

# Technical Documentation

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Head and Torso Simulator (HATS)  
Type 4128-C

Handset Positioner for HATS Type 4606

User Manual



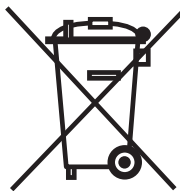
# **Head and Torso Simulator (HATS) Type 4128-C**

## **Handset Positioner for HATS Type 4606**

*User Manual*

## Safety Considerations

This apparatus has been designed and tested in accordance with IEC/EN 61010–1 and ANSI/UL 61010–1, *Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use*. This manual contains information and warnings which must be followed to ensure safe operation and to retain the apparatus in safe condition.



- Do not dispose of electronic equipment or batteries as unsorted municipal waste
- It is your responsibility to contribute to a clean and healthy environment by using the appropriate local return and collection systems
- Hazardous substances in electronic equipment or batteries may have detrimental effects on the environment and human health
- The symbol shown to the left indicates that separate collection systems must be used for any discarded equipment or batteries marked with that symbol
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# Introduction

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This manual covers the operation and basic maintenance of Head and Torso Simulator Type 4128-C and its accessories; Right Ear Simulator Type 4158-C, Left Ear Simulator Type 4159-C and Handset Positioner for HATS Type 4606. The manual is divided into two parts with the first part covering Types 4128-C, Type 4158-C and Type 4159-C, and the second part covering the Handset Positioner for HATS Type 4606.

## Head and Torso Simulator Type 4128-C

Head and Torso Simulator (HATS) Type 4128-C consists of a head mounted on a torso, both of which represent the international average dimensions of a human adult. In airborne acoustic measurements it provides correct simulation of the acoustic field around a human head and torso as specified in ITU-T Rec. P.58 and IEC 60318-7. You can use HATS free-standing, or fitted on a tripod or turntable using the tripod mounting adaptor.

### The Mouth Simulator

The mouth simulator in HATS has a high-compliance loudspeaker that gives powerful low-frequency response and low distortion. The acoustic transmission path from the loudspeaker to the mouth opening ensures an easily equalisable frequency response of the sound pressure level in front of the mouth. The equivalent lip plane containing the ITU-T Center of Lip (CL) is 6 mm in front of the mouth opening. The usual calibration position is at the ITU-T Mouth Reference Point (MRP), 25 mm in front of this plane. A chin clip is supplied with Type 4128-C that will hold a 1/4" reference microphone at precisely the correct distance for calibration at the MRP.

This chin clip can also hold a microphone at the opening of the mouth if you want to monitor or equalise the sound pressure at this point. Type 4128-C comes with an additional chin clip (Reference Microphone Holder UA-2127) for replacement.

The mouth simulator produces a sound-pressure distribution around the opening of the mouth that simulates that of a median adult human mouth, correlating with the figures given in ITU-T Rec. P.58.

The position of the acoustic center of the mouth simulator also follows that of humans over the speech frequency range.

## Ear Simulator Type 4158-C

Ear Simulator Type 4158-C consists of a soft, removable silicone rubber pinna with a hardness close to a real human ear pinna connected to an ear canal. A harder pinna is also available. The ear canal ends in an occluded ear simulator that simulates the inner part of the ear canal according to the IEC 60318-4 standard. The occluded ear simulator contains a 1/2" microphone and is connected to a microphone preamplifier via an adaptor. The ear simulator complies with ITU-T Rec. P.57.

Type 4158-C is the right ear of Type 4128-C. A left ear, Type 4159-C, is also available for binaural measurements. Both Type 4158-C and Type 4159-C are delivered with a calibration CD and chart specific to their ear simulator and pinna. Pistonphone Type 4228 and Sound Calibrator Type 4231 are both suitable calibrators for these ear simulators.

The combined influence of the torso, head, pinna and ear-canal on airborne sound signals can be quantified by the acoustic free-field transfer function (the frequency response from free-field to the eardrum). This is called the Listener free-field frequency response (LFR) in telecommunications and the Mannequin frequency response or the Head Related Transfer Function (HRTF) in technical audiology.

## Handset Positioner for HATS Type 4606

Brüel & Kjær has developed a handset positioner specifically for use with HATS. Handset Positioner for HATS Type 4606 accurately and repeatably positions telephone handsets on HATS for electroacoustic measurements. The device screws directly into the top of HATS and securely holds and positions virtually any handset, i.e., mobile, cordless or conventional. The handset mounts in the cradle, which is a multi-adjustable fixture capable of holding most types of handset firmly.

An alignment jig is supplied that allows you to position the handset within the cradle when setting up the handset ECRP and the ear-cap plane. Then, when the handset and cradle are mounted on the handset positioner, the ECRP of the handset corresponds to the nominal ERP of the HATS pinna.

All the important fixing and positioning adjustments are accomplished via precision mechanisms with graduated markings so that any position or adjustment is repeatable by simply setting all of the positioning parameters to the appropriate values. To this end, Brüel & Kjær supplies a table for noting down these parameters (available from [www.bksv.com/doc/HandsetPositionerTable.pdf](http://www.bksv.com/doc/HandsetPositionerTable.pdf) and shown in Fig.4.11). Once the cradle is mounted on the handset positioner, it can be adjusted in three different planes about the ERP and the corresponding angles can be read off graduated markings. Additional cradles are available as accessories.

The handset positioner presses the handset against the HATS pinna with an adjustable force of 0–18 N. A screw adjustment allows you to set the force via a graduated scale in newtons. The resulting deflection of the pinna and the movement of the handset ECRP occur along the ERP-axis formed by the nominal ERPs of the left and right HATS pinnae. The deflection can be read off the handset positioner graduations in millimetres.

Type 4606 is easy to set up to do standardised measurements. A standardised position, the “HATS position” as defined in ITU-T Rec. P.64, is clearly marked on the handset positioner. This standardised position takes into account the anatomy of the average human head.



For exploring the effect of asymmetrically mounted transducers and simulating left- and right-handed users, it is possible to perform measurements on both ears. This is done by reversing the position of the Cradle Positioner, with all graduations of the adjustment screws being repeated for the left-hand position. A built-in quick release mechanism makes the cradle quickly dismountable, making it easy to change handsets or to change between measurement on the left and right ears.

For users of the table top Telephone Test Head Type 4602-B, when it is fitted with the positioning jig labelled HATS, the telephone test head corresponds directly to the HATS position of Type 4606.



# Part I

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**HATS Type 4128-C**



# Chapter 1

## Operation

### 1.1 Accessories Supplied with Type 4128-C

**Fig. 1.1** The accessories supplied with Type 4128-C: (1) 3mm Allen key QX-1172; (2) and (4) Feet UA-1043; (3) Ear Mounting Tool QA-0167; (5) Ear Mould Simulators DB-2902 (short) and UC-0199 (long); (6) Calibration CD BC5000-C; (7) Right Pinna, soft DZ-9769; (8) Left Pinna, soft DZ-9770; (9) Tripod Mounting Adaptor UC-5290; (10) Adaptor for Calibration UA-1546; (11) Microphone Extension Cable AO-0419; (12) Pre-amplifier Mounting Tool QA-0233

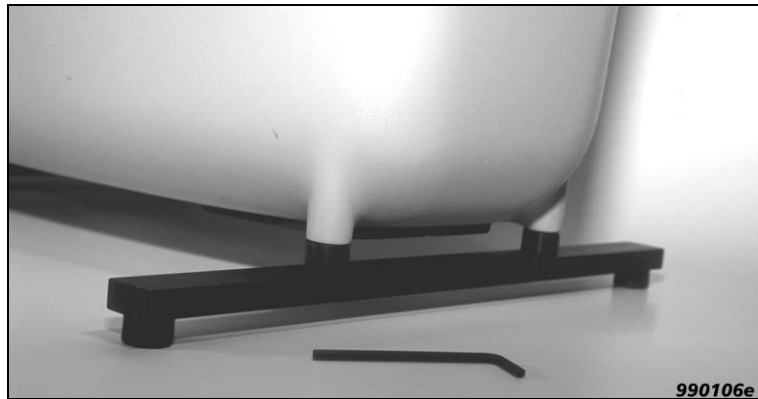


## 1.2 Mounting Type 4128-C

Head and Torso Simulator Type 4128-C can be used free-standing, or supported on a tripod using adaptor UC-5290 (Fig. 1.1.9). The adaptor screws onto the top of a tripod. The torso can then be fitted onto it and secured by tightening the locking nut.

If HATS is to be used free-standing, it is advisable to fit the extra feet supplied (UA-1043, Fig. 1.1.2 and 4) to give it extra stability. To do this, remove the small rubber feet from the base of the torso by unscrewing their securing screws. Then, ensuring that the spacers supplied are placed between the base of the torso and the extra feet, secure the extra feet with the screws supplied. The small rubber feet can be fitted to the extra feet if desired, as in Fig. 1.2.

**Fig. 1.2**  
*HATS with Feet UA-1043  
attached*



The head of Type 4128-C can be separated from the torso and used on its own, mounted on a tripod using the mounting thread in the neck. This is only recommended for applications where there is a very close acoustical coupling between the object under test and the mouth or the ear, as it is only in these circumstances that the contribution of the torso to the acoustical properties of Type 4128-C can be ignored.

## 1.3 The Mouth Simulator

### Connection and Driving of the Mouth Simulator

The loudspeaker of the mouth simulator (which has a nominal electrical input impedance of  $4\Omega$ ) can be driven from any voltage source, via a power amplifier if the sound pressure levels required make this necessary. The mouth simulator can be driven with a maximum continuous power of up to 10 W.



**CAUTION:** The mouth simulator is equipped with a protection circuit to prevent damage to the unit, and even though this protection circuit is present, there may be a risk of damaging the mouth simulator by excessive input power. Should the protection circuit be activated (due to a high power input), turn down the input level and wait until the protection circuit deactivates. The mouth simulator will be ready again after approximately two minutes.



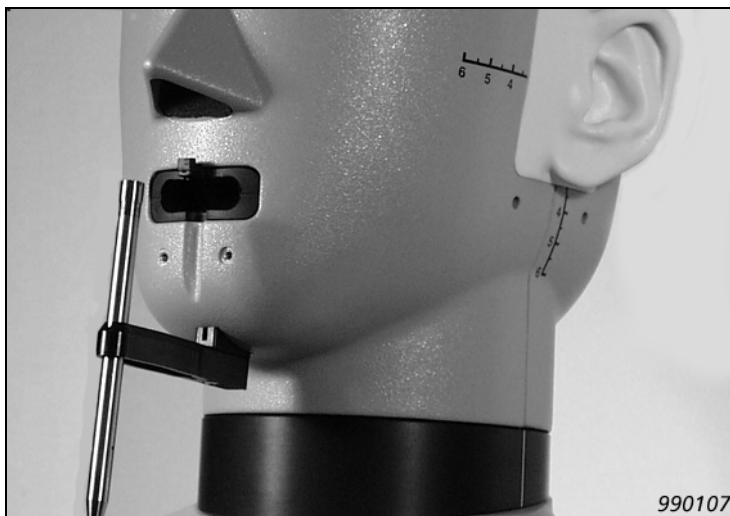
**WARNING:** Never apply mains voltage to the mouth simulator terminals.

A drive signal is applied to the mouth simulator via the two cables that run down through the torso from the head and are led out through the base of the torso. These cables are terminated with banana sockets which accept standard 4 mm banana plugs. The red socket is the positive connection, where positive means that a positive voltage on this terminal causes outward movement of the loudspeaker cone. Any type of drive signal can be used, ranging from a pure sine wave to an artificial voice (e.g., ITU-T Rec.P.50).

## 1.4 Calibration of the Mouth Simulator

The method of calibrating the mouth simulator depends on the application for which it is to be used. For example, the standards IEEE 269 and 661, and ITU-T Rec. P.51 for measurements on telephone equipment demand that measurements are referred to the Mouth Reference Point (MRP) 25 mm in front of the equivalent lip-plane. Therefore, the output sound pressure level should be measured at this position during calibration procedures. For this purpose, Type 4128-C has a microphone holder which positions a 1/4" microphone with preamplifier (e.g., Brüel & Kjær Type 4939 or previously Type 4135 with Preamplifier Type 2670) at the MRP (see Fig. 1.3). The diaphragm of the microphone should be positioned at the level of the centre of the mouth. This holder can also be used to hold a 1/4" microphone at the opening of the mouth simulator orifice in order to monitor the sound pressure at this location.

**Fig. 1.3**  
*1/4" microphone with  
preamplifier in the holder  
that positions them at the  
MRP, 25 mm from the  
equivalent lip-plane*



Before calibrating the drive system and mouth simulator, the microphone and measuring instrument to be used should be calibrated using either Pistonphone Type 4228 or Sound Calibrator Type 4231, along with calibration adaptor UA-1546 supplied with Type 4128-C.

Mouth simulator calibration is then simply a matter of noting the sound pressure levels which result from particular drive levels.

### **Mouth Equalisation**

Many applications require a constant or otherwise predefined sound pressure level with respect to frequency at a particular test position (for example at the MRP). There are three ways in which this can be done:

- By applying a particular weighting function to the mouth simulator using PULSE Audio Analyzer for example, so that the sound pressure level varies as required (or remains constant) at the test position throughout the frequency range of interest.
- By using post-processing of results to compensate for the frequency response of the mouth simulator. This does not actually produce the required sound pressure level, but gives results equivalent to those that would have been obtained with the required SPL (assuming linearity of the device under test).
- By using “live” compression, i.e., using a feedback signal from the mouth simulator output to control the drive level to the mouth simulator. (This is easiest when a constant sound pressure level is required. To obtain a predefined varying sound pressure level, a frequency-dependent feedback network must be used.)

## **1.5 The Ear Simulator**

On delivery, the HATS has an Ear Simulator Type 4158-C with soft pinna fitted in the right ear. Types 4128-C-002 and 4128-D-002 are also delivered with a left ear simulator Type 4159-C with soft pinnae. These soft pinnae have a hardness very close to that of a real human pinna. This enables easy and realistic mounting of any type of headphone. On models without the left ear simulator, an uncalibrated left pinna is enclosed to cover the absent ear simulator. This uncalibrated pinna has no serial number.

### **Connection to the Ear Simulator**

The cable from the ear simulator that carries the output from the microphone of the ear simulator terminates in a LEMO (1 B) plug. A LEMO-to-Brüel & Kjær adaptor ZG-0350 is available as an optional accessory for connection to preamplifier input sockets of Brüel & Kjær power supplies, analyzers, etc. The cable is long enough to go down through the neck of Type 4128-C and out through either of the holes in the base of the torso. The polarization voltage required for the microphone in the ear simulator (200 V) and the power for the preamplifier are supplied through the cable from the measuring instrument or a microphone power supply.

### **Use of Ear-mould Simulators**

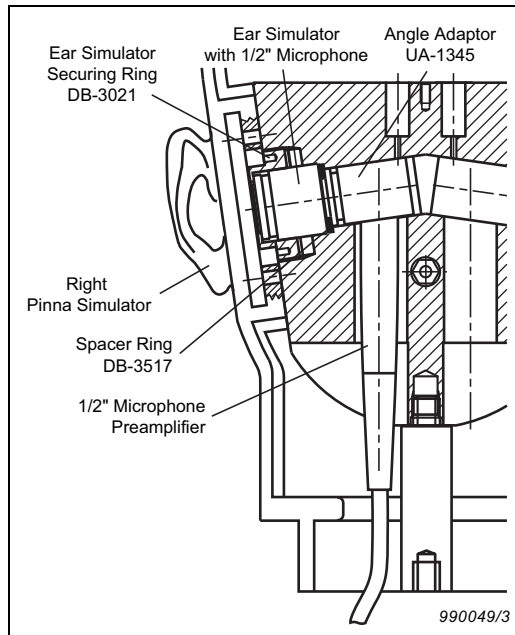
Two ear-mould simulators UC-0199 and DB-2902 (see Fig.1.1) are supplied with HATS. These are for use when testing in-the-ear (ITE) and behind-the-ear (BTE) hearing aids. Such aids bypass the initial part of the ear canal as they have moulds which fit into this part of the ear and so, when testing them on Type 4128-C, this part of the ear-canal must not be allowed to influence measurements.

