# Instruction Manual 2215

## Precision Sound Level Meter and Octave Analyzer Type 2215

A light-weight portable sound level meter that meets IEC R 179 (1973), DIN 45633 part 1, and ANSI S1.4-1971 Type S1 for precision sound level meters. It contains ten octave filters that fulfil IEC R 225 (1966), DIN 45651, and ANSI S1.11-1966 Class II, with centre frequencies from 31,5 Hz to 16 kHz. In addition there are Linear response, and A- and C-weighted networks. There is a switchable AC or DC output for connection to recorders, with 64 dB range on DC, directly proportional to dB. A wide range of accessories is available to extend the range of operations, including accelerometers to permit measurement of vibration.

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# PRECISION SOUND LEVEL METER
# OCTAVE ANALYZER
# TYPE 2215

June 1977

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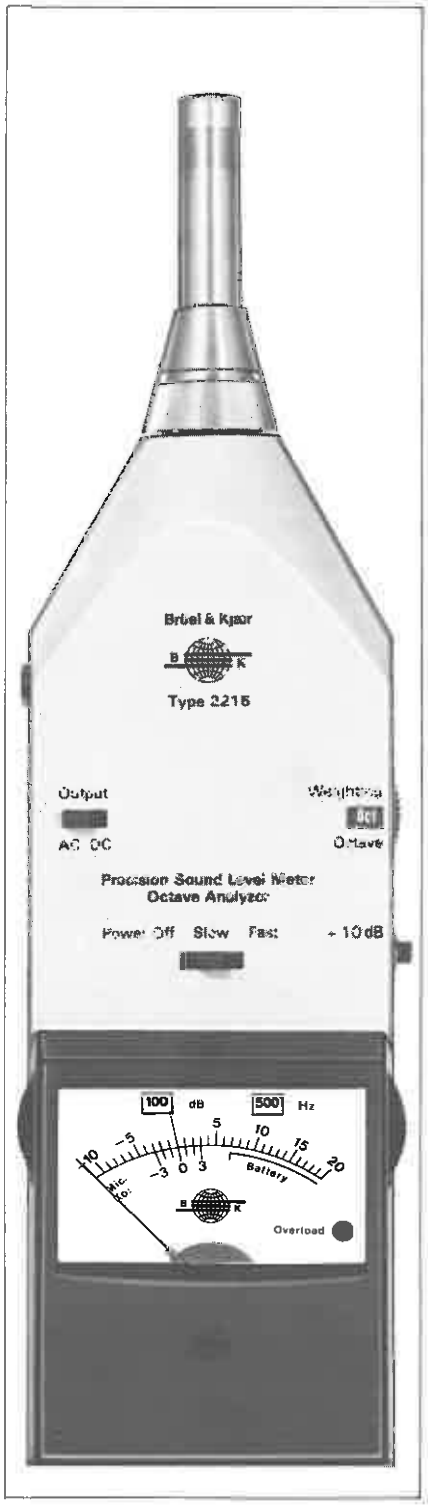
type 2215

# Precision Sound Level Meter and Octave Analyzer

FEATURES:

- Compliance with all existing standards for precision sound level meters
- Frequency range from 20 Hz to 20 kHz
- 10 octave filters to IEC R 225 (1966) and ANSI S1.11-1966 Class II
- Centre frequencies from 31,5 Hz to 16 kHz
- Individually calibrated precision condenser microphone
- Measuring range from 26 to 140 dB(A)
- DC output linear in dB with 64 dB range
- Built-in A- and C-weighting, plus linear response
- Ability to measure A-weighted octave levels
- Only 290 mm tall, weighing 1,1 kg
- Slow and Fast meter damping
- AC output
- Light weight, battery operated portability
- Robust, compact construction
- One single attenuator control
- Virtual one-handed operation
- Large, easily read linear 30 dB meter scale
- Attenuator and octave settings shown on meter scale
- Built-in calibration oscillator
- Conical front to give minimum disturbance to the sound field
- Overload warning lamp
- Power cutoff in event of low battery voltage




USES:

- Precision sound level measurement and octave band analysis
- Precision measurement and analysis of vibration
- Sound measurements in industrial work areas to check for health hazards
- Measurements for community noise protection
- Noise and vibration measurements in industry for quality control and product development
- Noise and vibration measurements to octave tolerance curves
- Loudness evaluation in accordance with ISO R 532
- Positive identification of dominant A-weighted octave band
- Measurement of sound insulation, sound distribution, and the acoustic properties of buildings and enclosures
- Audiometer calibration

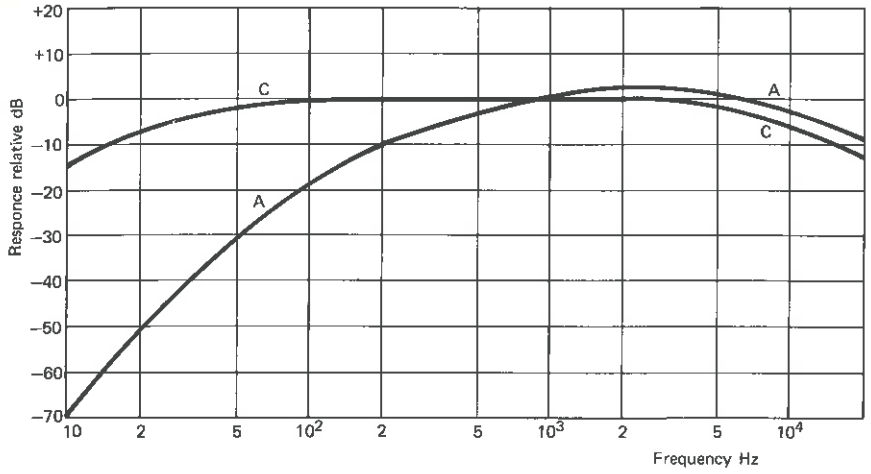



**Fig.2. Frequency response curves of the A and C weighting networks**

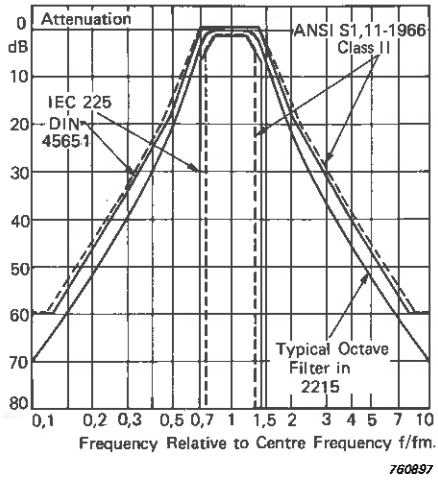



**Fig.3. Typical octave filter characteristic of the filters in Type 2215 with IEC, DIN, and ANSI limitation curves drawn in**

The Input section of the instrument contains a field effect transistor coupled as a source follower to provide the high input impedance required by the Microphone. The Input section complete with the screw-on Microphone capsule can be unplugged and removed to enable the Microphone to be used remote from the instrument. A remotely positioned microphone is very useful where space is too restricted to install the whole instrument, where the presence of the operator will disturb the sound field, where the sound levels to be measured are uncomfortably high for the operator or where the environment is dangerous. A suitable extension lead for these applications is the Microphone Extension Cable AO 0134, which is three metres in length.

### Amplifiers and Attenuators

From the Input section, the signal passes through a Weighting Network to the first Attenuator and fixed-gain Amplifier. To simplify the use of the instrument, a single rotary RANGE switch controls both the amount of attenuation applied and the sequence of operation of the Attenuators. This is done in such a way that the best possible signal to noise ratio is maintained automatically at all times, consistent with preventing overload in the Amplifiers and the Filters. In addition, there is a push button Attenuator that lets the user cope with sudden excess signal levels by instantly increasing the attenuation by 10 dB. This extra attenuation may also be used to cancel any possible overload of the Preamplifier.

Passing through a Weighting and Filter section containing the Octave Filters, the signal to be measured enters the final Attenuator and Amplifier section of the main amplifier. Here another stage of attenuation is applied. To facilitate reading the noise level directly from the meter, the combined Attenuator setting is indicated in a window by the meter scale zero line.

The Output Amplifier contains facilities to enable the overall sensitivity of the Sound Level Meter to be adjusted to match the sensitivity of any individual Microphone being used.

### Octave Filters and Weighting Networks

Filter and weighting functions are all selected by the WEIGHTING control, with the selected function being indicated in a window in the top plate of the instrument. The functions available are as follows:

"A-weighting"
"C-weighting"
"Linear"
"Octave"
"A-weighting plus Octave"

In "Linear" mode the frequency response of the instrument is linear within ± 3 dB from 20 Hz to 20 kHz. The built-in A- and C-weighting networks are in accordance with the IEC Recommendation for precision sound level meters.

There are ten Octave Filters built-in which have centre frequencies between 31,5 Hz and 16 kHz. They are all 6-pole Butterworth type active filters which conform to IEC R 225 (1966), DIN 45651, and ANSI S1,11-1966 Class II, (the most rigorous standards for octave filters). The total integrated random (white) noise power passed by the practical filters used in this Sound Level Meter is equal to that which would be

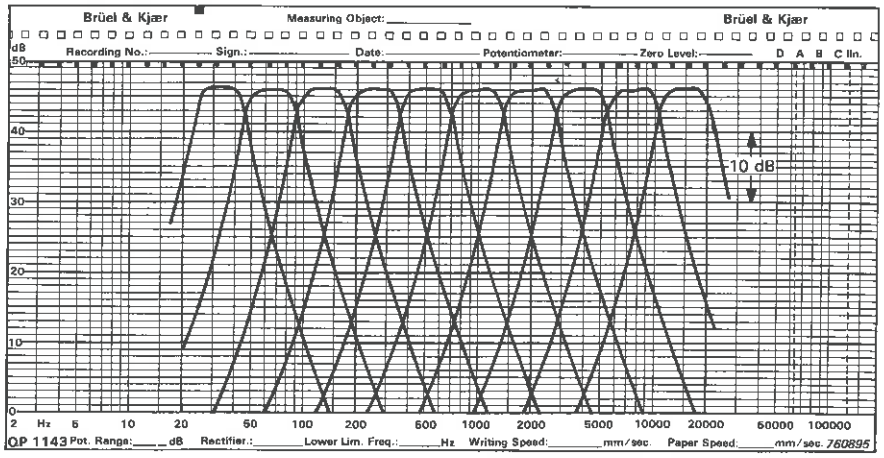



**Fig.4. Frequency characteristics of the ten octave filters in Type 2215**

The Precision Sound Level Meter and Octave Analyzer Type 2215 is a robust, battery-powered, go-anywhere instrument that can make precision sound level measurements, and analyze the levels into octave bands. It is a useful tool for noise abatement engineers, industrial hygienists, public health inspectors, quality control engineers, noise insulation specialists, product development engineers, and research workers in the fields of sound and vibration.

The Type 2215 employs modern miniaturisation techniques to obtain a compact instrument incorporating a set of ten octave filters made to the most rigorous standards to cover the audio frequency range. This tightly packed unit, weighing approximately one kilogramme, permits virtual one-handed operation. With the simplified operating procedures made possible by good ergonomic design, the Type 2215 can be used by inexperienced personnel after a minimum of training.

The Sound Level Meter fulfils the requirements of IEC R 179 (1973), DIN 45633 part 1, and ANSI S1,4-1971 Type S1 for precision sound level meters. And the built-in octave filters fulfil the strictest standards for octave filters; IEC R 225 (1966), DIN 45651, and ANSI S1,11-1966 Class II.

