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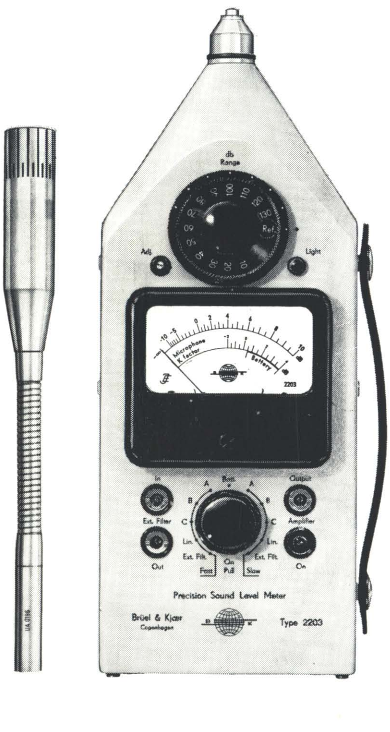
Instructions and Applications



Precision Sound Level Meter
Type 2203

A portable sound level meter made to the precision standards of IEC 179. It can also be used with an accelerometer input for the measurement of vibration.

BRÜEL & KJÆR

030-0617

PRECISION SOUND LEVEL METER
TYPE 2203

Applicable to instruments from serial
no. 467152

December 1973

CONTENTS

1. INTRODUCTION

1.1. PRECISION SOUND LEVEL METER TYPE 2203

The Brüel and Kjær Precision Sound Level Meter Type 2203 is a compact, portable instrument for precision sound and vibration measurement. The 2203 meets the standards of IEC 179/1973 for Precision Sound Level Meters.

Built into the 2203 are the A, B, and C weighting networks. Provision is also made for external filters such as the 1613 (Octave) and 1616 (Third Octave) filters permitting truly portable analysis.

The 2203 is capable of sound measurements over a wide frequency and dynamic range with the Condenser Microphone (4145) provided with it. It accurately measures the RMS values of signals with crest factors up to 5. *Slow* and *Fast* meter dampings are provided according to IEC 179. It can also be used for vibration measurements when fitted with a suitable accelerometer.

Sound Level Meters Type 2203 from serial number 467152 are of a new construction featuring generally improved gain stability with temperature variation, lower output impedances, and a new expanded list of accessories.

The 2203 is available with a wide range of accessories making it a versatile, portable instrument.

1.2. PRECISION SOUND LEVEL METER STANDARDS

The IEC (International Electrotechnical Commission) has set various standards for sound level meters. IEC Publication 123 gives the requirements for general purpose Sound Level Meters which are made more stringent in Publication 179 for Precision Sound Level Meters. The B & K 2203 meets or exceeds all requirements of IEC 179, the main points of which are given below:

Free-field sound pressure level measurement accuracy of ± 1 dB.

Essentially omnidirectional microphone characteristics (see Section 5.1). Square law type measurement indication.

Tolerances on meter scale calibration and range shift error are specified.

A "Fast" meter dynamic characteristic: Response to a 200 millisecond pulse must be within —2 and 0 dB of the indication for a continuous signal of same frequency and amplitude. Damping such that overswing on a suddenly applied steady signal is between + 0,1 and + 1,1 dB.

An alternative "Slow" meter characteristic (optional): Response to a 500 millisecond pulse must be within —5 and —3 dB of the indication for a continuous signal of same frequency and amplitude. Damping such that overswing on a suddenly applied steady signal is between + 0,1 and + 1,6 dB compared to final steady indication (which must be within 0,1 dB of level indicated with "Fast" characteristic).

Specifications are also given for frequency range capabilities, and maximum permissible sensitivity to external and environmental influences.

The IEC publication specifically states that the Precision Sound Level Meter is designed to give objective measurements which under certain conditions approximate the subjective impression of sound. The 2203 meets all applicable IEC criteria and can be used for the measurement of most continuous sounds.

Full discussion of sound and vibration measurement techniques is given in two Brüel & Kjær books; "Acoustic Noise Measurements" and "Mechanical Vibration and Shock Measurements" which are available on request.

2. CONTROLS

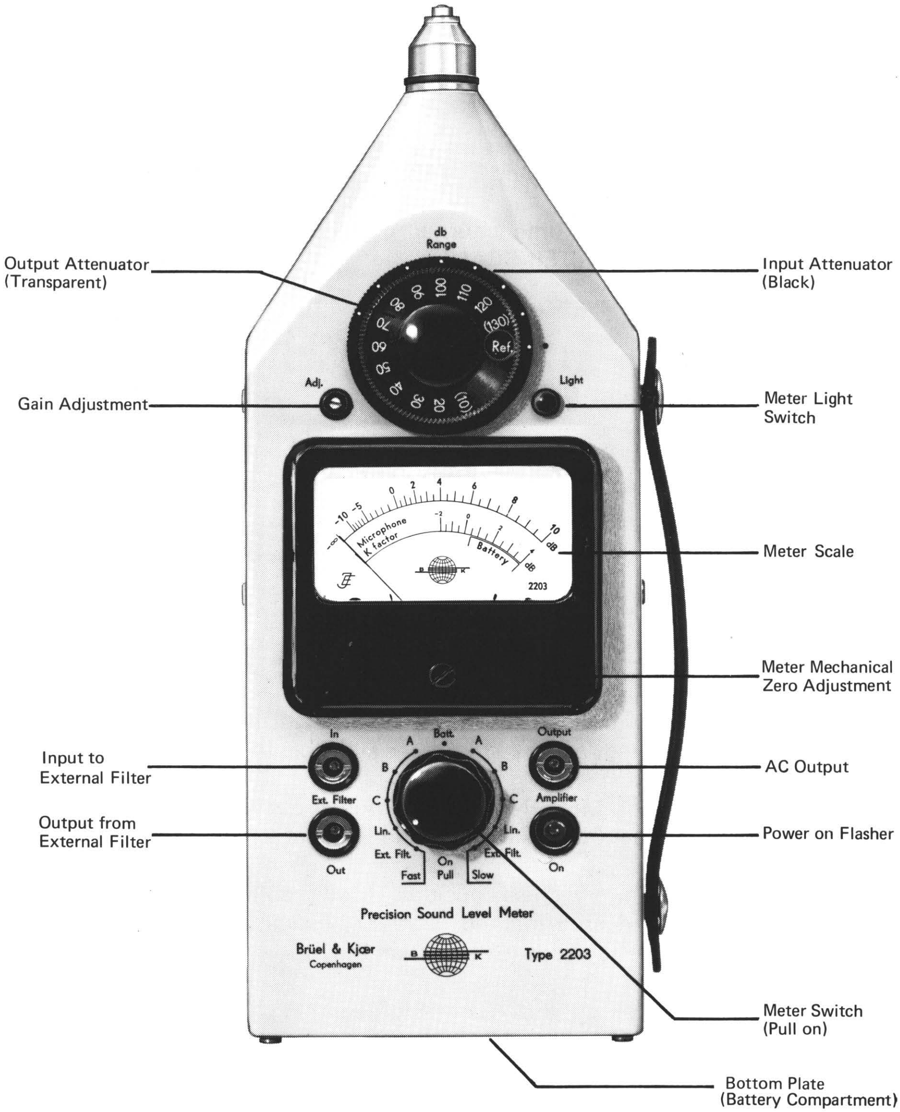


Fig. 2.1. Front view of 2203

METER SCALE

The upper scale is calibrated in dB from —10 to + 10 dB for the reading of sound pressure level or vibration level. The lower scale (red) is calibrated for the Microphone K-factor which takes into account various microphone sensitivities. Two red marks below the K scale give the range for "good" battery condition indication.

METER MECHANICAL ZERO ADJUSTMENT

Is adjusted with the instrument turned off to give a meter deflection on the — ∞ mark of the METER SCALE.

POWER ON FLASHER

This lamp flashes when the instrument is on.

METER LIGHT SWITCH

This momentary contact switch provides meter scale illumination while pressed in.

METER SWITCH

This 11 position switch serves as the main power switch, weighting network, meter damping, and external filter selector.

"Pull On"	The METER SWITCH is pulled out to turn the instrument on. Warm-up time is about 20 s.
"Batt."	Battery check position. Meter deflection below the red area marked "Battery" indicates batteries must be replaced (See Section 3.1).
"Fast"	Selects the *Fast* meter damping (according to IEC 179 .... See Introduction) for the five functions on the left side of the knob.
"Slow"	Selects the *Slow* meter damping (according to IEC

179 .... See Introduction) for the five functions on the right side of the knob.

"A", "B", "C" — Selects a standardized frequency weighting network for subjective indication of loudness (See Fig. 5.12).

"Lin." — Gives linear frequency response.

"Ext. Filt." — Permits connection of an external filter across the EXTERNAL FILTER sockets. In this position, a meter deflection is obtained only if an external filter is connected.

INPUT ATTENUATOR (black)

Controls the gain of the input amplifier in seven 10 dB steps. Its range of rotation is such that one of the markings "70" — "Ref." must always be opposite the black dot. Is used together with the OUTPUT ATTENUATOR to select the measuring range of the instrument. Also selects the internal reference signal for calibration purposes.

OUTPUT ATTENUATOR (transparent)

Controls the gain of the output amplifier in seven 10 dB steps. Its range of rotation is such that the red lines on the knob can only be rotated in positions anti-clockwise from the black dot. The measuring range of the instrument corresponding to 0 dB meter deflection is indicated inside the red lines.

GAIN ADJUSTMENT

This screwdriver operated potentiometer varies the gain of the 2203 over at least a 6 dB range (—2 to + 4 dB) permitting calibration for various K-factors (microphone sensitivities).

EXTERNAL FILTER IN

Connects to the input of an external filter. The output impedance of the socket is $< 5\,\Omega$ but should be loaded by at least $500\,\Omega$. Accepts plug JP 0006 or cable AO 0007.

EXTERNAL FILTER OUT

Connects the output of an external filter to the 2203. The input impedance of the socket is 146 kΩ//45 pF. Accepts plug JP 0006 or cable AO 0007.

AC OUTPUT

This socket provides an AC output of 3,16 V RMS at full scale meter deflection. Maximum output voltage is 16 V peak into a load impedance of at least 10 kΩ. For use in connecting to Level Recorder or Tape Recorder. Accepts plug JP 0006 or cable AO 0007.

TRIPOD MOUNTING THREADS

There are two tripod mounting threads on the rear of the 2203. The upper thread is used for mounting the 2203 alone, while the lower one is used for mounting the 2203 when fitted with Filter Sets 1613 or 1616. For vertical mounting, a thread is also provided on the battery cover on the bottom of the 2203.

3. OPERATION

3.1. BATTERY REPLACEMENT AND GENERAL CONSIDERATIONS

3.1.1. Battery Replacement

The three 1,5 volt standard flashlight cells (Type R 20 in IEC Publication 86-2) are replaced by unscrewing the four screws holding the bottom cover of the 2203. The batteries are placed in the battery compartment such that the positive terminals point to the front panel of the instrument.

Rechargeable nickel cadmium batteries may also be used giving the advantages of longer operating time without battery change and reduced long term battery costs.

The 2203 may also be powered directly from the Noise Dose Meter Type 4423 or Hearing Aid Test Box Type 4217 using Battery Adaptor UA 0363 as described in the 4423 or 4217 Instruction Manual.

3.1.2. General Considerations

- Store the instrument in a dry, preferably warm place.
- Remove batteries if instrument is not used for a long time.
- Connect and disconnect microphones and adaptors with the power off.
- Assemble microphones and adaptors at the same temperature.
- Use only light finger torque to tighten microphone and adaptors.
- In dry weather, discharge static electricity from your body before fitting microphones.
- Keep dust and foreign objects from the microphone diaphragm. Never touch the diaphragm with any object.

3.2. CALIBRATION FOR SOUND MEASUREMENTS

3.2.1. Using the Sound Level Calibrator or Pistonphone

A source of known sound level and stability is placed over the measuring microphone. The gain of the input amplifier is then adjusted to calibrate the Meter to this reference level. For the Sound Level Calibrator (4230) this is 94 dB and for the Pistonphone (4220) approx. 124 dB. An individual calibration chart giving exact sound level output is provided with the Pistonphone.

The calibration procedure is as follows:

1. Attach the desired Microphone, extension rods, or cables and adaptors.

2. Pull METER SWITCH out and wait about 20 seconds for instrument to warm up.

3. Set METER SWITCH to "Batt." to check the condition of the batteries.

4. Set METER SWITCH to "Fast" and "C".

5. Set the ATTENUATORS to the range indicated in Table 3.1 depending on microphone sensitivity.

6. The sound pressure level when calibrated will equal the ATTENUATOR setting plus the meter indication plus the correction factor given in Table 3.1.

7. Turn on the Sound Level Calibrator or Pistonphone, check that it is functioning properly, and place over the Microphone.

8a. For the Pistonphone, use a small screwdriver to adjust the ADJ. potentiometer so the meter indicates the sound pressure level (see step 6 above) given on the Pistonphone calibration chart. Correct as necessary for barometric pressure.

Microphone Open Circuit Sensitivity (mV/Pa)	Sound Level Calibrator ATTENUATOR SETTING (dB)	Pistonphone ATTENUATOR SETTING (dB)	Correction Factor (dB)
31,5 – 63	90	120	0
10 – 20	80	110	+ 10
3,15 – 6,3	70	100	+ 20
1 – 2	60	90	+ 30

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Table 3.1. Attenuator settings for calibration

8b. For the Sound Level Calibrator, use a small screwdriver to adjust the ADJ. potentiometer so the meter indicates the sound pressure level as follows.

One-inch free field microphones: 93,6 dB
Half-inch free field microphones: 93,8 dB
Pressure response microphones (any size): 94,0 dB

Although the Sound Level Calibrator provides an output of 94 dB, the figures for the free field microphones include the free field corrections for the microphones at the frequency of the Calibrator, 1000 Hz.

3.2.2. Using the built-in Reference Voltage

A stable internal voltage (± 0,2 dB at approx. 1 kHz) is fed to the input amplifier whose gain is adjusted to make the 2203 correspond to the open circuit sensitivity of the Microphone used. However, when possible, calibration is preferable using the Pistonphone or Sound Level Calibrator since this will take into account all possible Microphone and instrument changes in sensitivity due to environmental factors.

