Instruction Manual

Pistonphone Type 42AP

G.R.A.S.
SOUND & VIBRATION

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LI0053

Revision History

Any feedback or questions about this document are welcome at **gras@gras.dk**.

Revision	Date	Description
1	1 October 2005	First publication
2	4 July 2013	Section 3.1 “Shipment and transport” added

Before shipment, remove the batteries and wrap separately. Assure cautious handling during transport. Remove the battery as soon as it is discharged or if the 42AP is stored for a prolonged period of time. Leakage from the batteries may otherwise destroy the electronic components.

Trademarks

CONTENTS

1. General Description

The G.R.A.S. Pistonphone Type 42AP (Fig. 1.1) is a battery-operated, precision sound source for accurate and reliable calibration of measurement microphones, sound level meters and other sound measuring equipment.

1.1 Operation

When power is turned on, the coupler size will be displayed and the LED will light red.

After 1-2 sec. the frequency will be displayed, the Pistonphone will start and the LED will turn green indicating that the Pistonphone is now locked to the operating frequency.

After another second or two the Pistonphone will be in normal operation mode, pressing the button beside the LED will step the display to show the following (see Fig. 1.1):

- actual corrected sound pressure level in decibels re. 20 µPa
- actual corrected sound pressure level if measured with A-weighting in decibels re. 20 µPa
- static air pressure in h Pa
- calibration temperature in °C
- calibration temperature in °F

All information, including calibration data, can be read remotely via the RS-232 interface.

Fig. 1.1 Pistonphone Type 42AP shown with display examples

1.1.1 Coupler Size

It is important that the size of the coupler agrees with what is registered in the Pistonphone's memory. The Pistonphone can be fitted with either a ½" coupler (RA0048) or a 1" coupler (RA0023). Note: the coupler is calibrated together with the Pistonphone.

If the coupler size shown on the display (**`0.5 in`** or **`1 in`**) when first switched on does not agree

with the size of the coupler currently fitted, do one of the following:

- Change the coupler to agree with what is displayed when the Pistonphone is first switched on.

OR

- Switch the Pistonphone off then while holding down the button beside the LED switch the Pistonphone on again. The alternative coupler size will now be displayed.

1.2 Operating Frequencies

The operating frequency of the Pistonphone is programmable (see chapters 4 and 5) and is selected via the RS-232 interface to be either 250 Hz[1] or 251.2 Hz[2].

The current operating frequency is memorised and will be displayed for a short time on the screen whenever the Pistonphone is switched on.

1.3 Calibration Level

With a microphone inserted in the Pistonhone's coupler and the Pistonphone switched on, the nominal calibration level is:

- 114 dB[3] re. 20 µPa

The actual sound pressure level is shown on the display of Pistonphone, corrected for the static ambient pressure. The display can be selected to correct for using an A-weighting filter.

An individual calibration chart is delivered with each Pistonphone.

The Pistonphone complies with all the requirements of IEC Standard 60942 (2003) LS and is an extremely stable laboratory-standard sound source which can also be used for field calibrations - it retains its high accuracy even under hostile environmental conditions.

The Pistonphone works on the principle of two reciprocating pistons actuated by a precision-machined cam disc with a sinusoidal profile. The rotation speed of the cam disc is controlled to within 0.1% via a tachometer signal in a feed-back loop.

The operating procedure is straight forward, simply fit the microphone into the coupler of the Pistonphone and switch on. The Pistonphone will now produce a constant sound pressure level on the diaphragm of the microphone.

The Pistonphone is delivered fitted with the coupler (RA0048) for calibrating ½" microphones. Adapters for calibrating ¼" and ⅛" microphones are included. A coupler (RA0023) for calibrating 1" microphones is also included.

Note: When the Pistonphone is calibrated, it must be calibrated with its ½"coupler (RA0048), its 1" coupler (RA0023), and, if purchased, the two-port calibration coupler (RA0024).

[1] Factory setting

[2] True centre frequency of a 250 Hz ⅓-octave band filter

[3] 114 dB is the equivalent of 10 Pa

2. Theory

2.1 Principle

The Pistonphone works on the principle of a pair of similar opposing, reciprocating pistons (Fig. 2.1) actuated by a precision-machined cam disc with a sinusoidal (SHM) profile. The cam disc is mounted on the shaft of a small electric motor. The profile of the cam disc is such that the pistons follow a sinusoidal movement at a frequency equal to four times the speed of rotation. This results in a corresponding sinusodial variation in the effective volume of the closed coupler and, consequently, an acoustic signal within it. The RMS pressure, *P* (in pascals), of this acoustic signal is given by:

$$P = \gamma \cdot P_0 \cdot \frac{2A_p \cdot S}{V \cdot \sqrt{2}} \qquad (1)$$

Where :

- γ is the ratio of specific heats for the gas in the coupler (for air this is 1.402 at 20 °C and 1 atm.)
- P_0 is the ambient pressure in pascals (Pa)
- A_p is the cross-sectional area of one piston in square metres (m^2)
- S is the stroke length of the pistons in metres (m)
- V is the coupler volume in cubic metres (m^3)