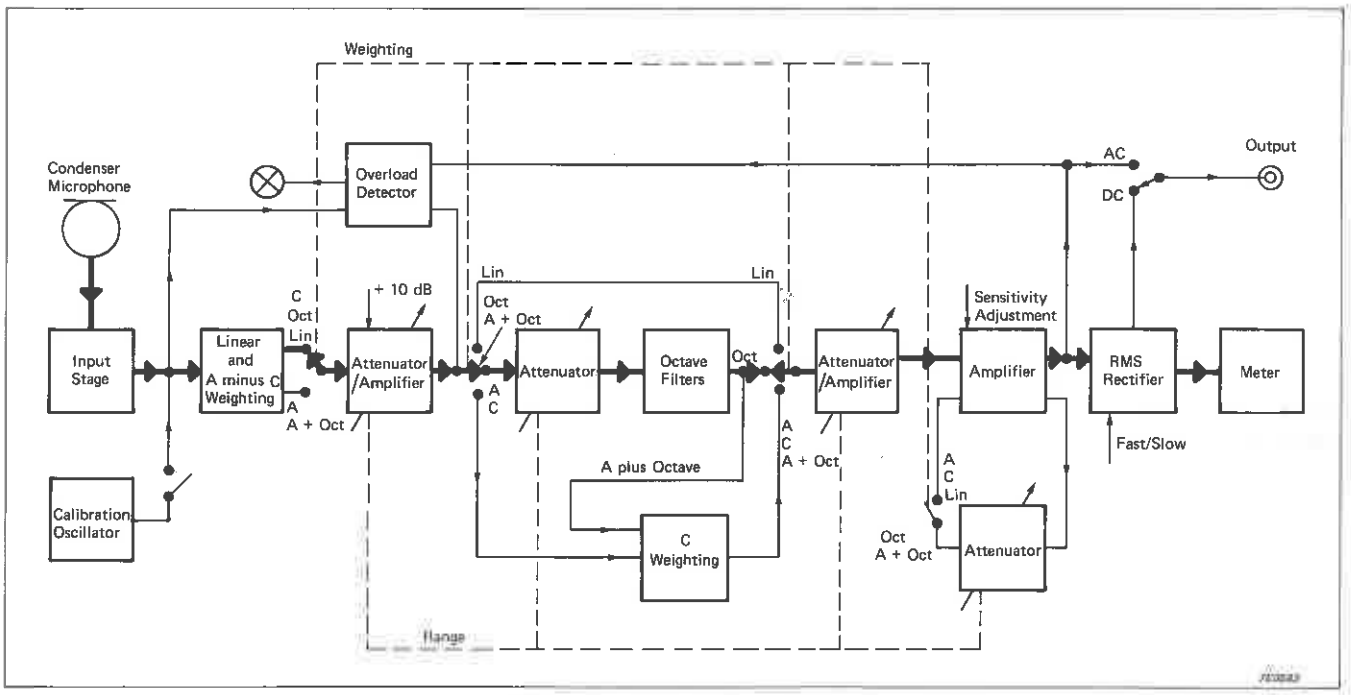



**Fig.1. Block diagram of Type 2215**

# Description

In one compact unit, the Sound Level Meter contains a condenser microphone with associated polarization voltage supply, a high impedance FET preamplifier, a low noise amplifier chain, a set of octave filters and weighting networks, and a true RMS rectifier circuit with a moving coil meter. A built-in reference generator to provide an easy check of the electrical circuits completes the system.

### Microphone and Input

The B & K Microphone Type 4165 employed in the Sound Level Meter is a 1/2" diameter precision condenser type with the high sensitivity of 50 mV/Pa (5 mV/$\mu$bar). It is specially constructed for use on sound level meters, where this combination of small size to minimise disturbance to the sound field being measured, and high sensitivity, equivalent to a 1" condenser microphone, is very important. The Type 4165 is very reliable in outdoor measuring situations, where its quartz covered diaphragm ensures comparative freedom from humidity effects. For full protection, its back venting permits use of Dehumidifier Type UA 0308

The microphone is designed to have a linear frequency response when used for free-field measurements with a zero degree angle of incidence. Each Microphone is calibrated individually, and a chart containing the frequency response curve and sensitivity data is supplied with the Sound Level Meter.

A Windscreen UA 0237 is supplied with the instrument, it should be fitted over the Microphone when measuring out of doors to reduce wind noise. An Input Adaptor JJ 2615 is also available which can be fitted instead of the Microphone to allow direct electrical inputs from accelerometers for vibration measurement, and from hydrophones for underwater sound measurement.

passed by an ideal octave filter. The effective bandwidth of these practical filters corresponds with the —3,7 dB points, i.e. where the characteristic curves of adjacent filters cross over. Fig.4 shows a set of typical frequency characteristics for the ten Octave Filters.

### Detector and Meter

The RMS Detector is accurate within ±0,5 dB for signals with crest factors up to 5 for full scale deflection. This crest factor capability increases proportionally up to a maximum of 50 for signals giving less than full scale deflection. This crest factor capability is available at the DC output too. The Detector is also equipped with the two standardised meter damping characteristics "Fast" and "Slow" as specified by IEC R 179.

To provide easy readability, the ribbon suspended moving coil DC indicating Meter is equipped with a scale 5,5 cm in length. The scale is calibrated linearly with one decibel divisions over 30 dB, from —10 dB to + 20 dB. There are two windows in the scale, one by the zero mark indicates combined attenuator setting, (or "Battery Check" or "Calibration" if either of these functions has been selected). The other window indicates centre frequency of the Octave Filter being used, so that complete level and frequency information can be obtained from the meter scale.

A DC output linear in volt per dB level direct from the Detector, or an AC output from the final Amplifier section is available at the Output terminal. The output signals have a range of up to 64 dB, (50 dB normal range plus 14 dB crest factor allowance). These calibrated signals can be recorded by tape or level recorders to obtain a permanent record of the measured levels. The output levels can also be fed to other instrumentation for further analysis.

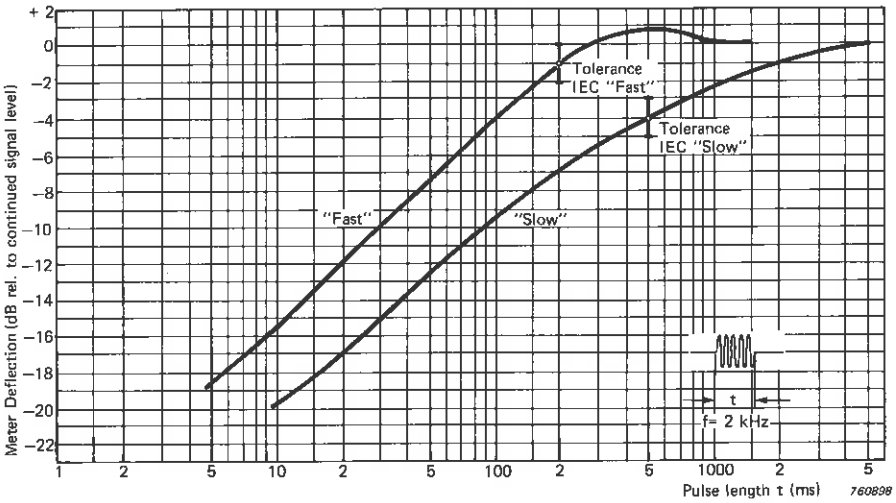



**Fig.5. "Fast" and "Slow" rectifier and meter response to tone bursts of varying duration**

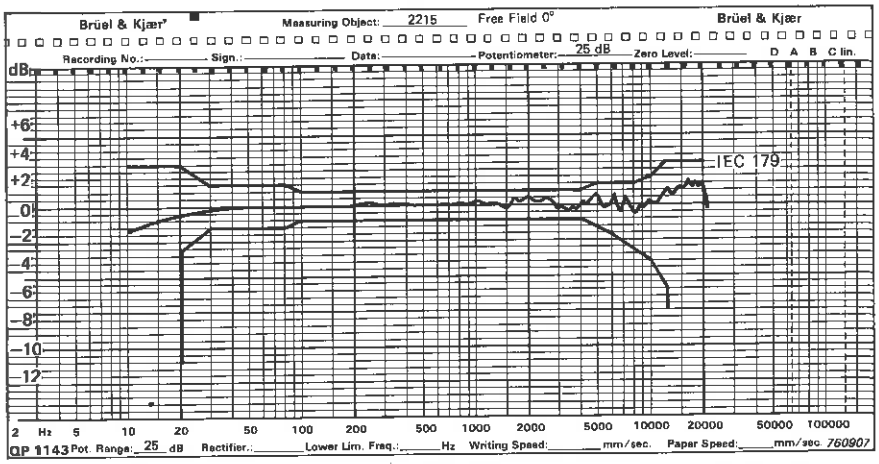



**Fig.6. Free-field frequency response of complete instrument to sine waves with 0° incidence**

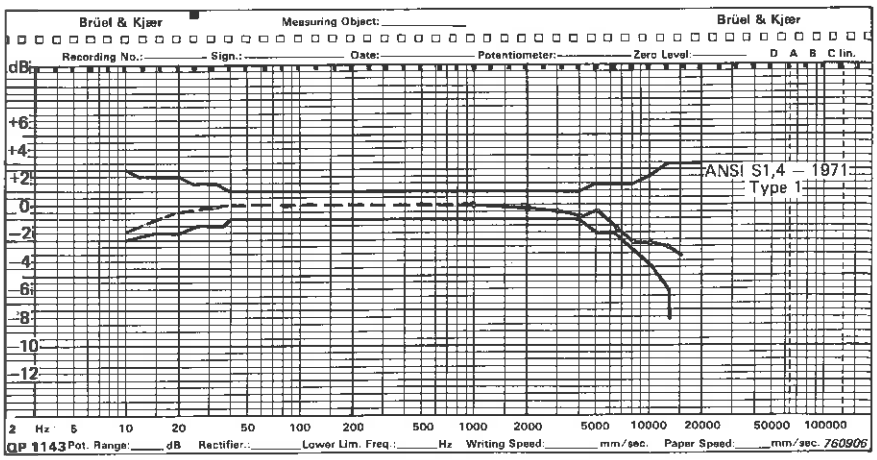



**Fig.7. Diffuse-field (random incidence) frequency response of the complete instrument**

### Calibration

Sound Level Meter calibration can be accomplished in two ways. By using the 1 kHz sine wave generated by the internal Calibration Oscillator the electronic portion of the instrument can be checked. The other method, acoustic calibration, employs an external sound source

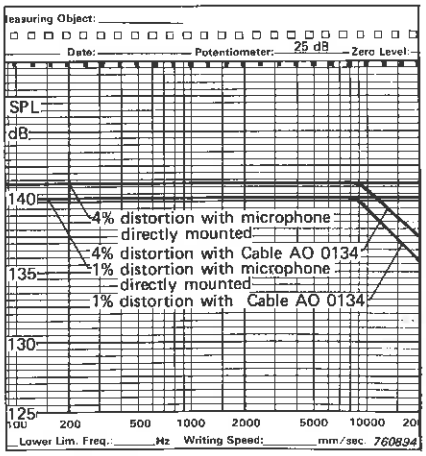



**Fig.8. Distortion of the input stage as a function of the S.P.L.**

to apply a known sound level to the microphone, thereby checking the complete instrument. Suitable calibrators for this purpose are the Sound Level Calibrator Type 4230 (94 dB at 1 kHz), and the Pistonphone Type 4220 (124 dB at 250 Hz).

### Power Supply

Power is obtained from four 1,5 V pen-light batteries carried internally. They are IEC Type LR 6 alkaline batteries B & K order No. QB 0013, which give the Type 2215 approximately 20 hours of continuous operation. Battery condition can be shown on the meter scale. When battery output falls below the minimum usable voltage, the power is automatically switched off, to prevent incorrect measurement.

### Characteristic Curves

Fig.6 shows a typical frequency response curve for the Sound Level Meter in a free sound field at 0° incidence, using "Linear" response. Fig. 7 shows a typical random incidence response for the Type 2215. Tolerances permitted by the measuring standards are also indicated.

## Accessories

A wide selection of accessory equipment can be employed together with the Type 2215 to expand its area of application. A survey showing connection possibilities for some of the most useful items is given in Fig.13. For detailed information on individual instruments and transducers, please ask for the relevant Product Data sheets.

