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Custom In-The-Ear Hearing Aids: A Survey Report

MARY HOWARD, M.A.[a]
Research Assistant

Biocommunications Laboratory
University of Maryland
College Park, Maryland 20742

LUCILLE B. BECK, Ph. D.
Associate Coordinator
Hearing Aid Program

ELEANOR S. WINTERCORN, Ph. D.
Coordinator
Hearing Aid Program

Audiology and Speech Pathology Services
Veterans Administration Medical Center
50 Irving Street, N.W.
Washington, D.C. 20422

A custom in-the-ear hearing aid incorporates the features of an individually selected hearing aid circuit within a custom-fitted earmold case (Fig. 1). The use of custom in-the-ear hearing aids by the hard-of-hearing population has increased over the past 5 years as a result of improvements in hearing aid case design and circuitry. Prior to that, in-the-ear hearing aids represented a small portion of hearing aid sales. The Hearing Industries Association reported that sales of in-the-ear instruments in the period from 1963 through 1974 accounted for from 2.1 percent to 3.4 percent of the total hearing aid market. As recently as 1975, in-the-ear hearing aids were still thought to be the least powerful of hearing instruments (1) and useful only to those hearing-impaired patients with the mildest of hearing losses. Because of such technological advances in hearing aid design as the integrated circuit and the electret microphone (which because of its small size allows very close placement of components without feedback problems) the 1975 description is no longer true. Recent Hearing Industries Association statistics indicate that in-the-ear hearing aid sales increased to 29.5 percent of total hearing aid sales in 1978 (2) and is 34 percent at present.

As the figures demonstrate, interest in the custom in-the-ear hearing aid is growing, presumably for reasons of cosmetic appeal, comfort, and improvement in hearing ability. But although interest is on the rise among patients and clinicians alike, very little research has been undertaken to study clinical differences between this type of instrument and current conventional behind-the-ear instruments (Fig. 2). Work by the hearing aid industry has provided some valuable information concerning the custom instruments, but this has only whetted the appetites of hearing habilitation professionals for more clinical research. Data available thus far are available principally from the industry rather than from refereed professional journals or textbooks.

Preves and Griffing (3) have suggested that microphone location for in-the-ear hearing aids takes advantage of pinna focusing (analogous to the gathering mechanism of a radar dish antenna) and of head shadow effects, to a greater degree than behind-the-ear hearing aids, thereby boosting amplification in the higher frequencies critical for speech discrimination. (Figures 1 and 2 illustrate the microphone placement for an in-the-ear hearing aid and an over-the-ear hearing aid, respectively.) Using patients with sensorineural type hearing losses, Hoke (4) found that mean speech discrimination scores in noise conditions (noise incidence 90, 180, and 270 degree) increased with in-the-ear microphone placement by 24 and 28 percentage points for 0-degree and 45-degree speech signal incidence, respectively, over performance with the microphone placement of current behind-the-ear instruments.

Franks and Hamm (5) also studied the effects of microphone

[a] Present Address:
Biocommunications Laboratory
Catholic University
Sponsored Programs
Cardinal Station, Box 657
Washington, D.C. 20064

