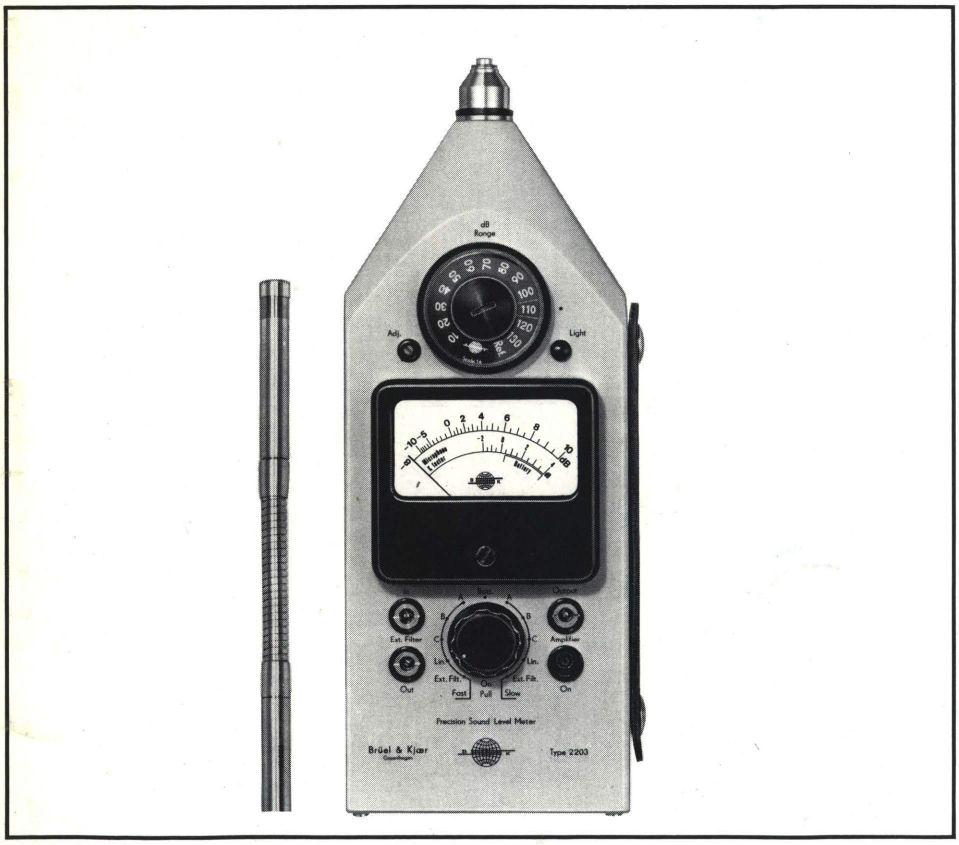
Instruction Manual 2203

Precision Sound Level Meter Type 2203



This portable sound level meter complies with all existing standards for precision sound level meters. It is equipped with an individually calibrated condenser microphone, an internal reference voltage for calibration, "Lin", "A", "B", and "C" weighting networks, "Fast" and "Slow" meter responses, and an AC output for connection to recorders, etc.. External filters can be directly attached, and a wide range of accessories is available. It can also be used with an accelerometer for vibration measurements.

Brüel & Kjær

033-0225

PRECISION SOUND LEVEL METER
TYPE 2203

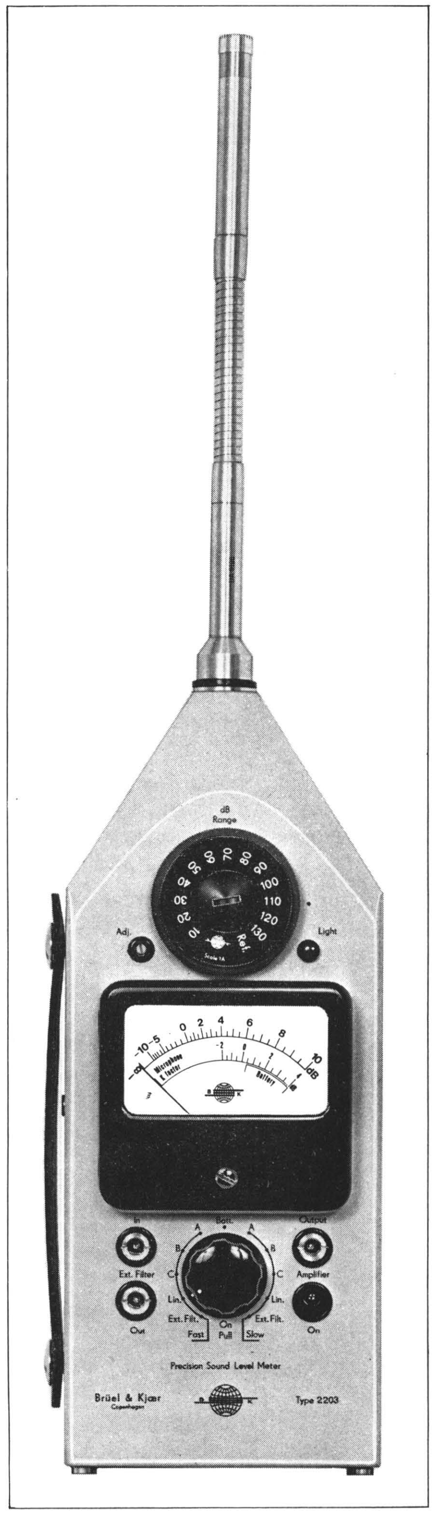
Applicable to instruments from serial no. 598006

Reprint April 1977

CONTENTS

type 2203

Precision Sound Level Meter



FEATURES:

- Complies with all existing standards for precision sound level meters
- Equipped with individually calibrated, high sensitivity, precision condenser microphone
- Conical shaped front-end for minimum disturbance of sound field
- RMS detector with crest factor capability up to 5
- "A", "B", "C" and "Lin" frequency weighting
- Performs as Octave or Third-Octave analyzer with system-matching filter sets
- AC output for recorders etc.
- Performs as Vibration Meter or Analyzer combined with appropriate accessories
- Wide selection of accessories

USES:

- Acoustics, measurement of sound insulation, sound distribution etc.
- Noise and vibration measurements in industry for quality inspection and development
- Noise and vibration measurements for health protection
- Audiometer calibration

The Precision Sound Level Meter Type 2203 has been designed as a robust compact unit able to perform sound and vibration measurements of almost any kind with the highest degree of accuracy. The instrument fulfils the requirements of IEC 179, DIN 45633 part 1 as well as ANSI S1.4-1971 Type 1 for precision sound level meters and includes the A, B and C weighting networks and the Fast and Slow meter responses. In- and output sockets, for connection of external filters for frequency analysis of the measured signal, as well as a recorder output, for connection of headphones, level recorders etc. are also provided. A built-in reference voltage provides easy electrical calibration of the instrument. The sound level meter is powered from three standard 1,5 volt batteries giving 10 hours of continuous operation. Longer operating times can be obtained using alkaline batteries or rechargeable NiCd-cells. The battery condition can easily be checked on the meter.

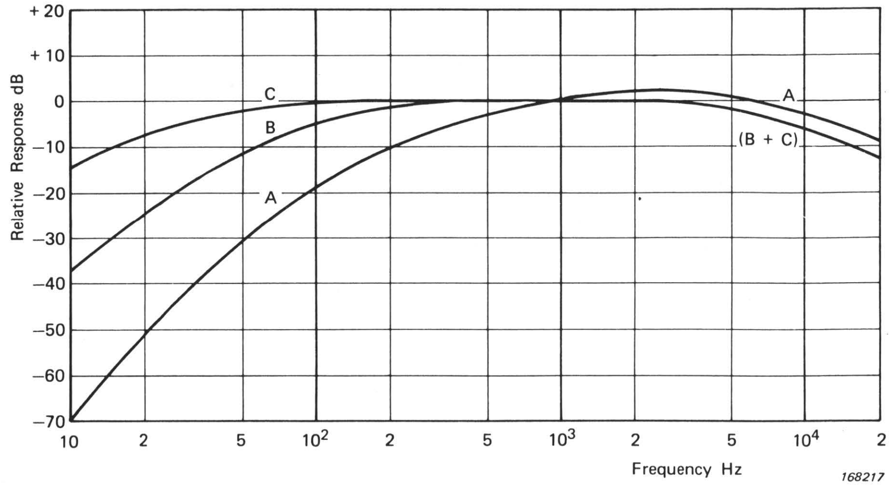


Fig.1. Frequency response curves of the A, B and C weighting networks

Sound Measurements

As standard, the instrument is equipped with a B & K high sensitivity, 1/2" diameter, free-field Condenser Microphone Type 4165, giving it a measuring range from 26 to 140 dB(A) and a wide frequency range, both in free and diffuse sound fields, due to its excellent omnidirectivity. The microphone is delivered with its own individual calibration chart giving all relevant calibration data and complete frequency response curve.

The microphone may be mounted directly on the instrument but should normally be mounted on the Extension Rod UA 0196, which is included, and which, together with the conical shaped front-end of the instrument secures the omnidirectional characteristics required to fulfil IEC, DIN and ANSI requirements for precision sound level meters. If it is desired to remove the microphone even further from the instrument, a 3 metre Extension Cable AO 0128 is available. A windscreen is supplied with the instrument and should be fitted over the microphone when measuring outdoors, to reduce wind noise. Also included is an input adaptor, to be fitted instead of the microphone, allowing direct electrical input, for instance from an accelerometer for vibration measurements, or from a hydrophone for underwater sound measurements.

The instrument can measure the linear sound pressure level as well as the standard frequency weighted sound levels. Two meter response times in accordance with the standard recommendations can be chosen.

Use with other Microphones. For the measurement of higher levels and frequencies than is possible with the 1/2" microphone Type 4165, or if a linear, random incidence microphone response is required, other 1/2" microphones from the B & K range can be used directly, for instance Type 4133, 4134, 4163 or 4166. For measurement of lower levels, the 1" microphones Type 4145 or 4161 can be used. Adaptors DB 0962 and DB 0375 are available for fitting these Microphones directly onto the input stage or onto the extension rod respectively. In order to fulfil the standard requirements to omnidirectivity, the 1" microphones require the use of a Random Incidence Corrector UA 0055 instead of the normal microphone protection grid. For special applications, the sound level meter can be used with other microphones than described here and the Product Data Sheet for the B & K microphone range should be consulted. See also survey of accessories available, on page 4.

Vibration Measurements

When the microphone is replaced by the Input Adaptor JJ 2614 (included) and one of the B & K accelerometers is connected, the instrument functions as a vibration meter indicating the acceleration level. Connection of the Integrator ZR 0020 between the accelerometer and Sound Level Meter permits measurement of vibration velocity and displacement as well as acceleration. A calculating disc delivered with the Integrator makes conver-

Fig.2. The Integrator ZR 0020

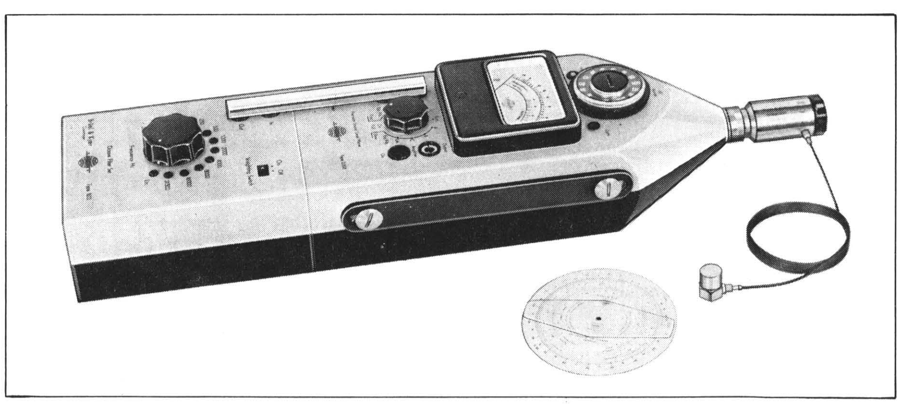


Fig.3. The sound level meter equipped with integrator and accelerometer for vibration measurements and Octave Filter Set Type 1613 for frequency analysis

sion of the dB reading into vibration units a simple matter.