The ear-mould simulators fit into the hole in the pinna simulator and provide a narrow tubular path to the eardrum. Hearing aids should be coupled to the ear-mould simulator via the tube which normally goes into the custom-made ear-mould of each hearing-aid wearer. UC-0199 complies with the requirements of IEC 60318-4 but can be difficult to use in practice with certain hearing-aid designs. DB-2902 is supplied for such situations.



Since the ear-canal extension of the HATS is made of pliant silicone rubber, it can accommodate some actual ear-moulds from ITE, BTE, and canal hearing-aids without the need for ear-mould simulators.

**Fig. 1.4**  
*Cross-section of the head of HATS with the ear simulator and preamplifier fitted*

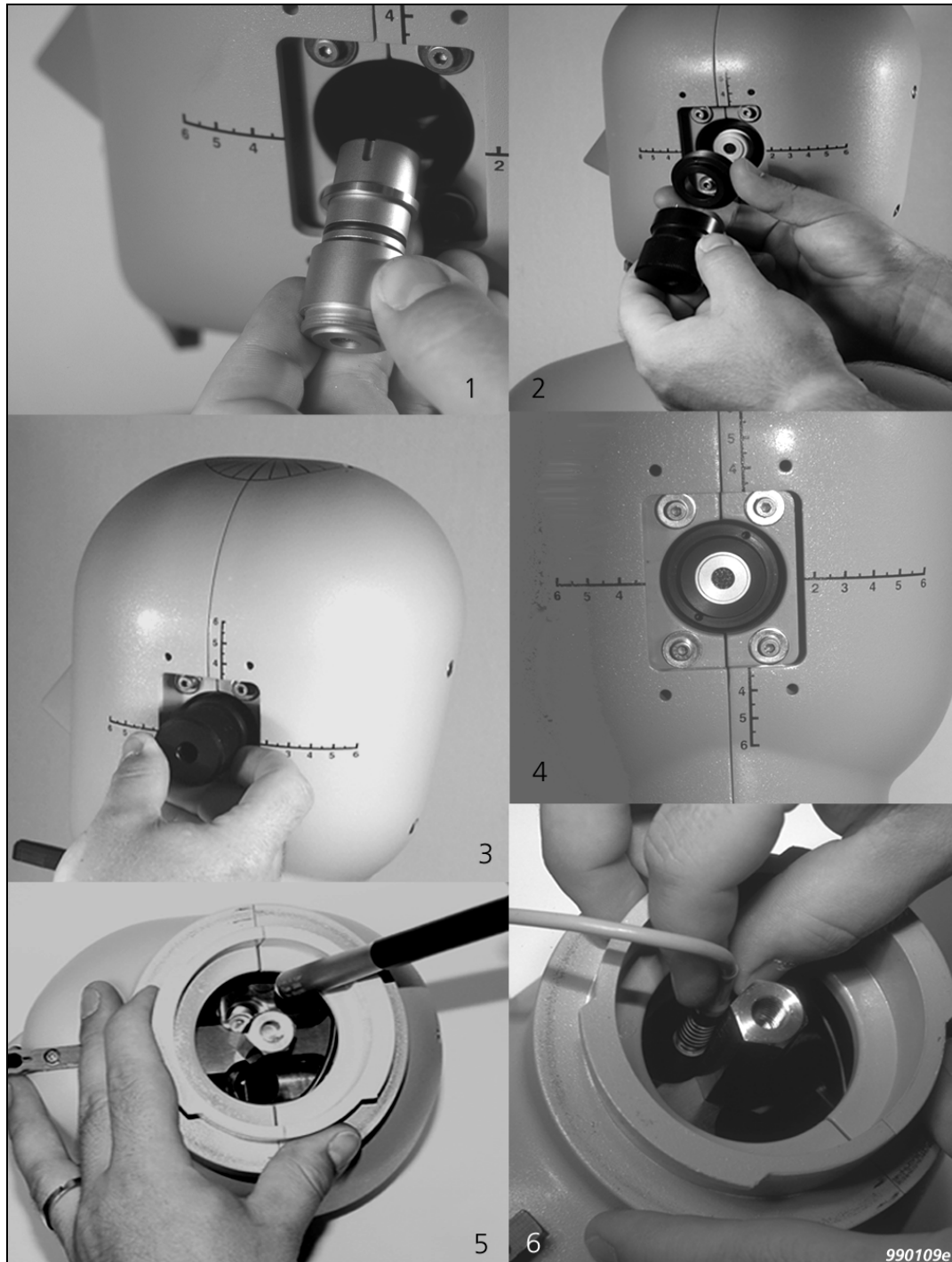


### Mounting the Ear Simulator and Preamplifier

It is not necessary to split the head to mount the preamplifier and ear simulator (ignore step 9 if the head is assembled). To mount an ear simulator and preamplifier (see Fig. 1.5) in the head (if the preamplifier and Angle Adaptor UA-1345 are already in position ignore steps 1 and 4):

- 1) Remove the head from the torso by turning it through 90° and lifting it off the torso.
- 2) Placing it on a cloth or similar so that it is not scratched, position the head on its side, with the side of interest facing upward.
- 3) Fit the 2.5 mm metal spacer ring DB-3517 into the ear hole.
- 4) Carefully screw the ear simulator onto the angle adaptor (UA-1345).
- 5) Slide the ear simulator/angle adaptor assembly into the ear hole and ensure that the recess in the angle adaptor slots together with the guide-pin inside the ear hole (see Fig. 1.5.1).
- 6) Screw in the black ear-simulator securing-ring using Ear Mounting Tool Type QA-0167. Use finger light torque only – do not over-tighten. (see Fig. 1.5.2–4).
- 7) Insert the microphone preamplifier (without the cable) from the bottom of the head and carefully screw it into the angle adaptor (clockwise) using Preamplifier Mounting Tool Type QA-0223. (see Fig. 1.5.5).

**Fig. 1.5** Mounting the ear simulator (steps 5 through 8)





**WARNING:** Be careful not to ruin the fine thread in the preamplifier or the angle adaptor. Do not use any force and make sure that the threads in the two pieces engage properly before you screw in the preamplifier (check that the preamplifier body can be moved slightly in all directions before screwing it fully in). Do not over-tighten.

- 8) Fit the microphone cable onto the microphone preamplifier (see Fig. 1.5.6).
- 9) If the head has been split you must reassemble it by reversing the dismantling procedure given later in this chapter (see “Splitting the Head” on page 14.).
- 10) Fit the pinna simulator onto the head.

The mounting procedure is the same for right and left ears.

## 1.6 Calibration of the Ear Simulator

Disassembly of the head or the ear simulator is not required for calibration, only the silicone rubber moulding of the outer ear (the pinna simulator) needs to be removed. Calibrate the measurement chain using either Pistonphone Type 4228 or Sound Calibrator Type 4231. Type 4228 supplies a stable, accurate signal at 250 Hz ( $\pm 1\%$ ) and gives a calibration accuracy of  $\pm 0.15$  dB. The signal supplied by Type 4231 is at 1 kHz ( $\pm 1.5\%$ ), and calibration accuracy is  $\pm 0.3$  dB.

To calibrate:

- 1) Remove the pinna simulator by sliding it towards the front of the head and then pulling the back of it outwards away from the head.
- 2) Push calibration adaptor UA-1546 (see Fig. 1.1.10) firmly into the ear canal.
- 3) Fit the calibrator onto the adaptor. Ensure that it is pushed firmly over the end of the adaptor.
- 4) Switch the calibrator on.
- 5) Adjust the sensitivity of the measuring instrument(s) to display the correct sound pressure level, as indicated in Table 1.1. The procedure for doing this should be described in the instruction manual for the equipment concerned.

**Table 1.1**

*The actual sound pressure level at the microphone diaphragm when using Calibrator Type 4228 or 4231 with Calibration Adaptor UA-1546*

| Calibrator                 | Adaptor                                       | Corrected Output Level (SPL)                    |
|----------------------------|---|---|
| Pistonphone Type 4228      | UA-1546 <sup>a</sup> and DP-0776 <sup>b</sup> | Stated SPL + $\Delta L_p - 0.8$ dB <sup>c</sup> |
| Sound Calibrator Type 4231 | UA-1546                                       | 97.1 dB   |

a. Supplied with Head and Torso Simulator Type 4128-C

b. Supplied with Pistonphone Type 4228

c. “Stated SPL” is the sound pressure level stated on the calibration chart (BC 0195) of Type 4228. The nominal SPL of Type 4228 is 124 dB  
 $\Delta L_p$  is the correction for the ambient pressure, which can be read directly from Correction Barometer UZ-0004 supplied with Type 4228

The SPL values in the table differ from those given in the instruction manuals for the calibrator. This is because the calibration coupler influences the actual sound pressure level at the microphone diaphragm, and the coupler used for calibration of Type 4128-C is different to that normally used for microphone calibration.

**Note:** The condenser microphone is an integral part of the ear simulator and must not be removed from the ear simulator assembly.

## 1.6.1 Dismantling the Head and Torso Simulator

### Separating the Head from the Torso

**Note:** Before removing the head from the torso, the rubber pieces in the base of the torso through which the cables run should be removed. This avoids putting unnecessary stress on the cables and connectors.

Separate the head from the torso by turning the head through 90° in either direction and then pulling it out from the torso. Cables attached to both the ear simulator and the mouth simulator can be pulled through the torso once the rubber pieces in the holes at the base of the torso (through which the cables run) have been removed. When replacing the head, make sure the marks on the neck of the torso are lined up with the line where the head splits. This ensures that the head is facing exactly forwards. This is how the head should be positioned in relation to the torso for the vast majority of applications, but the head can be set at other angles if required. Also, remember to refit the rubber pieces in the base of the torso once the cables from the head have been threaded through the holes.

### Splitting the Head

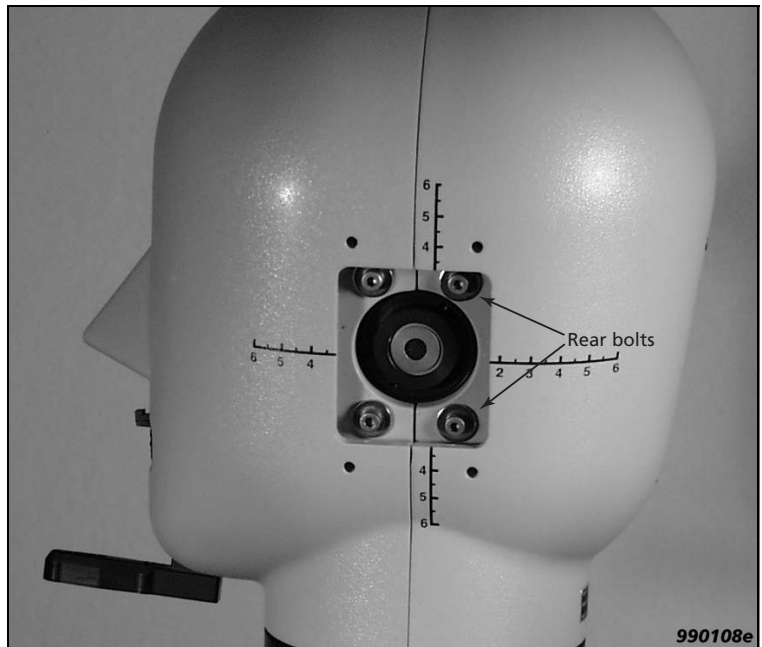
In normal use you will not need access to the inside of the head, but if it is required the head should be split as follows:

- 1) Separate the head from the torso as described above.
- 2) Remove both pinna simulators by sliding each of them towards the front of the head and then pulling the backs of them outwards.
- 3) Remove the two Allen bolts from the rear of the right ear and from the rear of the left ear position (see Fig. 1.6). A 3 mm Allen key, QX-1172, is supplied for this purpose.
- 4) Remove the two Allen bolts from the back of the head, which can then be separated from the front. The ear simulator, mouth simulator and mounting-block will remain secured in the front half of the head. The soft “cushion” in the top of the head can be removed.
- 5) Although not normally required, complete removal of the ear simulator, mouth simulator and mounting-block from the shell of the head is possible when the final four Allen bolts (two from the front of each ear position) are removed.

To reassemble the head, simply reverse the above procedure. Ensure that the soft “cushion” is replaced in the top of the head above the overload protection circuit before the two halves of the head are put back together. To refit a pinna simulator, push its front edge into the front of the ear-recess in the head and then push the back of the pinna in towards the head.

**Fig. 1.6**

*Bolts to be removed to split the head (remove from both sides of the head)*

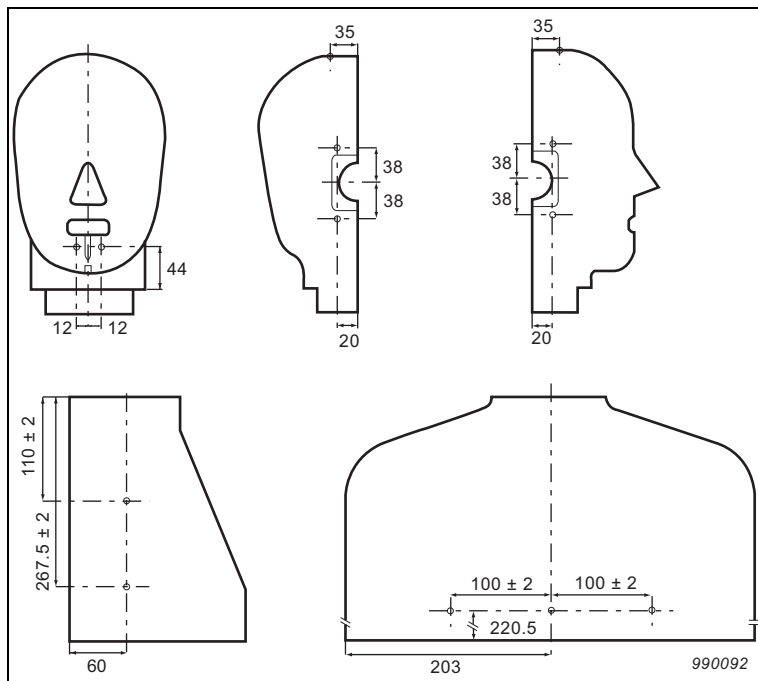


### 1.6.2 Fixing Holes of the Head and Torso Simulator

Threaded fixing holes are provided at various locations on the HATS. These allow attachment of user-designed support structures for the devices under test if required. Fig.1.7 shows the positions of the holes, which are all M3-threaded. To help position devices under test, the HATS has grids marked in centimetres both horizontally and vertically around both ears. Also, the top of the head has a polar “grid” divided into 15° steps.

