Model 394A40

Pistonphone

Installation and Operating Manual

**For assistance with the operation of this product,
contact PCB Piezotronics, Inc.**

Toll-free: 800-828-8840
24-hour SensorLine: 716-684-0001
Fax: 716-684-0987
E-mail: info@pcb.com
Web: www.pcb.com

PCB PIEZOTRONICS INC.
A PCB GROUP COMPANY

Warranty, Service, Repair, and Return Policies and Instructions

The information contained in this document supersedes all similar information that may be found elsewhere in this manual.

Total Customer Satisfaction – PCB Piezotronics guarantees Total Customer Satisfaction. If, at any time, for any reason, you are not completely satisfied with any PCB product, PCB will repair, replace, or exchange it at no charge. You may also choose to have your purchase price refunded in lieu of the repair, replacement, or exchange of the product.

Service – Due to the sophisticated nature of the sensors and associated instrumentation provided by PCB Piezotronics, user servicing or repair is not recommended and, if attempted, may void the factory warranty. Routine maintenance, such as the cleaning of electrical connectors, housings, and mounting surfaces with solutions and techniques that will not harm the physical material of construction, is acceptable. Caution should be observed to insure that liquids are not permitted to migrate into devices that are not hermetically sealed. Such devices should only be wiped with a dampened cloth and never submerged or have liquids poured upon them.

Repair – In the event that equipment becomes damaged or ceases to operate, arrangements should be made to return the equipment to PCB Piezotronics for repair. User servicing or repair is not recommended and, if attempted, may void the factory warranty.

Calibration – Routine calibration of sensors and associated instrumentation is recommended as this helps build confidence in measurement accuracy and acquired data. Equipment calibration cycles are typically established by the users own quality regimen. When in doubt about a calibration cycle, a good "rule of thumb" is to recalibrate on an annual basis. It is also good practice to recalibrate after exposure to any severe temperature extreme, shock, load, or other environmental influence, or prior to any critical test.

PCB Piezotronics maintains an ISO-9001 certified metrology laboratory and offers calibration services, which are accredited by A2LA to ISO/IEC 17025, with full traceablility to N.I.S.T. In addition to the normally supplied calibration, special testing is also available, such as: sensitivity at elevated or cryogenic temperatures, phase response, extended high or low frequency response, extended range, leak testing, hydrostatic pressure testing, and others. For information on standard recalibration services or special testing, contact your local PCB Piezotronics distributor, sales representative, or factory customer service representative.

Returning Equipment – *Following these procedures will insure that your returned materials are handled in the most expedient manner.* Before returning any equipment to PCB Piezotronics, contact your local distributor, sales representative, or factory customer service representative to obtain a Return

Materials Authorization (RMA) Number. This RMA number should be clearly marked on the outside of all package(s) and on the packing list(s) accompanying the shipment. A detailed account of the nature of the problem(s) being experienced with the equipment should also be included inside the package(s) containing any returned materials.

A Purchase Order, included with the returned materials, will expedite the turn-around of serviced equipment. It is recommended to include authorization on the Purchase Order for PCB to proceed with any repairs, as long as they do not exceed 50% of the replacement cost of the returned item(s). PCB will provide a price quotation or replacement recommendation for any item whose repair costs would exceed 50% of replacement cost, or any item that is not economically feasible to repair. For routine calibration services, the Purchase Order should include authorization to proceed and return at current pricing, which can be obtained from a factory customer service representative.

Warranty – All equipment and repair services provided by PCB Piezotronics, Inc. are covered by a limited warranty against defective material and workmanship for a period of one year from date of original purchase. Contact PCB for a complete statement of our warranty. Expendable items, such as batteries and mounting hardware, are not covered by warranty. Mechanical damage to equipment due to improper use is not covered by warranty. Electronic circuitry failure caused by the introduction of unregulated or improper excitation power or electrostatic discharge is not covered by warranty.

Contact Information – International customers should direct all inquiries to their local distributor or sales office. A complete list of distributors and offices can be found at www.pcb.com. Customers within the United States may contact their local sales representative or a factory customer service representative. A complete list of sales representatives can be found at www.pcb.com. Toll-free telephone numbers for a factory customer service representative, in the division responsible for this product, can be found on the title page at the front of this manual. Our ship to address and general contact numbers are:

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PCB PIEZOTRONICS INC.
VIBRATION DIVISION

Model 394A40 Pistonphone Operating Guide

Contents:

General Description

The PCB® 394A40 Pistonphone is a battery operated, precision sound source for accurate and reliable calibration of measurement microphones, sound level meters, and other sound measuring equipment. The calibration is performed at 250 Hz at 114.0 dB re. 20 μPa, with a calibration error of less than ± 0.1dB.

