BRITISH STANDARD

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Incorporating Amendment No. 1

Hearing aids —

Part 9: Methods for measurement of characteristics of hearing aids with bone vibrator output —

(Implementation of CENELEC HD 450.9 S1)

UDC 616.28-76:534.773.08

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Electronic Equipment Standards Committee (EEL/-) to Technical Committee EEL/24, upon which the following bodies were represented:

British Medical Association
British Society of Audiology
British Telecommunications plc
Confederation of British Industry
Department of Health and Social Security
Department of Trade and Industry (National Physical Laboratory)
Health and Safety Executive
Hearing Aid Industry Association
Institute of Acoustics
Institute of Sound and Vibration Research
Institution of Electronic and Radio Engineers
Medical Research Council
National Coal Board
National Health Service
Royal Aeronautical Society
Royal National Institute for the Deaf
Society of Hearing Aid Audiologists Limited

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Contents

National foreword

This Part of BS 6083 has been prepared under the direction of the Electronic Equipment Standards Committee and is identical with IEC Publication 118-9:1985 "*Hearing aids — Part 9: Methods of measurement of characteristics of hearing aids with bone vibrator output*", published by the International Electrotechnical Commission (IEC). This standard is also in agreement with Harmonization Document HD 450.9 S1 published by the European Committee for Electrotechnical Standardization (CENELEC).

BS 6083 consists of the following Parts:

— *Part 0:1984: Methods for measurement of electroacoustical characteristics;*

— *Part 1:1984: Method for measurement of characteristics of hearing aids with induction pick-up coil input;*

— *Part 2:1984: Methods for measurement of electroacoustical characteristics of hearing aids with automatic gain control circuits;*

— *Part 3:1984: Methods for measurement of electroacoustical characteristics of hearing aid equipment not entirely worn on the listener;*

— *Part 4:1981: Specification for magnetic field strength in audio-frequency induction loops for hearing aid purposes;*

— *Part 5:1984: Specification for dimensions of the nipple and sealing device for insert earphones;*

— *Part 6:1985: Specification for characteristics of electrical input circuits for hearing aids;*

— *Part 7:1985: Methods for measurement of the performance characteristics of hearing aids for quality inspection on delivery;*

— *Part 8:1985: Methods for measurement of the performance characteristics of hearing aids under simulated in situ working conditions;*

— *Part 9:1986: Methods for measurement of characteristics of hearing aids with bone vibrator outputs;*

— *Part 10: Guide to hearing aid standards;*

— *Part 11:1984: Specification for symbols and other markings on hearing aids and related equipment.*

Terminology and conventions. The text of the International Standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards.

Textual error. When adopting the text of the International Standard, the textual error given below was discovered. It has been marked in the text and has been reported to the IEC in a proposal to amend the text of the International Standard.

In the introduction, in line 2 of paragraph 5, for "(e.g. a headband type bone conduction hearing aid)" read "(e.g. a spectacle type bone conduction hearing aid)".

Cross-references

International Standards	Corresponding British Standards
IEC 68	BS 2011 *Basic environmental testing procedures* (Most Parts are identical or technically equivalent to the corresponding IEC Parts)
	BS 6083 *Hearing aids*
IEC 118-0:1983	Part 0:1984 *Methods for measurement of electroacoustical characteristics* (Identical)
IEC 118-1:1983	Part 1:1984 *Method for measurement of characteristics of hearing aids with induction pick-up coil input* (Identical)
IEC 118-7:1983	Part 7:1985 *Methods for measurement of the performance characteristics of hearing aids for quality inspection on delivery* (Identical)
IEC 263:1982	BS 6397:1983 *Specification for scales and sizes for plotting frequency characteristics and polar diagrams* (Identical)
IEC 373:1971	BS 4009:1975 *Specification for an artificial mastoid for the calibration of bone vibrators used in hearing aids and audiometers* (Technically equivalent)

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 8, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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Introduction

IEC Publication 118-0: Hearing Aids, Part 0: Measurement of Electroacoustical Characteristics, gives information on methods of test for air conduction hearing aids. The majority of hearing aids in use are of this type but a small percentage use a bone vibrator instead of an earphone. The use of a bone vibrator requires a different method of measuring the output from the hearing aid and also makes it impractical to measure amplification directly in terms of acoustic gain.

