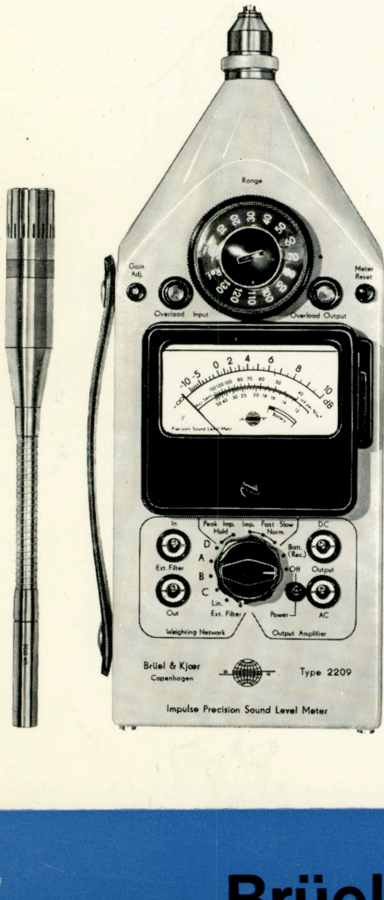
2209

Instructions and Applications



Impulse Precision Sound Level Meter Type 2209

A compact and portable instrument for precision sound and vibration measurements. It conforms to IEC 179 for Precision Sound Level Meters, the proposed IEC Recommendation for Impulse Precision Sound Level Meters and to DIN 45 633 parts 1 and 2.

Brüel & Kjær

030-0610

IMPULSE PRECISION SOUND LEVEL METER TYPE 2209

Reprint October 1974

CONTENTS

1. INTRODUCTION

1.1. DESCRIPTION OF 2209

The Brüel and Kjær Impulse Precision Sound Level Meter Type 2209 is a compact, portable instrument for precision sound and vibration measurement. It is designed to meet all current standards set by the IEC for both Precision Sound Level Meters and Impulse Sound Level Meters.

The 2209 is designed so that in the impulse mode, its response characteristics to short duration sounds (1 to 1000 milliseconds) approximate the response of the human ear. Thus it effectively measures the subjective loudness of short duration sound as heard by the human ear. The impulse response characteristics meet all applicable IEC and DIN standards.

The 2209 is capable of measurements over a wide frequency and dynamic range. In addition, it can accurately measure the RMS values of signals with crest factors up to 40 and also the peak values of signals with duration greater than 20μs. Built into the instrument are the A, B, and C frequency weighting networks plus the D weighting network for aircraft noise measurement.

With a wide range of accessories the 2209 is a versatile portable instrument. With the addition of the Third Octave Filter Set 1616 it becomes a portable, self-contained third octave measuring system.

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 2209 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 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 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 2209 meets all applicable IEC criteria and can be used for the measurement of most continuous sounds.

1.3. IMPULSE SOUND LEVEL METER STANDARDS

The purpose of the impulse response circuit is to approximate the rise, averaging, and storage time characteristics of the human ear for short duration sounds. Both the German Standard DIN 45 633 part 2 and the IEC draft for the extension of Publication 179 make similar specifications for Impulse Sound Level Meters. The 2209 conforms to all of these and the main points of the IEC draft are given below:

Impulse Sound Level Meters must have same response characteristics to steady sinusoidal signals as specified for Precision Sound Level Meters.

Overload indicators at input to filters and at input to meter rectifiers.

Minimum crest factor capability of 5.

Rectifier response time of 35 ms ± 0,5 ms. Storage circuit with rise time less than rectifier and decay time constant of 3 s ± 0,5 s.

The IEC also specifies testing procedures to assure compliance to standards. It should be noted that the 2209 is designed to approximate the subjective impression of short duration sound, and not for objective analysis of shock or other pulses.

2. CONTROLS

The external features and controls of the Impulse Precision Sound Level Meter 2209 are shown in Figs. 2.1 and 2.2.

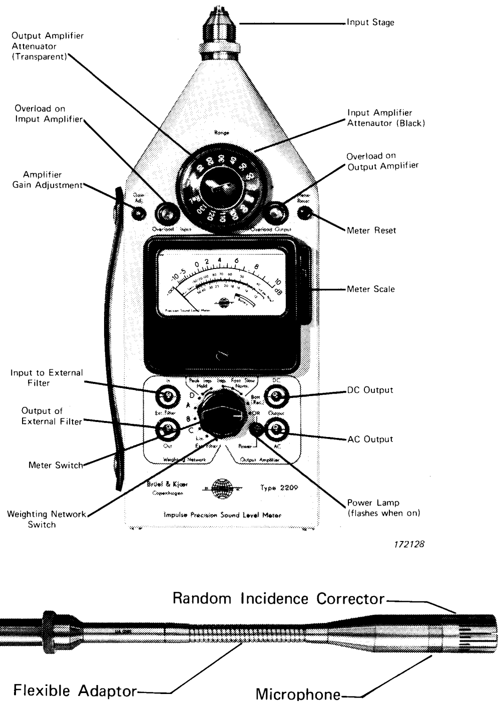


Fig. 2.1. Front view of 2209

METER SCALE

Removable by sliding out. The scale is reversible with one side calibrated for precision sound level measurements and the other for vibration measurements.

METER SWITCH

This is both the main power switch and meter function selector. It has seven positions:

"Off"	Power off position. In all other positions power is on and POWER light flashes.
"Batt. (Rec.)"	Battery check position. Meter deflection below red area indicates batteries must be replaced. (See Sec. 3.1).
"Slow"	Provides the *Slow* RMS meter characteristic specified in IEC Publication 179. See Introduction for details.
"Fast"	Provides the *Fast* RMS meter characteristic specified in IEC Publication 179. See Introduction for details.
"Imp."	Provides the *Impulse* meter characteristic for measurement of subjective level of short duration sounds as specified in the proposed extension to IEC Publication 179 and DIN 45633 Part 2. See Introduction for details.
"Imp. Hold"	Holds the maximum RMS value of the applied signal until METER RESET is depressed. Rise time is the same as the *Impulse* characteristics. Decay time is < 0,05 dB/s.
"Peak Hold"	Holds the maximum peak value of the applied signal until METER RESET is depressed. Rise time is < 20 μs.

WEIGHTING NETWORK SWITCH

This six position switch determines frequency response characteristics of the instrument electronics:

"Lin."	Gives linear response from 2 Hz (or 10 Hz see section 4.2) to 70 kHz.
"A", "B", "C", and "D"	Selects appropriate frequency weighting network for subjective indication of loudness (see Fig.5.22).
"Ext. Filter"	Permits external filter connection across EXT. FILTER sockets. In this switch position meter deflection is obtained only if external filter is connected.

INPUT SOCKET SWITCH

This screw operated switch is located in the center of the input stage socket (Fig.4.4). The lower frequency limit of the instrument is 2 Hz with this switch fully clockwise and 10 Hz when fully anti-clockwise.

INPUT ATTENUATOR (Black)

Controls the gain of the input amplifier in 10 dB steps. Is used together with the OUTPUT ATTENUATOR to select the measuring range of the instrument.

OUTPUT ATTENUATOR (transparent)

Controls the gain of output amplifier in 10 dB steps. For optimum signal to noise ratio and protection from overload, this control should be kept fully clockwise (red lines opposite black dot) whenever possible. The measuring range of the 2209 is read between the red lines on this knob.

ATTENUATOR SCALE

Ten reversible attenuator scales are provided with the 2209 to permit direct reading of virtually any sound or vibration unit. The scales are interchanged by unscrewing the coin slotted screw in the center of the attenuator knobs. With a properly calibrated meter, for sound level measurement the sum of the number between the red lines on the attenuator knob and the meter scale reading gives the correct result. For vibration and voltage measurements, the number between the red lines gives the full scale deflection of the meter.

GAIN ADJUSTMENT

This screwdriver operated potentiometer adjusts the gain of the input amplifier over a 13 dB range permitting calibration with various transducer sensitivities.

Fig. 2.2. Rear view of 2209

OVERLOAD INDICATORS

Separate flashing lights indicate overload on input and output amplifiers. Adjust attenuators to remove overloads which will give erroneous readings. If overload cannot be removed, note this together with measurements.

METER RESET BUTTON

Resets the meter in the "Peak Hold" or "Imp. Hold" positions.

EXTERNAL FILTER INPUT and OUTPUT SOCKETS

Socket IN:	Connect to filter input. Minimum output load of socket is 500 Ω.
Socket OUT:	Connect to filter output. Input impedance of socket is 146 kΩ. Maximum input voltage is 0,2 V RMS, 2 V peak.

DC OUTPUT

Feeds DC voltage from meter rectifier. Output impedance is 25 kΩ with 0,8 volts (open circuit) for full scale deflection. Meter reading is not affected by load. Matches JP 0006 plug or AO 0007 cable.

AC OUTPUT

Feeds AC voltage from output amplifier. With METER SWITCH in "Batt. (Rec.)" output is 5 V RMS (fsd) with $>$ 10 kΩ load required. In "Peak Hold", "Imp.", "Imp. Hold", "Fast", or "Slow" output is 0,5 V RMS (fsd) with an output impedance of 600 Ω, but any load may be applied without affecting meter reading. Matches JP 0006 plug or AO 0007 cable. Output voltages are open circuit values and may be used for tape recording purposes with any METER SWITCH position.

PILOT LIGHT (POWER)

Flashes when the power is on.

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 sliding the cover off the rear of the instrument. Observe polarity as marked in the battery compartment. See Fig.2.2.

Rechargeable nickel cadmium batteries may also be used giving the advantages of longer operating time without battery change and reduced long-term battery costs. They may be recharged using the 2808 Power Supply with Battery Box ZG 0073 and Charging Adaptor AQ 0043. See 2808 Instruction Manual for details.

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) 124 dB. Individual calibration charts giving exact sound level outputs are provided with the calibrators.

The procedure for calibration of the 2209 is as follows:

1. Turn the Meter Scale to "Precision Sound Level Meter".
2. Choose the appropriate attenuator scale depending on Microphone sensitivity from Table 3.1.
3. Attach the input stage and Microphone with desired accessories.
4. Check battery condition by turning METER SWITCH to "Batt. (Rec.)".
5. Set METER SWITCH to "Fast".
6. Set WEIGHTING NETWORK to "C".
7. Set attenuators to 90 for Sound Level Calibrator, 120 for Pistonphone.
8. Place Pistonphone or Sound Level Calibrator over Microphone with its normal protection grid and switch on the calibrator.

Microphone open circuit sensitivity	B & K Microphone Type	Scale No	Red Sensitivity Scale
40 – 160 mV per Pa*	4145 4144 4161	1A	Upper
11 – 50 mV per Pa	4133 4134 4149 4163	1B	Lower
4 – 16 mV per Pa	4133 4134 4149 4163	2A	Upper
1,1 – 5 mV per Pa	4135 4136	2B	Lower
0,4 – 1,6 mV per Pa	4138	3A	Upper

* 1 Pa = 1 N/m^2 = 10 μbar

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Table 3.1. Attenuator Scales for sound measurements

9. Using a small screwdriver adjust the gain of the 2209 (GAIN ADJ) to correspond to the calibration value of the calibrator as given on its calibration chart. Correct as necessary for barometric pressure in the case of the Pistonphone.

3.2.2. Using the built-in Reference Voltage

A stable internal voltage (± 0,2 dB at 2 kHz) is fed to the input amplifier whose gain is adjusted to make the 2209 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. Turn the meter scale to "Precision Sound Level Meter".
2. Choose the appropriate attenuator scale depending on Microphone sensitivity from Table 3.1.
3. Attach the input stage, desired Microphone and accessories.
4. Check battery condition by turning METER SWITCH to "Batt. (Rec.)".
5. Set METER SWITCH to "Fast".
6. Set WEIGHTING NETWORK to "Lin".
7. Set ATTENUATOR switches to "Ref." (between red lines).
8. Determine Microphone open circuit sensitivity in mV per Pa from Microphone calibration chart. (1 Pa = 1 N/m^2 = 10 μbar)
9. Using a small screwdriver adjust the GAIN ADJ potentiometer until the open circuit sensitivity of the Microphone in use is indicated on the red MICR. SENS. scale. Use either the upper or lower MICR. SENS. scale depending on Microphone used. See Table 3.1. Note that scaling differences by factors of 10 are accounted for by use of appropriate attenuator scales.

3.3. SOUND MEASUREMENTS

3.3.1. General Considerations

1. Select a Microphone with appropriate dynamic range, frequency range and directional characteristics. Choose proper attenuator scales for the given Microphone sensitivity to permit direct reading of levels. Also select appropriate accessories (see Chapter 6) for various environmental and measurement conditions.

2. Whenever possible mount the 2209 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 from 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 on the one-inch free field Microphone, or use the half-inch Microphone for better omni-directivity.

4. Calibrate the 2209 before use to ensure correct, reproducible results.

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

6. Before fitting the input stage, select the appropriate low frequency cut-off: 10 Hz with the input socket screw fully anti-clockwise, 2 Hz when fully clockwise. See Fig.4.4. The 10 Hz cut-off will help reduce inaudible low frequency disturbances.

7. To maintain a high signal to noise ratio the gain should be kept as low possible (OUTPUT ATTENUATOR as far clockwise as possible). Instrument gain should be increased first using the INPUT ATTENUATOR, then the OUTPUT ATTENUATOR.

8. To make high accuracy measurements in accordance with the standards of IEC 179 or DIN 45633 parts 1 and 2, the 2209 must be used with the following accessories:

Extension Rod	UA 0196
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 2209 as described in Section 3.2.

2. Select "Fast" or "Slow" METER SWITCH position.

3. Select "Lin" WEIGHTING NETWORK.

4. Set OUTPUT ATTENUATOR (transparent) at minimum gain (fully clockwise so red lines are opposite black dot).

5. Increase input gain turning the INPUT ATTENUATOR (black) clockwise for the highest possible reading without meter overdeflection and without OVERLOAD INPUT indicated.

6. Select the desired WEIGHTING NETWORK and METER SWITCH position.

7. If the meter now overdeflects reduce the gain by turning the INPUT ATTENUATOR (black) anti-clockwise to give a meter deflection between 0 and + 10 dB. (Also reset meter if a hold mode is used).

8. Adjust OUTPUT ATTENUATOR (transparent) for highest possible meter reading without meter overdeflection and without OVERLOAD OUTPUT indicated. The most accurate readings will usually be obtained with meter deflections between 0 and + 10 dB, but for signals with high crest factor, readings should be made in the —10 dB and 0 dB range to avoid errors due to output overload. If the OVERLOAD OUTPUT alone flashes, the signal crest factor exceeds the instrument's capability. If the overload cannot be removed while retaining a meter deflection between —10 and + 10 dB, the reading will be too low and the overload should be noted with the results. (See Section 5.7 for complete crest factor specifications).

9. The measured result is the sum of the meter deflection and the attenuator range setting as read between the two red lines on the transparent knob (i.e., the attenuator setting corresponds to the 0 dB level on the meter scale).

3.4. CALIBRATION FOR VIBRATION MEASUREMENTS

3.4.1. Using Accelerometer Calibrator 4291

The desired Accelerometer is mounted on the Accelerometer Calibrator. By choice of the appropriate attenuator scale from Table 3.2 and use of the Integrator ZR 0020, direct RMS readings of velocity and displacement may also be made. The calibration procedure is as follows:

1. Turn the meter scale to "Vibration Meter".

2. Determine type (acceleration, velocity, or displacement) and units of measurement and select appropriate attenuator scale from Table 3.2.