Calibration

Acoustical calibration, which also tests the microphone, can easily be performed by either of the two calibrators available: Pistonphone Type 4220, which gives a SPL of 124 dB with ± 0,2 dB accuracy at 250 Hz, and Sound Level Calibrator Type 4230, which gives a SPL of 94 dB with ± 0,25 dB accuracy at 1 kHz. When using the sound level meter for vibration measurements, complete calibration can be performed by means of the portable Accelerometer Calibrator Type 4291, which calibrates at 1 g peak and 79,6 Hz.

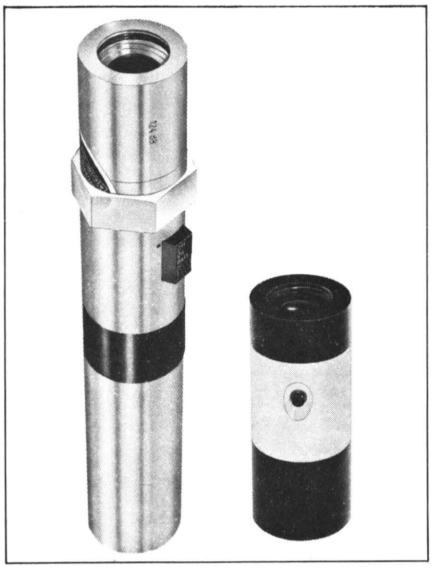


Fig.4. The Pistonphone Type 4220 and Sound Level Calibrator Type 4230

Audiometer Calibration, Hearing Aid Testing

When the microphone is replaced by an Artificial Ear Type 4152 or 4153 with microphone 4144 or 4134 respectively, a precise, compact and fully portable audiometer calibrator is created. If the Artificial Mastoid Type 4930 is connected instead of the microphone, measurements on bone vibrators and bone conduction hearing aids can be made, and if the sound level meter is used with Hearing Aid Test Box Type 4217, a complete test facility for hearing aids is created.

Frequency Analysis

For frequency analysis of the measured sound or vibration level, the Octave Filter Set Type 1613 or the Third-Octave Filter Set Type 1616

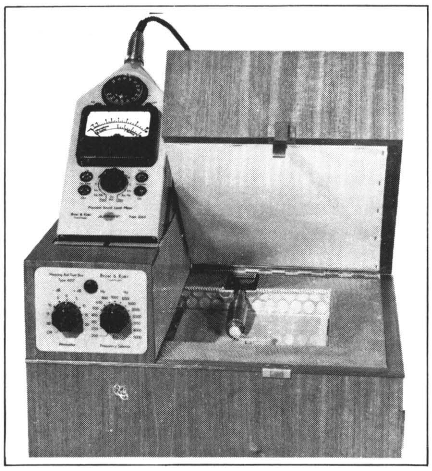


Fig.5. The sound level meter in combination with Hearing Aid Test Box Type 4217

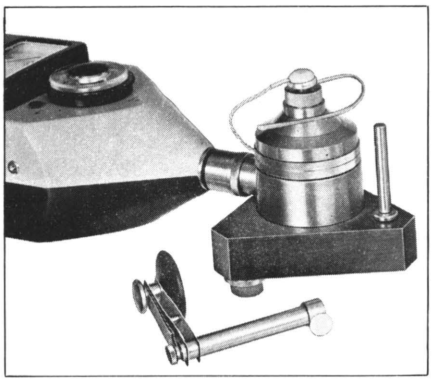


Fig.6. The sound level meter used with Artificial Ear Type 4152 for testing earphones and audiometers

is attached directly onto the sound level meter, and is connected electrically with a connection bar. Type 1613 contains 11 octave filters (with adjustable attenuation) with centre frequencies from 31,5 Hz to 31,5 kHz. Type 1616 contains 34 third octave filters with centre frequencies from 20 Hz to 40 kHz. Narrower band frequency analysis, as is often required for vibration analysis, can be made using the battery powered Tunable Band Pass Filter Type 1621, (or the Tracking Filter Type 1623.)

Field Recording

When measuring in the field, the tedious work of plotting levels with a pencil can be completely eliminated by use of the small, portable, battery operated Level Recorder Type 2306. It is connected via a cable to the output of the sound level meter and can record either sound levels as a function of time or, if the sound level meter is equipped with a filter, sound levels as a function of frequency. For time recordings, use can be made of very slow recording paper speeds, so that diagrams showing sound level variations over longer periods of time can be recorded on a reasonable length of paper. Such charts are of great help in almost any type of noise investigation and ease the location of noise events with respect to time as well as the possible source. Frequency spectrograms can be recorded directly on frequency calibrated paper, and can be made semi-automatically in a few seconds, using the filters Type 1616, 1621 or 1623. The recorded spectrograms and time histories provide immediate documentation of the measurement made and can be inserted directly in the measurement report. If further investigation of the measured signal is required back in the laboratory, the battery operated, portable Tape Recorders Types 7003 and 7004 should be used.

Fig.7. The portable Level Recorder Type 2306

Complete Sets

The sound level meter can be ordered with accessories according to requirement. However, to simplify ordering, four sets, containing the most commonly used accessories, have been assembled. There are two sets for sound and vibration measurements in the field, and two sets for audiometer calibration, the difference being the filter included (Type 1613 or 1616).

The sets combine complete portability with laboratory accuracy and are delivered in the sturdy fibreglass carrying case KE 0055 which has separate compartments for each item. The contents of the sets are listed on page 5.

Accessories

A wide selection of accessory equipment is available to expand the application possibilities of the sound level meter. A survey showing how the most useful items connect is given below. For more information on the individual instruments and transducers indicated, please ask for separate data sheets.

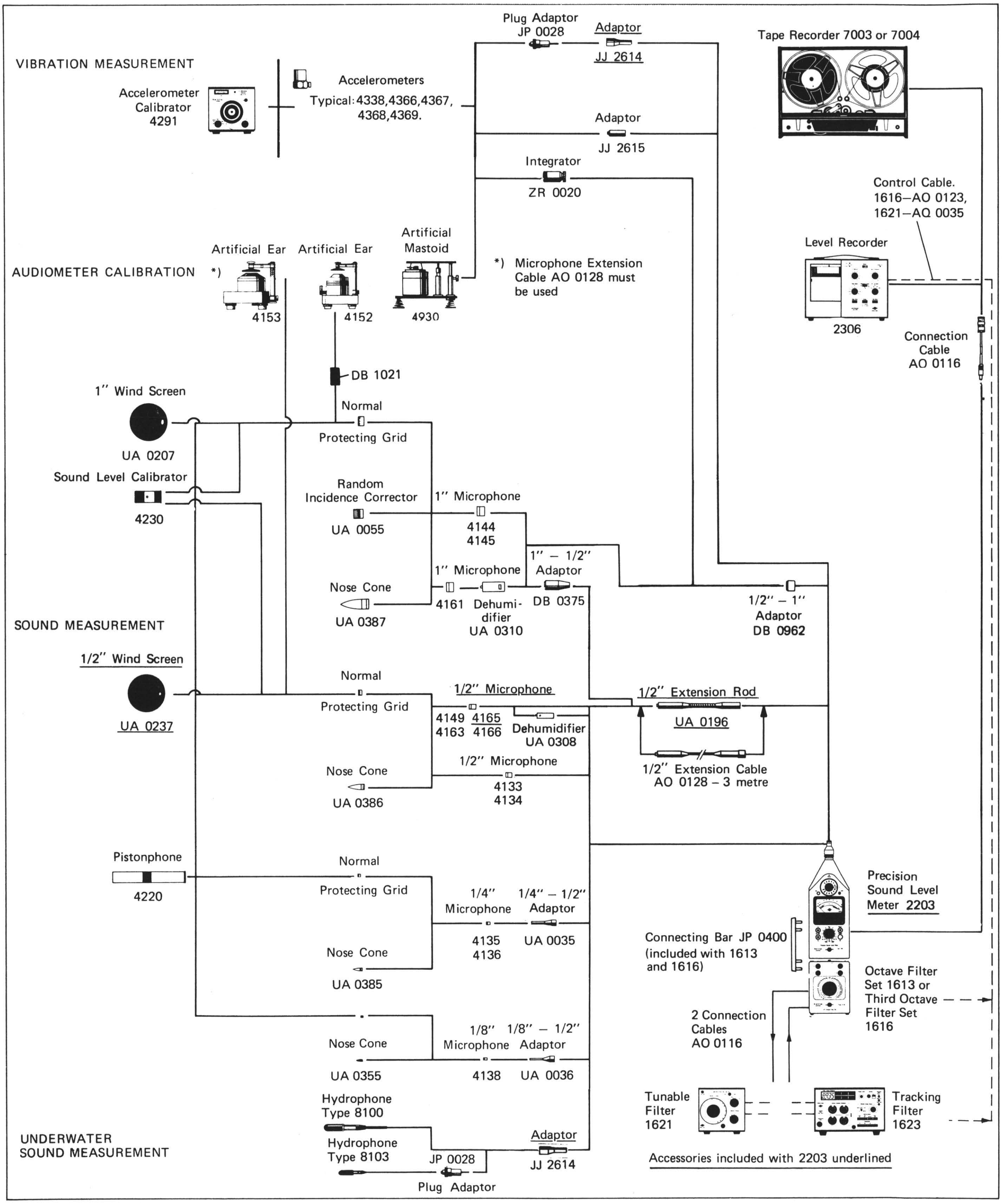


Fig.8. Survey of accessories available for sound and vibration measurements and audiometer calibration

Sound and Vibration Sets Type 3501 and Type 3509

Precision Sound Level Meter with standard accessories	Type 2203
Octave Filter Set	Type 1613 (3501 only)
Third-Octave Filter Set	Type 1616 (3509 only)
Pistonphone	Type 4220
Microphone 1/2″	Type 4166
Accelerometer Set	Type 4366S
Nose Cone 1/2″	UA 0386
Adaptor for tripod	UA 0354
Integrator	ZR 0020
Extension Cable	AO 0128
Carrying Case	KE 0055

Audiometer Calibrators Type 3502 and Type 3510

Precision Sound Level Meter with standard accessories	Type 2203
Octave Filter Set	Type 1613 (3502 only)
Third-Octave Filter Set	Type 1616 (3510 only)
Pistonphone	Type 4220
Artificial Ear	Type 4152
Microphone 1″	Type 4144
1″ Adaptor	DB 0375
Carrying Case	KE 0055

Fig.9 The Sound and Vibration Set Type 3501

Fig.10. The Audiometer Calibrator Type 3510

Description

The Precision Sound Level Meter Type 2203 contains a condenser microphone with associated polarization voltage supply and preamplifier, a low noise amplifier and a meter circuit with moving coil meter. A built-in reference signal provides a ready check of the amplifier and meter circuit.