The Pistonphone can be used both as an extremely stable laboratory-standard sound pressure level source, and for highly-accurate field calibration under severe environmental conditions. The Pistonphone fulfills the requirements in IEC standard 942, 1988 ”Sound Calibrators” Class 1 with the included barometer, and Class 0 with an optional precision barometer.

The Pistonphone principle is based on two reciprocating pistons driven by a precision-machined cam disc. The speed of the cam disc is controlled to within 0.5% by a tachometer signal and closed-loop circuit.

The operation procedure is simple; Fit the microphone into the coupler of the Pistonphone, and turn the Pistonphone on. The Pistonphone will now produce a constant sound pressure level on the diaphragm of the microphone.

The Pistonphone fits PCB® ½" and ¼" microphones, and other ½” and ¼" microphones according to IEC standard 1094. For calibration of 1” microphones, an optional 1” microphone coupler is available.

Fig. 1 394A40 Pistonphone

Theory

The Pistonphone works by displacing two pistons, as shown in Figure 2 below. The two pistons are symmetrically driven by means of a cam disc, mounted on the shaft of a small electric motor. The cam disc is precisely-machined so that the pistons follow a sinusoidal movement at a frequency equal to four times the speed of rotation. This results in a variation of the effective coupler volume, and consequently the RMS sound pressure *P* produced in the coupler will be:

$$P = \gamma P_0 A_p S / \sqrt{2} V$$

where:
γ is the ratio of specific heats for the gas in the coupler (1.402 for air at 20 °C and 1 atm
P_0 is the atmospheric pressure
A_p is the cross section area of one of the pistons
S is the peak to peak amplitude of motion the pistons
V is the coupler volume

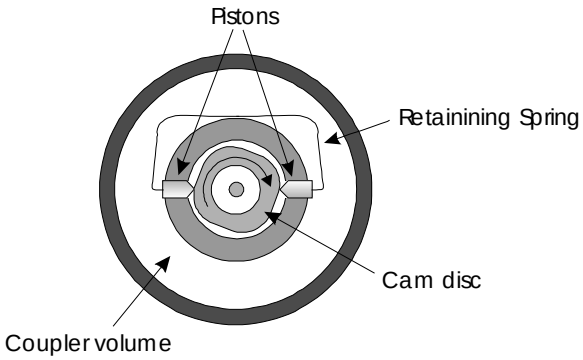

Fig. 2 Pistonphone principle

A_p and S are defined by the mechanical dimensions of the piston and the cam disc, while the atmospheric pressure is determined with a barometer.

Pistonphone Volume Correction

The coupler volume is defined partly by the dimensions of the coupler, and partly by the equivalent volume of the microphone and the microphone grid volume. The microphone grid volume is the volume between the microphone diaphragm and the protection grid, plus the volume made up of the slits in the protection grid.

The equivalent volume of the microphone is the apparent volume of the microphone behind the diaphragm. As the diaphragm is not completely stiff, the sound pressure will deflect the diaphragm slightly. This slight deflection of the diaphragm can be viewed as equivalent to a small volume. This small volume should be added to the grid volume and coupler volume. As the grid volume and equivalent volume may vary from one microphone model to another, the total coupler volume will vary slightly.

As the total coupler volume changes, the pressure in the coupler will change. The change in the sound pressure level ΔP, in dB, for a change in the volume of ΔV is given by:

$$\Delta P = 20\log\left(V \big/ V + \Delta V\right)$$

where V is 15.6 cm^3.

The 394A40 Pistonphone is calibrated with a ½" microphone, which has a total grid volume and equivalent volume of 200 mm^3. As all PCB ½" microphones have the same grid volume, the only correction necessary when calibrating other PCB microphone models is a correction for the different equivalent volumes. The following Table 1 gives the equivalent volume of several standard ½" microphones, and the corresponding pistonphone corrections.