The calibration procedure using the built-in reference voltage is as follows:

1. Choose desired Microphone and accessories.

2. Pull METER SWITCH out and wait about 20 seconds for instrument to warm up.

3. Set METER SWITCH to "Batt." to check battery condition.

4. Set METER SWITCH to "Fast" and "Lin".

5. Set ATTENUATORS to "Ref." (inside red lines).

6. Using a small screwdriver set the ADJ. potentiometer for the Microphone K-factor (defined below) on the lower red meter scale. 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. However, for K-factors between + 8 and + 14, the 2203 can be set for a K-factor of (K—10) and 10 dB can then be added to all readings.

Determination of K-factor

The 2203 along with other B & K instruments is calibrated for a standard microphone sensitivity of 50 mV/Pa which equals —26 dB relative to 1 V/Pa (1 Pa = 1 N/m^2 = 10 μbar).

Since differing microphone sensitivities and the attenuation caused by various adaptors, extension rods, and input stages of sound level meters result in a sensitivity other than this standard sensitivity, a correction factor K must be added to the meter reading to give the actual sound pressure level. K is determined by the formula:

$$K = K_0 - \text{input gain} - \text{adaptor gain}$$

Thus, using a one-inch Microphone, for example, the open circuit correction factor K_0 of + 0,6 dB is found on the microphone calibration chart. On the back of the chart is found the input gain of the 2203 (—1,2 dB). If the 2203 is used with Extension Rod UA 0196 which has a gain of —0,1 dB (attenuation of + 0,1 dB) we can calculate K:

$$K = 0{,}6 - (-1{,}2) - (-0{,}1)$$
$$= +1{,}9\ \text{dB}$$

For half-inch Microphones, the input gain given on the calibration chart includes the attenuation of certain adaptors and extension rods which are listed.

3.3. SOUND MEASUREMENTS

3.3.1. General Considerations

1. Select a Microphone with appropriate dynamic range, frequency range and directional characteristics. Also select appropriate accessories (See Chapter 6) for various environmental and measurement conditions.

2. Whenever possible mount the 2203 on a tripod and use the flexible extension rod to minimize interference from reflections from the meter itself and the body of the observer. Stand at least one meter behind the instrument to reduce interference when making readings. Position the Microphone so it faces the sound source.

3. When measuring sound fields other than normal incidence, use the Random Incidence Corrector UA 0055 on the one-inch free field Mi-

crophone, or use the half-inch Microphone for better omni-directivity. Alternatively, a pressure response microphone fitted with its normal protecting grid can be used for random or semi-random fields.

4. Calibrate the 2203 before use to ensure correct, reproducible results.

5. Keep notes on measurement conditions, equipment and accessories used, background noise levels, weighting networks and meter functions used.

6. Special attention should be paid to the procedure outlined below to ensure operation without input overload.

7. To make high accuracy measurements in accordance with the standards of IEC 179 or DIN 45633 parts 1 and 2, the 2203 must be used with the following accessories:

Extension Rod	UA 0196
Adaptor	DB 0375
One-inch Microphone	4145
Random Incidence Corrector	UA 0055
or	
Extension Rod	UA 0196
Half-inch Microphone	4133

3.3.2. Specific Sound Measurement Procedure

1. Calibrate the 2203 as described in Section 3.2.

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

3. Set OUTPUT ATTENUATOR (transparent) at minimum gain (fully clockwise, red lines opposite black dot).

4. Adjust INPUT ATTENUATOR (black) for the highest possible meter reading without overdeflection.

5. Set METER SWITCH to desired weighting network and meter damping.

6. If necessary, turn OUTPUT ATTENUATOR (transparent) anti-clockwise to obtain a meter deflection between 0 and + 10 dB (Do not adjust the INPUT ATTENUATOR at this stage since it may result in input overload).

7. The sound pressure level (SPL) equals the meter scale deflection plus the attenuator setting read inside the red lines. It may also be necessary to add the K-factor under certain conditions (See Section 3.2.2). Note the SPL along with the weighting network and meter damping used.

N.B. The importance of following the above procedure needs special emphasis. Some operators may find it convenient to follow an abbreviated (but erroneous) procedure in which the desired weighting network is selected directly without first making the INPUT ATTENUATOR adjustment in the "Lin." mode (steps 2 & 4).

This may result in severe input amplifier overload and hence inaccurate measurements. Frequently the level of low frequency sound components exceeds the level of the weighted audible sound field. These low frequencies may then overload the input amplifier. If the INPUT ATTENUATOR is first adjusted in the "Lin." mode for an on-scale meter deflection, input amplifier operation without overload is ensured.

3.4. CALIBRATION FOR VIBRATION MEASUREMENTS

3.4.1. Using Accelerometer Calibrator 4291

The Accelerometer Calibrator Type 4291 generates a vibration level of 1 g peak (0,707 g RMS) at 500 radians per second (79,6 Hz). Calibration and measurement can also be made for velocity and displacement using Integrator Type ZR 0020. The calibration procedure is as follows:

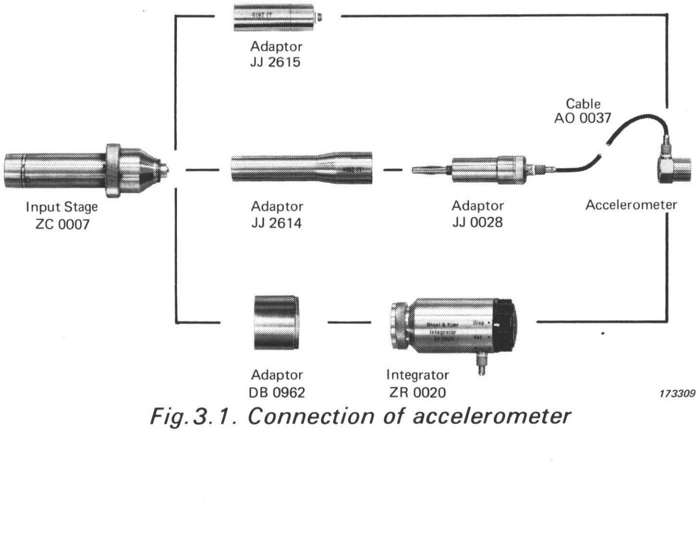

Fig. 3.1. Connection of accelerometer

1. Mount the Accelerometer on the 4291 and connect to the Integrator (if required) and the 2203 (Fig.3.1).

2. Set the Integrator (if used) to desired function.

3. Pull METER SWITCH out and wait 20 seconds for warm-up.

4. Set METER SWITCH to "Batt." and check battery condition.

5. Set METER SWITCH to "Fast" and "Lin.".

6. Set Accelerometer Calibrator to "Int. Gen." and then adjust ACC. LEVEL so the lower scale of the 4291 meter indicates the mass of the Accelerometer (given on its calibration chart).

7. Set ATTENUATORS of the 2203 for at least 1/3 full scale deflection.

8. Adjust the ADJ. potentiometer to give a meter deflection of + 7,0 dB.

9. Note the attenuator setting inside the red lines and add 10 dB. This gives the zero reference level in dB (Z) corresponding to 1 g RMS or any of the following vibration reference amplitudes (R) to which the 2203 is now calibrated depending on the Integrator setting:

Acceleration:	$9{,}80\ m/s^2$	$(1\ g = 386\ in/s^2)$
Velocity:	$19{,}6 \cdot 10^{-3}\ m/s$	$(7{,}71 \cdot 10^{-1}\ in/s)$
Displacement:	$39{,}2 \cdot 10^{-6}\ m$	$(1{,}54 \cdot 10^{-3}\ in)$

3.4.2. Using built-in Reference Voltage

1. Connect the Accelerometer to the Integrator (if required) and the 2203 (Fig.3.1).

2. Set Integrator (if used) to desired function.

3. Pull METER SWITCH out and wait 20 seconds for warm-up.

4. Set METER SWITCH to "Batt." and check battery condition.

5. Set METER SWITCH to "Fast" and "Lin.".

6. Set ATTENUATORS so "Ref." is inside the red lines.

7. Set ADJ. potentiometer for K-factor of zero for Integrator ZR 0020, + 0,8 dB for JJ 2614, and + 1,2 dB for JJ 2615.

8. 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.

3.5. VIBRATION MEASUREMENTS

3.5.1. General Considerations

For detailed instructions on Accelerometer use see the Accelerometer Instruction Manual.

When using the 2203 as an accelerometer preamplifier-measuring amplifier system it must be remembered that the Accelerometer has a high frequency resonance which probably lies within the frequency range of the meter. Hence measurements should be made with the use of an appropriate supplementary low-pass filter or with an octave or third octave filter set (such as B & K 1613 or 1616) to prevent measuring results of the resonance where it is thought possible that the signal to be measured contains such high frequencies.

The lower frequency limit of the measuring system of 10 Hz, is determined by the 2203.

Hold or mount the 2203 as far as possible from the vibration environment and other unrequired influences.

3.5.2. Specific Vibration Measurement Procedure

1. Calibrate the system as described in Section 3.4.

2. Mount the Accelerometer by one of the methods described in its Instruction Manual.

3. Set METER SWITCH to "Fast" and "Lin.".

4. Set OUTPUT ATTENUATOR (transparent) fully clockwise.

5. Adjust INPUT ATTENUATOR (black) for highest possible meter reading without overdeflection.

6. Select desired METER SWITCH position.

7. Adjust OUTPUT ATTENUATOR for highest possible meter reading

without overdeflection. (The INPUT ATTENUATOR should not be adjusted at this stage since it may result in input overload).

8. Note the reading in dB (which is the sum of the meter deflection and attenuator setting). This reading is used to calculate the vibration level as described in the following section.

3.6. CALCULATION OF VIBRATION AMPLITUDE

The dB level measured is converted to a vibration amplitude by a method determined by the calibration method and whether or not the Integrator was used. A slide rule to convert dB to vibration units is provided with the Integrator ZR 0020. This slide rule has two similar sides with the vibration units on one side being in m/s^2, m/s, and m and the other side in g, in/s, and in.

3.6.1. 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)
Z = zero reference level (from Section 3.4.1 step 9)

From Table 3.2 convert A from dB to a ratio (T). Then vibration amplitude = RT (where R is the reference vibration amplitude defined in Section 3.4.1 step 9).

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 acceleration in m/s^2.

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

A is converted to a ratio T = 0,2344 by Table 3.2.

Then the Acceleration = RT = (9,8 m/s^2) x 0,2344 = 2,30 m/s^2

If Slide Rule QH 0001 is available, the calculation is made as described in the following section.

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

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Table 3.2. Conversion of dB to ratio. Subtract a multiple of 20 (n x 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 then is 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 x (—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 x 10^n = 2,344 x 10^{-1} = 0,2344

3.6.2. With 4291 Calibration, With Integrator

The vibration amplitude can only be calculated in the same parameter as set on the Integrator. To determine another parameter the Integrator must be set and calibrated to that parameter and new measurements must be made. Slide Rule QH 0001 provided with the Integrator is used to make the calculation as follows:

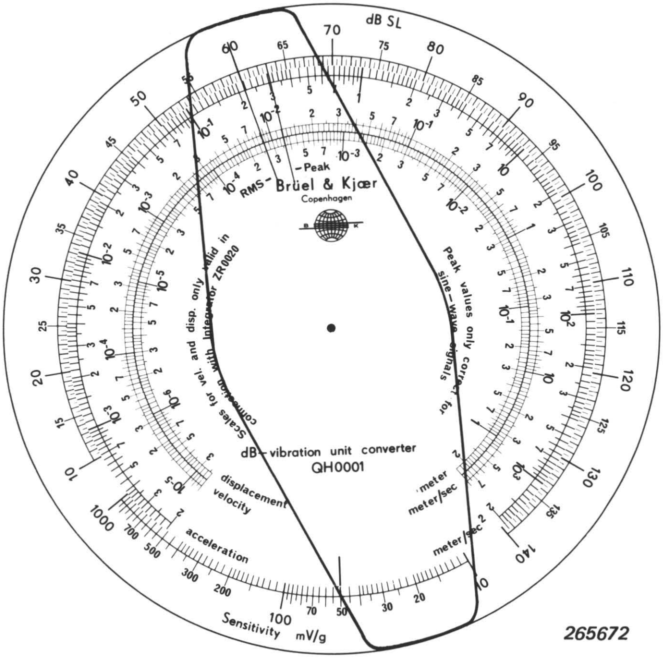


Fig. 3.2. Slide Rule QH 0001 set for an accelerometer sensitivity of 50 mV/g and an SPL of 60 dB

1. Set the reference vibration amplitude R (see Section 3.4.1 step 9) on the appropriate vibration scale opposite the zero reference level Z (see Section 3.4.1 step 9) on the dB SL scale.

2. Set the cursor to the meter reading of the 2203 on the dB SL scale and read the vibration level directly below on the same vibration scale as R was set.

Example: The zero reference level Z is 80 dB. The reference vibration amplitude R is $7{,}71 . 10^{-1}$ in/s. The measured level on the 2203 is 51 dB. $7{,}71 . 10^{-1}$ on the in/s scale is set opposite 80 on the dB SL scale. The cursor is moved to 51 on the dB SL scale and the velocity is read as $2{,}8 . 10^{-2}$ on the in/s scale.

3.6.3. With built-in Calibration, Without Integrator

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

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

where M is the measured level on the 2203 (dB) and S is the sensitivity of the Accelerometer in mV/g. A is then converted to acceleration units as described in Section 3.6.1.

If slide rule QH 0001 is available, the calculation is made as described in the next section.

3.6.4. With the built-in Calibration, With Integrator

Slide Rule QH 0001 is used as follows:

1. Set the isolated red line on the inner disc opposite the accelerometer sensitivity in mV/g.

2. Set the cursor to the measured level on the 2203 on the dB SL scale and read the vibration amplitude on the scale directly below. Use the scale corresponding to the integrator setting. The slide rule cannot be used to convert from one vibration parameter to another. To determine another vibration parameter, new measurements must be made with a different setting of the Integrator.

4. DESCRIPTION

In the technical description that follows reference is made to the block diagram in Fig.4.1.