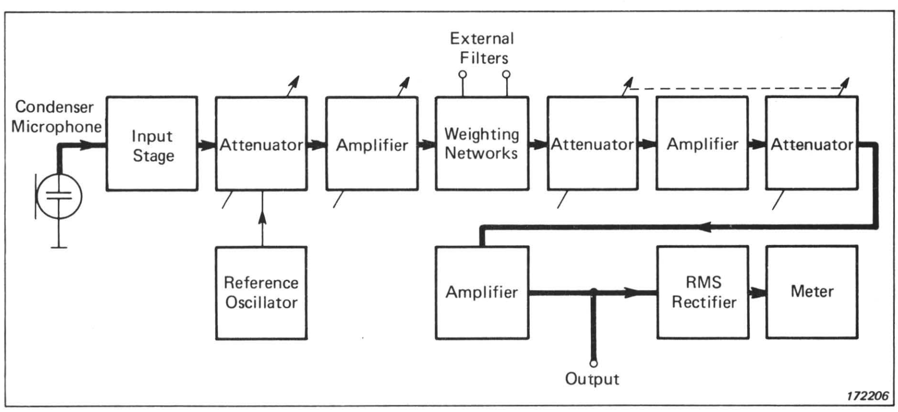


Fig.11. Block diagram of Type 2203

Microphone

The B & K Microphone Type 4165 employed in the sound level meter is a precision condenser microphone. It is designed to have a linear frequency response when used for free-field sound measurements where the sound has 0° angle of incidence (perpendicular to microphone diaphragm). The microphone has excellent directional characteristics over a wide frequency range. Characteristics of the microphone alone, and of the complete instrument are shown on page 7. Figs.12 and 13 show the frequency response curves of the complete instrument to 0° incident sine waves, and in a diffuse field. All curves are well within the requirements of the relevant standards. A calibration chart with frequency response

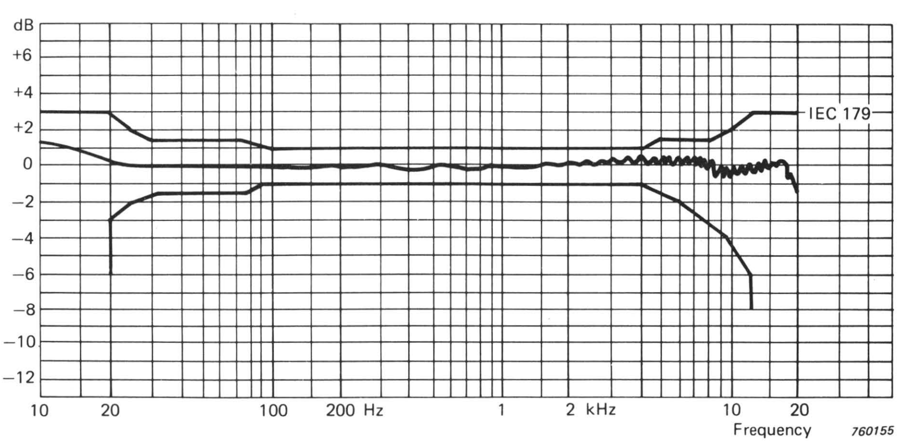


Fig.12. Free-field frequency response of complete instrument to sine waves with 0° incidence

curve and sensitivity data (individually determined for each microphone) is supplied with the sound level meter. The microphone is extremely reliable and unaffected by humidity and temperature variations over a wide range. The diaphragm is quartz-coated to offer protection in humid and corrosive atmospheres, and back-venting allows it to be used with the Dehumidifier UA 0308 for further protection in humid environments. The sensitivity of the microphone is typically 50 mV per Pa (5 mV/μbar) with a polarization voltage of 200 V.

Amplifier

The input stage of the amplifier has an extremely high input impedance, to match the high impedance of the condenser microphone. Each of the three sections of the following amplifier is preceded by an attenuator, the setting of these being controlled by the two concentric measuring range selectors on the front of the instrument. External filters can be inserted between the first and second sections, or the built-in weighting networks, A, B and C, can be switched in. In the linear position, where the weighting networks are bypassed, the frequency response of the instrument is linear from 10 Hz to 40 kHz to within ± 2 dB.

The amplifier output section is equipped with an output socket making it possible to use the instrument in conjunction with a level recorder, tape recorder etc.

The supply voltage for the amplifiers and the microphone polarization voltage are produced by a built-in oscillator.

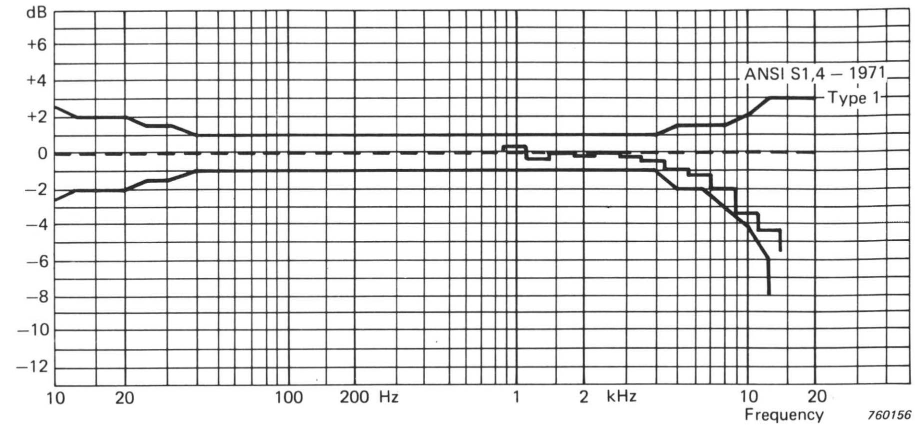


Fig. 13. Diffuse field (random incidence) frequency response of complete instrument

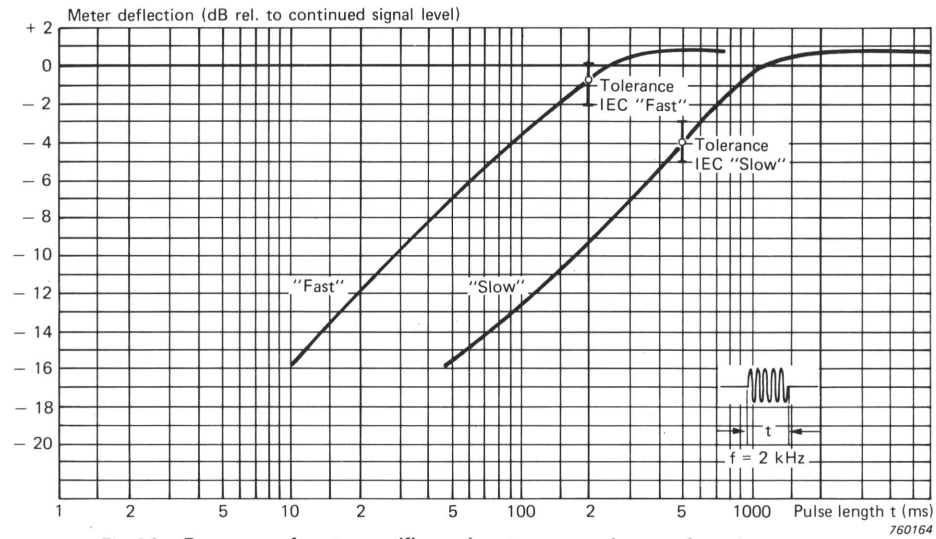


Fig. 14. Response of meter rectifier and meter to tone bursts of varying duration

Meter and Rectifier Circuit

The meter rectifier circuit is of the RMS type and is equipped with two meter damping characteristics, "Fast" and "Slow" in accordance with the standards for precision sound level meters. Fig. 14 shows their response to tone bursts as a function of pulse duration.

The meter is a ribbon-suspended, moving coil type. The meter scale is graduated from —10 to + 10 dB for reading of sound or vibration level. A smaller scale is provided for calibration of the instrument, to read correctly with microphones of different sensitivity using the built-in reference voltage and K-factor given for each microphone. Battery condition can also be read on the meter. To facilitate measurements in dim or badly lit places, a meter light can be switched on by means of a spring- loaded pushbutton.

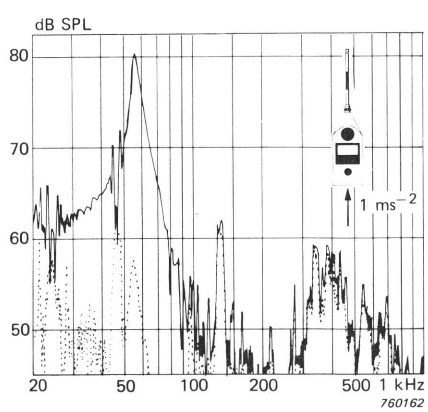


Fig. 15. Equivalent sound pressure level when complete sound level meter is excited vertically at 1 m/s 2

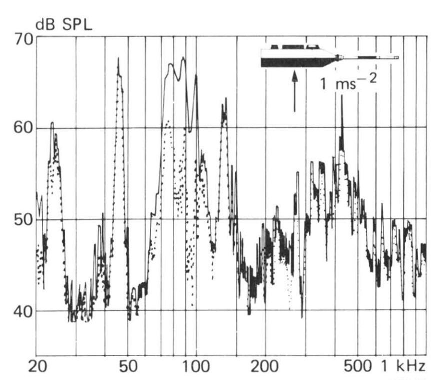


Fig. 16. Equivalent sound pressure level when complete sound level meter is excited horizontally at 1 m/s 2

