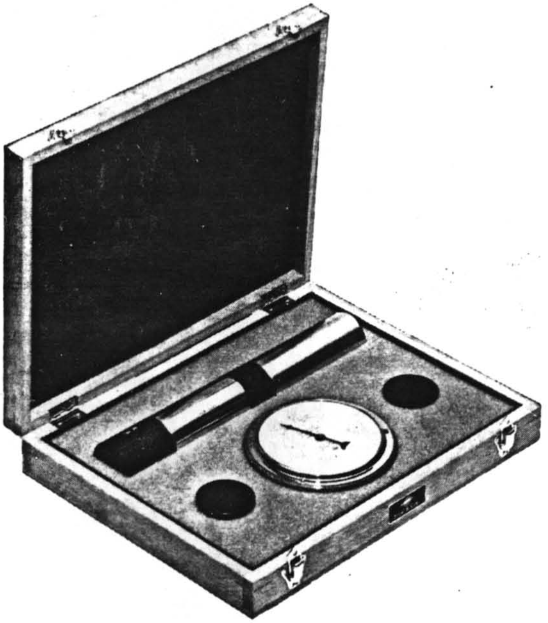
4220

INSTRUCTIONS AND APPLICATIONS

Pistonphone Type 4220



The Pistonphone is a compact battery-operated precision sound source, designed to enable quick and accurate overall calibration of sound measuring equipments. It produces a sound pressure level of 124 dB at the microphone diaphragm, at a frequency of 250 Hz.

Accelerometers
Acoustic Standing Wave Apparatus
Artificial Ears
Artificial Voices
Audio Frequency Response Tracers
Audio Frequency Spectrometers
Audio Frequency Vacuum-Tube Voltmeters
Automatic A. F. Response and Spectrum Recorders
Automatic Vibration-Exciter Control Generators
Band-Pass Filter Sets
Beat Frequency Oscillators
Complex Modulus Apparatus
Condenser Microphones
Deviation Bridges
Distortion Measuring Bridges
Frequency Analyzers
Frequency Measuring Bridges
Hearing Aid Test Apparatus
Heterodyne Voltmeters
Level Recorders
Megohmmeters
Microphone Accessories
Microphone Amplifiers
Microphone Calibration Apparatus
Mobile Laboratories
Noise Generators
Noise Limit Indicators
Pistonphones
Polar Diagram Recorders
Preamplifiers
Precision Sound Level Meters
Recording Paper
Strain Gage Apparatus and Accessories
Surface Roughness Meters
Variable Frequency Rejection Filters
VHF-Converters
Vibration Pick-ups
Vibration Pick-up Preamplifiers
Wide Range Vacuum Tube Voltmeters

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BB 4220

Contents

Introduction

The Pistonphone Type 4220 is designed for the absolute calibration of precision sound measuring systems.

A sound level measuring equipment basically consists of a microphone, followed by suitable amplifier stages and an indicating instrument. The amplitude and frequency characteristics of the electronic components are generally accurately defined, but the exact determination of the sensitivity of the equipment in relation to sound pressure is less easy to obtain.

The recommendations of the IEC for Precision Sound Level Meters (Technical Commission no. 29) requires: "The complete apparatus shall be calibrated in absolute values at any specified frequency between 200 and 1000 Hz. The accuracy of the calibration at this frequency, including errors due to the free field measurement, and those due to the actual electroacoustic measurements, shall always be better than ± 1 dB."

Different methods of sound level calibration have been adapted by Brüel & Kjær, i.e.: the Reciprocity Calibration, the Electrostatic Actuator, the Noise Source, and the Pistonphone. Each method has a particular field of application. They are all carried out as pressure calibrations (fictitiously in the case of the actuator), the calibrating sound source being tightly coupled to the microphone by a coupler of small dimensions. For small condenser microphones, such as the B & K microphones, there is no appreciable difference under 1000 Hz, between the pressure and the free field sensitivities.

The *Reciprocity technique**), which is the method retained in the American Standard ASA Z 24-4 (1949), is based upon the law of reciprocity of reversible transducers. It is carried out by permutation between three microphones and the measurement of voltage ratios only, with the knowledge of a few physical constants. This laboratory method enables absolute pressure calibration of microphones to be made with excellent accuracy. On the other hand, it is a relatively time-consuming operation.

The *Electrostatic Actuator**) produces a fictitious acoustic pressure on the diaphragm of a condenser microphone by electrostatic attraction. It is particularly useful and very reliable as a variable frequency exciter for the automatic recording of frequency response curves. However, the inaccuracy in the determination of the equivalent sound pressure hinders the electrostatic actuator from being used as an absolute calibration means.

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*) See the Instruction Manual for the B & K Microphone Calibration Apparatus Type 4142.

The *Noise Source* Type 4240 mechanically produces an approximate "white" random noise. The advantage of the "white" noise is that it calibrates over a wide range of audio frequencies, i.e. in conditions approaching an actual noise measurement. The noise source is a small independent device, well-adapted for field calibration check of sound measuring equipment, and requires no electric power for operation. The accuracy of the noise source is, however, limited to ± 1.5 dB.
The principle of the *Pistonphone* is that a sound pressure is produced in the coupler cavity by a piston moving in and out. This sound pressure is proportional to the variation of the coupler volume, i.e. to the stroke and area of the piston, and the error in the sound pressure level depends in particular on the accuracy in the measurement of the stroke.

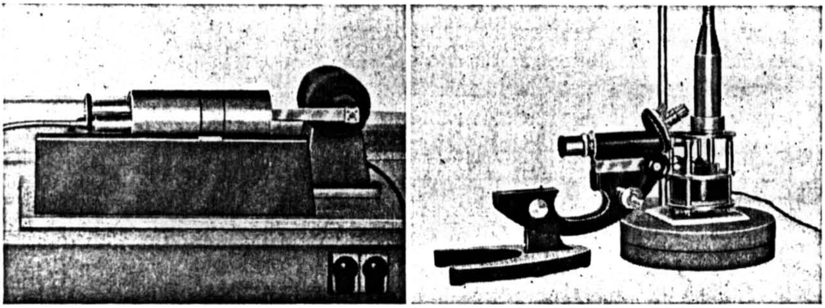


Fig. 1. The "old" pistonphones; to the left an old mechanically driven pistonphone, and to the right an electromagnetically driven pistonphone.