**Fig. 1.7**

The positions of the fixing holes on HATS. All dimensions shown in mm



### 1.6.3 Calibration CD

Each Type 4128-C comes with a CD containing calibration data both in ASCII format and for use with Brüel & Kjær PULSE Audio Analyzer. The CD contains calibration measurements for the mouth simulator and the right ear simulator (Type 4158-C) of Type 4128-C-001 and, for Type 4128-C-002, also for the left ear simulator (Type 4159-C). When upgrading Type 4128-C-001 to Type 4128-C-002 (adding the left ear simulator), a separate calibration CD with left ear simulator data is supplied. The calibration data supplied is listed in Table 1.2. Only the listener frequency responses and the talker frequency response are individually measured for every HATS. The other measurements are typical. The variation between different HATS is small and is mainly due to sensitivity variations between the ear simulators. Because of this, the individual measurements can be used to “correct” the typical measurements for a particular HATS. For example, using the post-processing facilities of PULSE it is simple to divide the file L\_000\_00 by the file LFR\_R (these are theoretically the same; any difference is due to the fact that one is individual and the other typical). The result of this division is the variation from typical of the ear simulator sensitivity, and so can be multiplied by any other ear measurements to “correct” the typical curve.

For users of Brüel & Kjær Audio Analyzer Type 2012 with floppy disk drive, appropriate files are contained on the CD as well. To generate a Type 2012 compatible calibration disk, simply copy all files within the directory “2012dat” to a formatted floppy disk.

**Table 1.2** Details of the files on the CD supplied with Type 4128-C. The CD supplied with Type 4159-C includes LFR\_L (the left ear listener frequency response) instead of LFR\_R

| File Name  | Contents  | Frequency Range | Comments   |
|--|---|-----------------|--|
| DFR  | Listener Diffuse-field Frequency Response, DFR  | 20Hz – 20kHz    | Typical data   |
| L_000_00<br>L_030_00<br>L_060_00<br>L_090_00<br>L_120_00<br>L_150_00<br>L_180_00<br>L_210_00<br>L_240_00<br>L_270_00<br>L_300_00<br>L_330_00 | LFR, 0° elevation, 0° azimuth<br>LFR, 0° elevation, 30° azimuth<br>LFR, 0° elevation, 60° azimuth<br>LFR, 0° elevation, 90° azimuth<br>LFR, 0° elevation, 120° azimuth<br>LFR, 0° elevation, 150° azimuth<br>LFR, 0° elevation, 180° azimuth<br>LFR, 0° elevation, 210° azimuth<br>LFR, 0° elevation, 240° azimuth<br>LFR, 0° elevation, 270° azimuth<br>LFR, 0° elevation, 300° azimuth<br>LFR, 0° elevation, 330° azimuth | 20Hz – 20kHz    | Typical Listener Free-field Frequency Responses measured at elevation angles of 0° and at azimuth angles of 0°, 30°, 60°, 90°, 120°, 150°, 180°, 210°, 240°, 270°, 300° and 330°. See Fig. 1.11.<br>Syntax: L_xxyzz<br>xxx indicates the azimuth angle,<br>y indicates whether the elevation angle is upwards ( ) or downwards (-),<br>zz indicates the elevation angle. |
| L_(000→330)_30<br>L_(000→330)_60<br>L_(000→330)_90<br>L_(000→330)-30<br>L_(000→330)-60<br>L_(000→330)-90                                     | LFR, 30° elevation, 0°→330° azimuth<br>LFR, 60° elevation, 0°→330° azimuth<br>LFR, 90° elevation, 0°→330° azimuth<br>LFR, -30° elevation, 0°→330° azimuth<br>LFR, -60° elevation, 0°→330° azimuth<br>LFR, -90° elevation, 0°→330° azimuth   | 20Hz – 20kHz    | Typical Listener Free-field Frequency Responses measured at elevation angles of 30°, 60°, 90°, -30°, -60° and -90°, and one each at azimuth angles of 0°, 30°, 60°, 90°, 120°, 150°, 180°, 210°, 240°, 270°, 300° and 330°. See Fig. 1.8   |
| L_(315→045)_00<br>L_(315→045)_15<br>L_(315→045)_30<br>L_(315→045)_45<br>L_(315→045)-15<br>L_(315→045)-30<br>L_(315→045)-45                   | LFR, 0° elevation, 315°→45° azimuth<br>LFR, 15° elevation, 315°→45° azimuth<br>LFR, 30° elevation, 315°→45° azimuth<br>LFR, 45° elevation, 315°→45° azimuth<br>LFR, -15° elevation, 315°→45° azimuth<br>LFR, -30° elevation, 315°→45° azimuth<br>LFR, -45° elevation, 315°→45° azimuth  | 20Hz – 20kHz    | Typical Listener Free-field Frequency Responses measured at elevation angles of 45°, 30°, 15°, 0°, -15°, -30° and -45°, and one each at azimuth angles of 315°, 330°, 345°, 0°, 15°, 30° and 45°. See Fig. 1.10  |
| ST_CL<br>ST_OP   | Sidetone, closed ear condition<br>Sidetone, open ear condition  | 100Hz – 20kHz   | Typical data for Ear canal occluded with ear-mould simulator DB-2902 (hole sealed)   |

**Table 1.2** (cont.) Details of the files on the CD supplied with Type 4128-C. The CD supplied with Type 4159-C includes *LFR\_L* (the left ear listener frequency response) instead of *LFR\_R*

| File Name         | Contents  | Frequency Range | Comments   |
|-------------------|---|-----------------|--|
| MNFF<br>(_01→_20) | Mouth normalised free-field responses                                     | 100Hz – 10kHz   | Typical data MNFF_01 → MNFF_20 correspond to the measurements made at the measurement points given in ITU-T Rec. P.51 <sup>a</sup> . See Table 1.3 |
| MSP_1VIN          | Sound power with mouth insert, 1V drive                                   | 100Hz – 10kHz   | Typical data   |
| MSP_1V            | Sound power without mouth insert, 1V drive                                |                 | Typical data   |
| MSPMRPIN          | Sound power relative to sound pressure at MRP, with mouth insert          | 100Hz – 10kHz   | Typical data   |
| MSPMRP            | Sound power relative to sound pressure at MRP, without mouth insert       |                 | Typical data   |
| ERP-DRP           | Ear Reference Point (ERP) to Drum Reference Point (DRP) transfer function | 100Hz – 8kHz    | The ERP-DRP correction function given in ITU-T Rec. P.57 <sup>b</sup>  |
| EEP-DRP           | Ear Entrance Point (EEP) to Drum Reference Point (DRP) transfer function  |                 | Typical data   |
| ERP-DRPM          | Ear Reference Point (ERP) to Drum Reference Point (DRP) transfer function | 20Hz – 20kHz    | Typical measured ERP-DRP transfer function   |

a. This document deals with a rotationally symmetrical artificial mouth and not a HATS, so care should be taken when comparing different sets of results of measurements at these points.

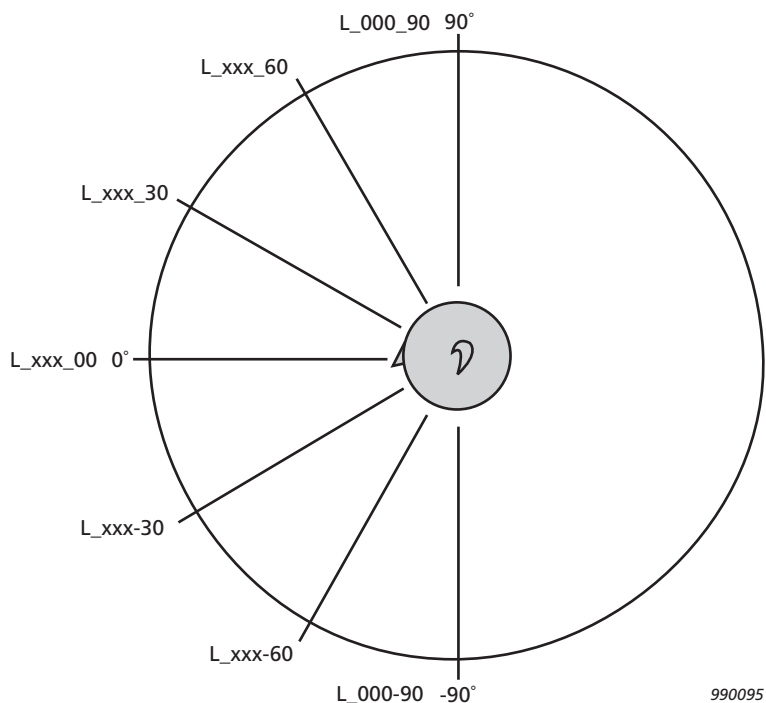
b. The sound pressure measured by the ITU-T Type 3.3 artificial ear (Brüel & Kjær Type 4158-C/4159-C) is referred to the Drum Reference Point. The correction function given in ITU-T Rec. P.57, Table 2 must be used for converting data to the Ear Reference Point.

Fig.1.8 to Fig.1.11 show the elevation angles to which the various measurement files correspond and for which azimuth angles measurements are given within these files. Numbering in ordinary type is for measurement data of the right ear and that in *italics* is for measurement data of the left ear.

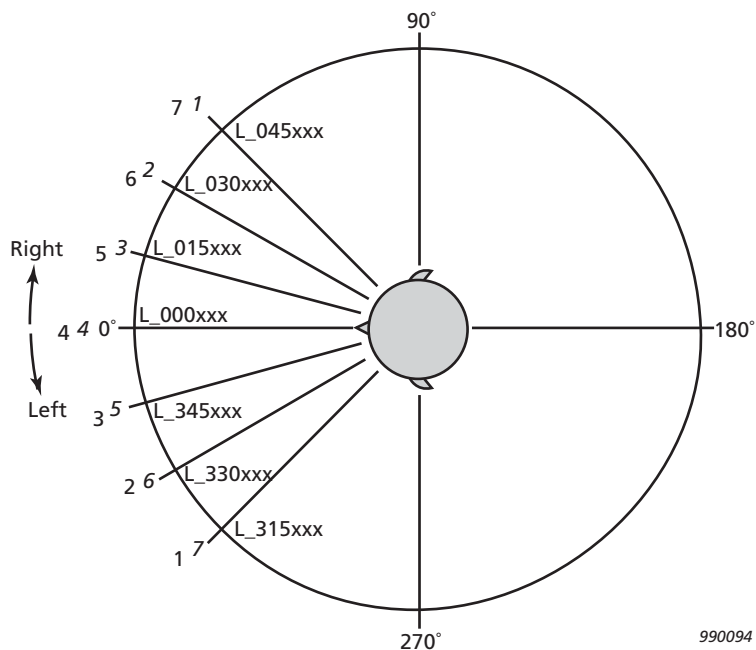


**Fig. 1.8**

The elevation angles of sound incidence to which files on the calibration CD refer (see Table 1.2 and Fig. 1.11)

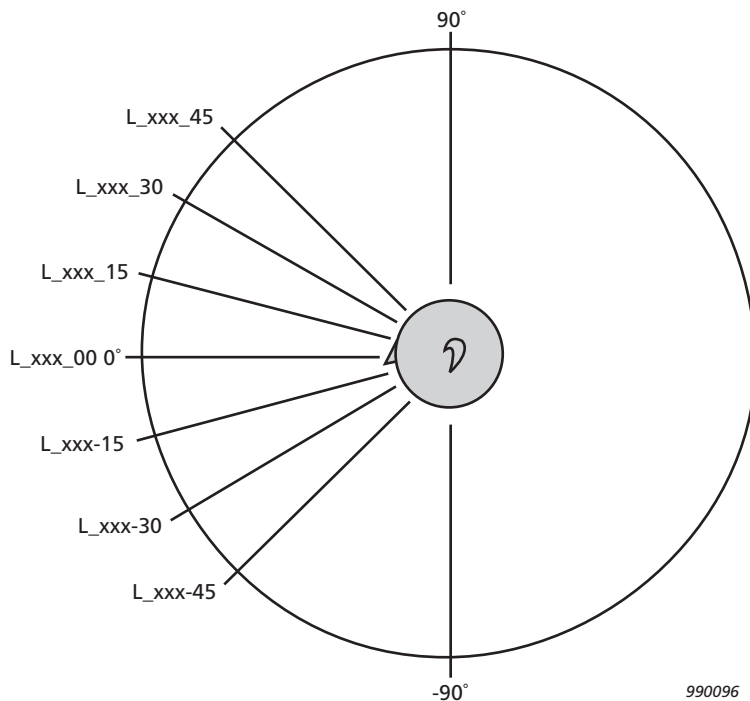
**Fig. 1.9**

The azimuth angles of sound incidence for which measurements are given in each of the files given in Fig. 1.10. Those numbers in normal type are for the right ear, and those in *italics* are for the left ear



**Fig. 1.10**

The elevation angles of sound incidence to which files on the calibration CD refer (see Table 1.2 and Fig. 1.9)

**Fig. 1.11**

The azimuth angles of sound incidence for which measurements are given in each of the files given in Fig. 1.8. Those numbers in normal type are for the right ear, and those in italics are for the left ear

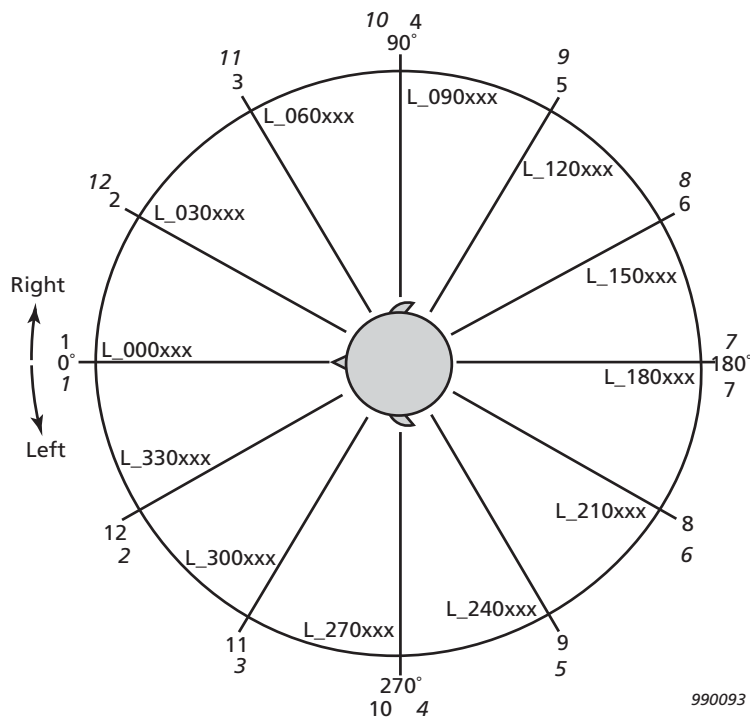


Table 1.3 lists the measurement points used for the measurements in files MNFF-01 to MNFF-20 on the CD. These are measurement points as specified in ITU-T Rec. P.51, which deals with a rotationally symmetrical artificial mouth and not a HATS, so care should be taken when comparing different sets of results of measurements at these points.