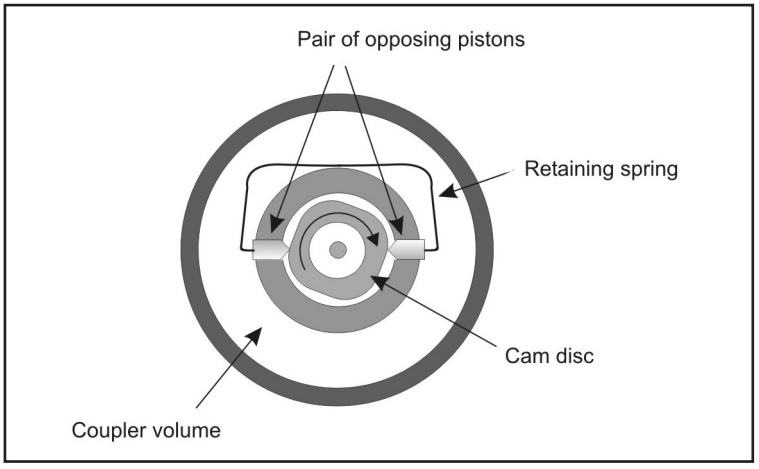

Fig. 2.1 Principle of the Pistonphone

A_p and S are determined by the physical dimensions of the pistons and the cam disc; the ambient pressure refers, in most cases, to the barometric pressure of the atmosphere.

2.2 Volume Corrections

The volume of the coupler is defined partly by the dimensions of the coupler itself and partly the effective load volume of the microphone. The effective load volume of the microphone is sum of the equivalent volume and the front cavity volume. The front cavity volume of the microphone is the volume between the microphone's diaphragm and the protection grid plus the volume contained in the slits of the protection grid.

The equivalent volume of the microphone is the apparent volume of the microphone behind the diaphragm. Since the diaphragm is not perfectly stiff, it will be deflected slightly by a sound pressure. This slight deflection of the diaphragm can be considered as equivalent to a small volume and, as such, should be added to the sum of the grid and coupler volumes. Since the grid and equivalent volumes can vary slightly from one type of microphone to another, the total volume of the coupler will, accordingly, also vary slightly.

A change in the total volume of the coupler will cause a change in the sound pressure level generated within the coupler. A change in the sound pressure level ΔP, in decibels, for a change in coupler volume ΔV is given by:

$$\Delta P = 20 \cdot Log \cdot \left(\frac{V}{V + \Delta V} \right) \qquad (2)$$

Where:

V = 15540mm^3, including the effective load volume of 40AG

ΔV is the equivalent volume correction

The Pistonphone is calibrated using a G.R.A.S. ½" Microphone Type 40AG. Since all G.R.A.S. ½" microphones have the same grid volume, the only correction necessary when calibrating the various types is the correction for the various equivalent volumes[4].

Table 2.1 shows the equivalent volumes of G.R.A.S. ½" microphones and the corresponding Pistonphone corrections.

G.R.A.S. Mic. Type	Equiv-volume correction (mm^3)	Correction (decibels)
40AC	−20	0.011
40AD	20	−0.011
40AE	25	−0.014
40AF	30	−0.017
40AN	25	−0.014
40AP	25	−0.014
40AQ	15	−0.008
40AR	25	−0.014
40AU	−137	0.077

Table 2.1 Corrections for G.R.A.S. ½" microphones re. the G.R.A.S. Microphone Type 40AG

The equivalent volume uncertainty is ±7mm^3.
The correction uncertainty is ±0.004 dB.

No equivalent volume correction is needed for calibration of ¼" microphones (G.R.A.S. type 40BD, 40BE, 40BF, 40BP) using the adaptor RA0049, nor 1" microphone (G.R.A.S. type 40EN) using the adaptor RA0023.

When calibrating 1/8" microphones (G.R.A.S. type 40DD, 40DP) using the adaptor RA0069 the equivalent volume correction is +19mm^3 and requires a correction -0.011 dB.

2.3 Static-pressure Corrections

The Pistonphone is factory adjusted to give a nominal sound pressure level of 114 dB re. 20 µPa. This nominal value is valid for the following ambient reference conditions:

- Temperature 23° C
- Static pressure 1013 hPa
- Relative humidity 50 %

[4] The G.R.A.S. Microphone Type 40AG is equivalent to the Brüel & Kjær Type 4134 and the volume correction for these are 0 dB. As a matter of interest, the volume correction for a G.R.A.S. Type 40AU and a Brüel & Kjær Type 4180 is 0.077 dB.

The displayed pressure level is corrected (by an amount ΔP) for static pressure variations given by the following equation:

$$\Delta P = 20 \cdot Log \cdot \left(\frac{P_a}{P_r} \right) \qquad (3)$$

Where:

P_a = measured static ambient pressure (hPa)

P_r = reference static pressure (1013 hPa)

The corrections for ambient static pressure are shown in Fig. 2.2 (see also Appendix A.1 for an extended pressure range).