The pistonphone was first developed as a normally driven piston (crank + connecting rod), see Fig. 1. With this arrangement is was practically impossible to carry out a calibration at a sufficiently high frequency. To obtain 200 Hz, the motor should run at 12ooo r.p.m., and even at much lower speeds than this, vibrations occurred in the bearings and in the connecting rod, with an eventual wobbling of the motor spindle, which produced an unacceptable error in the determination of the stroke. In addition, the distortion of the piston movement caused by the finite length of the connecting rod had to be taken into account, and due to the variations of the torque on the motor axle the frequency stability was also insufficient.
For these reasons, the mechanical drive has been superseded by an electromagnetic drive of the type used in loudspeakers, enabling audio frequencies to be easily obtained. The piston stroke has to be measured optically. This can be made with a certain accuracy by means of a good microscope. However, the use of a microscope and the difficulty in obtaining a high sound

pressure level limit the use of this type of pistonphone to laboratory work and demonstrations.

The **Pistonphone Type 4220** is a mechanical device of a new design which, by using two symmetrically mounted pistons, with a floating retaining spring arrangement, eliminates shaft eccentricity, and back-lash of bearings from any influence on the stroke of the pistons, and thus avoids the drawbacks of the old pistonphone. This small unit produces a pure tone of 250 Hz, with a sound pressure level of 124 dB (RMS) re. 2×10^{-4} μbar, allowing correct calibration to be made even in very noisy surroundings. The Pistonphone 4220 features outstanding simplicity and rapidity of operation and has a calibration accuracy of ± o.2 dB, which is of the same order as the precision usually obtained by the reciprocity method. It can be used anywhere where a well-defined sound source is required, and is especially suited for the direct calibration of precision sound measuring equipment in the field.

Description

General.

The Pistonphone Type 4220 (Fig. 2) is of cylindrical shape with small dimensions (comparable with the dimensions of a "flash light"), and is battery operated. It is consequently compact and portable, always ready for use, having no mains connections, and can be utilised under the most difficult ambient conditions. Once the microphone is fitted to the coupler the operation consists simply of starting the pistonphone and adjusting the sensitivity of the components in the sound measuring equipment until the deflection on the indicating instrument corresponds to the S.P.L. (RMS Sound Pressure Level) produced by the pistonphone.

Fig. 2. Photograph of the Pistonphone.

Each pistonphone is individually calibrated and the exact value of calibration, which can deviate a few tenth of dB from the nominal 124 dB, is indicated on the calibration chart which is supplied with the instrument upon delivery. The calibration is given at normal atmospheric pressure (760 mm Hg). The maximum error of calibration is less than ± o.2 dB.

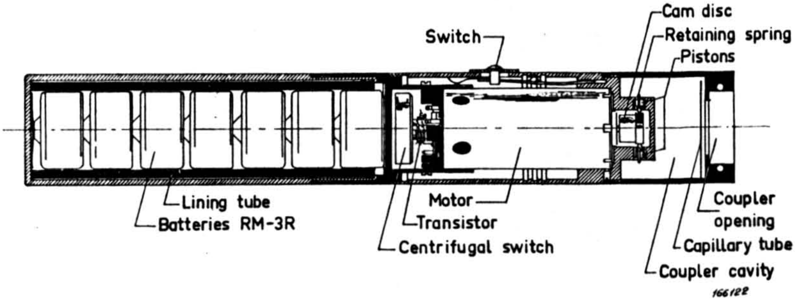


Fig. 3. Assembly drawing of the Pistonphone.

The necessary correction for variation in atmospheric pressure is read directly in dB off a barometer supplied with the pistonphone. In the ordinary range (0°—60°C), temperature has practically no effect on the pistonphone's calibration.
The Pistonphone Type 4220 is delivered in a wooden case with the barometer and different adaptors.

Principle of Operation.
The principle of operation of the Pistonphone Type 4220 is shown in Figures 4 and 5. The two pistons are symmetrically driven by means of a cam disc, mounted on the shaft of a miniature electric motor. The cam, which is made of specially selected tempered steel, is machined to a high degree of accuracy, according to the law $r = a + b \sin 4\alpha$ (Fig. 5).*) When rotating, the cam will give the pistons a sinusoidal movement at a frequency equal to four times the speed of rotation. Consequently the cavity volume is varied sinusoidally and the RMS sound pressure produced will be:—

$$P = \gamma \times P_o \times \frac{2 A_p S}{V\sqrt{2}} \text{ dynes/cm}^2$$

where:

- γ = C_p/C_v = ratio of specific heats for the gas in the cavity (γ = 1.402 for air, at 20°C and 1 atm.).
- P_o = atmospheric pressure, expressed in dyne/cm².
- A_p = area of one of the pistons.
- S = peak amplitude of motion of one piston from the mean position.
- V = volume of cavity with the pistons in mean position + the equivalent volume of the microphone.

The sound pressure level in dB is consequently: S.P.L. $= 20 \log \frac{P}{P_t}$, with $P_t = 2 \times 10^{-4}$ μbar = 0.0002 dynes/cm² = threshold of hearing.
It is assumed in the above equation that $A_p \times S << V$, and that the compression is adiabatic. These conditions are satisfied entirely in the case of the Pistonphone Type 4220, where $A_p \times S/V < 0.0002$, and where the heat conduction correction would be less than 0.05 dB at 20 Hz.**)
It is possible to define, with great precision, the different quantities involved in the equation. The piston stroke S, which was difficult to measure in the case of an electromagnetically driven pistonphone, is simply here, one fourth of the difference between the maximum and the minimum diameters of the cam. Accurate measurement of this difference, though relatively small, offers no problem by using a precision micrometer. In addition, as the pistons are

*) A cam disc corresponding to the law $r = a + b \sin 2\alpha$ is available on request. With this disc the reference frequency is 125 Hz and the distortion less than 1.5 %.

