Assistive Technologies 2

Human Computer Interaction Group (HCI)

Institute of Visual Computing & Human-Centered Technology,
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Hearing aid coupling

Transmission of an audio signal to a hearing aid or cochlear implant (CI)

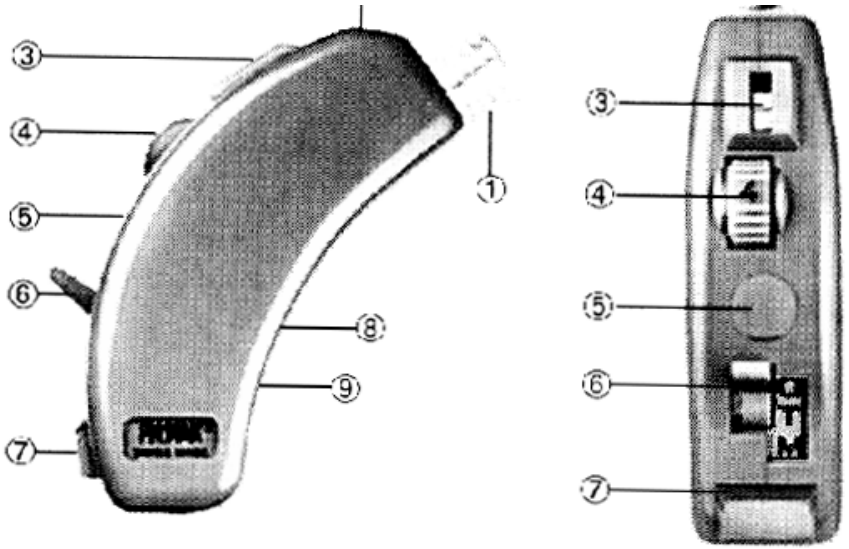
Possibilities:

- Via cable and connector
- Inductive
- Infrared
- FM radio

Inductive hearing aid coupling

Wireless transmission of an audio signal to a hearing aid or cochlear implant (CI)

Selector switch in position "T" (telephone) activates built-in receiver coil (tele coil) and usually deactivates the built-in microphone at the same time



Inductive hearing aid coupling

Coupling to the magnetic field of a telephone receiver

Coupling with a stationary fixed in space induction loop

Coupling to a body-worn induction loop (neck loop)

Induction receiver (Induktionsempfänger)

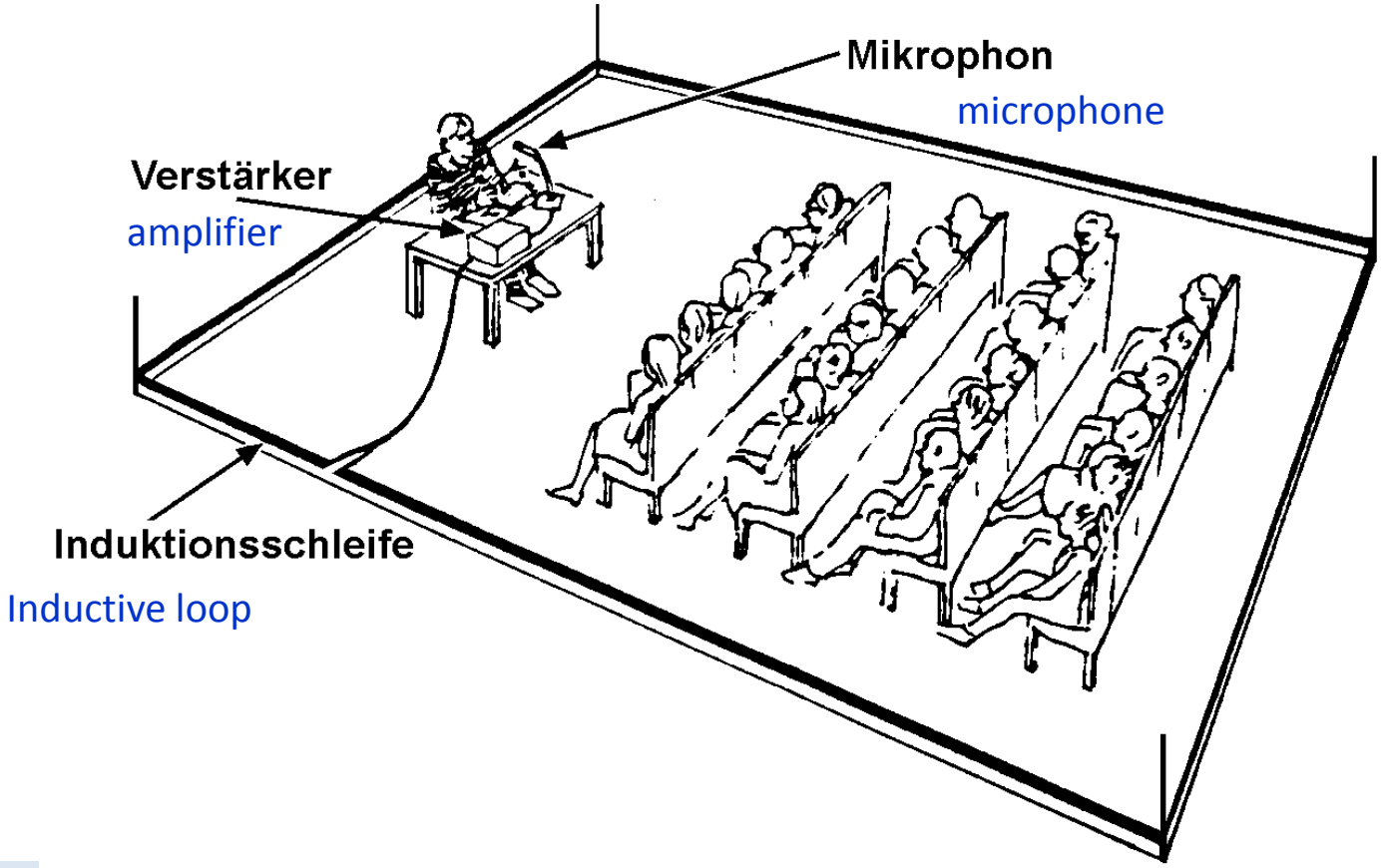
Receiver coil (telecoil) installed in the hearing aid
Prerequisite is sufficient space for the component (OK for BTE devices, but problems with ITC and CIC devices)
Switch position "T" - Telecoil or telephone (to receive the signal of the induction loop, usually the built-in microphone is switched off)
Optional switch position "TM" (has also microphone activated)
Alternatively, a headphone with induction receiver or a dedicated own ITC induction receiver can be used

If the microphone is turned off, it can also have the disadvantage of leaving all other sources of sound (such as what the next-of-kin at a conference contributes to the discussion) completely blanked out.
For children in classrooms equipped with an induction loop, it may be important to be able to hear their own voice through the hearing aid. In some situations, this may require frequent toggling between the "T" and "M" positions.
Hearing aids with a switch position "TM" (microphone and telecoil) offer a compromise here.

ITC induction receiver that can be carried in the ear canal

Stationary (fixed) inductive loop

(Ortsfeste Induktionsschleife)

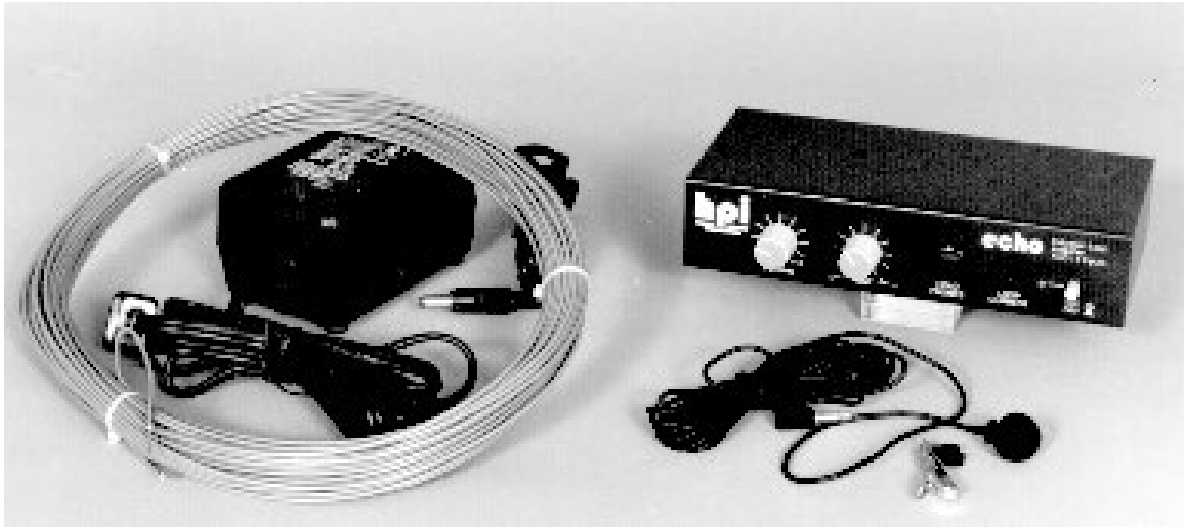


Induction loops

Ring line, optimal in head height, but also floor is possible

Whole room or part area

Always provide empty conduit / piping (Ger: Leerverrohrung)