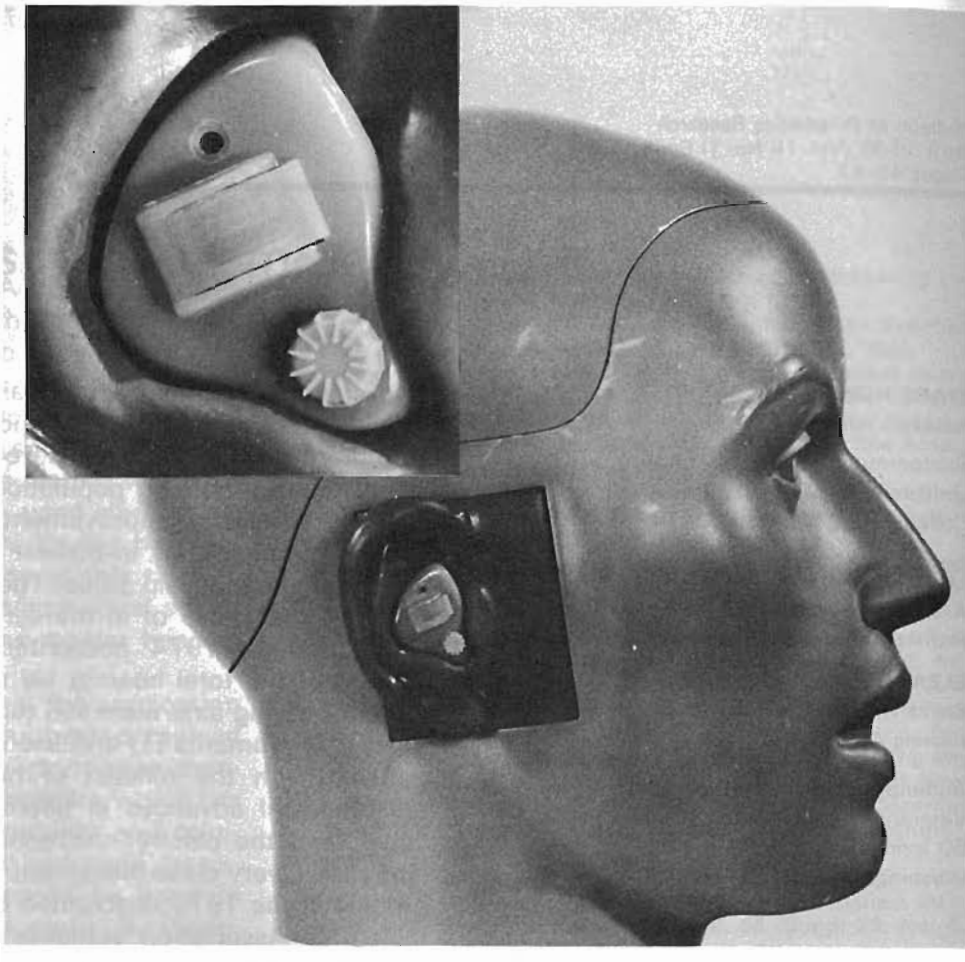

FIGURE 1.
A custom in-the-ear hearing aid, shown on KEMAR. In the enlarged view (insert) the microphone opening is shown clearly near the top of the aid.