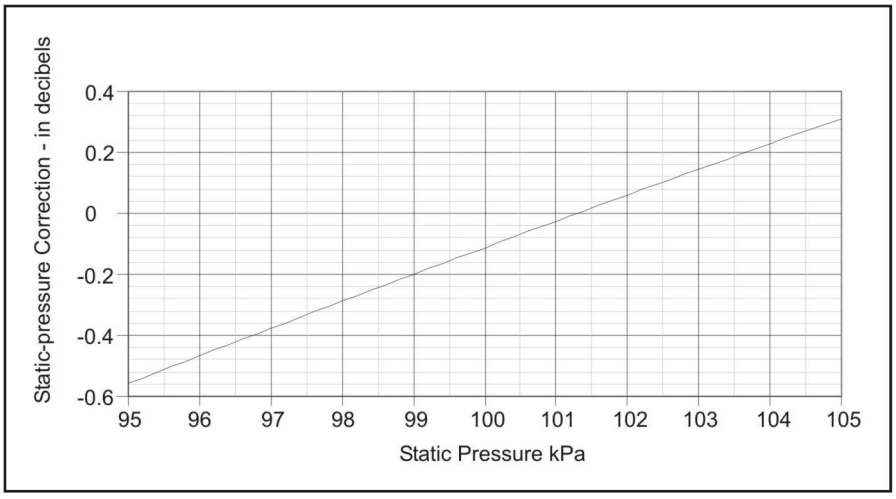

Fig. 2.2 Corrections for static ambient pressure

2.3.1 Built-in Barometer

The Pistonphone has a built-in precision barometer which measures and displays the static ambient pressure. This value can also be used by the user for correcting sound pressure levels for static ambient pressure. The Pistonphone already displays the corrected sound pressure level, with and without A-weighting. The corrected sound pressure level (*SPL*) is calculated as follows:

$$SPL = 20 \cdot Log \cdot \left(\frac{P_a}{P_r} \right) + SPL_{ref} \qquad (4)$$

Where:

P_a = the displayed static ambient pressure (hPa)

P_r = reference static pressure (1013 hPa)

SPL = the actual sound pressure level in the coupler (decibels re. 20 µPa)

SPL_{ref} = the sound pressure level at reference condition (decibels re. 20 µPa)

Note: SPL_{ref} is both stored in the memory of the Pistonphone and given on the calibration chart.

2.3.2 Thermometer

The Pistonphone has a thermometer that measures the temperature of the Pistonphone. The thermometer tracks the actual calibration temperature in the measuring chamber to within a degree. The measured temperature can be displayed both as °C and °F.

3. Handling and Operation

3.1 Shipment and Transport

Before any major shipment where rough handling is to be expected, remove the batteries to protect connectors and other internal parts from accidental damage.

Before shipment, remove the batteries and wrap separately.
Assure cautious handling during transport.

3.2 Batteries

The Pistonphone runs on four 1.5 V batteries (type AA [LR6]). To install or replace the batteries, remove first the lid of the battery compartment which is held in place by the screw shown in Fig. 3.1. Slide the lid in the direction shown after removing the screw. Insert four new batteries observing the correct polarity as indicated on the figure inside the battery compartment.

The Pistonphone can operate continuously for about 10 hours on a new set of batteries.

Remove the battery as soon as it is discharged or if the 42AP is stored for a prolonged period of time. Leakage from the batteries may otherwise destroy the electronic components.

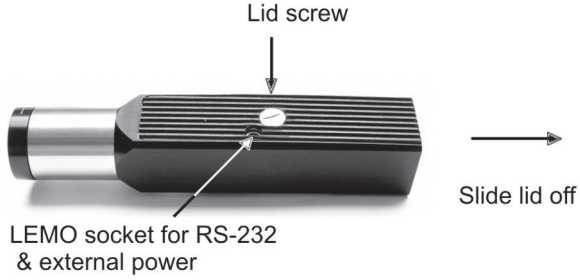

Fig. 3.1 Access to batteries

3.3 External Connector

The Pistonphone has a 4-pin LEMO socket for both an external power supply and an RS-232 connection (Fig. 3.1). Use the cable (AA0050) supplied for this purpose. The other end of this cable has a 9-pin D-sub connector (for RS-232) with a 2 mm DC socket for connecting to an external 6 V DC power supply (e.g. G.R.A.S. mains/line power supply AB0005). See also Fig. 4.1

3.3.1 External Power Supply

When an external 6 V DC (e.g. from a G.R.A.S. mains/line power supply AB0005) is applied to the Pistonphone via the input socket, the Pistonphone is automatically switched on independent of the on/off (**I/0**) button (unless programmed otherwise, see section 4.4.2) and the internal batteries are disabled.

3.3.2 RS-232 Connection

The RS-232 meets the electrical specifications defined by EIA/TIA-232, the 9-pin D-sub connector is defined by EIA-574 Specifications. Where:

Pin 2 for receive data (RX)

Pin 3 for transmit data (TX)

Pin 5 is ground which is connected to screen.

No other pins are connected.

3.4 Calibrating Microphones

3.4.1 Microphone Size

The Pistonphone is delivered ready to calibrate ½" microphones. For ¼" and ⅛" microphones, special adapters are included. For 1" microphones, the 1" coupler[1] RA0023 has to be fitted (see Fig. 3.6). Each case is described in the following four sections.