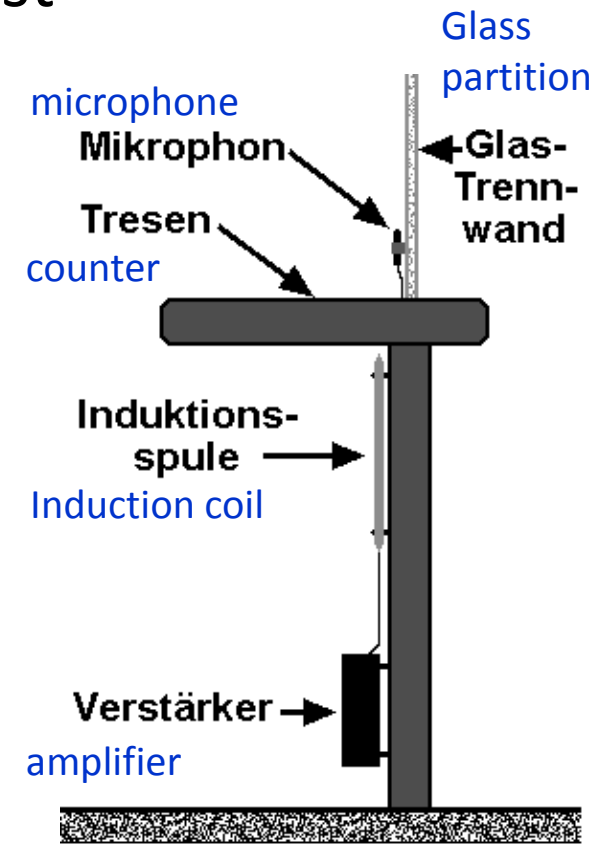


Induction loop in customer areas

For customer counters (e.g. bank, post office, ticket counters)

Laying in the ground is not always easy

Alternative: loop in the wall of the switch



Induction loop in the wall of a sales counter (Lic Audio)

Dimensioning

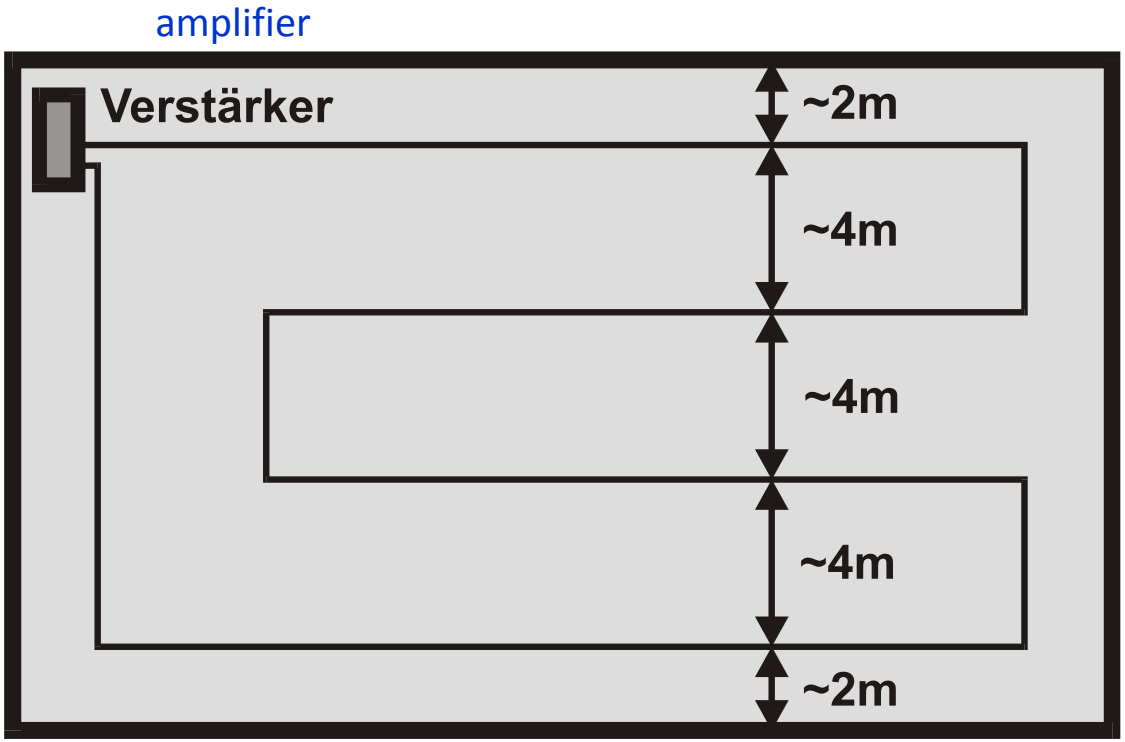
Field strength determined by IEC 60 118-4
at 100 ± 30 mA / m at 1.2 m height
Upper cutoff frequency (Grenzfrequenz) at least 5 kHz

Wire gauge (Leiterquerschnitt):
for fixed installations 1.5 to 2 mm^2
for mobile systems 0.5 mm^2

Typical laying pattern for larger rooms

Distance between the conductors should not exceed 4 m

Laying in several loops



Power requirement for an induction loop

Details of the total power in watts for certain loop areas

maximum floor area of the induction loop [m^2]	**amplifier power [W]**
Maximale Fläche der Induktionsschleife [m^2]	**Verstärkerleistung** [W]
50	20
100	35
250	100

Induction loop worn on the body

When a lecture hall is not equipped with a stationary induction loop, there is still the possibility to use the inductive coupling to the hearing aid:

- As a "neck loop" around the neck
- As a "ear hook" (silhouette inductor) behind the BTE hearing aid

Infrared transmission systems

Use of modulated infrared light,

Mostly AM with 95 kHz carrier

Receiver:

- Own headphones or
- receiver with inductive coupling

Kompakt-
Regieeinheit SE6

IR-2-Kanal-Empfänger mit
HdO-Hörerkombination, Audio-Y-Kombination
und Kopfhörer

Properties of infrared systems

Advantages:

- Easier / faster to set up than induction loops
- Good privacy (no eavesdropping from outside)
- Multi-channel operation possible (induction systems only single-channel).

Disadvantages:

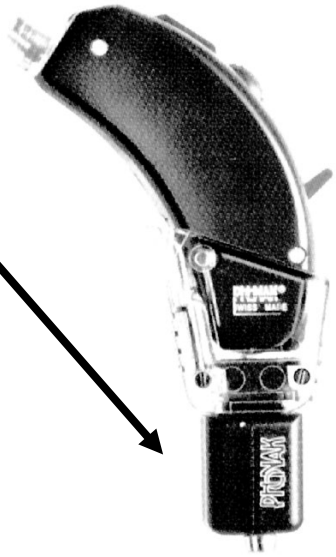
- Connection with a hearing aid often difficult to handle
- Receiving only with visual contact (problem of shading in close seating)
- Disturbances due to direct sunlight possible

FM Transmission Systems

Radio connection to the hearing aid / CI

Usual frequencies between 138 and 217 MHz

Own receiver or BTE additional module



Properties of FM Systems

Advantages

- Good value for money
- Easy installation (even spontaneous use of a system brought by the hearing impaired person is possible)
- No shadowing or interference from sunlight as with IR systems

Disadvantages

- Interference from other radio signals is possible
- No security against eavesdropping
- Not standardized

11: Replacement for hearing

Target group are people without usable residual hearing (German: Hörrest)

Imparting information tactile or visual

Tactile (haptic) mediation:

- bandwidth only about 1/100 of hearing, hence in general (only as) addition to lip reading

Visual mediation:

