DOCUMENT RESUME

ED 316 976 EC 230 032

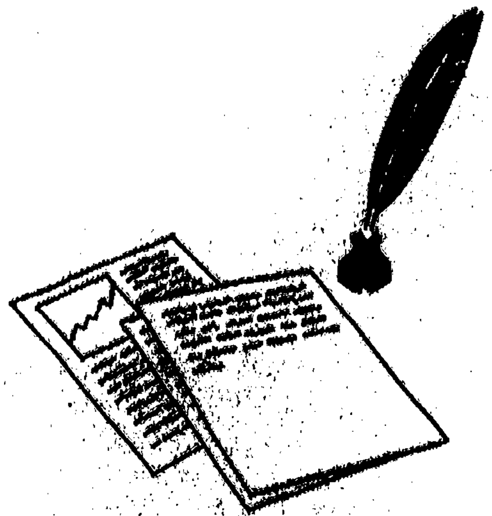
TITLE	Devices for Deaf and Severely Hard of Hearing People: An Annotated Bibliography. Working Paper 89-1.
INSTITUTION	Gallaudet Research Inst., Washington, DC.
PUB DATE	Jan 89
NOTE	43p.; A product of the Technology Assessment Program.
AVAILABLE FROM	Scientific Communications Program, Gallaudet Research Institute, 800 Florida Ave., N.E., Washington, DC 20002 ($2.00, quantity discount available).
PUB TYPE	Reference Materials - Bibliographies (131)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	*Assistive Devices (for Disabled); Communication Aids (for Disabled); Computers; *Deafness; Electromechanical Aids; Libraries; Mass Media; Sensory Aids; *Technology; Telecommunications

ABSTRACT

The bibliography contains about 200 citations related to devices for deaf and severely hard-of-hearing persons and published predominantly since 1975. Selected citations focus on devices which utilize a sense other than hearing. Articles involving obsolete technology are not included unless they appear to have some historical interest. Citations are listed alphabetically by author and include a non-evaluative abstract. Citations cover such topics as telecommunications, libraries, personal computers, vibrotactile aids, mass media, sensory aids, communication aids, video, alarm systems, tactile speech codes, telephone communication, and computer software. (DB)

Devices for Deaf and Severely Hard of Hearing People: An Annotated Bibliography

Compiled by the
Technology Assessment Program
Gallaudet University
1989



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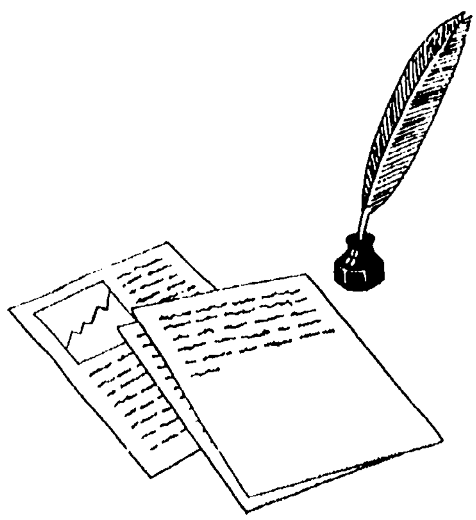

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Introduction

The literature related to devices for deaf and severely hard of hearing persons is large and diverse. Before beginning a survey of this literature it was necessary to define the boundaries. The following general rules were used to limit the items included in this bibliography:

- The search was limited to articles on devices for the deaf and severely hard of hearing which utilized a sense other than hearing. Instructional and clinical applications such as speech training aids were outside the boundaries of the study and were not included.

- Literature published prior to 1975 was not included unless it seemed especially relevant.

- Articles judged to involve technology which has become obsolete were discarded unless they were of some historical interest.

The survey of literature began with a computerized bibliographic search. Various online databases were searched and roughly 500 citations were obtained. In addition, certain sources such as the American Annals of the Deaf, Volta Review, JASA, IEEE, and RESNA Proceedings were combed. Many of the citations which were found were discarded as being beyond the boundaries of the study. The reference lists of remaining articles were consulted to see if they contained other relevant citations. Also, the Deafness Collection and Archives of Gallaudet University were searched for reports which were unpublished or might have been overlooked. Experts in the field were contacted and asked for suggestions on unpublished sources of information. Finally, brief articles in which sources of information were requested were sent to consumer journals and newsletters. As many articles as possible were located and reviewed. Relevant articles were abstracted, or their authors' abstracts accepted, and entered into a computerized database established for purposes of this project.

There was one area of the literature where the boundary rules were not strictly followed. This was the vibrotactile devices literature. Although there are relatively few vibrotactile aids on the market, there is a huge body of basic literature on this subject. For example, a review by Proctor (1984) contains more than 200 citations on this topic. Rather than duplicate bibliographic work already done, an attempt was made to focus on the most important articles and to include the various summary papers which are available. We thank Dr. Lynne Bernstein of Gallaudet's Center for Auditory and Speech Services for her guidance on this.

The final bibliography presented here contains nearly 200 citations, a reasonable and (we hope) balanced sampling of the literature, but far from a complete listing.

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Bibliography

Author not identified, (1977). Telecommunications for vocational rehabilitation. MITRE Corp., METREK Division, McLean, VA, Technical Report 7420.

This is one of several products of a project aimed at helping state rehabilitation agencies realize the potential benefits of telecommunications technology in delivering and administering vocational rehabilitation services. The general recommendation is for the establishment of a clearinghouse on telecommunications information for state VR agencies.

Author not identified, (1983). Communication aids in special education. Falls Church, VA: Educational Turnkey Systems, Inc.

One of four reports designed to assess the current state of new technologies, the document reviews technologically oriented communication aids for the handicapped. Private firms are reluctant to develop aids because of the "thin" market. Individuals and organizations develop aids with federal funds. Described are devices for the following groups of users (examples are in parentheses): (1) partially sighted (high powered lenses, television cameras and systems), (2) blind (readers, recording, Braille system), (3) hearing impaired (speech interpretation, voice recognition components), and (4) nonvocal physically handicapped (special menus on the computer display, voice recognition/microcomputer system). Six organizations which make communication devices are listed.

Author not identified, (1982). Help! Libraries and the hard of hearing. Paper presented at the Annual Conference of the American Library Association, Philadelphia, PA.

This transcript contains the text of three speeches on the problems of people with hearing impairments and the provision of library services to the hard of hearing. Howard (Rocky) Stone describes his difficulties as a hearing impaired person. Andrea Wilson discusses the special problems faced by hard of hearing people. Karen Hopkins reviews five technological devices for the hard of hearing, including: (1) amplifying devices for headsets; (2) the induction loop (audioloop) system; (3) closed-caption devices for television and captioned or interpreted video materials; (4) light devices, amplifiers, and other special devices for telephones; and (5) emergency warning systems.

Author not identified, (1982). Personal computers help the handicapped. Creative Computing 8 (3), 54-55.

Describes the winners of the Johns Hopkins competition on Applications of Personal Computing to Aid the Handicapped. Winners were Harry Levitt, Mark Friedman, and Robert Hight.

Abbott, G. D. (1987). AKL spatiotemporal representation in a tactile aid for the deaf. Rehabilitation R&D Progress Report (pp. 414). Baltimore, MD: Veteran's Administration Rehabilitation Research and Development Service.

A progress report on a series of studies to evaluate the spatiotemporal pattern recognition capabilities of the skin for conveying speech information to deaf people.

Allan, D. S. (1981). A nationwide communication system for the hearing impaired: Strategies toward commercial implementation. Menlo Park, CA: SRI International.

This report assesses the viability of developing a commercial computer communications network to provide communications services to the deaf community on a nationwide basis. Access to this network is considered for existing Baudot/Weitbrecht TDDs and ASCII terminals with Bell modems. The basic communications needs of the deaf and the potential market for a Deaf Network and Associated Services are defined. Examination of key concepts used to determine the commercial feasibility of DNAS, including supply and demand considerations and subsidy mechanisms, is followed by a review of current telecommunications provisions for the deaf, particularly Deafnet, a computer-based communication demonstration system. After discussing factors involved in a national commercial vendor-based framework for DNAS with special consideration of tariff design, the commercial performance of DNAS as it might be offered to a specific target population is evaluated. Preliminary commercial feasibility estimates are given for three alternative tariff structures and two supplier cost models. The study indicates that DNAS is likely to be commercially viable in the long-term, although initial subsidies will be required.

Applied Concepts Corporation. (1984). Telecommunication access with and within the federal government: A consideration of issues and applications for TDDs. Washington, D.C.: U.S. Architectural and Transportation Barriers Compliance Board.

This is a study of potential ways of providing telecommunications access to the federal government for persons with handicaps which inhibit or prevent their use of voice communications equipment. It recommends that a federal relay service be established which would interface between TDD users and federal offices. The annual cost is estimated at $3 million.

Armstead, K. A., & Lerman, L. (1985). System for acoustic vocational education. Proceedings of the Aid to the Disabled Session, Voice I/O Systems Applications Conference, San Francisco.

A study was conducted to see if three hearing impaired people could stabilize their voices enough to use a voice data entry system and to determine whether voice recognition systems could be a therapeutic tool in speech training. The instrument used was an Interstate VRT-101 Standalone Voice Terminal. The subjects learned to use the equipment and changes in their speech were observed, but the authors felt that it had not been adequately demonstrated whether voice recognition systems were a significant therapeutic tool.

Beachler, C. A., & Carney, A. E. (1981). Vibrotactile perception of suprasegmentals: A comparison of single-channel and multi-channel aids. Journal of Acoustical Society of America, Supplement 1, 69, S123.

The tactile percept of a speech stimulus is determined by the design of the vibrotactile aids used to deliver the stimulus. Single channel vibrotactile aids are placed at a single site on the body; the perception of vibration frequency is limited by the resolving power of the skin. Multi-channel aids perform a frequency-to-place transformation; the value of the input frequency corresponds to a particular place of the body. Two vibrotactile aids, one single- and one multi-channel, were compared with regard to their ability to transmit number of syllables, syllabic stress, and rising-falling intonation. Subjects were trained with either the single- or multi-channel device. Results indicate that these instruments transmit syllabic number and stress in a substantially different manner.

Becker, R. D. (1981). A comparison of two transforms from speech signals to tactile signals. Journal of Acoustical Society of America, **Supplement 1, 70, S53.**

To obtain a direct comparison between LPC-derived area function coding and spectral coding, naive subjects were trained successively on both coding schemes. The subjects were tested on identification and discrimination of four different C-V sounds presented to the index finger via a vibrotactile array (Optacon). The utterances were first processed to yield LPC coefficients, and then coded either in area function form or in spectral form by the use of a technical mel vocoder. The number of active vibrators was constant for all stimuli. The durations of the stimuli were approximately equal. There were five sessions per week of approximately 35 minutes each, extending for up to eight weeks. The relative merits of the coding schemes as well as the testing methods are considered.

Becker, R. D., Fluster, M., & Goldstein, M. H., Jr. (1981). Tactile reception of vocal tract shapes: A preliminary study. Journal of Acoustical Society of America, **Supplement 1, 69, 123.**

Six naive subjects were trained in identification and discrimination of four different vocal tract shapes corresponding to Russian vowels. The stimuli were presented to the index finger by means of a 6 x 24 vibrotactile array (Optacon). There were five one-half hour training sessions per week extended over four to six weeks. Three subjects achieved virtually perfect performance by the end of the training period.

Bell, D., Poza, F., Bernstein, J., & Murveit, H. (1987). An approach to telecommunication for the deaf using speech-to-text and text-to-speech conversions.

This paper describes telecommunication dialog between a hearing person and a deaf person in which the hearing person would need no special equipment and the deaf person would need only a stenotype machine and a CRT. Speech recognition and synthesis capabilities would reside in a central facility. The target is recognition of a large lexicon when spoken as isolated utterances by an arbitrary talker. The deaf user drives a text-to-speech converter that "speaks" to the hearing person over a standard telephone. Results of ongoing experiments are presented and discussed.

Bellefleur, K., & Bellefleur, P. (1979). Radio-TTY: A Community Mass Media System for the Deaf. Volta Review, **81(1), 35-39.**

An innovative communications tool called RTTY, or Radio-Teletype, provided a general news service to deaf people in the Philadelphia area. Many individuals were able to receive information simultaneously using only a teleprinter and a special RF tuner. The Radio-TTY service to the community was melded into the English courses for hearing impaired children at the Pennsylvania School for the Deaf where the broadcasts originated.

Bellefleur, P. A. (1976). TTY communication: Its history and future. Volta Review, **78(4) 107-12.**

The past, present, and future of Telecommunication Devices for the Deaf (TDDs), a system of transmitting the word-characters from one geographic location to another through electronically linked teleprinters, is reviewed. Basic review of TDD equipment and services to 1976.

Berg, F. S. (1976). Acceptance of the video articulator. Department of Communication Disorders, Utah State University, Logan, UT.

Described are basic electronic features and results of research on the Video Articulator, an electrovisual speech analyzing device which has been used in speech training for hearing impaired people. Data are presented from studies of the validity and reliability of video patterns produced by various speakers using the Video Atriculator and by the same speaker using two articulators. Results of several investigations are reported which indicated that hearing impaired persons are able to identify video patterns using the device. A target program using the Video Articulator for shaping and refining speech is explained briefly, and sensory contributions of the device (such as enabling a child to see sounds he cannot hear) are pointed out.