**) Experiments on the Pistonphone Type 4220 have shown that the compression can be considered as adiabatic down to a frequency of 1 Hz (the error being approx. 0.3 dB at 1 Hz).

symmetrically located with respect to the cam, any mechanical deviation due to the mounting or to a wobbling of the motor is compensated in the total movement of the pistons, and has no influence on the S.P.L. produced.

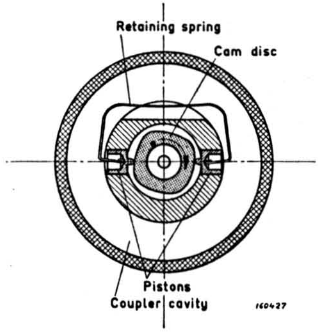
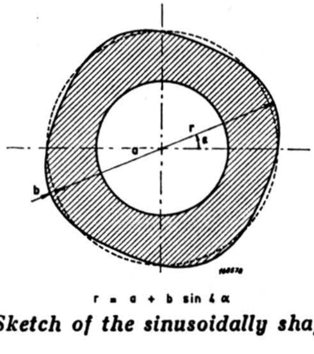


Fig. 4. Cross-section showing the principle of operation.

The frontal surface A_p of the pistons and the volume V of the cavity are also easy to measure accurately, and as the diameter of the pistons is great with regard to the stroke the influence of the space between the pistons and the walls is negligible. (The tightness of the pistons is satisfactory, without any lubricating material, down to about 20 Hz).
Finally a possible error on the ambient pressure P_0 is far under the required limit, as ten degrees on the scale of the barometer corresponds to o.04 dB.
These features make it possible to calculate the S.P.L. produced by the Pistonphone Type 4220 at the standard frequency of 250 Hz to within less than $\pm$ o.2 dB ($\pm$ 2 %).



$$r = a + b \sin 4\alpha$$

Fig. 5. Sketch of the sinusoidally shaped cam.

Pistons, Non-Linear Distortion.
The design of the piston drive in the Pistonphone 4220 makes an allowance for very low non-linear distortion. The distortion is produced, not by imper-

fection of the specially shaped cam which can be considered as of a rather perfect sinusoidal shape, but by the wear of the piston tips sliding on the cam. During experiments it has been noticed that the tips, if no special care has been taken, can become worn on one side, and in due course slightly distort the movement of the pistons.

The pistons are made of a special synthetic material, presenting a particularly low friction coefficient with steel. The cam and pistons are lubricated with high quality oil. Also, the tension of the retaining spring is carefully adjusted to maintain even contact of the piston tips on the cam, without excessive pressure. By means of these precautions, the distortion factor of the Pistonphone is maintained lower than 3 % at 250 Hz. The frequency spectrum of the signal produced by the pistonphone is shown in Fig. 6.

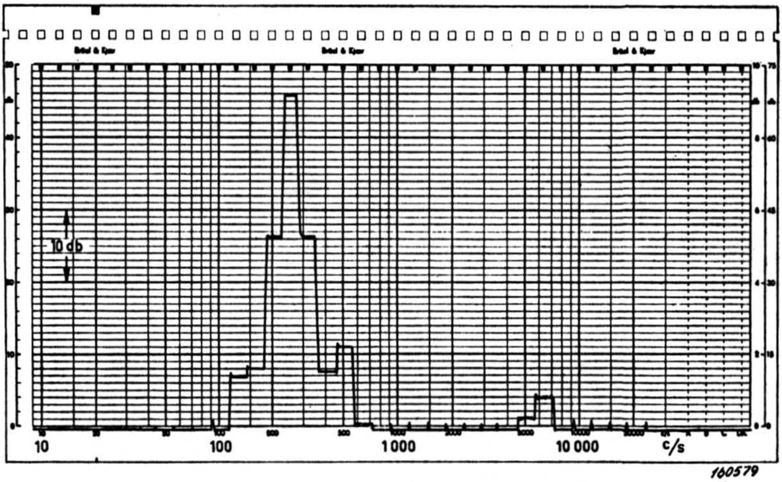


Fig. 6. Typical frequency spectrum of the Pistonphone recorded by means of the B & K Spectrum Recorder Type 3312. The spectrum shows a second harmonic of 1.8 %, and some noise caused in the coupler by the motor, around 7000 Hz.

Coupler and Adaptors.

The coupler cavity of the Pistonphone 4220 has been designed with dimensions which are small with respect to the wave-length of the sound, in the frequency range involved. The coupler has an opening diameter of 23.8 mm, fitting microphones with a standard diameter of 0.936 inch (as specified in A.S.A. Z 24-8-1949) such as the Types B & K 4131 and 4132, W. E. 640 AA, MR 103.

In addition, three adaptors are supplied with the Pistonphone, enabling the opening diameter to be reduced without changing the total volume of the cavity, for use with ½, ¼ and ⅛ inch diameter microphones. A special adaptor is available on request for fitting the old B & K Microphone Type 4111 with diameter 36 mm*). The adaptors are easily mounted onto the pistonphone by pressing them into the coupler opening and into each other. See Fig. 7.

The coupler opening and the adaptors are fitted with a rubber ring which ensures an airtight connection to the microphone under test. The coupler cavity is also fitted with a capillary tube for static pressure equalization with the pressure outside.

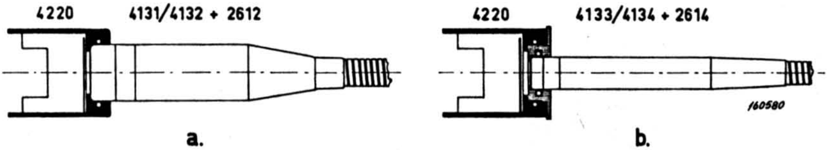


Fig. 7. Mounting the different B & K microphones on the Pistonphone.
(a) "one inch" Microphone Type 4131 or 4132.
(b) "half inch" Microphone Type 4133 or 4134.
The total volume of the cavity is the same in both cases.