- simple optical signals
- visually displayed text
- visually represented phonemes
- (synthetic) sign language

VC&HCT

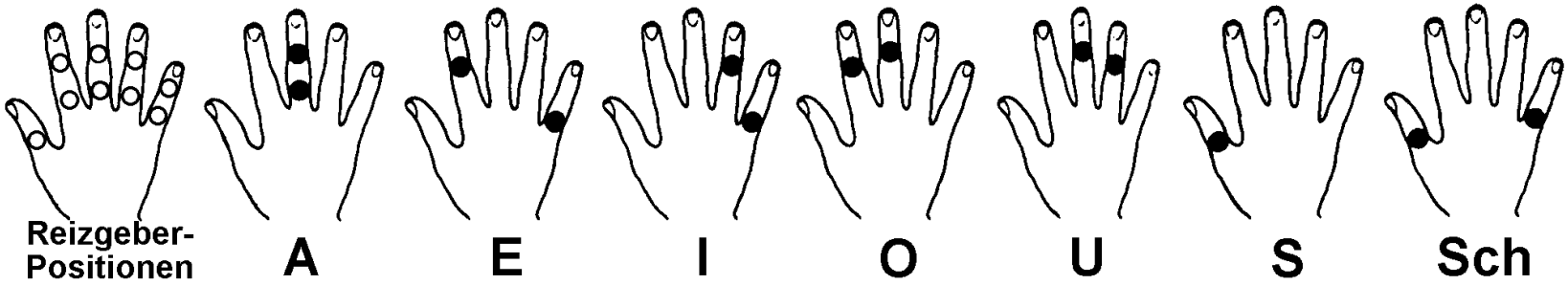
Vibrotactile hearing prostheses

Attempts for this since 1920

1950 experiments at MIT by Norbert Wiener (founder of cybernetics)

Distribution of the speech signal by bandpass filter in several channels or signal processing

Several vibrators in 9 different positions



Vibrator positions

Local stimulus patterns for the German language (selection)

Such systems provide useful results only in connection with lip reading. Only with much more complex preprocessing (such as automatic speech recognition) there is a chance to get along without lip reading

Simple vibrators

MiniVib-4: simple vibration system

Allows deaf person to become aware of environmental noise through vibration

Vibrator also follows the rhythm of a conversation and the amplitude of the voice - support in lip reading

Currently only commercially available device of this kind

VC&HCT

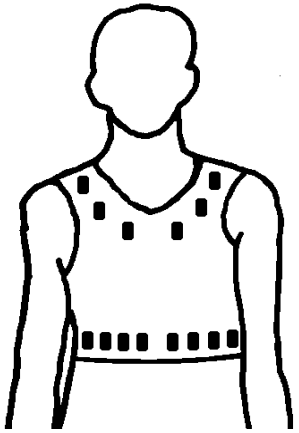
Mechanocutaneous Sound Communication (MKS)

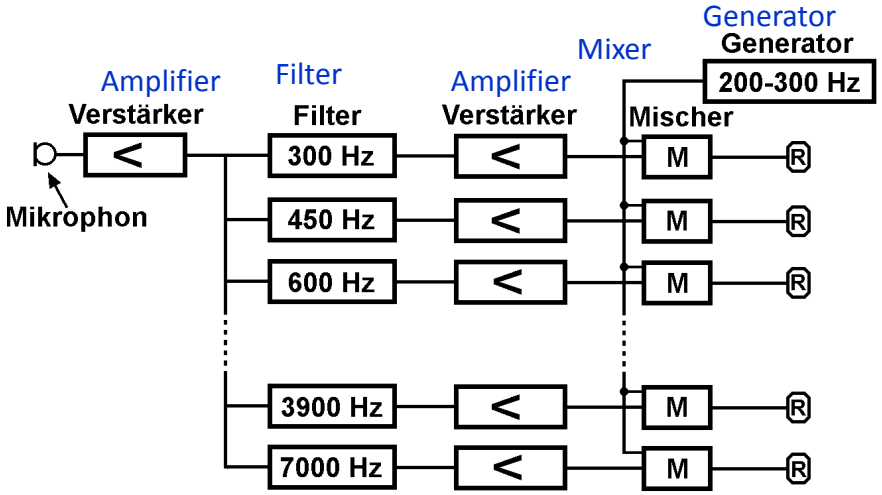
(MKS-Verfahren - Mechanokutane Schallvermittlung)

Developed by Pfalzinstitut (Germany)

Stimulus vest with 14 channels

For schoolchildren without residual hearing





Source (German & English): https://www.uzh.ch/orl/dga-ev/publikationen/zfaudiologie/archiv/AudAk_1986_25-1_032-036_Original.pdf
Breiner, H.L.: Das Verfahren zur mechanokutanen Schallvermittlung (MKS) Pfalzinstitut Frankenthal 1984

Results with MKS method

Recognition rate in identifying monosyllabic words (Göttinger Kindersprachverständnis-Test)

Type of presentation

Recognition rate of monosyllabic words in %

Art der Präsentation	Erkennungsrate einsilbiger Wörter in %
Nur auditiv (only auditory)	2,5
Auditiv zusammen mit Mundbild (Auditory with mouth picture)	69,8
Auditiv mit MKS (Auditory with MKS)	40,5
Auditiv mit Mundbild und MKS (Auditory with mouth picture and MKS)	82,4

Imparting via tactile displays

The fingertips are best suited for the tactile perception of acoustic signals.

Experiments with one or two-dimensional tactile displays (similar to Braille displays) matrices in the size 3x16 and 4x16 pens

Tactile representation of sound patterns

Significant improvements in lip-reading performance were observed in experiments

But: Without lip reading, the recognition rate did not exceed 55%

Tactile imparting after Automatic Speech Recognition (ASR)

Representation of tactile letters after automatic speech recognition

Requires high concentration

Probably without practical use

(as communication speeds are much lower than the usual speech rate and the required concentration in recognizing the characters is extremely large)

Visual imparting via optical signals

Communicating the speech rhythm and voicing (German: Stimmhaftigkeit) of the language optically.

1967 Hubert Upton experiments with a wearable analog computer ("wearable computing")

Representation of some speech parameters (voicing, frication) in a spectacle display

Experiments in Sweden with powerful microprocessors to work out additional significant speech parameters and display in glasses.

Visual imparting via text - subtitles

Manual subtitle generation

- The content of a lecture (or conversation) can be conveyed to deaf persons through presentation as text
- Technical term "Closed Captioning" (CC) - "Production of subtitles for a limited circle of users" (not visible to all)
- During lectures, speeches etc. the text is written by a hearing person
- Display (in real time) on monitor or display

Real-Time Captioning

Use of machine shorthand technology (Technologie der Maschinen-Stenographie)

Comes from the court and parliament shorthand

Capturing whole syllables with a stop

Transcription in full text is done via computer

CAN - Computer Assisted Notetaking

Performance: up to 225 words / min or 18 characters / sec

Remote Notetaking: Writer does tele-work over a data connection

Subtitle creation with Automatic Speech Recognition (ASR)

Although not yet generally in use, but already available as a commercial service

Speaker dependent, previously needed training

Either the lecturer him/herself or as an aid to the person who creates the subtitles and dictates instead of writing in the computer and controls the result

Do not forget: Lower phonetic competence (German: geringere Lautsprachkompetenz) of many deaf persons. A literal transfer in subtitles often unhelpful

Visual imparting via phonemes

Automatic speech recognition (ASR) is not yet error-free.

To assist deaf persons, orthographically correct transcription is not required.

Alternatively, transcription into a phonetic representation: phonetic script (German: Lautschrift)

Technically much easier, because the phonetic "vocabulary" is lower

Increase the recognition performance

Less delays - better in sync with the image of the lips

Visual imparting via sign

Human sign interpreter

- Teleworking via data line
- Mobile use via video telephony possible

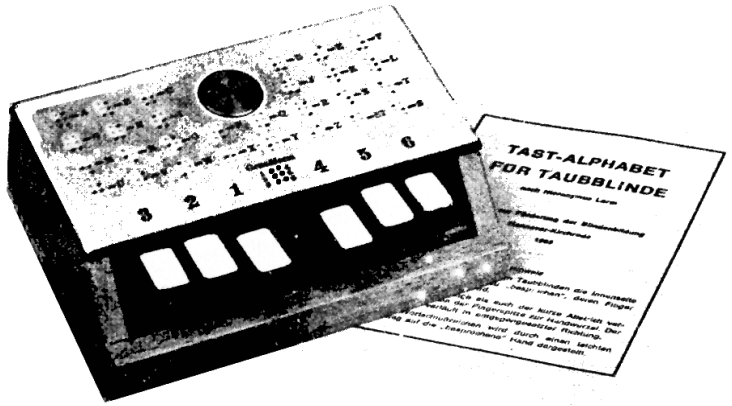
Using ASR and animated computer graphics (Avatar) e.g. for talks at the customer counter

12: Replacement for hearing and seeing

Direct communication with deafblind persons

Braille communication

Mechanical Braille communication device



Using a specific type of "Braille typewriter" in which the "speaker" operates a Braille keyboard. (Note: Braille skills so necessary for the speaking person). In contrast to the Braille sheetfed machine, however, no sheet of paper is embossed here, but the pens of a Braille display are moved. Braille displace is facing towards the deafblind person who scans directly from the pins.