### Other Microphones and Hydrophones

For measurements at higher levels than those possible with the 1/2" Microphone Type 4165 supplied, or if a linear response with random incidence is required, other 1/2" microphones from the B & K program, such as Types 4133, 4134, 4163, or 4166 can be fitted directly to the (removeable) Input stage. 1" microphones can be fitted using Adaptor DB 0962 which allows direct mounting on the Input stage. Note, to improve their omnidirectivity, 1" microphones must be used with a Random Incidence Cor-

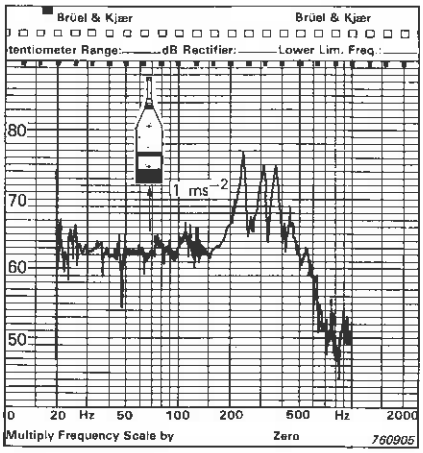



**Fig.9. Equivalent sound pressure level when complete sound level meter is excited vertically at 1 m/s²**

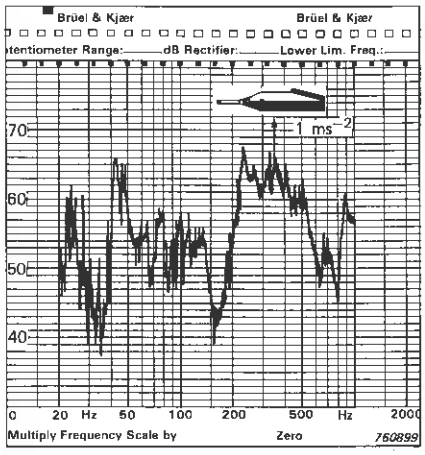



**Fig.10. Equivalent sound pressure level when complete sound level meter is excited horizontally at 1 m/s²**

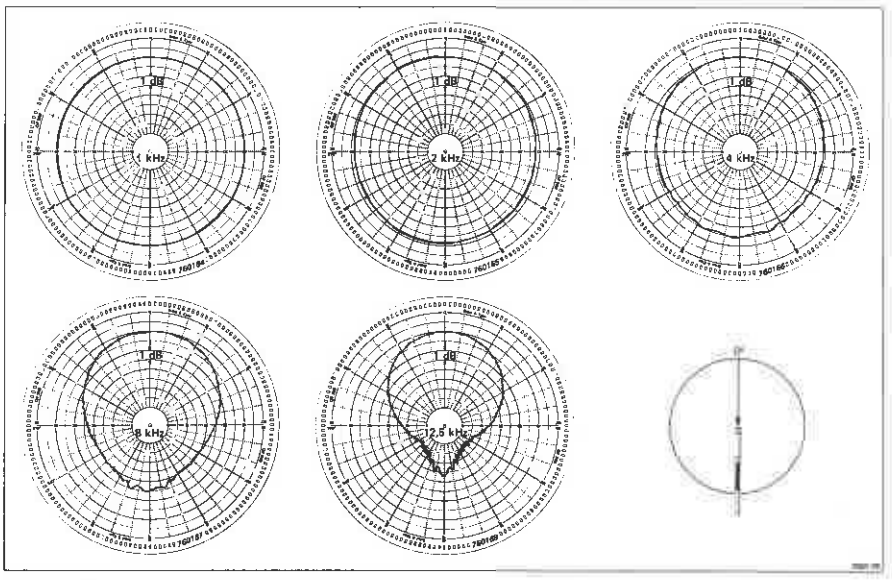



**Fig.11. Directional characteristics of the Microphone Type 4165 in a free-field**

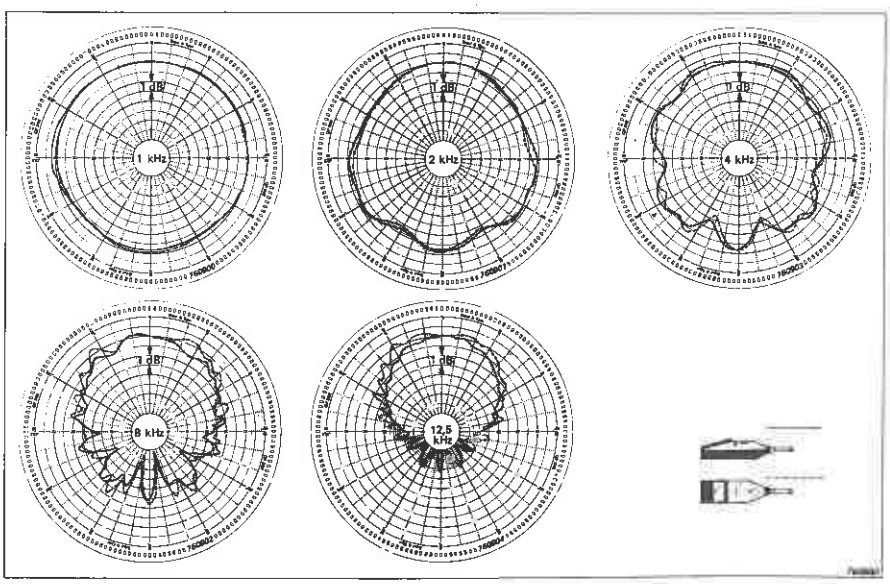



**Fig.12. Directional characteristics of the complete instrument in a free-field**

rector UA 0055 instead of the normal protection grid. Other microphones with their connection possibilities are indicated in Fig.13.

Underwater sound level measurement and frequency analysis can be performed when a suitable hydrophone, for example B&K Hydrophone Type 8100, or Type 8103 is employed. The normal Microphone is replaced by an input Adaptor JJ 2614 to accept the plug on the Hydrophone cable. The Type 8103 will require an Adaptor JP 0028 in addition.

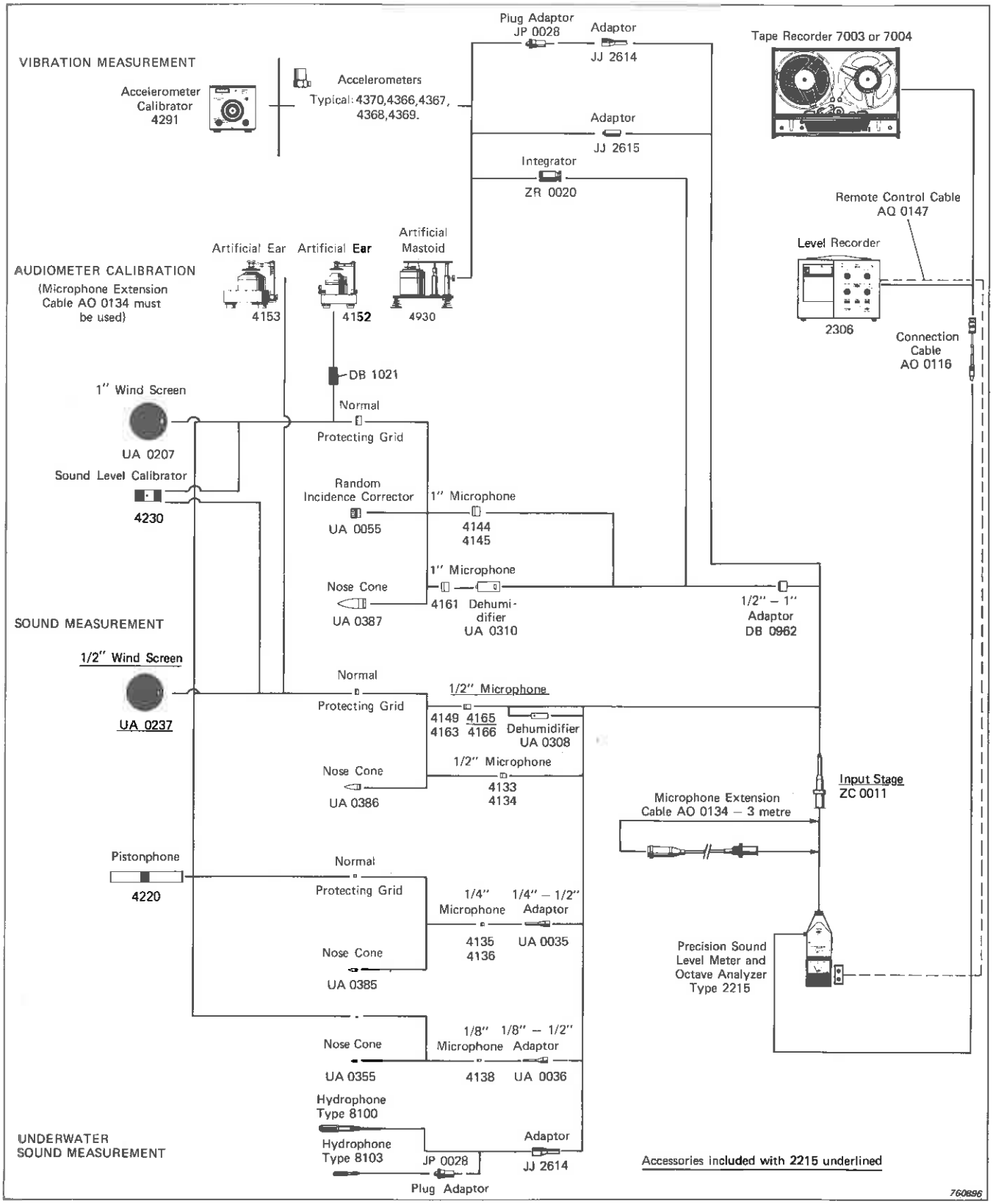



**Fig.13. Accessories available for sound and vibration measurement and analysis, and for audiometer calibration**

### Artificial Ears and Mastoids

An accurate, compact and fully portable audiometer calibrator is created when the Microphone is replaced by an Artificial Ear Type 4152 or Type 4153, using 1" Microphone Type 4144 or 1/2" Microphone Type 4134 respectively. These arrangements are also very suitable for making measurements on hearing aids and earphones. When the Artificial Mastoid Type 4930 is connected instead of the Microphone (using Adaptors), measurements on bone vibrators and bone conduction hearing aids can be performed.

### Accelerometers and Integrator

The Sound Level Meter will function as an accurate vibration meter with the additional ability to analyze vibration into octave bands, when the Microphone is removed, and B & K Accelerometers are connected via the input Adaptor JJ 2615. This configuration measures acceleration levels, but if the Integrator ZR 0020 is included in the line between Accelerometer and Meter (using Adaptor DB 0962) measurement and analysis of vibration velocity and displacement, as well as of acceleration are possible. A calculating disc delivered with the Integrator makes it a simple matter to convert the dB value shown on the Meter Scale into vibration units.

When using the Sound Level Meter for vibration measurement and analysis, complete system calibration can be achieved by means of the Portable Accelerometer Calibrator Type 4291 which excites the accelerometer to an acceleration of 1 g (9,81 m/s²) at 79,6 Hz.

### Level Recorder

The tedious work of plotting levels with a pencil can be completely avoided, even in the field, by using the small, battery operated Level Recorder Type 2306. It connects via a cable to the Output terminal of the Sound Level Meter, and records measured levels as a function of time, or of frequency. For time recordings, use can be made of the very slow paper speeds so that diagrams showing the variation of signal level over longer periods can be recorded on a reasonable length of paper. Such charts are a great help in almost any type of noise or vibration investigation, where they simplify location of events with respect to time, which is often sufficient to identify the source.

Frequency spectrograms can be recorded directly on frequency calibrated paper semi-automatically using the built-in Octave filters and the Remote Control Cable AO 0147 incorporating indicator lamp and start button.

## Specifications 2215

**Measuring Range** (with 1/2" Microphone Type 4165):

**Dynamic Range:**

| | |
|---|---|
| Linear | 45 to 140 dB (sine) |
| C-weighting | 34 to 140 dB (sine) |
| A-weighting | 26 to 140 dB (sine) |
| Octaves | |
| 31,5 and 63 Hz | 31 to 140 dB (sine) |
| 125 and 250 Hz | 26 to 140 dB (sine) |
| 0,5 to 16 kHz | 22 to 140 dB (sine) |
| A + Octaves | 22 to 140 dB (sine) |

**Note:** the stated values are RMS values from 5 dB above the inherent noise level to maximum permissible sinusoidal signal

**Frequency Range** (± 3 dB with 0° incidence):
20 Hz to 20 kHz

**Reference Conditions for Calibration Validity:**
Type of Sound Field: Free
Ref. Direction of Incidence: Perpendicular to microphone diaphragm
Ref. Sound Pressure: 20 $\mu$Pa
Ref. Sound Pressure Level: 84 dB
Ref. Frequency: 1 kHz
Ref. Temperature: 20°C (68°F)
Ref. Measuring Range: 70 dB Range Setting (90 dB FSD)

**Absolute Accuracy at Reference Conditions:**
± 0,7 dB

**Microphone:**

**Type:**
B & K Free-field response 1/2" Condenser Microphone Type 4165

**Polarization Voltage:**
200 V

**Frequency Response:** At 0° incidence; Free-field
± 1 dB from 4 Hz to 12,5 kHz
± 2 dB from 3 Hz to 20 kHz
An individual response curve is supplied with each microphone

**Sensitivity:**
Approx. 50 mV/Pa, individually calibrated

**Temperature Coefficient:**
Approx. —0,1 dB/10°C (—0,055 dB/°F)

**Permitted Temperature Range:**
—50°C to + 60°C (—58°F to + 140°F)

**Effect of Ambient Pressure:**
Approx. —0,01 dB per kPa at 101,3 kPa

**Long Term Stability:**
Better than 1 dB per 300 years at 27°C (81°F)
Typically 1 dB per 100 hours at 100°C (212°F)

**Input:**

**Input Section:**
Plugs in complete with Microphone capsule

**Input Impedance:**
> 2 GΩ || < 0,7 pF (0,9 pF with Extension Cable AO 0134)

**Maximum Input Voltage:**
10 V (sine) RMS

**Output:**

**Output Impedance:**
DC: 5 kΩ
AC: < 50 Ω

**Minimum Load Impedance:**
DC: 0 Ω (will not effect meter deflection)
AC: 5 kΩ or 2 nF
(for less than 0,2 dB error on meter and AC output)