<table>
<tr><th rowspan="2">Accelerometer Sensitivity</th><th rowspan="2">B & K Accelerometer Type</th><th colspan="2">Acc.</th><th colspan="2">Vel.</th><th colspan="2">Disp.</th></tr>
<tr><th>m/sec²</th><th>g</th><th>m/sec</th><th>inch/sec</th><th>m</th><th>inch</th></tr>
<tr><td>0,89–1,12 mV/g</td><td></td><td rowspan="2">4 B</td><td rowspan="2">5 B</td><td rowspan="2">6 A</td><td>4 A</td><td rowspan="2">7 B</td><td>5 B</td></tr>
<tr><td>1,12–2,8 mV/g</td><td>4344 8303 8307</td><td>4 B</td><td>6 A</td></tr>
<tr><td>2,8–3,55 mV/g</td><td></td><td rowspan="2">5 A</td><td rowspan="2">6 A</td><td rowspan="2">6 B</td><td>4 B</td><td rowspan="2">8 A</td><td>6 A</td></tr>
<tr><td>3,55–8,9 mV/g</td><td>4345</td><td>5 A</td><td>6 B</td></tr>
<tr><td>8,9–11,2 mV/g</td><td>4339 4343
8301 8302</td><td rowspan="2">5 B</td><td rowspan="2">6 B</td><td rowspan="2">7 A</td><td>5 A</td><td rowspan="2">8 B</td><td>6 B</td></tr>
<tr><td>11,2–28 mV/g</td><td>4333 4335 4340</td><td>5 B</td><td>7 A</td></tr>
<tr><td>28–35,5 mV/g</td><td></td><td rowspan="2">6 A</td><td rowspan="2">7 A</td><td rowspan="2">7 B</td><td>5 B</td><td rowspan="2">9 A</td><td>7 A</td></tr>
<tr><td>35,5–89 mV/g</td><td>4332 4334</td><td>6 A</td><td>7 B</td></tr>
<tr><td>89–112 mV/g</td><td>4338</td><td rowspan="2">6 B</td><td rowspan="2">7 B</td><td rowspan="2">8 A</td><td>6 A</td><td rowspan="2">9 B</td><td>7 B</td></tr>
<tr><td>112–280 mV/g</td><td></td><td>6 B</td><td>8 A</td></tr>
<tr><td>280–355 mV/g</td><td></td><td rowspan="2">7 A</td><td rowspan="2">8 A</td><td rowspan="2">8 B</td><td>6 B</td><td rowspan="2">10 A</td><td>8 A</td></tr>
<tr><td>355–890 mV/g</td><td></td><td>7 A</td><td>8 B</td></tr>
<tr><td>890–1120 mV/g</td><td></td><td rowspan="2">7 B</td><td rowspan="2">8 B</td><td rowspan="2">9 A</td><td>7 A</td><td rowspan="2">10 B</td><td>8 B</td></tr>
<tr><td>1120–2800 mV/g</td><td></td><td>7 B</td><td>9 A</td></tr>
</table>

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Table 3.2. Attenuator Scales for vibration measurements

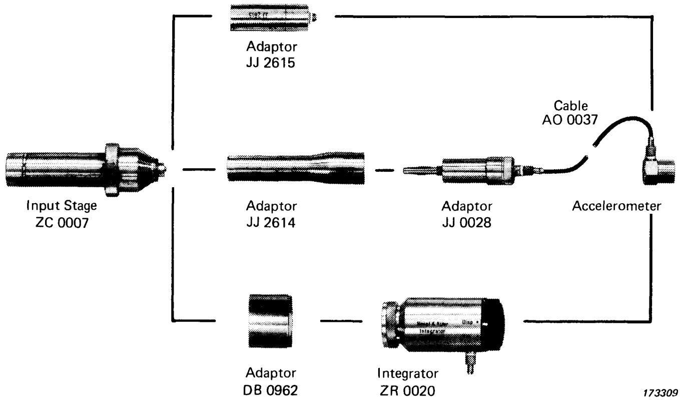


Fig. 3. 1. Connection of Accelerometer and Integrator to 2209

3. Attach the Accelerometer and Integrator (if required) as shown in Fig. 3. 1.

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

5. Check battery condition by turning METER SWITCH to "Batt. (Rec.)"

6. Set METER SWITCH to "Fast".

7. Set WEIGHTING NETWORK to "Lin".

8. Set Accelerometer Calibrator to "Int. Gen." and then adjust ACC. LEVEL so the lower meter scale of the 4291 indicates the mass of the accelerometer (given on its calibration chart). The acceleration is now 1 g peak (0,707 g RMS at approx. 80 Hz).

9. Set the ATTENUATORS of the 2209 for an on-scale reading of at least 1/3 full scale.

10. Using a small screwdriver set the GAIN ADJ potentiometer to give one of the following quantities depending on measurement parameter and units:

Acceleration:	6,94 m/s^2	($7,07 \cdot 10^{-1}$ g)
Velocity:	$13,9 \cdot 10^{-3}$ m/s	($5,46 \cdot 10^{-1}$ in/s)
Displacement:	$27,7 \cdot 10^{-6}$ m	($1,09 \cdot 10^{-3}$ in)

The 2209 is now calibrated to an appropriate quantity corresponding to 1 g peak at 79,6 Hz.

3.4.2. Using the built-in Reference Voltage

By using the built-in reference voltage of the 2209 and the known sensitivity of the Accelerometer (from its calibration chart), calibration may be made for the direct reading of calibration, and with the Integrator ZR 0020, velocity and displacement. The calibration procedure is as follows:

1. Turn the Meter Scale to "Vibration Meter".

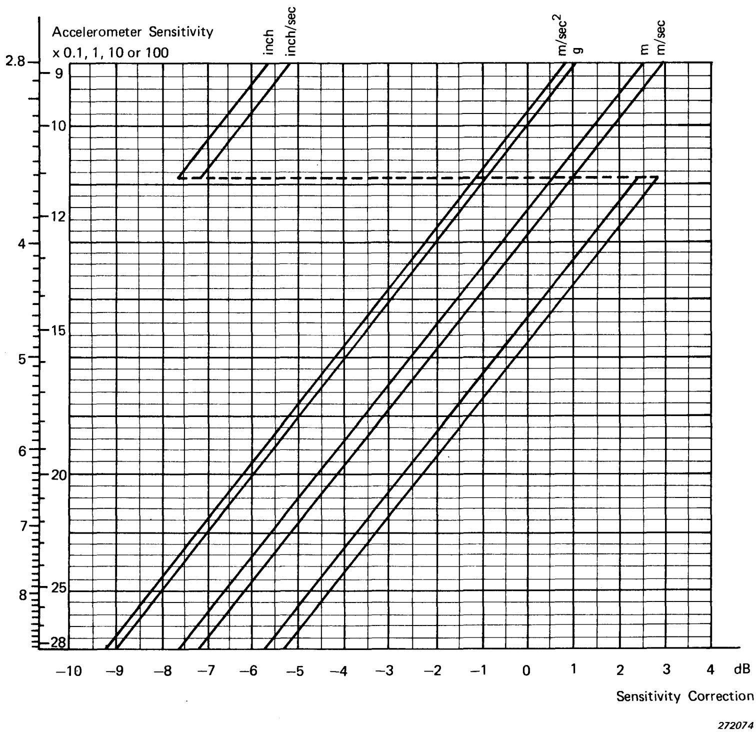


Fig.3.2. Accelerometer Sensitivity Correction chart

2. Determine type (acceleration, velocity, or displacement) and units of measurement, and select the appropriate attenuator scale from Table 3.2.

3. Attach the Accelerometer and Integrator (if necessary) as shown in Fig.3.1.

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

5. Check battery condition by turning METER SWITCH to "Batt. (Rec.)".

6. Set METER SWITCH to "Fast".

7. Set WEIGHTING NETWORK to "Lin".

8. Set ATTENUATORS to "Ref.".

9. Determine Accelerometer sensitivity in mV/g from its calibration chart. Determine quantity (acceleration, velocity, or displacement) and units of measurement to be used. With this information determine the Sensitivity Correction in dB from Fig.3.2. Note that the ordinate (vertical scale) is a double, or folded scale, and that Accelerometers with sensitivities which differ by factors of 10 have the same Sensitivity Correction.

10. Using a small screwdriver set GAIN ADJ for a meter reading on the red scale giving the Sensitivity Correction.

3.5. VIBRATION MEASUREMENT

3.5.1. General considerations

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

When using the 2209 as an accelerometer preamplifier-measuring amplifier system it must be remembered that the Accelerometer has a high frequency resonance which 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 low frequency limit of the measuring system is determined by the 2209 which can be set at either 2 Hz or 10 Hz (See Section 4.2). If the Accelerometer is to be mounted at some distance from the Meter, extension cables should be used between the input stage and the Meter, rather than between the Accelerometer and the input stage to prevent decrease in overall sensitivity.

Hold or mount the 2209 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. Select the desired low frequency cut-off (see Section 4.2).

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

4. Select "Fast" or "Slow" METER SWITCH position.

5. Select "Lin" WEIGHTING NETWORK.

6. Set OUTPUT ATTENUATOR (transparent) at minimum gain (fully clockwise).

7. Increase input gain by turning the INPUT ATTENUATOR (black) clockwise for the highest possible reading without meter overdeflection and without OVERLOAD INPUT indicated.

8. Select the desired WEIGHTING NETWORK or external filter and METER SWITCH position.

9. If the meter now overdeflects reduce the gain by turning the INPUT ATTENUATOR (black) anti-clockwise to give a meter deflection of at least 1/3 full scale. (Also reset the meter if a hold mode is used).

10. Adjust OUTPUT ATTENUATOR (transparent) for highest possible meter reading without meter overdeflection and without OVERLOAD OUTPUT indicated. (See Section 3.3.2. step 8 for crest factor considerations).

11. The attenuator scale setting indicates the full scale meter deviation for the given attenuator range.

3.6. VOLTAGE CALIBRATION AND MEASUREMENT

The 2209 may be used for voltage measurements up to 10V RMS over the frequency ranges indicated in the specifications.

1. Select the 2 or 10 Hz low frequency cut-off (see Section 4.2).
2. Fit the 2209 with its input stage, jack socket adaptor JJ 2614, and other connectors as may be necessary to connect to the voltage source.
3. Fit Attenuator Scale 3B.
4. Turn the meter scale to VIBRATION METER.
5. Check batteries (METER SWITCH "Batt. (Rec.)").
6. Set METER SWITCH to "Fast".
7. Set WEIGHTING NETWORK to "Lin".
8. Set ATTENUATORS to "Ref.".
9. Set GAIN ADJ for a sensitivity correction of 0 on the red scale. The instrument is now calibrated.
10. Connect to voltage source for measurement.
11. Turn INPUT ATTENUATOR (black) clockwise for maximum on scale meter deflection without OVERLOAD INPUT indicated.
12. Turn OUTPUT ATTENUATOR (transparent) anti-clockwise (if necessary) for maximum on scale meter deflection without OVERLOAD OUTPUT indicated.
13. The attenuator setting corresponds to full scale meter deviation. Read and record voltage.

4. DESCRIPTION

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

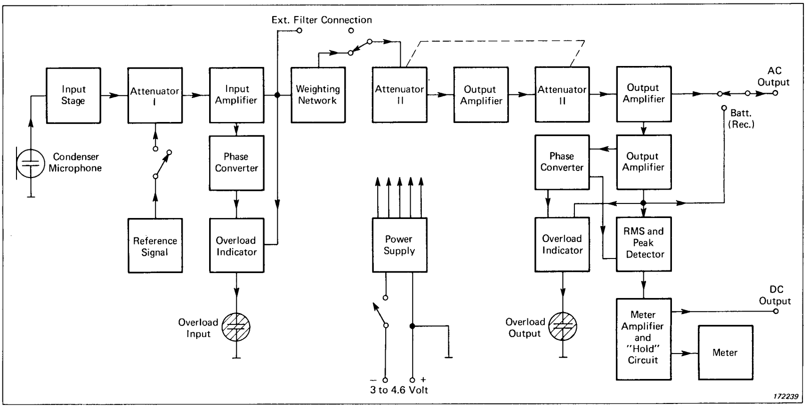


Fig.4.1. Block diagram of Impulse Precision Sound Level Meter 2209

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).

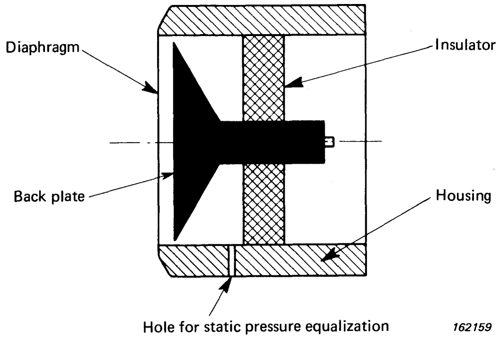


Fig. 4.2. Schematic of Condenser Microphone

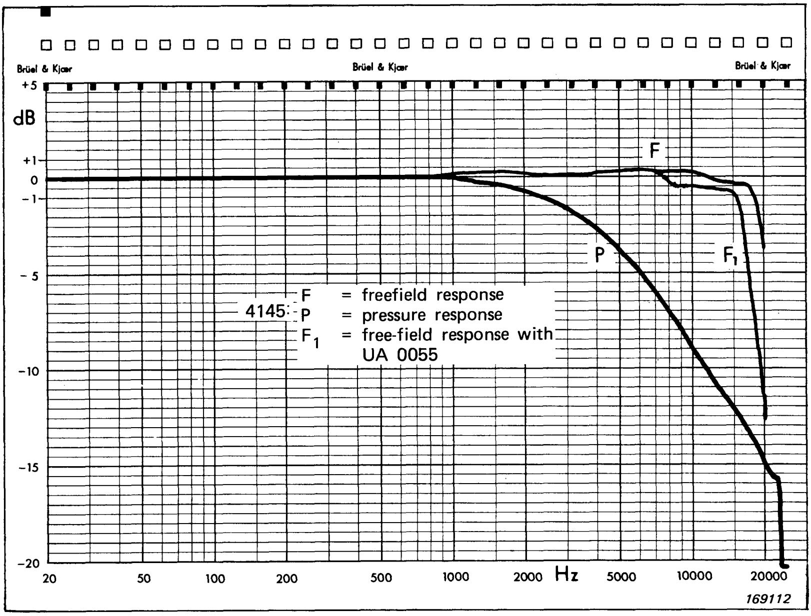


Fig. 4.3. Typical Frequency Characteristics of Microphone 4145

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

The 2209 Impulse 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 2209 is a fully transistorized impedance converter built around a low noise field-effect transitor. The stage converts the high input impedance to a low output impedance which drives the input amplifier of the 2209.

The input stage connects directly to the Condenser Microphone on one end and the other end is inserted into the 2209 using a 7-pin connector. (Fig.4.4). To use the Microphone on an extension cable the input stage may be removed from the 2209 and the extension cable (AO 0027/8/9) inserted between the two.

The low capacitance of the Condenser Microphone necessitates a high impedance load consisting of a high resistance (> 1 GΩ) to ensure good

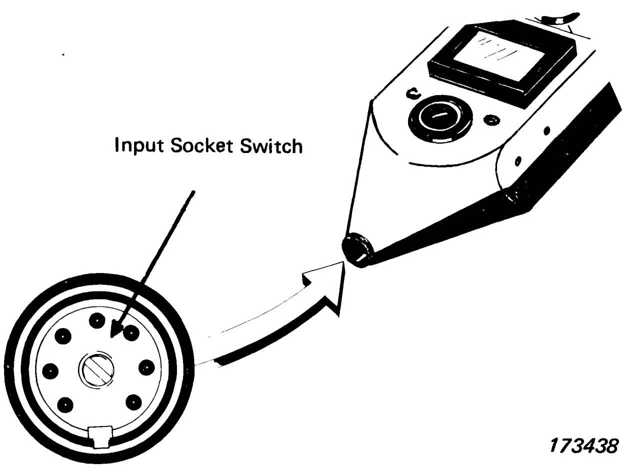


Fig.4.4. Input Socket of 2209

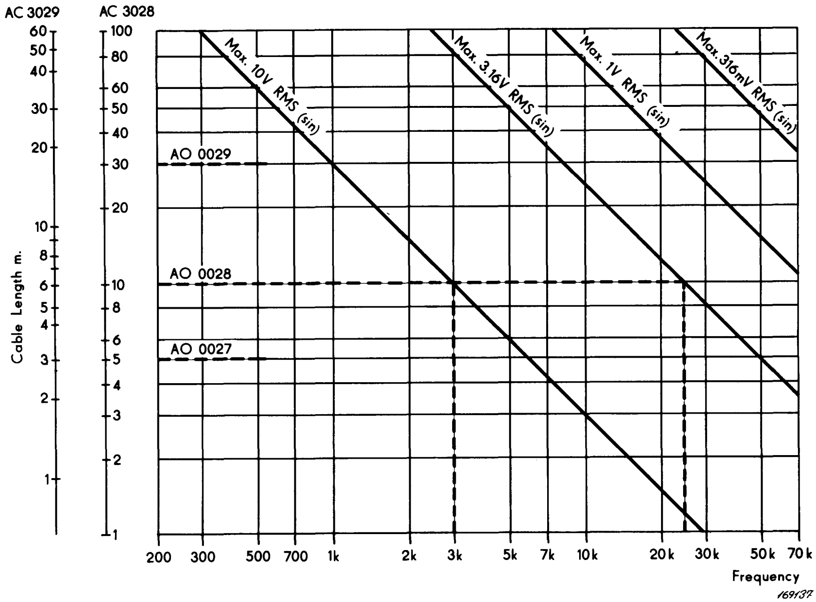


Fig. 4. 5. Frequency ranges with extension cables

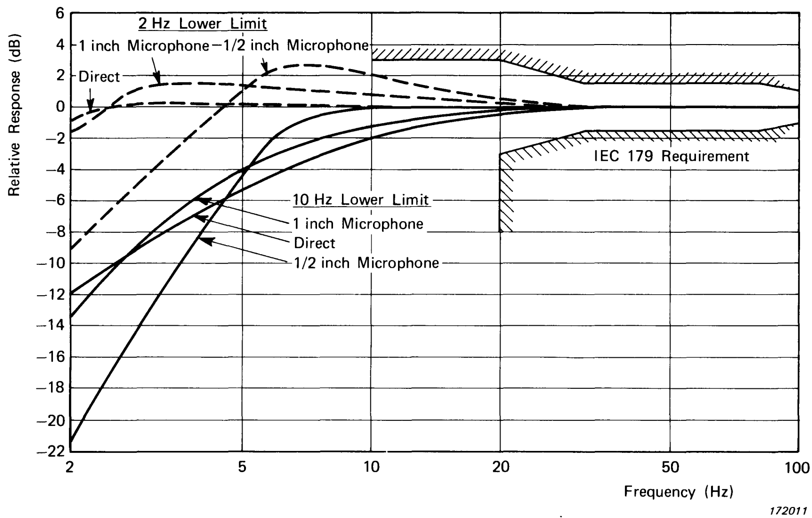


Fig. 4. 6. Low frequency response of 2209 with and without series capacitor

low frequency response and a low capacitance to ensure good sensitivity. Refer to the Microphone Instruction Manual for details on theory of input loading. See Fig.5.9 for specifications on attenuation caused by preamplifier input capacitance.