Berman, S. E. (1977). Vibrotactile reception and discrimination of speech signals: A comparison among body loci. Presented at the Annual International Convention, Council of Exceptional Children, Atlanta, GA.

In order to test detection thresholds and discrimination for certain speech sounds, 10 individuals received tape recorded programs of speech signals transduced into vibrotactile information. Stimuli were presented to the fingertip, palm, wrist, forearm, and thigh.

Results indicated that thresholds of detection could be elicited at all five body loci. Subjects' discrimination performances showed high intra test-retest reliability, with Ss consistently judging pairs as "same" or "different" for each body locus tested. Results had implications for use of vibrotactile stumuli with the hearing impaired.

Blaschke, C. L. (1984). Technology trends in special education. In Proceedings of the First Special Education Technology Research and Development Symposium. Washington, D.C.: National Association of State Directors of Special Education.

This article outlines microcomputer uses and trends including the changing needs in both instructional and administrative applications. Trends toward increased use of telecommunications are visible in the deaf community and more generally in the special education community through the use of electronic mail and bulletin boards. Evidence of a trend toward the use of interactive vidiodiscs is supported by the development efforts sponsored by the Department of Education. Major technology advances have occurred in the area of communication aids and devices including robotics.

Bond, S. L., & Scott, B. L. (1982). Evaluating a tactile aid on four-year-old profoundly deaf children. <u>Journal of Acoustical Society of America</u>, Supplement 1, <u>71</u>, S59.

The purpose was to develop a set of procedures for evaluating a speech reception aid on young, profoundly deaf children with limited linguistic skills. The most rudimentary level is the detection task, measuring the child's awareness of sound. The second task tests the child's ability to perceive and reproduce the syllable structure of brief utterances. The final task uses animal sounds to determine reception and production skills at a segmental level. The study ran for six weeks during which two childrenbegan the study with the aid on and then switched to aid off after three weeks. The other two children began with the aid off, then switched to aid on. Results show a statistically significant difference in the rate of learning with the aid. Data on each child illustrate the individual differences across subjects with differing linguistic skills.

Boothroyd, A. (1982). Communications aids for the deaf. In V. Stern & M. Redden (Eds.), Technology for Independent Living. Washington, D.C.: American Association for the Advancement of Science.

In this article, the author presents an overview of classes of communication aids (auditory devices, tactile devices, visual devices, and neural devices, paging/signalling and telecommunication aids). He then presents problems that need to be addressed, such as the failure of speech training aids because of inadequate attention to cognitive, linguistic, social, emotional, and educational factors. Barriers in the distribution and selection of speech aids, dissemination of information about technologies, and marketability of products are other important products. The author calls for improved interaction among technologists, researchers, teachers, and clinicians; training of professionals; distribution systems; dissemination of information; and financial support for the purchase of communication aids.

Boothroyd, A. (1984). Experiments with a wearable tactile pitch display. Proceedings of the Second International Conference on Rehabilitation Engineering combined with the RESNA Seventh Annual Convention (pp. 287-288). Bethesda, MD: Rehabilitation Engineering Society of North America.

This describes a wearable tactile device for the display of voice fundamental frequency. It has potential for functioning as a prosthetic aid to speech production and perception. Experiments show that it can be used to detect small changes in fundamental frequency and to discriminate among intonation contours.

Boothroyd, A. (1983). A tactile display of pitch period for use in sensory substitution. Journal of Acoustical Society of America, 73, S27.

A real-time tactile display of fundamental frequency was constructed. This device accepts a train of pitch-synchronous pulses from a pitch extractor and feeds them to one of eight miniature solenoids. With the index finger as the tactile input site, studies showed excellent discrimination among normal English intonation countours and between normal and abnormal contours.

Boothroyd, A. (1975). Technology and deafness. Volta Review, 77(1), 27-34.

This article provides an overview of devices (as of 1975) to help the deaf with warning, communication, education, entertainment, and the acquisition of information.

Boothroyd, A. (1970). Sensory aids research project -- Clark School for the Deaf. Pre-Congress Symposium, "Speech Communication Ability and Profound Deafness." International Congress of Education of the Deaf, Stockholm, Sweden.

A console was built containing a twin channel tape recorder, slide projector, rear projection screen, response buttons, and indicator lights. Grason-Stadler modular programming equipment controlled the console. Deaf students were given speech training through the use of this equipment.

Bourgeois, M. S., Sparks, D. W., & Kuhl, P. K. (1978). An investigation of the transmission of suprasegmental features of speech using the Multipoint Electrotactile Speech Aid (MESA). Journal of Acoustical Society of America, 64, S54.

Previous investigations of MESA have shown that subjects can correctly perceive certain segmental features of speech. This study evaluates the perception of one of the components of sentential rhythm-syllable number. Sentence stimuli of one, three, five, and seven syllables in length were videotaped. Five hearing adults were

required to "tap out" the rhythm of the sentences under three receptive conditions: (1) visual alone, (2) tactile alone, and (3) tactile plus visual. When scored for the absolute number of correct syllables, the results demonstrate significant differences for the main effects of modality and for the length of utterance.

Bowe, F. G. (1984). Personal Computers and Special Needs. Berkeley CA: Sybex, Inc.
A general discussion of how personal computers can help the handicapped. A variety of handicaps are covered and chapter 7 focuses on hearing impaired people.

Bowe, F. G. (1984). Alarms and alarm systems: Audible, visual, specialized and sensory, and personal signalling systems. Washington D.C.: U.S. Architectural and Transportation Barriers Compliance Board.
Four kinds of alarm systems are discussed: 1) audible, 2) visual, 3) specialized and sensory, and 4) personal signaling. Audible alarms are usually set at higher than speech-range frequencies. Adjustable intensity and frequency are desirable. On currently available equipment, intensity varies from 70 to 100 dB and frequency varies from 200 to 15,000 Hz. Light alarms vary from 70k to 500k candlepower and flash one to three times a second. Flashing alarm lights are believed to cause seizures in some epileptics but there is little documentation on this. Beepers, papers, vibrators, fans, and various other devices have been used for emergency signaling, but there has not been much experience and research on these devices. Almost nothing is available on personal signaling systems but TDD technolgy has potential for future development in this area. The article also gives a state-by-state summary table of alarm system codes.

Bowe, F. G. (1984). Access to information-age technologies: A report on an exploratory project examining the issue of "accessibility" for handicapped and older persons to Electronic Information Technology, Fayetteville, AK: U. of Arkansas, Rehabilitation Research and Training Center.
The project reviewed literature, surveyed manufacturers, and interviewed handicapped and elderly consumers to identify important accessibility issues with respect to the personal computer. Personal computers appear to be moving toward less rather than greater accessibility for persons with hearing, vision, mobility and learning limitations. Two critical considerations are redundancy and transparency. Redundancy is the provision of information both visually and auditorily. Transparency refers to steps which make it impossible for the machine to "know" whether information is entered directlyby keyboard or through some other input mechanism. Further work is necessary before formal standards for accessibility to information-age technologies may be formulated.

Braida, L. D., & Durlach, N. I. (1982). Comparison of two tactile speech codes. Journal of Acoustical Society of America, 71, S59.
Two methods of encoding speech for tactile displays were compared in experiments which measured the discriminability of tactile representations of short speech segments. One display represented the short-term speech spectrum in time-swept mode and used vibration amplitude to encode spectral amplitude. The other represented the vocal-tract shape derived from LPC analysis of the speech waveform and used the number of active vibrators to encode the logarithm of cross-sectional area. Results show a slight superiority for the spectral display in both vowel and consonant discrimination. Theoretical analysis of the stimuli suggests that the detailed characteristics of the tactile patterns were only crudely discriminated.

Brooks, P. L., & Frost, B. J. (1983). **Evaluation of a tactile vocoder for word recognition.** Journal of Acoustical Society of America, 74, 34-39.

Normal subjects learned to identify words through a tactile vocoder. Words were used as stimuli. In 40.5 h one subject learned 70 words and a second subject reached criterion on 150 words in 55 h. Words were identified more readily with increased experience. The features of voicing, nasality, and frication were reliably recognized, indicating the tactile vocoder will be useful in providing information to complement lipreading. Finally, subjects learned rapidly to generalize word-learning to unfamiliar speakers.

Brooks, P. L., Frost, B. J., Chung, K., & Mason, J. L. (1982). **Intelligibility of running speech using a tactile vocoder aided by lipreading.** Journal of Acoustical Society of America, Supplement 1, 72, s80.

A previous paper reported that an artificially deafened subject could identify 150 live spoken words using only the information obtained through a tactile vocoder. The subject continued word learning at approximately the same rate until 250 words were identified. Currently, the subject's performance is being evaluated through the use of (a) phrases derived from the 250-word vocabulary, (b) novel words, and (c) novel phrases composed of frequently occurring English words. With no additional training after the word-learning experiments, the subject could understand and correctly repeat (a) 81% of the phrases, (b) 75% of the words, and (c) 75% of the phrases using the tactile vocoder plus lipreading. In the lipreading condition alone (a) 59% of phrases, (b) 40% of words, and (c) 48% of the phrases were repeated correctly.

Canon, G. & Pine, C. (1983). **How to use a decoder as a demodulator too.** Educational and Industrial Television, 15 (3), 94-96.

Detailed instructions (with diagrams) are provided for adapting a Sears demodulator so that it will function as a decoder. The modification separates audio and video signals and decodes, and the parts cost only about $50. The modification should be performed by a qualified technician. Step-by-step procedures are given for modifying a Telecaption decoder to provide either A/V or RF output. (Note: this feature was designed into Telecaption II.)

Carney, A. E. (1982). **Vibrotactile perception of phonetic features of speech: A comparison of single-channel and multi-channel aids.** Journal of Acoustical Society of America, Supplement 1, 71, S59.

In an earlier paper two vibrotactile devices, one single-channel and one multi-channel, were compared with regard to their ability to transmit suprasegmental aspects of speech. Subjects with a single-channel device did significantly better than those with a multi-channel device in the identification of number of syllables in a word, syllable stress and intonation contour. As a follow-up, two additional groups of subjects were trained with the same two vibrotactile devices to recognize 20 consonants and eight vowels. Results indicated that there was essentially no difference between instruments.

Carney, A. E., Durkel, J. C., & Beachler, C. A. (1981). **An analysis of visual and vibrotactile cue interaction in speech perception.** Journal of Academy of Rehabilitation Audiology, 14, 112-123.

Two experiments were designed to answer the questions: (a) Is there any additive effect for visual and vibrotactile cues for the perception of vowels and consonants, and (b) Do these cues interact in the reception of connected discourse? Results of

the first experiment indicated a significant benefit in phoneme perception in the combined-modality condition for both vowels and consonants. Results of the latter experiment did not show any benefit for the combined-modality condition. It seems that the addition of vibrotactile cues to the visual stimulus is of limited importance when subjects are asked to perform beyond the sensory-perceptual level.

Castle, D. (1978). Signaling devices for hearing impaired people. Rochester, NY: National Technical Institute for the Deaf.
This is a brochure listing devices for hearing impaired people and giving information on where they may be purchased. It is out of date now.

Castle, D. (1977). Telephone training for the deaf. Volta Review, 79 (6), 373-378.
NTID is training deaf students to use the standard telephone and teleprinter (TTY) equipment. Two courses are available, a program that emphasizes oral/auditory telephone conversations with strangers and a program that emphasizes teleprinter conversations and prearranged codes with people who know the deaf caller.

Castle, D. (1981). Telecommunication and the hearing impaired, Volta Review, 83 (5), 275-284.
This is a general discussion of basic telephone use by hearing impaired people. Devices discussed include telecoils, built-in amplifiers, portable amplifiers, telecoil adapters, TDDs, electronic handwriters, devices for the deaf-blind, telephone coding systems, and radio paging.

Castle, D. L. (1984). Telephone training for hearing impaired persons: amplified telephones, TDDs, codes. (2nd ed.) Rochester, NY, National Technical Institute for the Deaf.
This consists of three separate books representing a textbook, student workbook, and teacher's guide. There are 14 units which make up two courses covering 10 weeks. The courses were designed to teach telephone skills to NTID students but can be adapted for other groups. Four areas are covered: Talking and listening, TDD communication, special code systems, and getting others to make calls.

Clements, M. A., Braida, L. D., & Durlach, N. I. (1982). Comparison of two tactile speech codes. Journal of Acoustical Society of America, Supplement 1, 71, S59.
Two methods of encoding speech for tactile displays were compared. One display represented the short-term speech spectrum in time-swept mode and used vibration amplitude to encode spectral amplitude. The other represented the vocal tract shape derived from LPC analysis of the speech waveform and used the number of active vibrators to encode the logarithm of cross-sectional area. Both displays were applied to the thigh via a 12 x 12 matrix of vibrators. Results show a slight superiority for the spectral display in both vowel and consonant discrimination.

Cornett., R. O. (1977). Automatic cued speech. Papers from the Research Conference on Speech Processing Aids for the Deaf, Washington, D.C.: Gallaudet Research Institute.
This article discusses the feasibility of a wearable speech-analyzing, speech-reading aid based on the principles of cued speech. It utilizes speech analysis techniques to classify the phonemes of running speech into groups that are different from each other (within groups) in appearance on the lips. These groups are identified by

"cues" delivered as visual symbols to the lip reader through an optical system similar to that of the Upton Eyeglass Lipreading Aid.