Amplification in the case of an air conduction hearing aid is expressed as the difference between the output sound pressure level in an acoustic coupler or ear simulator and the input sound pressure level measured in a specified manner. However, with bone conduction hearing aids the input is in terms of sound pressure level but the output will be in terms of mechanical vibration measured as an alternating force or force level.

This standard defines a method of expressing the input/output ratio as an acousto-mechanical sensitivity level measured on a mechanical coupler according to the second edition of IEC Publication 373: Mechanical Coupler for Measurements on Bone Vibrators.

By means of information provided in this standard the performance of hearing aids with bone vibrator outputs which do not form an integral part of the hearing aid for example body worn hearing aids, may be measured in a similar manner to aids with air conduction outputs as described in IEC Publication 118-0.

Where the bone vibrator forms an integral part of the hearing aid, or where it is attached in some fixed manner to the hearing aid (e.g. a headband type bone conduction hearing aid)[1)]. performance cannot be measured in the same way as for body-worn aids, due to the large dimensions of the mechanical coupler having to be in contact with the spectacle arm. This standard recommends a pressure method of controlling the input sound pressure level, to the hearing aid microphone.

The second edition of IEC Publication 373, describes the means of measuring the output from a bone vibrator.

1 Scope

This standard specifies methods of measurement of the characteristics of hearing aids using bone vibrator output.

2 Object

The methods described will produce a suitable basis for the exchange of information or for direct comparison of the electroacoustical characteristics of hearing aids using bone vibrator output. These methods are chosen to be practical and reproducible and are based on selected fixed parameters.

The results obtained by the methods specified herein express the performance under the conditions of the test, but will not necessarily agree exactly with the performance of the hearing aid under practical conditions of use.

3 General

3.1 Throughout this standard all sound pressure levels specified are referred to 20 μPa. When appropriate, sound pressure level will be abbreviated to SPL.

3.2 In this standard, reference is made to the following IEC publications:

Publication 68:	*Basic Environmental Testing Procedures.*
Publication 118-0 (1983):	*Hearing Aids,* Part 0: *Measurement of Electroacoustical Characteristics.*
Publication 118-7 (1983):	*Hearing Aids,* Part 7: *Measurement of the Performance Characteristics of Hearing Aids for Quality Inspection for Delivery Purposes.*
Publication 263 (1982):	*Scales and Sizes for Plotting Frequency Characteristics and Polar Diagrams.*
Publication 373 (—):	*Mechanical Coupler for Measurements on Bone Vibrators.*

4 Explanation of terms

Terms other than those used in IEC Publication 118-0 are given below.

4.1 Bone vibrator

An electromechanical transducer intended to produce the sensation of hearing by vibrating the cranial bones.

[1)] See national foreword for details of textual error.

4.2 Mechanical coupler

A device designed to present a specified mechanical impedance to a vibrator applied with a specified static force and equipped with a mechano-electric transducer to enable the alternating force level at the surface of contact between vibrator and mechanical coupler to be determined.

4.3 Vibratory force level (force level)

Twenty times the logarithm to the base 10 of the ratio of the r.m.s. value of the force transmitting the vibration to the reference value of 1 micronewton (1 μN), expressed in decibels.

4.4 Output force level (OFL)

The vibratory force level produced at a specified frequency on a mechanical coupler by the bone vibrator of the hearing aid under test.

4.5 Output force level frequency response (force level curve)

The OFL produced on the mechanical coupler by the hearing aid expressed as a function of frequency under specified test conditions for constant input sound pressure level.

4.6 Output force level for an input sound pressure level of 90 dB (OFL_{90})

The OFL at a specified frequency produced with an input sound pressure level of 90 dB and the hearing aid gain control in the full-on position.