The output impedance of the input stage is 50Ω to ensure negligible attenuation. The loading is limited by the current handling capacity of the input stage when long extension cables are used. (Fig.4.5).

Selectable low frequency cut-off is made possible by the switch mounted in the input stage socket of the 2209 (see Fig.4.4). Turning this switch fully anti-clockwise gives a low frequency cut-off of 10 Hz due to the series insertion of a 0,15 μF capacitor. In the fully clockwise position, the cut-off is 2 Hz (see Fig.4.6).

4.3. ATTENUATOR I AND INPUT AMPLIFIER

The input attenuator follows the input stage and has a range from 0 to 70 dB in accurate 10 dB steps. Its frequency characteristics are given in Fig.5.23.

The input amplifier follows the attenuator. Its high input impedancs (> 10 MΩ) ensures negligible loading of the attenuator, and its low output impedance (< 3Ω) prevents loading effects of the weighting networks or external filters. It should be loaded, however, by at least 500 Ω.

The calibration potentiometer (GAIN ADJ) is placed in the feedback loop and varies amplifier gain from + 3 to —10 dB.

4.4. REFERENCE OSCILLATOR

The built-in reference oscillator operates at 2 kHz with an amplitude accuracy of ± 0,2 dB. Care should be taken to operate the 2209 in the linear mode when using this reference for calibration purposes.

4.5. OVERLOAD INDICATORS

Short duration, high amplitude peaks can readily overload the amplifiers without resulting in meter overdeflection. Depending on individual attenuator settings, overload of input amplifier without overload of output amplifier, or vice versa is possible. Hence overload indicators are provided for both input and output amplifiers as suggested by the IEC extension to Publication 179 for Impulse Sound Level Meters. The overload indicators will respond to either positive of negative peaks of a duration as short as 50 μseconds and will continue to flash for about 1 second after overload. Flashing of the output overload indicator means that the crest factor of the signal exceeds the instrument capabilities at the given attenuator setting.

When operating the input attenuator in the top two ranges (120 and 130 dB for one-inch Microphone, 130 and 140 dB for half-inch Microphone) to measure high level sound, the input stage may be overloaded without any overload indicator flashing. To assure no input stage overload exists, measure the peak value of the signal. If the reading can be made on scale at the higest input attenuator setting, overload of the input stage does not exist.

4.6. WEIGHTING NETWORKS

The weighting network characteristics and tolerances are given in Section 5.17.

4.7. ATTENUATOR II AND OUTPUT AMPLIFIER

The output attenuator has a range from 0 to 50 dB in accurate 10 dB steps. Its two sections come immediately before and after the output amplifier for best signal to noise ratio. Its frequency characteristics are shown in Fig.5.23.

The output amplifier is divided into three sections. The first is placed between the two attenuator sections. The second provides 0,5 V RMS (fsd) to the AC output socket for connecting to level recorders etc., and may be connected to any load. With the METER SWITCH in the "Batt. (rec.)" position the available output is 5 V RMS (fsd) and the output load must be greater than 10 kΩ. The third section drives the meter detectors.

4.8. 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. If 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 2209 the squaring process is accomplished by using a circuit whose transfer characteristic approximates a parabola by a series of 8 straight lines. This gives a high crest factor capability of 40. The averaging is done by an RC network. Instead of using separate circuits for squaring and square root operations, the averaging capacitor voltage is fed back to the squaring circuit, changing the parabola size and effectively taking the square root (Fig.4.7).

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

See also Chapter 5 for detailed crest factor characteristics of the 2209.

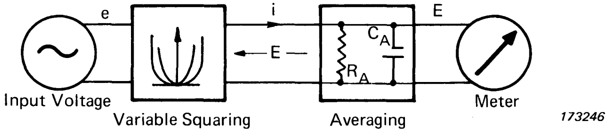


Fig.4.7. Principle of the RMS detector circuit for Type 2209

4.9. IMPULSE DETECTOR

The purpose of the impulse detector is to approximate the subjective effect of short duration sound on the human ear. The averaging time of the human ear is in the range of 30 to 100 milliseconds (according to various investigators). Hence for impulses shorter than the ear's averaging time, the subjective loudness will not be as great. This is shown graphically in Fig.4.8 and the impulse response of the 2209 to conform to this characteristic and IEC specifications is also shown.

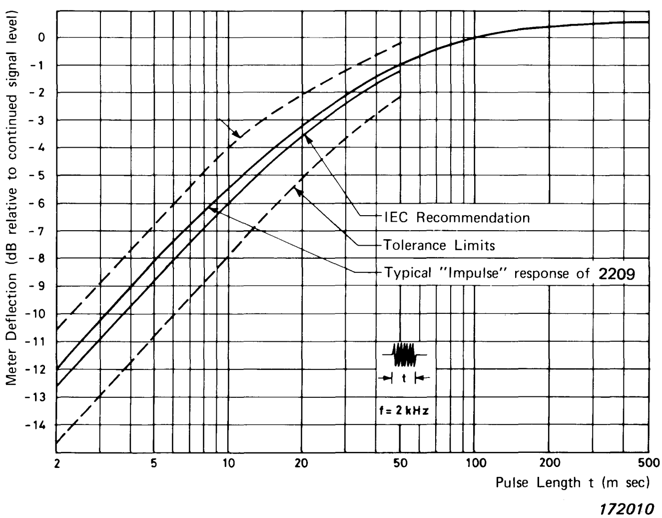


Fig.4.8. Response of the 2209 to single impulses

For repeated impulses, the greater the repetition rate, the greater the subjective loudness. The characteristics of the 2209 for repeated impulses and the IEC specifications are shown in Fig.4.9. The decay time of the impulse circuit is 3 seconds simulating the "forgetting" time of the human brain.

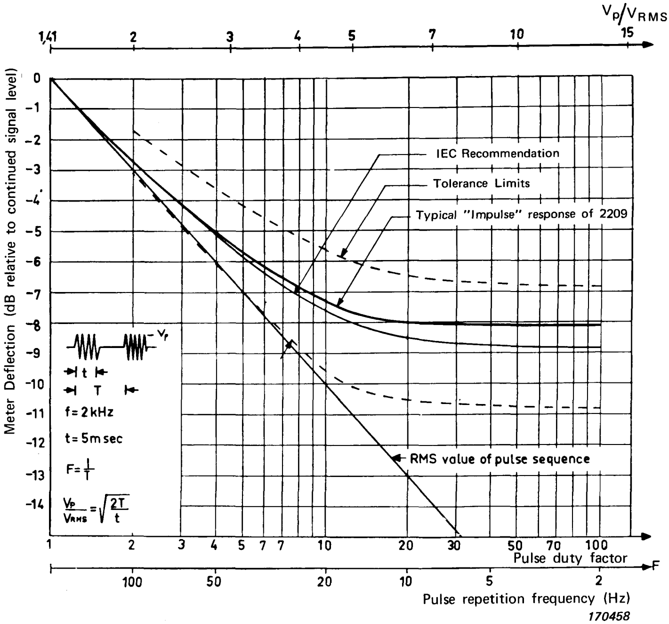


Fig. 4.9. Response of the 2209 to repeated impulses

4.10. PEAK DETECTOR

To detect peak levels the time constant of the RMS detector is shortened to 10 microseconds. The output of the peak circuit is then stored in the hold circuit to permit display by the relatively slow meter. Generally

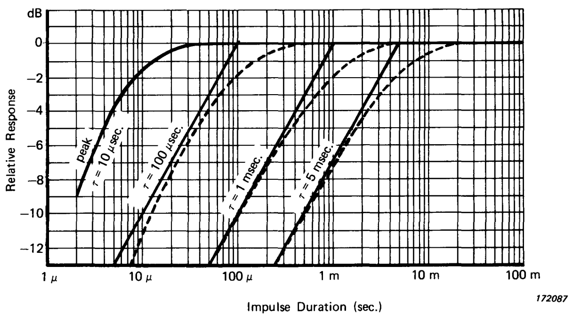


Fig. 4.10. Standard and optional "Peak Hold" responses of 2209

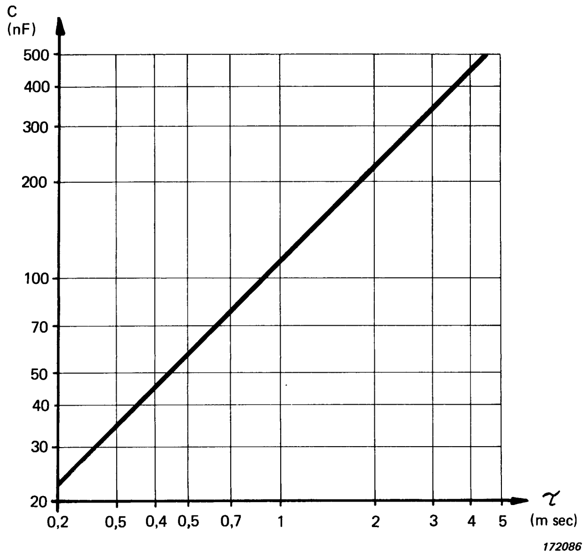


Fig.4.11. Optional charge capacitor vs. time constants for "Peak" rectifier

with noise, the peak values may be 10 to 20 dB or more above the RMS values.

An internal modification to the 2209 may be made to change the time constant of the peak circuit over a range from 10 μs to 5 ms by changing the value of one capacitor. See Figs.4.10 and 4.11 for response characteristics and capacitor values. Contact the B & K Service Department for details on modification.

4.11. HOLD CIRCUIT

The hold circuit stores the highest level fed from the impulse or peak detectors. If the meter overdeflects or if a new reading of lower level signals is wanted the meter must be reset. Note that once the circuit is holding a signal level, changing the attenuators will not decrease the meter deflection. The decay time of the hold circuit is less than 0,05 dB/s with temperature characteristics shown in Fig.4.12.

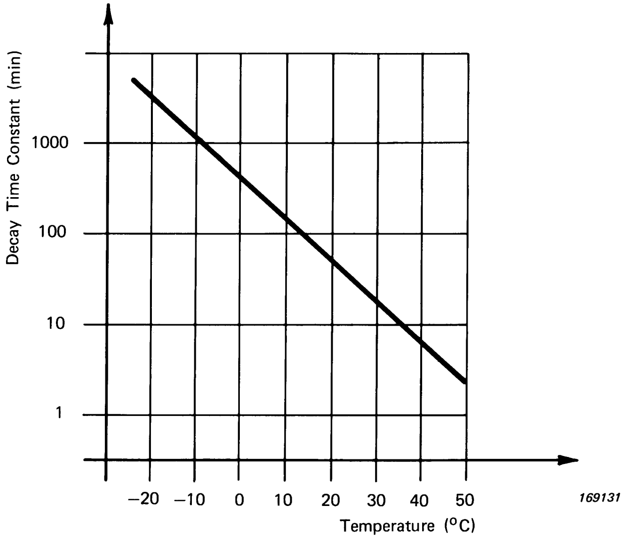


Fig. 4.12. Decay time vs. temperature for "Hold" circuit

4.12. 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 given in Fig.5.15. The power supply will operate correctly from a battery voltage of 3,0 to 4,6 V.

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 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.

Tests were made on the 2209 in an anechoic chamber (without the operator present unless otherwise stated). In all cases readings were taken with the meter held in two positions — with the meter horizontal, front panel upwards and with the meter horizontal, front panel sideways.

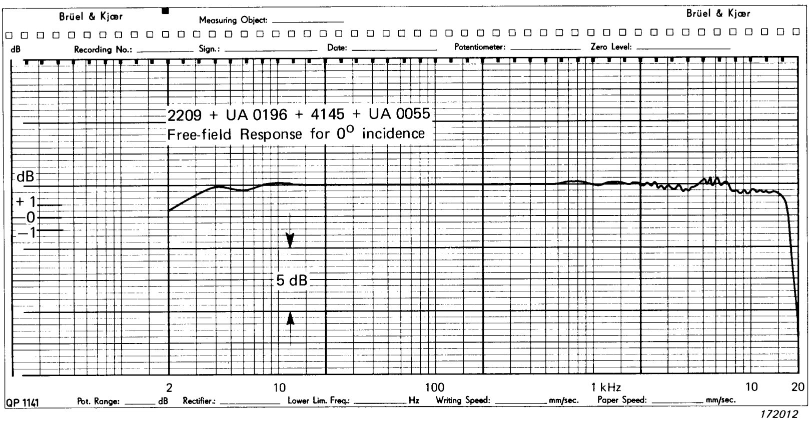


Fig. 5.1. Typical free-field response for 0° incidence with Gooseneck, one-inch Microphone, and Random Incidence Corrector fitted