Cote, A. J., Jr. (1983). Speech images in the IBM PC. BYTE, 8 (11), 402-407.
Describes an experimental speech-input card that will permit an IBM PC to plot an image of vowel sounds. A functional description of the speech-interface card and the acquisition/transformation software is included. The system is designed to reveal phonemes (meaningful sounds) in speech. Possible applications include auditory prostheses and continuous speech recognition for hearing impaired people.

Craig, J. C. (1983). Tactile pattern recognition and its perturbations. Journal of Acoustical Society of America, 73, S26.
Tactile patterns were generated on an array of vibrators (six columns by 24 rows) and presented to subjects' fingerpads. When pairs of patterns were presented in close temporal proximity, considerable masking was produced. There was more interference when the masking stimulus followed the target (backward masking) than when the masker preceded the target (forward masking). Masking increased as the time between the target and masking stumulus decreased. Masking also increased if the masking stimulus and the target contained similar features. It was also found that reducing the amount of backward masking improved recognition of a consonant. The critical temporal variable in measures of both masking and temporal integration appeared to be the time between the onsets of the successive patterns.

Craig, J. C., & Sherrick, C. E. (1982). Dynamic tactile displays. In W. Schiff & E. Foulke (Eds.), Tactual perception: A source book. Cambridge, England: Cambridge University Press, 209-233.
This chapter reviews dynamic tactile displays, which present changing patterns of stimulation to passive skin surfaces. Most displays of this type are electrical, electronic, or electromechanical, and most are designed to present coded information. The authors summarize work with the Optacon and related devices for blind persons. Much Optacon use is related to reading ink-print via tactile transformations of scanned print. Problems related to reading rate, letter processing, and letter-group processing are explored. The import of masking phenomena for tactile displays is explored. Temporal masking of tactile stimuli is a basic and major problem in using the skin as a system for rapid processing of information. The chapter also examines perceived movement and ways of displaying movement in tactile displays.

Damper, R. I., Baker, R. G., Lambourne, A. D., Downton, A. C., King, R. W., & Newell, A. F. (1984). Educational Subtitling for deaf children. Proceedings of the Second International Conference on Rehabilitation Engineering combined with the RESNA Seventh Annual Convention (pp. 304-305). Bethesda, MD: Rehabilitation Engineering Society of North America.
Subtitling has enormous potential for the language development of deaf children. Some degree of local captioning capacity is needed for it to be effective.

De Filippo, C. L. (1982). Tactile perception. In D. G. Sims, G. S. Walter & R. L. Whitehead (Eds.), Deafness and Communication Assessment Training. Baltimore, MD: Williams & Wilkins.
This chapter is an excellent overview of tactile perception research and its applications. The limitations of the skin as a receptor are reviewed. The point is

made that because of engineering limitations, sensory aids are being developed rather than sensory substitution devices. Input is needed from a variety of channels. The kinds of information that can be transmitted through tactile devices are summarized and methods of application are discussed.

Decker, T. N., & Folsom, R. C. (1978). A tactile method of increasing speechreading abilities: Two case studies. Audiology and Hearing Education, 4, 14-18.
A rational and therapy approach for the use of a wearable vibrotactile communication channel is discussed. The two case studies involved adults who were trained to use a wrist vibrator to help them speechread.

Dickson, E. M., & Bowers, R. (1974). The video telephone. impact of a new era in telecommunications: A preliminary technology assessment. NY: Praeger Publishers.
This book examines the technology involved in video telephones. A good explanation is given of the basics of video telephones, followed by an extensive discussion of the advantages, disadvantages, and potential for future development of this technology. A chapter on video telephones and deaf people is included. Although a bit old (early 1970s), much of the discussion is still valid and can be examined in light of the technological advances of the 1980s.

Donahue, A. M., & Letowski, T. (1983). Vibrotactile performance of normal and hearing impaired subjects. Journal of Acoustical Society of America, 73, S27.
The aim of this study was to measure sensitivity of untrained subjects exposed to vibrotactile stimulation. Vibrotactile thresholds and stress-pattern recognition curves were measured with two vibrators at three body placements. The results indicate that: (1) both wrist placements were less sensitive than fingertip placement; (2) vibrator plunger size had the greatest effect in the most sensitive frequency range; (3) the hearing impaired subjects were equally assensitive as or less sensitive than normal subjects; (4) stress-pattern recognition curves were a function of body placement but not a function of plunger size; and (5) stress-pattern recognition curves for hearing impaired subjects had lower plateaus than for normal hearing ones.

Durlach, N. (1987). Tactile communication of speech. Rehabilitation R&D Progress Report (pp. 415). Baltimore, MD: Veteran's Administration Rehabilitation Research and Development Service.
This is a progress report on a project involving four areas: Methods of tactile communication, augumented Tadoma, comparison of tactile stimulators, and encoding/display problems.

Durlach, N. I., Reed, C. M., Braida, L. D., Schultz, M. C., & Norton, S. J. (1977). Research strategy for the study of tactile speech communication. Research Conference on Speech Processing Aids for the Deaf, Washington, D.C.: Gallaudet College.
The Auditory Perception Group at M.I.T. has initiated a program concerned with aids for hearing impaired people. There are four general project areas: 1) signal enhancement, 2) matching speech to residual auditory functions, 3) psychophysics of hearing impairment, and 4) tactile communication of speech. The article discusses the tactile communication of speech project and outlines the group's research plans. These plans cover three main areas: 1) Tadoma, 2) Artificial articulatory displays, and 3) Spectoral displays.

Edmondson, W. A. (1975). A new vibrotactile speech training aid. Proceedings of the International Congress on Education of the Deaf, Tokyo, 383-385.

A device is described which provides both acoustic signals to the ears and tactile signals to the hands of a deaf person. It is designed for speech training in a classroom or therapy setting.

Elliot, L., & Sherrick, C. (1976). NINCDS workshop on tactile and visual aids for the deaf. Journal of Acoustical Society of America, 59, 486-489.

This covers a conference held June 30-July 1, 1975, at NIH. Attendance was limited to current grantees and contractors who were researching tactile and visual aids. The objective was to review the state of the art in tactile and visual aids, identify pressing research, and seek consensus on evaluative procedures. Topics covered included the nature of sensory aids, subject populations, training procedures, and evaluation of aids.

Engelmann, S., & Rosov, R. J. (1974). Tactual hearing experiment with deaf and hearing subjects. Research Bulletin, Vol. 14, No. 5. Eugene, OR: Oregon Research Institute.

Past research has used two ways of providing a device which functions like an ear: (1) visual (e.g. oscilloscopic) and (2) tactual. This focuses on a tactual approach. The first tactual device was reported by Gault and Crane in 1928. This report traces various tactual devices since that time. The authors of this study hypothesized that poor training was the reason tactual devices have not worked well. They constructed a tactual vocodor and experimented with training. The conclusion was that deaf subjects can be taught to "hear" fine speech discriminations through the tactual mode. Performance correlates with practice. Equipment can be evaluated only after sufficient training. Hundreds of repetitions are needed to learn simple tactual discriminations. Learning rate increases with mastery of previous material and levels off after about a year.

Fellendorf, G. (1982). Current developments in assistive devices for hearing impaired persons. Washington, D.C.: Gallaudet Research Institute.

(Executive summary). This report is a current [1982] summary and information source for the field of assistive devices for the deaf and hearing impaired. It is intended primarily for professionals but will also be useful to consumers. Assistive devices are broadly defined to range from simple visual "doorbells" to teletypewriters to advanced concepts such as computer mail and automatic speech recognizers. Existing devices are described in the following classes: alerting and alarm systems, telephone assistive systems, personal listening systems, captioned TV, and large-room amplification systems. Descriptions are functional, in terms of the consumer-community and client needs, rather than in technical terms. In addition to existing devices, prototype new devices and trends in research and development are discussed; these include concepts such as Picturephone, computerized teletext services, speech synthesis, and speech recognition systms. Device demonstration centers and other methods of dissemination of devices for the hearing impaired are presented as models for meeting the consumer's needs to obtain and try out devices. Studies of consumer needs, preferences, and actions are summarized (nine studies are covered: 1974-1982). In light of the above material, recommendations are made for future action to improve and develop further devices and to provide better education, cooperation of the concerned parties, and dissemination of assistive devices. An appendix lists representative devices that are currently available, their prices and sources of supply.

Fellendorf, G. (Ed.) (1984). Develop and deliver! Proceedings of the First International Conference on Assistive Devices for Hearing Impaired Persons. Washington D.C.: Fellendorf Associates.

The conference brought together representatives of consumer organizations, manufacturers, dispensers, and government agencies to help hearing impaired persons. The keynote address set the direction toward bringing technology to hearing impaired children as well as adults. There is a need to acquaint hearing impaired persons, and those who serve them, with the potential value of devices already commercially available. Also suggested were ways to achieve greater cooperation between public and private organizations in research, in dissemination of information, and in actual distribution of assistive devices. The costs of research and distribution for a limited market were discussed. Suggestions were made for changes in government regulations which might encourage greater research, production, and marketing of devices. Future conferences were considered essential to continue the dialogue and to refine policies and practices relating to assistive devices.

Fluster, M. (1981). Use of multiple training paradigms for the comparison of tactile speech displays. Journal of Acoustical Society of America, 70, S53.

Two training methods were used to train separate groups of subjects. One method is the "building block" strategy, a step-by-step approach by which a subject first learns to identify small, meaningless tactile patterns and progresses to larger and meaningful structures. The other, the "holistic" strategy, immediately immerses the subject in the final step of the "building block" process. Two displays were employed, a vocoder type and a flowed spectrographic type. Building block subjects learn to identify individual tactile phonemes and words before learning phrases. But preliminary results indicate that holistic subjects can learn to identify the phrases without necessarily knowing the constituent tactile words (out of context) or even having an awareness of the phonemic structure of the words. Conclusions are drawn concerning the use of these two different training strategies for the comparison of tactile speech displays.

Foulds, R. (1986). Toward telephonic transmission of sign language for the deaf. Proceedings of the Ninth Annual Conference on Rehabilitation Technology (RESNA). Minneapolis, MN.

It was shown that it is possible to consider transmitting ASL and fingerspelling over the narrow bandwidth residential telephone network. The reduction of every fifth frame to 51 feature points combined with additional intra and inter frame differential coding provide sufficient compression to allow a data transmission rate of less than 2400 baud. This information provides sufficient trajectory information so that an animation program can interpolate missing frames and display a stick figure that can be accurately interpreted as the original message. The success of this project has led to the continuation of the effort to pursue the methods whereby the 51 points can be identified in real-time. This will allow the realization of a sign language telephone.

Freiberger, H., Sherrick, C. E., & Scadden, L. (1977). Report of the Workshop on Sensory Deficits and Sensory Aids. San Francisco, CA: The Smith-Kettlewell Institute of Visual Sciences.

Reports on workshops to promote understanding of the special problems of the visually handicapped and auditorally handicapped, and of problems in sensory aids research, development, service delivery, training, and interdisciplinary communication. Most of this report tends to focus on blindness.

Friel-Patti, S., & Roeser. R. J. (1983). Evaluating changes in the communication skills of deaf children using vibrotactile stimulation. Ear and Hearing, 4, 31-39.

Results of a 9-month study evaluating the efficacy of a vibrotactile aid, the SRA-10, with four profoundly deaf preschool children are reported. Subjects were enrolled in 30-minute tri-weekly language therapy sessions, and changes in communication skills were measured. Subjects were evaluated during one 16-week phase in which the aid was used (aid-on condition) and another 8 week period in which the aid was not used (aid-off condition). The changes were found to be significant, indicating that the vibrotactile stimulation was positively associated with the communicative act.

Fuchs, V. E. (1983). Software publication considerations and the hearing impaired. American Annals of the Deaf, 128 (5), 600-604.

Seven factors are considered in terms of their influence on computer software for hearing impaired people: (1) computers are in-place technology, (2) marketing and distribution patterns for software, (3) consumer demand for software, (4) quality, (5) timelessness, (6) basic skills, and (7) the future.

Gammel, C. L. (1980). The effects on speechreading performance of profoundly hearing impaired children when a vibrotactile signal is provided to their fingertips. Hattiesburg, MS: University of Southern Mississippi. This study investigated the use of a vibrotactile device to provide supplementary information about the acoustic signal for profoundly hearing impaired children. No significant difference was found between experimental and control groups. The vibrotactile device did not significantly help speechreading performance.

Garret, C. (1973). Selected research, development and organizational needs of the hearing impaired. Washington, D.C.: National Academy of Engineering, Committee on the Interplay of Engineering with Biology and Medicine, Subcommittee on Sensory Aids.

Sensory Aids research, development, and organizational needs for hearing impaired people are identified. Discussion of the present status of sensory aids focuses on acoustic and nonacoustic aids and points out that practical long-term utility has been extremely limited. Organizational and planning needs are demographic surveys, public information programs, multidisciplinary interaction, sensory-aid centers, and a program to promote wider uses of existing sensory-aids. Research and development needs include fundamental research on speech and language acquisition of hearing impaired children, quantification of residual perceptual capacity, improvement of diagnostic techniques, development of evaluation procedures, evaluation of existing sensory aids, and improvement of conventional hearing aids.

Gavin, W. J. & Rosov, R. J. (1984). Design report: A wearable, multi-channel, vibrotactile aid: A sensory substitution device for the hearing impaired. Wichita, KS: Research Division, Institute of Logopedics.