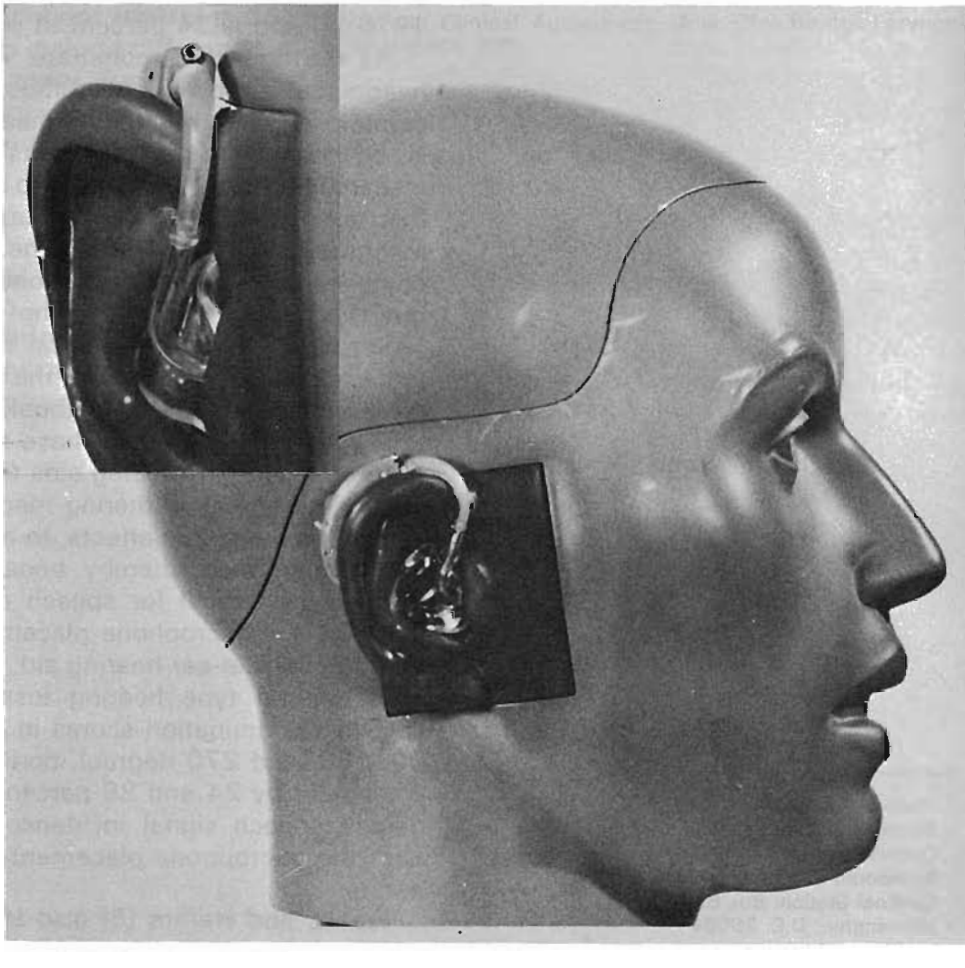

FIGURE 2.
An over-the-ear hearing aid, shown on KEMAR. The forward-facing microphone opening, located directly above the earhook, is shown clearly in the enlarged view (insert).

placement on speech discrimination in noise for normal-hearing patients. In a configuration of 0-degree noise incidence and −45 degree speech incidence, the in-the-ear and behind-the-ear aids' microphone placements produced similar intelligibility scores. Generally, the in-the-ear aid's microphone placement provided more noise resistance; therefore, scores tended to increase at a faster rate with increasingly favorable signal-to-noise ratios than was the case with the behind-the-ear aid's microphone placement.

A custom in-the-ear hearing aid fitting offers a viable alternative to those patients who are unwilling to accept the conventional current behind-the-ear instrument. It may also provide a more comfortable fit for those patients with pinnas situated very close to the head and who, for this reason, have a difficult time wearing a behind-the-ear aid. In addition, there is some evidence of fewer problems with perspiration if the aid is worn in the concha as opposed to behind the ear.

Recognizing the growing popularity of custom in-the-ear hearing aids, the Veterans Administration (VA) embarked on a trial program aimed at examining feasibility and wearer acceptance of these instruments. Of the 18,291 hearing aids issued by the VA in 1978, 6 percent were of the in-the-ear type. Later statistics indicated that the issue rate for 1979 was up to 10.76 percent for the custom in-the-ear instruments and continuing to grow.

The increasing use of this type of hearing aid by VA patients and by the hard-of-hearing population at large raises a number of questions concerning patient satisfaction and overall success with these instruments. Which patients benefit most from in-the-ear hearing aids? Is there a specific range of hearing impairment associated with the greatest success? Do patients with severe and steeply sloping hearing losses experience increased feedback problems, and can they be remedied to allow in-the-ear fittings? Clinicians might well ask whether experienced hearing aid users find an in-the-ear hearing aid more or less satisfactory than a conventional behind-the-ear hearing aid. Are there more maintenance problems with these hearing aids than with conventional instruments? The VA wished to answer these questions either directly or indirectly within the framework of its own hearing aid program. The purpose of this retrospective survey was to investigate the relationship between the above factors and success with custom in-the-ear hearing aids. It did not attempt a precisely controlled program nor a systematic controlled comparison with conventional behind-the-ear aids.