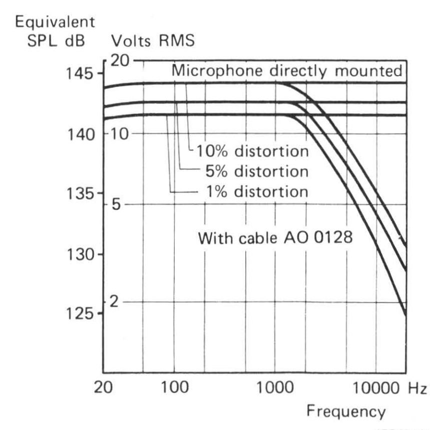


Fig. 17. Distortion as function of input voltage

Directional Characteristics

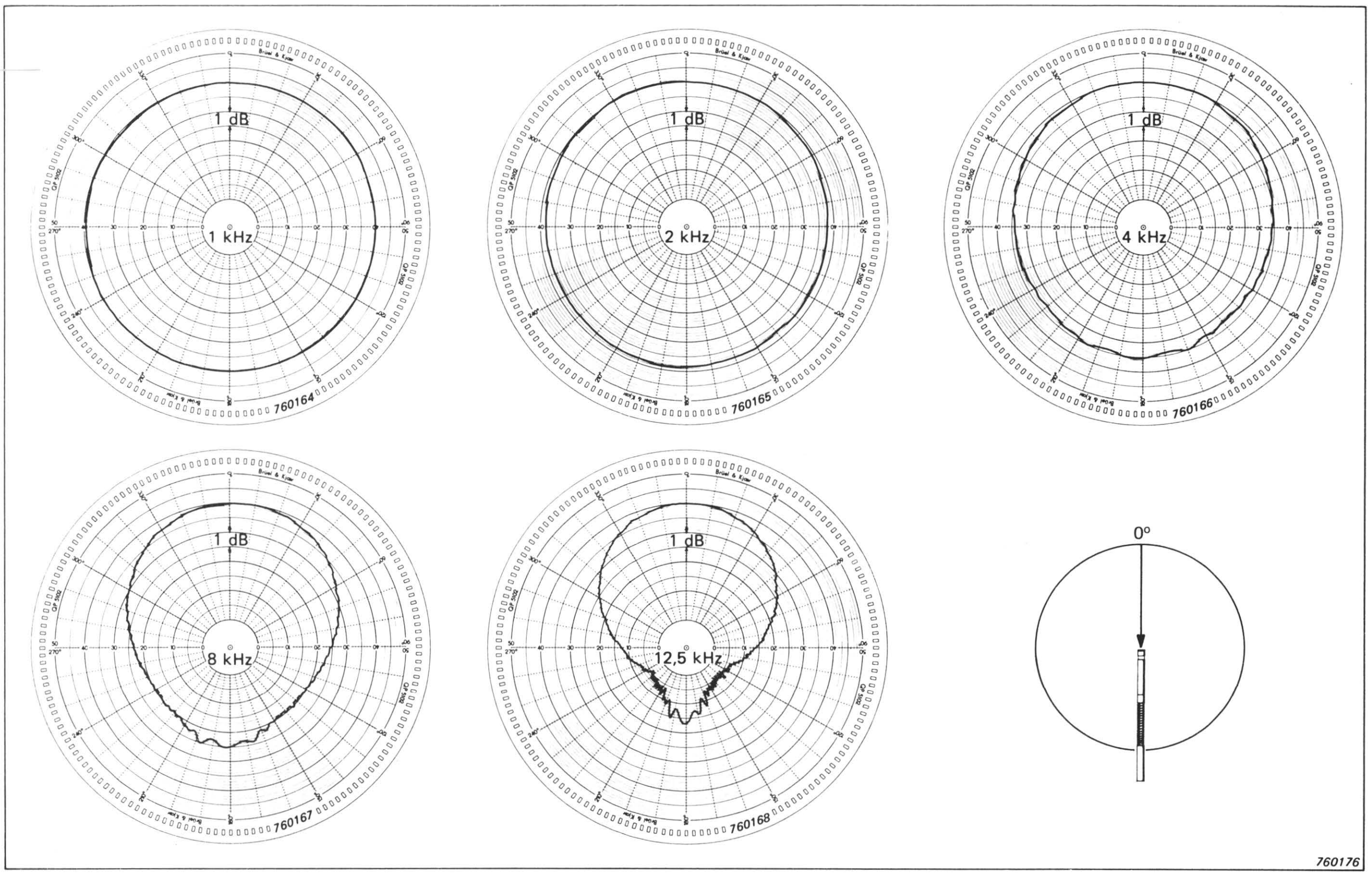


Fig.18. Directional characteristics of the microphone Type 4165 in a free-field

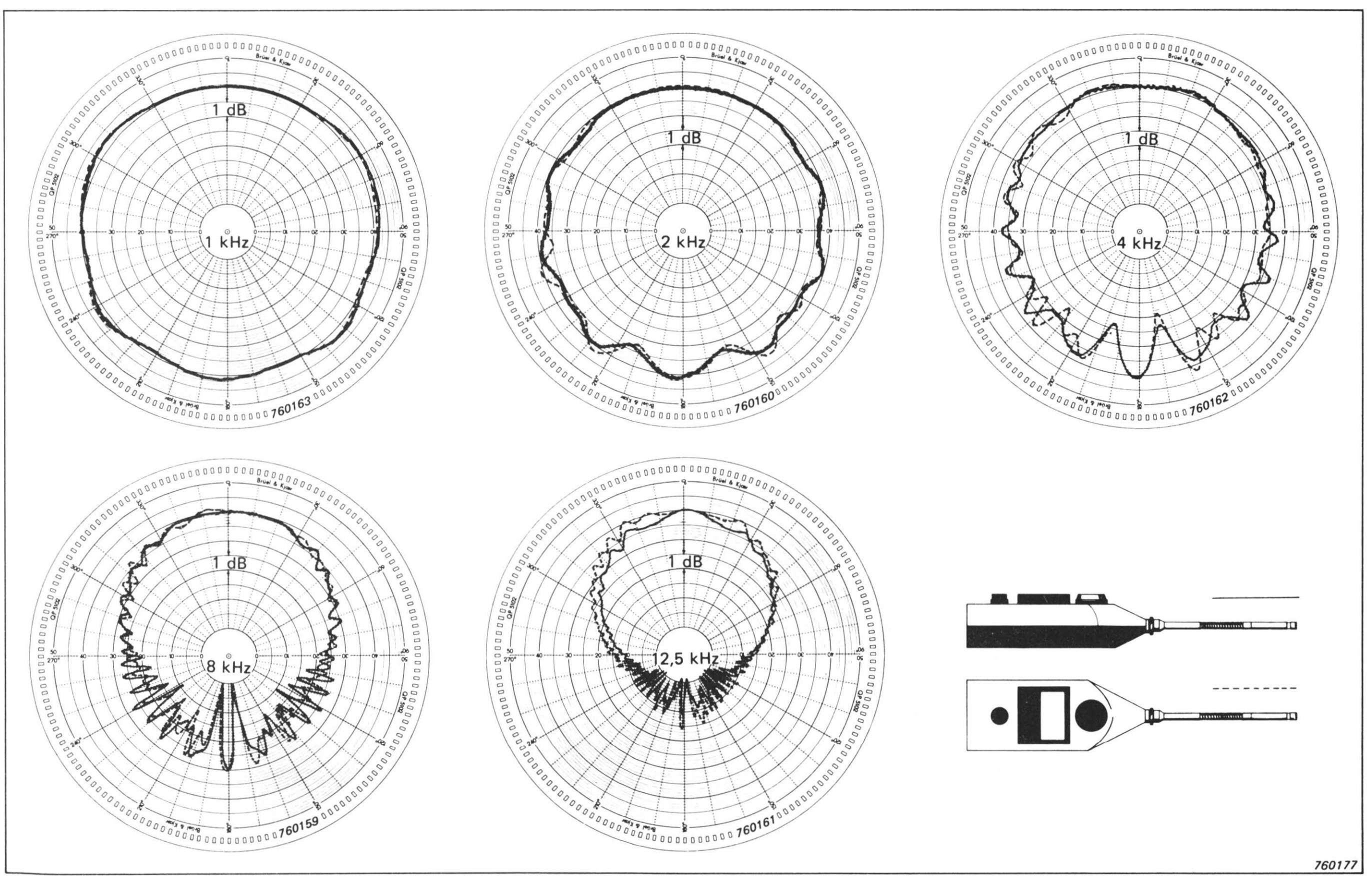


Fig.19. Directional characteristics of the complete instrument inclusive microphone and extension rod in a free-field

Specifications 2203

(Specifications refer to 2203 with Extension Rod UA 0196 and Microphone 4165, unless otherwise stated)

Measuring Ranges:

	Microphone Type No.	Max. Level (dB)	Minimum Level (dB): Weighting Network				External Filter Type No.: 1613 (Octave)			1616 (1/3 Octave)			
			A	B	C	Lin	31,5 to 63 Hz	125 to 250 Hz	0,5 to 16 (31,5) kHz	20 to 80 Hz	100 to 400 Hz	0,5 to 16 (40) kHz	Lin
1″	4144, 4145	140	19	23	28	38	25	20	15	25	22	22	30
1/2″	4165,* 4166	140	26	31	36	43	36	30	24	34	27	24	38
1/2″	4133, 4134	154	39	43	48	55	48	42	36	46	39	36	50

* Included in 2203

Frequency Response: (Microphone)*
(zero degree incidence, free-field)
± **1 dB:** 4 Hz to 12,5 kHz
± **2 dB:** 3 Hz to 20 kHz
*) individually calibrated

Frequency Response: (Amplifier)
± **0,5 dB:** 40 Hz to 25 kHz
± **1 dB:** 20 Hz to 25 kHz
± **2 dB:** 10 Hz to 40 kHz

Frequency Weighting:
A, B and C to IEC 179. (See Fig. 1)

Input Impedance:
> 2 GΩ//2,8 pF
(with extension cable AO 0128 > 2 GΩ//3,2 pF)

Max. Input Voltage:
10 V RMS (sinusoidal) (See also curves Fig. 17)

Total Amplification:
110 dB

Attenuators:
20 to 140 dB FSD in 10 dB steps, accuracy ± 0,2 dB

Output Impedance:
< 100 Ω. Maximum load 10 kΩ or 1 nF for less than 0,2 dB error.

Maximum Output Voltage:
16 V peak, (3,16 V RMS for FSD)

External Filter Sockets:
Output Impedance: < 5 Ω in series with 100 μF
Input Impedance: 146 kΩ

Inherent Noise:
Linear: max. 40 μV referred to input
Curve A: max. 4 μV referred to input

Detector:
RMS Accuracy:
± 0,5 dB for crest factors below 3
± 1 dB for crest factors below 5

Meter Damping:
"Fast" and "Slow" to IEC 179

Meter:
Graduation:
1 dB divisions from —10 to 0 dB
0,5 dB divisions from 0 to 10 dB
Accuracy:
0,5 dB for deflections below 0 dB
0,2 dB for deflections above 0 dB

Microphone Sensitivity:
Approx. 50 mV/Pa individually calibrated

Microphone Temperature Coefficient:
Approx. —0,01 dB/°C

Microphone Temperature Range:
—50 to + 60°C

Microphone Long Term Stability:
1 dB/300 years at operating temperature 27°C. At 100°C, typically 1 dB per 100 hours

Polarization Voltage:
200 V

Calibration:
Internal square wave generator, approx. 1 kHz, stability better than ± 0,2 dB

Directional Characteristics:
See curves page 7

Microphone K-factor Adjustment:
+ 4 dB to —2 dB

Reference Conditions for calibration validity:
Type of Sound Field: Free
Ref. Direction of Incidence: Perpendicular to microphone diaphragm
Ref. Sound Pressure: 20 μPa
Ref. Sound Pressure Level: 84 dB
Ref. Frequency: 1 kHz
Ref. Temperature: 20°C
Ref. Measuring Range: 80 dB (90 dB FSD)

Absolute accuracy at Reference conditions:
± 0,7 dB

Effect of Humidity:
< 0,5 dB from 0 to 90% RH provided no condensation occurs

Effect of Vibration:
See curves Fig. 15 and Fig. 16

Effect of Sound Field:
At least 60 dB below sensitivity of microphone 4165

Effect of Ambient Pressure:
Approx. —0,001 dB per mbar at 1013 mbar

Effect of Electrostatic field:
Negligible with microphone grid fitted

Effect of Electromagnetic Field:
80 A/m (50 Hz) gives:
< 36 dB(A)
< 38 dB(B)
< 46 dB(C)
< 46 dB(Lin)

Effect of Temperature:
—10 to 50°C (14 to 122°F) ± 0,5 dB

Batteries:
3 × 1,5 V. IEC Type R20 (B & K order No. QB 0004)

Battery Life: (Continuous operation)
12 hours with standard batteries
(Varta Super Dry 282)
(National Neo Hi-Top UM 1NE)

50 hours with Alkaline batteries
(Mallory MN 1300)

20 hours with rechargeable NiCd-cells
(B & K order No. QB 0008, 3rqd.)
(Saft Voltablock VR 4D)
(Varta RS 4)
Recharging from Power Supply Type 2808, Battery Box ZG 0073, and Charging Adaptor AQ 0043 + 3 dummy cells ZR 0017