4.7 Reference point (of a hearing aid)

A point on the hearing aid chosen for the purpose of defining its position, normally the centre of the main sound entry to the aid.

4.8 Acousto-mechanical sensitivity

At a specified frequency and under specified operating conditions the quotient of the vibratory force produced on the mechanical coupler by the hearing aid and the sound pressure at the reference point of the hearing aid.

4.9 Acousto-mechanical sensitivity level (AMSL)

Twenty times the logarithm to the base 10 of the ratio of the acousto-mechanical sensitivity to the reference sensitivity of $\frac{1\ \mu N}{20\ \mu Pa}$; expressed in decibels.

NOTE To calculate the acousto-mechanical sensitivity level (AMSL) from measurements made in this standard the following formula may be used:

AMSL = OFL – INPUT SPL

where OFL is expressed in decibels ref. 1 μN and sound pressure level to the hearing aid microphone in decibels ref. 20 μPa.

4.10 Reference test gain control position

The setting of the hearing aid gain control that provides an output force level on the mechanical coupler 15 ± 1 dB less than OFL_{90} for an input sound pressure level of 60 dB at the reference test frequency of 1 600 Hz. For certain hearing aids for which a higher reference test frequency is more appropriate (so called high-tone hearing aids) 2 500 Hz shall be used. If 2 500 Hz is used this shall be clearly stated. If the acousto-mechanical sensitivity level available will not permit this, the full on gain control position of the hearing aid shall be used.

4.11 Basic force level frequency response curve

The output force level frequency response curve obtained with the gain control in the reference test gain position and with an input SPL of 60 dB.

5 Test equipment

5.1 Equipment for the measurement of the output force level

The equipment used for measurement of OFL on the mechanical coupler produced by the hearing aid, shall comply with the following requirements:

5.1.1 For all measurements a mechanical coupler in accordance with the second edition of IEC Publication 373 shall be used.

5.1.2 The output force level corresponding to hum, vibration, thermal agitation and other noise sources shall be sufficiently low to ensure that the reading shall drop at least 10 dB when the test signal is switched off.

For this purpose a high-pass filter not affecting frequencies of 200 Hz and above may be employed.

5.1.3 The output indicator used shall give the r.m.s. indication within a tolerance of ± 0.5 dB at a signal crest factor of not more than 3.

NOTE 1 Under certain conditions it is necessary to use a selective measuring system in order to ensure that the response of the hearing aid to the signal can be differentiated from inherent noise in the hearing aid. The use of the selective system should be stated in the report on test results.

NOTE 2 It is well known that the type of output indicator employed may influence the test results significantly if a non-sinusoidal voltage is being measured. Such non-sinusoidal voltages may be present when making measurements with high input levels.

5.1.4 The overall accuracy of the electronic measuring system following the mechanical coupler shall be within ± 0.5 dB at a specified frequency.

5.1.5 The calibration of the mechanical coupler shall be in accordance with the second edition of IEC Publication 373.

NOTE The calibration of the mechanical coupler should be repeated sufficiently often, preferably at least once a year, to ensure that it remains within the permitted limits during measurements.

5.2 Equipment for automatic sweep frequency recording

Reference shall be made to IEC Publications 118-0 and 118-7, as appropriate.

6 Test conditions

6.1 General

The test conditions stated in this standard are additional to those given in IEC Publication 118-0 or 118-7 and the relevant sub-clauses of those publications should be consulted for conditions not stated here.

6.2 Ambient conditions

6.2.1 *Test space*

Ambient conditions in the test space at the time of test shall be stated and wherever possible kept within the following tolerances:

temperature:	23 ± 1 °C (basic)
	23 ± 5 °C (allowable only when 23 ± 1 °C cannot be achieved and when data for correcting the sensitivity of the mechanical coupler are available)
relative humidity:	40 % to 80 %
atmospheric pressure:	101.3^{+5}_{-20} kPa

NOTE Reference is made to IEC Publication 68.