**Output Voltage:**
DC: 5,5 V open circuit, corresponding to full scale meter deflection
AC: 3,16 V RMS, corresponding to full scale meter deflection
Linearity DC: 1 V per 10 dB
Range: up to 64 dB (50 dB plus 14 dB crest factor allowance)

**Maximum Output:**
DC: 6,5 V
AC: 32 V peak to peak

**Weighting Networks:**
A- and C-weighting according to IEC R 179 (1973), DIN 45633 Part 1, and ANSI S1,4-1971

**Octave Filters:**

**Type:**
6-pole Butterworth active filters conforming to IEC R 225 (1966), DIN 45651, and ANSI S1,11-1966 Class II

**Range:**
10 filters cover the frequency range 20 Hz to 20 kHz with centre frequencies 31,5 Hz to 16 kHz

**Attenuation in the Pass Band:**
0 dB ± 0,5 dB at centre frequencies

**Peak to Valley Ripple:**
< 0,5 dB
**Attenuation Outside the Pass Band:**
See Fig.3 and Fig.4
**Filter Change:**
Thumb-wheel rotary switch
**Remote Control of Type 2306:**
Permits manual synchronisation of Level Recorder 2306 with Filter change, uses Remote Control Cable AQ 0147 (accessory available)
**A-weighting plus Octave:**
Permits use of A-weighting network and Octave Filters simultaneously

**Indicating Meter:**
**Rectifier:**
RMS ± 0,5 dB at full scale deflection for crest factors up to 5. Crest factor capability increases proportionally for scale indication below FSD up to a maximum of 50. (This capability also applies at the DC output)
**Damping:**
"Fast" and "Slow" according to IEC R 179
**Scale:**
Linear graduations in 1 dB steps from —10 dB to + 20 dB
**Range Indication:**
In window on scale
**Battery Check and Calibration Indication:**
In "Range" window on scale
**$K_0$ factor adjustment:**
± 3 dB
**Octave Centre Frequency Indication:**
In window on scale

**Attenuators** (according to IEC 179):
**RANGE wheel:**
Gives 9 steps of 10 dB each
**Push Button:**
Gives 1 step of 10 dB

**Noise and Distortion:**
**Signal to Noise Ratio:**
≥ 5 dB for lower limit of dynamic range
**Distortion:**
< 1% at full scale deflection with maximum crest factor

**Overload Indication** (according to IEC R 179):
**Detector:**
Senses on all points in the instrument where overload is possible
**Indicator:**
Lamp in meter scale

**Calibration:**
**Built-in Generator**
1 kHz sine wave for electrical calibration
**Stability:**
Better than ± 0,2 dB

**Batteries:**
**Type:**
4 × 1,5 V IEC Type LR 6 (e.g. Mallory Type Mn 1500) B & K order No. QB 0013
**Life:**
Approximately 20 hours of continuous operation with recommended types of batteries
If battery output falls below the minimum usable voltage, the power is automatically switched off

**Instrument Environment:**
**Operating Temperature Range:**
—10°C to + 50°C (+ 14°F to + 122°F) give less than ± 0,5 dB change in indication
**Storage Temperature** (Batteries removed):
—20°C to + 50°C (—4°F to + 122°F)
**Permitted Humidity Range:**
The instrument is affected less than ± 0,5 dB between 0 and 90% relative humidity at a maximum of + 40°C and provided no condensation occurs
**Effect of Vibration:**
See curves Fig.9 and Fig.10
**Effect of Sound Field:**
At least 60 dB below sensitivity of Microphone Type 4165
**Effect of Electrostatic Field:**
Negligible with microphone grid fitted
**Effect of Electromagnetic Field:**
80 A/m (1 Ørsted) (50 Hz) gives:
< 38 dB(A)
< 40 dB(C)
< 42 dB (Lin)
< 38 dB (Oct 31,5 Hz)
< 46 dB (Oct 63 Hz)
< 29 dB (A + Oct 31,5 Hz)
< 44 dB (A + Oct 63 Hz)
< 28 dB (Oct, A + Oct 125 Hz to 16 kHz)

**Dimensions:**
**Length:** 290 mm (11,4 in)
**Width:** 77 mm (3,05 in)
**Height:** 67 mm (2,65 in)

**Weight:**
1,1 kg (2,4 lb)

**Accessories Included:**
1/2" Condenser Microphone Type 4165
Windscreen UA 0237
4 Batteries QB 0015
1 Screwdriver QA 0001
1 Leather Carrying Bag KE 0151
1 Wrist Strap DH 0128

**Accessories Available:**
Input Adaptor JJ 2615 for direct electrical input
Tripod Floor Stand UA 0049
Sound Level Calibrator Type 4230
Pistonphone Type 4220
3 m (9,75 ft) Microphone Extension Cable AO 0134 for remote mounting of Microphone and Input stage
2 m (6,5 ft) Remote Control Cable AQ 0147 for use with Level Recorder Type 2306
1,2 m (4 ft) Connection Cable AO 0116 for use with Recorders
Integrator ZR 0020 used with Accelerometers
See Fig.13 for further accessories

## 2. CONTROLS

Fig.2.1 identifies the various controls and parts on the front and sides of the Type 2215.

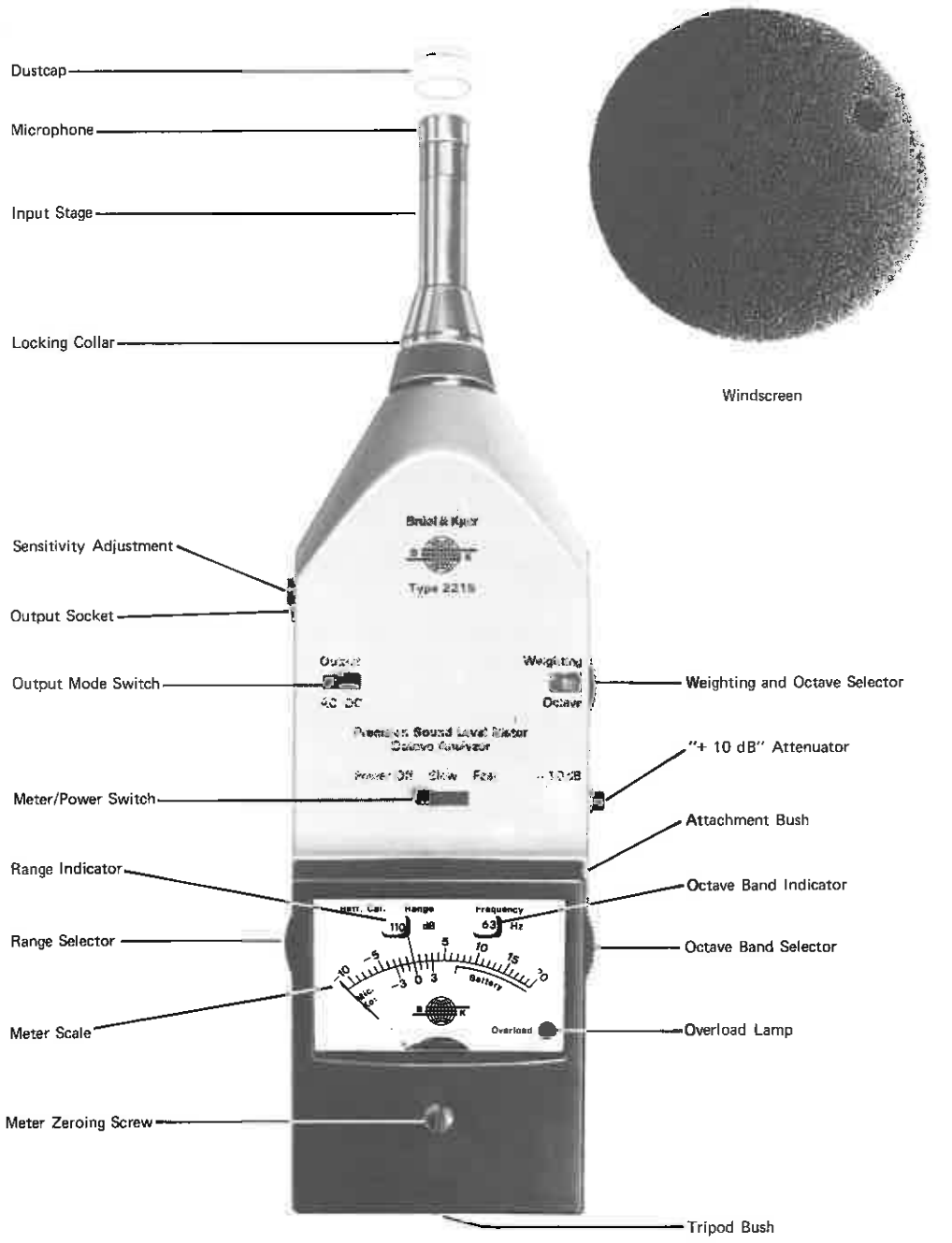



*Fig.2.1. Front view of 2215*

DUSTCAP: Protects the Microphone from dust and dirt. It is recommended that the dustcap be kept on the Microphone at all times when the instrument is not being used.

MICROPHONE: B & K 1/2" Condenser Microphone Type 4165. It can be unscrewed together with the protection grid and replaced by Adaptors JJ 2614 and JJ 2615 to permit direct inputs (from accelerometers for example) to be measured.

INPUT STAGE: Containing Microphone preamplifier can be unplugged and removed, permitting the Microphone to be used remote from the Sound Level Meter. See Fig.2.2 for pin connections. Input Impedance > 2 GΩ//< 0,7 pF.

LOCKING COLLAR: Locks the Input Stage in place.

SENSITIVITY ADJUSTMENT: A screwdriver operated potentiometer that varies the gain in the Output Amplifier over a 10 dB range. It permits calibrating the instrument for various microphone sensitivities.

OUTPUT SOCKET: Yields an AC or DC voltage proportional to the meter deflection, as selected by the Output Mode Switch. In AC mode the output impedance is < 50Ω in series with 33 μF, while 3,16 V RMS corresponds to full scale meter deflection, maximum load 5 kΩ. In DC mode the output impedance is 5 kΩ with an open circuit voltage of 5,5 V corresponding to full scale deflection on the meter. The DC output may be safely shorted to ground. The meter reading is not affected by load applied at the Output. These output facilities are used to feed Level Recorders or Tape Recorders to obtain permanent recordings of the measurements. Accepts plug JP 0006 (included) or Cable AO 0116.

OUTPUT MODE SWITCH: Selects whether AC or DC voltages will be fed to the Output Socket.

METER/POWER SWITCH: Is the main power switch for the instrument. It also determines which of the two meter damping functions Fast or Slow is used.

RANGE INDICATOR: Indicates which dB measuring range has been chosen for use, also shows if Calibration, or Battery Check functions have been selected.

RANGE SELECTOR: A 12 position rotary switch that sets the meter range, and allows internal Calibration function or Battery Check function to be selected. The function or range selected is indicated in the adjacent window in the meter scale. The functions available are as follows, ranges: 20, 30, 40, 50, 60, 70, 80, 90, 100, 110 dB, plus Battery Check and Calibration.

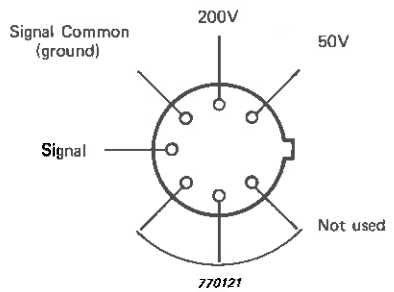



*Fig.2.2. External view of the Preamplifier Socket*

METER SCALE:

Has 5,5 cm main scale length, calibrated linearly with 1 dB graduations over 30 dB from —10 to +20 dB. Secondary scales for microphone sensitivity (K-factor) adjustment, and battery condition are also included.

METER ZEROING SCREW:

For mechanically zeroing the meter (with the power switched off).

TRIPOD BUSH:

1/4" Whitworth bush for mounting the instrument vertically on a tripod stand (UA 0049). Note that horizontal mounting from this bush can damage the casing. A similar bush in the centre of the rear panel permits horizontal mounting.

OVERLOAD LAMP:

Blinks red to give warning of overload conditions in the measuring circuitry. While this lamp is blinking the meter indication is inaccurate. (The meter probably reads low due to signal clipping.) To obtain accurate readings, the Range Selector should be adjusted until blinking stops, or the "+ 10 dB" Attenuator button pushed to decrease the overload of the preamplifier by 10 dB. The existance of an overload condition should be noted on any measurements made where it is not possible to eliminate it (such as with signals having too high a crest factor measured close to full scale deflection).