Dimensions:
90 × 120 × 550 mm (4 × 5 × 21,7 in)
(320 mm. (12,7 in) without extension rod)

Weight:
3 kg (6,6 lb)

Accessories included:
1/2″ Condenser Microphone Type 4165
Flexible Extension Rod UA 0196
Input Adaptor JJ 2614
Windscreen UA 0237
3 Screened Plugs JP 0006
3 Batteries QB 0004
1 Screwdriver QA 0001
1 Screwdriver QA 0027

Accessories Available:
See survey page 4

2. CONTROLS

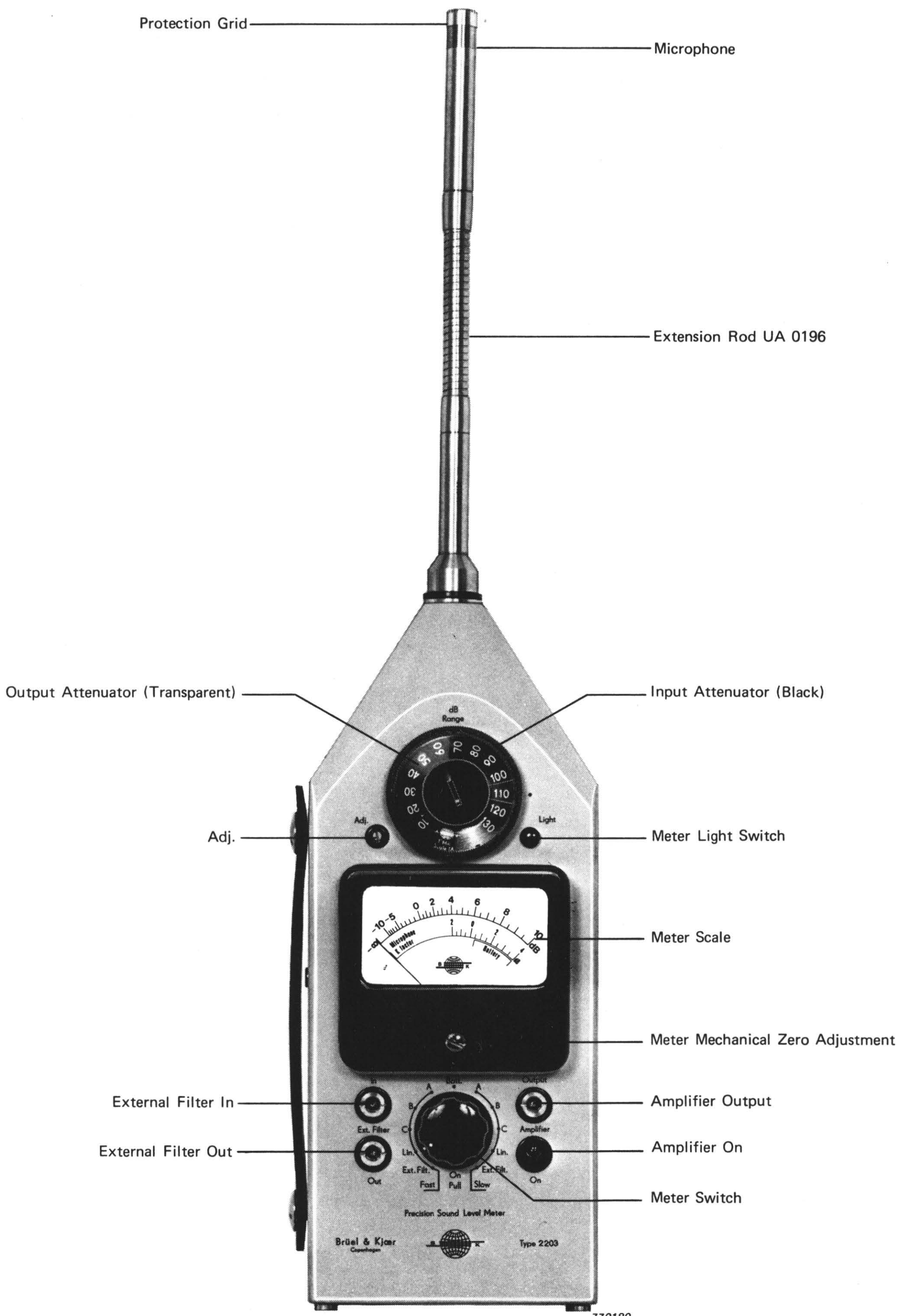


Fig.2.1. Front view of 2203

MICROPHONE: Half-inch condenser Microphone Type 4165.

PROTECTION GRID: Protects the diaphragm of the microphone from physical damage. This grid should not be removed, except when the microphone is to be fitted with a Nose Cone or Rain Cover, or for inspection of the diaphragm. DO NOT TOUCH THE DIAPHRAGM WITH ANY OBJECT.

EXTENSION ROD UA 0196: This flexible rod connects the microphone to the sound level meter at a sufficient distance that the influence of the body of the sound level meter and operator on the sound field is minimized. This extension rod must be used in order for the instrument to conform to precision standards.

If a Dehumidifier Type UA 0308 is used, it is placed between the microphone and extension rod.

When screwing the microphone, extension rod, and sound level meter together, only light finger torque should be used.

METER SWITCH: This 11-position switch controls the main functions of the 2203, as follows:

"On Pull": When the switch is pulled out, the 2203 is turned on and the AMPLIFIER ON lamp will flash. Allow at least 20 s for warm-up before using the instrument.

"Batt.": If the meter needle deflection is below the area marked "Battery", the batteries must be replaced (see section 3.1).

"Fast": The five positions on the left side of the METER SWITCH give the "Fast" meter response. (See Fig.14 in Chapter 1.)

"Slow": The five positions on the right side of the switch give the "Slow" meter response. (See Fig.14 in Chapter 1.)

"A", "B", "C": Each position selects one of the standardized frequency-weighting networks. (See Fig.1 in Chapter 1.)

"Lin.": Gives linear frequency response within the limits of the instrument, see Chapter 1.

"Ext. Filter": Selects an external filter connected to the EXTERNAL FILTER sockets. No meter needle deflection will be obtained in this position if a filter is not connected.

AMPLIFIER ON: This lamp flashes when the instrument is switched on.

METER SCALE: The upper scale (black) is calibrated from "—10"dB to "+ 10" dB for the reading of sound level (or vibration level). "0" dB on the scale corresponds to the attenuator setting indicated inside the red lines. Thus, for example, if the meter shows "—2" dB and the attenuator setting is "70" dB, then the sound level is 68 dB.

The lower scale (red) is used for calibration of the instrument using the microphone K factor. This K factor is found on the individual calibration chart provided with the microphone.

When checking the batteries (METER SWITCH in "Batt." position), the meter needle deflection must be in the range indicated by the red lines labelled "Battery" on the lowest meter scale.

METER LIGHT SWITCH: The METER SCALE is illuminated when this self-releasing switch is pressed down. It only functions when the instrument is switched on.

METER MECHANICAL ZERO ADJUSTMENT: The screw head just below the METER SCALE is adjusted with the instrument turned off to give a meter needle deflection on the "—∞" mark on the meter scale.

Since the 2203 can measure sound levels that vary over a wide dynamic range (from 26 to 140 dB) but the METER SCALE can only display 20 dB of this range at a time, an attenuator system is necessary to set the range of the instrument so that the sound level will be within the 20 dB indicated on the METER SCALE. In order to minimize the chances of an overload, and to give the best possible signal-to-noise ratio, a dual attenuator system consisting of INPUT and OUTPUT ATTENUATORS is used. The correct use of these switches is described in Chapter 3, Operation.

INPUT ATTENUATOR (black): This 8-position switch controls the gain of the input amplifier in **10 dB** steps, and also selects the internal reference voltage. The range of rotation of this switch is physically limited to a position from "70" dB to "Ref." being adjacent to the black spot. Maximum input gain is obtained in the fully clockwise position; and the internal reference voltage is selected in the fully anticlockwise position (provided the transparent OUTPUT ATTENUATOR is also set to its fully clockwise position).

OUTPUT ATTENUATOR (transparent): This 7-position switch controls the gain of the output amplifier in 10 dB steps. The range of rotation of this switch is physically limited so that the red lines on the knob may only be moved anticlockwise from the black dot. Maximum output gain is obtained in the fully anticlockwise position, while the minimum output gain (red lines by the black dot) is recommended for use whenever possible.

The total gain setting depends on both INPUT and OUTPUT ATTENUATOR positions; the measuring range corresponding to that gain setting is always directly indicated between the red lines on the knob.

ADJ.: This screwdriver-operated potentiometer just to the left of the ATTENUATOR switches is used for calibration the 2203. It is adjustable from "—2" dB to "+4" dB.

EXTERNAL FILTER IN: Socket for connection to the input of an external filter (such as Octave Filter Set Type 1613 or 1/3 Octave Filter Set Type 1616). The output impedance is < 5 Ω but should be loaded by at least 500 Ω. Maximum output voltage is 1,6 V peak. Accepts plug JP 0006 or cable AO 0007, etc..

EXTERNAL FILTER OUT: Socket for connection to the output of an external filter to the 2203. Input impedance is 146 kΩ//45 pF. An input voltage of 0,316 V RMS corresponds to a full-scale meter deflection. Accepts plug JP 0006 or cable AO 0007, etc..

The EXTERNAL FILTER IN and OUT sockets may be connected to a 1613 or a 1616 directly by means of the Connections Bar JP 0400 supplied with each filter.

AMPLIFIER OUTPUT:

This socket provides an AC output of 3,16 V RMS at full-scale meter needle deflection. The maximum output voltage is 16 V peak into a load impedance of at least 10 kΩ. It may be used for connection to a Level Recorder or Tape Recorder. Accepts plug JP 0006 or cable AO 0007, etc..

TRIPOD-MOUNTING THREADS:

There are two tripod-mounting threads on the rear of the 2203. The upper thread is for mounting of the 2203 alone, while the lower thread is for mounting of the 2203 when fitted with a filter set (Type 1613 or 1616). For vertical mounting, a thread is also provided on the battery cover on the bottom of the 2203.

3. OPERATION

This Instruction Manual describes the specific procedures necessary to correctly use the Precision Sound Level Meter Type 2203. However, there are many aspects of sound measurement of a more general nature that are important to consider in order to get correct reproducible measurements. Many of these are discussed in the accompanying booklet, "Measuring Sound", which should be considered as part of this Instruction Manual.

3.1. BATTERY CONSIDERATIONS

The 2203 is powered by three standard torch batteries (D cells or Type R 20 in IEC Publication 86-2). Access to the batteries is gained by unscrewing the four screws which hold the bottom cover of the 2203. The batteries should be inserted such that their positive terminals point to the front panel of the instrument, as shown in Fig.3.1.

Fig.3.1. Battery compartment of 2203

Good-quality dry cells give an operating time of 12 hours, while alkaline cells, such as Mallory Duracell MN 1300, give 50 hours of continuous operation. Rechargeable nickel-cadmium cells may also be used, giving an operating time of 20 hours. These cells may be recharged using the Power Supply Type 2808 with Battery Box ZG 0073 and Charging Adaptor AQ 0043 — see the 2808 Instruction Manual.

The 2203 may also be powered directly from the mains using Mains Power Supply WB 0004 which is inserted in the battery compartment and at the same time serves as a bottom cover for the instrument. If operated with Hearing Aid Test Box Type 4217 it may be powered by Power Supply Adaptor UA 0363 as described in the 4217 Instruction Manual.