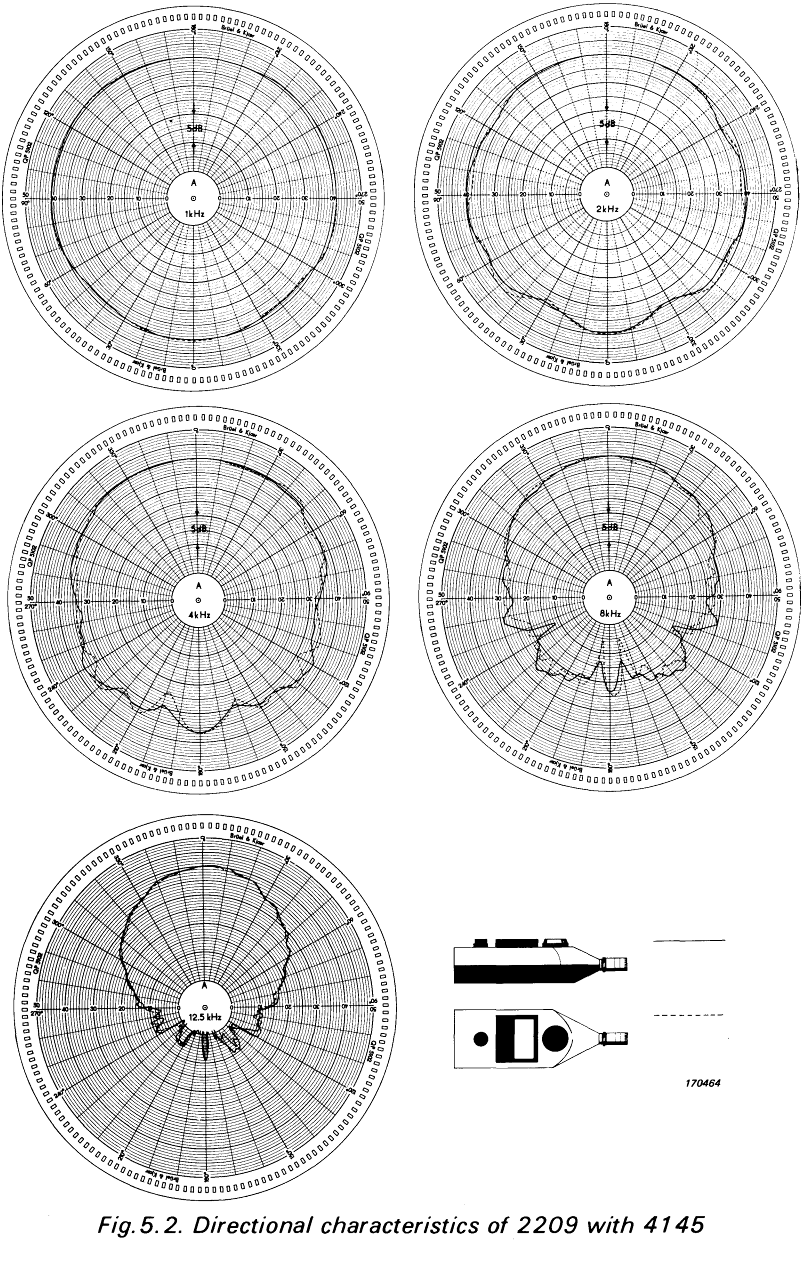


Fig. 5.2. Directional characteristics of 2209 with 4145

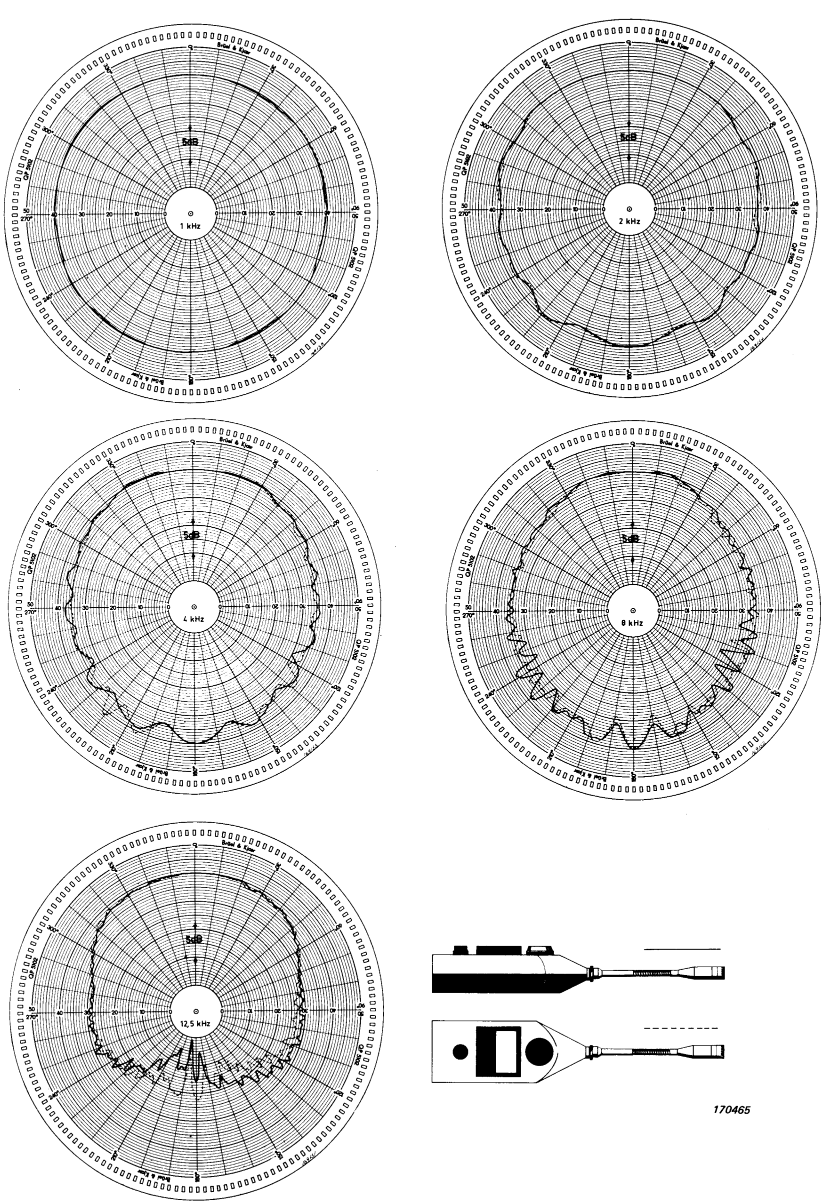


Fig. 5.3. Directional characteristics of 2209 with UA 0196, 4145, and UA 0055

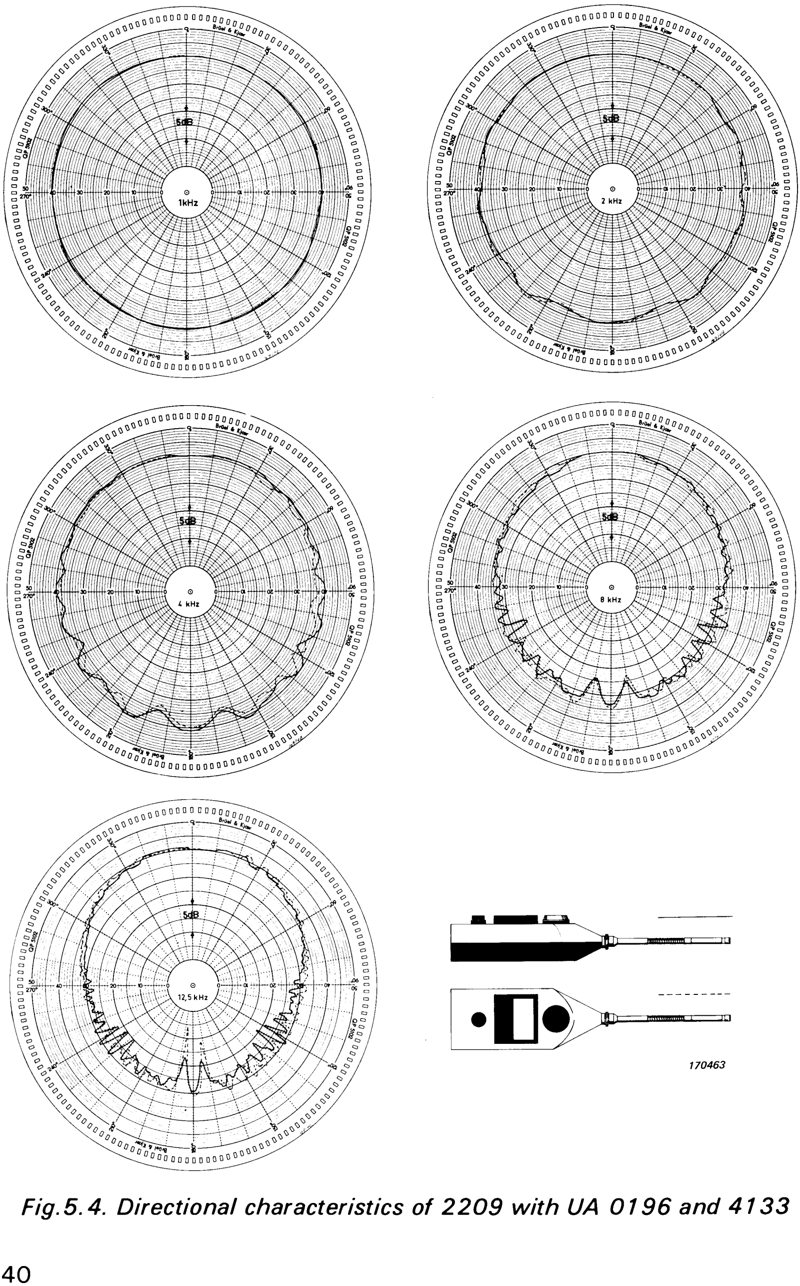


Fig. 5. 4. Directional characteristics of 2209 with UA 0196 and 4133

When the 2209 is fitted with a one-inch free field Microphone the results are quite directional but good accuracy is obtainable as long as the sound is incident at angles less than 20°. The free field zero incidence response of the meter fitted with extension rod one-inch Microphone is shown in Fig.5.1. Directional characteristics at particular frequencies are shown in Figs.5.2, 5.3 and 5.4.

Better omnidirectivity still can be obtained by separating Microphone and input stage from the 2209 by means of an extension cable (AQ 0027/28/29). This gives the microphone a similar directional characteristic to that which it has when mounted on one of the other B & K preamplifiers. Directional characteristics for this case are shown in the form of free field correction curves in Figs.5.5 and 5.6. Smaller microphones may also be used if a loss in sensitivity can be tolerated.

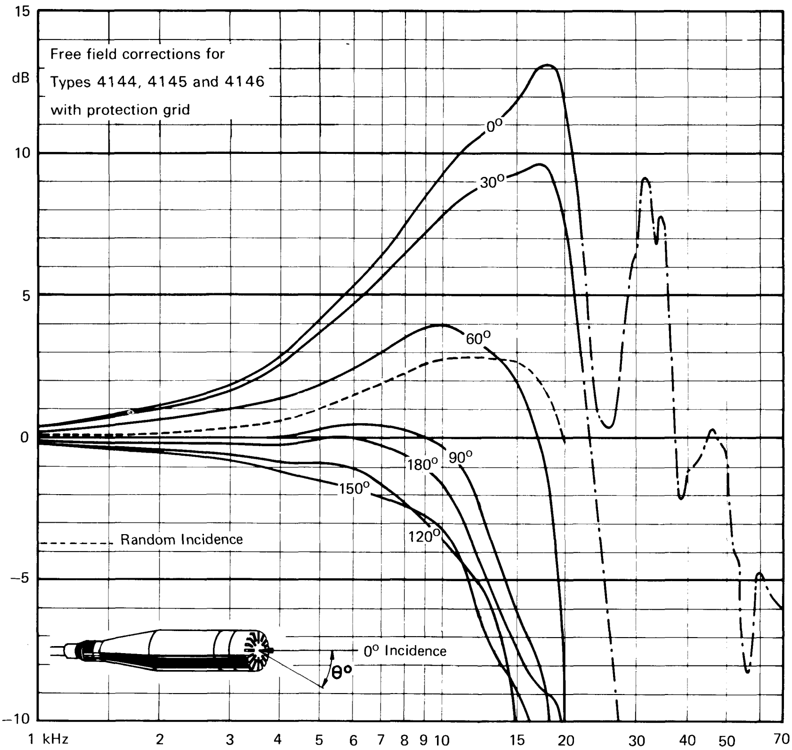


Fig.5.5. Free-field corrections for 4145 with protecting grid

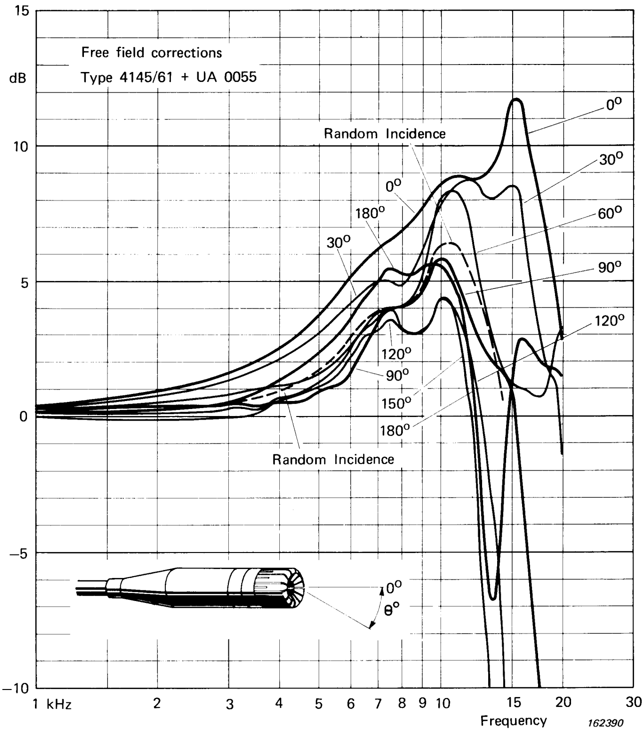


Fig. 5.6. Free-field corrections for 4145 with Random Incidence Corrector

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°

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 less than 30°

The IEC recommendation for Precision Sound Level Meters with respect to directional characteristics is summarized in Tables 5.1 and 5.2.

The 2209, when fitted with the extension rod, one-inch free field Microphone, and Random Incidence Corrector, or fitted with extension rod and half-inch free field Microphone, will meet these IEC tolerances and all other requirements of both IEC 179 and DIN 45633 parts 1 and 2.

5.2. RANDOM INCIDENCE RESPONSE

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.5.5 and 5.6.

5.3. 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. 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.

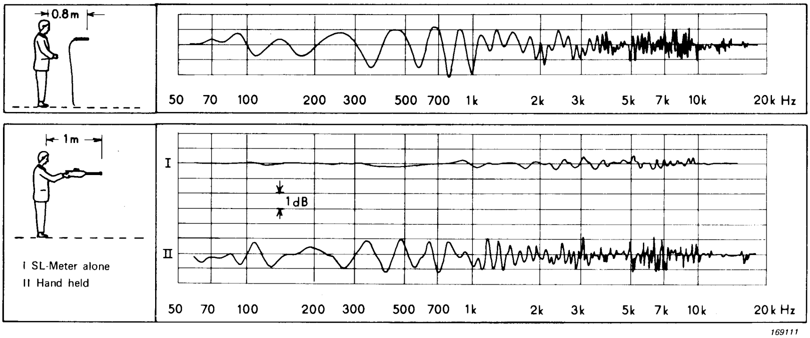


Fig.5.7. Reflections due to presence of operator

With this in mind, the front of the meter is cone shaped to reduce reflections.

An idea of the reflections caused by the operator can be obtained from Fig.5.7. Investigators have found that anomalies due to such reflections are usually most marked in the frequency range 200-400 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.

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 and the instrument for instance by holding the meter to one side and observing any difference in reading. 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.5.7.

To further reduce the influence of the operator, an extension cable may be used.

5.4. 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

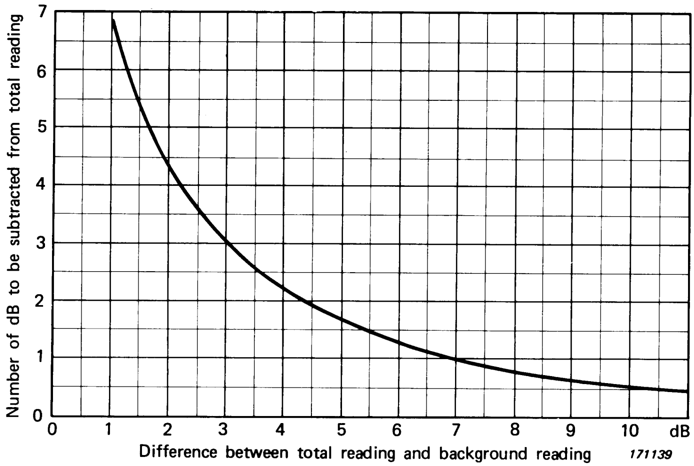


Fig. 5.8. Correction for influence of background noise

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. 5.8. 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.

5.5. INPUT CAPACITANCE

Due to the low capacitance of condenser microphones their sensitivity is affected by capacitive loads. See Fig. 5.9. For one-inch and half-inch Microphones the capacitance of the Microphones is from 70 to 20 pF, hence the input capacitance has relatively little effect. But for quarter-inch and eighth-inch Microphones (capacitance of 7 and 4,5 pF) the effect is more pronounced and system calibration using a Pistonphone is advisable.

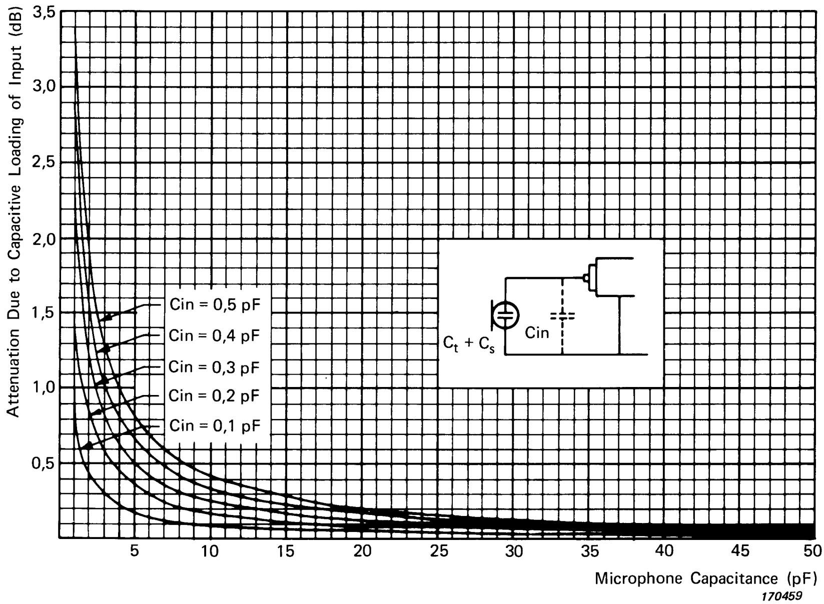


Fig. 5.9. Attenuation caused by preamplifier input capacitance

5.6. DISTORTION

The input amplifier will accept a maximum input of 10V RMS (sinusoidal) without significant distortion. Fig. 5.10 shows the voltages produced by various Microphones at given sound pressure levels. Hence the maximum SPL that can be measured with a given microphone can be determined from this chart. (For example: for the 4145, max. SPL (RMS) is 140 dB when used with the 2209).

5.7. CREST FACTOR CAPABILITIES

The crest factor (F_c) of a signal is defined as the ratio of the peak to RMS level. The 2209 is capable of measuring the RMS values of signals with crest factors up to 40. However, with high meter scale deflections and high crest factors the output amplifier may be overloaded. Hence the full crest factor capabilities of the instrument can only be used for less than full scale meter deflection as shown in Fig. 5.11.

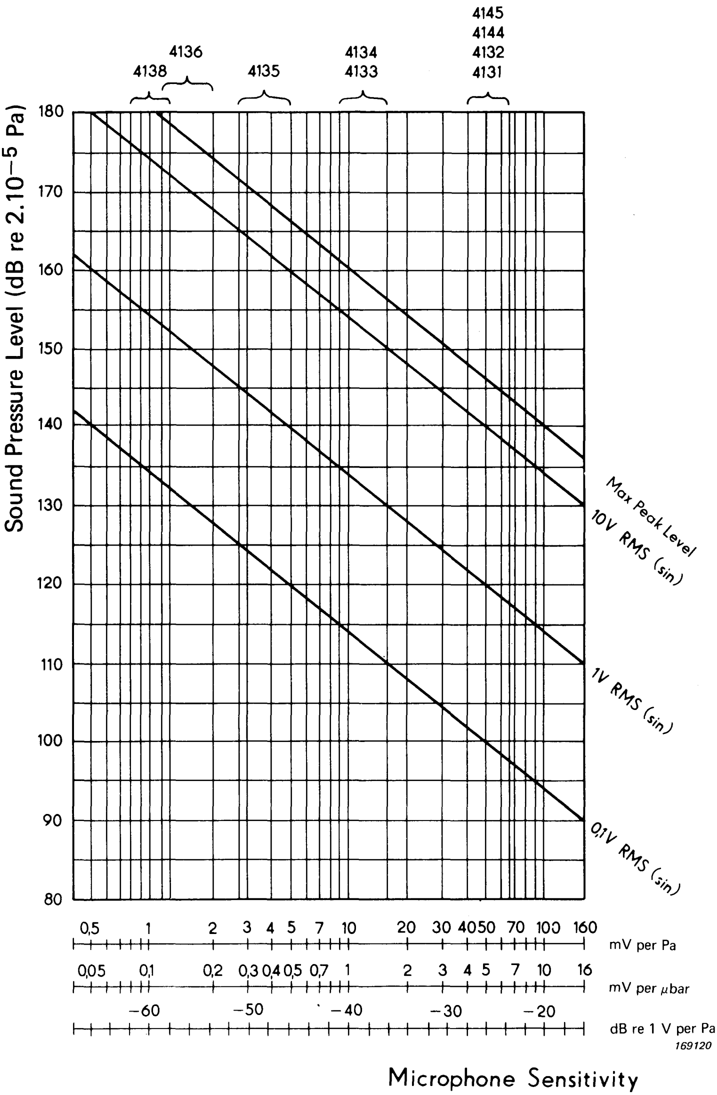


Fig. 5.10. Upper limit of dynamic range with various microphone inputs

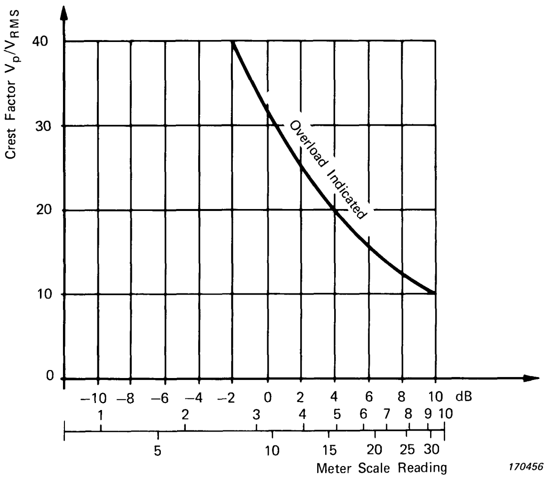


Fig. 5.11. Maximum Crest Factor at given meter deflection

The accuracy of RMS measurements as related to the crest factor of the signal is shown in Table 5.3.