The profoundly hearing impaired may overcome problems of speech communication through sensory substitution. Instead of amplifying or modifying a signal to a damaged auditory system, speech signals are presented to an undamaged sensory system, the sense of touch, thereby providing the feedback loop necessary for the monitoring and correction of the individual's own speech. Speech can be perceived through the sense of touch by using a class of devices called "tactual vocoders." These devices divide the acoustic frequencies found in speech into overlapping channels and use them to operate a vibrator on the skin. The purpose of this project was to reconfigure the existing non-portable, multi-channel vibrotactile vocoder at the Institute of Logopedics to produce a smaller, wearable device for continuous daily use. The result is a portable but still bulky harness to be worn on the body and legs.

Gibbs, L. K. & Nash, K. (1983). SpecialNet: Instant Information/Communication. American Annals of the Deaf, 128 (5), 631-635.

This article describes the SpecialNet project. SpecialNet is a computer-based communication network for persons concerned with services and programs for the handicapped. Four specific areas are discussed: electronic mail, electronic bulletin boards, data collection and information management, and equipment needs.

Giddings, W. (1980). Development of a Blissymbol terminal: An interactive TV display to enhance communications for the physically handicapped. Man-Computer Communications Conference. Toronto, Ontario: Blissymbolics Communication Institute.

This paper describes a collaborative project to develop a graphics terminal which will display Blissymbol messages on a home television set. The microprocessor-based equipment is designed to accept a variety of input controls and output devices to match individual needs. The user makes selections interactively from a "page" of symbols displayed on two-third of the TV screen. The remaining one-third of the screen is available for the user's message, which can then be transmitted to other terminals in a classroom, for example, or over the telephone. The rationale for selection of the 500-symbol vocabulary and its division into pages is described.

Glaser, R. E. (1982). Telephone communication for the deaf. American Annals of the Deaf; 127 (5), 550-555.

Push-button phones generate DTMF (dual tone multiple frequency) audiotones. These phones can be used to punch out messages which can be decoded by special equipment at the receiving end. Connection is from phone to coupler to message converter and then to a terminal via a RS-232 serial port. Either Baudot or ASCII terminals can be used. The equipment is available (1982) from Telesaver, Inc., Owings Mills, Md. 21117.

Gold, B., Blandenship, P. E., & McAulay, R. (1981). New applications of channel vocoders. IEEE Transactions on Acoustics, Speech, and Signal Processing, ASSP-29, 1, 13-23.

The basic channel vocoder's speech quality can be improved (1) when the number of channels is increased and the filters are equal in bandwidth, (2) when speechlike phase variations are introduced, and (3) when the excitation spectrum is flattened. Vocoder channel signals are correlated in both frequency and time. Thus the data rate should be reducible through coding techniques which use these redundancies. Two variable-rate channel vocoder algorithms are presented. Channel vocoders can be good for processing speech in additive noise.

Goldberg, L. M. (1979). Communications technology for the hearing impaired. Bulletin of the American Society for Information Science. 5 (4), 12-13.

A brief, general review of TDDs, radio-TDDs, closed captioning, reading machines, and other specialized devices.

Goldstein, M. H. (1987). Cutaneous communication for the deaf. Rehabilitation R&D Progress Report (pp. 415). Baltimore, MD: Veteran's Administration Rehabilitation Research and Development Service.

A progress report on a project to develop a wearable tactile speech communication aid for prelingually profoundly deaf children. A primary function of this aid will be aquisition of lipreading skills.

Goldstein, M. H., Stark, R. E. (1976). Modification of vocalizations of preschool deaf children by vibrotactile and visual displays. Journal of Acoustical Society of America, 59, 1477-1481.

Three groups of deaf preschool children were trained to produce consonant-vowel (CV) syllables. One group palpated a vibrotactile vocoder-type display of the acoustic signals. One group used an analogous visual display. The third (control) group was given slide or puppet displays. In the initial sessions, all three groups were trained to vocalize in response to a "light out" signal. No displays were used. The children were then trained to pay attention to the displays and to model CV syllable series. In the final sessions all three groups of children were given a model CV syllable series and were encouraged to vocalize when given a "light out" signal. At the same time they had to attend to the tactile, visual, or nonspeech display. The acoustically driven nonauditory displays were an essential factor in the change in CV production.

Goldstein, M. H. Jr., & Proctor, A. (1985). Tactile aids for profoundly deaf children. The Journal of Acoustical Society of America, 77 (1), 258-265.

This paper treats acoustic-tactile communication aids for the deaf. Children who obtain negligible help from conventional hearing aids are of particular interest. For the prelingually deaf child tactile aids may facilitate the acquisition of lipreading, and improve vocal production. Although attempts to use tactile aids for deaf people go back many years, only recently have developments in technology led to greatly improved processing possibilities and the feasibility of aids that can be worn. Here, we report case studies in which prelingually, profoundly deaf young children used tactile aids.

Goldstein, M. H., Jr., Proctor, A., Shimizu, H., & Bulle, I. (1983). Tactile stimulation in speech reception: Experience with a non-auditory child. In Hochberg, Levitt, & Osberger, (Eds.), "Speech of the hearing impaired: Research, training, and personnel preparation." Baltimore, MD: University Park Press.

A simple wearable vibrotactile aid was built and used with a young profoundly deaf child. The aid was worn as a vest and vibrotactile simulation was provided by a bone conduction hearing aid pressing on the breastbone. The sensitivity threshold was adjustable. First, conditioning techniques were used to teach the child to respond to bells, drums, and horns. Second, the child was trained to associate speech with sounds. Third, the child was taught to associate vibrations with her own voice. The experiment was carried out when the child was 32 to 42 months of age. The device was clearly not a sensory substitute but it did offer advantages in making the child aware of sound.

Grignetti, M., Myer, T., Nickerson, R., & Rubinstein, R. (1977). Computer aided communication for the deaf. Boston, MA: Bolt, Baranek and Newman.

The authors believe that deaf people could make better use of electronic communication media, and they discuss how this could be done. TTYs are noisy and expensive. A new generation of terminals for use for communication by deaf people needs to be developed. It is suggested that a computer aided telecommunication system based on a large timeshare computer can provide a solution.

Gulian, E. (1981). Computer-based aids, motor control and speech acquisition by the deaf. In T.V. Tobias & E. Schubert (Eds.), "Hearing research and theory." New York: Academic Press.

The author begins by observing that deaf people have two problems: they cannot hear and they cannot speak. She believes "their communication problem is more of

the latter type." There follows an extensive review of methods and devices for teaching speech to deaf people. As the author admits, "This contribution may seem like a plea for oral communication in general and the use of speech aids in particular."

Harkins, J.E. (1987). Disabled Consumers: An Exploratory Opinion Survey, Joint Telecommunications Project. Princeton, NJ: Opinion Research Corporation.
Interviews were conducted with 48 hearing impaired, 20 blind, 32 physically impaired, 7 speech impaired, and 11 speech/mobility impaired people. The interviews focussed on telephone needs and services. People with different dissabilities had different attitudes toward the telephone. Nearly half the respondents said problems with telephones limited them in daily living.

Harkins, J.E. (1988). Speech-to-text for deaf people. Journal of the Voice I/O Society, 5, 1-11.
This article provides an overview of speech-to-text applications for deaf people in light of current and future technology. Three general user environments are considered: telephone communication, face-to-face communication, and television captioning. Development is hampered by small market size; deaf people will probably need to hitch a ride on the larger general market.

Harkins, J.E. (1988). Speech recognition for communication between deaf and hearing people. The Official Proceedings of Speech Tech '88 Voice Input/Output Applications Show and Conference, 2, 1, 268-270. New York, NY: Media Dimensions, Inc.
Potential applications for automatic speech recognition technology are discussed as they relate to the needs of the deaf. Two major areas of application are message relay services and captioning of live events. Message relay services allow a deaf person to call a central number via TDD or computer terminal and have an operator serve as a remote interpreter for a conversation with a hearing person. Speech recognition has the potential of automating much of this process. For the second application, captioning of live events, speech recognition may someday replace the cumbersome and expensive court stenographer system currently used.

Harkins, J. E. (1986). Speech recognition and deaf individuals. Paper presented at the Ninth Annual Conference on Rehabilitation Technology (RESNA), special session on speech recognition, Minneapolis, MN.
This paper ties together information about deaf consumers, speech recognition technology, and the general marketplace for speech in an attempt to foresee issues that will arise as the technology matures and as developers apply speech recognition for deaf-hearing communication. The paper outlines possible applications of large-vocabulary speech recognition systems; presents an analysis of assumptions surrounding estimates of possible market size; discusses consumers' functional abilities in relation to skills needed to use such a system; and presents considerations in relation to system parameters for the application of speech recognition in deaf-hearing telephone communication.

Harkins, J. E. (1983). Telecommunication in tomorrow's world. Perspectives for Teachers of the Hearing Impaired, 1(3), pp16-18.
This article briefly describes research trends in TDDs, video telephones, captioning, and speech synthesis. Gives suggestions on what schools and organizations can do to help promote awareness of assistive devices.

Harkins, J. E. & Jensema, C. J. (1988). Lifestyles of the not-so-rich or famous: Focus group interviews for consulting with disabled consumers. <u>Proceedings of ICAART '88</u> (pp. 184-185). Washington, D.C.: RESNA.

This presentation discussed the use of focus groups as a tool for assessing needs in the area of rehabilitation technology, obtaining opinions from ordinary users, learning about attitudes, and exploring service delivery. Procedures used for a focus group study involving hearing impaired people were discussed and suggestions based on experience were outlined.

Harkins, J. E. & Jensema, C. J. (1988). Toward emergency vehicle detection: Systemic considerations. <u>Proceedings of ICAART '88</u> (pp. 228-229). Washington D.C.: RESNA.

People often cannot hear the approach of an emergency vehicle siren. This article discusses the situation and offers some basic approaches to a solution: acoustic signature detection, transmitted radio signal detection, and satellite tracking.

Harkins, J. E. & Jensema, C. J. (1988). Needs for sensory devices: An opinion survey. <u>Journal of the American Deafness and Rehabilitation Association</u> (in press).

A series of focus groups were conducted with deaf and severely hard of hearing people around the United States. Each group discussed their sensory device needs in four areas: in-person communication, telecommunications, mass media, and signal systems. A variety of device needs were apparent. The most commonly stated needs were for devices to caption speech and for improved signal systems.

Hazan, P. (1982). Personal computing to aid the handicapped--the Johns Hopkins national search: New horizons. <u>American Annals of the Deaf</u>, <u>127</u> (5), 546-549.

This article describes a contest for new applications of computers to the needs of handicapped people. The objectives of the contest were to (1) focus computer power on the needs of the handicapped, (2) stimulate individual innovation, and (3) encourage individuals and organizations to work together to meet a major human need.

Henoch, M. A., & Hunt, S. L. (1981). Application of vibrotactile aid in improvement of speech production in deaf children. <u>Journal of Academy of Rehabilitative Audiology</u>, <u>14</u>, 125-140.

Two profoundly hearing impaired eight-year-old male subjects were trained on phonetic reception and identification tasks and on discrimination of multisyllabic words. The results suggest that speech perception/production training using a vibrotactile unit may be superior to the same type of training using acoustic amplification in children who have similar hearing losses.

Hutchins, J. (1988). Real-time captioning: The current technology. <u>Proceedings of the Conference of Speech to Text: Today and Tomorrow</u>, Washington D.C.: Gallaudet University (in press).

This paper presents a state-of-the-art overview of real-time closed captioning hardware and software. The background and major features of the various systems are explained.

Hurvitz, J., & Carmen, R. (1981). Special devices for the hard of hearing, deaf, and deaf-blind persons. Eoston, MA: Little, Brown, & Company.

This is a compilation of products manufactured for hard of hearing, deaf, and deaf-blind persons. Manufacturers were contacted and queried about their products. Each product and its purpose are briefly described. Price and source are given.

Imai, H., Sugawara, H., & Arakawa, T. (1977). Voice-operated toy for pitch and intensity training. Proceedings of Research Conference on Speech Processing Aids for the Deaf, Washington, DC: Gallaudet College.

A voice-operated toy is described which gives a reward when a child's voice is under a preset target. It was used on four-to five-year-old children.

Jablonski, E. M. (1967). Response latency and accuracy for vibrotactile phi and intensity of vibration in compensatory pursuit. Unpublished Masters Thesis, Miami University, Miami, Florida.

Four students served as Ss to scale magnitude estimations of five vibratory intensities and five rates of vibratory phi. Stable scales of magnitude estimation could be produced and two pairs of signals, consistently discriminated and similar in estimated magnitude, could be drawn from the scales. The two pairs of signals were then correlated with "off-target" positions. Ten students were subjects in the compensatory tracking task.

The subjects were randomly assigned to an intensity signal group and to a phi signal group. The intensity signal group maintained a lower mean response latencyand made fewer errors than the phi signal group. The overall performance of the intensity signal group supports the hypothesis that intensity signals may serve in tracking situations.

Jaffe, D. L., & Gilden, D. (1987). A robotic hand communication aid for the deaf-blind. Rehabilitation R&D Progress Report (pp. 375-377). Baltimore, MD: Veterans Administration Rehabilitation Research and Development Service.

