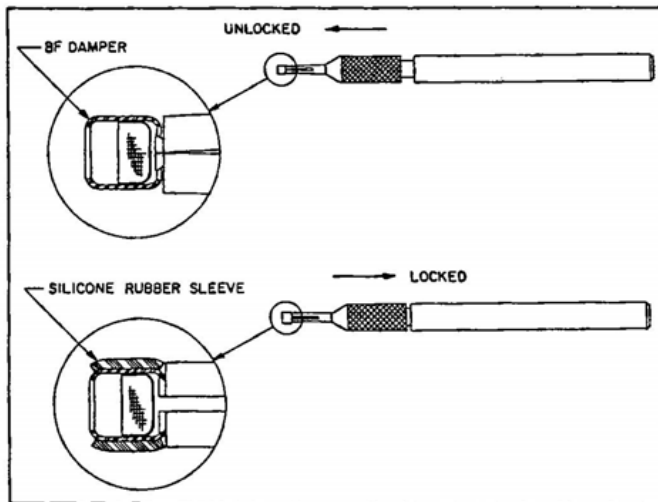


Figure 10. Knowles BF-1778 damper extraction tool.

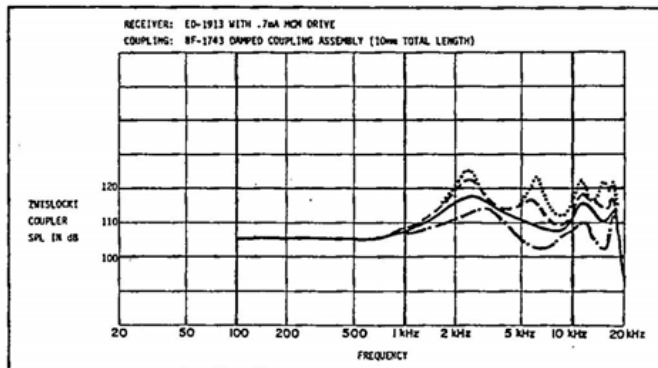


Figure 11. Effect of damping resistance in BF-1743 damped tubing assembly:

- (—————) 2200 Ohms — BF-1921 (supplied)
- (- - - -) 680 Ohms — BF-1859
- (- · - · -) 4700 Ohms — BF-1923
- (· · · · ·) NONE.

the wideband than with the narrow-band aids. (*Tape plays distorted symphonic passage.*) That's bad enough, and that was the *narrow-band aid!* Here is the wideband aid. (*Tape plays an irritating cacophony.*)

Now I will play the tape of another 1982 wideband hearing aid — this one with input compression. It is not perfect, but it has substantially lower distortion than the aid with peak clipping. Listen to how much better the 1982 wideband aid with input compression sounds than the 1960s narrow-band aid with peak clipping. (*Tape plays.*) What hearing wearer would choose peak clipping if he had the choice?

Unfortunately, there are such wearers: You may have a long-term patient for whom distortion products have become part of the everyday sound that he hears. If you give him a low-distortion hearing aid he may not think it's loud enough. He's lived so long with distortion he can't live without it. He needs to re-learn a new speech code, because the code he has learned is badly distorted.

In the 1960s, I first began wearing hearing aids as an exercise to learn what hearing aid wearers were being subjected to, and I experienced for myself all of the troubles that people complained of — I couldn't understand what people said, and I couldn't tell where sounds were coming from. It was, as they say, like trying to hear speech in a sea of noise. After a period of about six weeks I did just as well with the hearing aid on as I did with it off. I had learned to live with even a 1960s narrow-band, badly distorted hearing aid. I had adapted so well I didn't even notice the distortion unless I listened for it. But it took six weeks! You don't have to put first-time wearers through that agony anymore.

PROVIDING A CHOICE

For a first-time hearing aid wearer the positive difference between a good, smooth-response, low-distortion, wideband aid and a peak-clipping narrow-band aid can be dramatic. The hearing aid industry has made enormous progress in the last two decades. You can now provide the first-time wearer with a hearing aid that, in many cases, simply "works fine" right from the start. That has been my recent experience, and that of some of my dispensing friends. Doing that does involve two disadvantages: (1) It sometimes costs a little more, and (2) in the case of ITE hearing aids for someone with small ears the ITE manufacturer may have to use a slightly larger shell in order to accommodate the BF-1743 tube and/or low-distortion compression amplification. But why not let the wearer himself choose whether a substantial increase in naturalness of sound is worth a small increase in size? After all, it is the hearing aid wearer who must live with his hearing aid. The exciting thing for me is that we can now give him the choice! ☐

*A cassette tape containing most of the recordings described in this paper can be obtained through the courtesy of Knowles Electronics (3100 N. Mannheim Road, Franklin Park, IL 60131) by requesting the "Wideband Hearing Aids: Promises and Pitfalls" tape.

FOR FURTHER READING

- Knowles HS, Killion MC: Frequency characteristics of broadband receivers. *J Audio Technol* 1978 (Zeitschrift für Hörgeräte-Akustik); 17:86-89, 136-140.
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