The instrument's crest factor capabilities are also related to the maximum sound pressure levels that can be measured accurately. Fig. 5.12 shows these relationships for one-inch and half-inch Microphones.

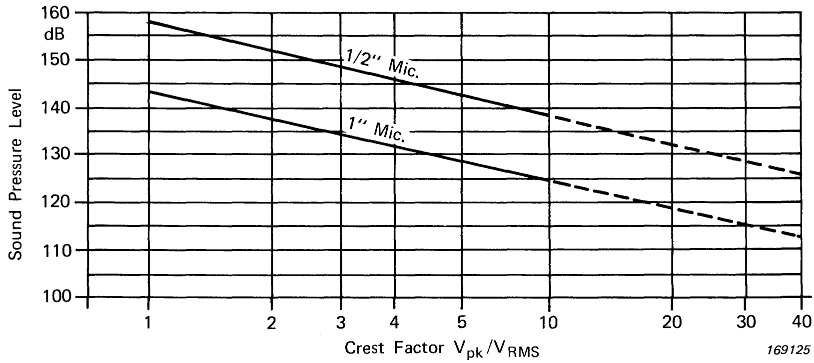


Fig. 5.12. Maximum SPLs that can be accurately measured with one-inch and half-inch microphones with respect to signal crest factor

METER DEFLECTION (dB scale)	CREST FACTOR		
	less than 10	10 to 20	20 to 40
−10 to − 2	± 1 dB	± 1,5 dB	± 2 dB
− 2 to +10	± 0,5 dB	± 1 dB	± 1,5 dB

073013

Table 5.3. Accuracy of Meter Scale readings for various Crest Factors within limitations given in Fig. 5.11.

5.8. TEMPERATURE

The Microphone is designed to operate at temperatures from —50 to + 150°C. However, at temperatures above + 50°C the Microphone should be mounted on the flexible extension rod to prevent input stage overheating. At high temperatures permanent sensitivity changes may occur. For instance, at + 150°C the rate of change is about 1 dB per two hours. But at room temperatures this is reduced to about 1 dB per 900 years. Non-permanent sensitivity changes with temperature are shown in Fig. 5.13 for two microphones. These changes are nearly random within the limits indicated and vary unpredictably from microphone to microphone.

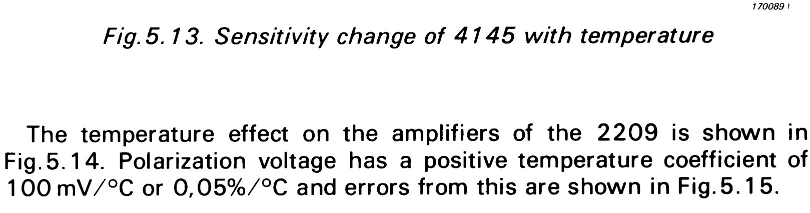


Fig. 5.13. Sensitivity change of 4145 with temperature

The temperature effect on the amplifiers of the 2209 is shown in Fig. 5.14. Polarization voltage has a positive temperature coefficient of 100 mV/°C or 0,05%/°C and errors from this are shown in Fig. 5.15.

In general, the calibration of the complete apparatus changes by less than 0,5 dB from —20 to + 50°C. Recalibration is recommended for operation outside this range.

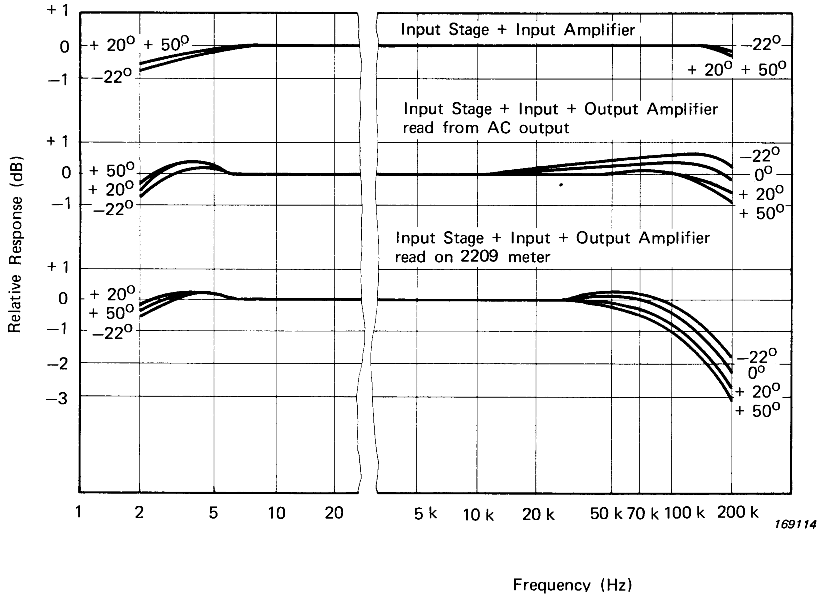


Fig. 5.14. Frequency response at various temperatures

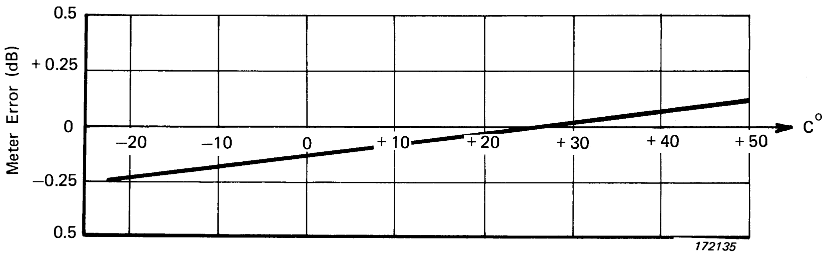


Fig. 5.15. Error caused by temperature changes affecting polarization voltage

5.9. 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.

5.10. 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.

Figs.5.16 and 5.17 show typical inherent noise levels for the 2209 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 dotted lines show the upper limit of the inherent noise.

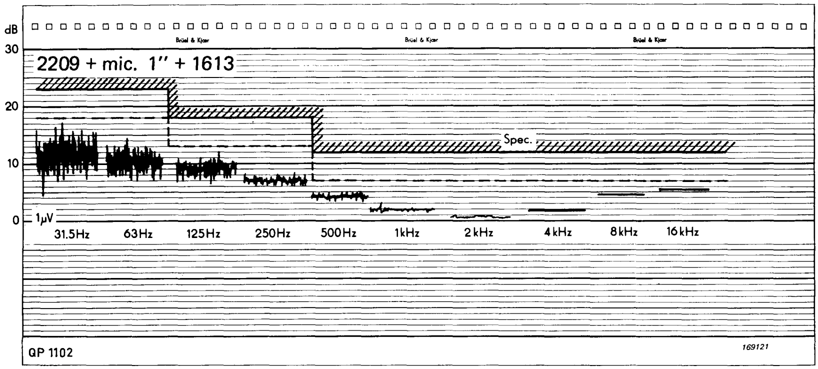


Fig.5.16. Inherent Noise with one-inch Microphone Input

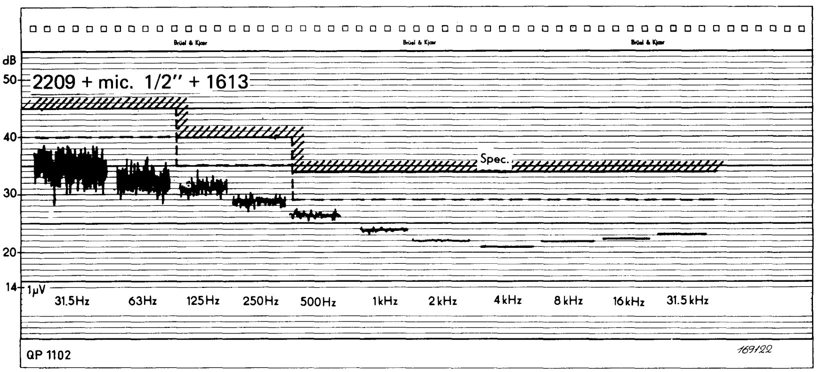


Fig.5.17. Inherent Noise with half-inch Microphone Input

5.11. SOUND

A typical graph of the acoustic sensitivity of the 2209 without a microphone is shown in Fig.5.18. These measurements were made with a linear weighting, but with any of the weighting networks, the acoustic sensitivity of the Meter is at least 60 dB below the applied SPL. This specification is especially of importance when the 2209 is used for voltage and vibration measurements.

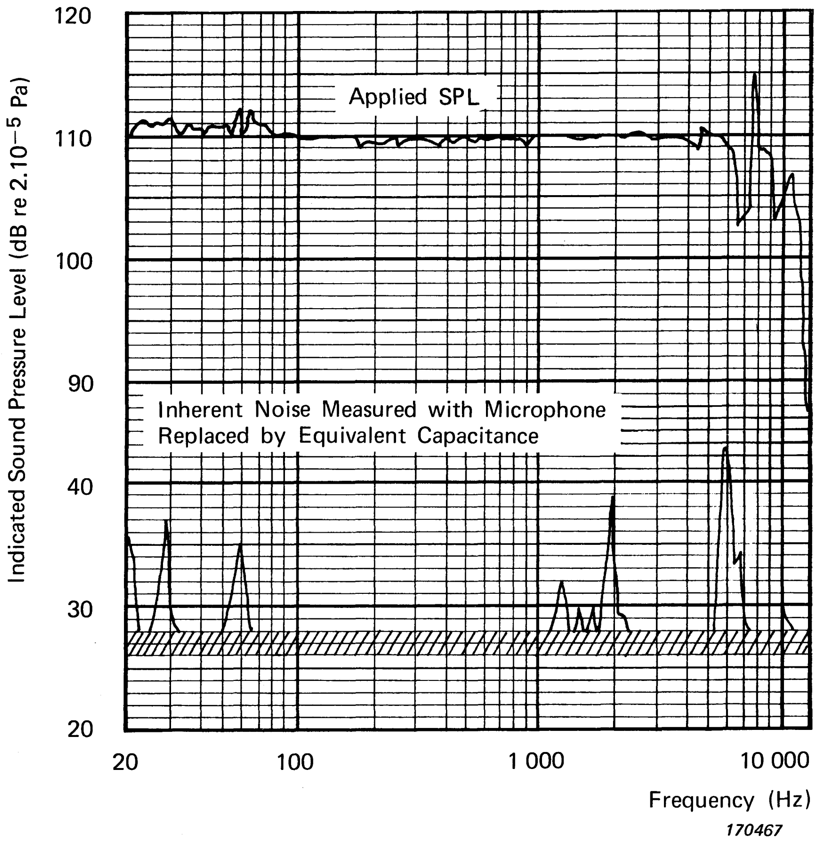


Fig.5.18. Influence of a sound field

5.12. VIBRATION

The effect of vibration on a typical microphone and input stage is shown in Fig.5.19. The constant 1 g acceleration is applied at the fix-

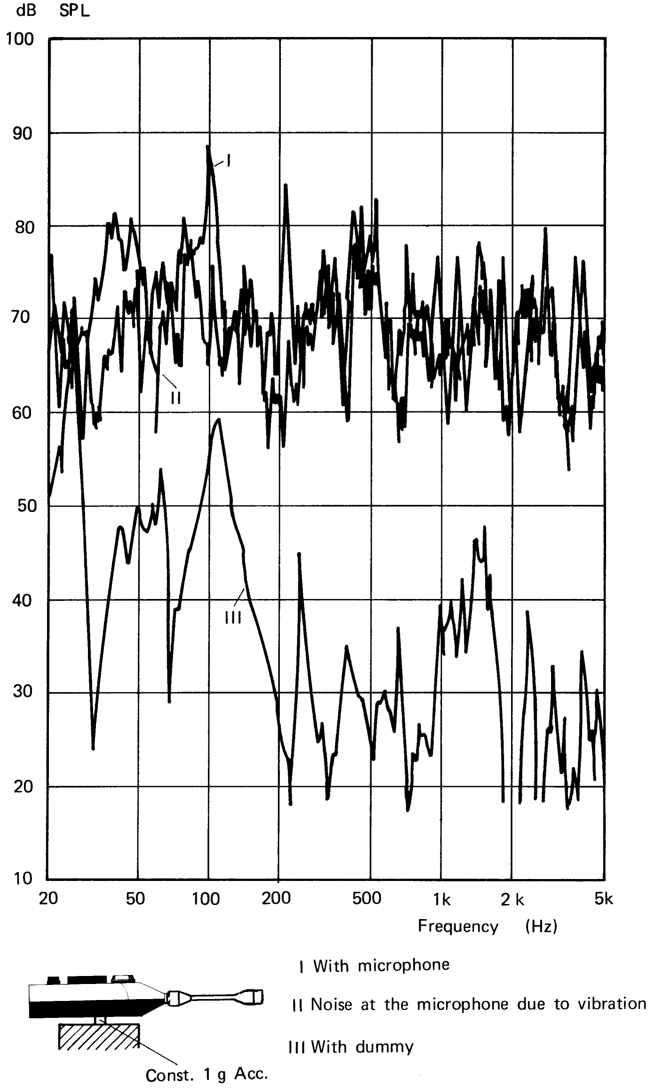
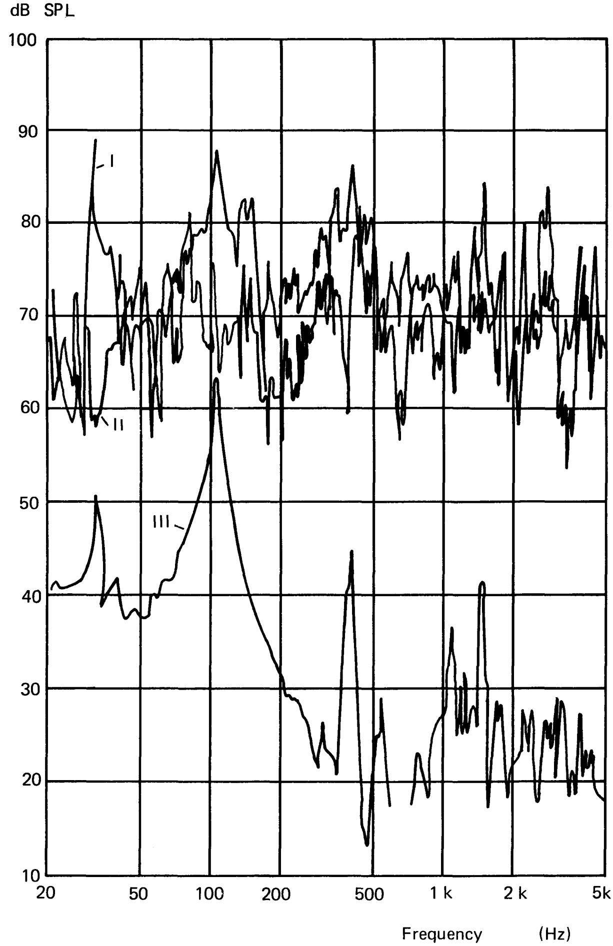
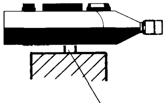