6.2.2 *Bone vibrator and mechanical coupler*

The bone vibrator and mechanical coupler shall both be brought to the proper operating temperature of 23 ± 1 °C. Deviations of up to ± 5 °C may be allowed, if the proper operating temperature cannot be achieved, provided that manufacturer's data for variation of sensitivity of the mechanical coupler with temperature is used to correct any results. Impedance variations, however, cannot be corrected.

The temperature of the mechanical coupler at the time of test shall be stated.

NOTE Stringent requirements for the temperature of the mechanical coupler are necessary due to considerable variations in both sensitivity and impedance of the coupler with temperature. As the mass of the mechanical coupler is large, long periods of time, for example 24 h, may elapse before its temperature stabilizes.

6.3 Locating the hearing aid in the sound field

6.3.1 *Free field measurements*

This method is only applicable to hearing aids with separate bone vibrators. That portion of the hearing aid containing the microphone shall be placed in the sound field in accordance with Clause **6** of IEC Publication 118-0.

The mechanical coupler to measure the output from the bone vibrator shall be situated so as not to influence the sound field at the test point significantly.

6.3.2 *Measurements according to the pressure method*

This method is applicable to any type of bone conduction hearing aid.

The sound field at the hearing aid reference point shall be controlled in accordance with Sub-clause **7.2** of IEC Publication 118-7.

For hearing aids with separate bone vibrators, that part of the aid containing the microphone shall, where possible, be removed from the vicinity of the mechanical coupler.

Figure A.1 of Appendix A, page 6, is an example of an arrangement for controlling the sound field in the case of a hearing aid with an integral bone vibrator.

NOTE When a controlling microphone is used care should be taken to avoid radiated airborne noise from the bone vibrator affecting that microphone.

6.4 Applying the bone vibrator to the mechanical coupler

6.4.1 *Locating the bone vibrator on the mechanical coupler*

The centre of the vibrating surface of the bone vibrator shall coincide with the centre of the mechanical coupler pad. At its centre the vibrating surface shall be perpendicular to the axis of the mechanical coupler.

Figure A.1 and Figure A.3 of Appendix A, pages 6 and 7, show examples of a spectacle aid mounted for test purposes.

Figure A.2 of Appendix A, page 6, is an example of a bone vibrator held in place on the mechanical coupler by its headband.

Figure A.4 of Appendix A, page 7, shows an example of a headband type bone conduction hearing aid, mounted for test purposes.

6.4.2 ***Static force***

The bone vibrator shall be applied to the mechanical coupler with a static force of 2.5 ± 0.3 N. The application of the bone vibrator to the mechanical coupler shall not add mass to the vibrator. Reference is made to the relevant sub-clause of the second edition of IEC Publication 373. The static force may be measured using a spring balance, care being taken that the force is measured along a line that coincides with the axis of the mechanical coupler.

7 Measurements

Data shall be quoted for that part of the frequency range between 200 Hz and 5 000 Hz over which the output of the hearing aid falls by at least 10 dB when the signal source is switched off.

7.1 Output force level frequency response curve for all input SPL of 90 dB (OFL_{90} curve)

The purpose of this test is to determine the frequency response of the OFL obtained on the mechanical coupler when using an input SPL of 90 dB and with the gain control in the full-on position.

The test procedure is as follows:

7.1.1 Turn the gain control full on and set other controls to required positions.

7.1.2 Adjust the input SPL to 90 dB at a suitable frequency.

7.1.3 Vary the frequency of the sound source over the recommended frequency range from 200 Hz to 5 000 Hz while keeping the input SPL constant at 90 dB and record the OFL obtained on the mechanical coupler.

NOTE As the output signal at saturation will contain high levels of distortion products, the method of measurement may influence the level measured. If the output signal is measured through a filter centred at the test signal frequency lower levels than would be measured using a wide band instrument may result. It is therefore recommended that only wide band measurements should be made for this purpose. (See also notes to Sub-clause **5.1.3**).