The pistonphone can be adapted to almost any type of microphone, as a suitable adaptor can easily be made, which has a larger or smaller diameter. The use of special adaptors does not offer any other problems than those of external leakages.**) However, the dimensions should remain small in comparison with $\frac{\lambda}{4}$ in order to avoid any disturbance due to wave motions in the cavity, ($\frac{\lambda}{4}$ in air is approximately 34 cm (13″) at 250 Hz, and 10 cm (4″) at 800 Hz), and a ratio of 1 to 3.5 between the total depth and the diameter of the coupler is recommended in order to obtain the best possible frequency response.

From the pistonphone formula it is seen that the S.P.L. produced by the Pistonphone is inversely proportional to the volume V of the cavity. The nominal S.P.L. of the Pistonphone corresponds to the situation where a B & K microphone, with the normal protecting grid, is inserted. In this case the total volume of the cavity is 19.6 cm^3, including the equivalent volume of the microphone: 0.15 cm^3 for B & K Types 4131—4132. For any change in the total volume V, a corresponding correction must be made on the given S.P.L. of the Pistonphone. See "Volume Correction" in the following chapter.

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*) B & K part number: DB 0386.

**) When using the Pistonphone with some types of microphones, a slight and slow variation in the reading of the indicating instruments may be noted. This is caused by poor equalization between the pressure inside these microphones and the external pressure.

Motor and Frequency Regulation.

The Pistonphone is equipped with a precision DC motor. In order to ensure the frequency stability, the rotating speed is regulated to within 1 % by a centrifugal switch and a current regulating transistor. See Fig. 8. This arrangement completely eliminates any distortion coming from the cam speed. In addition, such an accurate definition of the frequency is required for calibration of non-linear sound level meters (e.g. in the case of a sound level meter having the standardized "weighted" frequency response A, or B, it is known that the response at 250 Hz is 8.6 dB or 1.4 dB, respectively, lower than the response at 1000 Hz).

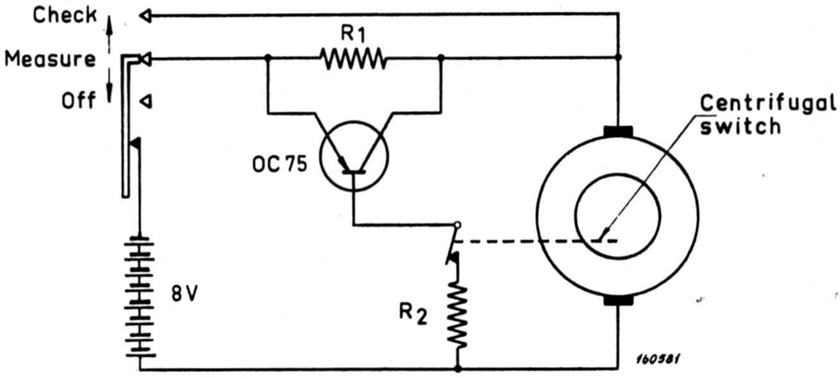

Fig. 8. Diagram of the frequency regulator.

The control switch ("flash-light" type) has three positions: "Off-Measure-Check". In the "Measure" position the current from the batteries is fed to the motor through the regulating system, which maintains a rotating speed of 3750 rpm, i.e. a frequency of 250 Hz. In position "Check" the batteries are directly connected to the motor, and the frequency will be somewhat higher, e.g. 350—400 Hz for fresh batteries. By pushing the switch back and forth between "Measure" and "Check" positions a quick check on the batteries is obtained. If no frequency variation is noted, it is time to replace the batteries. (The batteries could still give some more hours use, but the frequency of the produced sound would be lower than 250 Hz).

The frequency of the Pistonphone may be varied up to 800 Hz by using an external DC power supply instead of the batteries, the control switch being in position "Check". The motor has a shunt characteristic and its rotating speed is approximately proportional to the connected voltage. The upper limit of the motor rotating speed, corresponding to a frequency of 800 Hz, is attained for a voltage of approximately 24 Volts. It should never be exceeded and must be used only for short periods of time. (See also the Note p. 17). The lower limit depends on the leakage time constant in the coupler cavity and is about 20 Hz when no special care is taken to ensure the tightness (down to 2 Hz or even less with a simple film of grease). In position "Check" the stability of the rotating speed, i.e. of the frequency, is directly related to the stability of the voltage between the motor terminals, and especially at low frequencies the DC source should have a low internal impedance (less than 2 ohms). Between the given limits of the frequency, the S.P.L. produced by the Pistonphone is constant and independent of the frequency.*)

Batteries.

The Pistonphone is supplied with long-life mercury cell batteries (Mallory type RM - 3(R)) upon delivery. The battery compartment holds 7 cells giving a total voltage of approximately 8 volts. Though the cost of mercury cell batteries is higher than the cost of ordinary ones, the adoption of this type of battery is the cheapest in the long run. The reason is that in normal use, such as laboratory standard, the Pistonphone is utilized only a few minutes per day, and perhaps even less. Under these conditions, the batteries life is limited by their storage life. Therefore the use of mercury cells, which feature a long storage life, is recommended. According to the manufacturer, the batteries RM - 3(R), supplied with the Pistonphone can be, stored for more than 6 years. This duration corresponds to a utilization of the pistonphone of one or two minutes per day.

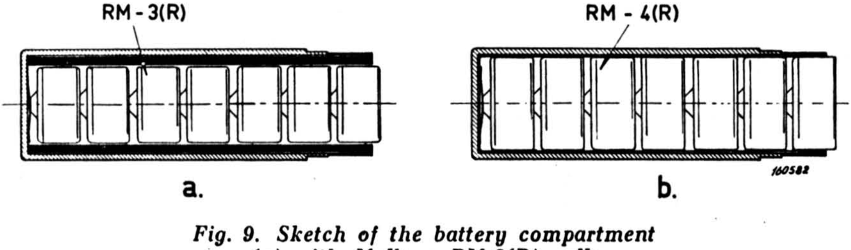

Fig. 9. Sketch of the battery compartment
(a) with Mallory RM-3(R) cells
(b) with Mallory RM-4(R) cells

Under circumstances where extended use is made of the Pistonphone, larger mercury cell batteries may be advantageous. These are Mallory type RM - 4(R) with a diameter of 30 mm (the diameter of the RM - 3(R) units is 25

*) The noise from the motor has a resonance peak at high frequency (7—8 kHz), but is always more than 40 dB below the signal. However, when running the motor at its highest speed (i.e. 800 Hz) the noise resonance peak can produce a small rise of about 0.2 dB of the total S.P.L. in the coupler cavity.

mm). They can be fitted in the battery compartment by removing the inner plastic lining tube. (Fig. 9). The service life, with these batteries, is extended approximately 50 %.