Fig.5.19a. Influence of vibration





I With microphone

II Noise at the microphone due to vibration

III With dummy

172052

Fig. 5.19b. Influence of vibration

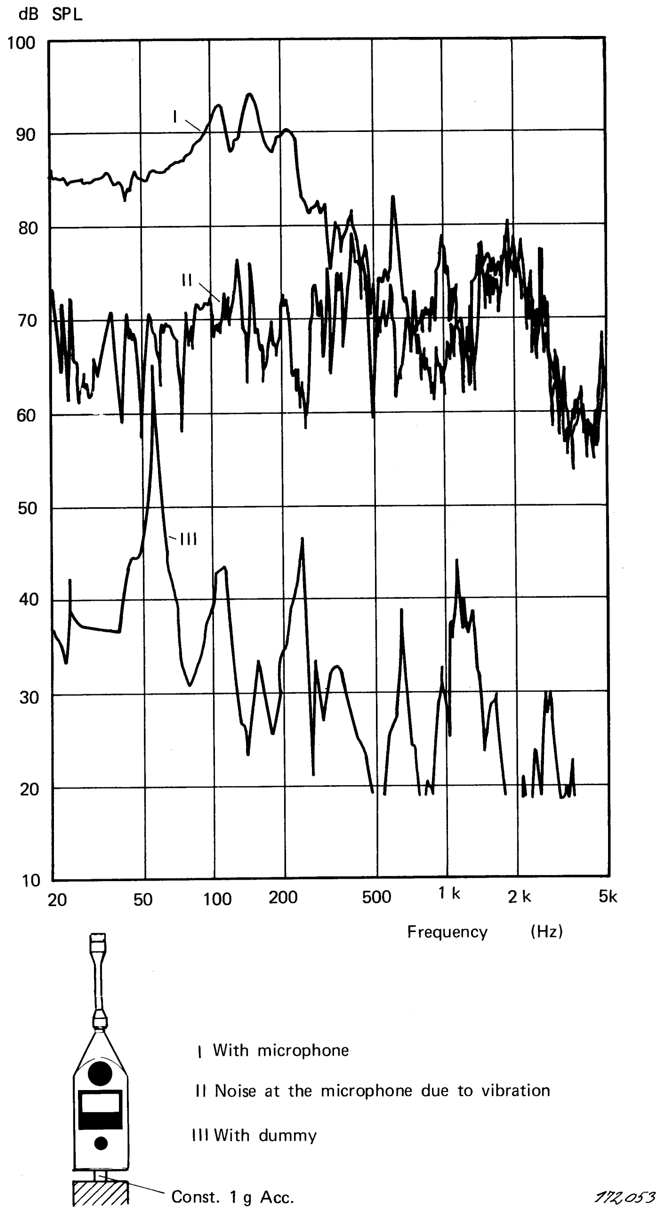
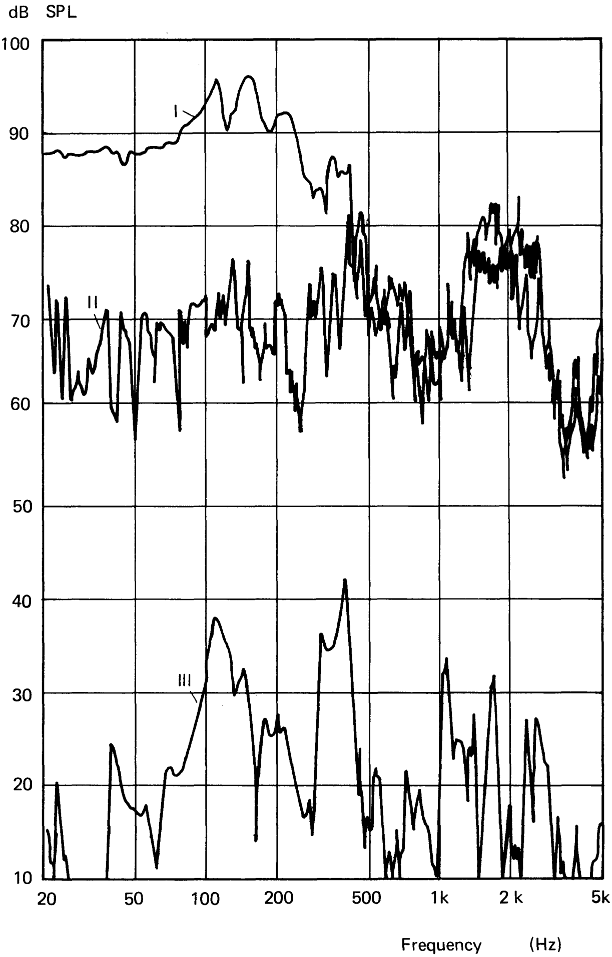
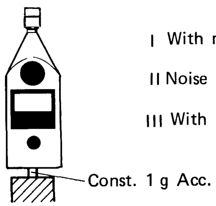


Fig. 5.19c. Influence of vibration





I With microphone

II Noise at the microphone due to vibration

III With dummy

172055

Fig. 5.19d. Influence of vibration

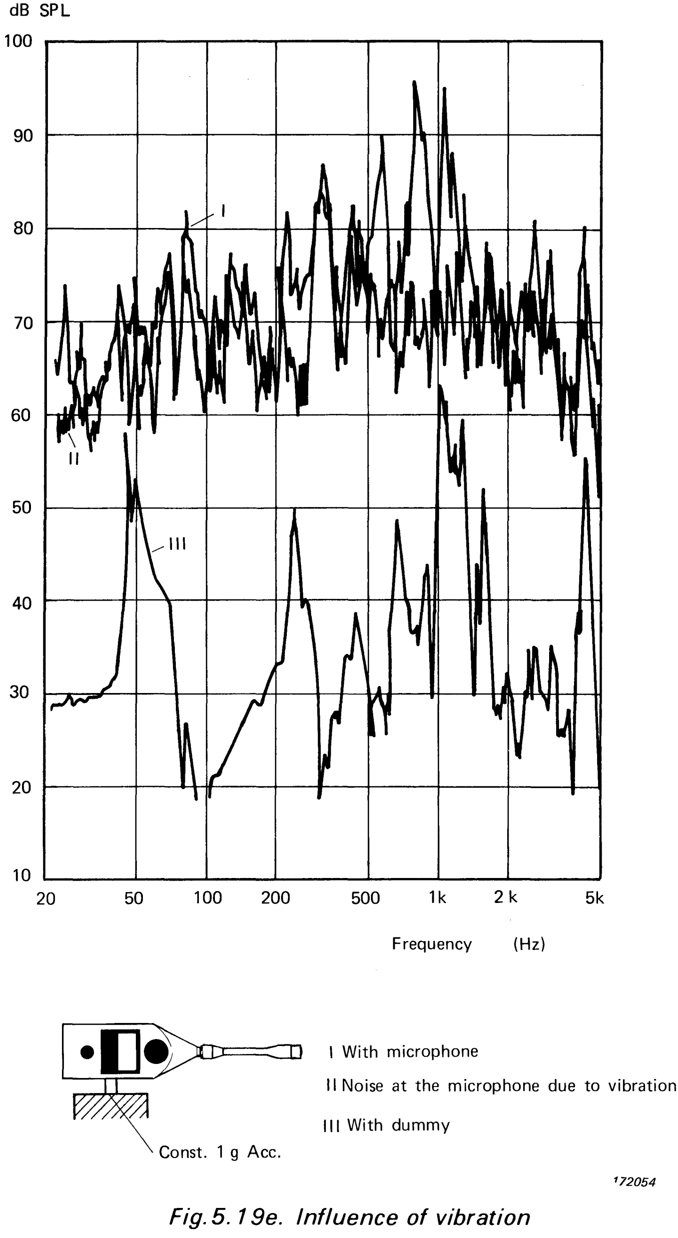


Fig. 5.19e. Influence of vibration

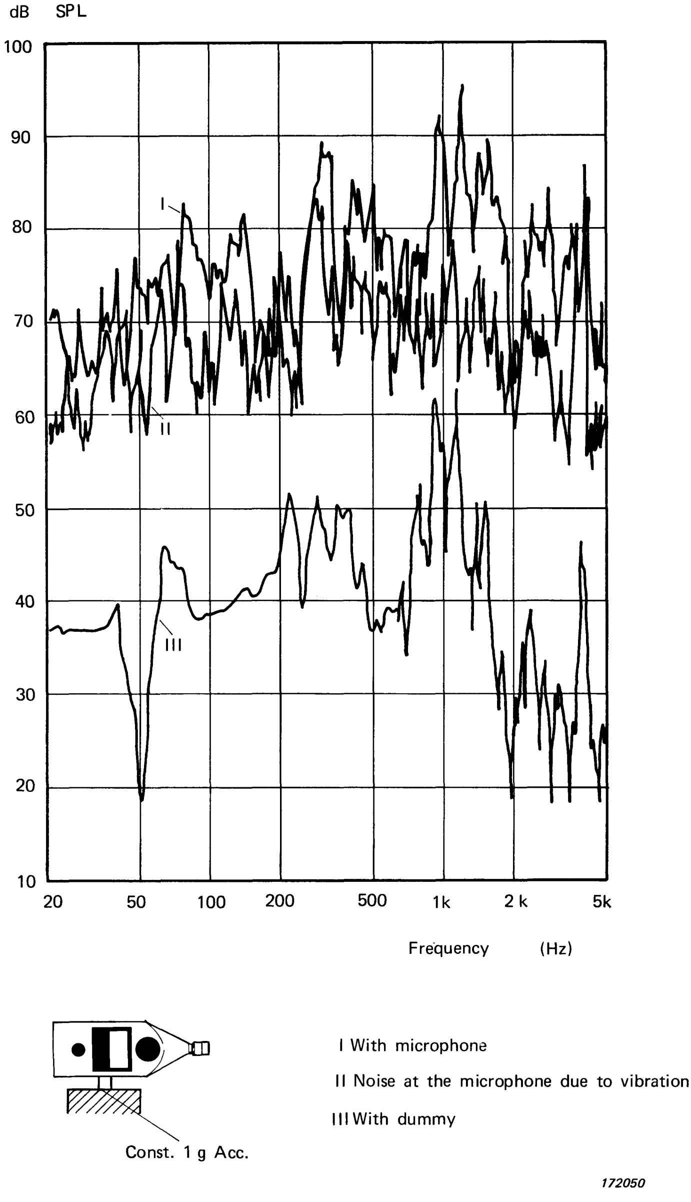


Fig. 5.19f. Influence of vibration

ture screw holes for the tripod in cases, a, b, c, & d. In cases e and f the instrument was firmly clamped to the vibration platform.

In these records, Curve I is the reading of the complete Meter and Microphone. Curve II is the noise at the microphone position measured by a stationary sound level meter. Curve III is the complete Meter, but with the Microphone replaced by a dummy with the same capacitance as the one-inch Microphone, but with negligible acoustic or vibration sensitivity. As is to be expected the Microphone is most affected when the vibration is perpendicular to the diaphragm. The noise from 1 g RMS can then amount to an equivalent SPL of about 88 dB.

5.13. PRESSURE

The effect of static ambient pressure on the sensitivity and frequency response of the Type 4145 Microphone is shown in Fig. 5.20 and 5.21.

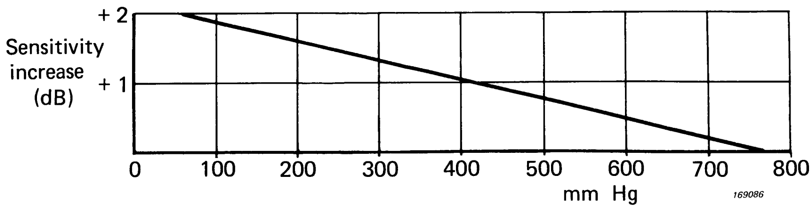


Fig. 5.20. Change in Microphone sensitivity with ambient air pressure

Fig. 5.20 was measured at 250 Hz and should not be applied at any other frequency without reference to the frequency response variations. A variation from normal atmospheric pressure of 10% produces a change in microphone sensitivity of ± 0,2 dB.

5.14. WIND

Complete specifications on the effect of wind on the Microphone are given in the Microphone Instruction Manual. Noise and response specifications are also given for various windscreens and nose cones.

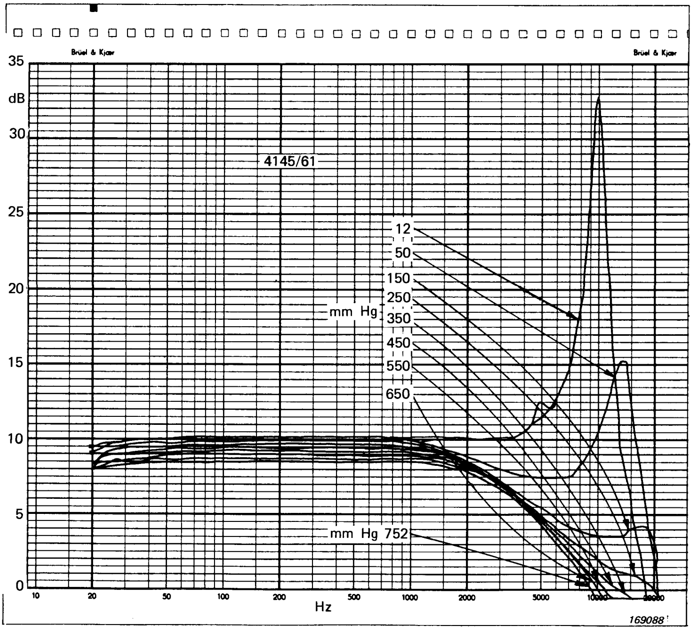


Fig. 5.21. Microphone frequency response with varying air pressure

5.15. ELECTROSTATIC 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.

5.16. MAGNETIC FIELDS

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 36 dB (Lin) on the Meter and input stage.

5.17. WEIGHTING NETWORKS

The four standard frequency weighting networks, A, B, C, and D are incorporated in the 2209. Their frequency characteristics and tolerances are shown in Fig.5.22 and Table 5.4. Note that these tolerances apply to the instrument as a whole in a free field with incidence normal to the microphone diaphragm.

Frequency Hz	Curve A dB	Curve B dB	Curve C dB	Tolerance Limits (dB) for Curves A, B and C		Curve D dB	Tolerance Limits (dB) for Curve D	
10	–70,4	–38,2	–14,3	3	– ∞	–26,6	3,0	– ∞
12,5	–63,4	–33,2	–11,2	3,0	– ∞	–24,6	3,0	– ∞
16	–56,7	–28,5	– 8,5	3,0	– ∞	–22,6	3,0	– ∞
20	–50,5	–24,2	– 6,2	3,0	–3,0	–20,6	3,0	–3,0
25	–44,7	–20,4	– 4,4	2,0	–2,0	–18,7	2,0	–2,0
31,5	–39,4	–17,1	– 3,0	1,5	–1,5	–16,7	1,5	–1,5
40	–34,6	–14,2	– 2,0	1,5	–1,5	–14,7	1,5	–1,5
50	–30,2	–11,6	– 1,3	1,5	–1,5	–12,8	1,5	–1,5
63	–26,2	– 9,3	– 0,8	1,5	–1,5	–10,9	1,5	–1,5
80	–22,5	– 7,4	– 0,5	1,5	–1,5	– 9,0	1,5	–1,5
100	–19,1	– 5,6	– 0,3	1,0	–1,0	– 7,2	1,0	–1,0
125	–16,1	– 4,2	– 0,2	1,0	–1,0	– 5,5	1,0	–1,0
160	–13,4	– 3,0	– 0,1	1,0	–1,0	– 4,0	1,0	–1,0
200	–10,9	– 2,0	0	1,0	–1,0	– 2,5	1,0	–1,0
250	– 8,6	– 1,3	0	1,0	–1,0	– 1,6	1,0	–1,0
315	– 6,6	– 0,8	0	1,0	–1,0	– 0,8	1,0	–1,0
400	– 4,8	– 0,5	0	1,0	–1,0	– 0,4	1,0	–1,0
500	– 3,2	– 0,3	0	1,0	–1,0	– 0,3	1,0	–1,0
630	– 1,9	– 0,1	0	1,0	–1,0	– 0,5	1,0	–1,0
800	– 0,8	0	0	1,0	–1,0	– 0,6	1,0	–1,0
1000	0	0	0	1,0	–1,0	0	1,0	–1,0
1250	0,6	0	0	1,0	–1,0	2,0	1,0	–1,0
1600	1,0	0	– 0,1	1,0	–1,0	4,9	1,0	–1,0
2000	1,2	– 0,1	– 0,2	1,0	–1,0	7,9	1,0	–1,0
2500	1,3	– 0,2	– 0,3	1,0	–1,0	10,4	1,0	–1,0
3150	1,2	– 0,4	– 0,5	1,0	–1,0	11,6	1,0	–1,0
4000	1,0	– 0,7	– 0,8	1,0	–1,0	11,1	1,0	–1,0
5000	0,5	– 1,2	– 1,3	1,5	–1,5	9,6	1,5	–1,5
6300	– 0,1	– 1,9	– 2,0	1,5	–2,0	7,6	1,5	–2,0
8000	– 1,1	– 2,9	– 3,0	1,5	–3,0	5,5	1,5	–3,0
10000	– 2,5	– 4,3	– 4,4	2,0	–4,0	3,4	2,0	–4,0
12500	– 4,3	– 6,1	– 6,2	3,0	–6,0	1,4	3,0	–5,0
16000	– 6,6	– 8,4	– 8,5	3,0	– ∞	– 0,7	3,0	– ∞
20000	– 9,3	–11,1	–11,2	3,0	– ∞	– 2,7	3,0	– ∞

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Table 5.4. Tolerances on the weighting network performance of a Precision Sound Level Meter as a whole in a free sound field with incidence normal to microphone diaphragm

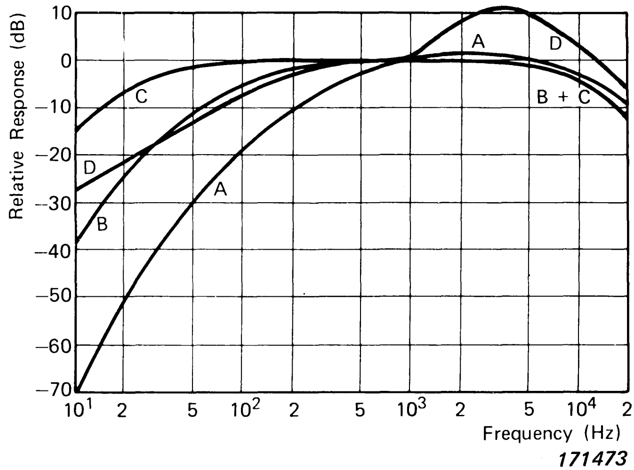


Fig. 5.22. A, B, C and D-weighting networks

5.18. ATTENUATOR FREQUENCY CHARACTERISTICS

The frequency characteristics of both the input and output attenuators are given in Fig. 5.23.