7.2 Full-on force level frequency response

The purpose of this test is to determine the full-on acousto-mechanical sensitivity level obtainable from the hearing aid as a function of frequency. The OFL on the mechanical coupler is measured at the full-on gain control setting with an input SPL sufficiently low to ensure essentially linear input-output conditions.

The test procedure is as follows:

7.2.1 Turn the gain control full on and set each of the other controls to the required position, preferably to give the widest frequency range.

7.2.2 At a suitable frequency adjust the input SPL to 60 dB or, if this does not produce essentially linear input-output conditions, to 50 dB. The input SPL shall be stated. Essentially linear input-output conditions are considered to exist if, at all frequencies within the range 200 Hz to 5 000 Hz, a change in the input SPL of 10 dB causes a change in the recorded OFL of 10 ± 1 dB.

NOTE For hearing aids with certain circuit arrangements, for example push-pull aids, non-linear input-output characteristics may be observed over a large portion of the operating range.

7.2.3 The output force level frequency response with full-on gain is measured by varying the frequency of the sound source over the recommended frequency range from 200 Hz to 5 000 Hz, while keeping the input SPL constant.

7.2.4 The full-on acousto-mechanical sensitivity level is plotted as a function of frequency and may be reported for a specified frequency.

7.3 Basic force level frequency response

The test procedure is as follows:

7.3.1 Adjust the gain control to the reference test gain position (see Sub-clause **4.10**) and set other controls to their required positions, preferably to give the widest frequency range.

7.3.2 Vary the frequency of the sound source over the frequency range 200 Hz to 5 000 Hz, while keeping the input SPL constant at 60 dB. Plot the OFL in the mechanical coupler as a function of frequency.

7.4 Effect of tone control position on the basic force level frequency response

The purpose of this test is to show the effect of tone control position on the basic force level frequency response of the hearing aid.

The test procedure is as follows:

7.4.1 Adjust the hearing aid as in Sub-clause **7.3.1**.

7.4.2 Vary the frequency of the sound source over the recommended frequency range from 200 Hz to 5 000 Hz, while keeping the input SPL constant at 60 dB.

7.4.3 Repeat the procedure in Sub-clause **7.4.2** at other remaining tone control settings.

7.4.4 The frequency response at the various tone control settings should be plotted together with the basic frequency response in terms of the OFL on the mechanical coupler as a function of frequency.

7.5 Battery current

The purpose of this test is to determine the battery current.

With the gain control in the reference test gain position measure the battery current at the reference test frequency and with an input SPL of 60 dB.

The direct-current measuring system shall have the following characteristics:

1) An accuracy of ± 5 % at the value of current measured.

2) A direct current resistance not exceeding 50 Ω/I, where I is the current being measured, in milliamperes.

3) An alternating current impedance not exceeding 1 Ω over the frequency range 20 Hz to 5 000 Hz.

NOTE One method of realizing Item 3 above is to bypass the current meter with a capacitor of at least 8 000 μF. The capacitor should not shunt the battery or power supply.

7.6 Non-linear distortion

Reference is made to IEC Publication 118-0.

7.7 Internal noise from the hearing aid

Reference is made to IEC Publication 118-0.

7.8 Characteristics of hearing aids with induction pick-up coil input

Reference is made to IEC Publication 118-1.

8 Frequency response recording chart

All curves showing variation of a parameter with frequency shall be plotted on a grid having a linear decibel ordinate scale and a logarithmic frequency abscissa scale with the length of one decade on the abscissa equal to the length of 50 dB on the ordinate, in accordance with IEC Publication 263.