**Table 1.3** Measurement points used in files MNFF\_01 to MNFF\_20, as specified in ITU-T Rec. P.51

| Measurement Point | On-axis Displacement from Lip Plane (mm) | Off-axis Perpendicular Displacement (mm) |                                 |
|-------------------|--|--|---------------------------------|
| 1                 | 12.5                                     | 0  |                                 |
| 2                 | 50                                       | 0  |                                 |
| 3                 | 100                                      | 0  |                                 |
| 4                 | 140                                      | 0  |                                 |
| 5                 | 0  | 20 horizontal                            |                                 |
| 6                 | 0  | 40 horizontal                            |                                 |
| 7                 | 25                                       | 20 horizontal                            |                                 |
| 8                 | 25                                       | 40 horizontal                            |                                 |
| 9                 | 25                                       | 20 vertical (downwards)                  |                                 |
| 10                | 25                                       | 40 vertical (downwards)                  |                                 |
|                   | Distance from Lip Plane (mm)             | Azimuth Angle Horizontal (deg.)          | Elevation Angle Vertical (deg.) |
| 11                | 500                                      | 0  | 0                               |
| 12                | 500                                      | 0  | +15                             |
| 13                | 500                                      | 0  | +30                             |
| 14                | 500                                      | 0  | -15                             |
| 15                | 500                                      | 0  | -30                             |
| 16                | 500                                      | 15                                       | 0                               |
| 17                | 500                                      | 30                                       | 0                               |
| 18                | 12.5                                     | 0  | 0                               |
| 19                | 25                                       | 0  | 0                               |
| 20                | 50                                       | 0  | 0                               |



# Chapter 2

## Characteristics

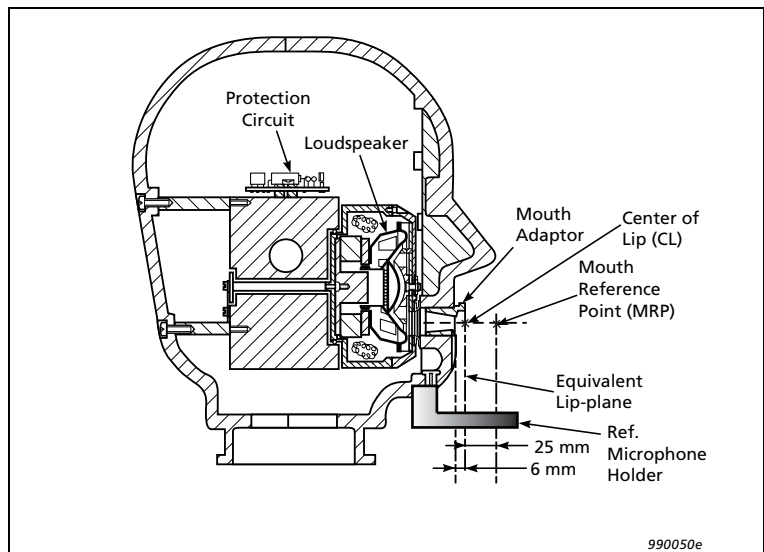
### 2.1 Construction of the Head and Torso Simulator

#### Head and Torso Construction

The shell of Head and Torso Simulator Type 4128-C is made up of three parts: the torso, which is in one moulded piece and cannot be dismantled, and the two halves of the head (front and back). The procedure for separating these parts is given in Chapter 1.

#### Mouth Simulator Construction

**Fig.2.1**  
*Construction of the mouth  
of HATS*



The construction of the mouth simulator of the HATS is shown in Fig.2.1. It features a high-compliance loudspeaker and has a carefully adjusted acoustic transmission path between the loudspeaker and the sound radiation opening which ensures that the sound pressure level in front of the mouth is easily equalisable with respect to frequency.

The loudspeaker has an impedance of  $4\Omega$  and a maximum power rating for continuous operation of 10 W. To reduce the risk of damage, the drive to the loudspeaker is limited by a protection circuit mounted in the head of Type 4128-C. The mouth opening of Type 4128-C has a removable adaptor SO-0007 which allows a choice of orifice size ( $30 \times 11$  mm or  $42 \times 16$  mm).

On the chin of the HATS there is a reference microphone holder which positions a 1/4" microphone (for example Brüel & Kjær Type 4939 with Preamplifier Type 2670) precisely at the ITU-T Mouth Reference Point (MRP) 25 mm from the equivalent lip-plane. It can also position the microphone at the opening of the mouth. If this holder is not required, it can either be removed by loosening the single cross-head screw that secures it to the chin, or pushed to one side as it can rotate on this screw.

During normal use of the HATS there should be no need to dis-assemble the mouth simulator. If problems are experienced with the mouth simulator, consult your local Brüel & Kjær representative.

### **Ear Simulator Construction**

The construction of the artificial ear in the HATS is shown in Fig.1.4. The ear consists of a removable silicone-rubber pinna coupled to an ear canal which is terminated by an occluded ear simulator. The ear simulator consists of a main housing into which are assembled a number of rings whose shapes form annular air volumes connected to the main volume of the housing by restricted air passages. This design results in the main ear canal being of similar shape and volume to an average human ear, and provides a representative acoustic impedance termination. The ear simulator can be removed from Type 4128-C but dismantling of the ear simulator itself should not be necessary and is not recommended. If problems are experienced with the ear simulator, consult your local Brüel & Kjær representative.

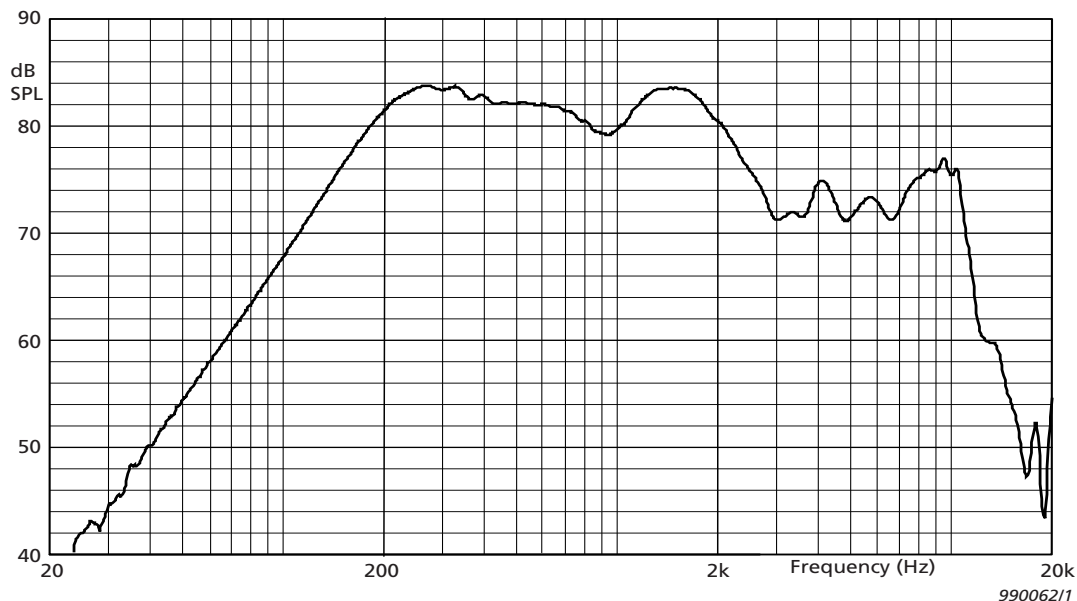
## **2.2 Mouth Simulator Operating Characteristics**

### **Talker Frequency Response**

Fig.2.2 shows the sensitivity frequency response of the mouth simulator of Type 4128-C measured 500 mm from the equivalent lip-plane (the equivalent lip-plane being 6 mm in front of the actual sound radiation opening) with the standard mouth insert in place.

The individually measured talker frequency response is given in file TFR on the calibration CD, and is on the calibration chart supplied with Type 4128-C.

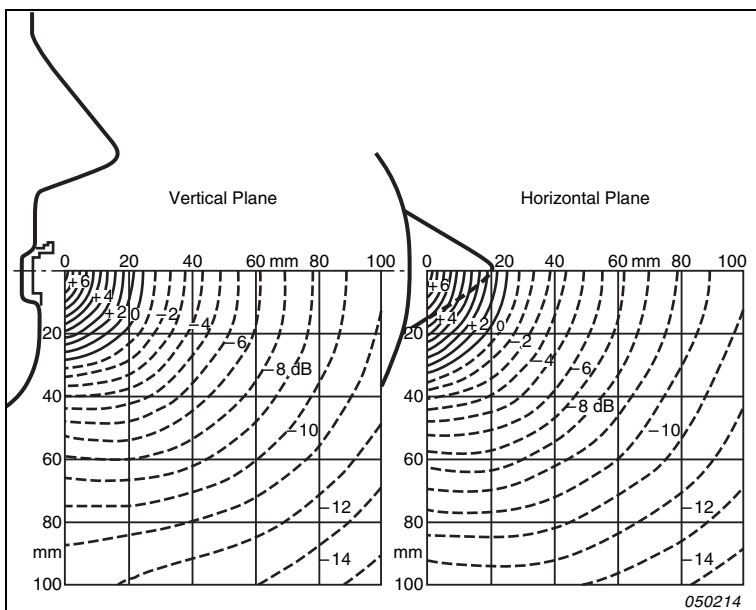
**Fig.2.2** Typical Talker Free-field frequency Response of Type 4128-C (20 Hz – 20 kHz)

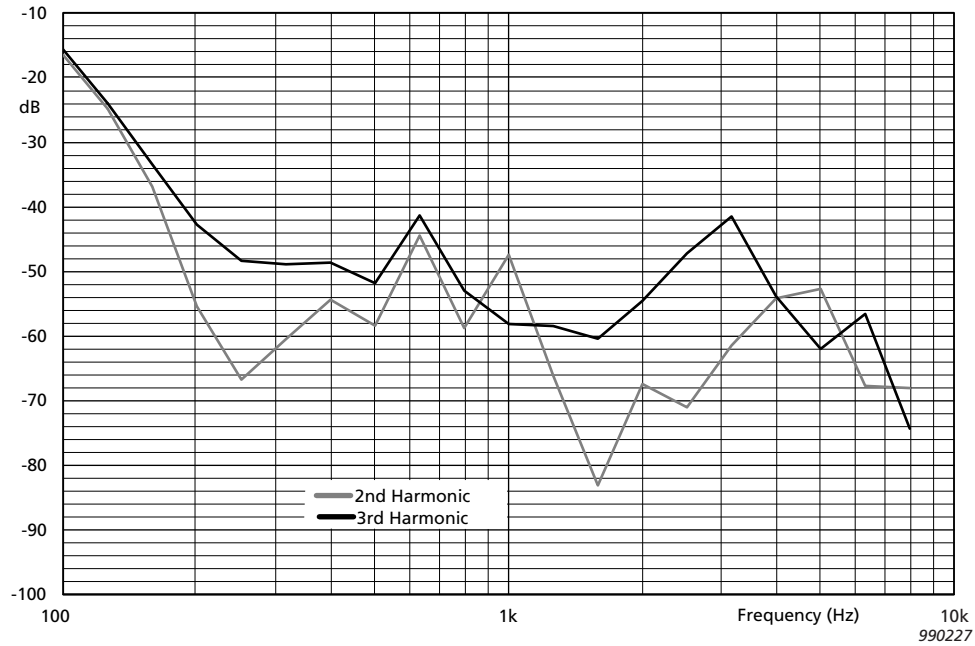


### Normalised Free-field Response Distribution

The sound-pressure level distribution around the mouth of Type 4128-C is shown in Fig.2.3 for “whole speech”; it closely follows that found around the human mouth. The measurement was made with the mouth insert in place.

**Fig.2.3**  
The sound pressure level distribution around the mouth opening with the mouth insert in place (average from 300 Hz to 3.3 kHz)



**Fig.2.4** Second and third harmonic distortion of the mouth simulator

### Harmonic Distortion

Fig.2.4 shows typical second-harmonic and third-harmonic distortion of the mouth simulator.

### Overload Protection

The mouth simulator of Type 4128-C has a built-in overload protection circuit, which will trigger automatically if the drive signal applied to the loudspeaker is too great or remains on for too long. The circuit can be seen on top of the mouth and ear mounting block if the head is split. It allows continuous operation up to 10 W and pulsed operation up to a maximum of 50 W for 2 seconds. If these limits are exceeded, the circuit disables the mouth simulator output. The protection circuit resets approximately half a minute after the drive signal is disconnected. The effect of the overload protection circuit can be seen in Fig.2.5.



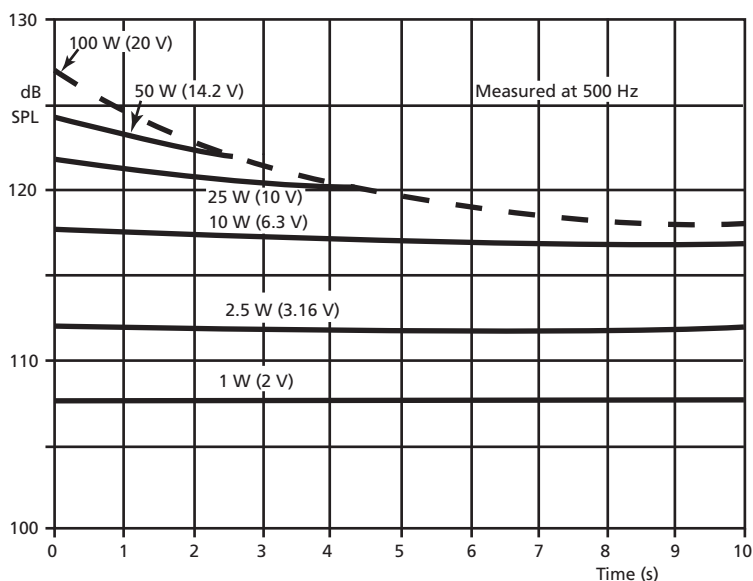


**CAUTION:** If the mouth simulator is excited with pulses of more than 50 W, damage may occur before the protection circuit reacts.

When operating at relatively high power levels, the output SPL of the mouth simulator changes with time for a short period after the signal is applied due to heating of the loudspeaker coil. Fig. 2.5 illustrates the short-term effect for different input power levels. If the mouth simulator is to be operated at consistently high power levels, then calibration should be performed at these high power levels. Calibration performed at low levels would lead to inaccuracies due to the heating effects.

Variation of performance with variation of ambient temperature and pressure is negligible within the specified operating temperature and pressure of the mouth simulator.

**Fig. 2.5**  
*Short-term variation of output sound pressure level with input power. Operation above the broken curve triggers the protection circuit*



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## 2.3 Ear Simulator Operating Characteristics

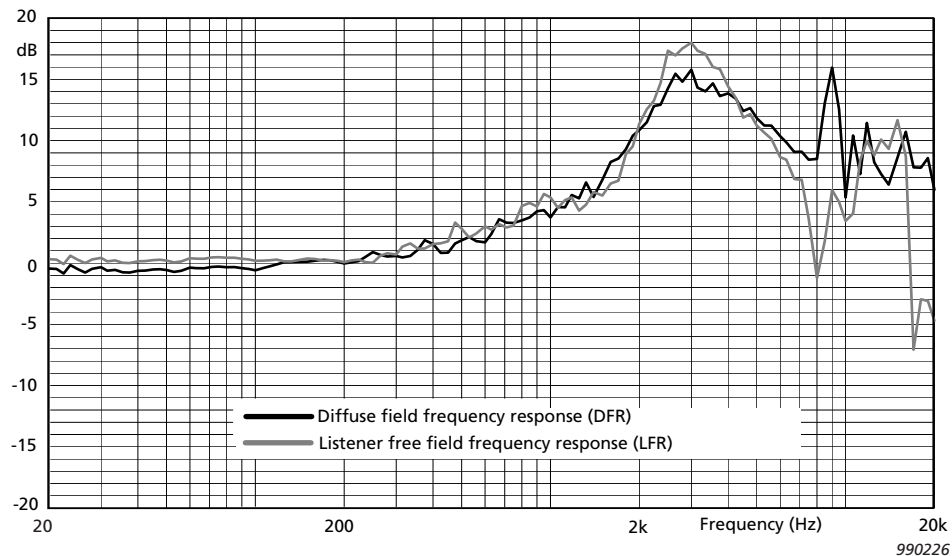
### Listener Free-field Frequency Response

The frequency response from the undisturbed free-field to the eardrum of a manikin has a variety of names. In this manual we refer to it as the Listener Free-field Frequency Response (LFR). Names which may be found in other publications include listener orthotelephonic (reference) sensitivity frequency response (particularly in ITU literature), Mannequin Frequency Response (MFR) (particularly in connection with hearing aids), and free-field frequency response.