OCTAVE BAND SELECTOR:

A 12 position (2 unused) rotary switch that selects the octave band in which measurements are to be made. The centre frequency of the octave band chosen is indicated in the adjacent window in the meter scale. Indications are as follows; Octave Bands: 31,5, 63, 125, 250, 500, 1 k, 2 k, 4 k, 8 k, 16 k, Unused:(),(), turn either way to reach an octave band.

OCTAVE BAND INDICATOR:

Shows which octave band has been chosen for use, provided the Weighting and Octave Selector has been turned to "Oct." or "A + Oct."

ATTACHMENT BUSH:

M-4 bush for mounting Remote Control Cable AQ 0147 while recording with Level Recorder Type 2306.

"+ 10 dB" ATTENUATOR:

Is a push button Attenuator giving an immediate 10 dB increase in attenuation, mainly to cancel overloading of the preamplifier by sudden excess signal levels.

WEIGHTING AND OCTAVE SELECTOR:

A five position rotary switch that controls selection of weighting functions. The functions available are as follows:
A-weighting plus Octave
Octave
Linear
C-weighting
A-weighting

WINDSCREEN (UA 0237):

90 mm in diameter, reduces wind noise and protects the Microphone from dust, dirt and precipitation. Always employ the windscreen. Remove the dustcap before mounting the windscreen.

# 3. OPERATION

This Instruction Manual describes the specific procedures necessary to operate the Precision Sound Level Meter and Octave Analyzer Type 2115 correctly. However, there are many aspects of sound measurement of a more general nature that are also important when considering how to get correct reproducible measurements. Many of these points are discussed in the accompanying booklet "Measuring Sound", which should be considered as part of this Instruction Manual.

## 3.1. PREPARATIONS FOR USE

It is important that the batteries and calibration always be checked before making any measurements.

### 3.1.1. General Considerations

1. Store the instrument in a dry, preferably warm place.
2. Always turn the instrument "Off" to conserve batteries when not in use.
3. Remove batteries if the instrument is not used for a long time.
4. Connect and disconnect microphones, adaptors, and input stage with the power turned off.
5. Assemble microphone and adaptors at the same temperature.
6. Use light finger torque only to tighten microphone and adaptor screws threads, but screw the locking collar on firmly.
7. In very dry weather, discharge static electricity from yourself before fitting microphones.
8. Keep dust and foreign objects from the microphone diaphragm. Do not touch the diaphragm with anything.

### 3.1.2. Insertion and Replacement of Batteries

1. Turn Power switch "Off".
2. Slide battery cover off rear of Type 2215, see Fig.3.1.
3. Pull up the tape end to lift used batteries out of the compartment.
4. Four IEC R-6 batteries are inserted on top of the tape, with their + and — terminals according to the diagram within the compartment. Note, incorrect battery polarity can cause component damage. Use recommended battery types for stated life expectancy.


*Fig.3.1. Inserting the Batteries*

5. Replace the battery cover.

### 3.1.3. Preliminary Adjustment

1. With the instrument turned "Off", check that the meter needle lies precisely on the line farthest to the left on the meter scale. If necessary, adjust the Meter Zeroing Screw to achieve this setting.

2. Switch the Sound Level Meter on by sliding the Meter/Power Switch to "Fast". Before calibration or use, wait approximately 15 to 20 seconds for the instrument to stabilize.

3. Rotate the Range Selector until "Batt." appears in the adjacent Range Indicator window. This checks the condition of the batteries. If the needle falls below the indicated "Battery" range on the scale, the batteries should be replaced. Note, due to the switch sequencing, the needle will give an initial indication above full scale, and then return to show the battery condition.

## 3.2. CALIBRATION FOR SOUND LEVEL MEASUREMENT

### 3.2.1. Calibration with Built-in Generator

When the Range Selector is turned to position "Cal.", an internally generated sinewave signal, stable within ± 0,2 dB at 1 kHz is applied to the input of the amplifiers, whose gain is adjusted to make the Type 2215 correspond to the open circuit sensitivity of the microphone in use. This arrangement excludes both microphone and input stage from

the calibration, but is adjusted during assembly to be correct for the actual microphone and input stage supplied. However, it is recommended that wherever possible acoustic calibration be employed, using the Pistonphone or Sound Level Calibrator, especially where 1/4" and 1/8" microphones are used.

1. Check adjustment and batteries as detailed in 3.1.3.

2. Rotate the Weighting and Octave Selector until "Lin." appears in the adjacent window.

3. Rotate the Range Selector until "Cal." appears in the adjacent Range Indicator window to apply the 1 kHz signal.

4. Using the small screwdriver supplied, carefully screw the Sensitivity Adjustment potentiometer until the meter needle lies exactly over the Ko-factor (defined below) for the microphone in use, on the "Mic. Ko" scale.

5. If the required Ko-factor is outside the range of adjustment of the potentiometer (approximately ± 6 dB), adjust for a Ko-factor of 0 and add the Ko-factor to all readings.

   **Note:** because internal calibration employs a sinewave at 1 kHz, it is possible to check the "A", and "C" weighting networks, and when the 1 kHz Octave Band is selected the "Octave" and "A + Octave" function can also be checked. Readings should be within 0,2 dB of "Lin.".

   **This completes electrical calibration, the sound level meter is now ready for use.**

### 3.2.2. Determination of Ko-factor

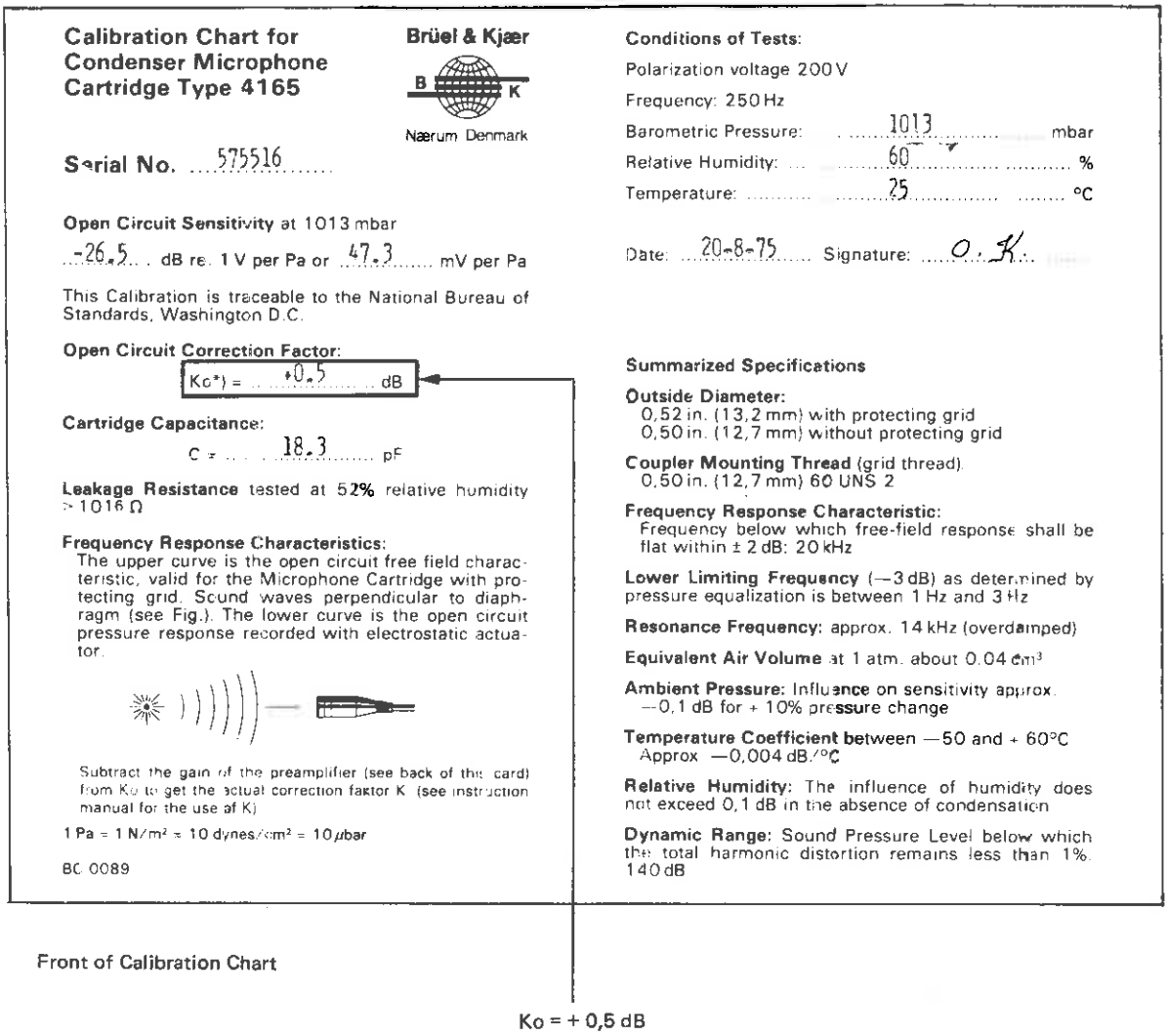
The Type 2215 is adjusted at the factory to match the actual Microphone (Type 4165) and Input Stage (ZC 0011) with which it is delivered. When it is required to use another microphone having a different sensitivity, a different correction factor (Ko) must be used, or the difference between the Ko-factors for the microphone supplied and the other microphone must be taken into account to obtain the actual sound pressure level. The most convenient method of making this correction is by adjusting the sensitivity to give the meter an initial offset from the calibration position, very simple on the Type 2215 which is equipped with a Sensitivity potentiometer and a Ko scale on the meter.

The Ko-factor of a microphone is the difference in dB between a standard microphone sensitivity of 50 mV/Pa and the sensitivity of the actual microphone in use. For example, the standard sensitivity for a Microphone Type 4165 is —26 dB re. 1 V/Pa: where 1 Pa = 1 $N/m^2$ = 10 $\mu$bar, a microphone with a sensitivity of —27 dB re. 1 V/Pa (they are all individually calibrated) has a Ko-factor of + 1 dB, and this value should be employed in 3.2. 1—5.

However, some situations arise where different input stages, adaptors, or extension leads may also have to be used or microphones with appreciably different capacity, that cause a further change to the actual sensitivity. As mentioned in 3.2.1 the recommended method of calibrating for these conditions is acoustically with the Pistonphone, or Sound Level Calibrator.

### 3.2.3. Acoustic Calibration

The Type 2215 may be calibrated using an acoustic calibrator — basically a miniature loudspeaker — which is fitted over the microphone. Acoustic calibration has the advan-



**Calibration Chart for Condenser Microphone Cartridge Type 4165**

**Brüel & Kjær**

Nærum Denmark

**Serial No.** 575516

**Open Circuit Sensitivity** at 1013 mbar

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

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

**Open Circuit Correction Factor:**

Kc*) = +0.5 dB

**Cartridge Capacitance:**

C = 18.3 pF

**Leakage Resistance** tested at 52% relative humidity > 1016 Ω

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

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

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

BC 0089

**Conditions of Tests:**

Polarization voltage 200 V

Frequency: 250 Hz

Barometric Pressure: 1013 mbar

Relative Humidity: 60 %

Temperature: 25 °C

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

**Summarized Specifications**

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

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

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

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

**Resonance Frequency:** approx. 14 kHz (overdamped)

**Equivalent Air Volume** at 1 atm. about 0.04 cm³

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

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

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

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

Front of Calibration Chart

Ko = + 0,5 dB

*Fig.3.2. Obtaining the K-factor from microphone calibration chart*

tage that it checks the entire instrument, including the microphone and input stage. Two different acoustic calibrators are available from B & K, the Pistonphone Type 4220 which produces a nominal 124 dB (individually calibrated) at 250 Hz, and the Sound Level Calibrator Type 4230 which generates 94 dB (= 1 Pa) at 1 kHz.

1. Check adjustment and battery condition as detailed in 3.1.3.
2. Fit the Pistonphone or Sound Level Calibrator with an adaptor sized to fit the microphone in use. The standard microphone delivered with the Type 2215 is 1/2" in diameter.
3. Remove the dustcap or windscreen from the microphone on the Sound Level Meter and carefully push the calibrator down over the microphone until it seats firmly.
4. Turn the Range Selector on the Type 2215 to the setting shown in Table 3.1 for the microphone sensitivity. Figures for the microphone delivered with the Type 2215 are shown in **heavy** type.
5. Set the Weighting and Octave Selector to "Lin.".
6. Slide the Meter/Power Switch to "Fast".