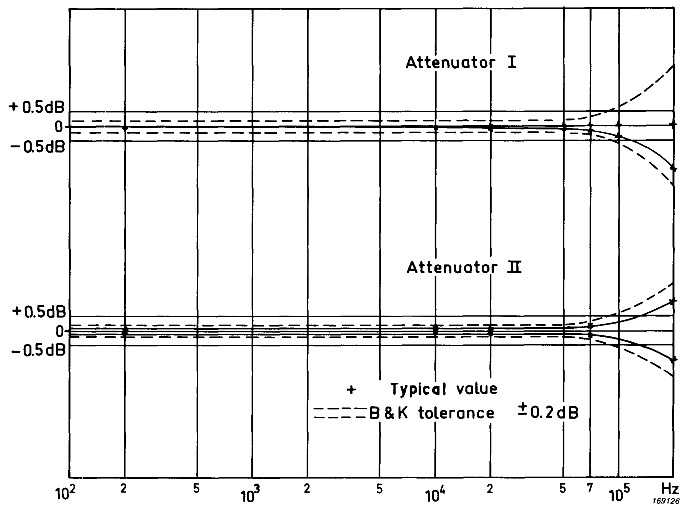


Fig. 5.23. Attenuator frequency characteristics

6. ACCESSORIES AND MEASURING SETS

The accessories available for the 2209 for sound and vibration measurement are shown in Fig.6.1a. The accessories for Artifical Ear and Artificial Mastoid measurements are detailed in Fig.6.1b. Many other instruments, couplers, and accessories may also be used with the 2209. See the B & K Main catalogue for details.

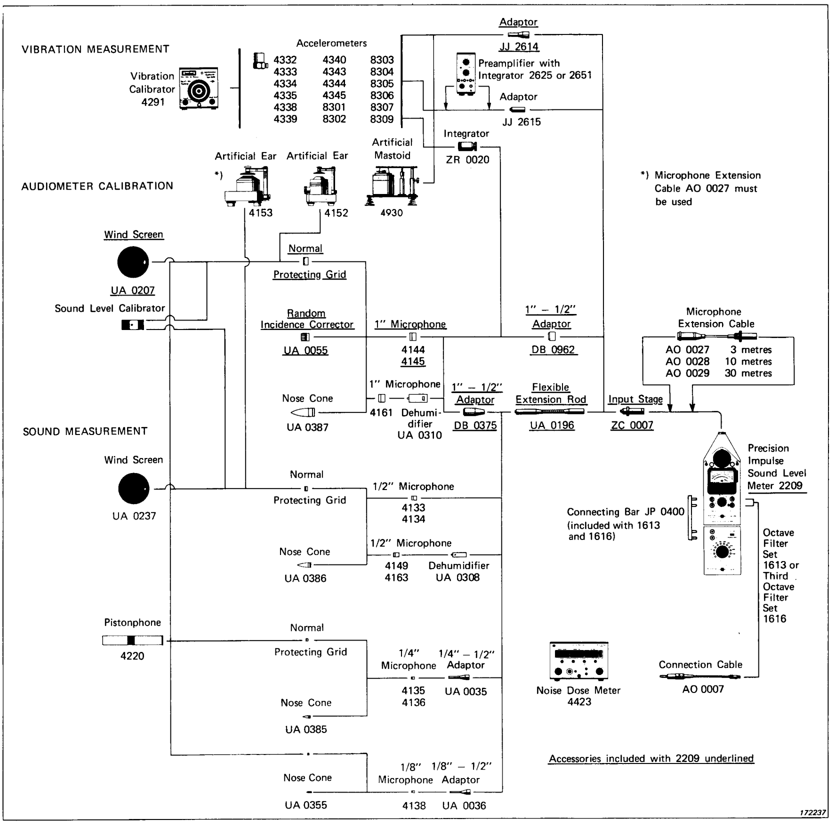
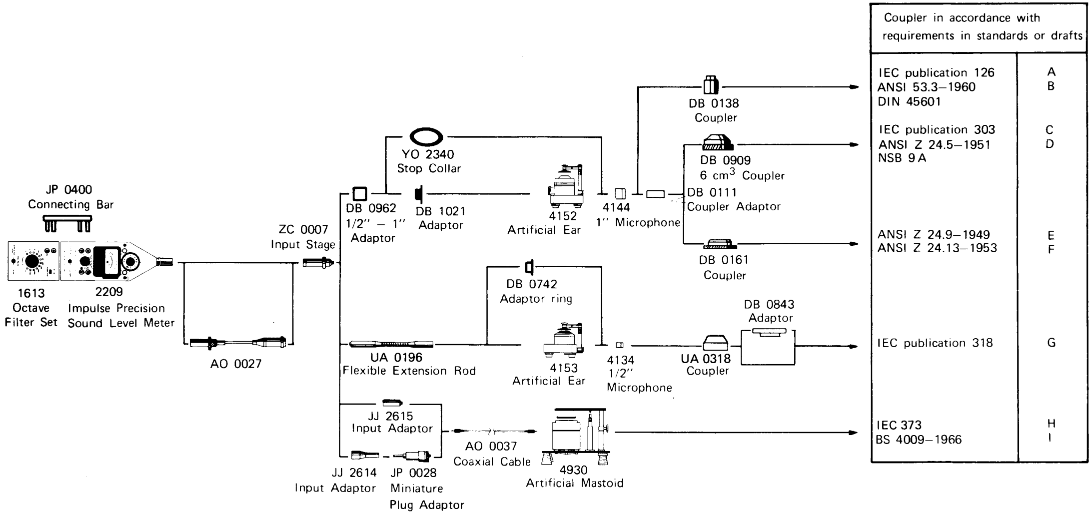


Fig.6.1a. Accessories for sound and vibration measurements



Notes:

Supplied with 2209:
JJ 2614, UA 0196, ZC 0007, 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 2209

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

Fig. 6.1b. Accessories for Artificial Ears and Artificial Mastoid

6.1. ACCESSORIES INCLUDED WITH 2209

The following accessories are supplied with the 2209:

Input Stage ZC 0007 (see section 4.2)
Adaptor JJ 2614
Half-inch to one-inch Adaptor DB 0962
Flexible Extension Rod UA 0196
Half-inch to one-inch Adaptor DB 0375
One-inch Microphone 4145 (See section 4.1)
Random Incidence Corrector UA 0055
Windscreen UA 0207
4 Plugs JP 0006
10 double sided Attenuator Scales
Miniature Screwdriver QA 0001

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.

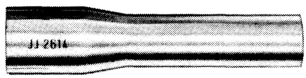


Fig. 6.2. JJ 2614

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.

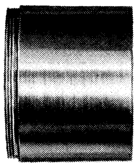


Fig. 6.3. DB 0962

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).

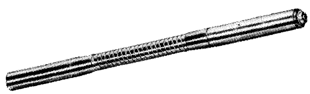


Fig. 6.4. UA 0196

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

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

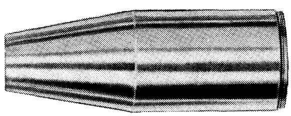


Fig. 6.5. DB 0375

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 and 5.2.

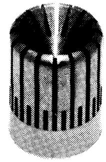


Fig. 6.6. UA 0055

6.1.6. Windscreen UA 0207

Refer to the Type 4145 Microphone Instruction Manual for details.

Scale No.		Function	B & K Type No.
1	A B	10 – 130 dB 20 – 140 dB	SA 0012
2	A B	40 – 160 dB 30 – 140 dB	SA 0013
3	A B	50 – 160 dB 10 μV – 10 V	SA 0014
4	A B	$3.10^{-1} - 3.10^{5}$ $10^{-1} - 10^{-5}$	SA 0015
5	A B	$3.10^{-2} - 3.10^{4}$ $10^{-2} - 10^{4}$	SA 0016
6	A B	$3.10^{-3} - 3.10^{3}$ $10^{-3} - 10^{3}$	SA 0017
7	A B	$3.10^{-4} - 3.10^{2}$ $10^{-4} - 10^{2}$	SA 0018
8	A B	$3.10^{-5} - 30$ $10^{-5} - 10$	SA 0019
9	A B	$3.10^{-6} - 3$ $10^{-6} - 1$	SA 0020
10	A B	$3.10^{-7} - 3.10^{-1}$ $10^{-7} - 10^{-1}$	SA 0021

Table 6.1. Attenuator Scales and Type Numbers

6.1.7. Plugs JP 0006

These coaxial plugs fit the input and output sockets of the 2209 and external Filter Sets 1613 and 1616. Four plugs are supplied with the 2209.

6.1.8. Attenuator Scales

Ten double-sided, interchangeable Attenuator Scales are provided for use with various transducers. See Tables 6.1, 3.1 and 3.2.

6.2. OPTIONAL ACCESSORIES

Many optional accessories are available for the 2209. The main ones are listed and briefly described below:

Octave Filter Set 1613*
Third Octave Filter Set 1616*
Adaptor JJ 2615
Integrator ZR 0020
Accelerometers*
Microphone Extension Cables AO 0027/28/29*
Half-inch, quarter-inch and eighth-inch Microphones
Microphones Adaptors UA 0035/36
Nose Cones UA 0387/86/85/55*
Windscreen UA 0237*
Pistonphone 4220*
Sound Level Calibrator 4230*
Accelerometer Calibrator 4291*
Artificial Ears 4152* and 4153*
Artificial Mastoid 4930*
Connection Cable AO 0007
Carrying Case KE 0055

6.2.1. Octave Filter Set 1613

This filter set (Fig.6.7) is designed for octave analysis of noise and vibration. It fits onto the 2209 with four screws thus making one compact, portable unit.

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

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 2209 are given in the 1613 Instruction Manual.

6.2.2. Third Octave Filter Set 1616

This filter set (Fig. 6.8) contains 34 active filters with third octave center frequencies from 20 Hz to 40 kHz. If fulfils the requirements of IEC R 225, DIN 45652, and ANSI S1.11 Class III.

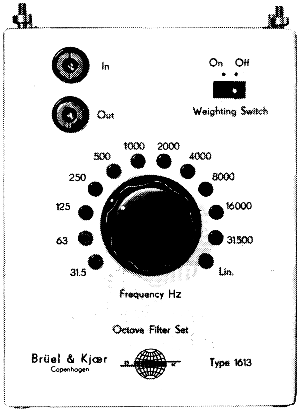


Fig. 6.7. Octave Filter Set 1613

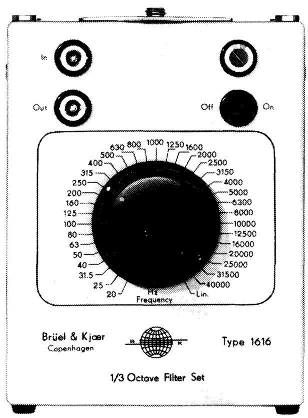


Fig. 6.8. Third Octave Filter Set 1616

See the Instruction Manual of the 1616 for full details.

6.2.3. Adaptor JJ 2615

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

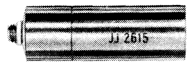


Fig. 6.9. JJ 2615

6.2.4. 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:

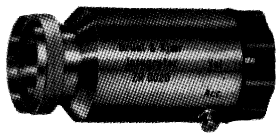


Fig. 6.10. ZR 0020

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
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 2209 are shown in Fig. 6.11.

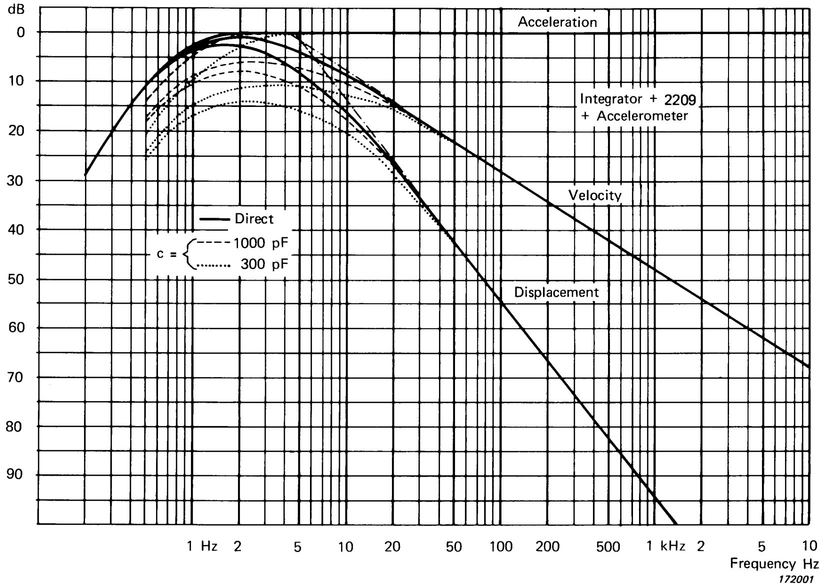


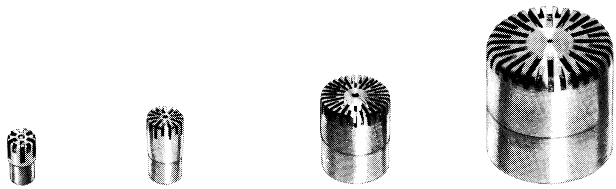
Fig.6.11. Integrator Frequency Characteristics

6.2.5. Accelerometers

The B & K Accelerometers are of the piezoelectric type. Their sensitivities range from 1,2 mV/g to 10 V/g (or 0,4 pC/g to 10000 pC/g). In use with the 2209, the lower frequency limit is 2 Hz while the upper frequency limit of measurement (within 2% of linear response) 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.

6.2.6. Microphones

The B & K Condenser Microphones suitable for use with the 2209 are shown in Fig.6.12. The microphones are designed for linear frequency response over the widest possible range and feature good temperature stability and excellent long term stability. All sizes have linear free field response at 0° incidence in the audio frequency range. Pressure response is linear over the widest possible range of frequencies.



Cartridge Type	4138	4135	4136	4133	4134	4144	4145
Open Circuit Sensitivity (mV/Pa)	1	4	1,6	12,5		50	50
Frequency Range with 2209 ± 2 dB	30 Hz – 70 kHz	8 Hz – 70 kHz	8 Hz – 70 kHz	5 Hz – 40 kHz	5 Hz – 20 kHz	2 Hz – 7 kHz	2 Hz – 18 kHz
Frequency Response	Free Field and Pressure	Free Field	Pressure	Free Field	Pressure and Rand.	Pressure	Free Field
Approx. Dynamic Range* with 2209 (dB)	76 – 170	64 – 162	70 – 170	36 – 150		15 – 140	
Diameter	1/8"	1/4"		1/2"		1"	

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

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Fig. 6.12. Condenser Microphones suitable for use with 2209

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. Smaller microphones are best suited for measurements in intense sound fields, and also generate less turbulence at high wind velocities.

6.2.7. Microphone Adaptors

UA 0035 adapts a quarter-inch Microphones to the half-inch input stage or extension rod. UA 0036 is for eighth-inch Microphones.

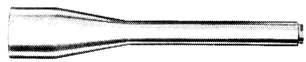

Fig. 6.13. UA 0035

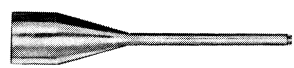

Fig. 6.14. UA 0036

6.2.8. 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). See section 3.4.1 for use with 2209.

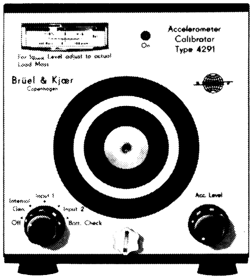

Fig. 6.15. 4291

6.2.9. Artificial Ears 4152/53

Artificial Ears Type 4152 and 4153 were designed for electro-acoustical measurements on earphones under well-defined acoustical conditions. The 4152 is used with couplers which fulfil the requirements of IEC R 126, 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 Impulse Precision Sound Level Meter 2209.

The 4153 was built in conjunction with working group WG 11 of the IEC technical committee TC 29 on the standardization of an improved artificial ear for calibration purposes.

6.2.10. 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.

6.2.11. Connection Cable AO 0007

Uses plug JP 0006 on one end and JP 0101 on the other for connecting the output of the 2209 to recording instruments.

6.2.12. Carrying Case KE 0055

This is a convenient carrying case that will hold the 2209, a Filter Set (1613 or 1616), and many accessories such as a Pistonphone, Accelerometer, Windscreen, extra Microphone, spare batteries, etc.