Barometer UZ 0001 for Ambient Pressure Correction.

The calibration of the Pistonphone is given for normal atmospheric pressure conditions: $P_o = 760$ mm Hg. For important barometric or altimetric changes in the ambient pressure, a correction must be made. A barometer, graduated both in dB of correction and in mm Hg of pressure is supplied with the Pistonphone for this purpose. The barometer range is from 795 to 595 mm Hg and is divided into two 360° scales. The outer graduation of the scales is in dB, and the inner, in mm Hg (Fig. 10).

The outer scale, graduated from 795 to 675 mm Hg, indicates the dB correction for the usual barometric variations and can be used at altitudes up to 600 m (1800 feet) above sea level. The inner scale, graduated from 715 to 595 mm Hg is intended to be used at altitudes from 600 to 2000 m (1800 - 6000 feet).

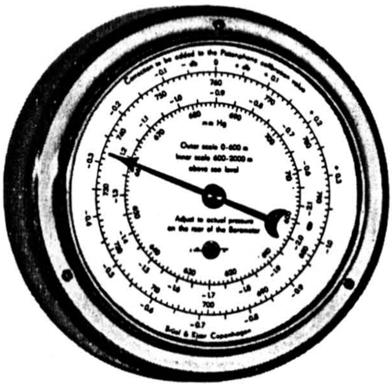

Fig. 10. The Pressure Correction Barometer UZ 0001.

From time to time, and especially after transport or after important changes in altitude, it is recommended to check the calibration of the barometer. The pointer of the barometer can be adjusted by means of a screw at the rear of the barometer.

For altimetric variation of the ambient pressure beyond 2000 m and up to 18000 m (55000 feet) i.e. down to 60 mm Hg, the correction curve given in Fig. 11 can be used.

A conversion chart giving the equivalence between the pressure expressed in different units is shown in Fig. 12.

Operation

General.

After the sound measuring equipment under test has been warmed up and made ready for use in the 120—130 dB range and with "linear" frequency response, operation of the Pistonphone is as follows:—

(1) Fit the microphone of the equipment under test to the coupler opening. The Pistonphone can be held in one hand, in any position.*)

(2) Start the Pistonphone by pushing the gliding switch, and check the batteries by pushing the switch forwards and backwards between the "Measure" and "Check" positions. A definite variation in frequency indicates that the batteries are in good condition.

(3) The Pistonphone's switch being in "Measure" position, adjust, with the free hand, the sensitivity of the sound measuring equipment until the

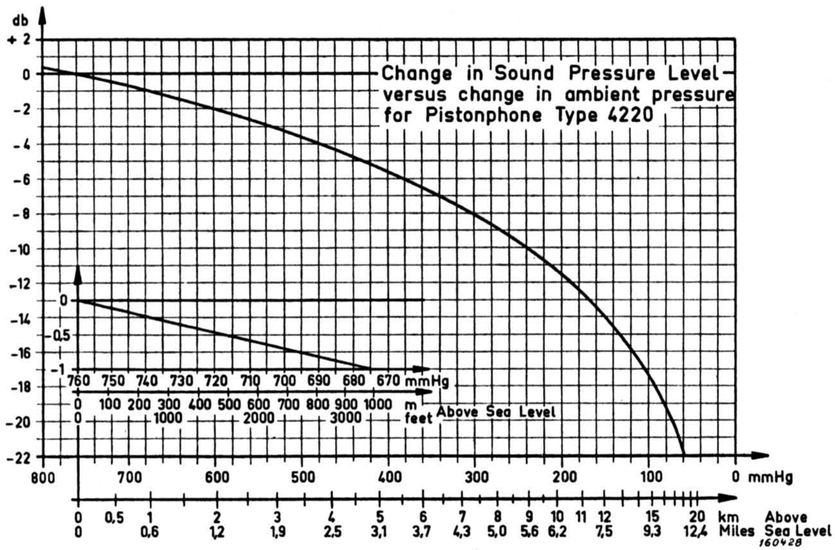

Fig. 11. Correction curve for operation at low pressures or high altitudes.

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*) A slight variation in the noise produced by the motor can be noticed when holding the pistonphone in different positions. This has no relation to the frequency and the S.P.L. produced.

indication coincides with the S.P.L. (RMS Sound Pressure Level) produced by the Pistonphone. See Applications, for the case of B & K equipment.

(4) Stop the Pistonphone as soon as the calibration has taken place in order to conserve the batteries.

Ambient Pressure and Volume Corrections.

The S.P.L. produced by the Pistonphone is equal to the calibration value indicated on the Calibration Chart. However, a correction must be made to this value, if the ambient pressure is not the normal atmospheric pressure (760 mm Hg = 1013 millibar = 29.9 inches Hg), and also, if the total volume of the coupling cavity, including the equivalent volume of the microphone, is not the same as in the reference case, where a B & K condenser microphone with normal protecting grid is inserted.

The ambient pressure correction is immediately read off the barometer supplied with the pistonphone, as described above.

The volume correction is, according to the pistonphone formula, if V' is the total volume of the coupler cavity: $20 \log_{10} \frac{V}{V'}$, dB, to be added to the calibration value which corresponds to the volume $V = 19.6$ cm^3.