PROCEDURE

Subjects

Subjects were 458 veterans ranging in age from 24 to 85 years, with a mean of 54 years. These subjects exhibited hearing losses from mild to profound. Eighty-five percent had sensorineural hearing loss, 11 percent demonstrated conductive impairment, and 4 percent had mixed hearing losses.

Method

Audiograms from 520 veterans from 30 VA clinics were analyzed and categorized according to (i) type, severity, and slope of hearing loss; (ii) type of fitting, i.e., monaural or binaural, and (iii) prior experience with amplification.

Preliminary results were returned to the clinics and additional information was requested regarding hearing aid evaluation procedures, post-fitting results, modifications, if needed, or whether aids were returned to manufacturers for credit. Further analysis was performed to determine trends according to slope and severity of hearing loss, improvement in discrimination score, and overall satisfaction with the hearing aid.

Because this was a retrospective survey rather than a prospective research study, complete information was not available for all of the initial patients. However, audiometric and hearing aid fitting information received for 458 patients fitted with 675 custom in-the-ear hearing aids comprised the data for our study. Since this population represents patients from 30 different VA Medical Centers which utilize various test procedures, not all tests were performed by all clinics. Therefore, subgroups of

varying numbers of patients and clinics will be analyzed according to the test procedures employed.

TABLE 1.
Percentage of veterans using custom in-the-ear hearing aids in each of four main categories. (N = 458)

Experienced hearing aid users	56%
Inexperienced hearing aid users	44%
Monaural hearing aid users	50%
Binaural hearing aid users	50%
Sensorineural hearing loss	85%
Conductive hearing loss	11%
Mixed hearing loss	4%
Mild hearing loss	3%
Moderate hearing loss	37%
Severe hearing loss	59%
Profound hearing loss	1%

TABLE 2.
Distribution of unaided speech discrimination scores (CID W-22 Lists) in quiet. (N = 675)

Discrimination scores	% of ears tested
90–100%	40.00%
80–89%	33.00%
70–79%	14.50%
60–69%	7.25%
Below 60%	5.25%

RESULTS AND DISCUSSION

Findings revealed that patients with a variety of hearing loss configurations were fitted with custom in-the-ear instruments. Table 1 shows the breakdown of this sample of veterans in terms of the type of hearing loss, severity of hearing loss, experience with hearing aids and type of hearing aid fitting (monaural vs. binaural). Figure 3 illustrates in audiogram form the total range of hearing loss fitted with custom in-the-ear hearing aids from our patient sample. This group spans from mild hearing to severe hearing losses with flat, gradual, and precipitous high-frequency slopes. Figure 4 shows the distribution of hearing aid fittings according to the degree of slope of the hearing loss. It is evident that custom in-the-ear hearing aids are now being issued for a wide range of hearing impairments and are no longer restricted to the mildest of hearing loss configurations.

The largest single category of our population (23 percent) is represented by the audiogram in Figure 5, which represents a fairly typical hearing loss in the veteran population. This group consists of patients with sensorineural hearing losses ranging from mild to severe with a flat audiogram at lower frequencies, then sloping precipitously downward at higher frequencies.

The general distribution of unaided speech discrimination scores in quiet for the total population surveyed is exhibited in Table 2. The data show that 73 percent of the veterans scored at or above 80 percent. Although 56 percent of the patients had

Problems*	No.	% of 72	% of total
Uncomfortable fit	24	33.3	3.5
Feedback	21	29.2	3.0
Increase in gain	20	27.7	3.0
Defective aids (dead, intermittant, broken switches or volume control wheel)	20	27.7	3.0
Needed additions	3	4.2	0.4

Repairs performed	No.	% of 72	% of total
Recasing	29	40.3	4.3
Increased gain	20	27.7	3.0
Other electronic	17	23.6	2.5
Physical repairs	3	4.2	0.4
Additions	3	4.2	0.4
	72	100.0	10.6

*Some of the aids required more than one modification.