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

760086

*Table 3.1. Range settings for acoustical calibration*

*Pistonphone Only*

7. Note the value from the Pistonphone calibration chart and add it to the correction (in dB) from the barometer supplied with the Pistonphone Switch on the Pistonphone and if necessary screw the Sensitivity Adjustment potentiometer until the meter needle indicates this value.

*Sound Level Calibrator Only*

8. Switch on the Sound Level Calibrator and if necessary screw the Sensitivity Adjustment potentiometer until the meter needle indicates sound pressure levels as follows:

   1/2" free field microphones: 93,8 dB

   Pressure response microphones (any size): 94 dB

   Note, although the Sound Level Calibrator provides an output of 94 dB, the values for free field microphones include the free field corrections for the microphones at the 1 kHz excitation frequency of the Calibrator.

9. Carefully remove the Pistonphone or Calibrator, and switch off the Pistonphone — the Sound Level Calibrator switches itself off automatically.

**The Sound Level Meter is now calibrated and ready for use.**

## 3.3. OPERATING PROCEDURE FOR SOUND MEASUREMENT AND ANALYSIS

Select a microphone that has dynamic range, frequency range and directional characteristics suitable for the particular measuring situation. The Microphone Type 4165 supplied as a standard accessory is ideal for most applications, but in random or semi-random noise fields, use a pressure response type microphone such as the Type 4166. For further guidance on the choice of a microphone, consult the B & K Microphone and Preamplifier Handbook.

Appropriate accessories for measurement requirements, conditions and environments should also be selected according to the Handbook.

The Type 2215 has been designed and human engineered for single handed operation. It is light enough to hold at arms length, this being the most commonly adopted method.

Use of the Flexible Extension Rod UA 0196 will reduce reflections from the observer's body while keeping hand held convenience. However, to further minimise interference with measurements caused by body reflections, or when maximum accuracy is required mount the Type 2215 on a tripod and stand at least one meter behind the instrument. Position the Sound Level Meter so that the microphone faces the sound source.

Keep a record of measuring conditions, equipment and accessories used, meter functions, weighting networks, and octave band frequencies employed, and note the background noise levels and the occurence of overload conditions.

### 3.3.1. Measurement of Sound Pressure Level

1. Check the preliminary adjustments and calibration as detailed in 3.1.3 and 3.2.1 or 3.2.3.
2. Set the Weighting Selector to "Lin.".
3. Adjust the Range Selector to "110".
4. Slide the Meter/Power Switch to "Fast".
5. In the rare event of the needle going beyond the top of the scale (> 130 dB SPL), and/or the Overload Lamp blinking, push the "+ 10 dB" Attenuator button to obtain an indication on the scale. If this does not produce a reading on the scale, a less sensitive microphone should be selected as described in the Microphone and Preamplifier Handbook.

   **NOTE: It is directly injurious to expose unprotected personnel to such a high sound level.**
6. If the meter needle does not come up on to the Scale, turn the Range Selector back until it does.
7. If the meter needle fluctuates too rapidly to obtain a meaningful reading, set the Meter/Power Switch to "Slow".
8. THE SOUND PRESSURE LEVEL IN dB = THE NUMBER IN THE RANGE INDICATOR WINDOW + THE ACTUAL METER READING.

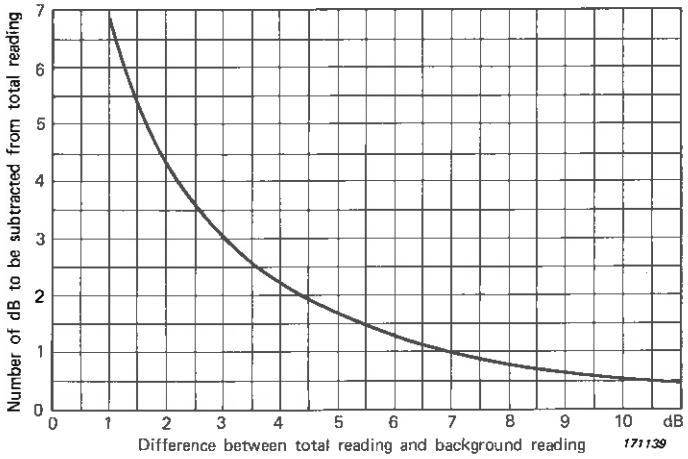



*Fig.3.3. Correction for the influence of high background noise levels*

Under some circumstances the Ko-factor must be added to the reading as mentioned in 3.2. 1—5, and 10 dB added if the "+ 10 dB" button is depressed. When microphones other than the one delivered as standard are in use, it may be necessary to add a correction factor from Table 3.1.

9. If it is necessary to make measurements where there is a lot of background noise, the background noise will contribute to the levels measured. A correction can be made. Noise levels should be recorded for the object being measured plus background, and for the background alone. Corrections are made according to the chart in Fig.3.3.

10. The meter circuit and outputs have a dynamic range of 50 dB, with a crest factor capability of 5 at full scale deflection. When measurements have to be made on signals with crest factors higher than 5 a lesser deflection on the meter scale must be used. The relationships between useful scale range and crest factor, and between maximum measureable sound pressure level and crest factor are given in section 4.2.

### 3.3.2. Measurement of Weighted Levels and Octave Analysis

A feature that simplifies operation with the Type 2215, is that it is no longer necessary to make a preliminary "Lin." measurement to obtain the necessary overload protection and best signal to noise ratio. On the Type 2215, provided there is no overload indication from the lamp in the scale, no overload condition exists in the instrument. Furthermore, the best possible signal to noise ratio is maintained automatically at all times.

Should overload be indicated, turn the Range Selector to obtain an indication on the lower portion (the left hand half) of the scale. If this is not sufficient, push the "+ 10 dB" Attenuator button and add 10 dB to the reading on the meter.

When not otherwise governed by preventing overload conditions from occurring, a meter reading on the upper portion of the scale is preferred as it gives a better signal to noise ratio, (but is otherwise no more accurate than readings on the lower portion of the scale).

1. Turn the Weighting and Octave Selector until the required function:- "A + Oct.", "Oct.", "Lin.", "C" or "A" appears in the window.

2. "C" and "A" weighted levels may be read directly from the meter scale in the same way as "Lin." described in 3.3. 1—8.

3. Select "Oct." or "A + Oct." when frequency analysis is required. Note that the "A + Oct." function permits frequency analysis to be made of A-weighted signals.

4. Turn the Octave Band Selector until the centre frequency of the band to be measured appears in the Octave Band Indicator window.

   Note, not only should the centre frequency be displayed in the Octave Band Indicator window, but "Oct." or "A + Oct." must **also** be selected by the Weighting and Octave Selector.

5. The sound level in the band is read directly from the meter as described in 3.3. 1—8.

## 3.4. CALIBRATION FOR VIBRATION MEASUREMENTS

The internally generated sine wave can be used for calibration for vibration measurement, or a known acceleration level can be applied to the accelerometer in use. Fig.3.4 indicates how an accelerometer is connected to the Type 2215.

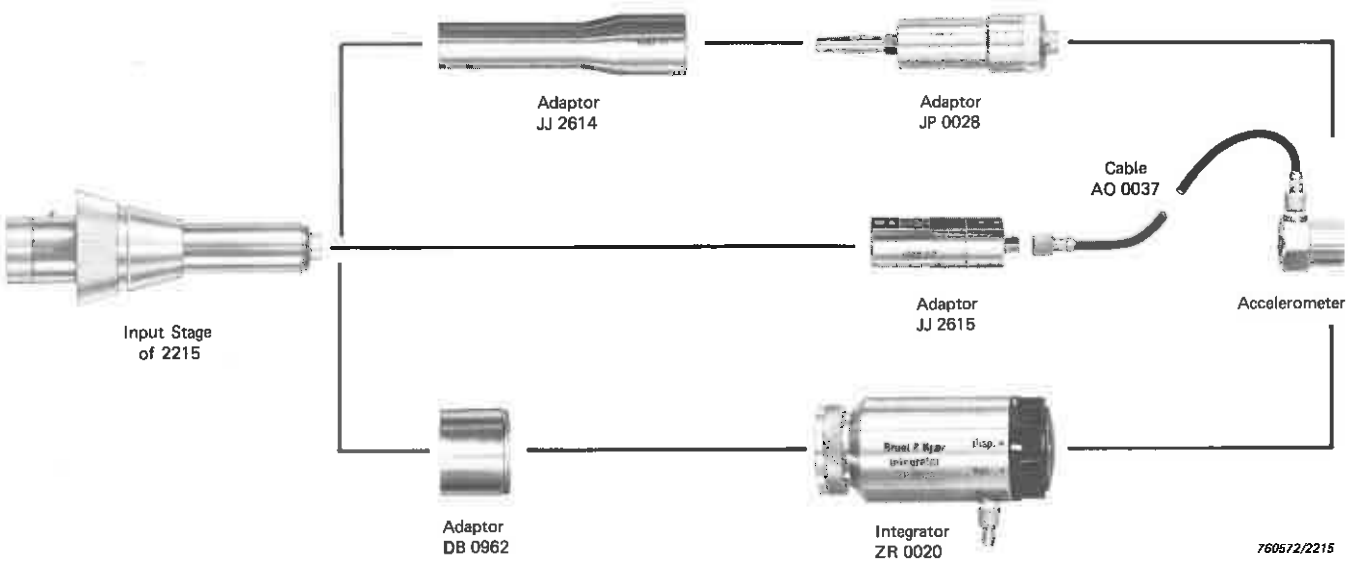



*Fig.3.4. Connection of an accelerometer to the sound level meter*

### 3.4.1. Calibration with the Built-in Generator

1. Connect the Accelerometer to the Integrator (if used) or to the Sound Level Meter.
2. Set the Integrator (if used) to the required function, "Acceleration", "Velocity", or "Displacement". If **all** functions are required they must **all** be calibrated.
3. Check adjustment and batteries as detailed in 3.1.3.
4. Rotate the Weighting Selector until "Lin." appears in the adjacent window.
5. Switch on by sliding the Power/Meter Switch to "Fast".
6. Rotate the Range Selector until "Cal." appears in the adjacent Range Indicator window. This applies the internally generated 1 kHz signal.
7. Using the small screwdriver supplied, carefully turn the Sensitivity Adjustment potentiometer screw until the meter needle indicates:

   0 dB for Integrator ZR 0020
   + 0,8 dB for JJ 2614
   + 1,2 dB for JJ 2615
   on the "Mic. Ko" scale.

The Sound Level Meter is now calibrated so that a reading of 94 dB corresponds to 9,81 m/s$^2$ (1 g) when an accelerometer with a sensitivity of 50 mV/g is used.

### 3.4.2. Calibration with Accelerometer Calibrator Type 4291

In some cases it is necessary to calibrate the whole measurement system to take different input stages, accelerometers, and cable connections into consideration. As with sound measurement, this is accomplished by applying a calibrated source, a suitable vibration source being the Type 4291.

The Accelerometer Calibrator Type 4291 is a battery powered generator that drives a miniature shaker at an accurately maintained vibration level of 9,81 m/s$^2$ peak (1 g) equivalent to 6,936 m/s$^2$ RMS (0,707 g) at 79,6 Hz (500 rad/s). An accelerometer can be mounted on the shaker as shown in Fig.3.5, so that it can be excited at the known vibration level and its output determined for calibration purposes.

1. Mount the Accelerometer on to the Type 4291, and connect to the Integrator (if used) on to the Sound Level Meter.

2. Set the Integrator (if used) to the required function, "Acceleration", "Velocity", or "Displacement". If all functions are required they must all be calibrated.

3. Check the adjustment and batteries as detailed in 3.1.3.

4. Rotate the Weighting Selector until "Lin." appears in the adjacent window.

5. Rotate the Range Selector until "110" appears in the adjacent Range Indicator window.

6. Switch on by sliding the Power/Meter Switch to "Fast".

*Fig.3.5. The Accelerometer Calibrator Type 4291 with accelerometer mounted*

7. Set the Accelerometer Calibrator to "Internal Generator" and adjust the "Acc. Level" so that the mass of the Accelerometer (given in its calibration chart) is indicated on the lower scale of the Accelerometer Calibrator's meter.

8. Adjust the Range Selector so that the needle in the Type 2215 has at least 1/3 of full scale deflection.

9. Screw the Sensitivity Adjustment potentiometer until the meter has a deflection of + 7 dB.

10. Note the value indicated in the Range Indicator window and add 10 dB. This is the zero reference level in dB (Z) corresponding to 1 g RMS, or to any of the following vibration reference amplitudes (R) to which the Sound Level Meter is now calibrated (depending on Integrator setting):

    Acceleration: 9,81 $m/s^2$ (1 g = 386 $in/s^2$), with or without Integrator
    Velocity: $19,6 \times 10^{-3}$ m/s (0,771 in/s)
    Displacement: $39,2 \times 10^{-6}$ m ($1,54 \times 10^{-3}$ in)

## 3.5. OPERATING PROCEDURE FOR VIBRATION MEASUREMENT AND ANALYSIS

For detailed instructions on using accelerometers see the Accelerometer Handbook.