3.4.2 ½" Microphones

Note: make sure the Pistonphone is set for the ½" coupler, see section 1.1.1.

To calibrate a ½" measurement microphone, first loosen the microphone retention collar as shown in Fig. 3.2. Then insert the microphone into the ½" coupler[1] as shown in Fig. 3.3. Make sure that the microphone is all the way in, then tighten the microphone retention ring so that the microphone is held firmly in place.

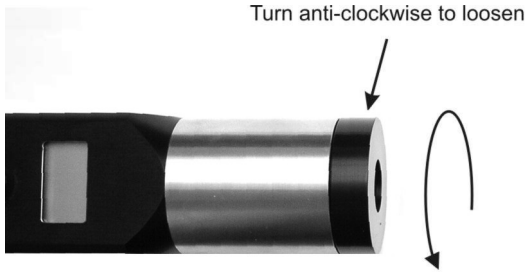

Fig. 3.2 Loosening the microphone retention collar

Fig. 3.3 ½" microphone inserted in the coupler

Switch the Pistonphone on via the on/off (**I/0**) button. The LED above the on/off button is a dual-colour LED for showing red or green. The LED shows green if the Pistonphone is operating properly at the specified frequency. If the LED shows red or flashing red, the Pistonphone is not operating at the specified frequency and the batteries should be changed (see section 3.2).

Wait approximately for 15 seconds for the static pressure in both the Pistonphone and the microphone to stabilise, and for the microphone itself to stabilise within the coupler.

The static pressure within the coupler volume is equalised via an air-equalisation tube located under the cap which protects the pistons and retention spring shown in Fig. 2.1.

With the Pistonphone switched on, the microphone is subjected to a sound pressure level L_C given as the sum of the Pistonphone's nominal sound pressure level L_N, the static pressure correction L_B and the volume correction L_V, i.e.:

$$L_C = L_N + L_B + L_V \qquad (5)$$

[1] The ½" coupler is individual calibrated with the pistonphone, and these must be considered as a pair

3.4.3 ¼" Microphones

Note: make sure the Pistonphone is set for the ½" coupler, see section 1.1.1.

To calibrate a ¼" measurement microphone, first loosen the microphone retention collar as shown in Fig. 3.2. Then insert the ¼" microphone adapter (RA0049) into the ½" coupler as shown on Fig. 3.4. Make sure that the adapter is all the way in, then tighten the microphone retention collar so that the adapter is held firmly in place. Insert the ¼" microphone into the ¼" adapter.

Switch the Pistonphone on via the on/off (**I/0**) button. The LED above the on/off button is a dual-colour LED for showing red or green. The LED shows green if the Pistonphone is operating properly at the specified frequency. If the LED shows red or flashing red, the Pistonphone is not operating at the specified frequency and the batteries should be changed (see section 3.2).

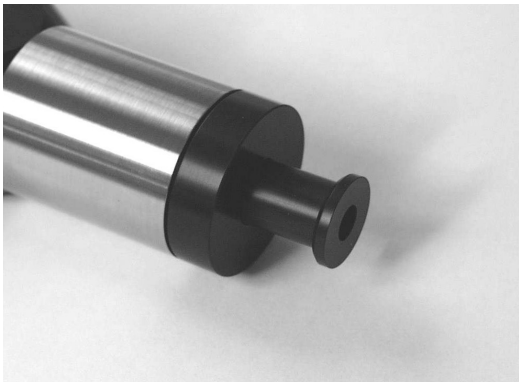

Fig. 3.4 ¼" microphone adapter inserted in the coupler

Wait approximately for 15 seconds for the static pressure in both the Pistonphone and the microphone to stabilise, and for the microphone itself to stabilise within the coupler.

The static pressure within the coupler volume is equalised via an air-equalisation tube located under the cap which protects the pistons and retention spring shown in Fig. 2.1.

With the Pistonphone switched on, the microphone is subjected to a sound pressure level L_C given as the sum of the Pistonphone's nominal sound pressure level L_N, the static pressure correction L_B and the volume correction L_V, i.e.:

$$L_C = L_N + L_B + L_V \qquad (6)$$

3.4.4 ⅛" Microphones

Note: make sure the Pistonphone is set for the ½" coupler, see section 1.1.1.

To calibrate a ⅛" measurement microphone, first loosen the microphone retention collar as shown in Fig. 3.2. Then insert the ⅛" microphone adapter (RA0069) into the ½" coupler as shown on Fig. 3.4. Make sure that the adapter is all the way in, then tighten the microphone retention collar so that the adapter is held firmly in place. Insert the ⅛" microphone into the ⅛" adapter.

Switch the Pistonphone on via the on/off (**I/0**) button. The LED above the on/off button is a dual-colour LED for showing red or green. The LED shows green if the Pistonphone is operating properly at the specified frequency. If the LED shows red or flashing red, the Pistonphone is not operating at the specified frequency and the batteries should be changed (see section 3.2).

Wait approximately for 15 seconds for the static pressure in both the Pistonphone and the microphone to stabilise, and for the microphone itself to stabilise within the coupler.

The static pressure within the coupler volume is equalised via an air-equalisation tube located under the cap which protects the pistons and retention spring shown in Fig. 2.1.