TABLE 3.
Number and percentage of hearing aids needing modifications according to the type of problem and repair performed, listed according to frequency from greatest to least. Two percentages are shown for each category representing both the portion of the total number of aids needing modification (N = 72) and the portion of the total custom in-the-ear hearing aid fittings. (N = 675)

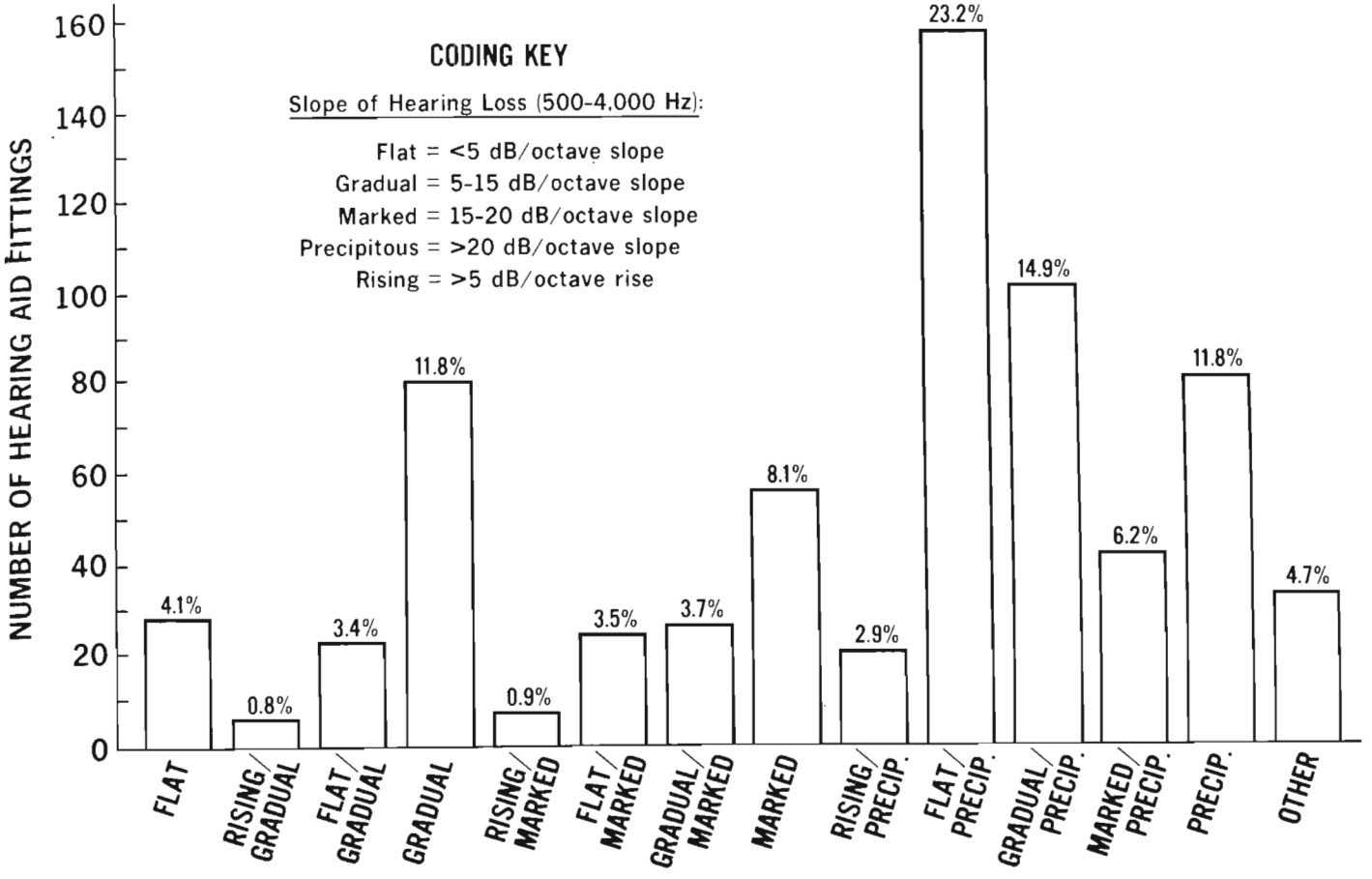

FIGURE 4.—Distribution of hearing aid fittings according to degree of slope. Percentages indicate portion of total population (N = 675). Degree of slope increases from left to right.