Electronic Braille communication device

"DIALOGOS"

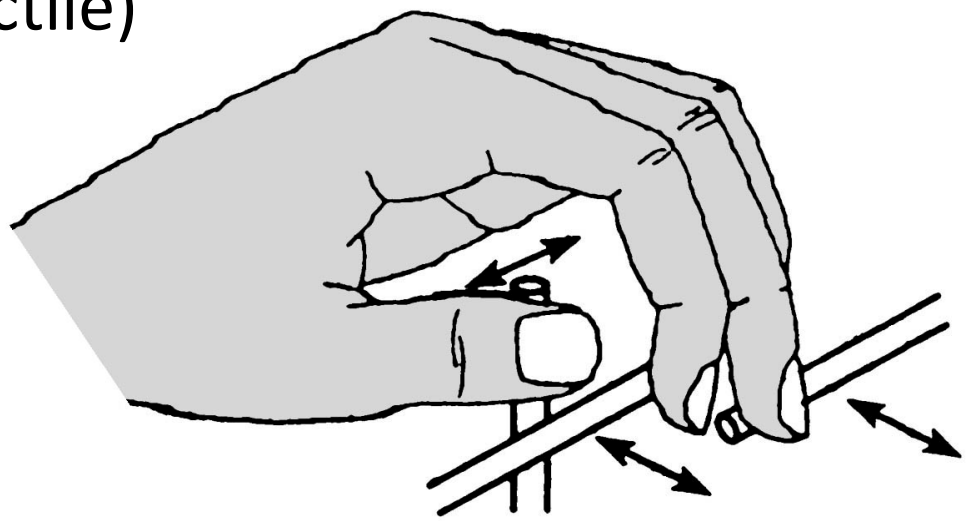
Electronic typewriter
Braille keyboard with
vibrating buttons

While the use of the above-mentioned mechanical communication device requires Braille knowledge also on the non-disabled person's side, a system called DiaLogos coming from Finland circumvents this problem by the non-disabled communication partner using a conventional electronic typewriter, from which a Braille Display is controlled. The special feature of the display used is that the six Braille points are not transferred to a fingertip, but by vibrators on each of three fingers of the two hands.

The Tactuator

A mechanical replica of the TADOMA method, which is used successfully (albeit with a lot of training) by deafblind people to read spoken language via the sense of touch in real time from the face of the person speaking.

Sensing of vibrations (tactile)
and movements (haptic)
of three bars
Information transfer
around 12 bit/s



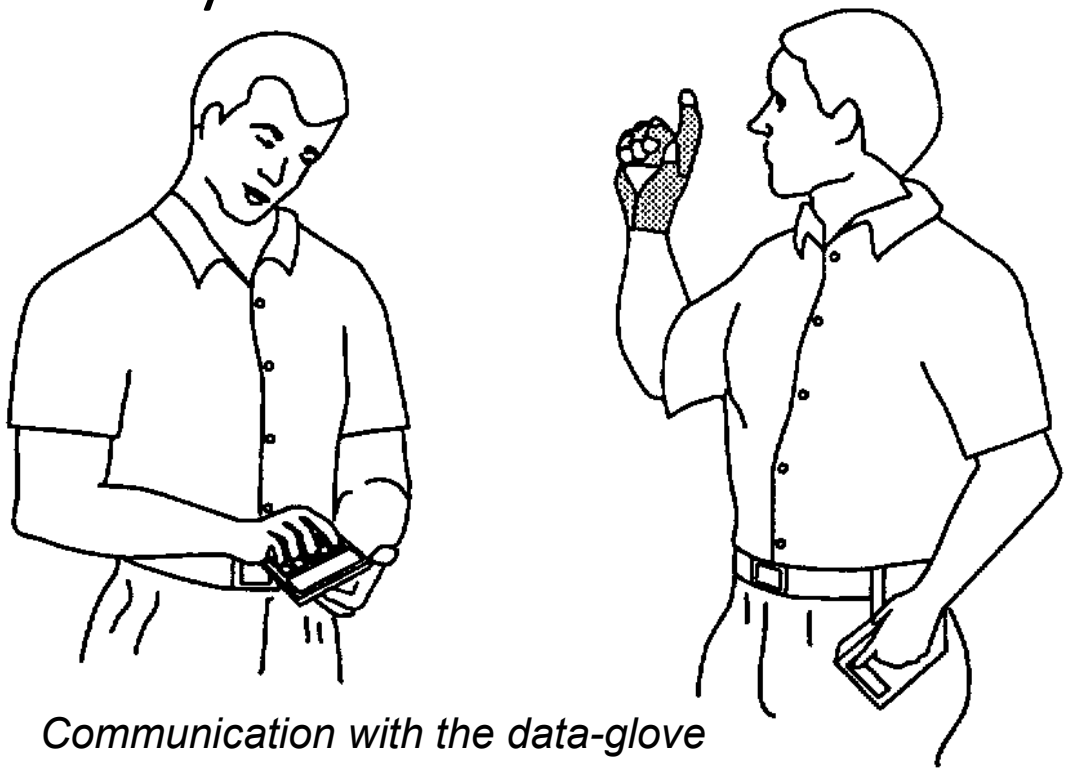
Hand position on feeling the haptic and vibro-tactile stimuli of the "Tactuator"

Communication via finger alphabet, text and braille

Deafblind person uses data glove for finger alphabet and reads from a braille display

Non-disabled person uses keyboard and LCD display

Wireless connection between the devices



Communication with the data-glove

Communication via tactile Morse code

Easy to implement is the use of vibro-tactile transmitted Morse code

13: Augmentative and alternative Telecommunication

13.1 For hearing impairments

Telephone sound amplifier (originally for landline phones) (Telefon Hörverstärker)

Essential support for hearing impaired persons with hearing loss between 35 and 80 dB

Each telephone handset already delivers 30 dB more than usual personal conversation (at about 1m distance) - already sufficient solution for up to 35 dB hearing loss (HV)

With additional (higher) gain a limiter (AGC, clipping) must be present to never exceed pain threshold

Frequency adjustment (as hearing aid) is not made

Standards concerning telephone sound amplifiers

ETSI (European Telecommunication Standards Institute) ETS 300 488 (1994)

Telephony for hearing impaired people; Characteristics of telephone sets that provide additional receiving amplification for the benefit of the hearing impaired

For predominantly use by a hearing-impaired person:

settings should be maintained after the end of the conversation

In mixed use:

Automatic return to normal gain after end of call

Gain of 20 dB and attenuation of 15 dB should not be exceeded

Telephone amplifier for occasional use

As add-on for the landline telephone receiver

Receiver with added amplifier (discontinued)

Improvement of the understanding

Not only the absolute volume but the ratio of useful signal to noise is of importance for clarity
(e.g. Closing of the second ear while telephoning in noisy environment)
Due to the "side tone" (each telephone device intentionally diverts a part of its own voice directly to the own earpiece), the noise also reaches the earpiece
Therefore, it is also advantageous to cover the microphone while listening or to use a PTT (push-to-talk) switch.

Telephone receiver with bone conduction

In the receiver a sound transducer for structure-borne sound is installed.
Is held behind the ear to the bone.

Electrical hearing aid coupling

Acoustic coupling "Telephone handset" and "hearing aid" always associated with disadvantages

- Frequency selective losses
- Tendency to feedback (generation of an acoustic short circuit by the telephone receiver held to the ear)
- Presence of background noise

Direct electrical connection to the hearing aid thus creates better conditions for several reasons.