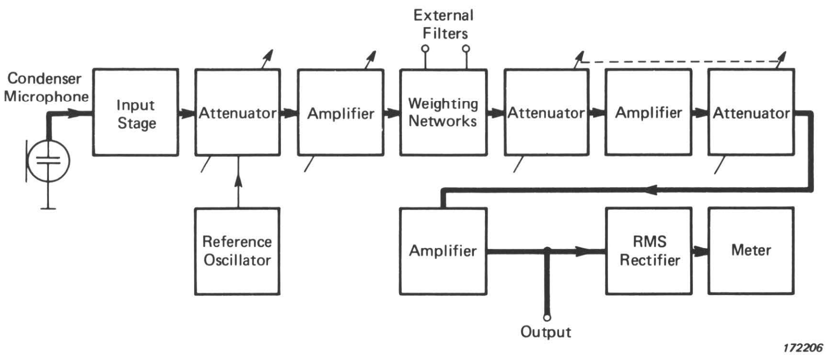


Fig.4.1. Block diagram of 2203

4.1. CONDENSER MICROPHONE

A condenser microphone is essentially a variable air dielectric capacitor with a constant charge (Q) impressed upon it by its polarization voltage. The total voltage (V) on the capacitor then is inversely proportional to the capacitance (C).

$$V = \frac{Q}{C}$$

and a change in capacitance will result in a change in voltage since Q is constant.

In practice the capacitor is a thin metallic diaphragm mounted in close proximity to but electrically insulated from a fixed back plate (Fig.4.2). Sound pressure waves will displace the diaphragm, thus changing the capacitance and the output voltage. The constant charge is provided from a stabilized DC polarization voltage fed through a high resistance

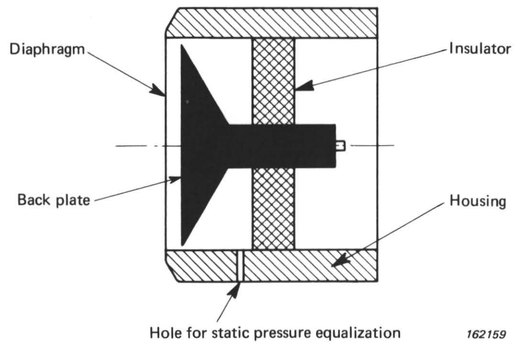


Fig. 4.2. Schematic of condenser microphone

giving a long RC charging constant and thus preventing charge variations due to capacitance changes resulting from the incident sound waves.

The 2203 Precision Sound Level Meter is provided with a one-inch Condenser Microphone Type 4145 and an individual calibration chart such as seen in Fig.4.3. (Curve F_1 is not shown on actual calibration chart).

4.2. INPUT STAGE

The input stage of the 2203 is a fully transistorized impedance converter built around a low noise field-effect transistor. The stage converts the high input impedance to a low output impedance which drives the input amplifier of the 2203.

The low capacitance of the Condenser Microphone necessitates a high impedance load consisting of a high resistance (> 1 GΩ) to ensure good low frequency response and a low capacitance to ensure good sensitivity. Refer to the Microphone Instruction Manual for details on the theory of input loading.

4.3. INPUT ATTENUATOR AND INPUT AMPLIFIER

The input attenuator follows the input stage and has a range from 0 to 60 dB in 10 dB steps. The accuracy of the attenuator is better than ± 0,2 dB within the rated frequency range of the instrument.

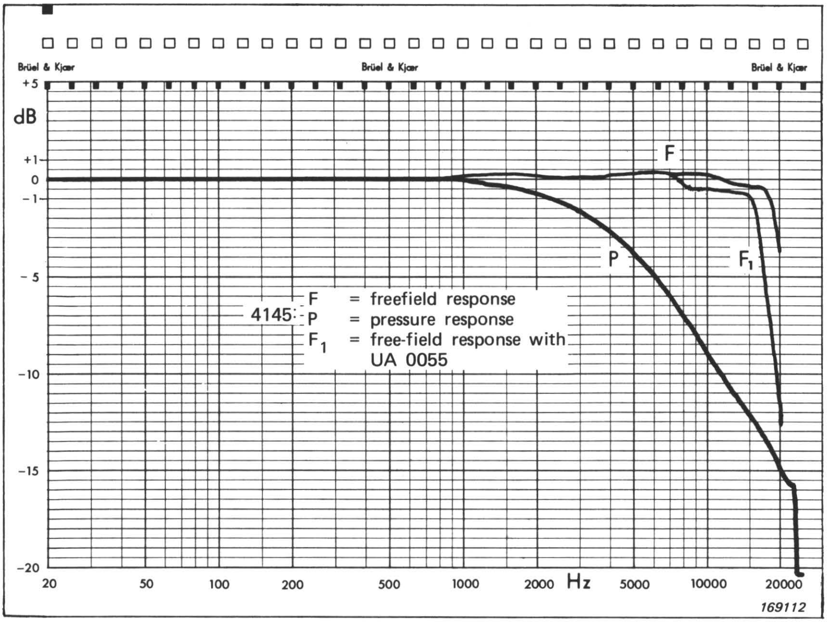


Fig. 4.3. Typical frequency response of Microphone Type 4145

The input amplifier follows the attenuator. Its high input impedance (> 10 MΩ) ensures negligible loading of the attenuator, and its low output impedance (< 5 Ω) prevents loading effects of the weighting networks or external filters. It should be loaded, however, by an impedance of at least 500 Ω.

The calibration potentiometer (ADJ.) is placed in the feedback of the input amplifier and varies its gain over a range of at least —2 to + 4 dB.

4.4. REFERENCE OSCILLATOR

The reference oscillator operates at approximately 1 kHz and gives a square wave whose amplitude accuracy is better than ± 0,2 dB. Since this reference voltage is inserted after the input stage, it must be remembered that the input stage and microphone is not included in any calibration using the built-in reference voltage.

4.5. WEIGHTING NETWORKS

The characteristics of the "A", "B", and "C" weighting networks built into the 2203 are given in Section 5.12.

4.6. OUTPUT ATTENUATOR AND OUTPUT AMPLIFIER

The output attenuator is divided into two sections placed immediately before and after the first stage of the output amplifier to optimize the signal to noise ratio. The range of the output attenuator is from 0 to 60 dB in 10 dB steps accurate to better than ± 0,2 dB.

The second stage of the output amplifier drives the meter rectifier circuit and the AC output socket through a 22 μF capacitor. The peak output voltage into a load impedance of at least 10 kΩ is 16 V. 3,16 V corresponds to full-scale meter deflection.

4.7. RMS DETECTOR

There are three common values used in characterizing the amplitude value of an AC signal: (1) Peak, (2) Average, and (3) RMS. The peak value is of use when wanting to protect against or observe amplifier overload and also in shock and vibration testing. However, the peak value is not related to the power or subjective loudness of the signal since it does not consider the time duration of the signal.

Both average and RMS values do consider the time duration of the signal, but both mathematically and practically the average value has found little use. However, the RMS value is directly related to the power dissipated in linear systems and has found widespread acceptance and use. It is defined as:

$$A_{RMS} = \sqrt{\frac{1}{T} \int_{t_1}^{t_2} a^2(t)\, dt}$$

According to this definition, a circuit to detect RMS amplitudes must square the instantaneous amplitudes (a) and average them over a time $T = t_2 - t_1$, then take the square root and present the result to the meter.

In the 2203 this is accomplished using a circuit which approximates the instantaneous parabolic transfer characteristics required by the above equation and performs the averaging (integrating) in a simple RC network. The circuit has an accuracy of ± 0,5 dB for signals with a crest factor of 3 or less, and ± 1 dB for signals with a crest factor of 5 or less. "Fast" and "Slow" meter dampings are also provided as specified by IEC 179 and described in Chapter 1.

See the following references for theory of RMS circuits:

1. J. Austin Hansen:	"RMS Rectifiers", B & K Technical Review 1972 No. 2
2. C. G. Wahrman:	"A True RMS Instrument", B & K Technical Review 1958 No.3
3. C. G. Wahrman:	"Impulse Noise Measurement", B & K Technical Review 1969 No.1

4.8. POWER SUPPLY

The power supply is a DC to DC converter delivering various stabilized and unstabilized voltages to the amplifier circuits and the polarization voltage to the Condenser Microphone. Polarization voltage stability with temperature variation is less than 0,1 dB. The power supply will operate correctly from a voltage of 3,0 to 4,6 V DC.

The converter operates at a frequency of approximately 1 kHz and also provides the signal for the built-in reference voltage.

5. OPERATIONAL CHARACTERISTICS AND ACCURACY

5.1. DIRECTIONAL CHARACTERISTICS

Ideally a sound level meter should have the same sensitivity for sound coming from all directions. Unfortunately this cannot be achieved in practice except in the case of relatively low frequencies.

For higher frequencies, when the dimensions of the sound level meter and microphone are comparable to the wavelength of the sound, the sound field around the instrument will be disturbed and the pressure on the Microphone diaphragm will depend on the direction from which the sound is coming.

The directional characteristics of the 2203 with Microphone Type 4145 are shown in Fig.5.1. Although response is very uniform at angles of incidence of less than 30°, high frequency response is reduced at angles greater than 30°.

The omnidirectivity of the instrument becomes more important when the sound is incident from all directions. Such examples are noise from several sources in a machine shop or noise from a single source in a room with reflections from hard boundaries making the field more or less diffuse. Under such circumstances, the Random Incidence Corrector, fitted in place of the normal protection grid on the one-inch Microphone gives enhanced overall characteristics. The effect of the Random Incidence Corrector can be seen from a comparison of Figs.5.2 and 5.3. These curves are valid for the Microphone mounted away from the 2203 which can be achieved using Extension Cables AO 0033 or AO 0059.

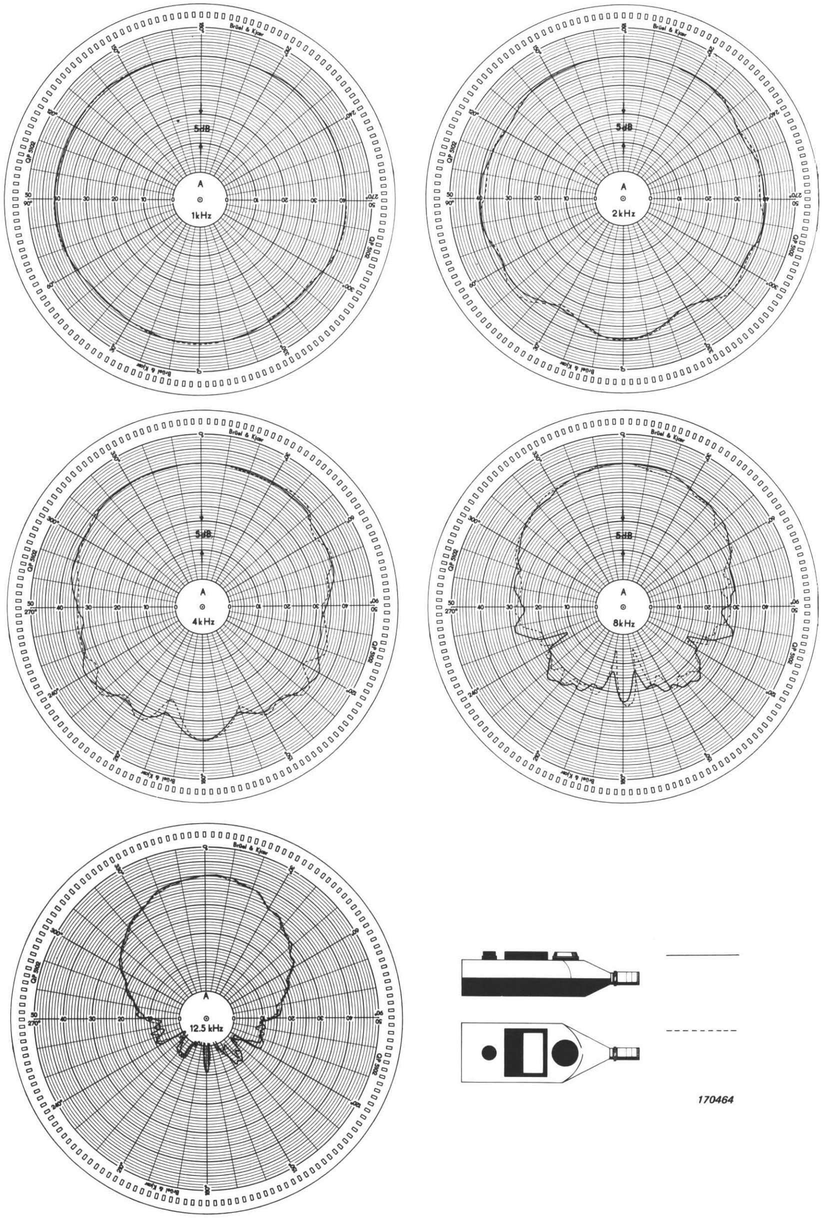


Fig.5.1. Directional characteristics of 2203 and 4145

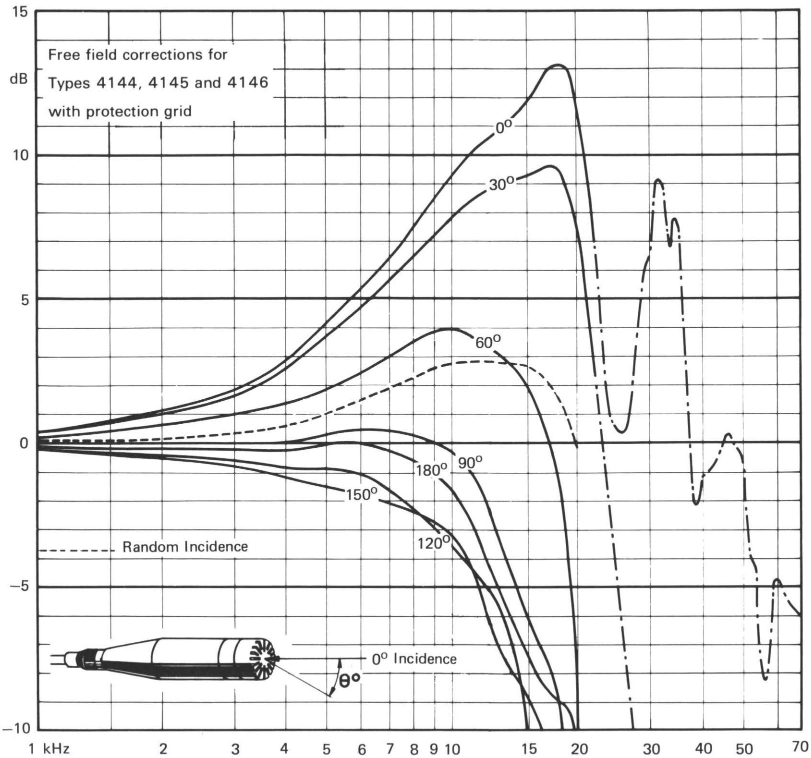


Fig. 5.2. Free field corrections for 4145

Excellent omnidirectional characteristics are also achieved by using the 2203 with Extension Rod UA 0196, and Microphone 4145 with the Random Incidence Corrector UA 0055 (Fig. 5.4), or by using the half-