When using the Type 2215 as an accelerometer preamplifier and measuring amplifier, it should be noted that the Accelerometer in use will almost certainly have a mounted resonant frequency within the 20 Hz to 20 kHz "Linear" range of the Sound Level Meter. Therefore measurements should be made using the built-in octave filters where it is thought possible that the signal being measured contains similarly high frequencies to prevent erronious readings due to this resonance. The lower limiting frequency of the measurements, 20 Hz is determined by the Type 2215.

Hold or mount the Sound Level Meter as far as possible from the source of vibration, and from other unrequired influences.

### 3.5.1. Measurement and Frequency Analysis of Vibration

1. Check preliminary adjustment and batteries as detailed in 3.1.3.

2. Calibrate for vibration measurement as described in 3.4.1. or 3.4.2.

3. Mount the accelerometer by one of the methods recommended by the Accelerometer Handbook.

4. Rotate the Weighting Selector until "A", "C", or "Lin." appears in the adjacent windows as required.

5. Turn the Range Selector until "110" appears in the adjacent Range Indicator window.

6. Switch on the Type 2215 by sliding the Power/Meter Switch to "Fast".

7. Adjust the Range Selector for the highest possible meter reading without overloading.

8. If the meter needle fluctuates too rapidly to obtain a meaningful reading, set the Meter/Power Switch to "Slow".

9. Read the overall vibration level "A", or "C" weighted, or "Lin." as the meter reading in dB plus the number in the Range Indicator window. This total value is used in calculating the vibration levels as described in 3.6.

10. Select "Oct." or "A + Oct." when frequency analysis is required. Note that the "A + Oct." function permits frequency analysis of A-weighted functions to be made.

11. Turn the Octave Selector until the centre frequency of the band to be measured appears in the Octave Band Indicator window.

12. The vibration level in the band is read from the meter scale as described in 3.5.1—9.

## 3.6. CONVERSION OF METER READINGS TO VIBRATION LEVELS

The indicated dB value is converted to a vibration level by a method that is determined by the way the instrumentation arrangement was calibrated, and whether the Integrator was used. A circulator calculator to convert dB to vibration units is supplied with the Integrator. Use of the calculator is described in 3.6.2. Fig.3.6 shows the frequency response of the Type 2215 used together with the Integrator ZR 0020.


*Fig.3.6. Frequency Response of Type 2215 connected to Integrator ZR 0020*

### 3.6.1. Conversion Method for Type 4291 Calibration, Without Integrator

Determine the acceleration level A in dB referred to 1 g RMS by,

$$A = M—Z$$

where M is the value indicated on the meter
Z is the zero reference level from 3.4. 2—10

Fraction component of Acceleration Level A (dB)

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

Equivalent Multiplication Factor T

770272

*Table 3.2. Conversion chart for determining multiplication factor T from the dB value indicated on the sound level meter*

From Table 3.2 convert A from a dB value to a ratio (T).
The vibration amplitude = RT

where R is the reference vibration amplitude defined in 3.4. 2—10.

*Example:* The zero reference level Z is 100 dB
the indicated value M is 87,4 dB
find acceleration in $m/s^2$

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

The equivalent multiplication factor T is found from Table 3.2 as described below.

1. Subtract a multiple of 20 (= n × 20 where n is a positive or negative whole number) from the A (dB) value which is to be converted, so that the remainder is a positive number between 0 and 19,9.

   i.e. —12,6 — (—20) = + 7,4 with n = —1

2. Find the Equivalent T value for this remainder in the Table.

   An A of + 7,4 gives T of 2,344

3. The actual multiplication factor (T) required will be $10^n$ times the value obtained from the Table.

   $2,344 \times 10^{-1} = 0,2344$

4. So the Acceleration = RT
   = 9,81 (= reference level from 3.4. 2—10) × 0,2344
   = 2,30 $ms^2$

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

### 3.6.2. Conversion Method for Type 4291 Calibration, With Integrator

The vibration level can only be calculated in the parameter that is set on the Integrator. Where another parameter is required, the Integrator must be set and recalibrated for that parameter as described in 3.4.2 and new measurements must be made. The calculator QH 0001 dB — Vibration Unit Converter, supplied with the Integrator, includes scales for determining acceleration, velocity, and displacement from sound level meter readings. One face (shown in Fig.3.7) is graduated in metric units, while the other has British units. Note that the calculator **cannot** be used to convert from one parameter to another. Use of the calculator is shown in the following example.

*Example:* the reference level (Z) is 90 dB in velocity mode
the indicated value (M) is 72 dB
find the velocity level in m/s

1. Set the reference vibration amplitude (R, see 3.4. 2—10) on the appropriate vibration scale, on the metric side of the calculator opposite the zero reference level (Z, see 3.4. 2—10) on the dB SL scale.

   From 3.4. 2—10, R is found to be 19,6 × $10^{-3}$ m/s (for velocity measured in metric units).

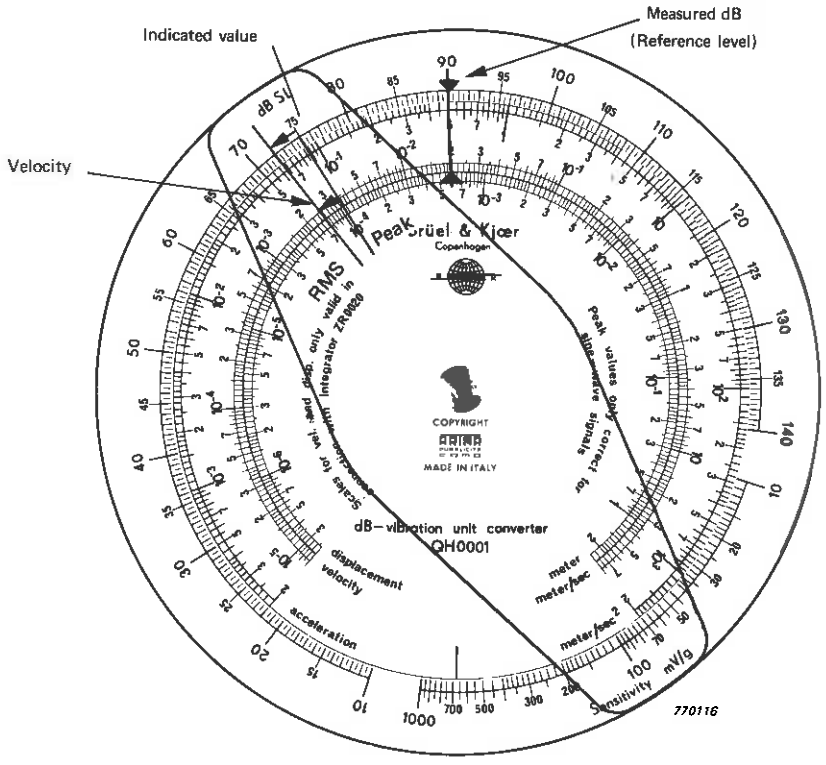



*Fig.3.7. The Vibration Unit Converter QH 0001, metric side*

In Fig.3.7 it will be seen that the $19,6 \times 10^{-3}$ m/s is lined up with 90 dB on the outer scale.

2. Set the RMS line on the cursor to the value indicated by the meter on the dB SL scale.

   The RMS cursor line is shown on 72 dB in Fig.3.7.

3. Read the vibration level directly in RMS or Peak, where the relevant cursor line crosses the vibration scale for the parameter to which the Integrator was set.

   A velocity level for the example of $2,5 \times 10^{-3}$ m/s is indicated in the figure.

### 3.6.3. Conversion Method for Built-in Calibration, Without Integrator

The acceleration level A in dB referred to 1 g is calculated by the formula:

$$A = M - 94 + 20 \log 10 (50/S)$$

where M is the level indicated by the meter (dB)
S is the sensitivity of the accelerometer (mV/g)

A is then converted to acceleration units as described in 3.6.1.

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

### 3.6.4. Conversion Method for Built-in Calibration, With Integrator

The conditions for using the Integrator to measure in the different vibration modes are described at the beginning of section 3.6.2. The calculator QH 0001 is used for the conversions, an example follows.

*Example:* the sensitivity of the accelerometer in use is 42 mV/g
the indicated level on the meter is 94 dB
find the displacement in inches

1. Set the isolated red line at the bottom of the sliding scale to the sensitivity of the accelerometer in use (in mV/g) on the outer Sensitivity scale at the bottom of the calculator, on the British units side.

   The red line is shown adjacent to 42 mV/g in Fig.3.8.

2. Turn the cursor so that its RMS line lies over the value indicated by the meter (in dB) on the outer dB SL scale.

   The RMS cursor line lies on 94 dB in Fig.3.8.

3. Read the vibration level in RMS or Peak directly from the corresponding line on the cursor, on the scale for the parameter to which the Integrator was set.

   Fig.3.8 gives values for the example of $6,0 \times 10^{-1}$ inches RMS displacement, and $8,5 \times 10^{-1}$ inches peak displacement.

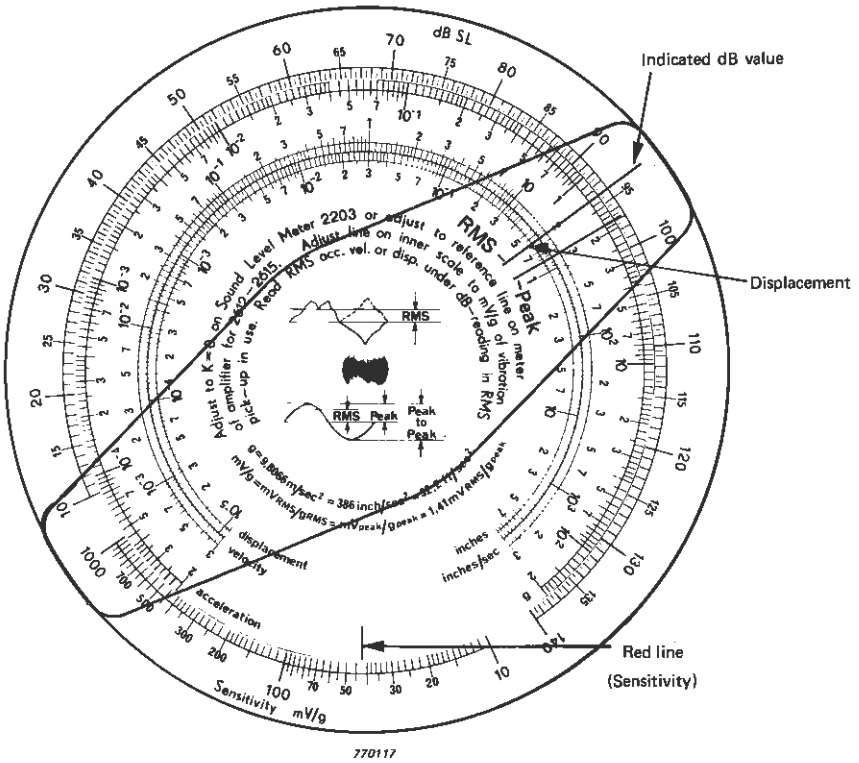



*Fig.3.8. The Vibration Unit Converter, example in British units*

## 3.7. USE OF OUTPUTS: RECORDING

Both AC and DC Outputs have up to 50 dB dynamic range with a crest factor capability of 5, or 14 dB from RMS to Peak — a total of 64 dB. To obtain the full dynamic range on both AC and DC the Range wheel position should be turned down sufficiently. For "A", "Oct." and "A + Oct." functions, the best positions lie between 60 and 110, while for "C" and "Lin." the best Range positions are between 70 and 110. The signal-to-noise ratio for the lower limit of these ranges is better than 5 dB.

Operation of the Type 2215 with the Level Recorder Type 2306, or with the Tape Recorders Type 7003 and Type 7004 is similar to recording with a Sound Level Meter Type 2203. Methods of recording are described fully in the Instruction Manuals for the different Recorders.

### 3.7.1. Use of Control Cable AQ 0147 for Semi-Automatic Spectrogram Plotting

Fig.3.9 shows a measuring arrangement for making semi-automatic frequency analysis with the Level Recorder Type 2306.