Fig. 6.16. Carrying Case KE 0055

6.3. COMPLETE MEASURING SETS

6.3.1. Sound and Vibration Sets Types 3507 and 3511

The sets contain the following:

Impulse Precision Sound Level Meter with standard accessories	2209
Octave Filter Set (3507 only)	1613
Third Octave Filter Set (3511 only)	1616
Half-inch Microphone	4133
Pistonphone	4220
Accelerometer Set	4332S
Windscreen	UA 0207
One-inch Nose Cone	UA 0387
Half-inch Nose Cone	UA 0386
Connection Bar	JP 0400
Integrator	ZR 0020
Extension Cable	AO 0027
Tripod Adaptor	UA 0027
Pressure Correction Barometer	UZ 0001
Carrying Case	KE 0055

6.3.2. Audiometer Calibration Sets Types 3508 and 3512

The sets contain the following:

Impulse Precision Sound Level Meter with standard accessories	2209
Octave Filter Set (3508 only)	1613
Third Octave Filter Set (3512 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 2209 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 2209 with other instrumentation, the following should be considered.

1. Be sure the impedance and levels of the instruments are matched. If the output level from the 2209 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 adjustment must be made in the order of the signal path, beginning with the 2209. Each instrument should be optimized from maximum dynamic range and crest factor capability. However, gain should be set such that with a high amplitude signal overload will **only** occur in the 2209 and none of the following stages.

3. Once the various gain controls of the system have been set, only the attenuators on the 2209 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 2209 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

7.2.1. AC Recording

For the recording of continuous, non-impulsive sounds the AC output of the 2209 gives the greatest dynamic range (> 50 dB) and linearity. Output for full scale meter deflection (FSD) is 0,5 V RMS. The METER SWITCH may be in any position without affecting the characteristics of the output signal (except in the Batt. (Rec) position where the output is 20 dB higher than in the other positions: 5 V RMS for FSD).

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

7.2.2. DC Recording

For discontinuous noise (typewriters, punch presses, etc.) the DC output of the 2209 will assure stable operation of the 2305 or 2307 Level Recorder. The DC output comes directly from the meter rectifier circuits and thus its characteristics will be selected by the METER SWITCH (See Fig. 7.1). For the recording of impulsive sounds the "Impulse" position should be used.

The DC output of the 2209 has a dynamic range of approximately 25 dB. Using 50 mm Level Recorder Paper and a 25 dB Range Potentiometer the dynamic range is optimized by adjusting the Level Recorder for an indication of 20 dB corresponding to full-scale deflection of the 2209. (For example: If 2209 reads + 4 dB when calibrating, the Level Recorder should indicate + 14 dB). Thus a signal 5 dB above full-scale deflection can be accurately recorded, provided no overloads occur.

For DC recording the Level Recorder controls may be set as follows:

POTENTIOMETER RANGE	25 dB
RECTIFIER	DC
LOWER LIMITING FREQUENCY	50 Hz
WRITING SPEED	250 mm/s
PAPER SPEED	0,3 mm/s

For use of the 2209 and Level Recorder with the Statistical Distribution Analyzer 4420 see the 4420 Instruction Manual.

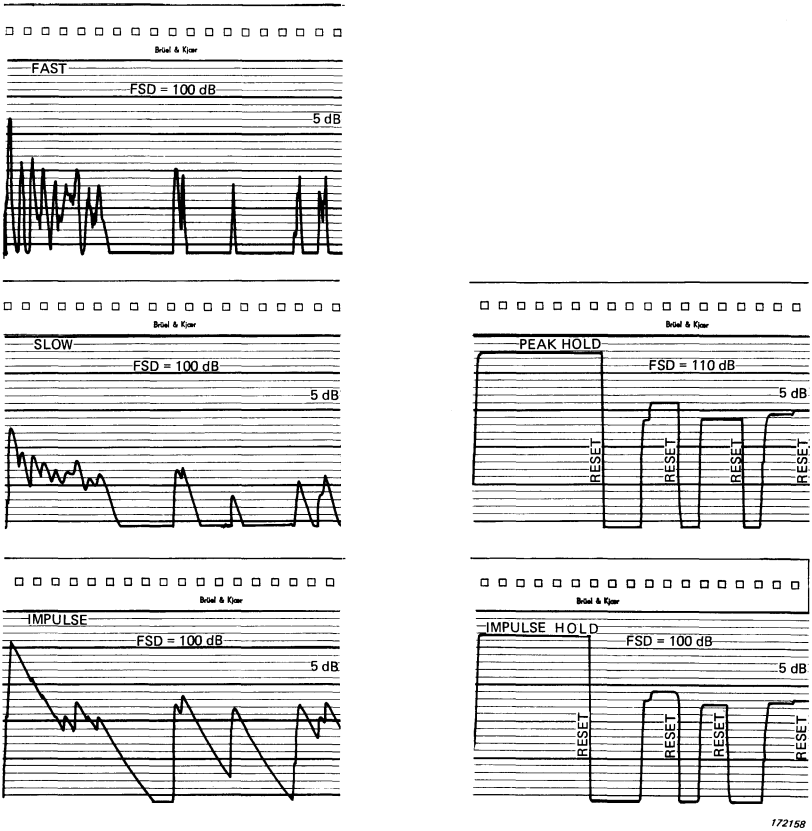

Fig. 7.1. Recordings of punch press noise from DC OUTPUT with various meter responses

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 2209. Since noise dose measurements are commonly made over periods of several hours, provision is made to power the 2209 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 2209 serves as a high quality input to a portable, battery operated recorder such as the B & K 7003 or 7004.

Always adjust tape recorder gain for best dynamic range without overload, and record a calibration reference level to which all attenuator range changes of the 2209 can be referred.

For the recording of impulsive or single event sounds the Tape Loop Cassette UD 0035 may be used with the 7003/4. 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 2209 may be connected to a variety of filters and analyzers permitting constant bandwidth, constant percentage, 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 2209 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 2209 and Filter Sets 1616 or 1613. The methods are described in ISO Recommendation 532 and in the B & K book "Acoustic Noise Measurement".

7.7. MAXIMUM ACCELERATION

When using the "Peak Hold" circuit, the 2209 is well suited for the measurement of maximum acceleration which is an important quantity in the investigation of materials fatigue. It may be necessary to use an external low-pass filter with the 2209 to prevent effects of the high frequency resonance common to accelerometers.

8. SPECIFICATIONS

Specifications for sound measurements refer to the meter with input stage, flexible extension rod and one-inch Microphone 4145 unless otherwise stated.

8.1. FREQUENCY RESPONSE

Low frequency cut-off at the 2209 can be set at either 2 or 10 Hz. See Section 4.2.

One-inch Microphone Type 4145

Linear:	6 Hz — 4 kHz	± 0,5 dB
—	4 Hz — 12 kHz	± 1 dB
—	3 Hz — 18 kHz	+ 1 —1,5 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

Linear:	10 Hz — 8 kHz	± 0,5 dB
—	6 Hz — 20 kHz	± 1 dB
—	4 Hz — 40 kHz	± 2 dB

* 1 Pa = 1 N/m² = 10 μbar

Sensitivity:	approx. 10 mV per Pa*
Temperature Coefficient:	<± 0,006 dB/°C

Individual calibration charts are supplied with every microphone.

Amplifiers

Linear:	3 Hz to 30 kHz	± 0,5 dB
—	2 Hz to 70 kHz	± 1 dB
	20 Hz to 30 kHz	± 0,5 dB*
	10 Hz to 70 kHz	± 1 dB*

Input Amplifier and Input Stage: (see also Fig.5.14)

Linear:	5 Hz to 100 kHz	± 0,5 dB
—	2 Hz to 200 kHz	± 1 dB
	20 Hz to 100 kHz	± 0,5 dB
	10 Hz to 200 kHz	± 1 dB

Total Instrument Amplification:	114 dB
Temperature range:	—20°C to 50°C

Attenuators

Accuracy of attenuator switching: (see also Fig.5.23)	5 Hz to 50 kHz	± 0,2 dB
	2 Hz to 80 kHz	± 0,5 dB

8.2. DYNAMIC RANGE

Measured from 5 dB above noise level to maximum permissible sinusoidal voltage RMS.

One-inch Microphone

"Lin"	10 Hz — 18 kHz	63 μV — 10 V	36 — 140 dB
"C"		13 μV — 10 V	22 — 140 dB
"B"		9 μV — 10 V	19 — 140 dB
"A"		6 μV — 10 V	15 — 140 dB
"D"		18 μV — 10 V	25 — 140 dB

* Optional: See section 4.2.

with 1613 1/1 oct.		500 Hz — 16 kHz*	12 — 140 dB
		125 Hz — 16 kHz	18 — 140 dB
		31,5 Hz — 16 kHz	23 — 140 dB
with 1614 1/1 oct.		500 Hz — 16 kHz	18 — 140 dB
		16 Hz — 16 kHz	25 — 140 dB
		4 Hz — 16 kHz	35 — 140 dB
with 1614 1/3 oct.		100 Hz — 16 kHz	15 — 140 dB
		20 Hz — 16 kHz	22 — 140 dB
		10 Hz — 16 kHz	32 — 140 dB
with 1614	"Lin"	10 Hz — 18 kHz	36 — 140 dB
	"Lin"	22,5 Hz — 18 kHz	26 — 140 dB
	"C"		31 — 140 dB
	"B"		28 — 140 dB
	"A"		21 — 140 dB
	"D"		25 — 140 dB

Half-inch Microphone

"Lin"	10 Hz — 40 kHz	60 — 150 dB
"C"		46 — 150 dB
"B"		40 — 150 dB
"A"		36 — 150 dB
"D"		46 — 150 dB
	500 Hz — 31,5 kHz	34 — 150 dB
with 1613 1/1 oct.	125 Hz — 31,5 kHz	40 — 150 dB
	31,5 Hz — 31,5 kHz	45 — 150 dB
with 1614 1/1 oct.	500 Hz — 31,5 kHz	34 — 150 dB
	125 Hz — 31,5 kHz	40 — 150 dB
	4 Hz — 31,5 kHz	54 — 150 dB
with 1614 1/3 oct.	500 Hz — 40 kHz	30 — 150 dB
	125 Hz — 40 kHz	36 — 150 dB
	20 Hz — 40 kHz	42 — 150 dB
	10 Hz — 40 kHz	50 — 150 dB

* Where filters are used the filter center frequency is quoted

with 1614	"Lin"	10 — 40 kHz	60 — 150 dB
	"Lin"	22,5 — 40 kHz	48 — 150 dB
	"C"		55 — 150 dB
	"B"		50 — 150 dB
	"A"		42 — 150 dB
	"D"		46 — 150 dB

8.3. INPUT STAGE

Removable to permit mounting remote from meter body in connection with B & K standard cables AO 0027, AO 0028, AO 0029 (See also Fig.4.5).

Input impedance > 1 GΩ in parallel with < 0,5 pF, (typically 0,25 pF).

Maximum input voltage 10 V RMS (sinusoidal).

8.4. WEIGHTING NETWORKS

A, B and C to specification of IEC Recommendation 179.

D see Table 5.4.

8.5. EXTERNAL FILTER SOCKETS

In: Output impedance: < 5 Ω in series with 400 μF. Minimum load: 500 Ω.

OUT: Input impedance: 146 kΩ.

8.6. OUTPUT

AC OUTPUT

Meter Switch in position "Peak Hold", "Imp. Hold", "Imp.", "Fast", "Slow".

Output Impedance: 600 Ω

Max. permissible load: Any load permissible without affecting meter deflection
Output voltage corresponding to FSD (open circuit): 0,5 V RMS

Meter Switch in position "Batt. (Rec.)"

Output Impedance: 200 Ω

Minimum Load Impedance: 10 kΩ//200 pF

Output Voltage for the signal which would give full scale meter deflection (open circuit) 5 volts RMS

Maximum output 100 volts peak to peak

Noise at least 50 dB below full scale deflection

DC OUTPUT

Output Impedance: 25 kΩ

Direct short circuit of the DC OUTPUT will not affect the meter reading

Output voltage corresponding to FSD (open circuit): Approx. 0,8 V

Dynamic Range: 25 dB (see Section 7.2.2)

8.7. METER DAMPING

"Fast" and "Slow" in accordance with IEC Recommendation 179

"Impulse" in accordance with proposed extension to IEC 179

"Imp. Hold" indicates maximum RMS level of input signal. Integrating time constant 35 ms. Decay time < 0,05 dB/s

"Peak Hold" indicates maximum peak level of input signal. Rise time 20 μs. Decay time < 0,05 dB/s

8.8. METER INDICATION

RMS (Meter Switch in position "Imp Hold", "Imp", "Fast", "Slow"):

Crest Factor Capability:	10 at FSD increasing to 40 at 12 dB below FSD
Meter Accuracy:	For crest factor up to 10: ± 0,5 dB from FSD to 12 dB below FSD ± 1 dB from 12 dB to 20 dB below FSD

These limits are increased by 0,5 dB for crest factors between 10 and 20 and by 1 dB for crest factors between 20 and 40. See also Fig.5.11 and Table 5.3.

Peak (Meter Switch in position "Peak Hold"):

Rise Time:	Less than 20 μs
Meter Accuracy:	± 0,5 dB from FSD to 12 dB below FSD
Frequency Response:	± 1 dB from 2 Hz (or 10 Hz) to 16 kHz

8.9. INHERENT NOISE

"Linear"	2 Hz 70 kHz:	Max. 30 μV referred to input*
"Linear"	10 Hz 70 kHz:	Max. 30 μV referred to input**
"A"		Max. 2,8 μV referred to input**

8.10. POLARIZATION VOLTAGE

200 volts stabilized.
Effect of temperature shown in Fig.5.15.

8.11. OVERLOAD INDICATORS

Indicate overloads over 50 μs in duration on input and output amplifiers. Some limitation of effectiveness appears at the two highest input attenuator settings. See section 4.5.

8.12. CALIBRATION

Sound Measurements

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

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* With 300 pF in parallel to input
** With 60 pF in parallel to input

Vibration Measurements

The instrument can be calibrated at 1 g peak at 80 Hz by Accelerometer Calibrator Type 4291.

Sound, Vibration and Voltage Measurements

A reference voltage is incorporated to check the amplifiers and meter circuit. Stability is better than ± 0,2 dB over the range of operating temperatures.

8.13. DIRECTIONAL CHARACTERISTICS

See chapter "Operational Characteristics and Accuracy", section 5.1.

8.14. EFFECT OF SOUND FIELD ON AMPLIFIERS

At least 60 dB below sensitivity of one-inch Microphone. See Fig. 5.18.

8.15. EFFECT OF STATIC PRESSURE

Approx. 0,003 dB per mm Hg. See section 5.13.

8.16. EFFECT OF MAGNETIC FIELD

With one-inch Microphone fitted, a magnetic field due to a current of 80 A/m (1 Ørsted) produces a meter deflection of 36 dB SPL.

8.17. EFFECT OF HUMIDITY

Less than 0,5 dB for relative humidity 0 to 90%.

When subjected to extremes of humidity for considerable lengths of time it may be necessary to recalibrate the instrument.

When not in use, the instrument should be stored in a dry place.

8.18. OPERATING TEMPERATURE

—20°C to 50°C (—4°F to 122°F)

8.19. BATTERIES

3 x 1,5 volt flashlight cells (Type R 20 in IEC Publication 86-2) 8 hours battery life for normal operation. Means of checking battery voltage provided.

Rechargeable nickel cadmium batteries may also be used, giving 14 hours continuous operation. The SAFT VOLTABLOC Type VR 3.5 (stocked by B & K as QB 0008) are rated at 1,2 V and 3,5 ampere hours. Minimum number of charge cycles is 300. Rechargeable using B & K Power Supply 2808, Battery Box ZG 0073 and Charging Adaptor AQ 0043.

Alkaline batteries such as Mallory MN 1300 give 20 hours continuous operation.

8.20. DIMENSIONS

Length: 56 cm (22 in) including flexible extension rod and Microphone 33 cm (13 in) meter with input stage

Width: 12 cm (4,75 in)

Height: 9 cm (3,5 in)

8.21. WEIGHT

2,7 kg (6 lb)

3 kg (6,6 lb) with Extension Rod UA 0196

8.22. ACCESSORIES

The accessories available for the 2209 may be seen in Figs.6.1a and 6.1b. Many Couplers, Adaptors and Extension Cables suitable for various working conditions are also available. The reader is referred to the B & K Main Catalog for full details.

The accessories supplied with the 2209 are:

Input Stage ZC 0007 (see section 4.2)
Adaptor JJ 2614
Half-inch Adaptor DB 0962
Flexible Extension Rod UA 0196
Half-inch to one-inch Adaptor DB 0375
One inch Microphone 4145 (see section 4.1)
Random Incidence Corrector UA 0055
Windscreen UA 0207
4 Plugs JP 0006
Attenuator Scales 1A to 10B (SA 0012 to SA 0021), (See Table 6.1)
Miniature Screwdriver QA 0001

Other main accessories available for the 2209 are:

Octave Filter Set 1613
Third Octave Filter Set 1616
Adaptor JJ 2615
Integrator ZR 0020
Accelerometers
Microphone Extension Cables AO 0027/28/29
Half-inch, Quarter-inch, Eighth-inch microphones
Half-inch to Quarter-inch and Half-inch to Eighth-inch Adaptors UA 0035/36
Noise Cones UA 0387/86/85/55
Windscreen UA 0237
Pistonphone 4220
Sound Level Calibrator 4230
Accelerometer Calibrator 4291
Artificial Ears 4152/53
Artificial Mastoid 4930
Connection Cable AO 0007
Carrying Case KE 0055

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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