With the Pistonphone switched on, the microphone is subjected to a sound pressure level L_C given as the sum of the Pistonphone's nominal sound pressure level L_N, the static pressure correction L_B and the volume correction L_V, i.e.:

$$L_C = L_N + L_B + L_V \qquad (7)$$

Fig. 3.5 ⅛" microphone adapter inserted in the coupler

3.4.5 1" Microphones

Note: make sure the Pistonphone is set for the 1" coupler, see section 1.1.1.

To calibrate a 1" measurement microphone, the ½" coupler has to be replaced by the 1" coupler[1] (RA0023), see Fig. 3.6. Unscrew the ½" coupler from the Pistonphone body. The pistons and retention spring shown in Fig. 2.1 are protected so there is no risk of accidentally damaging these parts when removing the coupler. Screw the 1" coupler (RA0023) onto the Pistonphone body. Then insert the 1" microphone into the 1" coupler. Make sure that the microphone is all the way in.

Fig. 3.6 1" and ½" couplers

[1] The 1" coupler is individual calibrated with the pistonphone, and these must be considered as a pair

Switch the Pistonphone on via the on/off (**I/0**) button. The LED above the on/off button is a dual-colour LED for showing red or green. The LED shows green if the Pistonphone is operating properly at the specified frequency. If the LED shows red or flashing red, the Pistonphone is not operating at the specified frequency and the batteries should be changed (see section 3.2).

Wait approximately for 15 seconds for the static pressure in both the Pistonphone and the microphone to stabilise, and for the microphone itself to stabilise within the coupler.

The static pressure within the coupler volume is equalised via an air-equalisation tube located under the cap which protects the pistons and retention spring shown in Fig. 2.1.

With the Pistonphone switched on, the microphone is subjected to a sound pressure level L_C given as the sum of the Pistonphone's nominal sound pressure level L_N, the static pressure correction L_B and the volume correction L_V, i.e.:

$$L_C = L_N + L_B + L_V \qquad (8)$$

3.5 Calculation of Microphone Sensitivity

The sensitivity of a microphone under test can be calculated via a measurement of the microphone's output voltage. If the measured output voltage is V_o, and the sound pressure level in the Pistonphone's coupler is L_C (decibels), the microphone sensitivity S is given by:

$$S = \frac{V_o}{20\,\mu Pa \cdot 10^{L_C/20}} \qquad (9)$$

The value $20\,\mu Pa$ is the standard reference sound pressure. The result here includes the loading effect of the preamplifier's input impedance as well as the gain or attenuation within the preamplifier. To measure the "Open Circuit Sensitivity" of the microphone (i.e. when the microphone's output is not affected by the load of a preamplifier), a special preamplifier, for example the G.R.A.S. Type 26AG (which has insert voltage calibration capability), should be used.

4. Remote Control via RS-232 Interface

4.1 Introduction

Commands and responses, comprising ASCII characters, can be sent to and from the Pistonphone via its RS-232 interface, using a suitable utility program (e.g. HyperTerminal[1] as illustrated in the following).

4.2 Interface

Connector: RS-232 9-pin D-sub using adapter cable AA0050

RS-232: 9600,8,n,1

(i.e. 9600 bits per second, 8 data bits, no parity bit, 1 stop bit)

There is no flow control/handshaking; therefore commands must be sent one by one, waiting for each response.

The input buffer is 32 bytes, in case of overflow, a response “Buffer overflow” will be submitted. This will not happen under normal conditions.

Fig. 4.1 shows how the Pistonphone should be connected to the computer and Figs. 4.2 and 4.3 show the relevant dialogue boxes (of HyperTerminal) for selecting the COM port in use and entering the required settings, i.e. 9600,8,n,1 as mentioned above.

Note: The RS-232 connection must always be made with the Pistonphone disconnected from an external power supply.

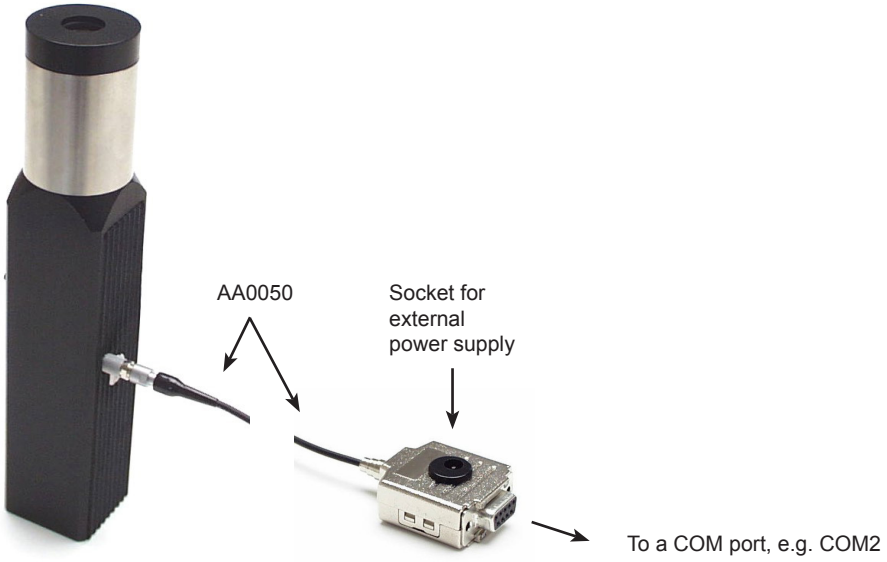

Fig. 4.1 Pistonphone connection to computer

[1] Developed for Microsoft® by Hilgraeve Inc.