This describes progress on the development of "Dexter," a robotic fingerspelling hand for use as a communication device by deaf-blind people. Dexter is computer-based, pneumatically powered, and made out of machined aluminum. Much work remains to be done, but progress to date appears encouraging.

Jensema, C. (1984). School use of closed captioned television. Falls Church, VA: National Captioning Institute, Inc.

In 1984, the National Captioning Institute contacted 70 of the largest schools for the hearing impaired in the United States. The average enrollment was 228 students per school. All but one of the schools had both a closed-caption decoder and a video cassette recorder. All of the schools reported that students viewed captioned entertainment video materials, and 94% thought students benefited from this. About 80% of the schools used captioned instructional materials and thought closed captioning helped improve their students reading and language skills.

Jensema, C. & Fitzgerald, M. (1981). C-C decoder sales and the "core" of the hearing impaired community. Falls Church, VA: National Captioning Institute, Inc.

The National Captioning Institute's Consumer Advisory Board interviewed 113 hearing impaired individuals. Those interviewed represented the "core" of the deaf community. They were relatively young, socially active, prelingually deafened individuals with below-average incomes. They watched an average of 3.3 hours of television per day in spite of the fact that most of them did not own decoders. The

respondents knew about closed captioning, usually from a source connected with the deaf community.Very few had heard of it through television, newspapers, or magazines. The two major reasons for not buying a decoder were 1) "too expensive" and 2) "not enough closed-caption programs."

Jensema, C. & Fitzgerald, M. (1981). A survey of captioned TV news program preference. Falls Church, VA: National Captioning Institute, Inc.

A questionnaire was sent to a random sample of people who were interested in closed-caption television. After newspapers, television news programs were the most frequently reported sources of news. About 83% of the respondents said they understood little or none of the news programs televised without captions. The only captioned news program currently available was PBS's rebroadcast of the "ABC World News Tonight" and 43% of the respondents never watched, mostly because of the inconvenient broadcast time. When given a choice, 82% of the respondents preferred a closed-captioned news program early in the evening rather than an open-captioned news program late at night.

Jensema, C. & Fitzgerald, M. (1981). Captioned films and C-C TV viewing by clubs for the deaf. Falls Church, VA: National Captioning Institute, Inc.

A sample of organizations which receive captioned films for the deaf was surveyed concerning their use of captioned films and closed captioned television. Most limited themselves to entertainment films, and only a few obtained educational films. Almost half obtain at least one film per week. Viewing was usually done on weekends, particularly Saturday night. The availability of close-captioned television does not appear to have reduced the demand for films or the size of the audience. Captioned films remain extremely popular. Close captioned television appears to have added a new dimension to the video resources available to the deaf rather than serving as a replacement for captioned films.

Jensema, C. & Fitzgerald, M. (1981). Daytime closed caption television preferences. Falls Church, VA: National Captioning Institute, Inc.

Questionnaires were sent to 500 households interested in closed captioning and 206 were returned. Over 31% of the residents regularly watch daytime television, and 80% would watch more daytime television if it were closed captioned. The most popular viewing times were noon and late afternoon. The most preferred program types for daytime closed-captioning were news, movies, soap operas, comedies, sports, and game shows.

Jensema, C. & Fitzgerald, M. (1981). The attitudes of hearing impaired viewers toward closed caption TV commercials. Falls Church, VA: National Captioning Institute, Inc.

A sample of closed-captioned television decoder owners was sent a questionnaire. Over half of the respondents said they keep their decoder turned on whenever they watch television, implying that they would see closed captions on commercials even if the regular program was not captioned. Most respondents wanted commercials to be closed captioned even if the program was not, and were more likely to watch a commercial if it was closed captioned. Closed-captioned commercials were judged to be both informative and entertaining. Only a few of the respondents found the commercials to be annoying. About two-thirds of the sample said they were more likely to buy a product if its commercials were closed captioned. Almost a third said they had changed brands because of captioned commercials.

Jensema, C. & Fitzgerald, M. (1983). The reaction of the closed caption television audience to text services. Falls Church, VA: National Captioning Institute, Inc.

A questionnaire was sent to 1,045 decoder owners and 523 responded. Of these, 462 (88%) knew how to tune in the closed caption text services. The Program Listing Update Service (PLUS), the Prudential Weekend Scoreboard, and the Text News Summary are each viewed at least once a week by 83%, 53%, and 72% of the respondents, respectively. Early evening is the most popular viewing time for the Text News Summary. About 49% of the respondents had seen text news bulletins and 95% of those who had seen them thought they were helpful. The majority wanted the text services to continue. Deaf community news was the additional service most often requested. The time most preferred was in the evening between 7:00 and 10:00.

Jensema, C. & Fitzgerald, M. (1983). Reactions to captioned news services. Falls Church, VA: National Captioning Institute, Inc.

To assess viewer reactions to the closed-captioned ABC World News Tonight, a survey of closed-captioning decoder owners was conducted. Of 1,525 closed-captioning decoder owners, 58% (886) responded. About 75% watch the captioned news every night and 96% reported that they understand the news captions. Although the speed of caption presentation is high, 69% said they liked the speed. The real-time captioning technique used leads to some captioning errors; 89% of the sample had noticed these errors, but 85% were satisfied with the captioned news and 99% wanted the service to continue.

Jensema, C. & Fitzgerald, M. (1983). The hard of hearing market for closed caption television. Falls Church, VA: National Captioning Institute, Inc.

Although hard of hearing people represent 85% of the hearing impaired population, relatively few of them have closed caption television decoders. A sample of hard of hearing people indicated that the majority turn up the volume and use a hearing aid when they watch television. Only 22% thought closed captioning would help them and 10% said they plan to buy a decoder.

Jensema, C. & Fitzgerald, M. (1983). Hearing impaired children's comprehension of closed captioned television programs. Falls Church, VA: National Captioning Institute, Inc.

This study assessed the effects of closed captioning on hearing impaired children's comprehension of television program content and determined whether closed captions were differentially effective for children of varying reading levels. One hundred hearing impaired children viewed a televised situation comedy either with or without captions. Their understanding of the program was assessed with literal and inferential test items. The closed-captioned treatment group comprehended significantly more than those who viewed the program without captions. Reading level also affected comprehension, with the availability of closed captions significantly increasing comprehension for students reading at or above the third grade level.

Jones, R. L. (1966). Telephone communication for the deaf: Speech Indicator manual. Northridge, CA: San Fernando Valley State College Leadership Training Program.

This is the manual for a telephone speech indicator. The indicator consists of a suction cup magnetic pickup wired to a portable meter which indicates sound. The suction cup is attached to a telephone handset and a deaf person can talk over the phone while receiving a simple coded response through the meter. The instructional manual is designed to accompany the Speech Indicator, a small, portable, economical ($15) device for deaf persons for telephone communication (available from Leadership

Training Program in the Area of the Deaf, San Fernando State College). The device indicates when the other party speaks, not what he says. A topic outline and sequence of instructional procedures are suggested. Materials for practice with the Speech Indicator are drawn from actual problems encountered in use of the device by previous instructors and students. Standard operating procedures are explained, as are special procedures (use of pay phone, calls through a switchboard, emergency calls). Also described are special systems for communication (number, dial code, alphabet division systems, Morse code, common amateur abbreviations, and phonetic code) and examples of Speech Indicator applications.

Kaplan, H. (1983). A vibrotactile fitting for a totally deaf adult. The Hearing Journal, 36, 21-22.

An adult who had recently lost his hearing was fitted with a vibrotactile device as a speechreading aid. A bone vibrator was coupled to the palm of the nonwriting hand with a terrycloth wrist band. The transmitter (a hearing aid) was worn in a shirt pocket with a cord traveling down the arm under a shirtsleeve. The hearing aid power control was set at maximum and the volume was set at 6 out of a range of 8. Four speechreading tests were administered. Large differences on all four tests were noted when the vibrotactile device was used in addition to visual input.

Kirman, J. H. (1973). Tactile communication of speech: A review and analysis. Psychology Bulletin, 80, 54-74.

This paper reviews attempts to present the acoustic speech signal to the skin. Explanations for the relative failure of these are examined: first, a current theory that speech is a special code necessarily incomprehensible to the skin, and second, evidence that tactile masking effects preclude analysis of speech by the skin. Both are rejected. It is suggested that the displays reviewed failed to provide the stimulus structure necessary for effective tactile perception. The stimulus requirements for perceptual organization by the skin of various levels of linguistic structure are discussed. Suggestions are then made for the future development of tactile displays of speech.

Kirman, J. H. (1982). Current developments in tactile communication of speech. In W. Schiff & E. Foulke (Eds.), Tactual perception: A source book. Cambridge, England: Cambridge University Press.

This chapter discusses deaf people's apprehension of speech as well as the capacities and potential of the skin senses. It traces the historical failures to develop a tactile display of speech information. Many such efforts were abandoned before sufficient training had taken place and without a full consideration of the capabilities of the skin as an information-processing system. The chapter examines systems as diverse as the Tadoma method and microprocessors analyzing acoustical patterns and driving electrocutaneous stimulators. The import of recent research, both basic and applied is reviewed and evaluated. Problems associated with several forms of sensory interaction as they pertain to tactile displays of speech patterns are discussed. Such problems may be circumvented by treating the skin like a slower-acting basilar membrane. The skin's apparent capacity for making sense out of coherent, two-dimensional spatiotemporal patterns unfolding over time may have been neglected in work focusing on unidimensional spatial displays.

Kopp, H. G. (1981). Future implications for technology in the 80s. Volta Review, 83(5), 350-358.

The author sees the growth of computer-assisted instruction and computer managed instruction. Hearing aid research must focus on areas which will make diagnostic/

prescriptive hearing aids an effective reality. Speech output will improve through better feedback devices. Evaluation of technology is difficult and sometimes holds back technological innovations. Tranformation of acoustic information via speech synthesizers and other devices will become more common. Mainstreaming and funding patterns could have a major impact on technology utilization.

Kravontka, S. (1975). A fire signal system for deaf school children. National Fire Prevention Association.

Suggested requirements for a visual fire alarm system for deaf children are discussed. Epileptic seizures could be generated by flashing lights at certain rates. However, the same is true of aural signals and no attention is given to this by most signal manufacturers. The recommended visual flashing rate is 100 flashes per minute with a 50% adjustment range (50 to 150 flashes per minute). The light must be bright enough to be seen by reflection. A typical classroom would require a light of about one million candlepower. Short arc xenon gas lamps are suggested. Every room, hall and stairway require a light. Because of ultraviolet radiation, the lamps should be shielded from direct vision. A suggested wiring layout is given.

Letellier, P., Nadler, M., Abramatic, J. F. (1985). The Telesign Project. Proceedings of the IEEE, 73, 4.

Telesign is designed to offer a means of visual telecommunication among the deaf community. The system consists of an edge detector followed by digital compression coding to meet channel requirements. Psychometric experiments have shown the need for 25 frame/second with a minimum definition of 128 x 128 points. Edge-detection techniques are discussed from the viewpoint of the subjective resemblance of the contoured image to the original and the intelligibility of the image sequence. A classification of edge detectors is given, based upon the position of the contour with respectto the dark/light contrast boundaries in the picture. The relationship of this classification to the quality criterion yields the definition of a new gradient display, called the "shifted gradient," with improved visual quality. The pseudo-Laplacian is analyzed. Various binary coding techniques are reviewed, and the results of compression given. A psychovisual experiment is described; the results validate the proposed approach. Guidelines are proposed for the design of a real-time device. The application of Telesign to closed-caption TV programs for the deaf viewer is also suggested.

Levitt, H. (1986). Computer voice I/O for the hearing-impaired. Proceedings of the American Voice I/O Society (AVIOS) 1986 Voice I/O Systems Applications Conference, September 16-18, 1986, Alexandria, VA.

Signal processing technology of the type used in computer voice I/O can be of great benefit to hearing impaired persons. The extent to which this technology can be of value depends on the type and degree of the hearing impairment. For the most part, the greater the degree of impairment, the greater the degree of speech processing that can be usefully employed. This paper provides a review of various sensory aids for the hearing impaired which utilize modern speech processing techniques.

Levitt, H. (1982). The use of a pocket computer as an aid for the deaf. American Annals of the Deaf, 127 (5), 559-63.

The disadvantages of TTYs include high purchase price, high maintenance cost, low communication rate, relatively inflexible in mode of operation and limited portability. This article discusses using a TRS-80 programmable pocket calculator as a substitute.

Levitt, H. (1986). Hearing impairment and sensory aids: a tutorial review. Journal of Rehabilitation Research and Development, 23 (1), xiii-xviii.

This article is divided into three sections: 1) the nature and incidence of hearing impairment, 2) speech perception by hearing impaired persons, and 3) types of sensory aids. Over 8% of the adult population is hearing impaired. Hearing impairments are divided into conductive and sensorineural. The aging process is the most common cause of hearing loss.A graph is given which shows the effects of hearing loss on the perception of speech. A table provides a scheme for classification of sensory aids according to degree of speech processing and the senses involved.

Levitt, H., Pickett, J. M., & Houde, R. A. (Eds.). (1980). Sensory aids for the hearing impaired. New York, NY: IEEE Press.

This book brings together from various sources a set of papers on the background, key developments, and central problems underlying research in the field of sensory aids. The 62 reprinted papers cover hearing aids, visual and tactual aids for speech reception, speech training aids, electrical stimulation of hearing, and current trends in basic research. Each of these parts is preceded by an introductory commentary by the editors.