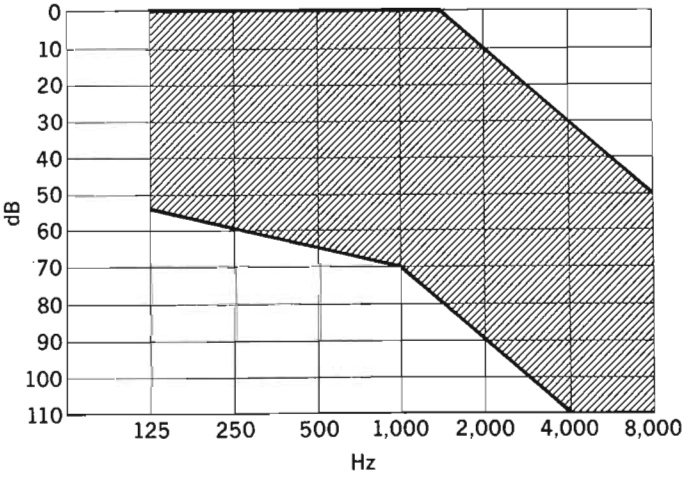

FIGURE 3. Audiogram representing the range of hearing loss for the veteran population fitted with custom in-the-ear hearing aids (N = 675).

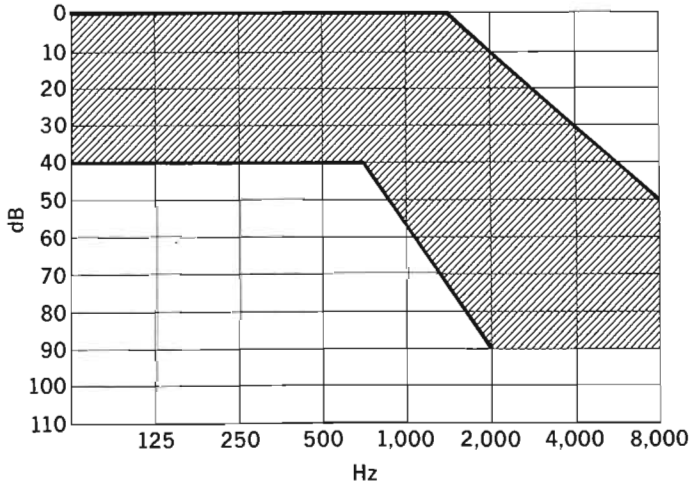

FIGURE 5.
Audiogram for the slope representing the largest category of the population surveyed (23%).

precipitous hearing losses, 47 percent of the total population had normal thresholds through 750 Hz; this fact probably contributed to the relatively good unaided discrimination scores in quiet.

A composite group totaling 53 veterans was examined by any of several clinics using a quiet sound field (SF) situation to compare unaided and aided discrimination scores. Aided scores for 38 patients of this group showed improvement of more than 12 percentage points, 12 veterans showed an improvement of between 6 and 12 percentage points, 2 patients showed less than 6 percentage points improvement, and one showed a decrease of 2 percentage points. Aided scores changed over a range of −2 to 100 percentage points, with a mean improvement of 23 percentage points.

In another group from our sample, 26 patients were tested in a noise SF under aided and unaided

conditions. A range of improvement in aided discrimination scores was observed from −2 to 44 percentage points, with a mean improvement of 20.3 percentage points over aided scores.

Results were also obtained concerning the rate of return to the manufacturer for hearing aid modification. The problems encountered by veterans are listed in Table 3. Modifications were fairly evenly distributed among four of the five main categories. Some of these problems are interrelated, e.g., a poorly fitting hearing aid case and feedback problems.