Manufacturer	***Model Number***	***Equivalent Volume correction (mm^3)***	***dB Correction***
PCB Piezotronics	377A02	40	-0.022
	377A11	38	-0.021
	377A20	38	-0.021
G.R.A.S.	40AF	40	-0.022
	40AC	6	-0.003
	40AP	38	-0.021
	40AE	40	-0.022
	40AD	38	-0.021
	40AR	100	-0.055
	40AN	40	-0.022
	40AQ	38	-0.021
B & K	4134	200	0
	4180		0.101

Table 1 Volume corrections for ½" microphones

Barometric Pressure Correction

The 394A40 Pistonphone is factory adjusted to give nominally 114 dB re. 20 µPa. This value is valid at the reference conditions: 23º C, 101.3 kPa and 50% humidity. For other barometric pressures, the Pistonphone nominal level will have to be corrected. The correction of the pistonphone level ΔP, in dB, is given by equation:

$$\Delta P = 20\log(P_a / P_r)$$

where P_a is the actual ambient pressure and P_r is the reference condition pressure.
The static pressure corrections are given in figure 3 below (see also Appendix A on page 8 for extended pressure range). These values should be added to the nominal Pistonphone level. The 394A40 Pistonphone includes as standard accessories a small barometer to check the static pressure. This barometer has the correction values printed directly on the scale.

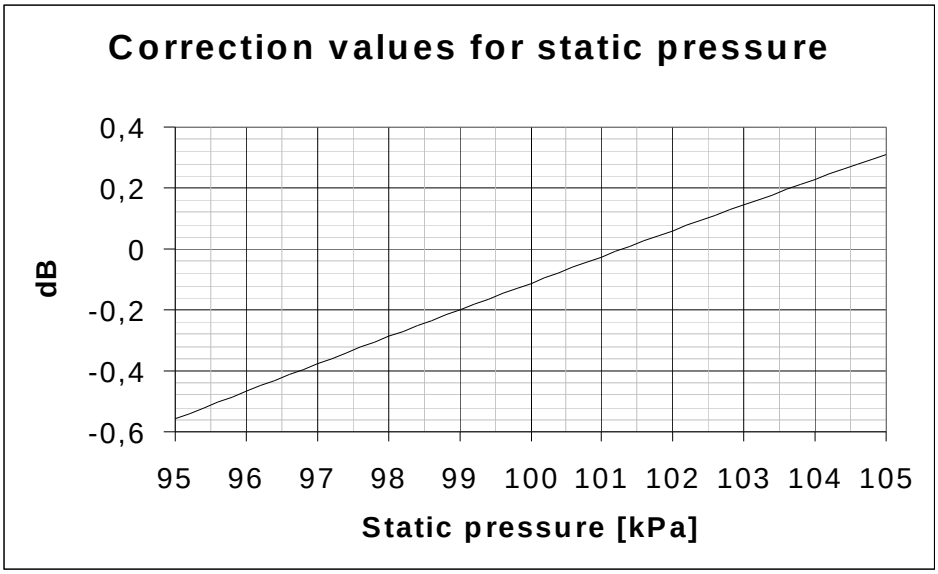

Fig. 3 Correction values for different static pressures

Operation- Batteries

The 394A40 Pistonphone operates on 4 AA 1.5 V batteries. To install or replace the batteries, remove the bottom lid. The bottom lid is removed by first unscrewing the bottom lid screw, (see Figure 4 below), and then sliding the bottom lid backwards. Insert

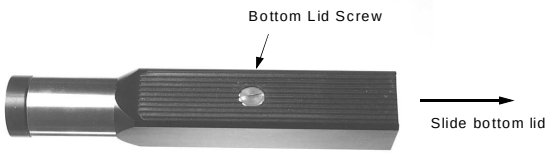

Fig. 4 Access to batteries

4 new batteries, with the polarity as indicated on the figure. The Pistonphone can operate continuously for 20 hours on a new set of batteries.

Calibration of ½" Microphones

To calibrate a ½" measurement microphone, first loosen the microphone retention ring as shown in Figure 5 below. Then insert the microphone into the ½" coupler as shown in Figure 6 below. Make sure that the microphone is all the way in, and tighten the microphone retention ring so that the microphone is held firmly in place. Turn the pistonphone on with the On/Off button. The LED on the front of the Pistonphone is a two color LED with red and green. The LED will be green if the Pistonphone is operating properly at the specified frequency. If the LED is red or flashing red, the Pistonphone is not operating at the specified frequency and the battery should be changed.