Frequencies Hz	Tolerances dB	
31,5 – 1000	+ 1	−1
1000 – 2000	+ 1	−2
2000 – 4000	+ 1	−3
4000 – 8000	+ 1	−6
8000 – 12500	+ 1	−10

073015

Table 5.1. IEC tolerances on microphone sensitivity over an angle of ± 90°

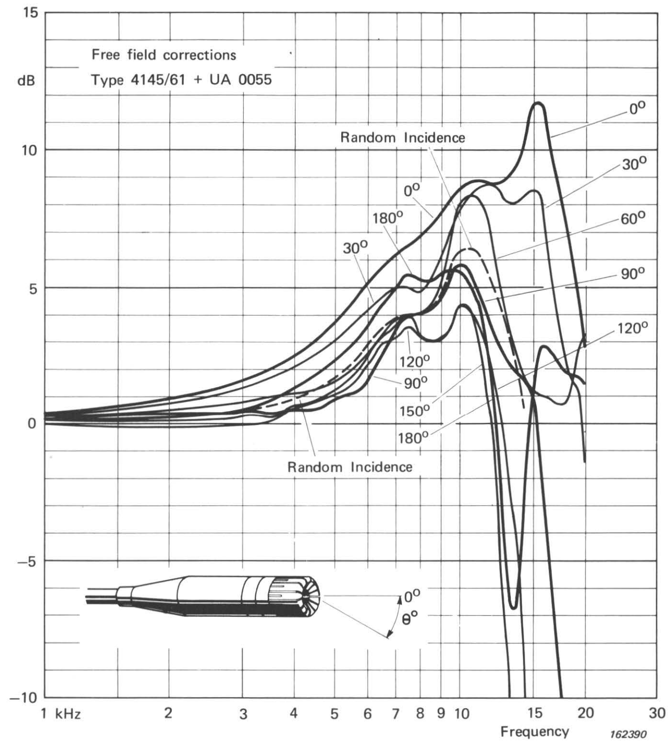


Fig.5.3. Free field corrections for 4145 with Random Incidence Corrector UA 0055

inch Microphone 4133 on the Flexible Extension Rod Type UA 0196 (Fig.5.5). When the 2203 is used with these accessories it meets the requirements of IEC 179 and DIN 45633 parts 1 and 2. The directional characteristics required by IEC 179 are given in Tables 5.1 and 5.2.

Frequencies Hz	Tolerances dB	
up to 2000	+ 0,5	–0,5
2000 – 4000	+ 0,5	–1,0
4000 – 8000	+ 0,5	–1,5
8000 – 12500	+ 0,5	–2,0

073014

Table 5.2. IEC tolerances on microphone sensitivity over an angle of ± 30°

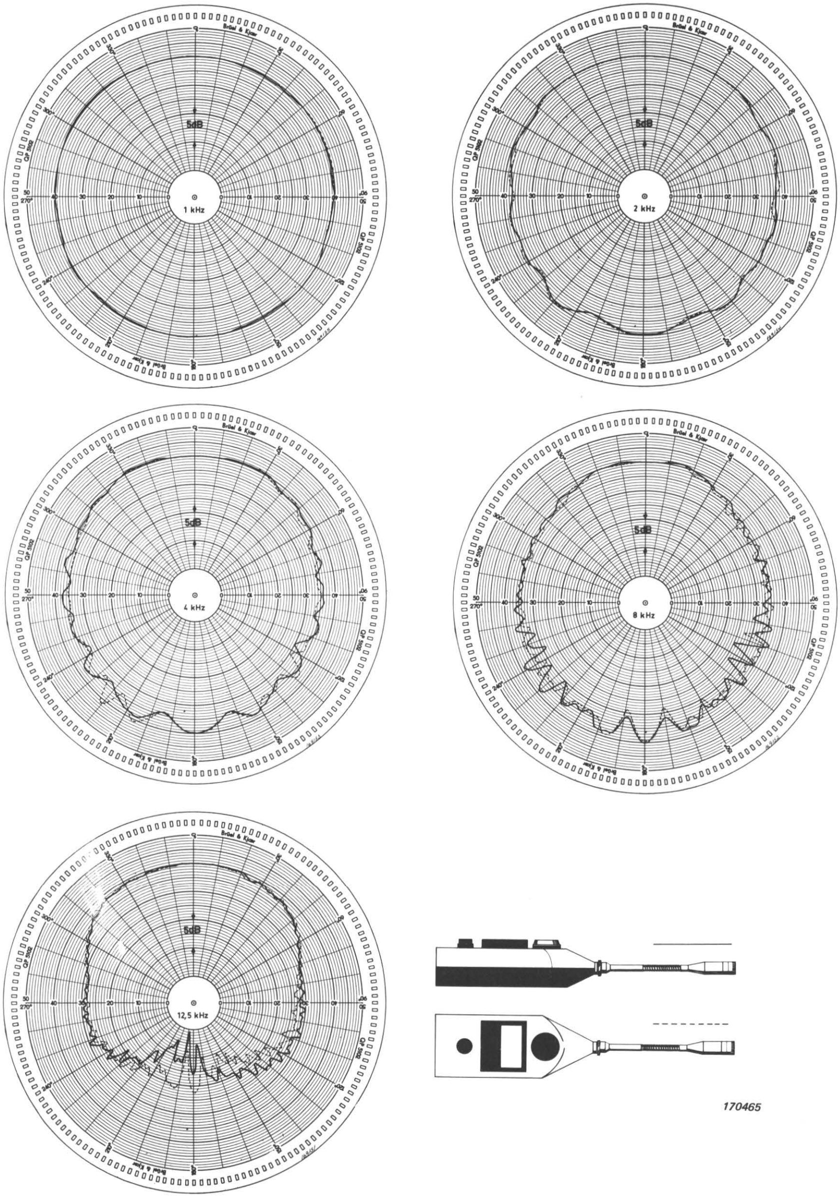


Fig.5.4. Directional characteristics of 2203, UA 0196, 4145 and UA 0055

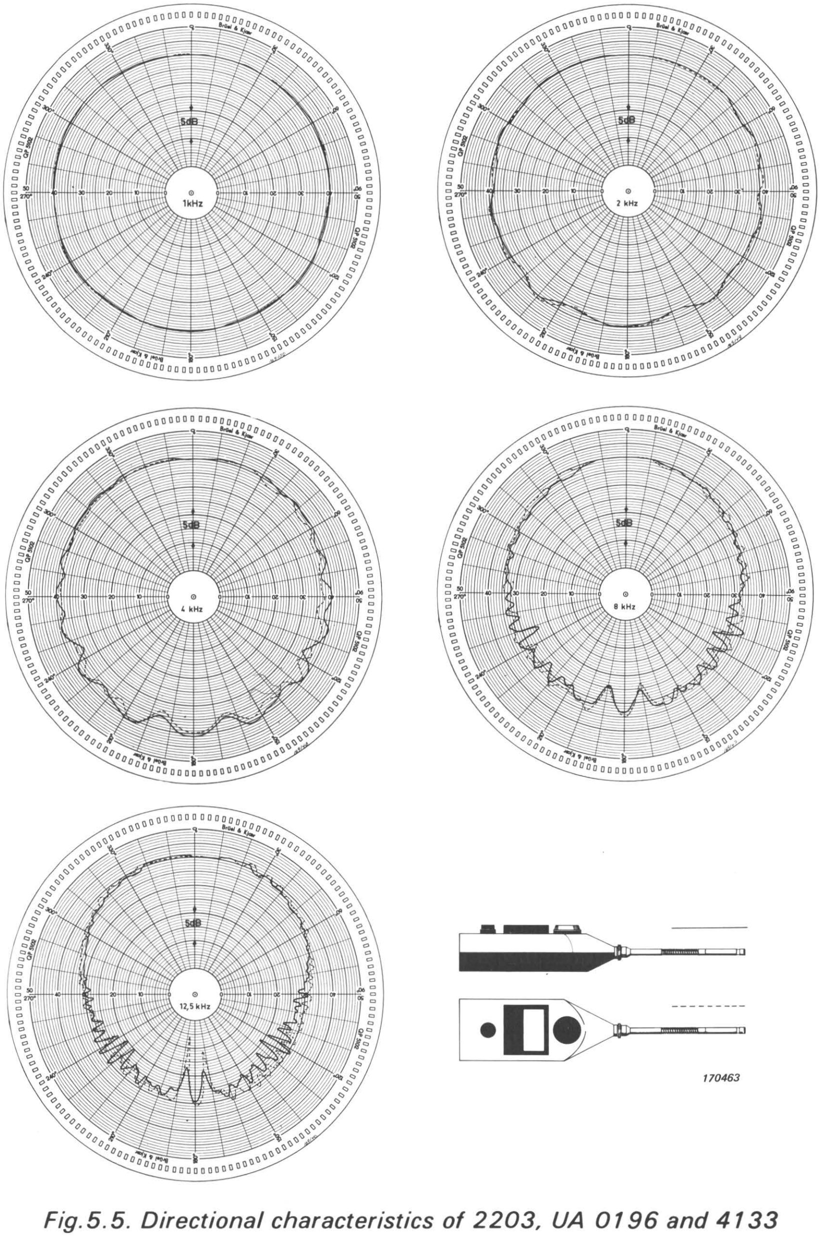


Fig.5.5. Directional characteristics of 2203, UA 0196 and 4133

5.2. REFLECTION

Whenever an object as large or larger than the wavelength of the sound is placed in the sound field, it will cause reflections and therefore irregularity in the field. Normally, when the sound field is diffuse, or consists of many frequencies, or both, no problem arises, but if the sound waves are free, plane or spherical with one or two predominant frequencies the reflections produced can cause considerable errors of measurement.

To reduce reflections from the Sound Level Meter to a minimum, the front of the instrument is cone shaped.

An idea of the reflections caused by the operator can be obtained from Fig.5.6. Investigators have found that anomalies due to such reflections are usually most marked in the frequency range 200— 4000 Hz. Errors of 2— 3 dB may easily result and around 400 Hz (where the maximum reflections from the human body occur) up to 6 dB may even be experienced. An excellent treatment of this rather complicated subject of reflections has been published by R. W. Young in the journal "Sound", Vol. 1 1962 page 17.

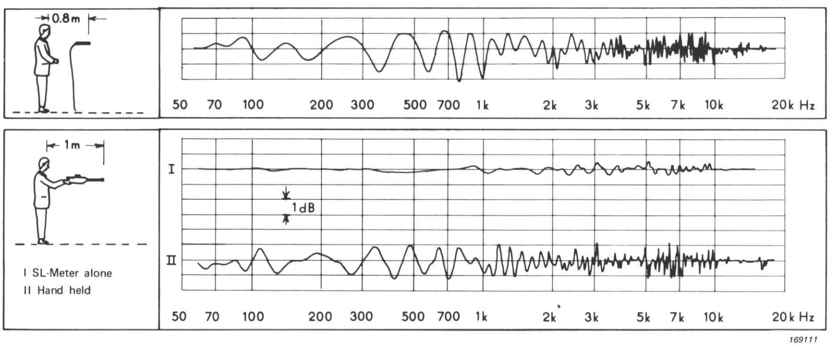


Fig.5.6. Reflections due to the presence of an operator

Whether the presence of the operator has any influence on the sound level reading or not can be determined by changing the relative position of the operator to the instrument. Usually, sufficiently accurate readings are obtainable by simply fitting the extension rod and holding the sound level meter forward so the microphone is 1 m away from the body. See Fig.5.6.

To further reduce the influence of the operator, an extension cable may be used to remove the Microphone from the operator.

5.3. EFFECT OF BACKGROUND NOISE

If it is required to measure the noise produced by a particular source e.g., an electric motor, best results would be obtained if it could be measured in a quiet place. However, this is not always possible, so measurements often have to be taken with background noise present. If the noise level when the machine under test is shut down (i.e., the background noise level) is more than 10 dB lower than that when the machine is operating, then no correction for background noise is necessary.

When the difference between "total" noise level and the background noise level is between 3 and 10 dB an approximate correction may be made by consulting the chart in Fig.5.7. If the difference between "total" and background noise level is less than 3 dB, it is advisable to perform the measurements in a quieter place.