Fig. 2.6 shows a typical LFR for sound incident at  $0^\circ$  for Type 4128-C, with the ear simulator in the right ear. The LFR is the overall frequency response from the free-field to the eardrum and includes the effects of the head, torso, pinna, ear-canal and ear simulator. The calibration chart supplied with each Type 4128-C illustrates the measured LFR for sound incident at  $0^\circ$  for that

particular model, and this measurement can also be found in file LFR\_R on the calibration CD. A similar measurement for the left ear can be found in file LFR\_L on the CD supplied with Left Ear Simulator Type 4159-C.

**Fig.2.6** Typical Listener free-field (LFR) and diffuse-field (DFR) curves for HATS (20 Hz – 20 kHz)



If measurements are to be made using both ears at the same time, then the matching between the left and right ears of Type 4128-C will be a combination of the tolerances on the pinnae (as given in the specifications), and the tolerances on the ear simulators fitted, as given in the IEC 60318-4 standard with which the ear simulators comply. Using the individual LFR measurements supplied on CD with Types 4158-C and 4159-C, mismatch can be corrected for using the post-processing facilities of an analyzer like Brüel & Kjær PULSE Audio Analyzer.

If left- and right-ear measurements are not needed simultaneously, the possible mismatch can be reduced to that due to pinna differences by using only one ear simulator; the ear simulator is easily transferred from one ear to the other.

The variation between any two left pinnae or any two right pinnae is less than 1 dB, so if replacement pinnae are used there will be no problem comparing results with those of previous measurements. For optimum accuracy the pinna marked with the serial number of Type 4158C (i.e. that which is part of Type 4158-C) should be used, as it is with this pinna that the calibration of Type 4158-C is made. The same applies to Type 4159-C.

### Listener Diffuse-field Frequency Response

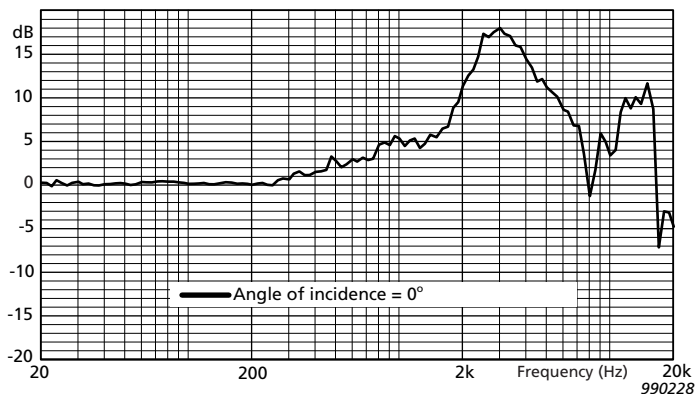
The Listener Diffuse-field Frequency Response (i.e., the overall frequency response from the undisturbed diffuse-field to the eardrum of the simulated listener) is shown in Fig.2.6. The measurement is stored on the calibration CD in file DFR.

### Off-axis Listener Free-field Frequency Responses

The frequency response of the HATS to off-axis sound in the free-field is illustrated in Fig. 2.7 to Fig. 2.10. These measurements were made using Brüel & Kjær PULSE Audio Analyzer, with an ear simulator fitted in the right ear of Type 4128-C.  $0^\circ$  corresponds to sound incident on the face of Type 4128-C, and  $90^\circ$  to sound incident on the right ear. More off-axis curves can be found on the calibration CD.

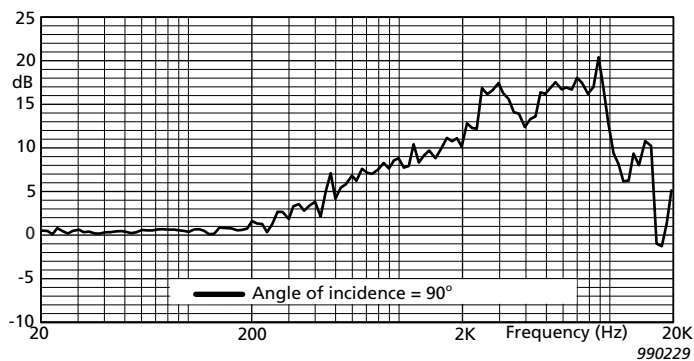
**Fig. 2.7**

*Off-axis response of Type 4128-C ( $0^\circ$ ) in the free-field (20 Hz – 20 kHz)*



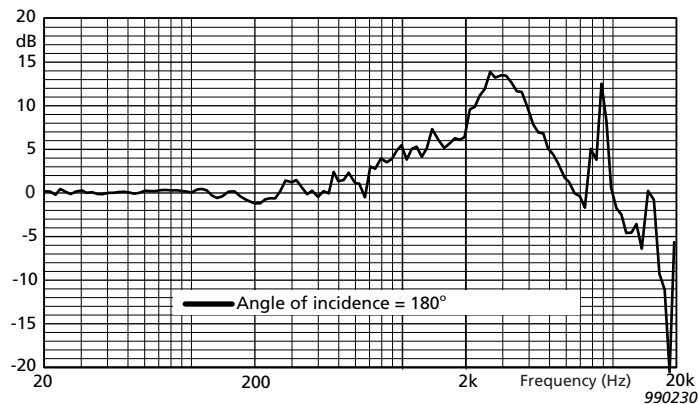
**Fig. 2.8**

*Off-axis response of Type 4128-C ( $90^\circ$ ) in the free-field (20 Hz – 20 kHz)*

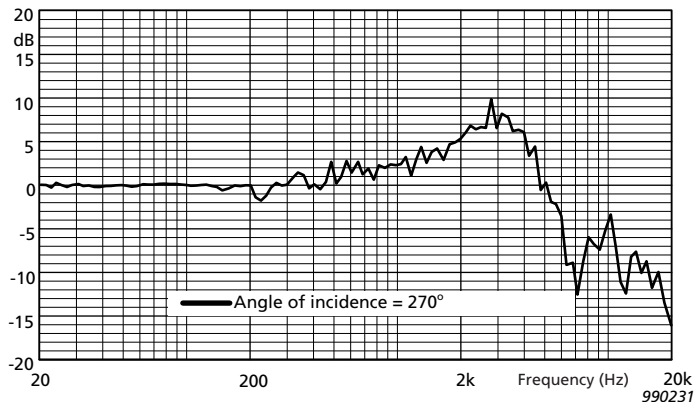


**Fig. 2.9**

Off-axis response of Type 4128-C ( $180^\circ$ ) in the free-field (20 Hz – 20 kHz)

**Fig. 2.10**

Off-axis response of Type 4128-C ( $270^\circ$ ) in the free-field (20 Hz – 20 kHz)



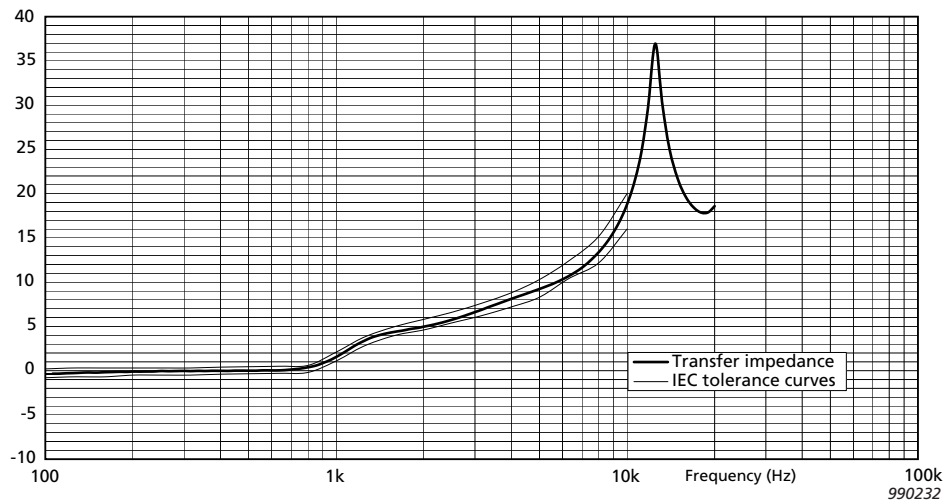
### 2.3.1 Closed-volume Characteristics of the Ear Simulator

The Right Ear Simulator Type 4158-C delivered with the HATS is equivalent to Brüel & Kjær Type 4157, but is usually used open, instead of with coupling devices. Nevertheless, the closed-volume characteristics of the ear simulator may be of interest and so are included here reprinted from the Type 4157 instruction manual.

#### Transfer Impedance

The transfer impedance was measured using a special adaptor DP-0276, which allows a 1/4" condenser microphone Type 4938 to be attached to Type 4157 and used as a sender microphone. The measurements are made by driving the simulator at its input reference plane by a known acoustic volume velocity and then measuring the output of the ear simulator microphone.

**Fig.2.11** *Magnitude of the ear simulator transfer impedance times frequency relative to the value at 500 Hz*



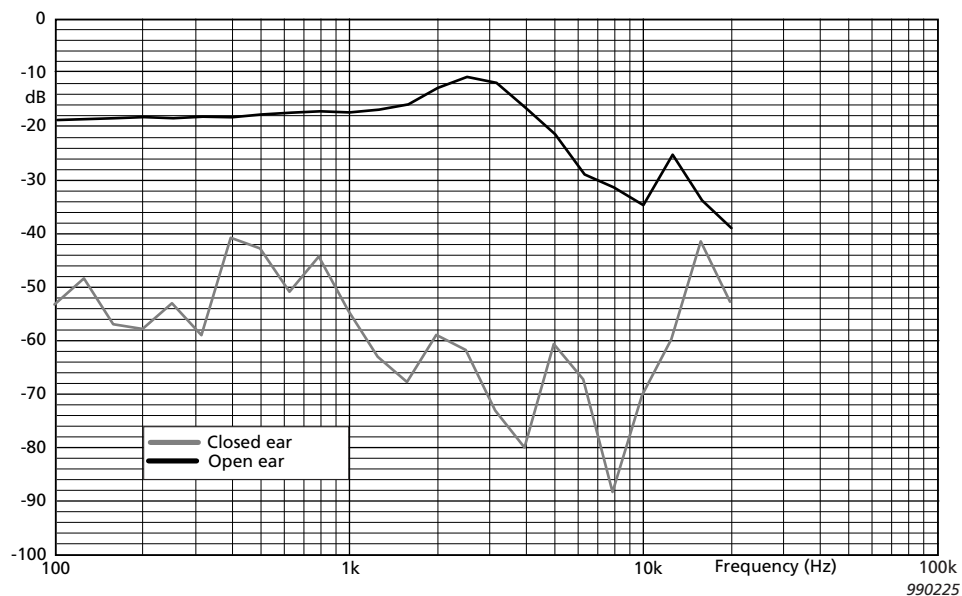
### 2.3.2 General Operating Characteristics

#### Sidetone

The mouth-ear sidetone characteristic of the HATS (i.e., the influence of the mouth simulator output on the ear simulator output) is shown in Fig.2.12 for both an open and a closed ear. Open-ear sidetone is for practical purposes identical to the airborne portion because the structure-borne portion has been minimised by special decoupling arrangements. For the closed-ear measurement a closed coupler DB-2902 is used.

Full duplex operation of the HATS is possible, i.e., both the ear simulator and the mouth simulator can be used at the same time.

**Fig.2.12** The sidetone characteristic of Type 4128-C for both an open and closed ear (100 Hz – 20 kHz)



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# Chapter 3

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## Service and Repair of Type 4128-C

Head and Torso Simulator Type 4128-C has been designed to provide many years of reliable operation and under normal use there should be no significant deviation from the stated specifications. However, if a fault occurs, disconnect the HATS from all external instruments and consult your local Brüel & Kjær service representative. Under no circumstances should repair be attempted by persons not qualified in the service of electronic instrumentation.





# Part II

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## **Handset Positioner for HATS Type 4606**



# Chapter 4

## Type 4606 Features and Functions

### 4.1 Operational Parts of Type 4606

**Fig. 4.1** Main components of Type 4606. (1) Alignment Jig UA-1535; (2) Cradle Positioner Assembly UA-1542; (3) Mounting Bracket UA-1534; (4) Cradle UA-1541



Type 4606 has been developed expressly for use with Types 4128 and 4128-C HATS and bolts directly to the top of the head of the HATS. Type 4606 positions most types of telephone handset for measurements. All positions are repeatable by simply noting down the values shown on the graduations in the special table provided (see section 4.3), and re-applying them.

Type 4606 allows measurement in both standardised and non-standardised positions. One of the standardised positions is the HATS position (see section 4.3.5). Once a handset is set in the HATS position where its ECRP and the HATS pinna ERP coincide, all rotational adjustments provided by the Type 4606 occur around the ERP.

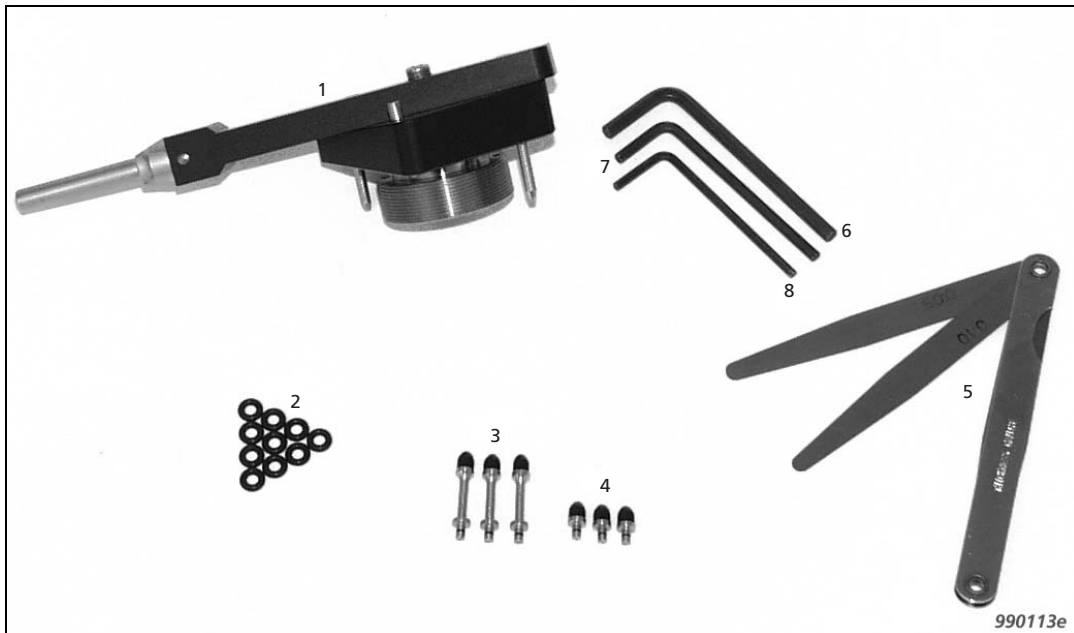


**WARNING:** The supplied feet (see Fig.1.2) must be fitted to HATS to provide added stability. Otherwise, the additional weight of Type 4606 may lead to HATS tipping over and being extensively damaged together with the Type 4606.

Handset Positioner for HATS Type 4606 consists of three major assemblies: The Cradle, the Cradle Positioner Assembly and the Mounting Bracket. See Fig.4.1.