For example, in the case of a pistonphone calibrated to 123.9 dB, and assuming the pointer of the barometer indicating — o.2 dB and the pistonphone fitted with a special coupler to a certain microphone so that the total volume is V' = 24.1 c.c., the S.P.L. produced will be in dB:

$$\text{S.P.L.} = 123.9 - 0.2 + 20 \log \frac{19.6}{24.1} = 123.9 - 0.2 - 1.8 = 121.9$$

Volume corrections for use with different types of standard microphones directly fitted to the Pistonphone are given in the following table:

Type	Without Protecting grid	With Protecting Grid
WE 640 AA	+ o.3 dB	+ o.42 dB
MR 103	+ o.3 dB	+ o.42 dB
B & K 4131, 4132	+ o.3 dB (with coupler adapting ring DB 0111)	0

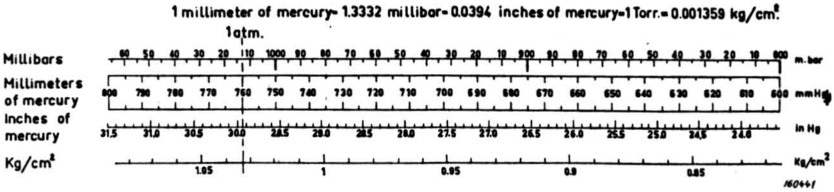


Fig. 12. Chart for conversion of barometer readings in different units.

Use of External DC Power Supply.

The Pistonphone is normally used at a fixed frequency. However, in certain instances, use can be made of the fact that the S.P.L. is independent of the frequency, to check the response of a sound measuring system.

The frequency of the Pistonphone can be varied within the range 30 Hz—800 Hz by applying an external DC voltage varying from 1.5 to 24 volts approximately. The necessary connections should be made to the rings which are seen when the battery compartment is unscrewed. (The — is connected to the outer ring, and the + to the center ring, marked "BATT +"). The Pistonphone switch is set in "Check" position. When approaching 800 Hz (at 800 Hz the motor runs at 12ooo r.p.m.), the Pistonphone must only be used for short periods of time, and as it could be dangerous for the motor to exceed the maximum speed, the voltage corresponding to the maximum frequency should be progressively attained, for example by means of a potentiometer as shown in Fig. 13. At the lowest frequencies, around 20 Hz, it is necessary to have a DC source with low internal resistance (less than 2 ohms) in order to ensure stability of the rotating speed of the motor.

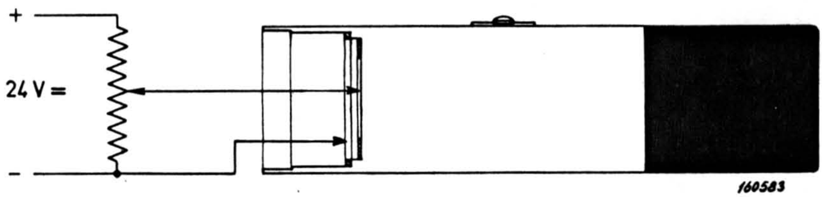


Fig. 13. Connection of external DC power supply.

An easy, but rather rough way of obtaining low frequencies, consists of rapidly moving the switch back and forth between the "Off" and "Measure" positions. When calibrating a sound level meter equipped with an indicating instrument featuring a convenient dynamic characteristic, a quick check of the low frequency response of the sound level meter can be obtained in this way by observing the deflection on the instrument, and an abnormal loss of sensitivity at the low frequencies can rapidly be detected. Inversely, an abnormal leakage in the coupler of the Pistonphone can be detected when calibrating an instrument the linearity of which is ascertained at low frequencies.

Dismantling of the Pistonphone.

To take the Pistonphone apart, proceed as follows (see also Fig. 2):—

(1) Remove the coupler by unscrewing it from the Pistonphone.

(2) Remove the piston retaining spring and take out the pistons.

(3) Unscrew the two set-screws from the body of the Pistonphone.

(4) Unscrew the motor housing from the black motor mounting piece.

(5) Gently push out the pistons.

To reassemble the Pistonphone:—

(1) If necessary, the cam disc and the pistons should be cleaned in a detergent.

(2) Screw the motor housing onto the motor unit.

(3) If necessary, apply a drop of high quality oil to the cam disc (e.g. Esso "Univis 40" or Shell "Microtime Type A Ultra Light").

(4) Replace the two set-screws.

(5) Insert the pistons and replace the retaining spring. Finally replace the coupler.

Note: The pressure of the retaining spring should be 20 g. approximately. A too low pressure would cause distortion, and a too high pressure produces an excessive wear on the piston tips. If it is intended to operate the Pistonphone at 800 Hz it may be necessary to slightly increase the spring pressure in order to ensure constant contact of the piston tips on the cam disc, in spite of the high rotating speed. However, the spring pressure must be decreased again as soon as returning to the normal rotating speed.

Spare springs and pistons can be ordered separately. See the parts list.

Caution: Never touch the pistons while operating.

Applications

The direct, absolute pressure calibration of sound level meters provided by the Pistonphone is more reliable and accurate than calibration from a built-in reference voltage and the knowledge of the microphone sensitivity (K factor).

Calibration of the Precision Sound Level Meter Type 2203.

The Pistonphone is well adapted for use in connection with the Sound Level Meter Type 2203 which is also portable and battery operated (Fig. 14). The operation is as follows:

(1) Switch on, by pulling out the central knob. The indicating lamp starts to flash.

(2) Turn the transparent knob fully clockwise.

(3) Turn the black knob until "120 dB" is in the red circle. The S.P.L. is read on the sound level meter as the deflection on the meter scale (— 10 to + 10 dB) plus the dB number in the red circle.

(4) After a short wait, check the batteries by setting the central knob to "Batt.". The deflection should lie between the two limits of the "Battery" scale.

(5) Set the control knob to "Lin." (Fast). 30 seconds after switching on, the Sound Level Meter is ready for calibration.

(6) Push the Pistonphone onto the microphone of the Sound Level Meter and operate as described in "Operation", p. 14.

(7) The indication of the Sound Level Meter should be equal to the S.P.L. produced by the Pistonphone. If not, correct by means of the screw-driver operated potentiometer marked "Adj.".