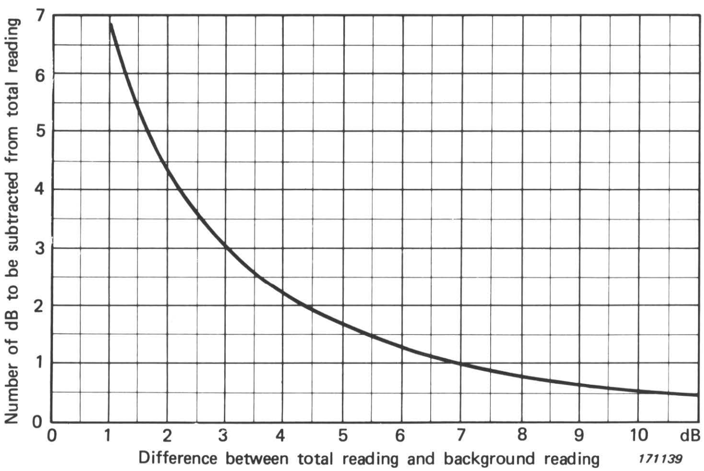


Fig.5.7. Correction for the influence of background noise

5.4. DISTORTION

The input stage will accept a maximum level of 10 V RMS without clipping. For a microphone with a sensitivity of 50 mV/Pa this corre-

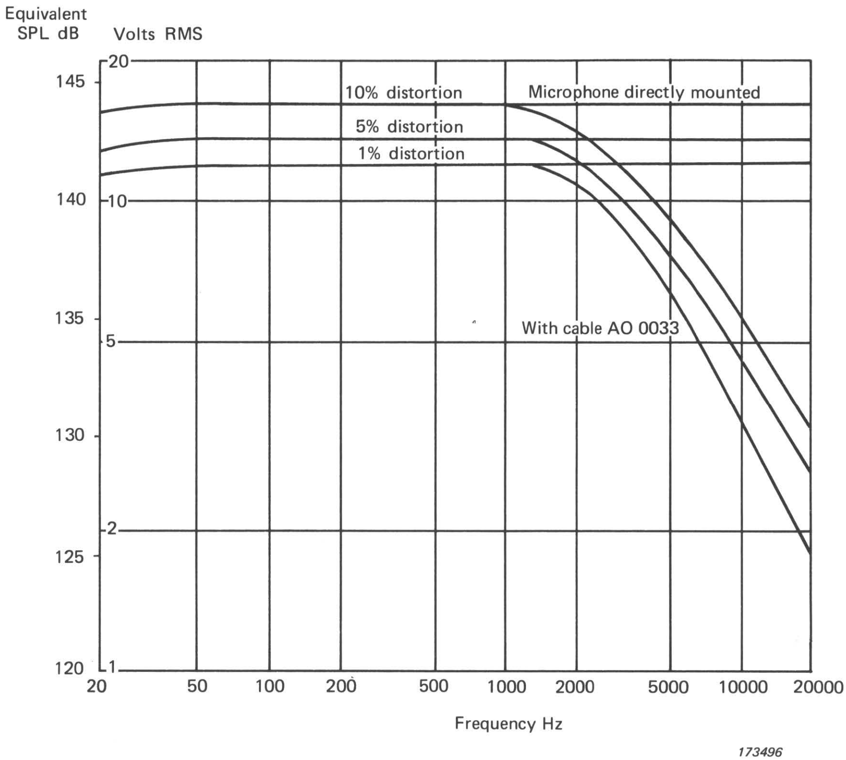


Fig.5.8. Distortion originating in the 2203

sponds to a sound pressure level of 140 dB. If the sensitivity of the Microphone is higher or lower than 50 mV/Pa, the maximum sound pressure level that can be measured will differ from 140 dB by the number of dB the Microphone sensitivity differs from 50 mV/Pa. For example, for a microphone with 12,5 mV/Pa sensitivity (12 dB less than 50 mV/Pa) the maximum sound pressure level is 152 dB (12 dB higher than 140 dB).

The distortion characteristics of the 2203 with and without Extension Cable AO 0033 are shown in Fig.5.8. For distortion characteristics of the Microphones themselves, refer to the appropriate Microphone Instruction Manual.

5.5. EFFECT OF TEMPERATURE

The temperature stability of the 2203 is such that overall instrument gain will not change by more than ± 0,5 dB in the range of —20° to + 50°C. Many of the gain changes with temperature of various parts of the instrument are opposite and thus to a large extent cancel each other.

The Microphone sensitivity varies less than ± 0,2 dB within the operating temperature range of the instrument. These changes are nearly random and vary unpredictably from microphone to microphone.

The effect of temperature on the RMS indication is shown in Fig.5.9.

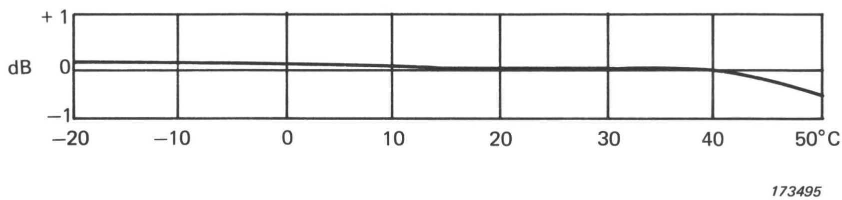


Fig.5.9. Effect of temperature on amplifier and RMS circuit

5.6. EFFECT OF HUMIDITY

The Microphone is unaffected by humidity as long as no condensation occurs inside it. The microphone cap contains silica gel which absorbs moisture during storage and prevents condensation. For the instrument as a whole, the effect of humidity is negligible (less than 0,5 dB) up to 90% relative humidity.

5.7. INHERENT NOISE LEVELS

The lower level limit of measurement is determined by the inherent noise of the instrument and also depends on the weighting network used.

Fig.5.10 shows typical inherent noise levels for the 2203 when used with the Octave Filter Set 1613 and one or half-inch Microphones. The lines marked "Spec." show the lower limits of the instrument as specified by B & K. The shaded areas show typical values of the inherent noise.

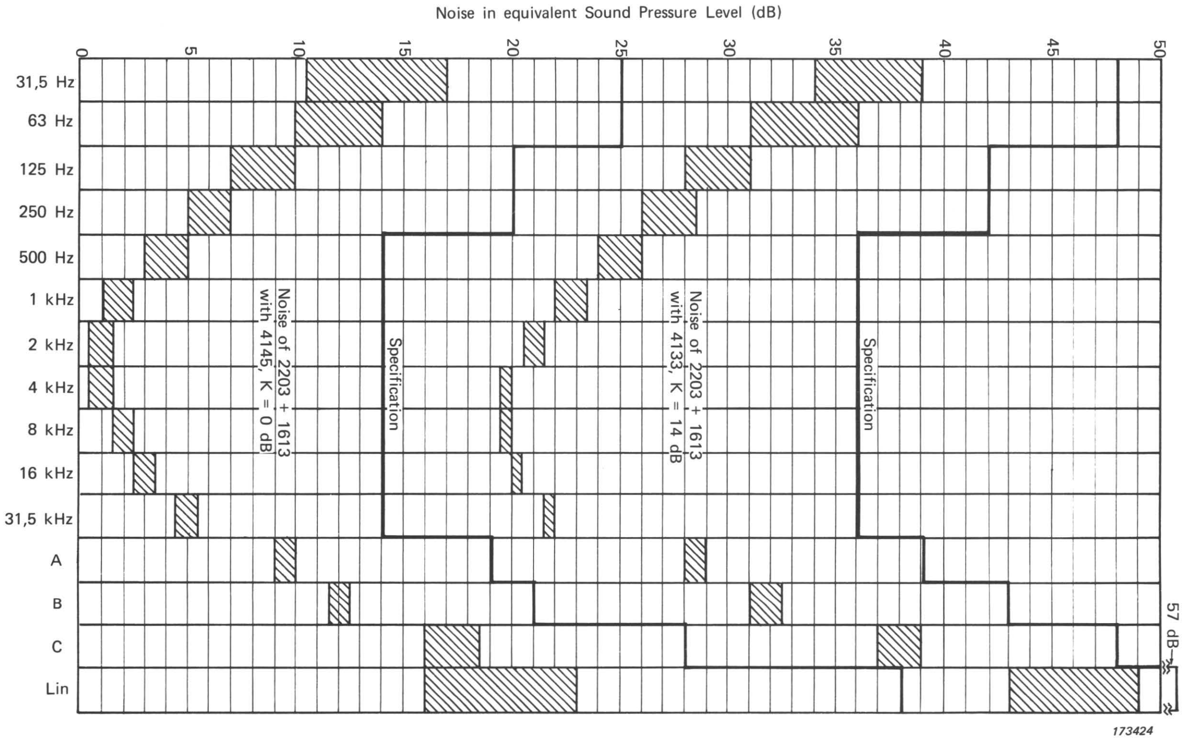


Fig.5.10. Octave noise characteristics of 2203 with half-inch and one-inch Microphones

5.8. EFFECT OF SOUND FIELD

The acoustic sensitivity of the 2203 without a microphone measured with a linear or any weighting network, is at least 60 dB below the applied SPL. This specification is especially of importance when the 2203 is used for voltage and vibration measurements in the presence of a high level sound field.

5.9. EFFECT OF VIBRATION

The effect of vibration on the 2203 is shown in Fig.5.11a-f.

For these tests the instrument was vibrated along each of its three axes both with and without the Flexible Extension Rod UA 0196. The vibration level was 10 m/s^2 (approx. 1 g). Curve I indicates the effect of vibration on the Microphone and Meter as a whole. Curve II shows the sound pressure level at the Microphone generated by the vibration of the shaker. Curve III shows the noise level of the 2203 with the Microphone replaced by an equivalent capacitance.

5.10. EFFECT OF ATMOSPHERIC PRESSURE

The effect of atmospheric pressure on the sensitivity and frequency response of the Microphone is less than ± 0,2 dB for a pressure variation of 10%. Detailed specifications are given in the Microphone Instruction Manual.

5.11. EFFECT OF ELECTROSTATIC AND ELECTROMAGNETIC FIELDS

The sensitivity of the Microphone to an electrostatic field is negligible as long as the protection grid is kept on. For the rest of the meter, electrostatic fields have negligible influence.

The effect of a magnetic field on the Microphone and input stage is negligible. A magnetic field of 80 A/m (1 Ørsted) at 50 Hz produces an equivalent SPL of 40 dB (Lin.) on the Meter and input stage.