Electrical coupling - standards

ETSI standard ETS 300 679 (1994)

Bandwidth should be 315 Hz to 4,000 Hz. If necessary, a frequency band limitation to be provided

The signal should be taken from the connection to the telephone receiver (handset).

It must not be possible to feed a signal into the telephone system.

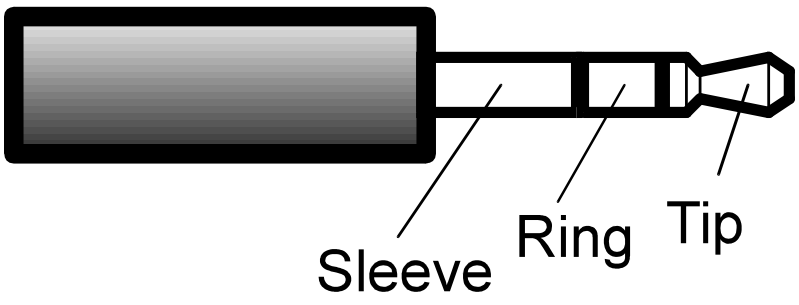
Load of the output assumed to be 2 kOhm.

The output must be electrically isolated

Realisation of the electrical coupling

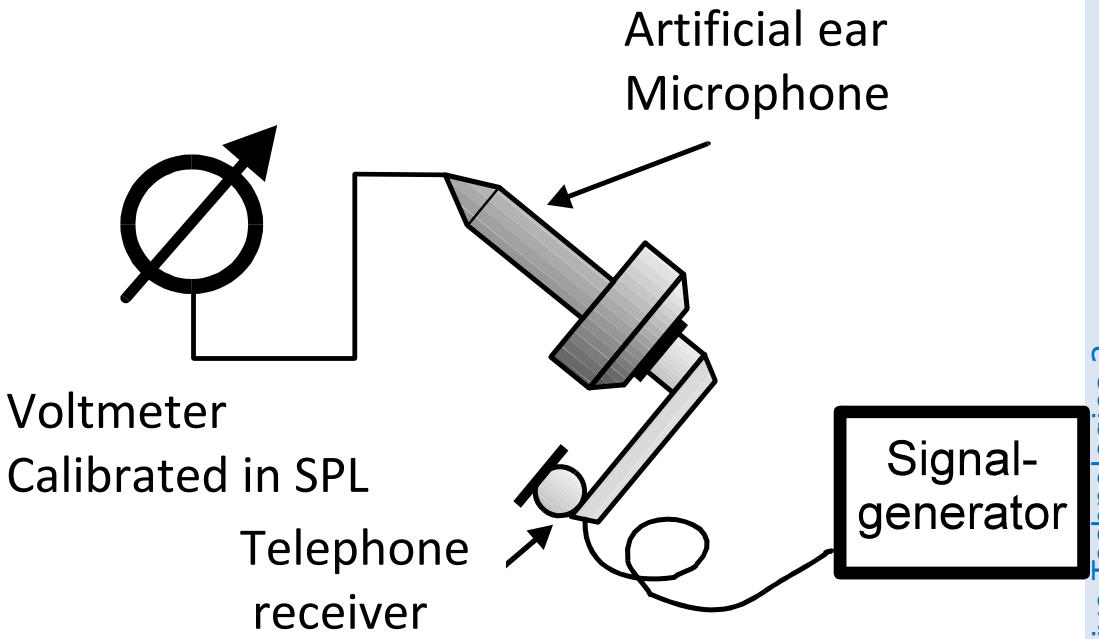
On the side of the hearing aid: Audio Shoe (DAI = Direct Audio Input)

On the side of the phone: 3.5 mm stereo jack plug (socket on the phone, not in horizontal surfaces to avoid contamination) signal on "tip" and "ring", screen (optional) on "sleeve"



Level measurement - level adjustment measuring circuit:

- Set the generator so that the voltmeter reads 14 dB Pa SPL
- Then at 1 kHz at the audio output - 35 dBV must be present

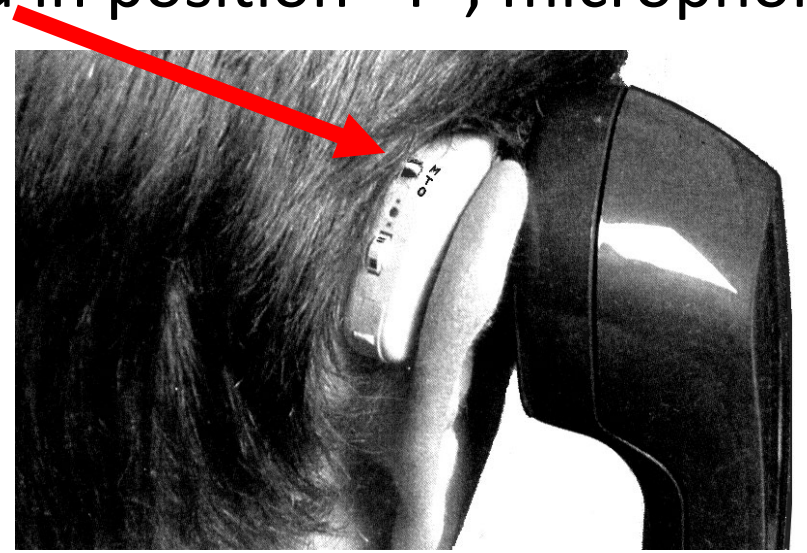


Inductive coupling

Earlier telephone receivers had an electromagnetic speaker with a strong stray field.

Audio signal could therefore be easily picked up with an induction coil.

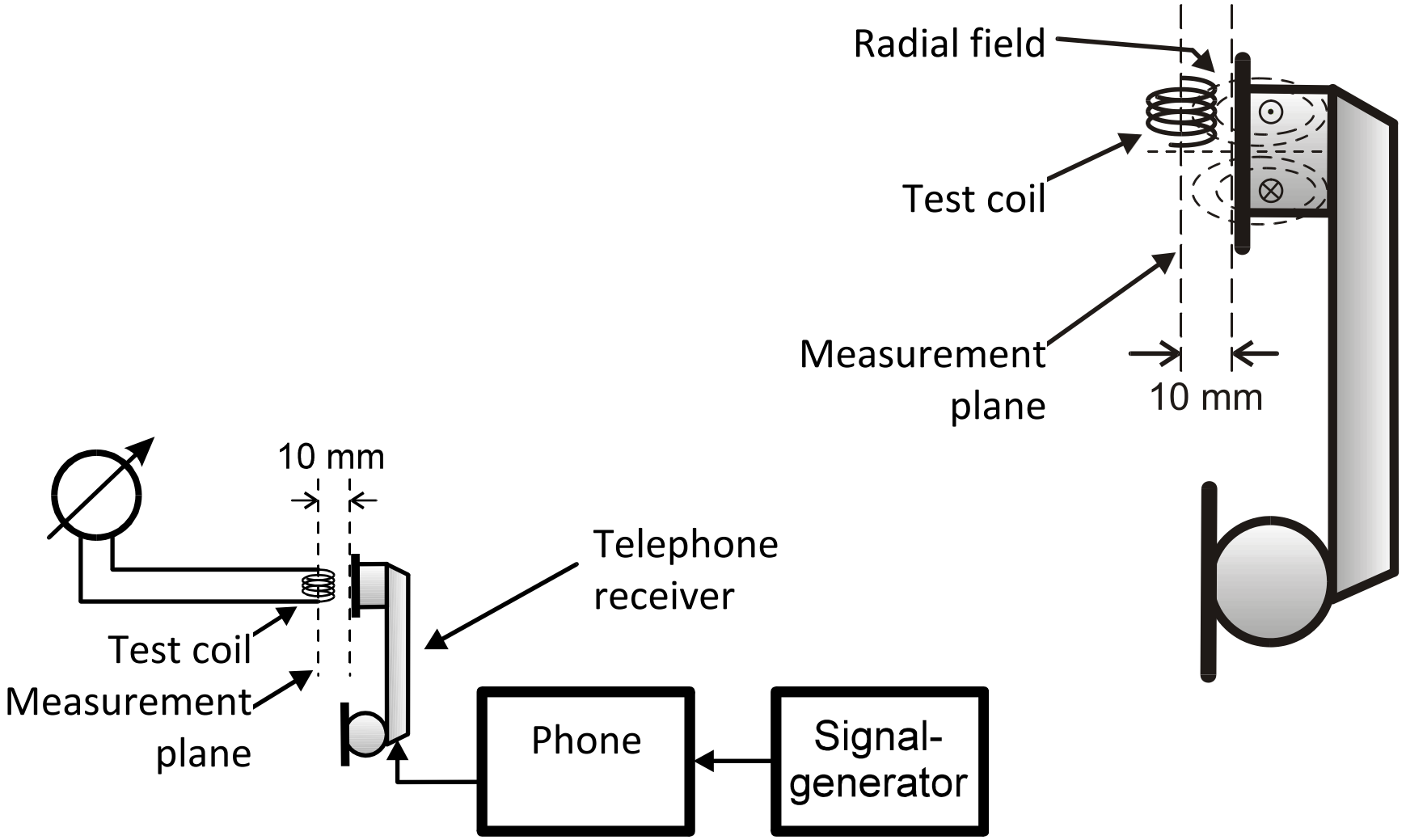
Hearing aid is to be operated in position "T", microphone is switched off.