#### 4.1.1 Accessories supplied with Type 4606

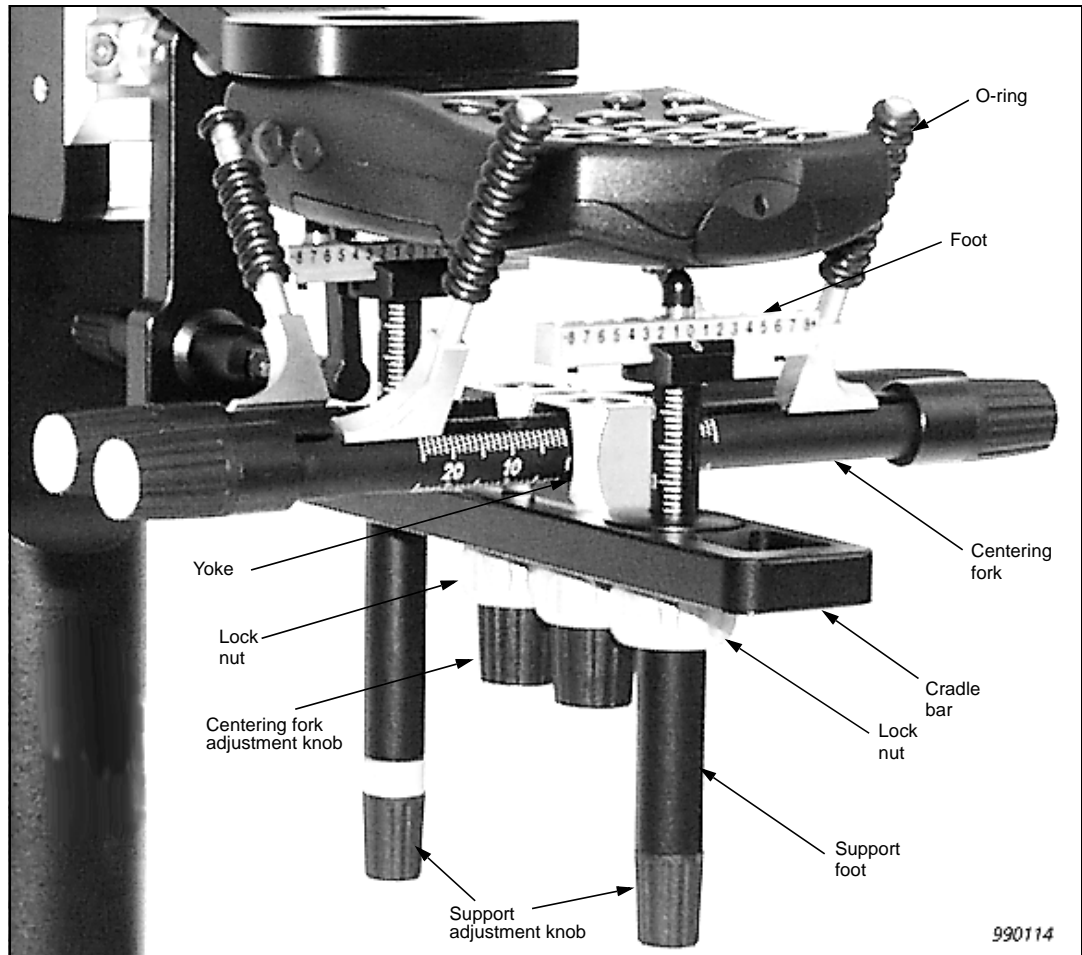
**Fig. 4.2** Accessories supplied with Type 4606: (1) Calibration Tool UA-1549; (2) O-rings (10 pcs.) UA-0997; (3) Spikes, long (3 pcs.) UA-0999; (4) Spikes, short (3 pcs.) UA-0998; (5) Feeler Gauge QX-1253; (6) 4 mm Allen Key QX-1173; (7) 3 mm Allen Key QX-1172; (8) 2.5 mm Allen Key QX-1171



### 4.1.2 The Cradle

The cradle is used for firmly holding and positioning handsets of almost any shape. The cradle then attaches to the rest of the handset positioner for HATS, accurately locating the handset. The cradle is crafted from precision, CNC machined aluminium and stainless steel parts for accuracy and durability.

**Fig. 4.3** Cradle with mounted handset



#### Major Components of the Cradle

The centering forks (see Fig. 4.3) have rubber grips (O-rings) for firmly holding the telephone handset in place without marking or damaging it. The O-rings can be removed or placed individually, so that they are only in contact with specified areas of the handset, avoiding buttons, etc. The adjustment knob located at the bottom of the assembly allows the centering forks to be offset and inclined. The knurled lock nut above it secures the assembly to the cradle. The two centering forks can be placed in any two of the five sockets in the cradle. The five

sockets are shaped to prevent the centering fork being mounted in a reversed position, which would change the direction in which the centering mechanism functioned.

The supports help to position the handset under test before it is clamped in place with the forks. The supports can be extended or retracted using the adjustment knobs at the bottom of their shafts.

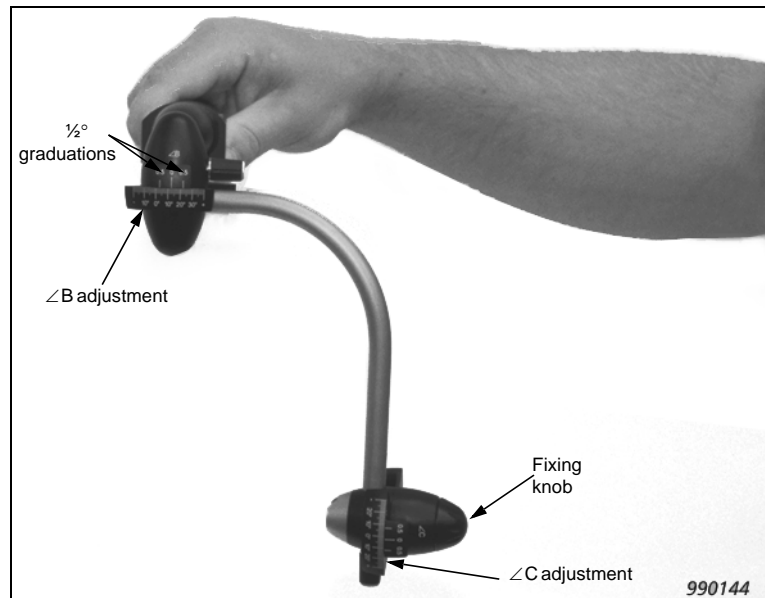
To prevent damage to the handset under test, a friction lock is used to limit the amount of pressure the supports can apply. At the top of the supports are the support feet, which can be slid laterally on a ratchet. The feet are marked with a graduated scale. Spikes (see Fig.4.2) are plugged into the feet to support the phone. The general method is to support the phone in three places on the spikes which come in two lengths, 5 mm and 20 mm. When fitting the spikes into the support feet, twisting them slightly on insertion ensures that they seat properly. The front support (closest to the end stop) is positioned to be directly under the handset's ECRP when the handset is correctly mounted in the cradle. The rear support (opposite end to the end stop) can be positioned in any one of the five sockets available for the centering forks and is held in place with a knurled locking ring similar to those used on the centering forks.

The end stop works in the same way as the supports, only in the horizontal plane, and controls the positioning of the phone along its longitudinal axis.

The centering forks, supports, and end stop all have laser etched graduations on them that allow you to read and duplicate their settings. This makes handset positioning repeatable as you only have to repeat these settings to locate the handset in exactly the same position.

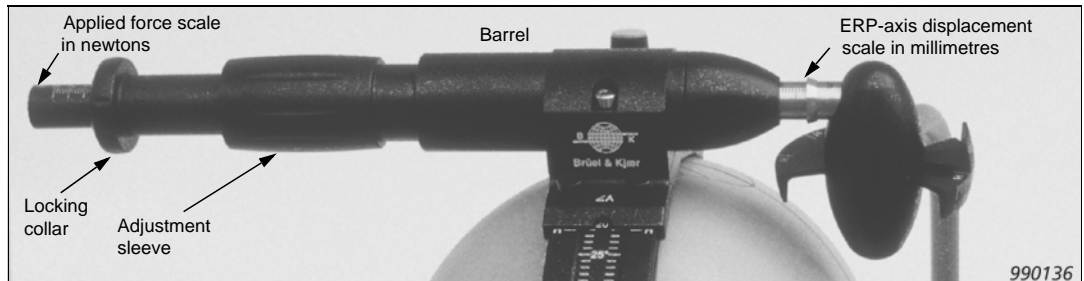
### 4.1.3 Cradle Positioner Assembly

**Fig. 4.4**  
*Cradle Positioner  
Assembly showing two  
single plane, graduated  
swivel joints*



The cradle positioner provides much of the adjustment flexibility of the handset positioner. It consists of the barrel (see Fig. 4.5), which bolts onto the mounting bracket (see Fig. 4.6), and the arm, which contains two single-plane swivel joints with graduations (see Fig. 4.4). The barrel provides adjustment parallel to the ERP axis (formed by the ERPs of the left and right ears of HATS). The handset positioner is adjusted along this axis by rotating the adjustment sleeve. The displacement can be read off a graduated millimetre scale at end of the barrel. Pulling the collar located at the end of the sleeve, disengages the adjustment mechanism for quickly dismounting/repositioning the cradle or handset.

**Fig. 4.5** Cradle Positioner Assembly showing barrel and features



**Note:** The locking collar must be set to the “Lock” position for the adjustment mechanism to work.

The cradle positioner can be reverse mounted on the mounting bracket and all graduations are mirrored giving the option of measurements on both left and right ears. Special markings are placed either side of the main pointer to give you the option of setting positions to within half a degree. The first joint on the cradle positioner allows you to adjust  $\angle B$  (see Fig. 4.9.8) and is graduated on both sides to allow measurements on both ears. The second joint also serves as the mounting socket for the cradle and allows you to adjust  $\angle C$  (see Fig. 4.9.9). The cradle is fixed in place by tightening the fixing knob located at the closed end of the second joint. This joint also has graduations on both sides to allow measurements on both ears. The joints are positioned to allow the inclination of the handset about the ECRP in two planes.

#### 4.1.4 Mounting Bracket

This mounting bracket sits on the head of HATS locating the whole handset positioner for HATS accurately. The lockable slide mechanism (see Fig. 4.6) allows mounted handsets to be rotated about the ERP axis (formed by the ERPs of the left and right ears of HATS). As with all points of adjustment on Type 4606, the bracket has graduations that can be easily read off and noted down for documenting the measurement. To ensure accurate positioning, which is essential for mounting Type 4606 correctly, four screw studs are provided that are the points of contact between the HATS head and Type 4606. For details see section 4.2.

**Fig. 4.6**

HATS head with mounting bracket



#### 4.1.5 Alignment Jig

To position the telephone handset correctly within the handset positioner cradle, an alignment jig is supplied (see Fig. 4.1). This table top instrument allows you to accurately fix the position of the telephone handset's ECRP and then position the handset in the cradle so that the telephone handsets ECRP lies on the HATS ERP axis when mounted together with the rest of the handset positioner.

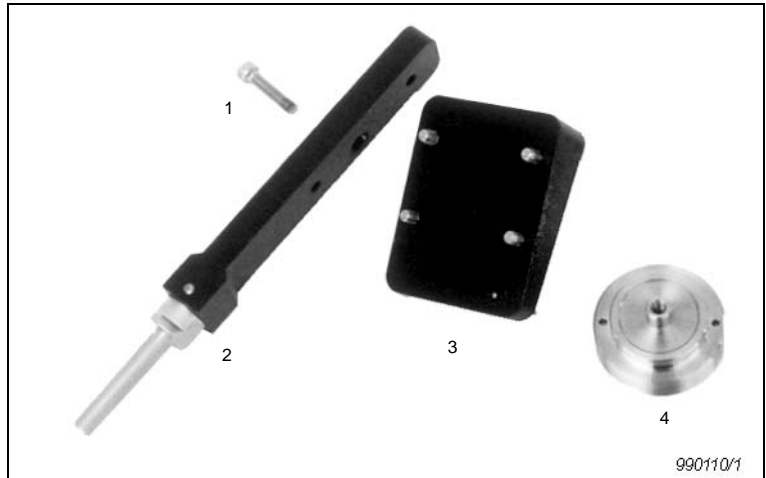
## 4.2 Mounting and Calibration (Right Ear)

**Note:** You can order the mounting and calibration of Type 4606 on HATS from the factory as service 4606 - TCF.

This procedure is performed to correctly mount Type 4606 on HATS for measurements on the right ear (see Fig. 4.8 and Fig. 4.9). The same procedure can be used for the left ear, taking care to reverse the position of Support Arm UC-0220 on the ear brick (see Fig. 4.7), and the position of the cradle positioner on the mounting bracket. The two joints on the positioner assembly should also be adjusted to their “left-hand” positions.

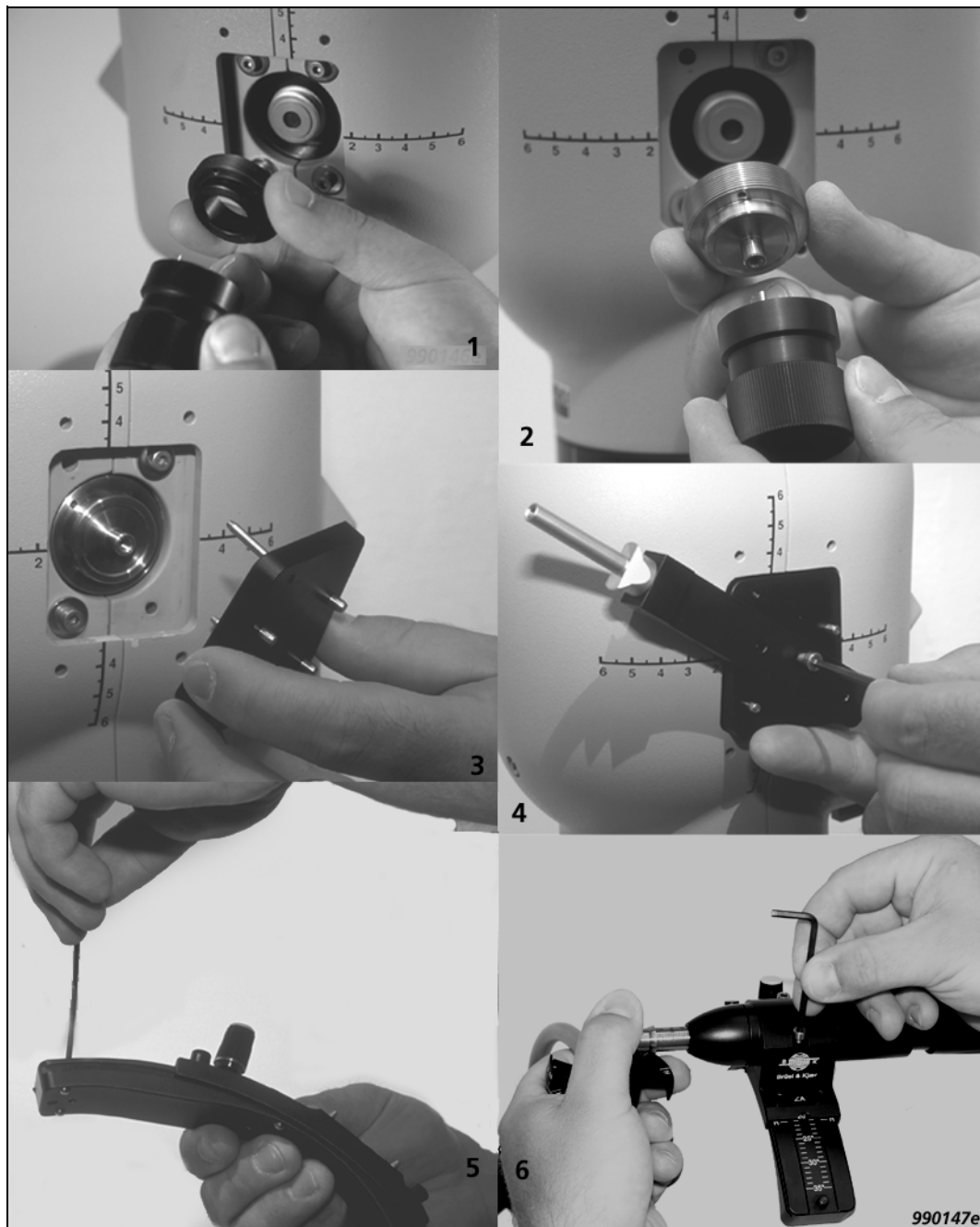


**Fig. 4.7**  
*Handset Positioner  
Calibration Tool UA-1549  
as delivered  
(disassembled)*  
(1) Allen Bolt YQ-0096  
(2) Support Arm UC-0220  
(3) Ear Brick UC-0219  
(4) Mounting Collar  
DB-3761