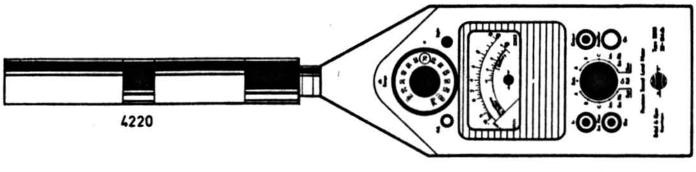


Fig. 14. Calibration of the Precision Sound Level Meter Type 2203.

Calibration of Sound Measuring Equipment Consisting of a "B & K" Condenser Microphone Connected to one of the Following Instruments:
(a) Microphone Amplifier Type 2603 or 2604 (Fig. 15a).
(b) Frequency Analyzer Type 2107 (Fig. 15b).
(c) Audio Frequency Spectrometer Type 2111 or 2112 (Fig. 15c).

1. Case of the "one inch" microphones (Cartridges Type 4131 or 4132).

For calibration by means of the Pistonphone, the control knobs of these instruments should be adjusted as follows:

(1) POWER to "On".
(2) INPUT SWITCH to "Condenser Microphone".
(3) METER RANGE to "120 dB".
(4) WEIGHTING NETWORK to "Linear" or "Curve C".
(5) METER SWITCH to "R.M.S. - Fast".
(6) RANGE MULTIPLIER to "x o.3 - 10 dB".

The measured S.P.L. in these conditions is read directly in dB re. 2×10^{-4} μbar, as the sum of the "dB SL" setting of METER RANGE switch + the dB setting of RANGE MULTIPLIER + the meter pointer deflection in dB. Calibration (item (3) of the general procedure p. 14) consists of adjusting the indication of the instruments to the S.P.L. value produced by the Pistonphone, by means of the screwdriver operated potentiometer marked SENSITIVITY CONDENSER MICROPHONE. With, for example, a Pistonphone producing 124.1 dB, the deflection should be 14.1 dB.

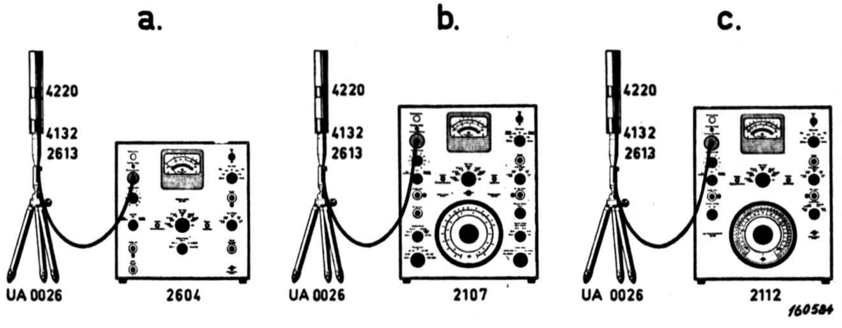


Fig. 15. The Pistonphone used for direct S.P.L. calibration of:—
(a) Microphone Amplifier 2604.
(b) Analyzer 2107.
(c) Spectrometer 2112.

2. Case of the "1/2-inch" and "1/4-inch" microphones (Cartridges Types 4133, 4134, 4135, 4136).

Due to the lower sensitivity of these microphones, a correction has to be made to the "dB SL" global reading obtained from the indications of the control knobs and the meter deflection as explained above. A suitable increase of sensitivity should be given the amplifier by means of the attenuators in order to obtain a convenient deviation of the pointer during the calibration. For example, in the case of the half-inch microphone having a sensitivity which is around 14 dB lower than the one-inch microphone, the sensitivity of the measuring instrument can be increased by 20 dB by shifting the METER RANGE switch one step down with respect to the adjustment indicated for the one-inch microphones. The pointer will then deflect around 20 dB (full deflection) when calibrating with the 124 dB S.P.L. of the Pistonphone. If now the deflection is adjusted, by means of the SENSITIVITY CONDENSER MICROPHONE potentiometer to *exactly* 20 dB, the global reading is 110 dB, while the sound level is 124 dB, which means immediately that the correction to be made on the global reading is + 14 dB. With a Pistonphone producing 123.8 dB S.L., the correction is exactly + 13.8 dB etc. By this procedure, the correction is determined with an error which is equal to the pistonphone calibration error (less than ± o.2 dB) plus the reading error.

Reference level on Sound Level Recordings and Spectrograms.

The recording of the Sound Level as a function of time can be made by means of a level recorder, such as the B & K High Speed Level Recorder 2305 connected to the output of the measuring instrument.

In addition, the Analyzer Type 2107 and the Spectrometer Type 2112 are often used in connection with the B & K Level Recorders in order to obtain the frequency distribution of the sound being investigated. They are designed to be driven synchronously with the pre-calibrated recording paper of the level

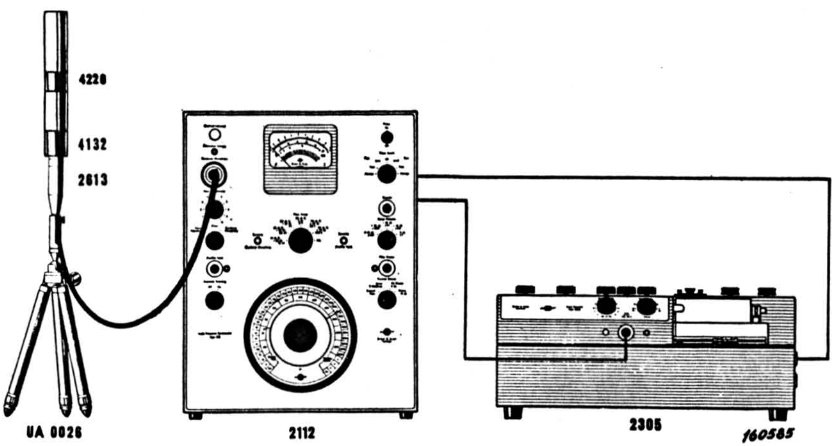


Fig. 16. Calibration of a set-up for frequency analysis of noise.

recorder, making possible the automatic recording of the amplitude frequency curve (Fig. 16).