These problems were remedied in several ways, as noted in Table 3. One of the solutions for uncomfortable fit and feedback was recasing. Since a large percentage of aids (40.3 percent) required recasing, strategies to reduce the need for this modification should be considered. The need for recasing may stem from poor ear impressions, shrinkage of impression material, or a poorly fabricated custom in-the-ear case. A case that does not fit properly can result in irritation, acoustic feedback and loss of cosmetic appeal. Any one of these problems may lead to dissatisfaction with the hearing aid and possible rejection of the instrument by the veteran.

Long-term data are not yet available on the life-span and repair history of this type of hearing aid. Because of the intrinsic relationship between the hearing aid and earmold, the device may need to be recased several times over the life-span of the instrument, just as replacement of earmolds is necessary with more conventional current types of hearing aid. The concha-ear canal area may change size and shape; feedback can develop, and sometimes cases break. Therefore, when recommending custom in-the-ear hearing aids, audiologists should give some consideration to the nuisance and expense that may be incurred by the patient or the VA each time recasing is necessary.

Figure 6 illustrates the portion of hearing aids from each slope category that were returned to the manufacturer for credit. Returns for credit occurred only for a small portion of the population surveyed (6 percent). The reasons for return varied, with the most common being feedback, insufficient gain, and patient adjustment problems.

Ideally, no aids should be returned to the manufacturer for credit or modification. To approach this desired status would require a combined effort on the part of the audiologist submitting the order and the manufacturer. The audiologist must provide all of the necessary information to the manufacturer to facilitate fulfilling patient needs. Clinicians must be certain that the ear impressions are made properly, or the patient may again have to return the aid for recasing or modification.

The clinician is also responsible for determining candidacy for the custom in-the-ear hearing aid. Our survey indicated that some clinics successfully fit a very large portion of their patients with this type of instrument, while other clinics dispense very few. One could surmise that this difference might be attributed to the degree of use in and of itself—that is, success breeds success. Whether the inclination to try the unknown or the new is tied to individual personality traits of the clinicians or whether, in this case, other factors are operating can only be supposition. Possible considerations are (i) lack of information, e.g., belief that only mild hearing losses can be helped with these aids; and (ii) reluctance to abrogate the audiologist's prerogative of selection of the electroacoustic characteristics of the hearing aid, leaving it entirely to the manufacturer.

The results of this survey may serve to inspire some confidence in the custom in-the-ear concept for those who have lacked it. At the same time, the results should serve as a caution to audiologists in view of the absence of long-term repair and life-span data about these instruments.

In conclusion, custom in-the-ear hearing aids have proved to be successful in providing selected veterans with useful amplification, as well as cosmetic appeal. It is evident that there exist some problems associated with this type of instrument. In an effort to alleviate some of these problems and provide patients with better service and greater satisfaction with in-the-ear amplification, audiologists and manufacturers might focus their attention on certain issues, such as improvement in earmold impressions and fabrication, better quality control to decrease the number of defective hearing aids delivered, and greater care in determining patient candidacy for in-the-ear devices. In addition to the normal concerns in fitting over-the-ear hearing aids, consideration should be given to pinna size and ear-canal configuration, especially if multiple controls and vents are necessary. The audiologist might also ask if a custom hearing aid is truly the aid of choice, keeping in mind the aforementioned problems associated with this type of instrument. These and other solutions need to be explored to provide the best possible hearing health care for the veteran population.