The later emerged dynamic and piezoelectric transducers have a much lower or no electromagnetic stray field.

For mobile phones, attention must be paid to Hearing Aid Compatibility (HAC).

Measurement set-up ETSI ETS 300 381



Interference problems with GSM and DECT

Interference from GSM and DECT does not come from the transmission frequency (this is for GSM at 900 MHz and 1.8 GHz, for DECT at 1.8 GHz).
Disturbances by the TDMA method (Time Division Multiple Access). Clocking of the GSM transmitter at a rate of 217 Hz.
With DECT the pulse rate is 100 Hz.
Makes a buzzing sound.

Interference:

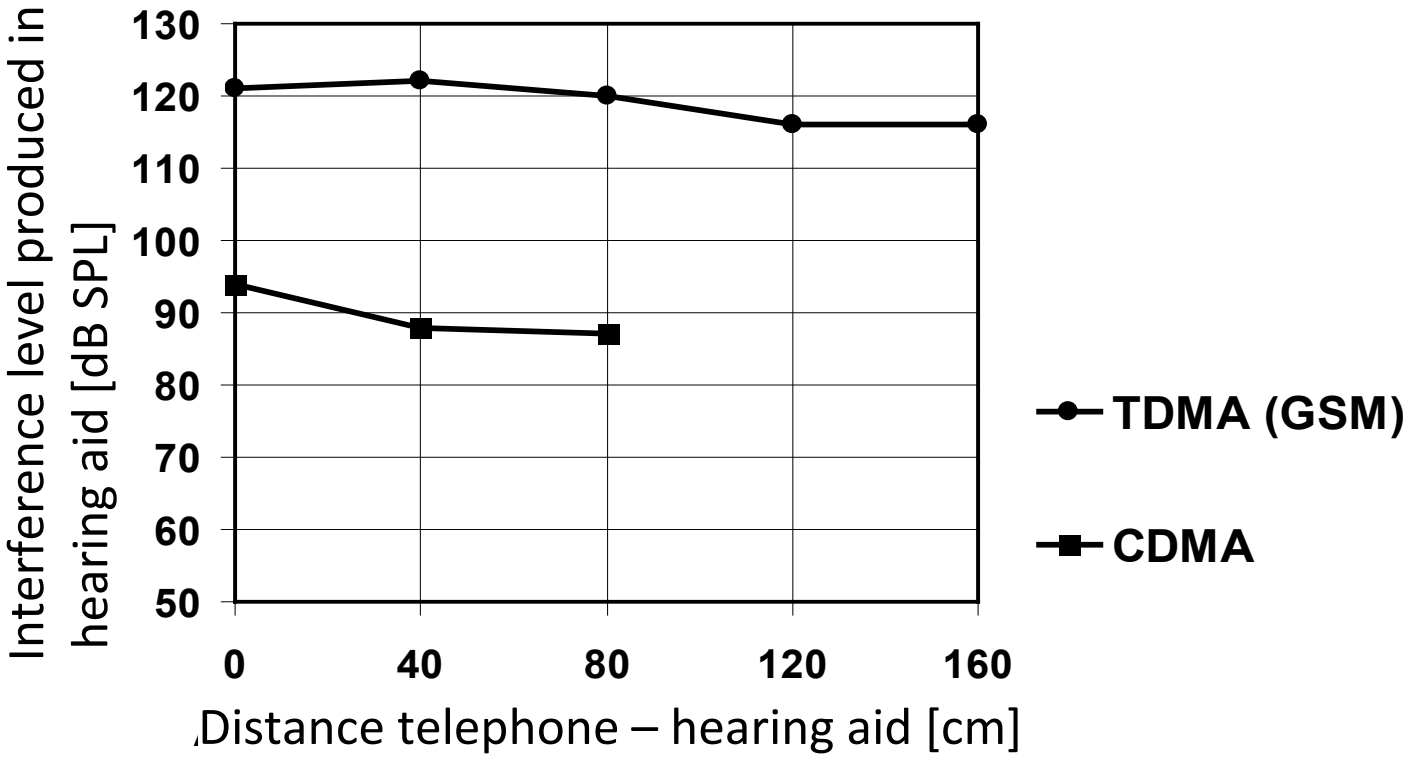
- Disruption due to external use
- Disruption by self-use

Possible countermeasures:

- Shielding of the hearing aid by metallic conductive lining of the housing.
- Shorting the interspersed frequencies with blocking capacitors.
- Avoidance of "antennas in the hearing aid“.
- Increasing the distance to the source of interference.

Interference in a hearing aid

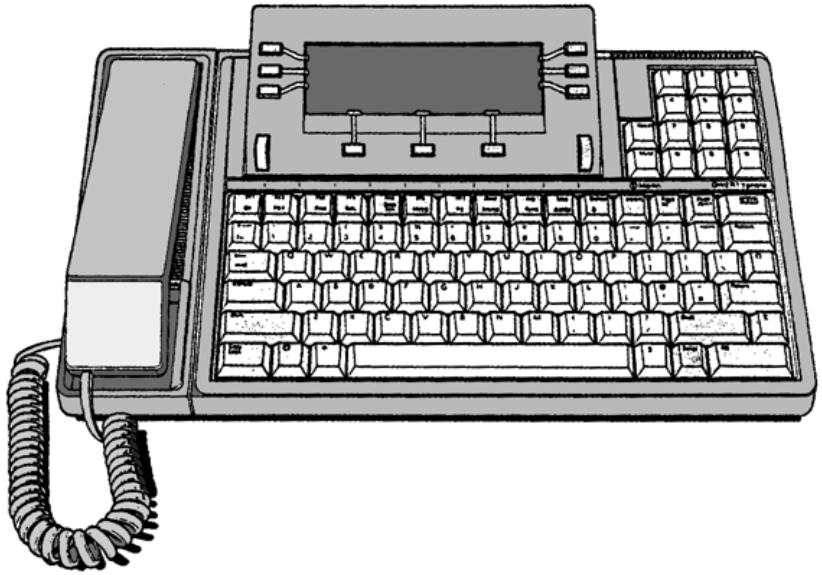
with TDMA (Time Division Multiple Access) and CDMA (Code Division Multiple Access)



Text phone (telecommunications device for the deaf = **TDD**, teletypewriter = **TTY**)

Telegraph/teletypewriter-compatible communication device that operates over the PSTN (Public Switched Telephone Network, landline).

Stationary devices (rare)



Mobile Text telephone

- Acoustic coupler
- Battery operation

Nowadays replaced by modern smartphones

Properties of text telephones

All acoustic information must be visualized
(text, control lamps)

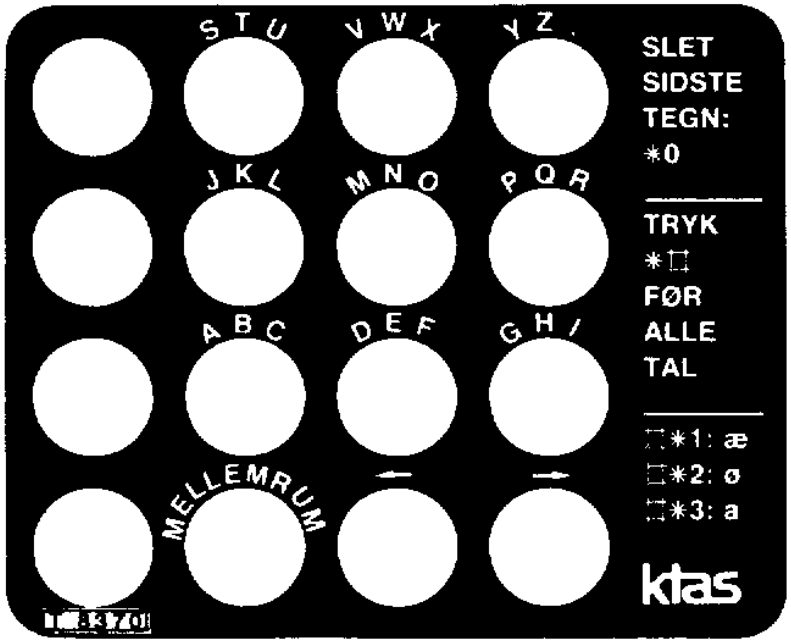
dial tone, busy tone, no such number etc.