When using the Pistonphone, an absolute calibration is immediately obtained on the recording paper. Attention must be paid, however, whether the Recorder measures the RMS, the arithmetic average, or the peak value of the signal. The Pistonphone is calibrated in RMS value. The peak value is 1.41 times, the RMS value (peak = RMS + 3 dB), and the average value is 0.90 times the RMS value (av. = RMS — 0.9 dB).

The zero level on the level recorder should be chosen so as to avoid overloading of the amplifier of the preceding instrument. Calibration consists of setting, by means of the Level Recorder input potentiometer, the recording stylus to any suitable deflection corresponding to the reference S.P.L. produced by the Pistonphone.

N.B. When using the former Level Recorder Type 2304, which is a peak rectifying instrument (if not modified) a correction should be made, equal to the practical crest factor difference between the measured signal and the calibration signal. Since the crest factor of the acoustical noises encountered in practice is generally around 8 dB (with respect to the 2304) the correction to be made is about —5 dB (i.e. the reference level on the paper is 119 dB S.L.).

Level calibration of Tape Recordings.

The Pistonphone is well suited for supplying a reference sound level for sound measurements which are recorded on magnetic tape. The calibration signal is recorded at the beginning and at the end of the tape. In some cases, the calibration level of 124 dB will fall in the S.P.L. range of the measurement. If not, the level of the tape calibration can be modified a certain amount of dB by means of the microphone amplifier attenuator, but this must be taken into account when the measurements are evaluated and frequency analysed by playing back the tape in the laboratory.

Specification

Accuracy: ± o.2 dB.

Sound Pressure Level: 124 dB re. 2 × 10^{-4} μbar (individually calibrated).

Frequency: Pos. "Measure": 250 Hz ± 1 %.
Pos. "Check": 350 to 400 Hz (with new batteries).

Distortion: Less than 3 % at 250 Hz.

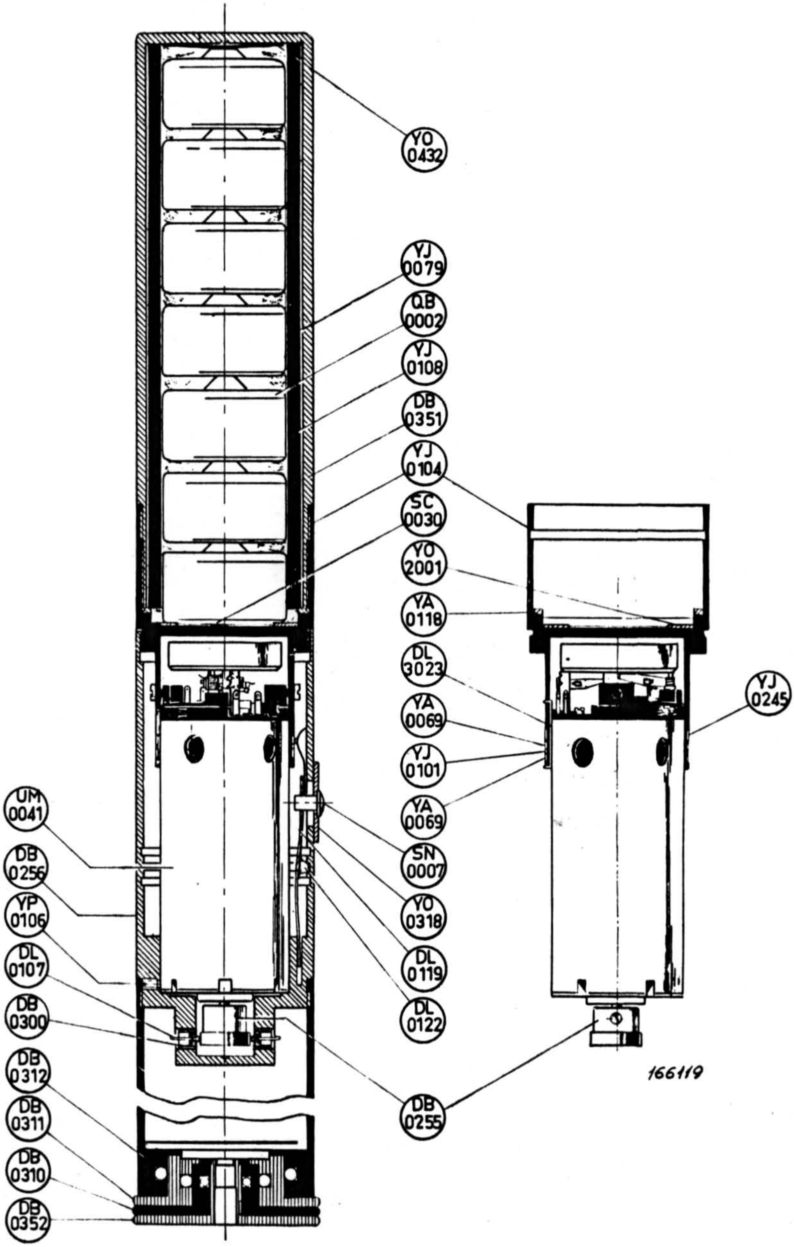
Batteries: 7 Mallory RM-3(R) mercury cells supplied. (B & K part No. QB 0002) Diameter 25.1 mm (o.98"). The battery compartment can also fit RM-4(R) cells (diameter 30.2 mm, 1.19"), giving 50 % longer service life.

Temperature Range: Batteries: 0°—60°C (32°—140°F).
Pistonphone alone: — 40° to 60°C (— 40° to + 140°F).

Humidity: Relative humidities of up to 100 % will not influence the calibration.

Dimensions: Length: 230 mm (9"). Diameter: 36 mm (1.4").

Weight: Pistonphone with batteries: o.7 kg (1.5 lbs.).
Total weight of the case containing pistonphone, adaptors, and barometer 1.6 kg (3.5 lbs.).



Pistonphone Type 4220. Part Numbers.