Martin, M. C. (1977). Communication systems for deaf people: A review of possibilities. Journal of Medical Engineering and Technology.

This article reviews the possibilities for communication in deaf people. The various types of deafness are categorized and their associated problems briefly discussed. Communication aids are then described in greater detail in terms of the three possible modes of transmission and reception: speech, the written word, and coded signals.

Mazur, T., & Brant, I. (1986). The PC hear and now. PC World, 4, 11.

This article reviews the state-of-the-art in personal computer voice recognition systems. Such systems are used mostly in industrial and telemarketing applications. One of the best boards on the marked at this time is Votan's VPC 2150 VoiceCard (Votan Corp., 4487 Technology Dr., Fremont, CA 94538). Kurzweil recently came out with a voice terminal that recognizes 1000 words or phrases for a single speaker. It plans to have it up to 10,000 words within a year. "Parsing" is the process of determining where a word begins and ends. "Discreet speech" means a pause between words. "Connected speech" means no unnatural pause between words. "Continuous speech" means normal conversation without pauses or limited word use.

Middleton, T. (1983). DEAFNET--The word's getting around: Local implementation of telecommunications networks for deaf users. American Annals of the Deaf, 128 (5), 619-24.

This article describes Deafnet and gives a summary of its history. Survival depends on whether it is adopted by the deaf and whether national networking of local systems can be planned and carried out. (A government-supported two-year project was under way at the time the article was written.)

Miller, J. D., Engebretson, A. M. & De Filippo, C. L. (1974). Tactile speech-reception aids for the hearing impaired. Journal of the Acoustical Society of America, 56, S47.

Attempts to transmit speech to the hearing impaired through the skin are briefly reviewed. Major emphasis is on recent research by the authors demonstrating that certain phonetic features can be well recognized on the skin (voicing, nasality, and plosion) at least in isolated syllables and words. Possible directions for relevant psychophysical research and engineering development are discussed.

Miller, J. D., Engebretson, A. M. & De Filippo, C. L. (1974). Preliminary research with a three-channel vibrotactile speech-reception aid for the deaf. Talk presented at Speech Communication Seminar, Stockholm, 97-103.

The envelopes of nasal vibrations, equalized speech sounds, and throat vibrations are displayed as 100-Hz square waves on the skin of normally-hearing subjects with simulated total deafness. Phonetic features of voiced/voiceless, continuant/interrupted, and nasal/oral are discriminated well. Changes in vowel duration with changes in final consonant are clearly felt, while the tense/lax distinction of vowels is not as clear. Lipreading of 240 familiar words or randomly selected monosyllabic words with 95-25% accuracy is improved by 0-30% depending on a variety of factors.

Miyamoto, R. T., Myres, W. A., Wagner, M., & Punch, J. L. (1987). Vibrotactile devices as sensory aids for the deaf. Otolarngology -- Head and Neck Surgery, 97, (1), 57-63.

A 28-year-old deaf man's performance with a vibrotactile device was compared with the performance of a group of cochlear implant patients. The vibrotactile simulation provided benefit on most of the suprasegmental tasks, some of the segmental tasks, and supplemented lipreading skills to a modest degree. But performance was considerably below that of the cochlear implant patients.

Mulholland, A. M. (1975). A tactile modality and sensory aids. Proceedings of the International Congress of Education of the Deaf, Tokyo, 377-380.

The history of tactile research with the deaf is covered in some detail. A case study is presented on the use of the Siemens Polyfonator, a device which presents audio information via headphones and tactile information through a vocoder on the wrist.

Myers, W. (1982). Personal computers aid the handicapped. IEEE Micro, 2 (1), 27-39.

Reviews the needs of handicapped computer users and describes several systems designed to meet those needs. These systems, entered in the Johns Hopkins First National Search for Application of Personal Computing to Aid the Handicapped, are specifically designed for blind, deaf, and both vocal and nonvocal movement handicapped individuals. Entries in the visually impaired categories included reading machines, talking terminals, and braille systems. Systems for the deaf included ways to improve telephone communication, handsigning, lip-reading training, vocalization training, and alarm systems. Entries for the movement-handicapped are divided into two groups (i.e., vocal and nonvocal). For the vocally handicapped, entries include aids for activating control devices such as switches and knobs, wheelchair controls, and voice-recognition controls. Entries for the nonvocal movement-handicapped included eye-tracking devices, menu-basis computer programs, and dynamic matrix scanning and selection.

Office of Technology Assessment. (1982). Technology and handicapped people. Washington, DC: Congress of the U.S.

This report covers the results of a study requested by Congress on the role of technology in the lives of disabled persons and on problems associated with the appropriate use of technology by disabled persons. Discussions of issues are divided into three sections, one on technology, one on disabilities (demographics, definitions, assessment), and one on resource allocation. A section on policy options is organized around the following issues: (1) How can the federal government increase the probability that technologies will reach the people who need and desire them? (2) How can policies and programs be designed to encourage or assure the effective involvement of disabled people and other consumers in the development and delivery of technologies? (3) How can R & D activities be organized and funded to produce

knowledge, techniques, or devices that serve the needs of disabled people and relevant providers in accordance with the magnitude of various problem areas and opportunities? How can evaluation activities be organized? (4) How can financial barriers to the acquisition of technologies be reduced, within reasonable constraints? Can the levels and distribution of available funding be made more appropriate in relation to the level of the problems addressed? (5) How can federal policies assure an adequate number of well-trained personnel at all stages of the development and use of technologies?

Oller, D. K., Payne, S. L., & Gavin, W. J. (1980). Tactual speech perception by minimally trained deaf subjects. <u>Journal of Speech and Hearing Research</u>, <u>23</u> (4), 769-78.

The study demonstrates that, with a brief training period, deaf adolescents (N=8) can attain a high level of perceptual performance with a tactual speech system in discrimination of certain hard to lipread word pairs pronounced by both a male and a female speaker. Past research on tactual perception of speech has emphasized long-term training to achieve maximum tactual performance. This study shows that after a brief training period, deaf adolescents can attain a high level of perceptual performance using a tactual speech system to discriminate certain hard-to-lipread word pairs pronounced by both a male and female speaker. Some sounds are immediately distinguishable while others require extensive training. The reason for this may be found in the pattern perception postulate of Gavin (1924). Word patterns that result in stimulation across a greater area of skin tend to be more discriminable than word patterns which stimulate only small areas of the skin.

Perier, O., & Boorsma, A. (1982). A prosthetic device utilizing vibro-tactile perception of profoundly deaf children. <u>British Journal of Audiology</u>, <u>16</u>, 277-279.

The vibratory stimulation prosthetic device (VSPD) described by Boorsma and Courtoy (1975) was examined. It consists of a small vibrator clipped to an earmold and connected to a standard body-worn hearing aid. The vibrator and earmold are fitted to the patient's ear. The device is intended for profoundly deaf children with no residual cochlear hearing. The devices were fitted to 41 children. All wore it for 11 months, and a minority of them wore it for several years. Wearing the vibrator on the ear had advantages. The ear is protected and the vibrator is psychologically considered a hearing aid. The basic purpose of the device is to help promote speech production and facilitate language acquistion.

Perkins, R. (Ed.). (1971). Proceedings of the First National Conference on Television for the Hearing Impaired. Knoxville, TN: University of Tennessee. Southern Regional Media Center for the Deaf.

This is the report that laid the goundwork for the national closed caption television system. It contains summaries of five general sessions and five appended papers which focus on captioned television for the aurally handicapped. The first general session attempts to identify the potential hearing impaired audience in America and its demographic characteristics, and to clarify the position of the Federal Communications Commission on the question of captioned television. The demonstration of two possible television captioning techniques is discussed in the second session. The third general session has short descriptions of selected television programs shown with captions. The fourth and fifth general sessions cover establishment and implementation of captioned television. Appended are related papers, one of which points out that that the deaf audience must compete for television consideration on the basis of numbers, not need. In this report (appendix C),Schein estimates the potential deaf audience as 2 million. National Bureau of

Standards engineers estimate the simplest caption display module would be available as early as 1973 and would cost $20.

Pflaum, M. E. (1982). The California connection: Interfacing a telecommunication device for the deaf (TDD) and the Apple computer. American Annals of the Deaf, 127 (5), 573-84.

The California Senate passed bill 597 to mandate that TDDs be given out free of charge. This article gives the background and describes the process of distributing TDDs in San Diego. The TDDs distributed can communicate with computers. The article discusses this communication and its potential in education. California currently adds 15 cents to the monthly phone bill of every customer in order to cover the cost of TDDs. Two TDD models are available, the Krown Porta Printer Plus and the Plantronics VuPhone. Distribution was slow. Many people did not understand what a TDD was. A successful program to educate people was implemented. A number of suggestions are given for TDD improvement: (1) modular jack to allow TDD data to be output to a TV screen or CRT; (2) switchable baud rates, 110 and 300; (3) a standard way of handling line-wrap problems; and (4) addition of an ASCII key, a CARR RET key, and an ANS/ORIG switch.

Pickett, J. M. & McFarland, W. (1985). Auditory implants and tactile aids for the profoundly deaf. Journal of Speech and Hearing Research, 28, 134-150.

This paper reviews data on speech perception via implanted electrodes and via tactile aids. For the foreseeable future, neither approach can provide more than a modest aid to lipreading. Speech reception test results from multichannel-implanted subjects are better than for single-channel subjects. However, the best single-channel results are comparable to the best multichannel in tests using simple sentences. There is great variation among subjects with the same implant. Tactile aid performance by highly practiced subjects seems comparable to that of the better implant subjects.

Pickett, J. M. (1981). Speech technology and communication for the hearing impaired. Volta Review, 83 (5), 301-309.

A review of experimental speech aids. Items covered include Upton glasses, a color TV speech trainer, various speech movement indicators, cochlear implants, artificial speech and speech recognition systems, the processing of deaf speech to improve intelligibility, computer modeling of speech production, hearing aids with signal enhancement, and computer-processed speech for hearing diagnosis.

Pickett, J. M., (Ed.). (1977). Papers from the Research Conference on Speech Processing Aids for the Deaf. Washington, D.C.: Gallaudet Research Institute.

A collection of papers on the progress and potential applications of speech technology to aids for the deaf. The topic areas are: speech perception and speech production by the deaf and profoundly hearing-impaired; spoken language acquisition through the modalities of vision, touch, and residual hearing; speech-recoding; tactile speech devices; models of speech training; visual-speech devices; automatic cued speech; and speech-aids in schooling.

Pickett, J. M. (1982). Hearing through sight and feeling: microelectronic aids to speech and comprehension in the form of visual and tactile devices may soon be available. IEEE Spectrum, 19 (4), 37-41.

Hubert Upton began to develop an eyeglass speechreading aid in 1965. Scott Instruments built a vibrating speechreading aid to be worn on a wrist or arm.

Using the tactile sense to receive sound information is not well understood and basic research is needed. Bell Labs predict commercially useful speech recognizers in 10 years. Currently, such recognizers have a small vocabulary and confuse words, and their performance varies from speaker to speaker. Electronic speech synthesis from typed input is already fairly well developed. This article also briefly discusses a variety of speech training aids.

Pickett, J. M. (1984). Sensory Aids for the deaf: visual, tactile, and electro-auditory. Proceedings of the Second International Conference on Rehabilitation Engineering (pp. 150-153). Bethesda, MD: Rehabilitation Engineering Society of North America.

This article reviews current research and development of electronic devices which aid speech communication for the deaf. Topics include visual aids, tactile aids, and auditory nerve implants.

Plant, G. L. (1982). Tactile perception by the profoundly deaf: Speech and environmental sounds. British Journal of Audiology, 16, 233-244.

Single chanel vibrotactile aids were used with four subjects to test their lipreading performance and ability to detect enbvironmental sounds. It was concluded that the vibrotactile aids provided useful information and have several advantages.

Posell, A. (1984). Caption media for hearing impaired youngsters: What parents need to know. Silver Spring, MD: National Association of the Deaf.

The manual is intended to assist parents in improving the quality of television viewing for their hearing impaired children. Basic concepts associated with technology of captioning (e.g. open and closed captions and script editing) are described, and information and suggestions are offered that can make caption reading easier for children. Recent advances in captioning are noted, and a brief resource list for parents is appended.

Proctor, A. (1983). Tactile aids for the deaf: Applications for clinic and classroom. Folio Phoniatrica, 35, 3-4, 165.

A review of nonacoustic aids for the deaf will be presented with particular emphasis on a recently designed wearable, vibrotactile communication device. Principles underlying sensory aid development and types of nonacoustic devices will be treated in relation to conventional auditory amplification. Results of previous and ongoing clinical research with the wearable device will serve as the basis for discussion of therapeutic use, in clinic and classroom, of nonacoustic aids for the deaf.

Proctor, A. (1982). Effects of a wearable, tactile aid on language comprehension of prelingual profoundly deaf children. Workshop at the Second National Child Development Conference, Melbourne, Australia.

Factors influencing the use of nonacoustic aids (such as visual displays and tactile devices) with the hearing impaired are reviewed. The benefits of tactile devices in improving speech reading/lipreading and speech are pointed out. Tactile aids which provide information on rhythm, rate, intensity, and duration of speech increase lipreading and therefore facilitate gains in language comprehension. Reported are findings of a study in which a vibrotactile aid was used with five deaf children (9 months to 6 years old). It is concluded that the aid appears to assist with social communication and in the localization of the sound source.