Very late transnational cooperation
Rarely in the public sector (at least in most European countries)

Text-telephone Standards

Standard	Use	Comment
V.23 (1200/57 bit/s)	France	Minitel Standard, BTX
EDT (110 bit/s)	Germany, Switzerland, Austria, Italy, Spain, Malta	Carrier only during transmission
V.21 – Nordic (300 bit/s)	Sweden, Norway, Finland	Full duplex, 7 bit, even parity
V.21 – British (300 bit/s)	UK	Full duplex
DTMF (Mehrfrequenzwahl)	Denmark, Netherlands	Combination oft wo dial tones
Baudot/TDD (45.45 bit/s)	USA, Irland, Island, parts of UK	FSK 1400/1800 Hz
Bell (300 bit/s)	USA	Full duplex

Template for creating texts via the DTMF procedure (Netherlands)



International ITU Standard V.18

To overcome the national barriers in the Text-telephone traffic

Backward compatible with all previous standards
Connection is always at the highest possible level
In addition, also fixing the international character sets.
Multi-Mode: Allows simultaneous transmission of text and speech

Text Telephones - Relay Services (TRS)

Sender and receiver must each have a (compatible) text phone

Otherwise, switching service must be inserted

Deaf person (with text phone) communicates with a hearing person (on a standard phone) using a human relay operator

Mediation / exchange services

In some countries (such as USA) required by law
Voluntary or non-existent in other countries

Voice Carryover (VCO) - In one direction, the voice (the audio signal) is transmitted directly to the remote station (for people who cannot hear but can speak)
Hearing Carryover (HCO) – the voice is transmitted directly from remote station to local station (for people who cannot speak but can hear)

Mediation service can also be done using sign language (video-telephone with at least 18 fps)
In future, use of ASR is expected

Fax machines and Internet (-chat)

Low penetration of text telephones and the lack of exchange services in some countries led to the search for alternatives

- Messages via fax
- e-mail
- Internet chat
- SMS

All these types of communication are visually accessible but do not allow a real dialogue like the telephone (speech and counter-speech)

Electronic Braille communication

For deaf-blind people who are proficient in Braille (usually if the blindness occurred early and before the hearing impairment).
Telecommunication via a computer equipped with a Braille display (Braille line)

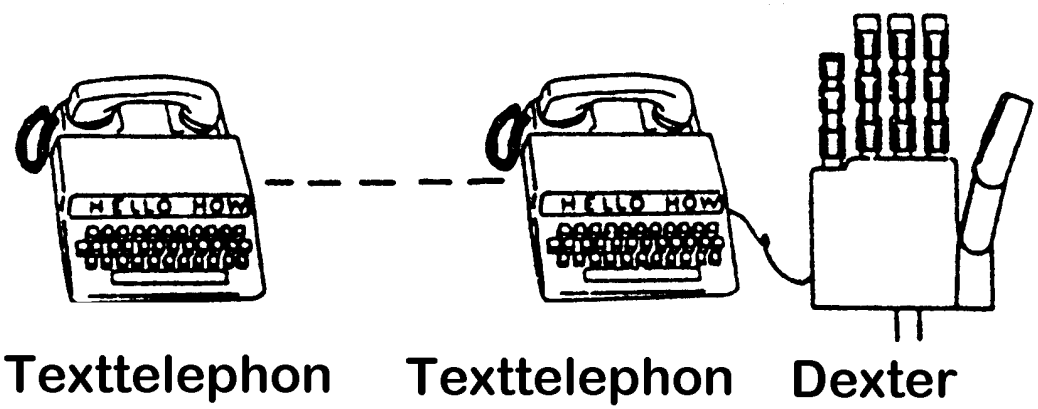
Earlier: connection to the telephone network via modem, now Internet

Telecommunications with mechanical hand (DEXTER)

For deaf-blind people using tactile hand alphabets (usually when deafness has occurred early and before visual impairment)

Mechanical replica of a hand (finger alphabet)

Control via interface of a text telephone



Basics, technology

Transmission of picture and sound
Decisive for the image quality is the **resolution** and the **repetition rate** (fps = frames per second).
Prior to the development of effective compression algorithms, bandwidths of up to 200 Mbps were required.
Compression 1: 100 to 1: 1000 allows transmission via DSL or mobile internet

Use for hearing and speech impairment

Support communication through the usual visual components (gestures, facial expressions)

- Lip reading
- Finger alphabet
- Signing

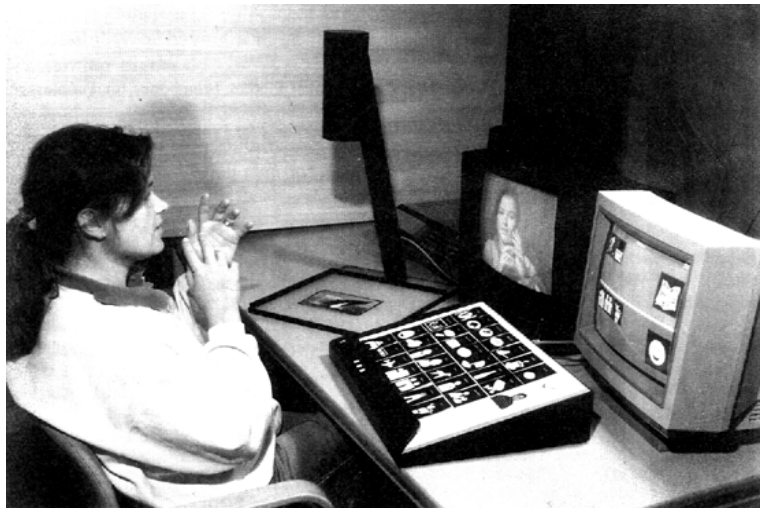
Frame rate should be at least 18 fps, better 25 fps.

Possibility to transfer texts (for example, proper names, numbers) should be given

Use for signing

Use of video telephones in conjunction with symbol languages

For people with intellectual disabilities, any additional modality means a gain in communication.
Seeing a conversation partner makes telephoning easier to understand.



Videophone used with symbol language

Videophone and visual impairment

Support of the video telephone by a sighted person (e.g., to read aloud or explain in words what is shown on the picture telephone)

"Be My Eyes" App (Android, iOS)

Smartphone owners (registered as volunteers) receive a video call from blind people from their smartphone. The sighted volunteers tell the blind people what they see on their smartphones.

https://www.hilfsgemeinschaft.at/app-test-be-my-eyes

https://youtu.be/6GRfFuWsjNU (Duration: 1:30 minutes)

For old and isolated persons:

Video telephony creates more social relationships than traditional telephony.

Touch screen videophone for the elderly

Simple and intuitive to use.

A finger tap on the photo is enough - a telephone conversation is established.