Fig. 4.2 Selecting the COM port in use, e.g. COM2

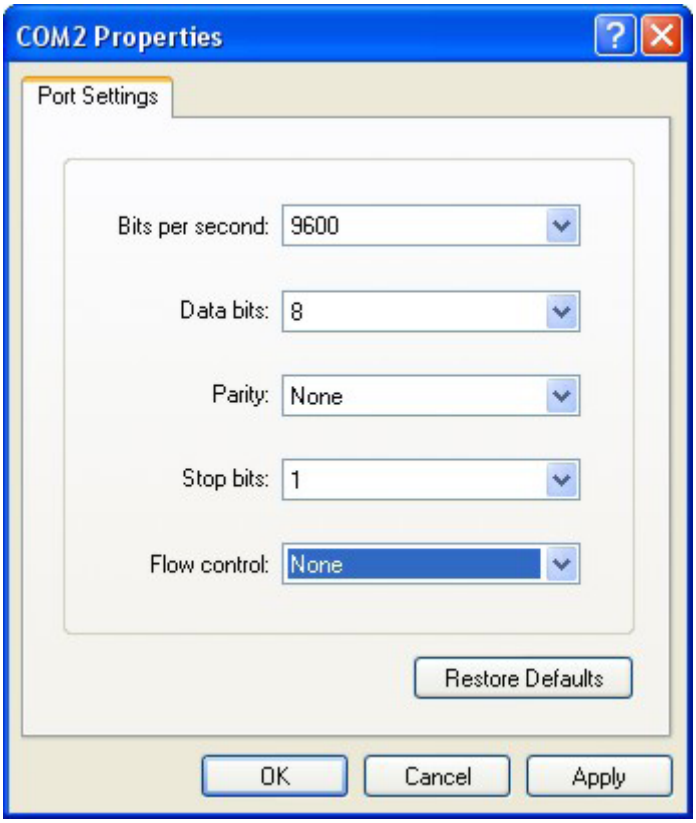

Fig. 4.3 Showing the correct setup for the selected COM port

4.3 Behaviour

When the Pistonphone is powered up, a “Ready”<CRLF> messages is sent.

A watchdog will restart the Pistonphone if the processor stops working.

4.4 Commands and Responses

About commands:

Two types of command are used. These are:

1. Interrogational commands
   which return information about the Pistonphone, its setup parameters and measured ambient conditions.
2. Setup commands
   which are for changing setup parameters and controlling the Pistonphone.

Syntax

1. Commands are not case sensitive.
2. All commands are executed by first typing in the command then striking the <Enter>[1] key (usually symbolised nowadays by “↵ ”), e.g.:

   C↵ ...if you want to know the temperature in the Pistonphone’s coupler in °C.

For clarity, <Enter> and “↵ ” are implied if not shown in the following.

About responses:

1. All responses to commands are followed by <CRLF>[2].

For clarity, <CRLF> is implied in the following.

4.4.1 Interrogational Commands

Commands	*Responses*
C	Returns temperature measured inside the Pistonphone in °C.
F	Returns temperature measured inside the Pistonphone in °F.
hPa	Returns static pressure in h Pa.
dB	Returns actual corrected sound pressure level in dB
dBA	Returns actual corrected sound pressure level in dB measured with an A-weighting filter.
type	Returns “**G.R.A.S. Type 42AP**”.
serial	Returns, e.g. “**Serial no.: 46345**”.
firmware	Returns “**Firmware ver. 1.1**”.
info	Equivalent to commands **type**, **serial** and **firmware**.
frequency	Returns currently selected Pistonphone frequency in Hz, e.g. “**250**”.
status	Returns “**locked**” or “**not locked**”.
coupler	Returns selected coupler size in inches, e.g. “**0.5**”.
SPLref.used	Returns the currently selected reference level in decibels, e.g. “**114.01**”.
SPLref.0.5in	Returns calibration level in decibels at reference conditions for a ½″ coupler, e.g. “**114.01**”.
SPLref.1in	Returns calibration level in decibels at reference conditions for a 1″ coupler.

[1] The equivalent of <CRLF> i.e. “Carriage Return Line Feed”. However, the commands ignore the <LF>.

[2] “Carriage Return Line Feed” which moves the cursor to the start of a new line.

4.4.2 Setup Commands

Command	*Response*
ON	Turns on the Sound pressure
OFF	Turns off the Sound pressure
250HZ	Set Pistonphone frequency to 250 Hz and memorise setting
251.2HZ	Set Pistonphone frequency to 251.2 Hz and memorise setting
0.5in	Set coupler size to ½″ and SPL_{ref} to that used for factory calibration. Note: command valid only if the Pistonphone is calibrated for this coupler size. It also cancels any current user-applied correction.
1in	Set coupler size to 1″ and SPL_{ref} to that used for factory calibration. Note: command valid only if the Pistonphone is calibrated for this coupler size. It also cancels any current user-applied correction.
restart	Restarts the Pistonphone, allow about 1 second for restart.
↵	Empty command, returns **OK**.