- 1) Remove the rubber pinna by sliding it forward (towards the face of HATS) and then pull outwards at the rear of the pinna.
- 2) Using Ear Mounting Tool QA-0167 (Fig. 1.1.3) supplied with Type 4128-C, loosen and remove Microphone Retaining Collar DB-3021 (Fig. 4.8.1).
- 3) Again using the ear mounting tool, mount (by screwing in) the mounting collar (Fig. 4.7.4) until hand tight (see Fig. 4.8.2).
- 4) Remove the upper left and lower right head brick retaining screws from the pinna socket, mount the ear brick UC-0219 (Fig. 4.7.3) with its thicker end downwards and the long locating spikes fitting into the retaining screw sockets (see Fig. 4.8.3).
- 5) Mount Support Arm Type UC-0220 (Fig. 4.7.2) on the ear brick, taking care to position it on the locating pins with the support arm pointing rearwards and upwards. Use Allen Bolt YQ-0096 (Fig. 4.7.1) to securely fasten the support arm to the mounting collar through the ear brick. Tighten carefully using the 3 mm allen key (Fig. 4.2.7) supplied (see Fig. 4.8.4).
- 6) Using the 2.5 mm allen key (Fig. 4.2.8) supplied, retract the four adjustment screw studs until they reach their adjustment stops (see Fig. 4.8.5).
- 7) Mount the cradle positioner assembly on the mounting bracket in the right ear measuring position, using the mounting locators and the two allen bolts to secure it firmly (see Fig. 4.8.6).
- 8) Set the barrel so that the arm and swivel joints are as far right as possible and then set the quick release collar to "Lock". Use the adjustment sleeve to adjust the barrel until the displacement graduation is at the ERP position (see Fig. 4.9.10).
- 9) Set  $\angle A$  to  $33^\circ$  on the mounting bracket by loosening the locking knob and sliding the top of the assembly to the desired position and re-tightening the locking knob (see Fig. 4.9.7).

**Fig. 4.8** Mounting the handset positioner correctly on HATS



- 10) Set  $\angle B$  on the cradle positioner joint to  $0^\circ$  and lock it with the locking knob (see Fig.4.9.8).
- 11) Set  $\angle C$  on the other joint to  $-10^\circ$  without locking it and fit the socket for the cradle onto the end of the support arm, tightening the locking screw hand tight (see Fig.4.9.9).
- 12) Gently move the mounting bracket towards the top of the HATS until  $\angle C$  reads zero. Now use the locking knob to lock it in position. There should be a thin gap ( $<1$  mm) between the top of the head of the HATS and the four screw studs (see Fig.4.9.11).

**Note:** Check the cradle positioner barrel to ensure that it is still set at the ERP position.

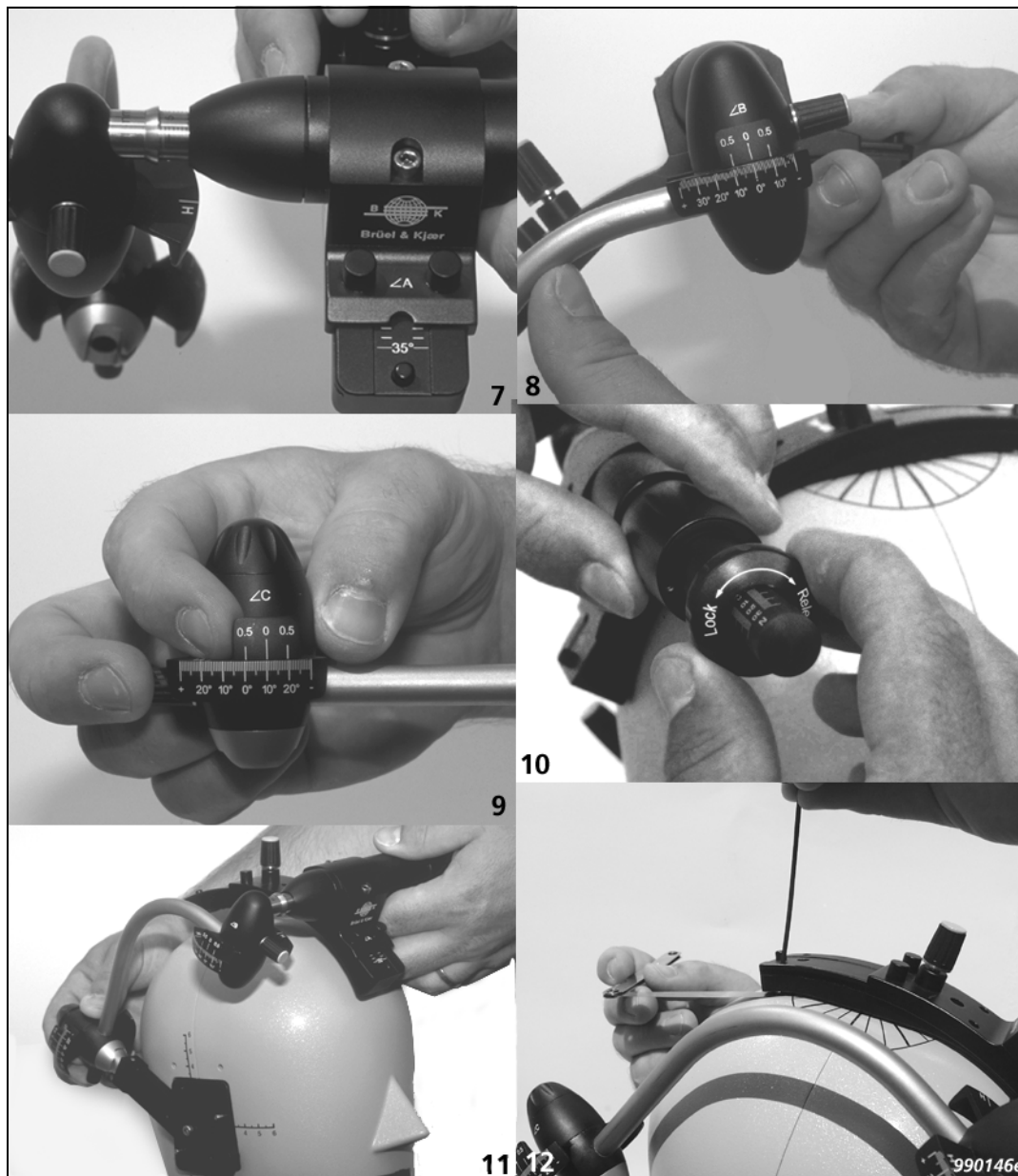
- 13) Use Feeler Gauge QX-1253 (Fig.4.2.5) to set the gap between the four screw studs and the top of the HATS head to 0.05 mm (see Fig.4.9.12).
- 14) Now use the supplied M3 allen bolts and washers to bolt the mounting bracket to the top of the HATS head.

The mounting bracket should now be correctly mounted.

To remove the calibration tool:

- 1) Remove the allen bolt holding the support arm and ear brick together.
- 2) Unlock the quick release on the cradle positioner barrel and slide the support arm/ear brick assembly out of the pinna socket.
- 3) Detach the support arm from the joint it is mounted in on the cradle positioner assembly.
- 4) Using Ear Mounting Tool QA-0167 (Fig.1.1.3), remove Mounting Collar DB-3781 (Fig.4.7.4) and remount Microphone Retaining Collar DB-3201. Finally refit the rubber pinna.

**Fig. 4.9** Mounting the handset positioner correctly on HATS



### 4.2.1 Mounting a Telephone Handset correctly in the Cradle

**Fig. 4.10**

*The cradle mounted in the alignment jig prior to fitting a telephone handset*



For the given handset, make sure that the centering forks are placed in suitable holes in the cradle bar. The optimum way of positioning the centering forks is so that they point in opposite directions, i.e., the centering fork closest to the sight points forwards and the rear centering fork points backwards.

- 1) Place the cradle in the alignment jig and tighten the knob on the back of the fixture.
- 2) Retract the support feet and the end stop and widen the centering forks, so that they will not interfere with the handset.
- 3) Tip down the sight and lock it in position.
- 4) Make sure that the handset can be supported by both support feet by selecting an appropriate mounting hole for the rear support.
- 5) The handset should be supported with only three spikes; one positioned in the rear support foot and two positioned in the front support foot below the ERP or vice versa. Position the spikes in suitable holes in the support feet. Choose whether to use short or long spikes or both. Choose spike positions that do not interfere with projections caused by batteries, antennas, etc.
- 6) Position the handset so that its ECRP is in the middle of the alignment jig sight and tighten the support foot directly below the ERP until the ear-cap plane is positioned correctly against the under side of the sight.
- 7) Extend the rear support foot until it just supports the other end of the handset.
- 8) Adjust the end stop until it just touches the edge of the handset.

- 9) Rotate the centering forks to angles that do not interfere with buttons on the side of the handset or project much above the top side of the handset (this is to prevent them from fouling the cheek of HATS when mounting the cradle on the cradle positioner assembly). Tighten the forks around the handset.
- 10) Tighten the knob that locks the angle and the offset adjustments of the centering forks.
- 11) Unlock the sight and remove the cradle from the alignment jig.

The cradle is now ready to be mounted on the cradle positioner assembly and used for measuring.

### **Mounting a Telephone Handset with an Asymmetrically Mounted Transducer**

If the offset distance of the transducer is known, set the offset of the centering forks to the desired value and go through the steps in the previous section. The offset of the centering forks is set using the graduations marked on them.

If the offset distance is not known, go through steps in the previous section adjusting the centering forks offset so as to ensure that the handset ECRP remains directly under the alignment jig sight. In each case offset the support feet accordingly to maintain a stable mounting for the handset.

### **Applying the Cradle to the Cradle Positioner Assembly**

- 1) With the telephone handset firmly located in the cradle, attach the cradle to the cradle positioner assembly in the second swivel joint and lock it in place with the screw fitting at the opposite end of the joint.
- 2) Slide the barrel of the cradle positioner assembly to move the cradle along the ERP axis until the telephone handset is firmly pressed against the HATS pinna. Now use the collar to lock the barrel in place.
- 3) For further adjustments along the ERP axis, use the screw adjustment mechanism on the barrel operated by rotating the sleeve.
- 4) The force with which the handset is being applied to the pinna can be read off the scale at the opposite end of the barrel to where the displacement readings are shown.

**Note:** Measurements in the HATS position require the use of the “soft pinnae” supplied, as the pinna needs to be able to deform to allow the correct positioning of the handset ECRP.

### **Rotation in Three Planes**

All three adjustment angles  $\angle A$ ,  $\angle B$  and  $\angle C$  (see Fig.4.9.7–9) rotate about the handset ECRP point. When operating the angle adjustments, disengage the locking mechanism first by loosening the locking knobs.

$\angle A$  allows the handset to be rotated about the ERP axis and is set from on top of the Mounting Bracket. (The ERP axis is parallel to the  $y_m$ -axis described in section 4.3.5.)

$\angle B$  and  $\angle C$  are both adjusted via the joints on the handset positioner assembly and, in contrast to  $\angle A$ , allow handset motion in only one plane at a time. Adjusting  $\angle B$  rotates the handset about an axis perpendicular to the normal of the ear-cap plane and the line of intersection of the handset symmetry plane with the ear-cap plane. (This axis is also referred to as the  $z_e$ -axis of the handset – see further details in section 4.3.5.) The  $\angle C$  rotates the handset about the line of intersection of the handset symmetry plane with the ear-cap plane (also referred to as the  $y_e$ -axis).

## 4.3 Handset Positioner Table and Standardised Measurements

This table (see Fig.4.11) has been developed to provide a convenient means of noting down all measurement parameters to make repeatable measurements and to set up Type 4606 for standardised measurements according to ITU-T Rec. P.64. The table provides fields for all the parameters with graduated scales on them. The points at which readings should be taken are indicated by arrows on the diagrams in the table.

### 4.3.1 Centering Fork

The front and rear labels relate to the centering fork placed closest to the front support foot and rear support foot, respectively. The offset label relates to the scale on the crosspiece of the centering fork which should be read off at the point where the crosspiece passes through the yoke (see Fig.4.3) as shown in the Handset Positioner Table in Fig.4.11. Five sockets are provided for mounting the centering forks and the rear support foot. These sockets are numbered 1 – 5 with socket 1 closest to the front support foot.

### 4.3.2 Support Foot

Front and rear share the same definitions as the centering forks along with socket position. However, the front support foot is fixed and cannot be placed in other sockets. The height is read off the graduated shaft of the support foot at the point where the shaft emerges from the cradle bar. The foot on the end of the support foot in which the spikes are mounted slides from left to right on a ratcheted guide. The foot has markings running from  $-5$  to  $+5$ , the offset position of the foot can be read from the number above the pointer at the centre of the guide. The spikes can be placed in holes on the foot. The holes correspond to even numbers on the foot markings. The type and position of the spike is noted  $-4S$ ;  $4S$  representing two short spikes positioned in the  $-4$  and  $4$  positions respectively. For long spikes  $L$  should be used to replace  $S$  in the label.

### 4.3.3 End Stop

The end stop values are read from where the graduated shaft emerges from the sleeve that forms its guide.

Fig. 4.11 Handset Positioner Table


Serial Number:

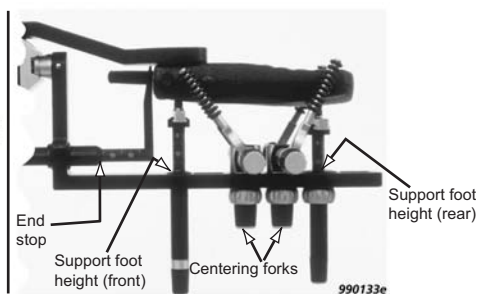
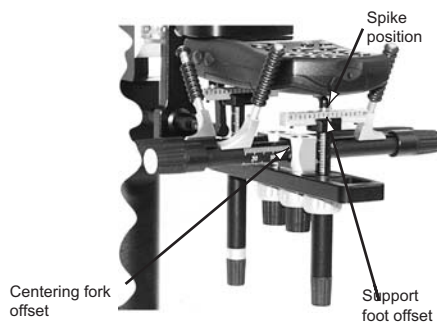
Brüel & Kjær 

Telephone Handset Type:

Operator:

Date:

| Centering Fork        |       |      | Support Foot           |   | End Stop      |  |
|-----------------------|-------|------|------------------------|---|---------------|--|
|                       | Front | Rear | Front                  | Rear  | End stop [mm] |  |
| Offset [mm]           |       |      | Height [mm]            |   |               |  |
| Socket position [1–5] |       |      | Offset [–5 to 5]       |   |               |  |
|                       |       |      | Socket position [1–5]  |  |               |  |
|                       |       |      | Spike [position, type] |   |               |  |



| Angle Settings |                |                | $y_m$ axis            |                   | MECRP                                |            |
|----------------|----------------|----------------|-----------------------|-------------------|--------------------------------------|------------|
| $\angle A$ [°] | $\angle B$ [°] | $\angle C$ [°] | Application Force [N] | ERP-position [mm] | Distance from actual ECRP $y_e$ [mm] | $z_e$ [mm] |
|                |                |                |                       |                   |                                      |            |



Comments:

Measurement Data Path:



#### 4.3.4 Position

$\angle B$  and  $\angle C$  are recorded to the nearest  $\frac{1}{2}^\circ$  using the markings provided on the swivel joints.  
 $\angle A$  is measured off the end of the slide on the mounting bracket.