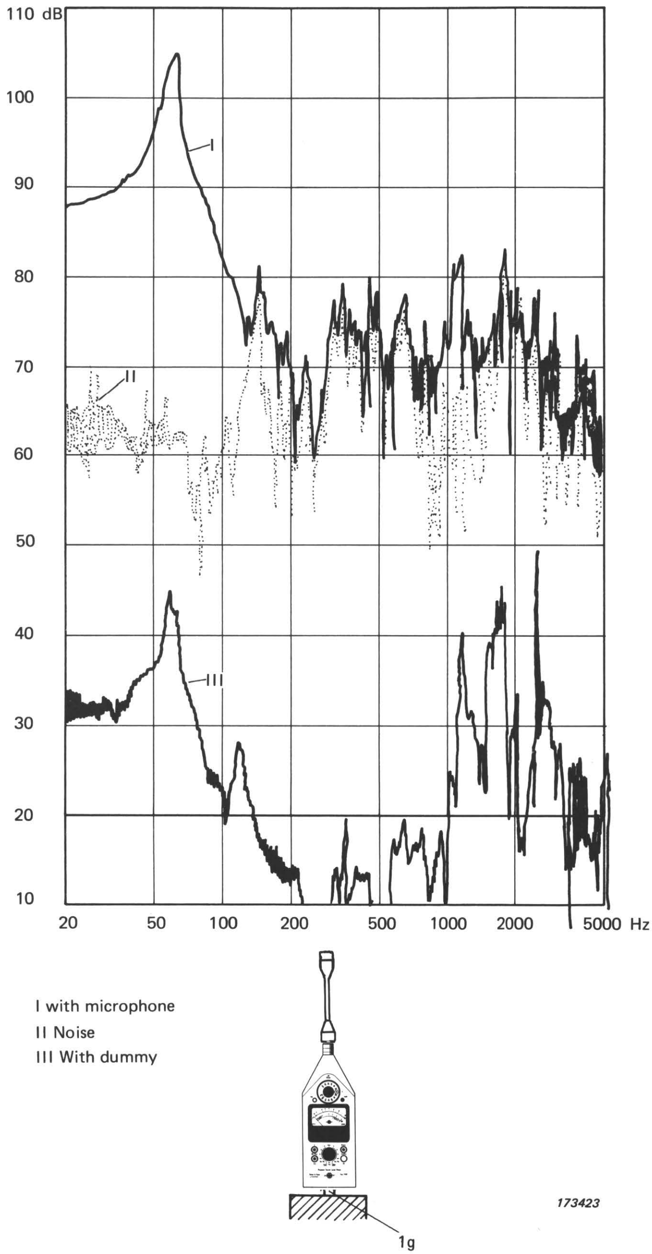


Fig.5.11a Effect of vibration

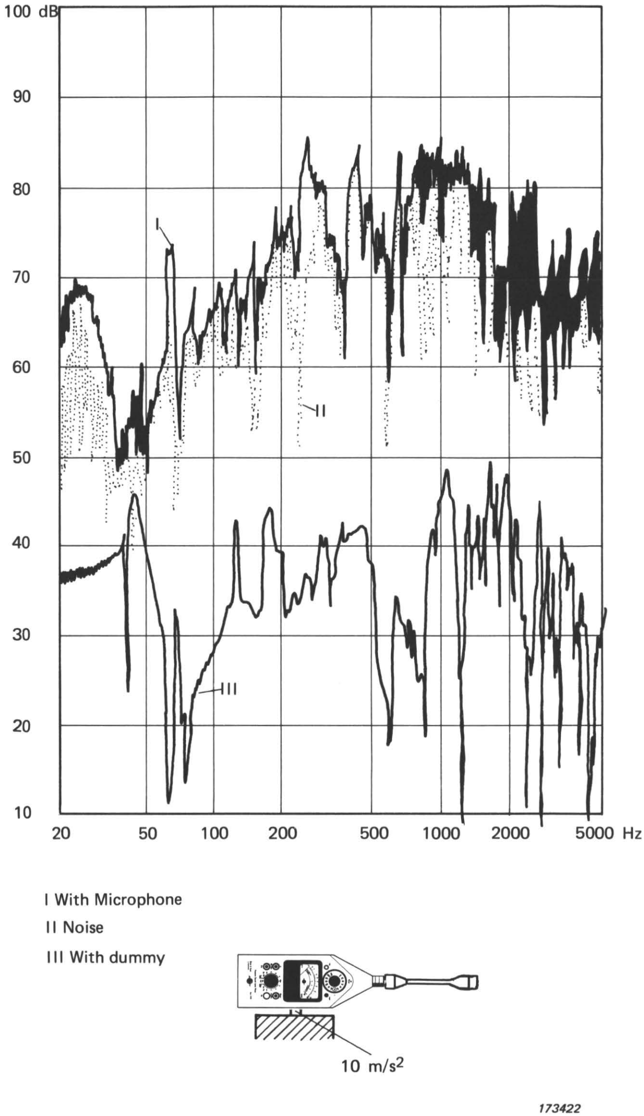


Fig.5.11b Effect of vibration

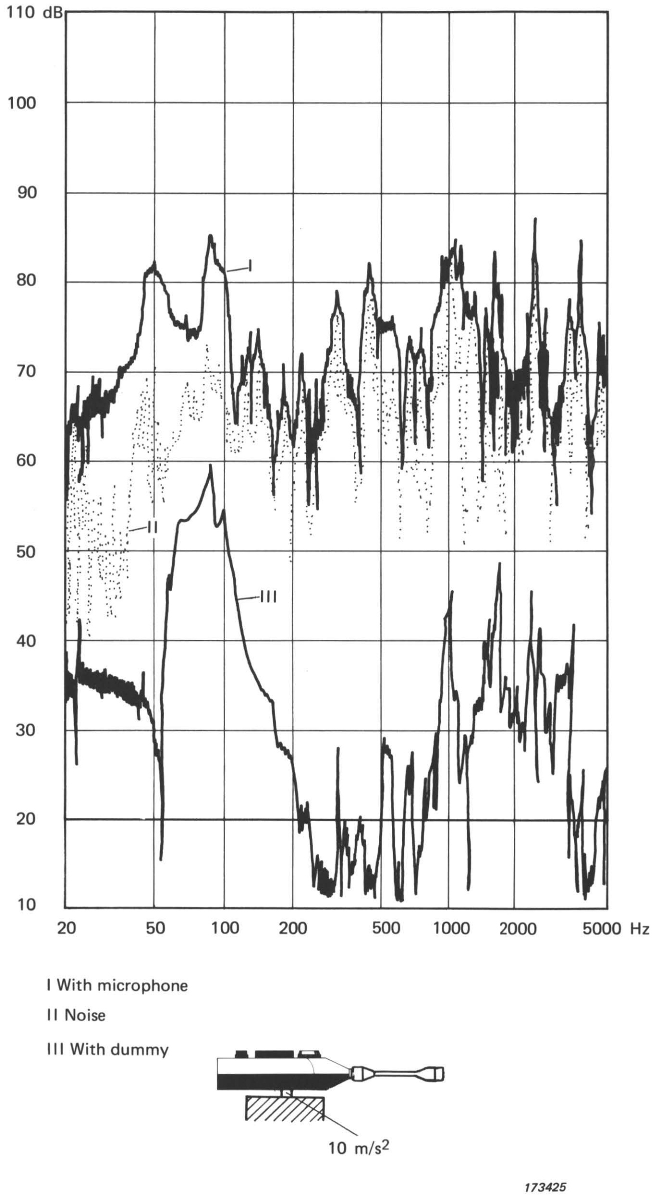


Fig.5.11c Effect of vibration

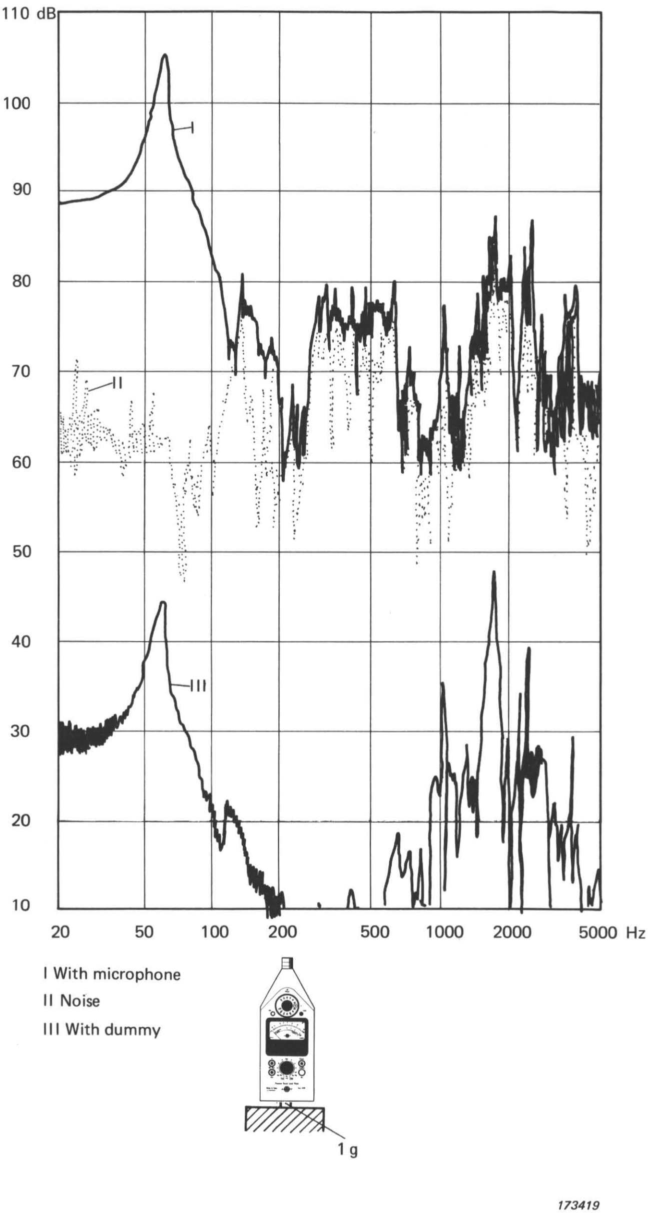
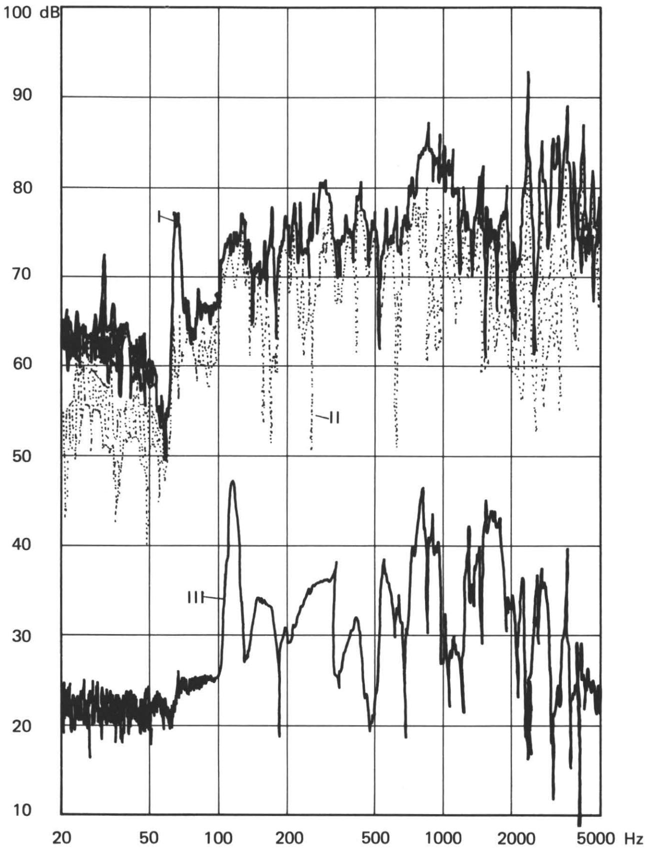


Fig. 5.11d Effect of vibration



I With microphone

II Noise

III With dummy

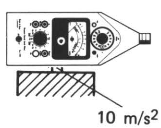


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Fig.5.11e Effect of vibration

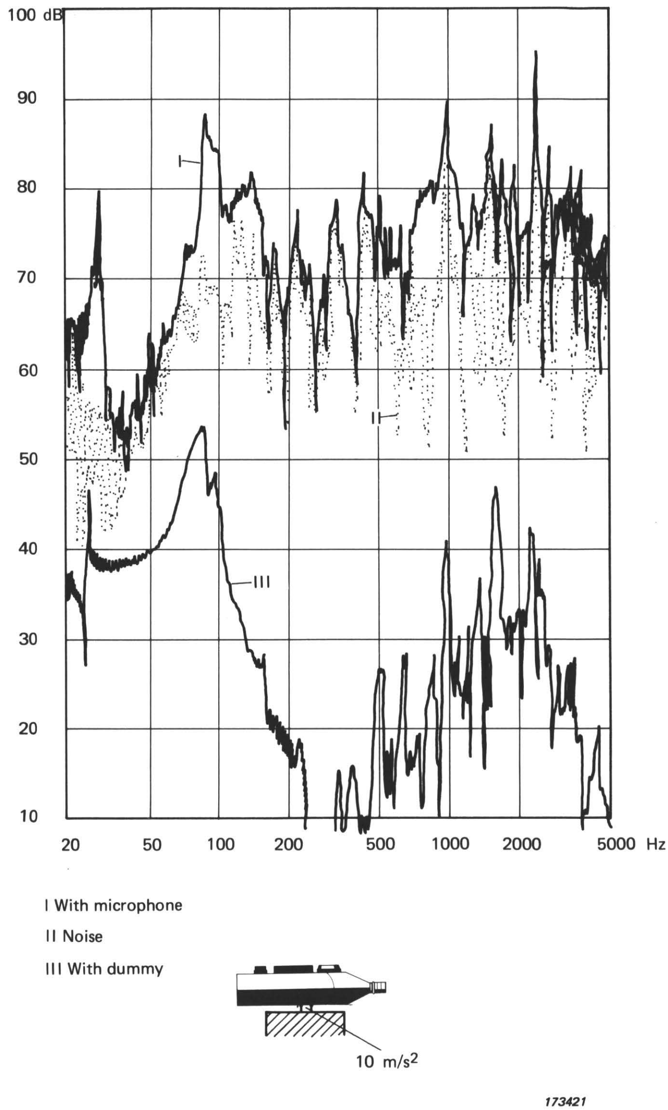


Fig.5.11f Effect of vibration

5.12. WEIGHTING NETWORKS

The three standard frequency weighting networks, A, B and C are incorporated in the 2203. Their frequency characteristics and tolerances are shown in Fig.5.13 and Table 5.3. Note that these tolerances apply to the instrument as a whole in a free field with incidence normal to the microphone diaphragm.

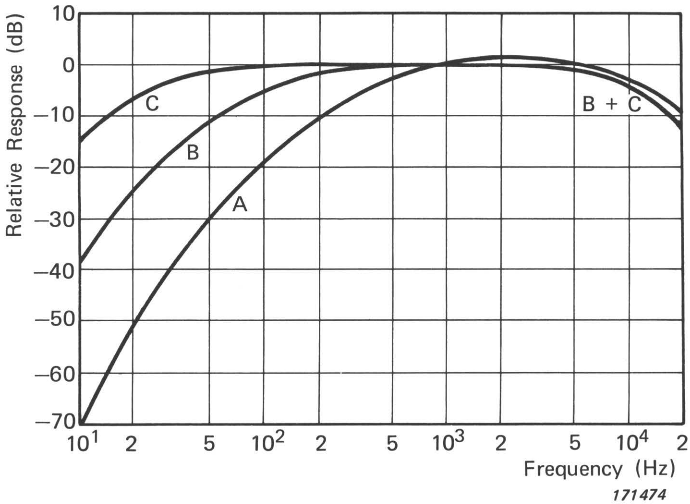


Fig.5.12. A, B and C weighting curves

Frequency Hz	Curve A dB	Curve B dB	Curve C dB	Tolerance Limits (dB) for Curves A, B and C	
10	–70,4	–38,2	–14,3	3	– ∞
12,5	–63,4	–33,2	–11,2	3,0	– ∞
16	–56,7	–28,5	– 8,5	3,0	– ∞
20	–50,5	–24,2	– 6,2	3,0	–3,0
25	–44,7	–20,4	– 4,4	2,0	–2,0
31,5	–39,4	–17,1	– 3,0	1,5	–1,5
40	–34,6	–14,2	– 2,0	1,5	–1,5
50	–30,2	–11,6	– 1,3	1,5	–1,5
63	–26,2	– 9,3	– 0,8	1,5	–1,5
80	–22,5	– 7,4	– 0,5	1,5	–1,5
100	–19,1	– 5,6	– 0,3	1,0	–1,0
125	–16,1	– 4,2	– 0,2	1,0	–1,0
160	–13,4	– 3,0	– 0,1	1,0	–1,0
200	–10,9	– 2,0	0	1,0	–1,0
250	– 8,6	– 1,3	0	1,0	–1,0
315	– 6,6	– 0,8	0	1,0	–1,0
400	– 4,8	– 0,5	0	1,0	–1,0
500	– 3,2	– 0,3	0	1,0	–1,0
630	– 1,9	– 0,1	0	1,0	–1,0
800	– 0,8	0	0	1,0	–1,0
1000	0	0	0	1,0	–1,0
1250	0,6	0	0	1,0	–1,0
1600	1,0	0	– 0,1	1,0	–1,0
2000	1,2	– 0,1	– 0,2	1,0	–1,0
2500	1,3	– 0,2	– 0,3	1,0	–1,0
3150	1,2	– 0,4	– 0,5	1,0	–1,0
4000	1,0	– 0,7	– 0,8	1,0	–1,0
5000	0,5	– 1,2	– 1,3	1,5	–1,5
6300	– 0,1	– 1,9	– 2,0	1,5	–2,0
8000	– 1,1	– 2,9	– 3,0	1,5	–3,0
10000	– 2,5	– 4,3	– 4,4	2,0	–4,0
12500	– 4,3	– 6,1	– 6,2	3,0	–6,0
16000	– 6,6	– 8,4	– 8,5	3,0	– ∞
20000	– 9,3	–11,1	–11,2	3,0	– ∞

073012

Table 5.3. IEC specifications for A, B and C weighting networks

6. ACCESSORIES AND MEASURING SETS

The accessories available for the 2203 for sound and vibration measurement are shown in Fig.6.1. The accessories for Artificial Ear and Artificial Mastoid measurements are detailed in Fig.6.2. Many other instruments, couplers, and accessories may also be used with the 2203. See the B & K Main Catalogue for details.