All setup commands will return **OK** if successful or **Error** if not.

4.4.3 Special Responses

ready	Submitted when the Pistonphone is powered up.

Fig. 4.4 shows an example of a dialogue between user and Pistonphone. Each command is followed immediately by the response. In this example, the terminal has been setup to echo the outgoing commands.

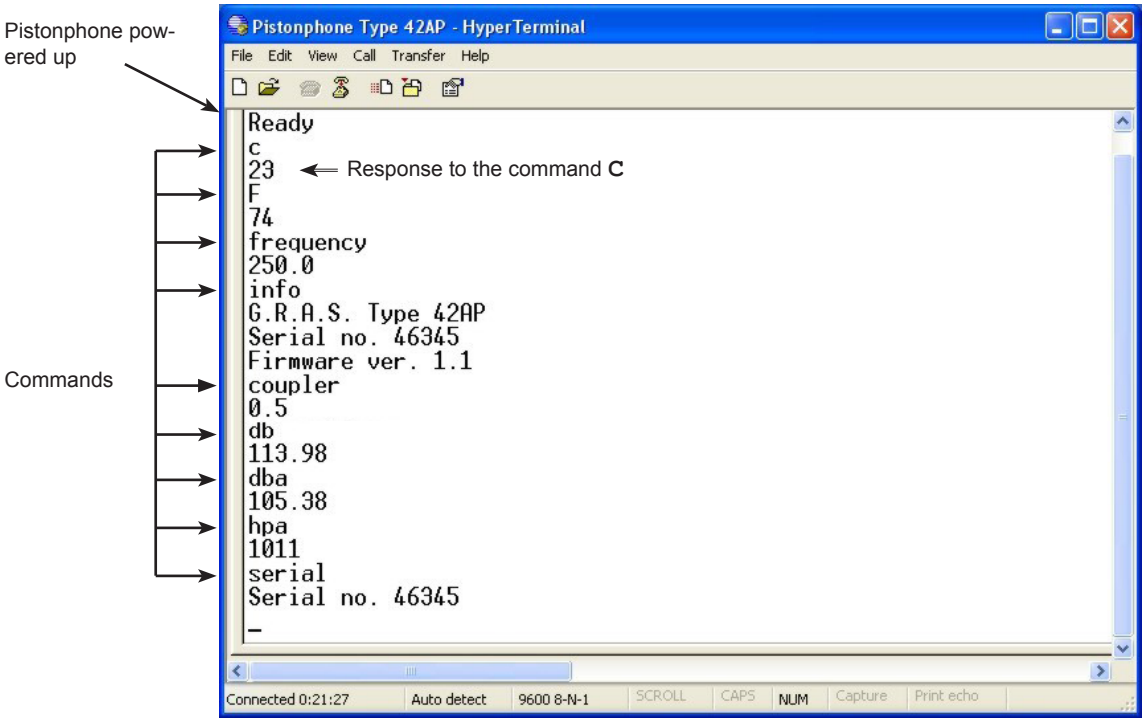

Fig. 4.4 Example of a dialogue showing commands and responses

5. Specifications

Sound pressure level:

Nominal:	114 dB re. 20 µPa
Individually calibrated under the following reference conditions:	
Ambient pressure:	1013 hPa
Ambient temperature:	20 °C
Ambient humidity:	65% RH

Calibration accuracy:

Absolute:	1/2" mic.:	±0.09 dB at reference condition
	1" mic.:	±0.2 dB at reference condition
When corrected for ambient pressure:	1/2" mic.:	±0.1 dB
	1" mic.:	±0.2 dB

Frequencies:

250 Hz	± 0.1%
251.2 Hz	± 0.1%

Distortion:

<1.5%

Barometer:

Range:	750 hPa to 1100 hPa
with reduced accuracy (± 4hPa):	300 hPa to 1100h Pa
Calibration accuracy:	
Absolute:	± 1 hPa (0 °C to +55 °C)
Long-term stability:	– 1 hPa (12 months)

Thermometer:

Range:	– 10 °C to + 55 °C
Absolute:	± 1 °C

Nominal effective coupler volume:

15540 mm^3 (including effective load volume of microphone type 40AG or type 40EN)

Temperature range:

Batteries permitting:	– 10 °C to + 55 °C

Batteries:

Four standard LR6-AA alkaline cells

External power:

Voltage:	6 V DC
Current:	90 mA

Dimensions:

Length:	184 mm (7.24 in)
Width:	35 mm (1.38 in)
Height:	35 mm (1.38 in)
Weight (with batteries):	437 g (1 lb)

Accessories included:

Adapter for ¼" microphones:	RA0049
Adapter for ⅛" microphones:	RA0069
Coupler for 1" microphones:	RA0023
Coupler for ½" microphones:	RA0048
Four LR6-AA alkaline cells:	EL0001
Adapter cable for RS-232 and external power supply	AA0050

Accessories available:

Mains/line power supply	AB0005
Adapter for Outdoor Microphone System[1]:-	
Type 41AM:	RA0009
Type 41CN:	RA0041
Adapter for Environmental Microphone[1]:-	
Type 41AL:	RA0010
Two-port calibration coupler:	RA0024 (see Fig. 5.1)
Octopus coupler (½" mics.):	RA0072

Note: When the Pistonphone is calibrated, it must be calibrated with its ½″coupler (RA0048), its 1″ coupler (RA0023), and, if purchased, the two-port calibration coupler (RA0024).