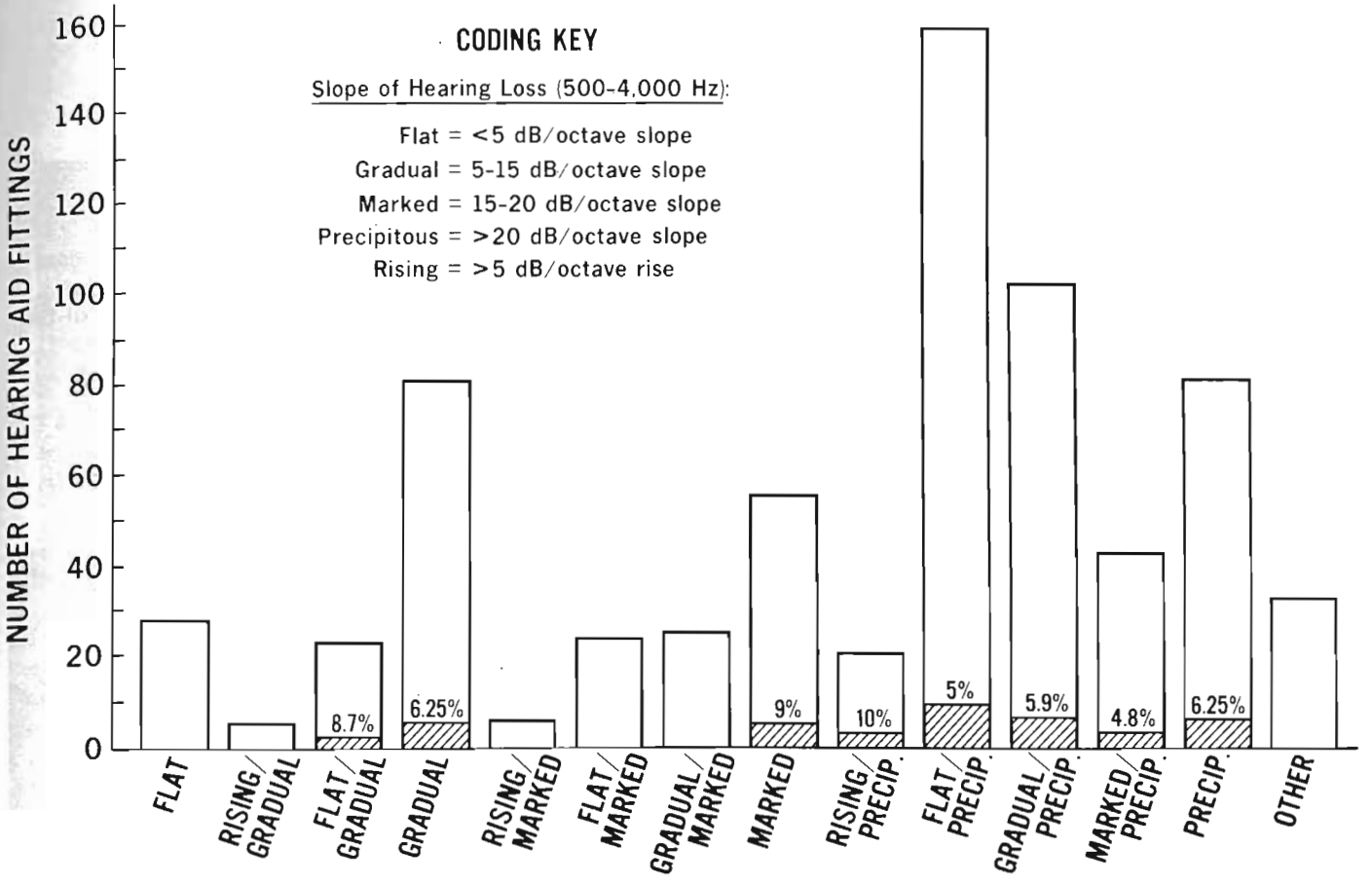

FIGURE 6.—Distribution of clinically unacceptable hearing aids returned to the manufacturer (for credit) according to the slope category of the fitting (striped area). Degree of slope increases from left to right. Percentages indicate portion of slope category that was returned. Total aids returned = 40 (6%). N = 675.

Many questions were raised at the outset of this survey. Some have been answered but definitive answers to the long-term questions of durability and user satisfaction may be available only through longitudinal studies of the issues addressed in this survey report ■

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