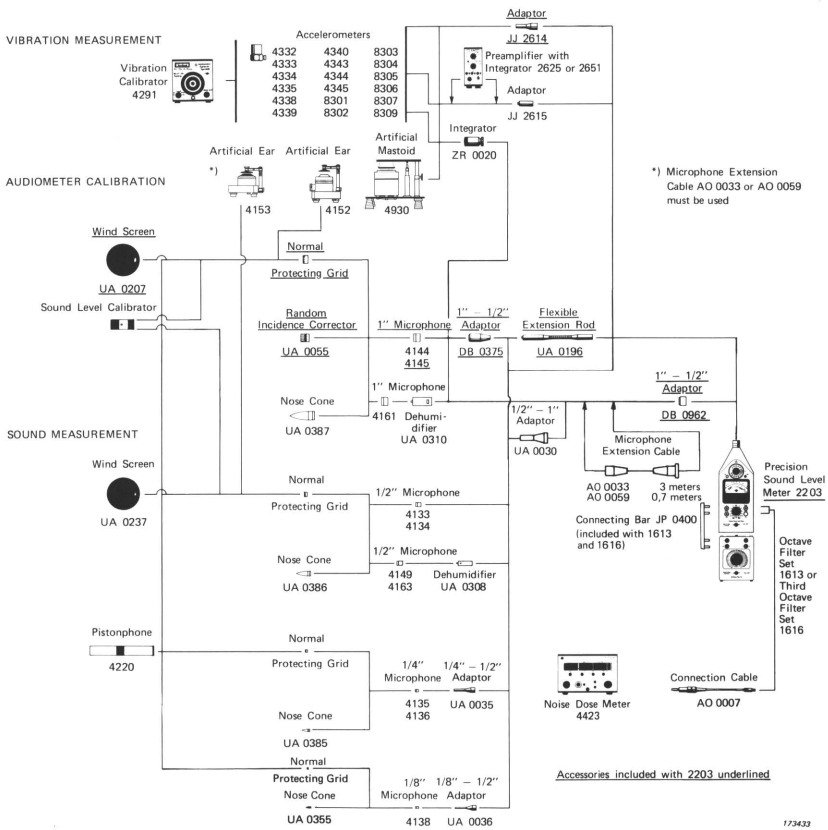


Fig.6.1. Accessories for sound and vibration measurements

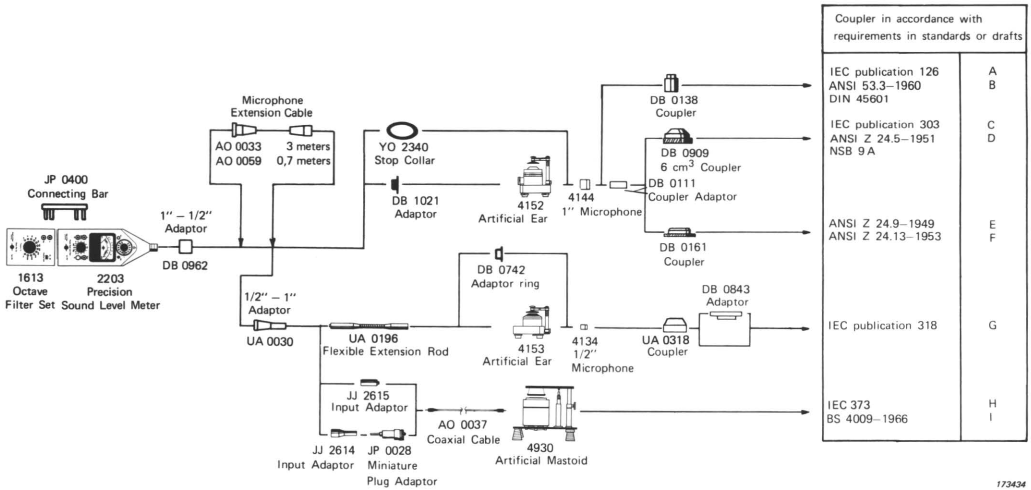


Fig. 6.2. Accessories for Artificial Ear and Artificial Mastoid measurements

Notes:

Supplied with 2203:
JJ 2614, UA 0196, DB 0962

Supplied with 4152:
DB 1021, DB 0138, DB 0913
YO 2340 and DB 0111 are supplied assembled with
DB 0913 (as DB 0909) and with
DB 0165 (as DB 0161)

Supplied with 4153:
DB 0742, DB 0843, UA 0318 (= YJ 0304 + UA 0141)
Use AO 0027 to connect to 2203

Supplied with 4930:
Cable AO 0037

A IEC reference coupler for measurements on hearing aids using earphones coupled to the ear by means of ear inserts
B Electroacoustical Characteristics of Hearing Aids
C IEC provisional reference coupler for calibration of earphones used in Audiometry
D Audiometers for general diagnostic purposes
E Coupler for calibration of earphones
F Specifications for Speech Audiometers
G IEC Artificial Ear (wide-band type) for calibration of earphones used in Audiometry
H IEC Mechanical Coupler for calibration of Bone Vibrators of a specified contact area and applied static force
I Artificial Mastoid for calibration of Audiometers and Bone Vibrators in Hearing Aids

6.1. ACCESSORIES INCLUDED WITH 2203

The following accessories are supplied with the 2203:

One-inch Microphone Type 4145 (see Section 4.1)
Adaptor JJ 2614
Half-inch to one-inch adaptor DB 0962
Flexible Extension Rod UA 0196
Half-inch to one-inch adaptor DB 0375
Random Incidence Corrector UA 0055
Windscreen UA 0207
3 Plugs JP 0006

6.1.1. Adaptor JJ 2614

This screws directly onto the input stage and allows connection of an accelerometer cable via a miniature/standard plug adaptor JP 0028 supplied with accelerometer sets.

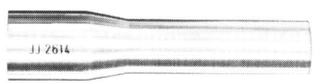


Fig.6.3. JJ 2614

6.1.2. Half-inch to one-inch Adaptor DB 0962

This screws directly onto the input stage and allows direct connection of a one-inch Microphone, or Integrator ZR 0020, to the input stage.

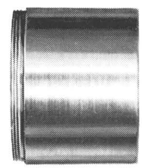


Fig.6.4. DB 0962

6.1.3. Flexible Extension Rod UA 0196

This is 21 cm (8,25 in) long and fits between the input stage and the half-inch Microphone (or Microphone Adaptors for other sizes).

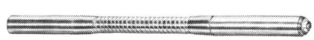


Fig.6.5. UA 0196

6.1.4. Half-inch to one-inch Adaptor DB 0375

Permits attaching the one-inch Microphone to the Flexible Extension Rod.

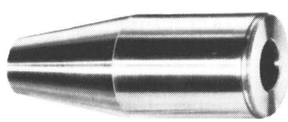


Fig.6.6. DB 0375

6.1.5. Random Incidence Corrector UA 0055

This is intended to be used for all normal measurements with a one-inch Microphone. It replaces the normal protecting grid and considerably improves the omnidirectivity of the system. See Section 5.1.

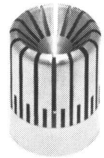


Fig. 6.7. UA 0055

6.1.6. Windscreen UA 0207

Refer to the Type 4145 Microphone Instruction Manual for details.

6.1.7. Plugs JP 0006

These coaxial plugs fit the input and output sockets of the 2203 and external Filter Set 1613 and 1616. Three plugs are supplied with the 2203.

6.2. OPTIONAL ACCESSORIES

Many accessories are available for the 2203. The main ones are listed, and briefly described below:

Octave Filter Set 1613*
Third Octave Filter Set 1616*
Half-inch Microphones*
Microphone Adaptor UA 0030
Nose Cones UA 0387/86
Extension Cables AO 0033/59
Pistonphone 4220*
Sound Level Calibrator 4230*
Artificial Ears 4152* and 4153*
Artificial Mastoid 4930*
Accelerometers*
Integrator ZR 0020
Adaptor JJ 2615
Accelerometer Calibrator 4291*
Connection Cable AO 0007
Carrying Case KE 0055
Tripod UA 0049*

* These are described in the Microphone Instruction Manuals (4133 or 4145) or their own Instruction Manual.

6.2.1. Octave Filter Set 1613

This filter set (Fig.6.8) is designed for octave analysis of noise and vibration. It fits onto the 2203 with four screws thus making one compact, portable unit.

The 1613 has 11 octave filters with center frequencies from 31,5 Hz to 31,5 kHz according to IEC standards.

Full details on the 1613 and its use with the 2203 are given in the 1613 Instruction Manual.

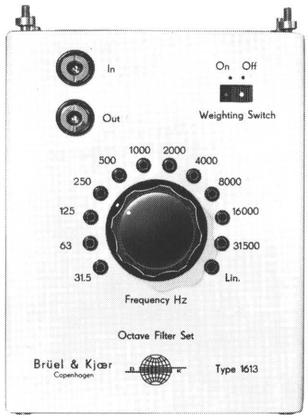


Fig.6.8. 1613

6.2.2. Third Octave Filter Set 1616

This filter set (Fig.6.9) contains 34 active filters with third octave center frequencies from 20 Hz to 40 kHz. If fulfills the requirements of IEC R 225, DIN 45652, and ANSI S1.11 Class III. For a 2203 with serial No. 424272 or less, a new bottom plate, DD 0135 must be used to permit mounting of the 1616.

See the Instruction Manual of the 1616 for full details.

6.2.3. Microphones

The B & K Condenser Microphones suitable for use with the 2203 are shown in Fig.6.10. The microphones are designed for linear frequency

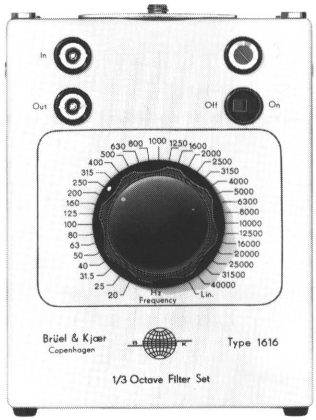
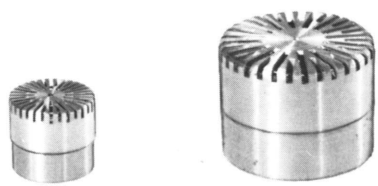


Fig.6.9. 1616



Cartridge Type	4133	4134	4144	4145
Open Circuit Sensitivity (mV/Pa)	12,5		50	50
Frequency Range with 2203 ± 2 dB	10 – 40 kHz	10 – 20 kHz	10 – 7 kHz	10 – 18 kHz
Frequency Response	Free Field	Pressure and Rand.	Pressure	Free Field
Approx. Dynamic Range* with 2203 (dB)	39–154		19 – 140	
Diameter	1/2"		1"	

* Range from 5 dB above equivalent A-weighted inherent noise level to 4% harmonic distortion. 073027

Fig.6.10. Microphones suitable for use with 2203

response over the widest possible range and feature good temperature stability and excellent long term stability. All free field microphones have linear free field response for 0° incidence in the audio frequency range. Pressure response microphones have linear response over the widest possible range of frequencies.

The most important considerations in choosing a microphone are its frequency response, sensitivity, and omnidirectivity. Generally, smaller microphones give wider frequency range, better omnidirectivity, but lower sensitivity. Small microphones are best suited for measurements in intense sound fields, and also generate less turbulence at high wind velocities.

6.2.4. Microphone Adaptor UA 0030

UA 0030 permits mounting of the half-inch microphone on Extension Cable AO 0033/59. This adaptor gives an attenuation of 0,1 dB.

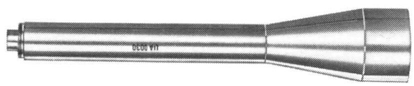


Fig.6.11. UA 0030

6.2.5. Nose Cones

Nose Cones are available for all microphone sizes. Their characteristics for reducing wind noise are given in the appropriate Microphone Instruction Manual.

6.2.6. Extension Cables AO 0033/59

Extension Cable AO 0033 is 3 meters (10 ft) long and can be used to remove the Microphone from the Sound Level Meter. Its attenuation is approximately 0,1 dB with one-inch microphones and 0,3 dB with half-inch microphones.

Extension Cable AO 0059 is similar to AO 0033 except it is 70 cm (27,5 in) long. Attenuation is approximately 0,05 dB with one-inch microphones and 0,2 dB with half-inch microphones.

6.2.7. Artificial Ears 4152/53

Artificial Ears Types 4152 and 4153 were designed for electro-acoustical measurements on earphones under well-defined acoustical conditions. The 4152 is used with couplers which fulfill the requirements of IEC R126, ANSI Z.24.5-1951 and ANSI Z.24.9-1949. It is used with Condenser Microphone Type 4144 with either Microphone Preamplifier 2619 or the Precision Sound Level Meters 2203 and 2209.

6.2.8. Artificial Mastoid 4930

The Artificial Mastoid 4930 is a near ideal mastoid for objective calibration of bone vibrators as used in bone conduction hearing aids. It conforms to BS 4009:1966 and also to the proposed IEC standard for Artificial Mastoids.

6.2.9. Accelerometers

The B & K Accelerometers are of the piezoelectric type. Sensitivities range from 1,2 mV/g to 10 V/g (or 0,4 pC/g to 10000 pC/g). In use with the 2203 the lower frequency limit is 10 Hz while the upper frequency limit of measurement is up to 25 kHz depending on accelerometer chosen. All accelerometers are waterproof, sealed construction capable of operating under severe environmental conditions. Further details on Accelerometers available may be obtained from the B & K Product Data leaflets or the Accelerometer Instruction Manual.

6.2.10. Accelerometer Calibrator 4291

The 4291 is a portable vibration calibrator generating a 1 g peak level with an accuracy of better than 2% at a frequency of 500 radians/second (79,6 Hz).

Fig. 6.12. 4291

6.2.11. Integrator ZR 0020

This is a two-stage integration network which allows measurement of acceleration, velocity, and displacement in vibration studies. Its frequency response is:

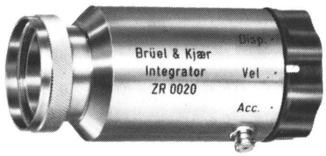


Fig. 6.13. Integrator ZR 0020

Accelerometer capacitance 1000 pF:

Acceleration:	3 Hz — 10 kHz ± 0,5 dB
Velocity:	25 Hz — 5 kHz ± 0,5 dB
	15 Hz — 10 kHz ± 1,5 dB
Displacement:	50 Hz — 2 kHz ± 0,5 dB
	20 Hz — 4 kHz ± 1,5 dB

Accelerometer capacitance 300 pF:

Acceleration:	5 Hz — 10 kHz ± 0,5 dB
	3 Hz — 10 kHz ± 1,5 dB

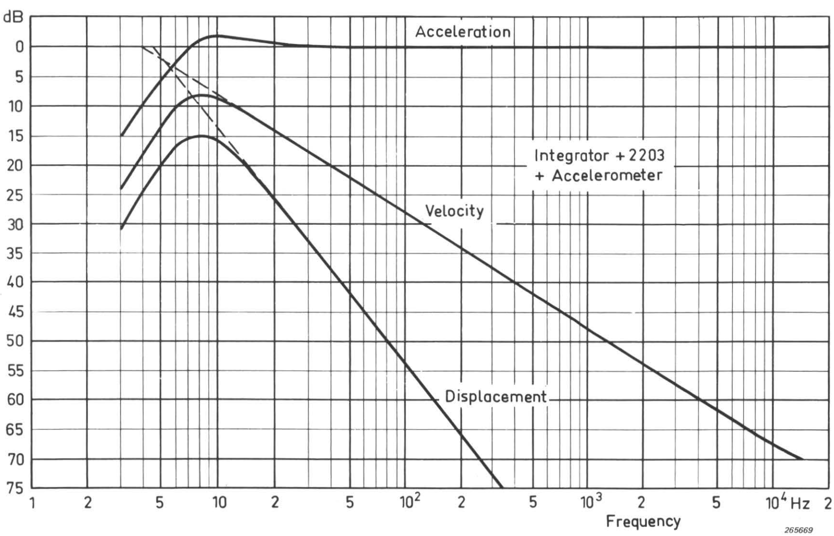


Fig. 6.14. Integrator Frequency characteristics when used with 2203

Velocity:	35 Hz — 5 kHz ± 0,5 dB	
	25 Hz — 10 kHz ± 1,5 dB	
Displacement:	50 Hz — 2 kHz ± 0,5 dB	
	30 Hz — 4 kHz ± 1,5 dB	

The temperature coefficients are:

Velocity + 0,02 dB/°C
Displacement + 0,04 dB/°C

Frequency response curves for the Integrator and 2203 are shown in Fig.6.14.