The batteries should be removed from the instrument if it is not used for a long time to prevent possible battery leakage.

3.2. GENERAL CONSIDERATIONS

When connecting or disconnecting the microphone, be sure that the instrument power is turned off. In dry weather, it is recommended that static electricity be discharged from your body before fitting or removing microphones. Only light finger torque should be applied to the microphone and extension rod. Dust and foreign objects should be kept off the diphragm, which must not be touched with any object. If the diaphragm must be cleaned, cotton wool should be used very carefully. When storing the instrument, dry and preferably warm conditions are recommended.

3.3. CALIBRATION FOR SOUND MEASUREMENTS

3.3.1. General

The 2203 may be calibrated in two ways: either using an acoustic calibrator (effectively a miniature loudspeaker) placed over the microphone; or using the built-in reference voltage in the measurement. The acoustical method has the advantage that it checks the entire instrument, including the microphone. When the instrument is first received, it is a useful check to calibrate it by both methods; these should agree to within about 0,5 dB.

3.3.2. Acoustical Calibration (External Source)

The Sound Level Calibrator Type 4230 or Pistonphone Type 4220 is recommended. The 4230 generates 94 dB (± 0,25 dB) at a frequency of 1000 Hz while the 4220 generates 124 dB (± 0,2 dB) at a frequency of 250 Hz.

Calibration with Microphone Type 4165

The calibration procedure when the 2203 is used with the microphone with which it is normally supplied (Type 4165) is as follows:

1. Using a screwdriver, adjust the METER MECHANICAL ZERO ADJUSTMENT screw if necessary to give a meter needle setting on the "—∞" mark of the METER SCALE while the instrument is switched off.

2. Attach the microphone, extension rods, or cables and adaptors to be used by screwing them together finger tight. (See Fig.8 of Chapter 1 for the selection of accessories, and Fig.2.1 for a view of the standard assembly.) These must be included in the calibration since they all affect the sensitivity.

3. Pull the METER SWITCH out to turn the power on, and set it to "Batt." to check the batteries; then set it to "Fast" and "C" or "Lin.". (The instrument warm-up time is 20 s.)

4. Set the ATTENUATORS to "90" dB if the Sound Level Calibrator Type 4230 is used, or "120" dB if the Pistonphone Type 4220 is used, with the OUTPUT ATTENUATOR (transparent) as far clockwise as possible (red lines by the black dot).

5. Fit the half-inch adaptor on the acoustic calibrator and place it over the microphone. Turn the acoustic calibrator on, and hold it still over the microphone. (See also the separate Instruction Manuals.)

6. Adjust the ADJ. potentiometer with a small screwdriver to give a meter reading of "+ 3,8" (= 93,8 dB) if a 4230 is used, or to give a reading of the value given on the calibration chart (corrected as necessary for barometric pressure) if a 4220 is used. (See also the separate Instruction Manuals.)

Calibration with microphones other than Type 4165

The 2203 is only recommended for use with half-inch and one-inch Brüel & Kjær condenser microphones because of losses due to input capacitance when using a quarter-inch or eight-inch microphone. These half-inch and one-inch microphones have nominal sensitivities of either 12,5 mV/Pa or 50 mV/Pa (see their individual calibration charts). For those microphones with a 50 mV/Pa sensitivity, the calibration procedure is as above. For those with a 12,5 mV/Pa sensitivity, the only change is that the attenuator setting in step 4 is 10 dB lower, i. e. "80" dB and "110" dB respectively. 10 dB must then be added to the indicated reading when making measurements.

In addition, the microphones fall into the free-field or pressure-type categories. Although this does not affect the Pistonphone calibration procedure (at 250 Hz), it does affect the value to which the 2203 should be calibrated with the Sound Level Calibrator (at 1 kHz). These values should be set as follows:

One-inch free-field microphones:	"93,6" dB
Half-inch free-field microphones:	"93,8" dB
Pressure microphones of both sizes:	"94,0" dB

3.3.3. Calibration using the Internal Reference Voltage

The stable internal voltage (± 0,2 dB at about 1000 Hz) in the 2203 may also be used for calibration, as follows:

1. Using a screwdriver, adjust the METER MECHANICAL ZERO ADJUSTMENT screw if necessary to give a meter needle setting on the "—∞" mark of the METER SCALE while the instrument is switched off.

2. Connect the microphone, extension rod, etc. as required.

3. Pull the METER SWITCH out (thus turning the power on) and set it to "Batt." to check the batteries. Then switch to "Fast" and "C" or "Lin.". (The instrument warm-up time is 20 s.)

4. Set the ATTENUATORS to "Ref." (between the red lines).

5. Adjust the ADJ. potentiometer with a small screwdriver to give a meter needle deflection on the red "K-factor" scale equal to the K-factor of the microphone, which is found as described in the next section. (If the K-factor is outside the "—2" to "+ 4" range, adjust for a K-factor of 0, and add the K-factor to all readings. For K-

Calibration Chart for Condenser Microphone Cartridge Type 4165

Brüel & Kjær
Nærum Denmark

Serial No. 575516

Open Circuit Sensitivity at 1013 mbar

-26.5 dB re. 1 V per Pa or 47.3 mV per Pa

This Calibration is traceable to the National Bureau of Standards, Washington D.C.

Open Circuit Correction Factor:

Ko*) = +0.5 dB

Cartridge Capacitance:

C = 18.3 pF

Leakage Resistance tested at 52% relative humidity $> 10^{16}\ \Omega$

Frequency Response Characteristics:
The upper curve is the open circuit free field characteristic, valid for the Microphone Cartridge with protecting grid. Sound waves perpendicular to diaphragm (see Fig.). The lower curve is the open circuit pressure response recorded with electrostatic actuator.

* Subtract the gain of the preamplifier (see back of this card) from Ko to get the actual correction factor K. (see instruction manual for the use af K)

1 Pa = 1 N/m² = 10 dynes/cm² = 10 μbar

BC 0089

Conditions of Tests:

Polarization voltage 200 V

Frequency: 250 Hz

Barometric Pressure: 1013 mbar

Relative Humidity: 60 %

Temperature: 25 °C

Date: 20-8-75 Signature: O. K.

Summarized Specifications

Outside Diameter:
0,52 in. (13,2 mm) with protecting grid
0,50 in. (12,7 mm) without protecting grid

Coupler Mounting Thread (grid thread):
0,50 in. (12,7 mm) 60 UNS 2

Frequency Response Characteristic:
Frequency below which free-field response shall be flat within ± 2 dB: 20 kHz

Lower Limiting Frequency (—3 dB) as determined by pressure equalization is between 1 Hz and 3 Hz

Resonance Frequency: approx. 14 kHz (overdamped)

Equivalent Air Volume at 1 atm. about 0.04 cm³

Ambient Pressure: Influence on sensitivity approx. —0,1 dB for + 10% pressure change

Temperature Coefficient between —50 and + 60°C Approx. —0,004 dB/°C

Relative Humidity: The influence of humidity does not exceed 0,1 dB in the absence of condensation

Dynamic Range: Sound Pressure Level below which the total harmonic distortion remains less than 1%: 140 dB

Front of Calibration Chart

$K_o = +0,5$ dB

$K = K_o$ — Input Gain = 0,5 — (—2,1) = + 2,6 dB

Typical Gain in some B & K Preamplifiers or input stages of Sound Level Meters

G	2614/15	2619	2203 + UA 0196	2209 + UA 0196
1/2" Microphones (17 pF)	—2.2 dB	—0.4 dB	—2.1 dB	—0.1 dB

Rear of Calibration Chart

Input Gain = —2,1 dB

760548

Fig. 3.2. Calculation of K-factor using figures from microphone calibration chart

factors between + 8 and + 14, the 2203 can be set for a K-factor of (K — 10), and 10 dB can be added to all readings.)

Determination of K-factor

The K-factor of a microphone is the difference in dB between a standard microphone sensitivity of 50 mV/Pa (—26 dB re 1 V/Pa) to which B & K instruments are calibrated and the sensitivity of the actual microphone. For example, if a microphone has a sensitivity of —27 dB re 1 V/Pa, then the K-factor is 1,0 dB. This means that the gain of a Sound Level Meter must be increased by 1 dB compared with its standard gain, in order to give correct readings.

The K-factor is also influenced by the loading due to cables, adaptors, etc.. Therefore the K-factor should be determined using several different factors according to the formula:

$$K = K_o - \text{input gain} - \text{adaptor gain}$$

where K_o is the open-circuit correction factor.

For the Microphone Type 4165 supplied with the 2203, the K-factor is found as indicated in Fig.3.2.

In the example, for use with the set-up shown in Fig.2.1, K_o is found on the front of the calibration chart (+ 0,5 dB). From this is subtracted the input gain of —2,1 dB indicated on the back of the calibration chart. This gives a total K-factor of + 2,6 dB, to which the 2203 should then be calibrated.

If a 3 m (10 ft) extension cable AO 0128 is used, it has an attenuation of approximately 0,3 dB with half-inch microphones and approximately 0,1 dB with one-inch microphones. This should also be taken account of in the K-factor adjustment on the meter.

Because of these complications, it is easier to use a Pistonphone Type 4220 or a Sound Level Calibrator Type 4230, quite apart from the fact that when using these the complete system is calibrated.

3.4. SOUND MEASUREMENTS

3.4.1. General

The accompanying booklet "Measuring Sound" should be read through before proceeding with measurements, as it contains much useful general information on the subject. One or two points should perhaps be emphasized. Ensure that the microphone has the required dynamic range, frequency range and directional characteristics. Always use a Windscreen for outdoor measurements and in a dusty environment. Various Nose Cones are available for reducing wind noise (see Fig.8, Chapter 1), as well as Dehumidifiers. The microphone must be mounted on the Extension Rod UA 0196 to fulfil the requirements of the precision standards. If a one-inch microphone is used, a Random Incidence Corrector may also be necessary for certain measurements. Ensure that the measuring position is suitable and hold the Sound Level Meter at arm's length, or mount it on a tripod, to minimize reflections from the operator. Finally, make sure that the background noise level is not too high to make meaningful measurements.

3.4.2. Procedure for Sound Measurements

1. Calibrate the 2203 (including checking the batteries) as described in section 3.3.

2. Set the METER SWITCH to "Lin." "Fast".

3. Set the OUTPUT ATTENUATOR (transparent) at minimum gain, i. e. fully clockwise so that the red lines are adjacent to the black spot.

4. Adjust the INPUT ATTENUATOR (black) to give the highest possible meter reading without over-deflecting.

5. The METER SWITCH may now be set to the weighting network (or external filter) and meter response required for the actual measurements. However, once a weighting network (or an external filter) has been selected, the INPUT ATTENUATOR should not be moved without repeating steps 2 to 4, even though the meter reading may drop. (See note below.)

6. If necessary, turn the OUTPUT ATTENUATOR (transparent) anticlockwise to obtain a meter needle deflection in the measuring range, i. e. between "0" and "+ 10" dB, if possible.

7. With the microphone directed in the correct orientation for measurements, the sound (pressure) level equals the meter needle deflection plus the attenuator setting indicated inside the red lines. It may also be necessary to add the microphone K-factor (or 10 dB) to the reading, depending on the calibration (see sections 3.3.2 and 3.3.3). The meter reading **and** the weighting network/meter damping used should be noted.