Appendix A Examples of test assemblies

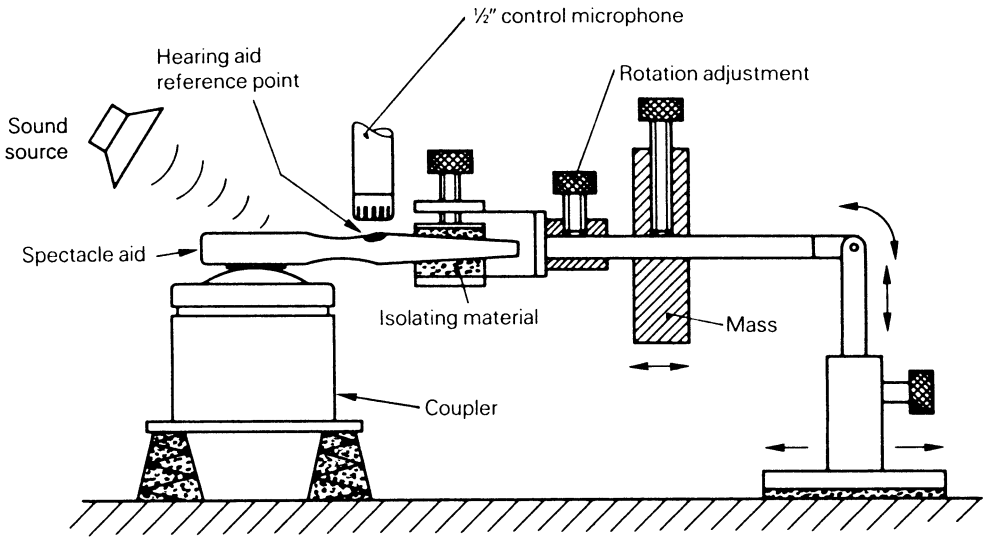

Figure A.1 — An example of a hearing aid with an integral bone vibrator under test

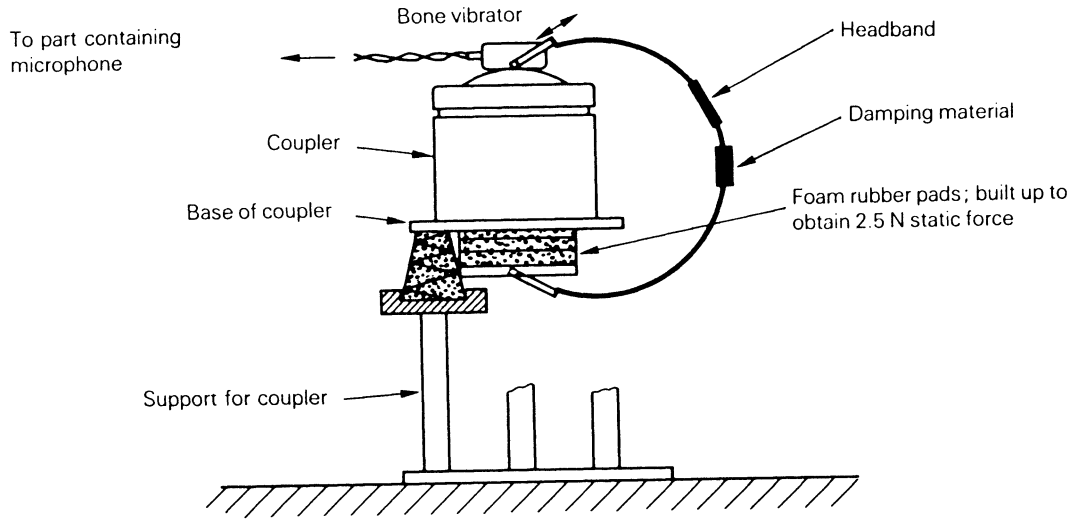

Figure A.2 — An example of a bone vibrator with headband mounted on the mechanical coupler

NOTE Figure A.1 and Figure A.2 are only intended as a schematic representation illustrating the principle of measurement.