6.2.12. Adaptor JJ 2615

Allows direct connection of a miniature accelerometer cable (AO 0037) to the input stage.

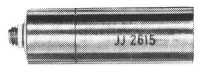


Fig.6.15. JJ 2615

6.2.13. Connection Cable AO 0007

Uses plug JP 0006 on one end and JP 0101 on the other for connecting the output of the 2203 to B & K recording instruments.

6.2.14. Carrying Case KE 0055

Fig.6.16. KE 0055

This is a convenient carrying case that will hold the 2203, a Filter Set (1613 or 1616) and many accessories such as a Pistonphone, Accelerometer, Windscreen, extra Microphone, spare batteries etc.

6.3. COMPLETE MEASURING SETS

6.3.1. Sound and Vibration Sets Types 3501 and 3509

The sets contain the following:

Precision Sound Level Meter with standard accessories	2203
Octave Filter Set (3501 only)	1613
Third Octave Filter Set (3509 only)	1616
Half-inch Microphone	4133
Pistonphone	4220
Accelerometer Set	4332S
Windscreen	UA 0082
One-inch Nose Cone	UA 0387
Half-inch Nose Cone	UA 0386
Connection Bar	JP 0400
Integrator	ZR 0020
Extension Cable	AO 0033
Tripod Adaptor	UA 0027
Pressure Correction Barometer	UZ 0001
Carrying Case	KE 0055

6.3.2. Audiometer Calibration Sets Types 3502 and 3510

The sets contain the following:

Precision Sound Level Meter with standard accessories	2203
Octave Filter Set (3502 only)	1613
Third Octave Filter Set (3510 only)	1616
Artificial Ear	4152
One-inch Microphone (pressure)	4144
Pistonphone	4220
2 cm^3 Couplers (NBS 9A)	DB 0138
6 cm^3 Couplers (NBS 9A)	DB 0913
Coupler Adaptor Ring	DD 0111
Guard Ring Adaptor	DB 1021
Connection Bar	JP 0400
Pressure Correction Barometer	UZ 0001
Carrying Case	KE 0055

7. USE WITH OTHER INSTRUMENTS

The 2203 can serve as the input to many instruments, providing various degrees of sophistication in analysis and recording. The reader is referred to the individual Instruction Manuals of the instruments used, and also to the book "Application of B & K Equipment to Acoustic Noise Measurements" for detailed discussion of many applications and noise analysis techniques.

7.1. SYSTEMS CONSIDERATIONS

When connecting the 2203 with other instrumentation, the following should be considered.

1. Be sure the impedance and output/input levels of the instruments are matched. If the output level from the 2203 is too high, the input gain on the succeeding instrument must be reduced or an attenuator must be placed between the two.

2. Adjust the gain of the total system using a calibration reference (such as a Pistonphone, Sound Level Calibrator, or built-in reference voltage). Gain adjustments must be made in the order of the signal path, beginning with the 2203. Each instrument should be optimized for maximum dynamic range and crest factor capability.

3. Once the various gain controls of the system have been set, only the attenuators on the 2203 should be adjusted as the signal or measurement conditions vary.

4. When absolute level measurements are required an accurate calibration must be used. Notes should then be made of all subsequent attenuator adjustments of the 2203 with respect to the calibration level. In the tape recording of sound, the recording of the calibration reference level is also vital.

7.2. LEVEL RECORDERS

The AC output of the 2203 provides a signal suitable for the recording of continuous, non-impulsive sounds. The dynamic range of the output is greater than 50 dB (except in the four most sensitive ranges) and the output voltage corresponding to full scale deflection is 3,16 V RMS.

Consult the Instruction Manual of the appropriate Level Recorder (Type 2305 cr 2307) for detailed operating procedures.

For use of the 2203 and Level Recorder with the Statistical Distribution Analyzer 4420 see the 4420 Instruction Manual.

7.3. NOISE DOSE METER

The Noise Dose Meter 4423 determines a noise dose based on both the time and amplitude of exposure to noise as specified by various DIN, ISO, and English standards. It is designed to operate with a Sound Level Meter such as the 2203. Since noise dose measurements are commonly made over periods of several hours, provision is made to power the 2203 from the Noise Dose Meter.

See the 4423 Instruction Manual for details.

7.4. TAPE AND DIGITAL RECORDING

When tape recording is required for remote recording and data storage, frequency transformation, and later analysis, the 2203 serves as a high quality input to a portable, battery operated recorder such as the B & K 7003 or 7004.

Always adjust the tape recorder gain for best dynamic range without overload, and record a reference level to which all attenuator range changes of the 2203 can be referred.

For the recording of impulsive or single event sounds the Tape Loop Cassette UD 0035 may be used with the 7003/04. However, the ideal and most flexible approach to impulse recording is the Digital Event Recorder 7502 which provides an extremely wide range of frequency transformation and also permits recording of information before the trigger.

7.5. ANALYSIS

The 2203 may be connected to a variety of filters and analyzers permitting constant bandwidth, constant percentage bandwidth, octave or third octave, or real time analysis. The reader is referred to the B & K Main Catalogue for further information on these instruments.

For portable third octave analysis, the 2203 and Third Octave Filter 1616 connect into one portable hand-held unit. Although this is a manual procedure it is more economical than automatic recording and is convenient in terms of ease of portability.

7.6. LOUDNESS EVALUATION

Third octave loudness analysis (Zwicker-method) and octave loudness analysis (Stevens method) may be made using the 2203 and Filter Sets 1616 or 1613. The methods are described in ISO Recommendation 532 and in the B & K book "Acoustic Noise Measurement".

8. SPECIFICATIONS

Specifications refer to 2203 with extension rod and one-inch Microphone Type 4145 unless otherwise stated.

8.1. FREQUENCY RESPONSE

One-inch Microphone Type 4145

Zero incidence response (free field):

Linear:	10 Hz to 15 kHz ± 1 dB 10 Hz to 18 kHz ± 2 dB
Sensitivity:	approx. 50 mV per Pa*
Temperature Coefficient:	< ± 0,006 dB/°C
Temperature Range:	—50 to 150°C
Long Term Stability:	± 0,1 dB plus < 0,1 dB per 10 years at operating temperature below 35°C. At 100°C, typically + 0,2 dB per 100 hours.

Half-inch Microphone Type 4133

Zero incidence response (free field):

Linear:	10 Hz to 30 kHz ± 1 dB 10 Hz to 40 kHz ± 2 dB
Sensitivity:	12,5 mV per Pa*
Temperature Coefficient:	< 0,006 dB/°C

Individual calibration charts are supplied with every Microphone.

* 1 Pa = 1 N/m² = 10 μbar

Amplifiers

Frequency response for temperatures from —20 to 50°C (14 to 122°F)

Linear:	40 Hz to 25 kHz ± 0,5 dB
	20 Hz to 25 kHz ± 1 dB 10 Hz to 40 kHz ± 2 dB
Total Amplification:	110 dB
Attenuators:	10 dB steps with ± 0,2 dB accuracy

8.2. DYNAMIC RANGE

The lower value is 5 dB above the noise level, the upper value is the maximum sinusoidal RMS sound pressure level.

One-inch Microphone

Linear:	38 to 140 dB
C weighting:	28 to 140 dB
B weighting:	21 to 140 dB
A weighting:	19 to 140 dB
Octave (1613):	14* to 140 dB
Third Octave (1616):	16* to 140 dB

Half-inch Microphone

Linear:	57 to 154 dB
C weighting:	48 to 154 dB
B weighting:	43 to 154 dB
A weighting:	39 to 154 dB
Octave (1613):	36* to 154 dB
Third Octave (1616):	33* to 154 dB

* Valid above 500 Hz. Below 500 Hz, see Fig.5.10.

8.3. INPUT

Input Impedance:	Approximately 2 GΩ//2,8 pF
With extension cable AO 0033:	Approximately 2 GΩ//3,2 pF
Maximum input voltage:	10 V RMS

8.4. OUTPUT

Output impedance:	< 100 Ω
Maximum capacitive load:	1000 pF
Meter error:	< 0,2 dB with 10 kΩ load
Max. output voltage:	16 V peak
Minimum load impedance:	10 kΩ
FSD corresponds to:	3,16 V RMS

The output amplifier is not damaged by short-circuit.

8.5. EXTERNAL FILTERS

EXT. FILTER IN	
Output impedance:	< 5 Ω in series with 100 μF
EXT. FILTER OUT	
Input impedance:	146 kΩ

8.6. METER INDICATION

Graduation:	1 dB divisions from —10 to 0 dB 0,5 dB divisions from 0 to 10 dB
Scale Accuracy:	0,5 dB for deflections below 0 dB 0,2 dB for deflections above 0 dB
RMS Accuracy:	± 0,5 dB for crest factors to 3 ± 1,0 dB for crest factors to 5
Meter Damping:	"Fast" and "Slow" to IEC 179

8.7. INHERENT NOISE

Linear:	maximum 40 μV referred to input
A weighting:	maximum 4 μV referred to input

8.8. POLARIZATION VOLTAGE

Stabilized supply of 200 V DC.
See Fig. 5.9 for temperature stability.

8.9. CALIBRATION

Sound Measurements

The whole instrument can be calibrated at 124 dB (re 20 μPa) at 250 Hz using the Pistonphone Type 4220 with an accuracy of ± 0,2 dB, or at 94 dB (re 20 μPa) at 1000 Hz using the Sound Level Calibrator Type 4230 with an accuracy of ± 0,25 dB. This calibration is valid for free-field measurements with sound incident normal to the Microphone diaphragm.

Vibration Measurements

The 2203 can be calibrated at 1 g peak at 80 Hz using Accelerometer Calibrator Type 4291.

Internal

An internal reference voltage (square wave at approx. 1 kHz) is incorporated. Stability is better than ± 0,2 dB over the range of operating temperatures. This voltage checks all stages of the 2203 after the input stage.

8.10. DIRECTIONAL CHARACTERISTICS

See Chapter 5.1 and Microphone Instruction Manual for Type 4145 or 4133.

8.11. EFFECT OF HUMIDITY

Less than 0,5 dB from 0 to 90% relative humidity provided no condensation occurs.

Recalibration may be necessary when subjected to humidity extremes for extended time periods.

8.12. EFFECT OF VIBRATION

See Section 5.9.

8.13. EFFECT OF SOUND FIELD

When exposed to a sound field of 120 dB the meter deflection is at least 60 dB lower with a dummy microphone than with the measuring Microphone in place. See also Section 5.8.

8.14. EFFECT OF STATIC PRESSURE

Approximately —0,003 dB per mm Hg. See also appropriate Microphone Instruction Manual.

8.15. EFFECT OF ELECTROSTATIC FIELD

The effect of an electrostatic field on the Microphone is negligible as long as the protection grid is kept on. For the rest of the instrument, the influence is negligible.

8.16. OPERATING TEMPERATURE

—20°C to 50°C (—4°F to 122°F).

8.17. BATTERIES

3 x 1,5 volt flashlight cell (type IEC R 20): 12 hours continuous operation.

3 x 1,5 volt nickel-cadmium (NiCd) cells (rechargeable): 20 hours continuous operation.

3 x 1,5 volt Mallory MN 1300: 50 hours continuous operation.

8.18. DIMENSIONS

Meter alone:

Height:	32 cm (12,7 inches)
Width:	12 cm (5 inches)
Depth:	9 cm (4 inches)

Meter with UA 0196 extension rod and Microphone:

Height:	55 cm (21,7 inches)

8.19. WEIGHT

2,7 kg (6 lb) meter alone

3 kg (6,7 lb) with extension rod and Microphone.

8.20. ACCESSORIES SUPPLIED

One-inch Microphone Type 4145
Adaptor JJ 2614
Half-inch to one-inch adaptor DB 0962
Flexible extension rod UA 0196
Half-inch to one-inch adaptor DB 0375
Random Incidence Corrector UA 0055
Windscreen UA 0207
3 plugs JP 0006
3 batteries QB 0004

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

ACOUSTICAL MEASUREMENTS
Condenser Microphones
Piezoelectric Microphones
Microphone Preamplifiers
Sound Level Meters
Precision Sound Level Meters
Impulse Sound Level Meters
Standing Wave Apparatus
Noise Limit Indicators
Microphone Calibrators

ACOUSTICAL RESPONSE TESTING
Beat Frequency Oscillators
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

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
Multi-point Panels
Automatic Selectors

MEASUREMENT AND ANALYSIS
Voltmeters and Ohmmeters
Deviation Bridges
Measuring Amplifiers
Band-Pass Filter Sets
Frequency Analyzers
Real Time Analyzers
Heterodyne Filters and Analyzers
Psophometer Filters
Statistical Distribution Analyzers

RECORDING
Level Recorders
Frequency Response Tracers
Tape Recorders

DIGITAL EQUIPMENT
Digital Encoder
Digital Clock
Computers
Tape Punchers
Tape Readers

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