Note: It is important that the above procedure be followed. Some operators may find it convenient to follow an abbreviated (but erroneous) procedure in which the desired weighting network (or external filter position) is selected directly without first making the INPUT ATTENUATOR adjustment in the "Lin." mode.
Failure to make the INPUT ATTENUATOR adjustment in the "Lin." mode may result in severe input amplifier overload and distortion, and hence inaccurate measurements, because only the weighted (or filtered) signal is fed to the meter, while the full linear signal is fed to the input amplifier. Low-frequency sound (and vibration) components often exceed the weighted audible-sound (or vibration) field. Following the procedure correctly ensures there is no overload.

3.5. CALIBRATION FOR VIBRATION MEASUREMENTS

3.5.1. General

The Sound Level Meter Type 2203 may also be used to measure vibration levels by using one of the adaptors or the Integrator ZR 0020 shown in Fig.3.3. Full details of the ZR 0020 may be found on its Product Data Sheet. Using the adaptors, acceleration only can be measured; if the Integrator is used, acceleration, velocity, and displacement are all available. The meter reading (in dB) may be simply converted to vibration units (ms^{-2} , ms^{-1} , m, in metric units or g, in s^{-1} , in, in Imperial units) using the circular Slide Rule QH 0001 provided with the Integrator.

As with sound measurements, the 2203 can be calibrated in two ways: either using an external calibrator (vibrating the accelerometer at a known rate); or using the built-in reference voltage in the instrument. The external method has the advantage that it checks the entire instrument, including the accelerometer.

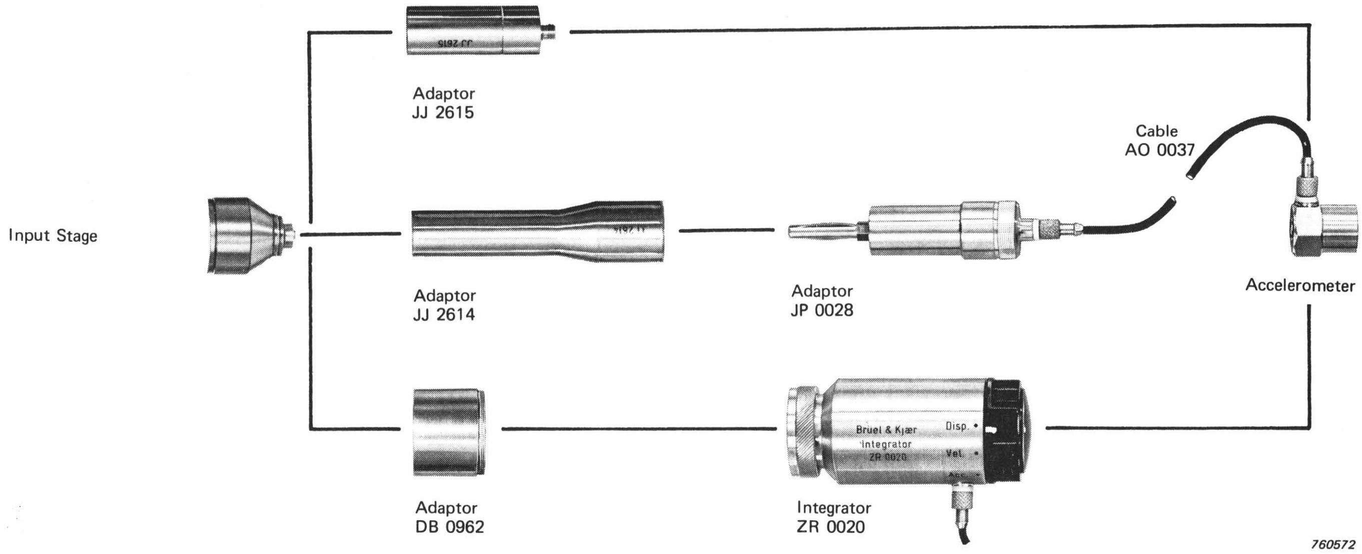


Fig. 3.3. Connection of accelerometer

3.5.2. Calibration using Accelerometer Calibrator Type 4291

The portable battery-operated Accelerometer Calibrator Type 4291 generates a vibration level of 1 g peak (0,707 g RMS) at 500 rad s^{-1} (79,6 Hz). The calibration procedure is as follows:

1. Mount the accelerometer on the 4291 (see the 4291 Instruction Manual), and connect it to the 2203 using one of the methods shown in Fig.3.3. If an Integrator is used, set it to the required position ("Acc.", "Vel.", or "Disp.").

2. Pull the METER SWITCH out, and set it to "Batt." to check the batteries; then set it to "Fast" and "Lin.". (The instrument warm-up time is 20 s.)

3. Set the 4291 to "Internal Gen." and adjust the ACC. LEVEL so that the lower scale of the 4291 meter indicates the mass of the accelerometer (given on its calibration chart). The accelerometer is now vibrating at exactly 1 g peak.

4. Set the ATTENUATORS of the 2203 to give the meter needle a deflection of at least 1/3 full scale with the OUTPUT ATTENUATOR (transparent) as far clockwise as possible, and turn the ADJ. potentiometer with a small screwdriver until the needle lies on "+ 7,0" dB.

5. Note the attenuator setting inside the red lines, and add 10 dB. This gives the zero reference value in dB (Z) corresponding to 1 g RMS, or any of the following vibration reference amplitudes (R) (which are equivalent to 1 g RMS at 79,6 Hz) to which the 2203 is now calibrated depending on the Integrator setting:

Acceleration:	9,81 ms^{-2} RMS	(1 g RMS ≡ 386 in s^{-2} RMS)
Velocity:	$19,6 \times 10^{-3}$ ms^{-1} RMS	($7,71 \times 10^{-1}$ in s^{-1} RMS)
Displacement:	$39,2 \times 10^{-6}$ m RMS	($1,54 \times 10^{-3}$ in RMS)

This adjustment will need to be made for each parameter to be measured. It is thus easier to calibrate for, and to make all measurements of, one parameter first, then recalibrate for another parameter and make measurements, if possible, rather than switch from one to another.

3.5.3. Calibration using the Internal Reference Voltage

The stable internal voltage (± 0,2 dB at about 1000 Hz) in the 2203 may also be used for calibration, as follows:

1. Connect the accelerometer to the 2203 using one of the methods shown in Fig.3.3. If an integrator is used, set it to the required position ("Acc.", "Vel.", or "Disp.").

2. Pull the METER SWITCH out, and set it to "Batt." to check the batteries; then set it to "Fast" and "Lin.". (The instrument warm-up time is 20 s.)

3. Set the ATTENUATORS of the 2203 so that "Ref." is inside the red lines (adjacent to the black dot) and turn the ADJ. potentiometer with a small screwdriver to give one of the following readings, depending on the method of connection:

K-factor of "0" dB	for Integrator ZR 0020
K-factor of "+ 0,8" dB	for JJ 2614
K-factor of "+ 1,2" dB	for JJ 2615

4. The 2203 is now calibrated so that a reading of "94" dB corresponds to 1 g RMS using an accelerometer with a sensitivity of 50 mV/g. For accelerometers of different sensitivities, the results should be corrected afterwards, as explained in section 3.7.3.

3.6. VIBRATION MEASUREMENTS

3.6.1. General

When using the 2203 as a preamplifier and measuring amplifier for an accelerometer, it should be remembered that the accelerometer has a high-frequency resonance (given on its calibration chart) which probably lies within the frequency range of the meter. Measurements should therefore be made with the use of an appropriate supplementary low-pass filter, or with a band-pass filter set (see Chapter 1), to prevent measuring the results of the resonance, where it is thought possible that the signal may contain such high frequencies. The lower limiting frequency of the measuring system is set at 10 Hz by the 2203.

For detailed instructions on the use of the accelerometer, see its Instruction Manual. The 2203 itself should be kept out of the vibration environment.

3.6.2. Procedure for Vibration Measurements

1. Calibrate the 2203 (including checking the batteries) as described in section 3.5, and mount the accelerometer by one of the methods described in its Instruction Manual.

2. Set the METER SWITCH to "Lin." "Fast".

3. Set the OUTPUT ATTENUATOR (transparent) fully clockwise so that the red lines are adjacent to the black spot.

4. Adjust the INPUT ATTENUATOR (black) to give the highest possible meter reading without over-deflecting.

5. Select the desired METER SWITCH position. (See the note in section 3.4.2.)

6. Adjust the OUTPUT ATTENUATOR (transparent) anticlockwise to give the highest possible meter needle deflection without over-deflecting. The INPUT ATTENUATOR should not be adjusted at this stage since it may result in an overload of the input. (See the note in section 3.4.2.)

7. Note the reading in dB (which is the sum of the meter needle deflection and the attenuator setting). This reading is used to calculate the vibration amplitude as described in section 3.7.

3.7. CALCULATION OF VIBRATION AMPLITUDE

The conversion of the measured level in dB to a vibration amplitude depends on the method of calibration and on whether or not the Integrator has been used. The circular Slide Rule QH 0001 used for conversion has two similar sides, one in metric units and the other in Imperial units.

3.7.1. With 4291 Calibration, Without Integrator

Determine the acceleration level (A) in dB referenced to 1 g RMS by:

$$A = M - Z$$

where M = measured value on 2203 (dB)
and Z = zero reference level (dB) (from section 3.5.2 step 5).

From Table 3.1 convert A from dB to a ratio (T). The vibration amplitude is then given by the product RT, where R is the vibration reference amplitude defined in section 3.5.2 step 5.

Example: The zero reference level (Z) is 100 dB. The measured value (M) on the 2203 is 87,4 dB, and it is desired to find the acceleration in ms^{-2} .

$$A = M - Z = 87{,}4 - 100 = -12{,}6\,dB$$

From Table 3.1, —12,6 dB becomes a ratio of T = 0,2344

Then Acceleration = RT = 9,81 ms^{-2} × 0,2344 = 2,30 ms^{-2} RMS.
(The peak acceleration level (for a sinusoidal signal) is 2,30 × 1,414 = 3,25 ms^{-2} peak.)

This calculation may be made more simply using the circular Slide Rule QH 0001 (if available) as described in the following section.