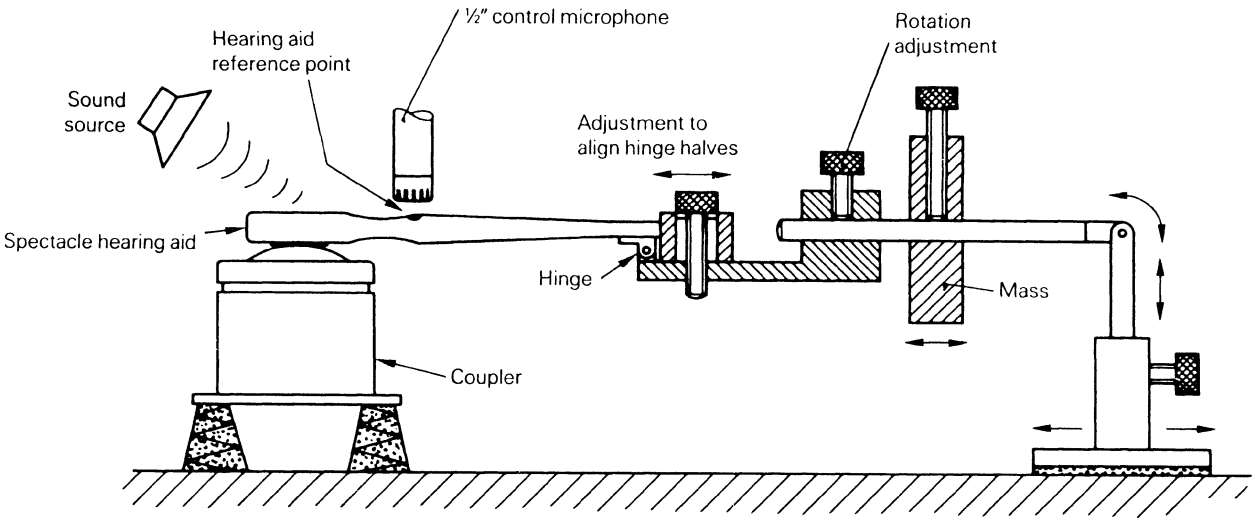

Figure A.3 — An example of a spectacle hearing aid with an integral bone vibrator under test and spectacle arm attached to hinge

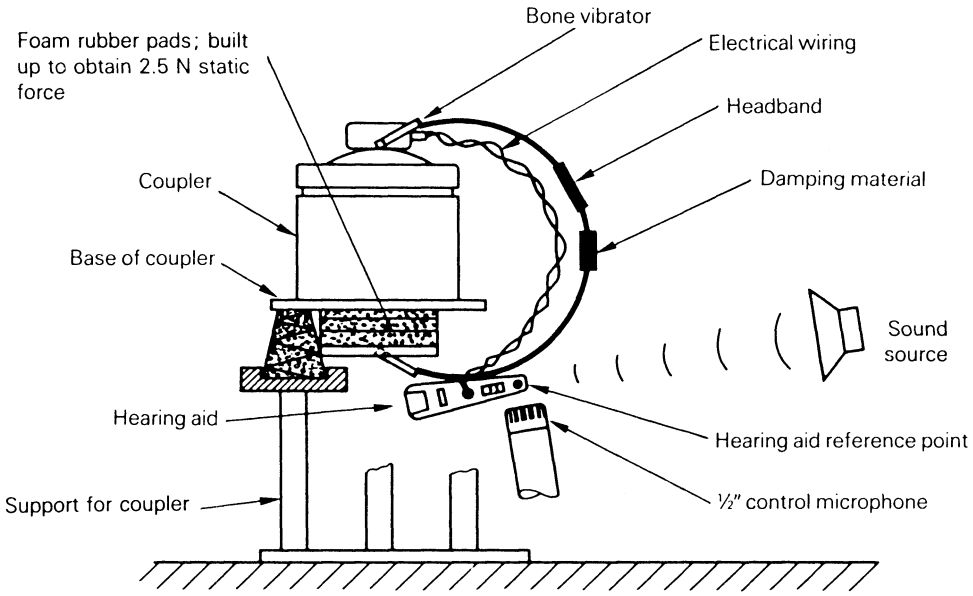

Figure A.4 — An example of a bone vibrator with headband mounted on the mechanical coupler and amplifier with microphone permanently attached to the headband

NOTE Figure A.3 and Figure A.4 are only intended as a schematic representation, illustrating the principle of measurement.

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Publications referred to

See national foreword.

BSI — British Standards Institution

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