Proctor, A. (1984). Tactile aids for the deaf: A comprehensive bibliography. American Annals of the Deaf, 129 (5), 409-16.

This bibliography is intended as a resource guide for teachers and clinicians. Over 200 references are listed. It is a very complete document.

Proctor, A. & Goldstein, M. H. (1983). Development of lexical comprehension in a profoundly deaf child using a wearable, vibrotactile communication aid. Language Speech and Hearing Services in the Schools, 14 (3), 138-49.

Analysis of audio and videotapes revealed an increase from an understanding of 5 words at 33 months to 469 words after 10 months of training with a vibrotactile device and traditional aural-oral teaching techinques in a deaf two-year-old. Compared to younger hearing children, she exhibited similar development patterns for rate of acquisition and stages of lexical comprehension.

Pronovost, W. L. (1978). Speech-processing aids for the deaf: International research. Volta Review, 80 (1), 41-44.

This article briefly reviews the state of the art in speech processing aids, including the Upton Visual Speechreader, a vibrotactile/electrotactile aid at the Central Institute for the Deaf, and an electrotactile belt at the University of Washington.

Redden, M. R. & Stern, V. W. (1981). Technology for independent living II: Issues in technology for daily living, education and employment. Proceedings: 1981 Workshop on Science and Technology for the HC., Washington, D.C.: AAAS.

This book is based upon group participation and presentations given at three regional workshops on science and technology for the handicapped. The first workshop focused on issues in technology for daily living. Papers presented examined such areas as daily living technology for the disabled, psychological aspects of rehabilitation engineering, technology for recreation, and technology for the living environment. The second workshop addressed issues in technology for education. Papers presented considered such areas as low-budget ideas for the visually impaired in science, modifications of effective teaching of handicapped students, robotic manupulation aids in rehabilitaion, computer-assisted lipreading for the deaf, and closed captioning of motion film for use on national television and for delayed broadcast by affiliates. The third workshop explored issues in technology for employment. Papers presented considered such topics as barrier-free office design, factors in choosing technology for the job site, access to the total work environment, and innovations in adaptive equipment and job site modifications.

Reed, C. M., Durlach, N. I., & Braida, L. D. (1982). Research on tactile communication of speech: A review. Rockville, MD: American Speech-Language-Hearing Association. (ASHA Monographs No. 20).

This paper has six sections: (1) description of Tadoma communication, (2) description of spectral displays and encoding schemes, (3) comparison of Tadoma and spectral, (4) comparison of Tadoma and lipreading, (5) use of tactile input to supplement lipreading, and (6) future research strategy. Section 2 relates most to sensory devices. The review focuses on tactile vocoders which analyze the acoustical signal into frequency bands and transforms them into tactile stimulation. Sixteen devices developed between the 1950s and 1970s are reviewed.

Reed, C.M., Rabinowitz, W.M., Durlach, N.I., Braida, L.D., Conway-Fithian, S., & Schultz, M.C. (1985). Research on the Tadoma method of speech communication. Journal of the Acoustical Society of America, 77 (1), 247-249.

In Tadoma, speech is received by placing a hand on the talker's face and monitoring actions associated with speech production. Our initial research has documented the speech perception, speech production, and lingustic abilities of deaf-blind individuals highly trained in Tadoma. This research has demonstrated that good speech reception can be achieved through the tactile sense: Performance is roughly equal to that of normals listening in noise or babble with a sign-to-noise ratio in the range 0-6 dB. It appears that the principal cues employed are lip movement, jaw movement, oral airflow, and laryngeal vibration, and that the errors which occur are caused primarily by inadequate information on tongue position.

Rhodes, N. W. (1982). An Apple talks with the deaf. BYTE Publications, Inc.

The M-1 coupler made by Phone-TTY can be used with an apple computer if there is an appropriate interface. This article gives the schematic diagram for this interface.

Risberg, A. (1975). The development and evaluation of sensory aids. Proceedings of the International Congress of Education of the Deaf, Tokyo, 88-95.

This article surveys current research and development in sensory aids. Experiments with tactile and visual speechreading aids look promising. Results show speech training aids can reduce training time and improve speech, but technology is a long way from a sensory substitute for hearing. Current development is hampered by long training times and lack of efficient feedback from users.

Rubinstein, R. & Goldenberg, E. P. (1978). Using a computer message system for promoting reading and writing in a school for the deaf. SIGCAPH Newsletter, No. 24.

A computer-based message system is used to provide written communication for students, teachers, and staff in a school for the deaf. Initial experience suggests that this is an effective way to motivate deaf children to write. It is providing a good research vehicle for studying the development of written language in deaf children.

Russell, Y., Kasner, M., Houde, R., (1986). VIDVOX: Final report on a feasibility model for a speech recognition communication aid for deaf persons. Proceedings of the American Voice I/O Society voice I/O systems application conference, September 16-18, 1986, Alexandria, VA.

The initial phase of the Vidvox Project to develop a speech recognition communication aid for hearing impaired persons has been completed. The Vidvox was conceived as a device to convert continuous speech into a stream of phonetic symbols, and to display it in a form that would allow a deaf reader to understand the speech. The initial project consisted of two parts: development of a speech recognizer to demonstrate the feasibility of the phonetic text concept, and an investigation of the human factors requirements for a hearing-impaired user. In the recognizer system acoustic-phonetic features and speech spectrum measurements were combined in a hidden-Markov model used to model phonemes in triphone context. The Human Factors Investigation explored whether deaf readers could learn to read phonemic text at useful rates, which alphabet was most easily read, what types and rates of errors could be tolerated and the effects of errors on reading rates, the best strategies for handling recognizer errors, and the effects of reading rates of prosodic information in the display.

Russell, Y. S. & Ruder, D. (1982). Vidvox, a feasibility model of a communication aid for deaf persons. Proceedings of the Fifth Annual Conference on Rehabilitation Engineering (pp. 117). Bethesda, MD: Rehabilitation Engineering Society of North America.

Vidvox is a voice recognition system which will display a stream of phonetic symbols. This article describes the characteristics it will have after it is developed. It is expected to be an imperfect system.

Saunders, F. A. (1979). Rehabilitation engineering aids and devices for persons with impaired hearing. San Francisco, CA: Smith-Kettlewell Institute.

Devices for the hearing impaired which were available or under development in 1979 are reviewed. The names and addresses of people to contact for more information are given.

Saunders, F. A. (1973). An electrotactile sound detector for the deaf. IEEE Transactions on Audio and Electroacoustics. AU-21 (3).

An electrotactile sound detector designed to help deaf persons detect and localize sounds is described. Two microphones are worn bilaterally on the head, the sounds received are converted to electrical pulses, and the pulses are fed to two electrodes applied to the forehead. Differences in intensity of the pulses permit the wearer to localize the source of the sound.

Schein, J. D. & Schiff, W. (Eds.) (1973). A field evaluation of devices for maintaining contact with mobile deaf and deaf-blind children: electronic communication with deaf and deaf-blind persons. New York, NY: Deafness Research and Training Center, New York University School of Education.

Behavioral and engineering tests were conducted to assess effectiveness and usefulness of the Vibralert, an electronic device for maintaining contact with deaf and deaf-blind children and adults. The vibrating portable signal system was used by 24 deaf and hearing parents to maintain contact with their deaf children at play outside and inside the home for a two-month period. Findings showed that the majority of the parents and children liked and used the system, and that one third of the test group indicated willingness to buy the system, despite problems encountered, which corroborated test results. The tests revealed major weaknesses in the system such as restricted range of less than 75 feet, sensitivity to moisture, erratic performance, and difficult maintenance of battery charge. Similar testing was conducted with deaf-blind adults in domestic and industrial settings using the Vibralert and another similar device, the MIT TAC-COM. The investigations showed that the Vibralert was preferred over the MIT TAC-COM in both conditions and that complaints were similar to complaints expressed in the previous field test.

Scilley, P. L. (1980). Evaluation of an auditory prosthetic device for the profoundly deaf. Unpublished master's thesis, Queen's University, Kingston, Ontario, Canada.

A vibrotactile auditory prosthetic device was shown to help the deaf: (1) identify environmental sounds, (2) improve speech production, (3) identify English words spoken "live voice," and (4) receive information complementary to that obtained through lipreading. Frequencies were ranging from 200-8000 Hz. The output was detected and transmitted to a solenoid array placed on the subject's forearm. One subject learned 150 words in 55 h and was able to generalize this learning to unfamiliar speakers. The vast majority of words were identified correctly over 70% of the time. A profoundly deaf 13-year-old learned to identify 50 environmental sounds in 12 h. Discrimination of phonemes within lipreading mouth movement

groups increased from 39% in the lipreading condition to 88% in the tactile condition. Finally, the intelligibility of the subject's speech improved 104% when vocalizations were made with vibrotactile feedback.

Scott, B. L. (1979). Development of a tactile aid for the profoundly hearing impaired: Implications for use with the elderly. In M. Henoch (Ed.), Aural Rehabilitation for the Elderly. New York, NY: Grune & Stratton.

A tactile aid to speech reception was developed and used experimentally. The author believes that in some cases of high frequency hearing loss vibrotactile stimulation may be more beneficial than amplification in sensing high frequency signals. The article concludes with ideas for the design of a tactile supplement to a hearing aid.

Scott, B. L. (1987). Development of a wearable vibrotactile aid -- phase II. Rehabilitation R&D Progress Report (pp. 417). Baltimore, MD: Veterans Administration Rehabilitation Research and Development Service.

A progress report on a project to develop a wearable vibrotactile array consisting of seven piezoelectric vibrators in one package and a power supply in another package. Phase II consists of developing a breadboard model, evaluating the model, constructing 12 wearable units, and field testing the units.

Scott, B. L. & De Filippo, C. L. (1977). Progress in the development of a tactile aid for the deaf. Journal of Acoustical Society of America, 62, S76.

Eight normal-hearing adults learned to lipread with one of two lipreading aids. Both aids relied on changes in sensation rather than locus of stimulation. One aid had electrotactile and vibrotactile transducers and the other had only vibrators for transducers. Performance was measured with delayed shadowing using ongoing text. Results indicate that the aids can enhance tracking scores and can facilitate the learning of lipreading skills.

Sherrick, C. E. (1984). Basic and applied research on tactile aids for deaf people: Progress and prospects. Journal of Acoustical Society of America, 75, 5, 1325-1342.

The introduction describes the alternative methods for replacement of the sense of hearing, the medical procedure of cochlear implants, and the sensory substitution procedures of visual or tactual displays. For the tactual displays, a listing of desirable objectives is discussed. Among these are a better understanding of the processing capabilities of the skin, the form an efficient transducer may take, and what features of speech may most profitably be extracted for processing and display to the sense of touch. The precise specification of a transducer for the tactile display is given; included is a discussion of direct electrocutaneous stimulation as a realistic alternative. A number of multichannel displays exist, and may be workable if their transducer elements can be kept small and use little energy. What is important is the deployment of a single-channel tactile aid to permit the assessment of the effectiveness of a simple sensory adjuvant for a deaf person.

Sosnowski, T.P. & Hsing, R. (1983) Toward the conveyance of deaf sign language over public telephone networks. In Bowman, B. (Ed) Proceedings of the Sixth Annual Conference on Rehabilitation Engineering (pp. 162-164). Bethesda, MD: Rehabilitation Engineering Society of North America.

This article discusses the use of low bandwidth telephone lines to transmit sign language images. Image processing, picture coding, and spatial/temporal resolution

reduction techniques are applied to images of a deaf personsigning. Specialized hardware allows selective degrading of the image in both time and space. A series of experiments were conducted to determine the minimum image quality needed to convey meaning.

Sparks, David W. (1977). A remotely activated tactual communication aid for the hearing impaired. Journal of Speech and Hearing Disorders, 42, 416-421.

The author has developed a tactile aid which enables a sender to communicate with a hearing impaired receiver within a 500-yard radius. It operates even though the transmitter is located in a different building than the receiver. The system has (1) a radio frequency (RF) transmitter, (2) an RF receiver, and (3) an electrotactile stimulator delivering up to 10 mA to the skin. The receiver and stumulator were mounted on a belt and attached to the skin of the abdomen. The device was successfully tested on five hearing and five hearing-impaired people using Morse code.

Spens, K. E., Plant, G. (1983). A tactual "hearing aid" for the deaf. In A. Cohen & M. V. D. Broeke (Eds.), Abstracts of the 10th International Congress for Phonetic Sciences. Drodrecht: Foris Publications.

A one-channel tactile aid was developed which had the following features: Battery life of 50 hours, similar in size and weight to a hearing aid, no feedback problems, and signal processing to fit skin characteristics. All subjects reported the aid helped lipreading and assisted in monitoring environmentsl sounds.

Sperling, G. (1980). Bandwidth requirements for video transmission of American Sign Language and fingerspelling. Science, 210 (4471), 797-99.

The American video telephone (Picturephone) and the British version (Viewphone) transmit a picture by means of raster scan. They require a bandwidth of 10,000,000 Hz compared with 3,000 Hz for a voice telephone. Existing phone lines and facilities are not suitable for videophone. The research in this article tries to find the bandwidth of a videophone which would have an acceptable picture quality and be within the limitations of voice grade phone lines. American TV has 525 lines, 30 pictures per second, and a 4,000,000 Hz bandwidth. This research showed that at 21,000 Hz there was 90% comprehension and at 4,000 Hz there was 40-50% comprehension of ASL signs.