Fig. 5.1 Two-port Coupler RA0024 shown here with the two phase-matched microphones of an intensity probe

Manufactured to conform with:

CE marking directive: 93/68/EEC

WEEE directive: 2002/96/EC

RoHS directive: 2002/95/EC

[1] For Pistonphones fitted with a 1″ microphone coupler RA0023

A Appendix

A.1 Corrections for Static Ambient Pressure

Fig. A.1 shows the correction curve for ambient static-pressures over an extended range.

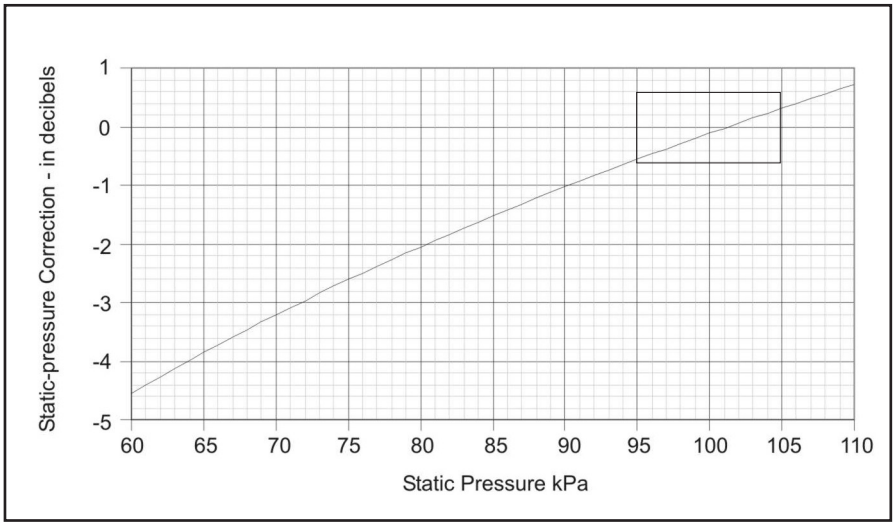

Fig. A.1 Corrections for static ambient pressure; the small rectangle outlines the range covered by Fig. 2.2

A.2 Corrections for Humidity

For highly-precise calibrations in accordance with IEC Standard 942 Class 0, it will be necessary to correct for the influence of air humidity. The influence of air humidity depends on both air temperature and barometric pressure.

The curves in Fig. A.2 show corrections (*C)* which account for the effects of both temperature and humidity when the ambient pressure equals the reference pressure P_r (101.3 kPa).

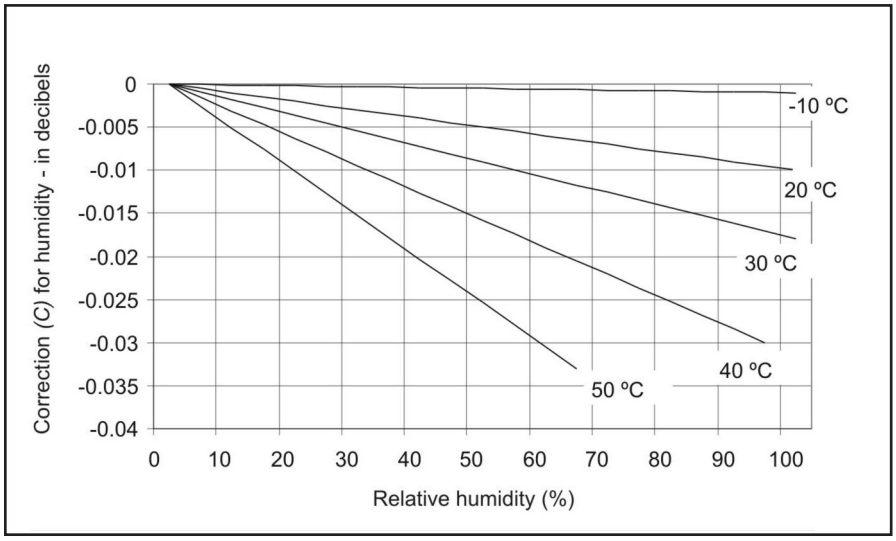

Fig. A.2 Corrections for temperature humidity

The value *(C)* together with the actual value of the barometric pressure P_A are used as follows to calculate the actual correction humidity:

$$\Delta L_H = \frac{P_r}{P_a} \cdot C \cdot + 0.0064\,dB \qquad (10)$$

Where:

P_a = measured static ambient pressure (hPa)

P_r = reference static pressure (1013 hPa)

The correction ΔL_H has to be added to the other correction factors in equations 5, 6, 7 and 8.