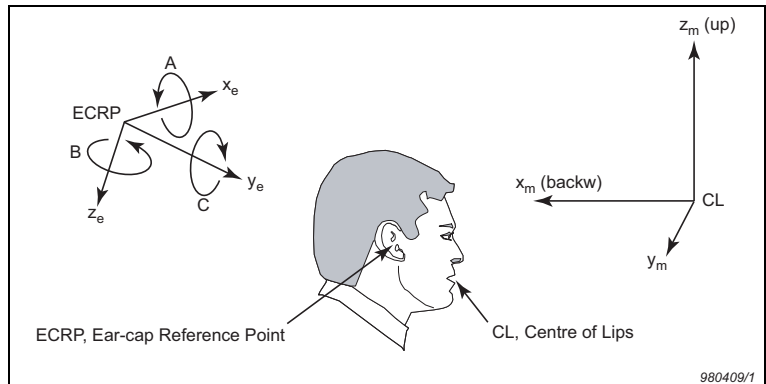
#### 4.3.5 Standardised Measurements

Type 4606 is easy to set up for standardised measurements according to ITU-T Rec. P.64 (11/2007). The following descriptions are valid for HATS mounted with Artificial Ear ITU-T Rec. P.57 Type 3.3 (Brüel & Kjær Types 4158-C and 4159-C).

##### Positioning Terminology

A Cartesian coordinate system is used to describe the standardised position by means of vectors. Using ITU-T Rec. P.64 terminology, the coordinate system originates at CL and consists of three axes called  $x_m$ ,  $y_m$  and  $z_m$ . The  $x_m$ -axis has positive direction into the mouth and coincides thereby with the mouth reference axis. The  $y_m$ -axis is horizontal, perpendicular to the  $x_m$ -axis with positive direction towards the right side of the head and the  $z_m$ -axis is perpendicular to the  $x_m$ -axis and  $y_m$ -axis with positive direction upwards. This head-fixed coordinate system corresponds to the HATS reference plane (see Fig.4.12).

**Fig. 4.12**  
*Diagram of vector directions for head fixed coordinate system*



Similar to the head-fixed coordinate system, a Cartesian coordinate system must be defined for the telephone handset. This coordinate system originates from the handset ECRP and defines three axes:  $x_e$ -axis is normal to the ear-cap plane with positive direction away from the earphone. The  $y_e$ -axis is the line of intersection of the handset symmetry plane with positive direction towards the microphone. The  $z_e$ -axis is normal to the other two axes and is for handsets applied to the right ear. The  $z_e$ -axis points obliquely downwards.

With these two coordinate systems in mind, the standardised positions as defined in ITU-T Rec. P.64 can be set up as described in the following.

Refer to ITU-T Rec. P.64 for the exact vector definitions of the standardised positions.

### **The Standard Handset/HATS Position According to ITU-T Rec. P.64 Annex E.1**

For the standard handset position, the settings of the three angles are clearly marked on the handset positioner by an “H” at  $\angle A$ ,  $\angle B$  and  $\angle C$  and by “ERP” on the mm scale on the handset positioner barrel (the ERP-axis). The nominal angles for the standard handset position are  $\angle A = 21.2^\circ$ ,  $\angle B = 12.9^\circ$ ,  $\angle C = 2.3^\circ$ . Note that for the standard handset position ERP and ECRP (Ear Cap Reference Point) of the handset are coincident.

### **The Alternative Handset Positions According to ITU-T Rec. P.64 Annex E.2**

For the alternative position, the three angles  $\angle A$ ,  $\angle B$  and  $\angle C$  can be rotated within acceptable ranges relative to the standard position – and the Manufacturer-defined Ear Cap Reference Point (MECRP) allows for movement of the ECRP point on the surface of the phone.

The acceptable ranges of handset rotation about the MECRP are:

- $\pm 6^\circ$  in rotational degree of freedom A, defined as clockwise rotation about the  $x_e$  unit vector
- $\pm 6^\circ$  in rotational degree of freedom B, defined as clockwise rotation about the  $z_e$  unit vector
- $\pm 5^\circ$  in rotational degree of freedom C, defined as clockwise rotation about the  $y_e$  unit vector

The acceptable range of offset of the MECRP relative to ECRP are.

- $+15/-10$  mm along unit vector  $y_e$
- $\pm 10$  mm along unit vector  $z_e$

Note that the application force employed to the handset against the HATS ear will define the position of the handset along the  $y_m$  axis or the “ERP-axis”. That is, movement of the handset takes place along the “ERP-axis”. See Fig.4.12.

The actual angle settings, MCERP settings and application force can be noted down in the Handset Positioner Table, Fig.4.11.

#### **4.3.6 Conformity with Telephone Test Head Type 4602(-B)**

The “HATS-position” of ITU-T Rec. P.64 annex E.1 can also be implemented on the Telephone Test Head Type 4602(-B). When this table top telephone test head is fitted with the supplied HATS positioning jig, the position corresponds directly to the standardised “HATS-position”.

# Chapter 5

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## Use With Telephone Test Systems

Brüel & Kjær offers a wide range of telephone systems for acoustical measurements on telephone equipment, including hand-held telephones, hands-free telephones and headsets. The ear and mouth simulator are operational in full duplex for realistic testing.

Measurements can be made using the dedicated Voice Testing System for Mobile Phones Type 6712 enabling reliable and realistic OTA measurements for cellular phones including GSM, UMTS, CDMA, and W-CDMA.

Furthermore, Type 6712 and PULSE software systems support the transfer function of Ear Simulators Types 4158-C and 4159-C (ITU-T Rec. P57. Type 3.3, Left/Right) enabling correctly compensated measurements using the HATS and Handset Positioner Type 4606.

For more information please consult [www.bksv.com](http://www.bksv.com) or contact your local Brüel & Kjær representative.



# Chapter 6

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## Service and Repair of Type 4606

With normal usage your Type 4606 should not require any elaborate maintenance. However, it is important to remember that Type 4606 is a precision instrument and must be treated accordingly.

### 6.1 Storage

Type 4606 should be stored in a clean dry environment in its box or mounted on a HATS. The rubber O-rings that form the grips should be checked for cracks before use.

### 6.2 Cleaning

Dust and dirt can be removed using a clean dry cloth. In the case of more stubborn soiling a damp cloth can be used, but no industrial solvents or detergents should be brought into contact with Type 4606 as they may cause damage to the finish and markings.

### 6.3 Lubrication



All joints are lubricated from the factory and should not need further lubrication. The centering mechanism on the centering forks may occasionally need lubrication, especially if used in a dusty environment. A small amount of sewing machine oil can be applied to the exposed thread of the centering mechanism to lubricate it.



# Chapter 7

## Specifications

### 7.1 Compliance with Standards 4128-C and 4128-D

|   |  |
|---|--|
|   | CE-mark indicates compliance with: EMC Directive and Low Voltage Directive.<br>C-Tick mark indicates compliance with the EMC requirements of Australia and New Zealand   |
| <b>Safety</b>   | EN/IEC 61010–1: Safety requirements for electrical equipment for measurement, control and laboratory use.<br>ANSI/UL 61010–1: Safety requirements for electrical equipment for measurement, control and laboratory use.  |
| <b>EMC Emission</b>   | EN/IEC 61000–6–3: Generic emission standard for residential, commercial and light industrial environments.<br>CISPR 22: Radio disturbance characteristics of information technology equipment. Class B Limits.<br>FCC Rules, Part 15: Complies with the limits for a Class B digital device.                             |
| <b>EMC Immunity</b>   | EN/IEC 61000–6–1: Generic standards – Immunity for residential, commercial and light industrial environments.<br>EN/IEC 61326: Electrical equipment for measurement, control and laboratory use – EMC requirements.<br><b>Note:</b> The above is only guaranteed using accessories listed in the Product Data (BP 0512). |
| <b>Temperature</b>  | IEC 60068–2–1 and IEC 60068–2–2: Environmental Testing. Cold and Dry Heat.<br>Operating Temperature: –5°C to +40°C (+23°F to +104°F)<br>Storage Temperature: –25°C to +70°C (–13°F to +158°F)  |
| <b>Humidity</b>   | IEC 60068–2–78: Damp Heat: 90% RH (non-condensing at 40 °C (104 °F))   |
| <b>Mechanical</b>   | Non-operating:<br>IEC 60068–2–6: Vibration: 0.3 mm, 20 m/s <sup>2</sup> , 10–500 Hz<br>IEC 60068–2–27: Shock: 1000 m/s <sup>2</sup><br>IEC 60068–2–29: Bump: 1000 bumps at 250 m/s <sup>2</sup>  |

## 7.2 Specifications Type 4128-C and 4128-D

### LISTENER FREQUENCY RESPONSE

Conforms to ITU-T Rec. P.58 for measurements on telecommunications devices and to IEC 60318–7 and ANSI S3.36–1985 for measurements on air conducting hearing aids

### EAR SIMULATOR

IEC 60318–4/ITU-T Rec. P.57 Type 3.3-based calibrated ear simulator complying with ITU-T Rec. P.57, IEC 60318–4 and ANSI S3.25 standards. Output from the ear simulator is via a 7-core 3 m cable (2.3 m from the bottom of the torso) terminated with a Lemo (1B) plug. For connection to a preamplifier input socket of Brüel & Kjær Power Supplies, Analyzers, etc., a Lemo-to-Brüel & Kjær adaptor is supplied

#### Typical Sensitivity:

12.6 mV/Pa (–38 dB re 1 V/Pa) at 250 Hz

#### 3% Distortion Level:

162 dB re 20  $\mu$ Pa at eardrum position

### LEFT EAR TO RIGHT EAR TRACKING

$\pm 1$  dB up to 5 kHz,  $\pm 3$  dB up to 8 kHz (measured using the same ear simulator)

### PINNA SIMULATORS

Dimensions similar to those specified in ITU-T Rec. P.58, IEC 60318–7 and ANSI S3.36. Minor adjustments in the dimensional details have been made which enable Type 4128-C to conform with the acoustic specifications of these documents in the frequency range 100 Hz to 8 kHz. Types 4158-C and 4159-C are supplied with calibrated pinna simulators with hardness shore-OO 35. An additional pair of uncalibrated hard pinna simulators are available as accessories

### MOUTH SIMULATOR

Input to mouth simulator via 0.75 m cables (0.2 m from the bottom of the torso) terminated with banana-sockets

**Sound Pressure Distribution:** conforms to ITU-T Rec. P.58

**Mouth Opening:** W  $\times$  H: 30  $\times$  11 mm (1.18  $\times$  0.43")

**Equivalent Lip Plane Position, CL:** 6 mm in front of the sound radiation opening

**Mouth Reference Point, MRP:**

25 mm in front of mouth CL

**Continuous Output Level at MRP:**

Min. 110 dB SPL, 200 Hz to 2 kHz

Min. 100 dB SPL, 100 Hz to 8 kHz

**Typical Sensitivity at 1 kHz:** 80 dB SPL 2 V/500 mm

**Distortion (Harmonic Components up to 8 kHz) at 94 dB SPL:**

<2%, 200 Hz to 250 Hz

<1% >250 Hz

**Max. Average Input Power:** 10 W max. continuous average power (at 20°C (68°F))

**Max. Pulsed Input Power:** 50 W for 2 seconds



**CAUTION:** If the mouth simulator is excited with pulses of more than 50 W, damage may occur before the protection circuit reacts

**Loudspeaker Impedance:** 4  $\Omega$

### DIMENSIONS AND WEIGHT

The main dimensions comply with the dimensional requirements of ITU-T Rec. P.58 and the reports from IEC 60318–7 and ANSI S3.36-1985

**Total Height, Head and Torso:** 695 mm (27.4")

**Torso:**

**Height:** 460 mm (18")

**Width:** 410 mm (16")

**Depth:** 183 mm (7.2")

**External Neck Diameter:** 112 mm (4.4")

**Head Angles:** Vertical or 17°

**Weight:** 9 kg (19.8 lb.)



## 7.3 Specifications Type 4606

### **SPEAKING POSITION**

**Standardised position:** HATS position as defined in ITU-T Rec. P.64  $\angle A = 21.2^\circ$ ,  $\angle B = 12.9^\circ$ ,  $\angle C = 2.3^\circ$

**Variable positions:**

$\angle A$  can be adjusted from  $+15^\circ$  to  $+35^\circ$

$\angle B$  can be adjusted from  $+30^\circ$  to  $-10^\circ$

$\angle C$  can be adjusted from  $+20^\circ$  to  $-20^\circ$

**Angle resolution:**  $0.5^\circ$

**Precision:** Once mounted, the handset Ear Cap Reference Position ECRP can be positioned within 1mm relative to the nominal ERP of the HATS pinna.

### **HANDSET THICKNESS**

**Min.:**  $\geq 0$  mm

**Max.:** 44 mm

### **HANDSET WIDTH**

**Min.:** 26 mm

**Max.:** 66 mm

### **OFFSET ADJUSTMENT**

For asymmetrical handset the offset perpendicular to the handset can be adjusted in the range  $\pm$  half the handset width minus 8 mm.

### **END STOP ADJUSTMENT**

The End Stop can be adjusted from 8 to 36 mm (0 mm is located at the Ear Cap Reference point, ECRP of the handset)

### **APPLICATION FORCE**

The force that a handset exerts against the HATS pinna can be adjusted from 0 to 18 N

### **WEIGHT**

**Handset Positioner (incl. cradle, excl. handset):**

1.4 kg

**Alignment Jig (excl. cradle):** 2.4 kg



# Appendix A

## Literature References

|  |  |
|--|--|
| ANSI S3.25-1979  | Occluded Ear Simulator   |
| ANSI S3.25-1985  | Methods of measurements of performance characteristics of hearing aids under simulated in-situ working conditions  |
| ANSI S3.36-1985  | Specification for a manikin for simulated in-situ airborne acoustic measurements   |
| ITU-T Rec. P.50  | Artificial voices  |
| ITU-T Rec. P.51  | Artificial Mouth (this document refers to a rotationally symmetric artificial mouth, not a HATS)   |
| ITU-T Rec. P.57  | Artificial ears  |
| ITU-T Rec. P.58  | Head and torso simulator for telephonometry  |
| ITU-T Rec. P.64  | Determination of sensitivity/frequency characteristics of local telephone systems  |
| IEC 60318-7  | Provisional head and torso simulator for acoustic measurements of air conducting hearing aids  |
| IEC 60318-4  | Occluded ear simulator for the measurements of earphones coupled to the ear by ear inserts   |
| HUMANSCALE™ 1/2/3 (1978)   | N. Diffrient, A.R. Tilley, J.C. Bardagjy & Henry Dreyfuss Associates. MIT Press, Massachusetts Institute of Technology, Cambridge, MA 02142. ISBN 0-262-54027-4. |
| Instruction manual for Brüel & Kjær Mouth Simulator Type 4227 (BE 0940)  |  |
| Instruction manual for Brüel & Kjær Pistonphone Type 4228 (BE 1094)      |  |
| Instruction manual for Brüel & Kjær Sound Calibrator Type 4231 (BB 0910) |  |



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