Stepp, R. E. Jr. (1981). Educational media and technology for the hearing impaired learner: an historical overview. Volta Review, 83 (5), 265-274.

The history of educational media for the deaf is traced from the late 1940s to 1980, with emphasis on the government's establishment of media centers.

Stern, V. W., & Redden, M. R. (1982). Selected telecommunications devices for hearing impaired persons. Washington, D.C.: Congress of the U.S., Office of Technology Assessment.

This is a comprehensive overview of telephone use by the hearing impaired, and the history of TDD development. Particular attention is paid to special issues and concerns of hearing impaired telephone users, including telephone rate reductions, public TDDs, cost of TDDs, TDD distribution programs, and Baudot-ASCII standardization.

Stevens, G., Bell, D. W., & Bernstein, J. (1984). Telephone communication between deaf and hearing persons using speech-to-text conversion. Proceedings of the Second International Conference on Rehabilitation Engineering combined with the RESNA Seventh Annual Convention (pp. 273-274). Bethesda, MD: Rehabilitation Engineering Society of North America.

This reports on a system which allows deaf and hearing people to communicate over a telephone. A speech recognition system processes an isolated-word sentence spoken by a hearing person and displays output as a sequence of short lists of words that match the speech input. The deaf person interprets the output from contextual information and "speaks" by typing into a voice synthesizer.

Stevens-Carlson, G., & Bernstein, J. (1986). A system for telephone communication between hearing impaired and normal-hearing people. Volta Review, 367-373.

Using the technologies of speech recognition and speech synthesis, a hearing impaired person may be able to converse by voice with a normal-hearing person over the telephone using special equipment only at the hearing impaired person's end of the connection. The spoken words are processed at the hearing impaired person's end by a large-vocabulary isolated-word speech recognition system that displays a sentence lattice (sets of likely words for each word spoken). The hearing impaired person then reads the spoken material by trying to find a meaningful path through the lattice. A limited prototype was set up and experimental tests of both human and machine characteristics were conducted. The results suggest such a system may be possible with extensions of current technology.

Stevens-Carlson, G., Bernstein, J., Bell, D., (1986). Proceedings of the American Voice I/O Society voice I/O systems applications conference, September 16-18, 1986, Alexandria, VA.

A person whose speech is unintelligible to human listeners may speak consistently and distinctly enough so that an automatic speech recognizer can recognize the speech. In a pilot study, we compared the accuracy of a high performance, template based speech recognizer with that of human listeners when recognizing 40 words spoken by four vocally impaired deaf talkers. The accuracy of speech recognition of three of the four deaf speakers was more than 60% higher for the recognition device than for human listeners. A current NIH-supported project is aimed at extending the results of the pilot study to a 300-word vocabulary and at identifying categories of vocally impaired speakers who might be good candidates for such a communications aid. The speech of 80-100 impaired speakers (primarily deaf and cerebral palsy) will be analyzed. The results of the pilot study and the results from the first 17 speaking-impaired subjects of the current study are presented.

Stevens, G., Bell, D. W., Bernstein, J., (1984). Telephone communication between deaf and hearing persons using speech-to-text and text-to-speech conversions. Proceedings of the Second International Conference on Rehabilitation Engineering, June, 1984, Ottawa.

SRI has been studying a system designed to enable a deaf person and a hearing person to converse over the telephone. The hearing user speaks sentences as isolated words to a large-vocabulary speech recognizer. The output of the recognizer is displayed to the deaf user as a sequence of lists of words that match the input speech. The deaf person interprets this output from contextual information, and then "speaks" by typing to a text-to-speech converter.

Stoffels, B. (1980). A service and product whose time has come: telecommunication devices for the deaf. Telephone Engineer and Management, 84, 19, 69-73.
This article briefly traces the development of the TDD network and summarizes the TDD devices on the market in 1980.

Stoker, R. G. (1982). Telecommunications technology and the hearing impaired: Recent research trends and a look into the future. Volta Review, 84(3), 147-155.
This article discusses four areas of telephone development. Transmission quality has greatly improved, leading to much better acoustical signals. In the past, hearing aids were able to use the strong magnetic field produced by telephone receivers. Technology is making these magnetic fields obsolete and telephones will soon have non-magnetic receivers. The most promising development has been a magnetic-to-acoustic coupler to fit on a telephone receiver. An Audiometer Telephone Interface is now available. It allows audiologists to give standard tests to evaluate the performance of a hearing aid over a telephone. TDDs are becoming smaller and less bulky.

Stratton, W. D. (1974). Intonation feedback for the deaf through a tactile display. Volta Review, 76, 26-35.
This research examines the use of tactile feedback for improving the intonation of hearing impaired speakers. Voice fundamental frequency determines a mild vibratory sensation, monitored with finger or hand, which is capable of dynamically tracking the intonation contours of speech. A training program was used to teach pitch control to 12 deaf students. A panel of listeners judged before- and after-training phonation in 80% of the comparisons. This performance was maintained when tactile feedback was withdrawn and unpracticed phrases were phonated. The fleeting, transient character of the tactile patterns was the major drawback of the approach. The primary training problem was the breaking of habitually rigid and repetitive intonation patterns.

Strauss, K. P. (in press). Telecommunications issues for disabled persons: The role of federal and state regulation. In K. Seelman and J. Harkins, (Eds.), Marketplace Problems in Communication Technology for Disabled Persons. Washington, D.C.: Annenberg Schools of Communication.
A few years ago there was a major restructuring of the telecommunications industry in the U.S. This paper discusses federal and state involvement in and reaction to this restructuring. A major federal move was the Telecommunications for the Disabled Act of 1982 which set a goal of universal access to telecommunication services for disabled persons. On the state level there has been increasing state involvement in rate discounts and TDD distribution programs.

Strong, W. J., (1975). Speech aids for the profoundly/severely hearing impaired: Requirements, overview and projections. Volta Review, 77, 536-556.
A brief review of speech acquisition by children is given. The requirements of sensory speech aids for hearing impaired persons are discussed: overview of sensory speech aids that have been and are being tested is presented. Projections are made on sensory speech aids that are being developed and tested.

Stuckless, E. R. (1981). Real-time graphic display and language development for the hearing impaired. Volta Review, 83 (5), 291-300.
This article is a general discussion of the role of graphic displays in language

development of the hearing impaired. The topics covered range from TDDs to TV captioning to voice recognition systems.

Stuckless, E. R. (1983). Real-time transliteration of speech into print for hearing impaired students in regular classes. American Annals of the Deaf, 128 (5), 619-24.
A computerized stenographic system was used for classroom interpreting at NTID. This is the same general system used for live TV captioning. The system has 3.5 to 5 seconds delay and 95% accuracy. Research is continuing. There are several technical problems, one of which is lack of portability.

Torr, D. V. (1976). Cost-related decisions in the application of technology at Gallaudet College. Washington D.C.: Gallaudet College.
Gallaudet College, a liberal arts college serving the deaf, has explored educational technology as a way to improve the instructional process for deaf students. Closed-circuit television and on-line computers have been used with the effect of kindling student interest and increasing the capacity of instructors, but no formal analysis has been undertaken to see if the resulting gains in language skills merit the additional expenditures for the new technology. Television has been especially useful when used to present captioned news broadcasts and to present direct translations from sign language to written English. Despite the difficulty of measuring the outcomes of such projects, in the future, cost-effectiveness analysis will be undertaken to assess the benefits derived from the new technology.

Upton, H. W. (1968). Wearable eyeglass speechreading aid. American Annals of the Deaf, 113, 222-229.
A concept is described that uses visual symbols, representative of distinct speech features, displayed on a deaf subject's eyeglasses to aid in speech-reading. An electronic analyzer is used to extract voicing, fricative and stop information from speech. Miniature lights mounted on the subject's eyeglasses are caused to flash in synchronism with the speech to form dynamic light patterns representative of the presence of these speech qualities. The subject sees the light patterns superimposed upon the features of the speaker and recognizes speech content from the combined lip motion and light patterns. A chart is presented to show the theoretical contribution of the added light symbols to speechreading. The construction of an experimental analyzer is described and a diagram of the circuity is shown.

Vanderheiden, G. C. (1983). Curbcuts and computers: Providing access to computers and information systems for disabled individuals. In J.E. Roehl (ed.) Computers for the Disabled. Conference papers from "Discovery '83," Minneapolis, MN.
This article discusses how computers can either become a great help or a great additional handicap to the disabled. The key is gaining and maintaining access to computers and software. This access must be transparent, a term which refers to the computer's inability to tell if input is coming in through a standard or non-standard device.

Vanderheiden, G. & Scadden, L. (1986). Guidelines for the design of computers and information processing systems to increase their access by persons with disabilities. Version 2.0, Madison, WI: Trace R & D Center, University of Wisconsin.
This is a "living document" which is updated periodically by the authors as new technology becomes available. It outlines the features computers should have to make them accessable to people with various kinds of disabilities.

Weisenberger, J. M. (1987). Basic and applied studies of tactile perception. Rehabilitation R&D Progress Report (pp.418). Baltimore, MD: Veterans Administration Rehabilitation Research and Development Service.

A progress report on a project to study the basic abilities of tactile systems and examine the design and evaluation of tactile aids for speech perception for deaf persons.

Weisenberger, J. M. and Miller, J. D. (1987). The role of tactile aids in providing information about acoustic stimuli. Journal of the Acoustic Society of America, 82, (3), 906-916.

Laboratory experiments have shown that converting sound patterns to vibrotactile patterns enable many people to appreciate their acoustic environment. This article outlines a framework for describing normal listening situations as a hierarchy of tasks requiring increasingly complex analysis. This includes sound detection, environmental sound identification, syllable rhythm and stress categorization, phoneme and word identification, and comprehension of connected speech. For each of these tasks, the benefits of tactile aids are examined using data from various research studies. There is a discussion of the acoustic features which can be transmitted by a tactile aid, differences between commercial and laboratory devices, and a comparison with cochlear implants.

Weisenberger, J., Heidbreder, A., & Miller, J. (1987). Development and preliminary evaluation of an earmold sound-to-tactile aid for the hearing-impaired. Journal of Rehabilitation Research and Development, 24 (2), 51-66.

A binaural earmold sound-to-tactile aid was constructed by inserting a vibrating element into a Lucite earmold. The earmold could be vibrated at either 80 Hz, at 300 Hz, or both. Subjects were fitted with oneof these earmolds in each ear. Normal-hearing and hearing impaired subjects were tested in three tasks: sound localization, environmental sound identification, and syllable rhythm and stress. The device provided some benefit to performance, although the amounts of improvement varied across tasks and subjects.

Weller, D. R. (1988). Technology enhancements for telecommunications network for the disabled (deaf). The Official Proceedings of Speech Tech '88 Voice Input/Output Applications Show and Conference, 2, 1, 275-279. New York, NY: Media Dimensions, Inc.

Progress toward a system which will allow deaf people to converse with hearing people over a public telephone network is described. Several versions of the system, called Telecommunications Network for the Deaf (TDN), have been laboratory tested. The system utilizes off-the-shelf technology, including personal computers, voice recognizers, speech synthesizers, and telephone interface components. Software uses the UNIX operating system and the C language.

Withrow, F. B. (1976). Applications of technology to communication. Volta Review, 78 (4), 102-106.

The author defines aids as either sensory or educational. Sensory aids are those which either bypass or override the deficient sensory system. They have four charcteristics: (1) can pick up spoken words from any direction, 2) transform auditory code to a substitute sensory code, (3) are compatible with the residual hearing of the user, and (4) are reliable, portable, and cosmetically acceptable. Educational aids tend to store and retrieve knowledge. Captioning developments are discussed as an educational aid.

Wyman, R., & Eachus, T. (1974). A field test of electronic telecommunication terminals for the deaf. Final report, 1973-1974 Northeast Regional Media Center for the Deaf, Amherst, MA: University of Massachussets.

Telecommunications devices for the deaf were evaluated in social communications, business uses, and educational and general data systems uses. Approximately 80 TV Phones (tdds manufactured by Phonics Corporation) placed in the homes of deaf adults were evaluated in such areas as equipment utility and reliability and user reaction through collection instruments such as user questionnaires and electronic devices for recording cumulative time for calls. Business installation of the TV Phone was done at a Montgomery Ward's Catalog Sales Office, and use by approximately 412 deaf persons in the area was evaluated. Exploratory applications of the communications equipment in educational/systems utilization was done through the media departments of two schools for the deaf, and a university instructional technology department which examined its use as an on-line computer terminal for handicapped individuals confined to home. Users in the social setting reported advantages such as compactness and portability and disadvantages such as the lack of hard-paper copies of conversations (which TTYs provide). Utilization of the telephone catalog ordering service increased during the study period from approximately 3 orders per week to 8 to 12 orders per week. Educational uses for the TV Phone identified included continuing education programing for deaf adults.

Gallaudet University, in Washington, DC, is the world's only liberal arts university for deaf students. In addition to offering on-campus educational programs from the preschool to doctoral levels, Gallaudet is an internationally recognized center for research, program development, and consultation related to deafness and hearing loss. Gallaudet University is an equal opportunity employer/educational institution. Programs and services offered by Gallaudet receive substantial financial support from the U.S. Department of Education.