3.7.2. With 4291 Calibration, With Integrator ZR 0020

The vibration amplitude may only be calculated in the same parameter as that set on the Integrator, and the Slide Rule must not be used to convert from one parameter to another. To determine another parameter, the Integrator must be set and the 2203 calibrated for that parameter and new measurements made. The circular Slide Rule QH 0001 (shown in Fig.3.4) provided with the Integrator should be used to make the calculations as follows:

dB	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9
0	1,000	1,012	1,023	1,035	1,047	1,059	1,072	1,084	1,096	1,109
1	1,122	1,135	1,148	1,161	1,175	1,189	1,202	1,216	1,230	1,245
2	1,259	1,274	1,288	1,303	1,318	1,334	1,349	1,365	1,380	1,396
3	1,413	1,429	1,445	1,462	1,479	1,496	1,514	1,531	1,549	1,567
4	1,585	1,603	1,622	1,641	1,660	1,679	1,698	1,718	1,738	1,758
5	1,778	1,799	1,820	1,841	1,862	1,884	1,905	1,928	1,950	1,972
6	1,995	2,018	2,042	2,065	2,089	2,113	2,138	2,163	2,188	2,213
7	2,239	2,265	2,291	2,317	2,344	2,371	2,399	2,427	2,455	2,483
8	2,512	2,541	2,570	2,600	2,630	2,661	2,692	2,723	2,754	2,786
9	2,818	2,851	2,884	2,917	2,951	2,985	3,020	3,055	3,090	3,126
10	3,162	3,199	3,236	3,273	3,311	3,350	3,388	3,428	3,467	3,508
11	3,548	3,589	3,631	3,673	3,715	3,758	3,802	3,846	3,890	3,936
12	3,981	4,027	4,074	4,121	4,169	4,217	4,266	4,315	4,365	4,416
13	4,467	4,519	4,571	4,624	4,677	4,732	4,786	4,842	4,898	4,955
14	5,012	5,070	5,129	5,188	5,248	5,309	5,370	5,433	5,495	5,559
15	5,623	5,689	5,754	5,821	5,888	5,957	6,026	6,095	6,166	6,237
16	6,310	6,383	6,457	6,531	6,607	6,683	6,761	6,839	6,918	6,998
17	7,079	7,161	7,244	7,328	7,413	7,499	7,586	7,674	7,762	7,852
18	7,943	8,035	8,128	8,222	8,318	8,414	8,511	8,610	8,710	8,810
19	8,913	9,016	9,120	9,226	9,333	9,441	9,550	9,661	9,772	9,886

073010

Table 3.1. Conversion of dB to ratio. Subtract a multiple of 20 (n × 20 where n is a positive or negative integer or 0) from the dB value to be converted such that the remainder is a positive number between 0 and 19,9. Look up the ratio of that remainder in the table. The desired ratio is then 10^n times the value from the table. Example: —12,6 dB must be converted to a ratio. To get a positive number between 0 and 19,9 subtract —20 (= 20 × (—1)) from —12,6, giving + 7,4. The ratio of 7,4 is found in the table to be 2,344. Hence the ratio of —12,6 dB = 2,344 × 10^n = 2,344 × 10^{-1} = 0,2344

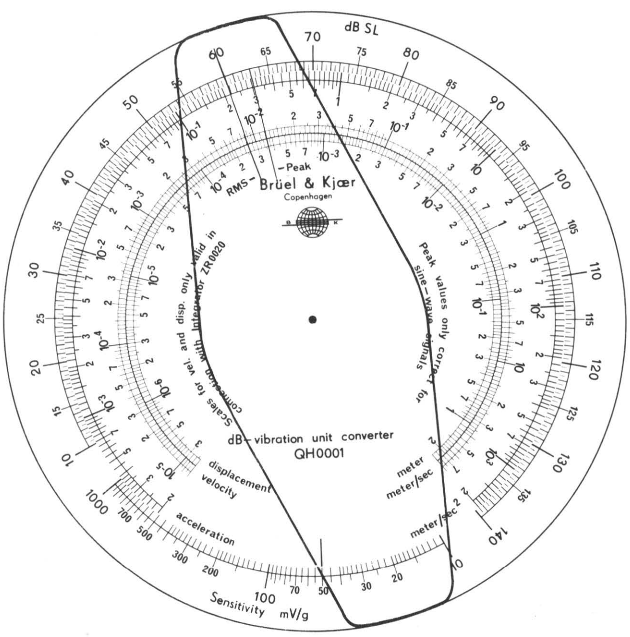


Fig.3.4. Slide Rule QH 0001 set for an accelerometer sensitivity of 50 mV/g and an SPL of 60 dB

1. Turn the cursor until its RMS line lies over the zero reference level (Z) from section 3.5.2 step 5) on the outer dB SL scale.

2. Rotate the sliding scale until the vibration reference amplitude (R) (see section 3.5.2 step 5) on the appropriate vibration scale (acceleration, velocity or displacement) also lies under the RMS line on the cursor.

3. Turn the cursor until its RMS line lies over the value of the 2203 meter reading (in dB) on the outer dB SL scale of the Slide Rule.

4. Read the vibration level (RMS or peak, depending on the requirement) on the **same vibration scale** as that used for step 2.

Example: The zero reference level (Z) is 80 dB. The vibration reference amplitude (R) is $7{,}71 \times 10^{-1}$ in s^{-1}, and the 2203 meter reading is 51 dB. Find the equivalent velocity in in s^{-1}.

Set the RMS line on the cursor over the "80 dB" dB line on the outer dB SL scale, and turn the sliding scale until the value of "$7{,}71 \times 10^{-1}$" on the VELOCITY INCHES/SEC. scale also lies under the RMS line. Turn the cursor to "51" dB on the outer dB SL scale. The velocity is "$2{,}8 \times 10^{-2}$" in s^{-1} RMS or "$3{,}9 \times 10^{-2}$" in s^{-1} peak (for a sinusoidal signal).

3.7.3. With Internal Calibration, Without Integrator

The acceleration level (A) in dB referenced to 1 g RMS is calculated by the formula

$$A = M - 94 + 20 \log_{10} (50/S)$$

where M is the meter reading on the 2203 (dB)
and S is the sensitivity (in mV/g) of the accelerometer used (from its calibration chart).

A is now converted to vibration units as described in section 3.7.1.

The complete calculation may be made more simply using the circular Slide Rule QH 0001 provided with the ZR 0020 (if available) as described in the following section.

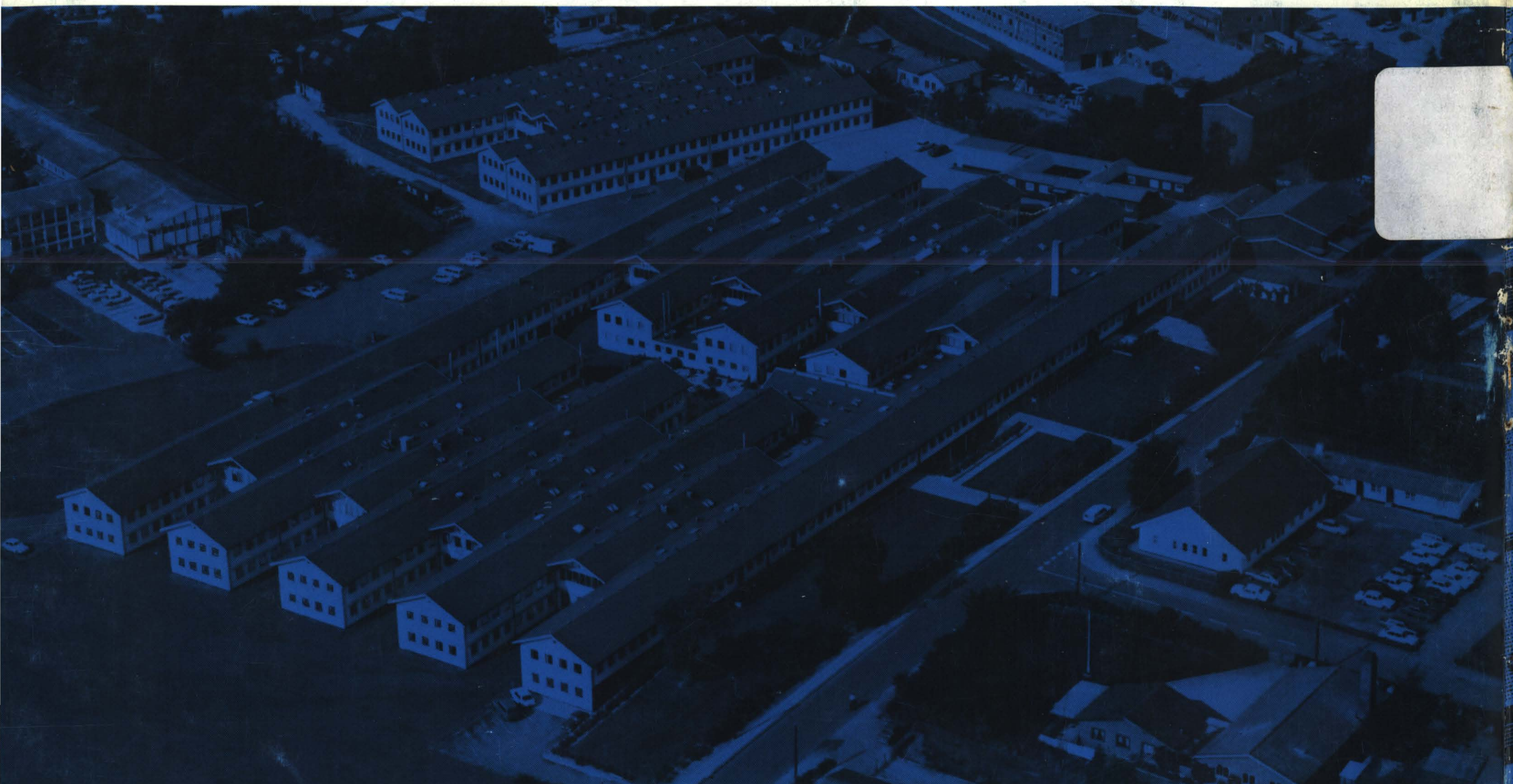
3.7.4. With Internal Calibration, With Integrator ZR 0020

The vibration amplitude may only be calculated in the same parameter as that set on the Integrator, and the Slide Rule must not be used to convert from one parameter to another. To determine another parameter, the Integrator must be set and the 2203 calibrated for that parameter, and new measurements made. The circular Slide Rule QH 0001 should be used to make the calculations as follows:

1. Set the isolated red line on the sliding scale adjacent to the accelerometer sensitivity in mV/g on the outer scale of the Slide Rule. (It is shown adjacent to 50 mV/g in Fig.3.4.)

2. Turn the cursor so that its RMS line lies over the value of the 2203 meter reading (in dB) on the outer dB SL scale of the Slide Rule.

3. Read the vibration level (RMS or peak) on the **scale corresponding to the Integrator setting.**



BRÜEL & KJÆR instruments cover the whole field of sound and vibration measurements.
The main groups are:

ACOUSTICAL MEASUREMENTS
Condenser Microphones
Piezoelectric Microphones
Microphone Preamplifiers
Hydrophones
Sound Level Meters
Precision Sound Level Meters
Impulse Sound Level Meters
Noise Dose Meters
Noise Level Analyzers
Standing Wave Apparatus
Calibration Equipment
Reverberation Processors
Sound Sources

ACOUSTICAL RESPONSE TESTING
Sine Generators
Random Noise Generators
Sine-Random Generators
Artificial Voices
Artificial Ears
Artificial Mastoids
Hearing Aid Test Boxes
Audiometer Calibrators
Telephone Measuring Equipment
Audio Reproduction Test Equipment
Tapping Machines
Turntables

VIBRATION MEASUREMENTS
Accelerometers
Force Transducers
Impedance Heads
Accelerometer Preamplifiers
Vibration Meters
Accelerometer Calibrators
Magnetic Transducers
Capacitive Transducers
Complex Modulus Apparatus
Bump Recorders

VIBRATION TESTING
Exciter Controls — Sine
Exciter Controls — Sine — Random
Exciter Equalizers, Random or Shock
Exciters
Power Amplifiers
Programmer Units
Stroboscopes

STRAIN MEASUREMENTS
Strain Gauge Apparatus
Multipoint Selectors

MEASUREMENT AND ANALYSIS
Voltmeters
Phase Meters
Deviation Bridges
Measuring Amplifiers
Band-Pass Filter Sets
Frequency Analyzers
Real Time Analyzers
Heterodyne Filters and Analyzers
Distortion Measuring Equipment
Psophometers
Statistical Distribution Analyzers
Tracking Filters

RECORDING
Level Recorders
Frequency Response Tracers
Tape Recorders
Alphanumeric Printers
Digital Event Recorders

DIGITAL EQUIPMENT
Computers
Tape Punchers
Tape Readers

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