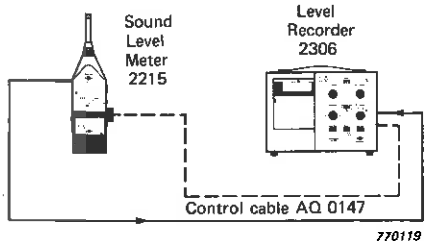



*Fig.3.9. Arrangement for recording spectrograms semi-automatically*

1. The Level Recorder should be adjusted as described in its Instruction Manual.

2. When the 2306 is switched on it will advance the paper until the red 1/1 Octave "Filter Shift" lamp lights. At the same time the green "Filter Shift" lamp on the switch in the AQ 0147 Control Cable will also light and the paper transport stop.

3. The Octave Band Selector on the Type 2215 should be advanced to the next position.

4. The switch in the cable should be depressed, and held down until the lamps are extinguished and the paper starts to move again.

5. Another octave is plotted on the paper, and the whole process from 3.7. 1—2 repeated.

**Note:** when a Level Recorder Type 2306 bearing a serial number earlier than 567700 is used, it will have to be modified by connecting a 1 kΩ resistor across the diode connected to pin 3 of the External Power/Remote Control socket, or the green Filter Shift lamp will not light.

## 3.8. OPERATION WITH REMOTELY POSITIONED MICROPHONE

It is possible to make measurements with the Microphone and Input Stage positioned further away from the Sound Level Meter than the 3 m allowed by the Extension Cable AO 0134. Use can be made of the standard B & K Screened Microphone Cables AO 0027 (3 m: 6 mm dia), AO 0028 (10 m: 9 mm dia), and AO 0029 (30 m: 9 mm dia). Connection is achieved simply by exchanging the outer screw-off sleeve (short) from the socket on the AO 0134 with the outer sleeve (long) from the socket on one of the standard Microphone Cables and vice versa. Fig.3.10 illustrates how the socket sleeves are exchanged to accommodate the long and short plugs. The variation of distortion of the input signal to the Type 2215 with length of cable is shown in Fig.3.11.

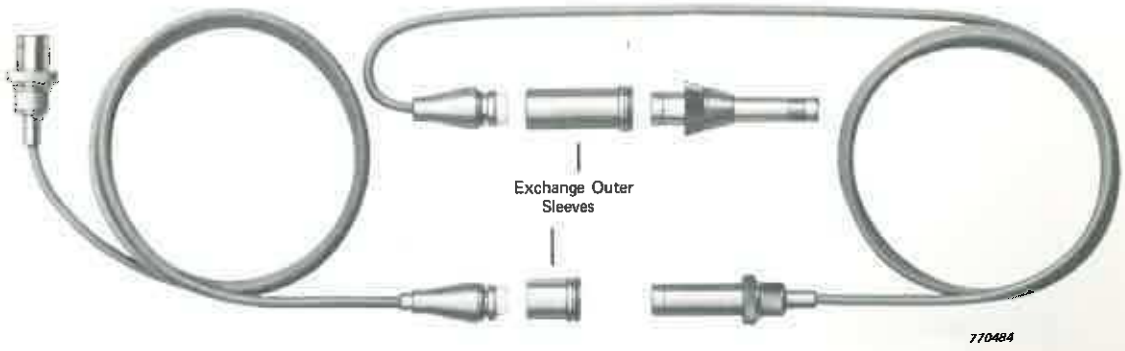



*Fig.3.10. Connecting extension cables*

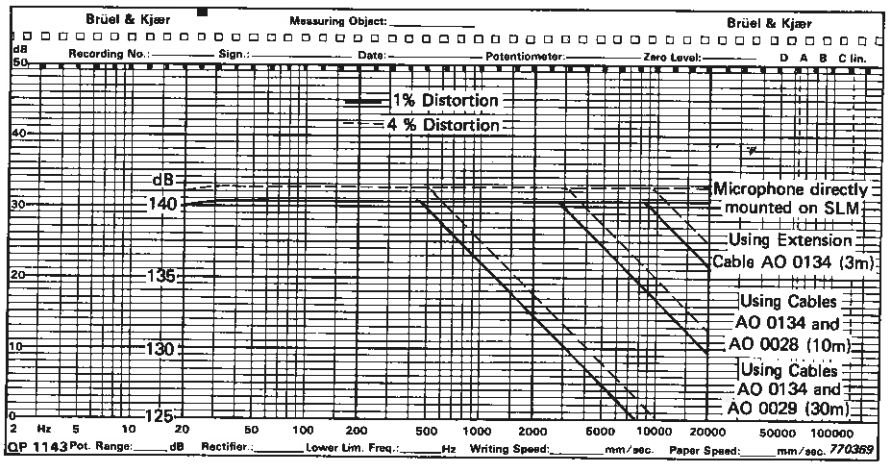



*Fig.3.11. Input distortion variation with cable length*

# 4. SPECIAL CHARACTERISTICS

A brief general description of the Type 2215 is given in Chapter 1, including most of the more important characteristics and complete specifications. However, it is possible that the operator will require a little more information on the variation of sensitivity with input capacitance, and on the crest factor capability of the Type 2215, so they are included here.

## 4.1. INPUT CAPACITANCE

Due to the low capacitance of condenser microphones, their sensitivity is affected by capacitive loads, as shown in Fig.4.1. For one-inch and half-inch microphones, their capacitance is between about 18 and 65 pF (the actual values are given on the calibration charts), and hence the input capacitance has relatively little effect. With the quarter-inch and eighth-inch microphones, however, whose capacitance is about 6,5 and 3,5 pF respectively, the loading effect is more pronounced, and system calibration using a Pistonphone Type 4220 or Sound Level Calibrator Type 4230 is recommended.

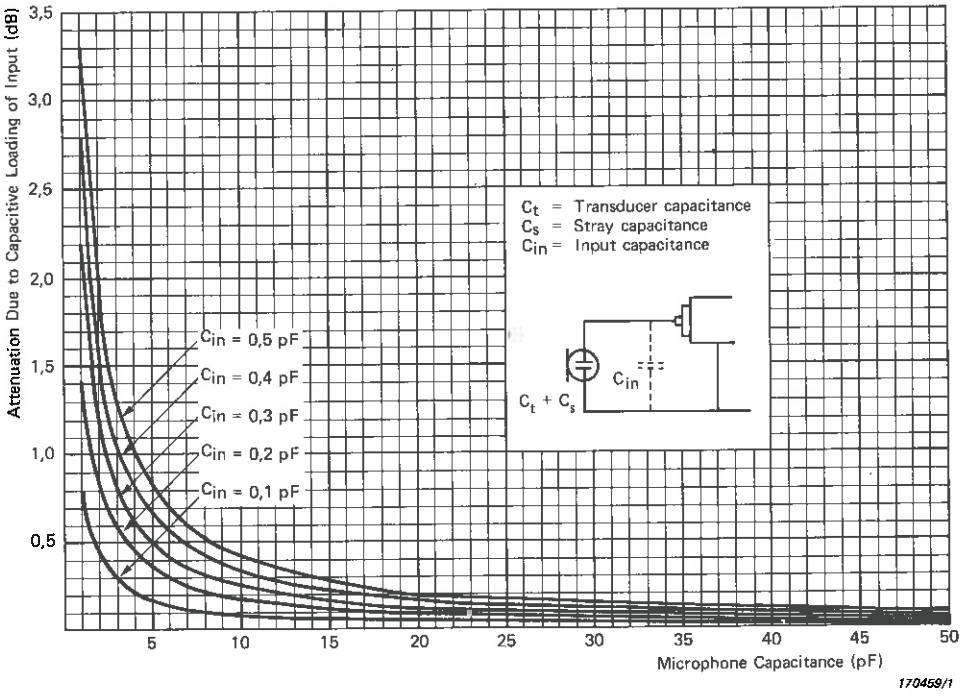



*Fig.4.1. Attenuation caused by preamplifier input capacitance*

## 4.2. CREST FACTOR CAPABILITIES

The crest factor of a signal is defined as the ratio of the peak to the RMS value. The Type 2215 is capable of measuring RMS values of signals with crest factors up to 50 for less than full scale meter needle deflections. This feature in combination with the

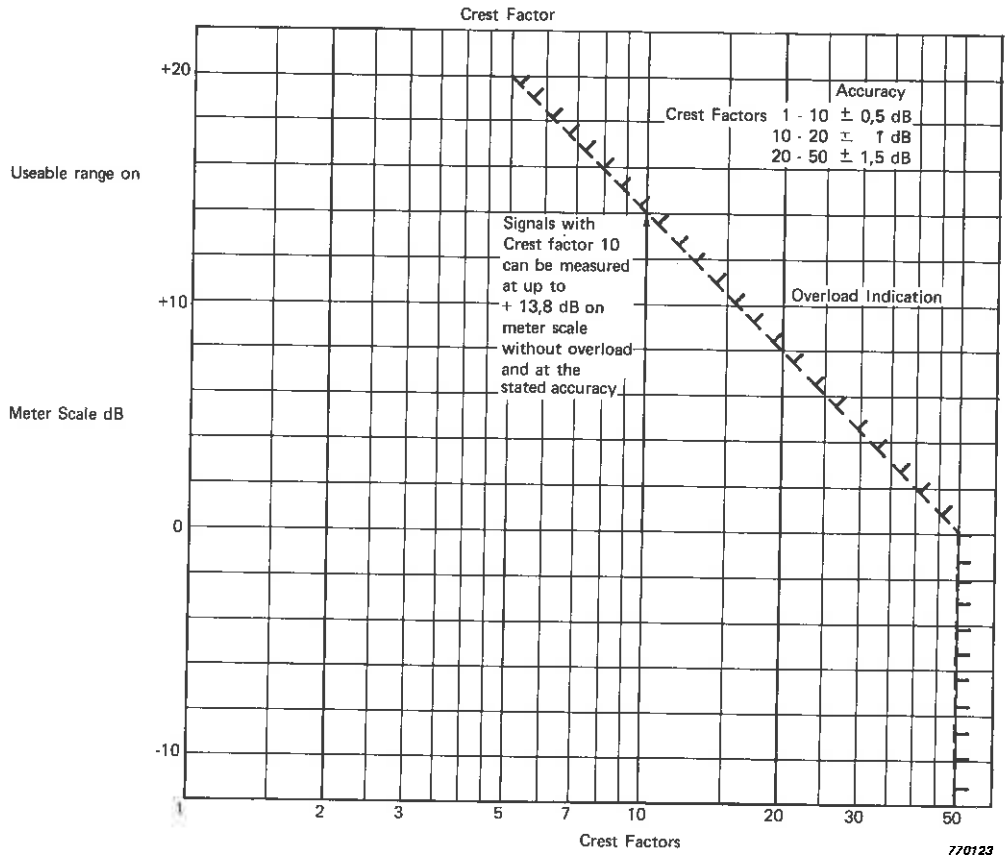



*Fig.4.2. Relationship between useful meter range and crest factor*

multi-point overload detector ensures there is no undetected overload in the rectifier circuit. Crest factor capability for less than full scale deflection is shown in Fig.4.2. The same capability applies to the DC output which has up to 20 dB more dynamic range than the meter.

The accuracy of the RMS measurements as related to the crest factor of the signal is indicated in Table 4.1.

Crest factor capabilities are also related to the maximum sound pressure levels that can be measured accurately. Fig.4.3 indicates the relationship for the Type 4165 delivered with the sound level meter.

| Crest Factor | Measuring Accuracy |
|---|---|
| 1 – 10 | ± 0,5 dB |
| 10 – 20 | ± 1,0 dB |
| 20 – 50 | ± 1,5 dB |

760087

*Table 4.1. Accuracy of meter scale readings for various crest factors*

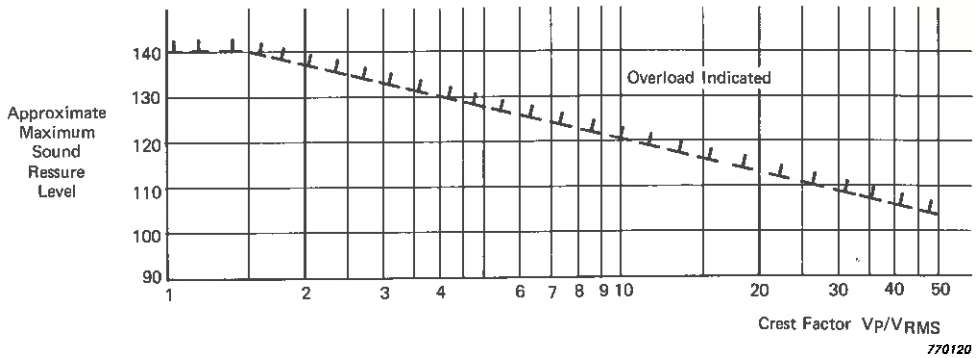



*Fig.4.3. Maximum SPL that can be accurately measured with the Type 4165 Microphone, delivered with the Sound Level Meter*