For example, if the device is not in use, it may show a

Source: http://www.tuwien.ac.at/aktuelles/news_detail/article/8007/ (in German)

14: Mass media

14.1 AT in print media

Audio Books

- Earlier on analog media
- Records (foil)
- Cassettes (4 tracks 2.4 cm/s)

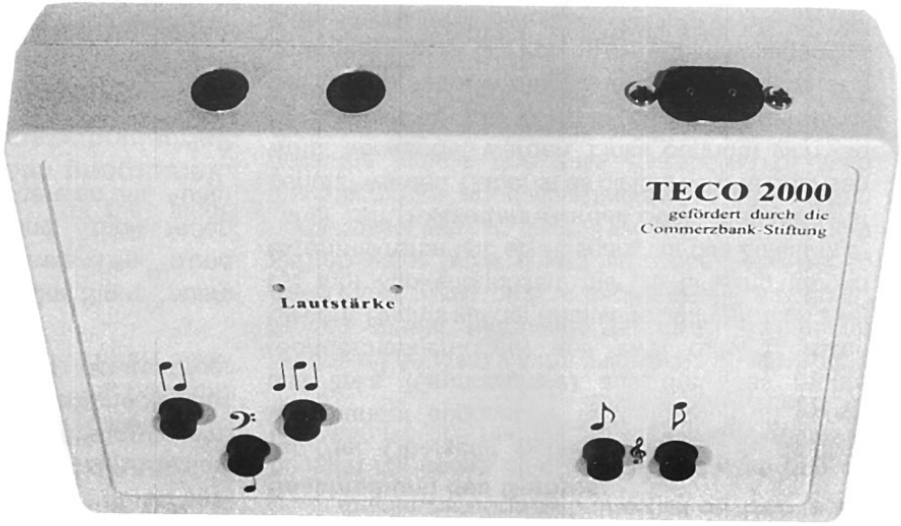
Left: Record player / cassette recorder combination - special edition for audiobooks, Library of Congress, USA. Middle: Typical cassette recorder for playing audio books. right: Cassette player with pitch compensation

Index marks

Sounds that are audible only in cue / review mode (23.5 and 31.0 Hz)

Sounds audible during playback (750 and 1500 Hz)

To make it easier to find specific passages, the tape can be provided with index marks (distinctive sound signals, which are also clearly audible in cue and review mode). They are used to mark page and chapter separations. These tone signals were generated by index markers, such as the TECO 2000 shown here.



Production process

Recording the text in the recording studio
Making a master tape or a master audio cassette
Duplicate by Quick Copy (for example x16)
Shipping.

Disadvantages of audio cassettes

Maximum running time 8 hours (at C 120, 4 tracks and 2.4 cm/s)
"Reading" only sequentially possible - looking up information difficult
No international standard.

Despite the emergence of digital audiobooks, analogue audiobooks continue to be used and loan services are usually offered by the national institutions for the blind.

Digital audiobooks:

DAISY = Digital Audiobased Information System

Name of a worldwide audiobook standard for navigable, accessible multimedia documents.

- DAISY standards (ANSI / NISO Z39.86-2005 and earlier versions) do not specify media used or audio standard. The medium (data medium) was originally a CD-ROM now also memory cards or direct Internet access.

Work on the DAISY standard since 1992 (in Sweden).

- Since 1996, the international DAISY Consortium (6 national libraries for the blind) exists and coordinates the development of the standard worldwide (http://www.daisy.org/).
- Since 2000, the DAISY standard has also been supported by Microsoft.

DAISY audiobooks include:

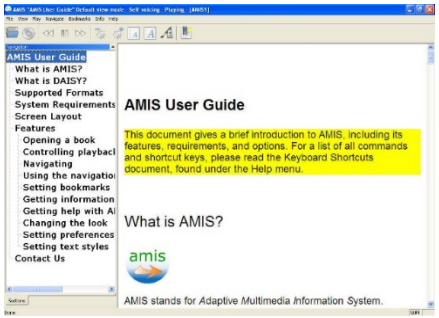
- Powerful hierarchical navigation features: You can jump from heading to heading in the text and navigate page, paragraph, and sentence by sentence.
- Interactivity, recording of speech, text (and images) possible
- Up to 40 hours of speech on a CD
- Manage bookmarks, set markers
- Variable playback speed at the same pitch, variable pitch at the same speed.

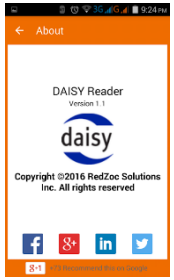
DAISY players:

Hardware players cost several to many 100 euros. (Pure listening is also possible with standard CD or MP3 players, but without extensive navigation options).

CD devices - a bit bigger than a CDROM

SD memory card devices - much smaller





Software Player - AMIS Player (Windows, free), Apps for Android and iOS

Sources: German Central Library for the Blind https://www.dzb.de/
See also: http://www.incobs.de/produktgruppen/items/daisy-player.html

DAISY Standard – 6 types

	Audio file	Structure file	Text file
Type I	yes	no	no
Type II	yes	yes	no
Type III	yes	yes	partly
Type IV	yes	yes	Full text
Type V	partly	yes	Full text
Type VI	no	yes	Full text

Newspapers for blind people

Since 1980 experiments with electronic newspapers for blind people

- Extraction of text and structure from the publishing data
- Distribution via FM radio
- Distribution via RDS (Radio Data Signal)
- Distribution via teletext
- Distribution via telephone (modem)
- Distribution via e-mail

Today:

Distribution via internet

Many newspapers are also available online today and can therefore be used e.g. be read by screen reader, which makes a costly conversion unnecessary.

important: accessibility of websites according to WAI

Newspapers for speech impaired people

Simplification of press texts using NLP (Natural Language Processing)

- Separation of long sentences
- Passive forms replaced by active forms
- Replacement of rare and complicated words with common and simple words
- Anaphora *) replaced with the reference words
- Often a good layout on the screen is much easier to read than a printed newspaper.

*) An anaphor means a linguistic expression that refers to an expression preceding it in the text (for example, a pronoun). A replacement of anaphora would, for example, effect the following transformation. E.g. "The man could not find his glasses" becomes "The man could not find the man's glasses".

Improvement of the intelligibility of the TV sound

Presbyacusis (Altersschwerhörigkeit) causes hearing loss in the treble range.

Increasing the volume only in the treble range (2,000 to 6,000 Hz).

Special speaker system that offers this gain only for a narrow solid angle.

Achievable improvement of word intelligibility e.g. from 26% to 64%.

Subtitling of TV programs

For deaf and severely hearing-impaired people

In the USA since 1972.

"Open Captioning" (visible to all)

"Closed Captioning" (= CC, only visible with decoder).

USA 1993: "Television Decoder Circuitry Act"

Europe (BBC) 1973: subtitles on teletext

Different fonts and colors possible

In VCR recording, subtitles got (mostly) lost.

New standards for digital television.

Creation of subtitles

Enter text before broadcasts
For news broadcasts, use "teleprompter" texts
Machine shorthand for live broadcasts
Automatic Speech Recognition (ASR)
Problem with 38% "Paralanguage" (e.g., emotions)

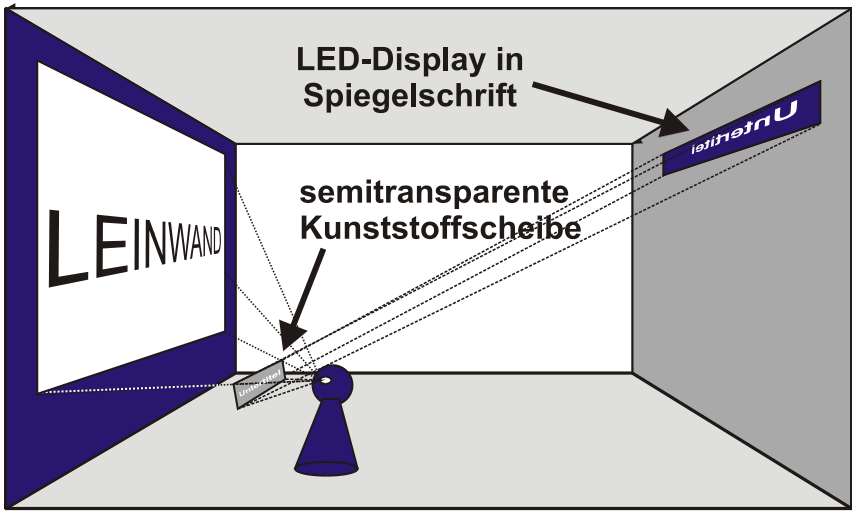
Instead of or in addition to subtitles insert
(small picture with interpreter) for sign languages

Rear Window

Mirroring subtitles in the cinema and theater

Semi-translucent mirror

Luminous band display on the back wall of the cinema / theater hall (in mirror writing)



Audio-Description:

Objective: To make TV programs (or even cinema performances and theatrical performances) accessible to blind viewers.

Method: In dialog pauses a concise but accurate scene description is made by a spoken commentary.

Description of plot, scenery, persons, gestures etc.

Outlook to Block 7

15. AAL – Ambient Assisted Living
    - 15.1 Introduction, Basics and Definitions
    - 15.2 AAL and the Demographic Change
    - 15.3 The History of AAL
    - 15.4 Target Groups and Application Areas
    - 15.5 The Technology of AAL – Sensors / Actuators
    - 15.6 Interconnection and Platforms
    - 15.7 Social Robotics
16. Ethical Questions
    - 16.1 Privacy and Safety
    - 16.2 An Ethics Fable