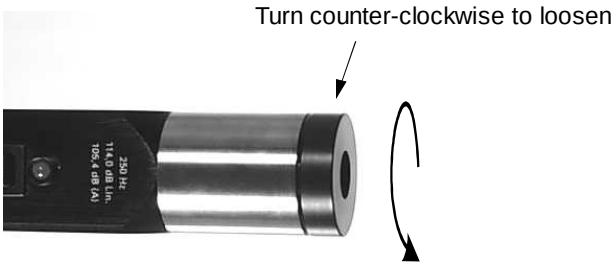

Fig. 5 Loosening the microphone retention ring

Wait approximately 15 seconds for the static pressure to stabilize in the Pistonphone and for the microphone to stabilize in the pistonphone. The static pressure inside the coupler volume is equalized by an air equalization tube protected behind the piston protection cap. The microphone will now be subjected to a sound pressure level L_C given by the nominal Pistonphone pressure level L_N , the static pressure correction L_B and the volume correction L_V:

$$L_C = L_N + L_B + L_V$$

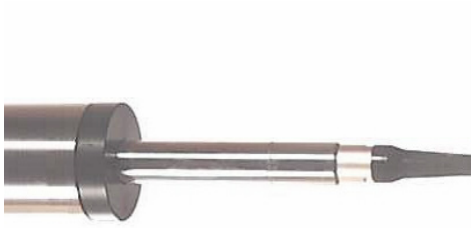

Fig. 6 Microphone mounted in coupler

Calibration of ¼" Microphones

To calibrate a ¼" measurement microphone, first loosen the microphone retention ring as shown in Figure 5. Then insert the ¼" microphone adapter into the ½" coupler as shown in Figure 7 below. Make sure that the adapter is all the way in, and tighten the microphone retention ring so that the adapter is held firmly in place. Insert the ¼" microphone into the ¼" adapter. Turn the Pistonphone on using the On/Off button. The LED on the front of the Pistonphone is a two color LED with red and green. The LED will be green if the Pistonphone is operating properly at the specified frequency. If the LED is red or flashing red, the Pistonphone is not operating at the specified frequency, and the battery should be changed.

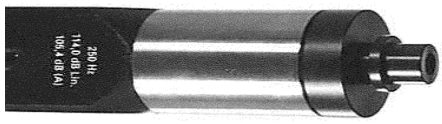

Fig. 7 ¼" Microphone adapter in ½" coupler

Wait approximately 15 seconds for the static pressure to stabilize in the Pistonphone and for the microphone to stabilize in the Pistonphone. The microphone will now be subjected to a sound pressure level L_C given by the nominal Pistonphone pressure level L_N, the static pressure correction L_B and the volume correction L_V:

$$L_C = L_N + L_B + L_V$$

Calibration of 1" Microphones

To calibrate a 1" measurement microphone, the standard ½" coupler should be replaced with the optional 1" coupler (see Figure 8 on following page). Unscrew the ½" coupler from the Pistonphone body. The pistons and retention spring shown in Figure 2 are protected, so there is no risk of accidental damage to these parts when the coupler is removed. Screw the 1" coupler onto the Pistonphone body. Then insert the 1" microphone into the 1" coupler. Make sure that the microphone is all the way in. Turn the Pistonphone on using the On/Off button. The LED on the front of the Pistonphone is a two color LED with red and green. The LED will be green if the Pistonphone is operating properly at the specified frequency. If the LED is red or flashing red, the Pistonphone is not operating at the specified frequency and the battery should be changed. Wait approximately 15 seconds for the static pressure to stabilize in the Pistonphone and for the microphone to stabilize in the Pistonphone. The microphone will now be subjected to a sound pressure level L_C given by the nominal Pistonphone pressure level L_N, the static pressure correction L_B and the volume correction L_V:

$$L_C = L_N + L_B + L_V$$

Fig. 8 ½" coupler and 1" coupler

Microphone Sensitivity Calculation

The sensitivity of the microphone under test can be calculated from a measurement of the microphone output voltage. If the measured output voltage is V_o and the Pistonphone coupler pressure level is $L_{C,}$ then the microphone sensitivity S is given by:

$$S = V_0 \Big/ 10^{L_C/20} * 20\,\mu Pa$$

This sensitivity will include the loading of the preamplifier input impedance and the gain or attenuation in the preamplifier. To measure the Open Circuit Sensitivity (the output of the microphone without the load from the preamplifier) of the microphone, a special preamplifier for insert voltage calibration should be used.

Appendix A- Barometric Pressure Correction Curve

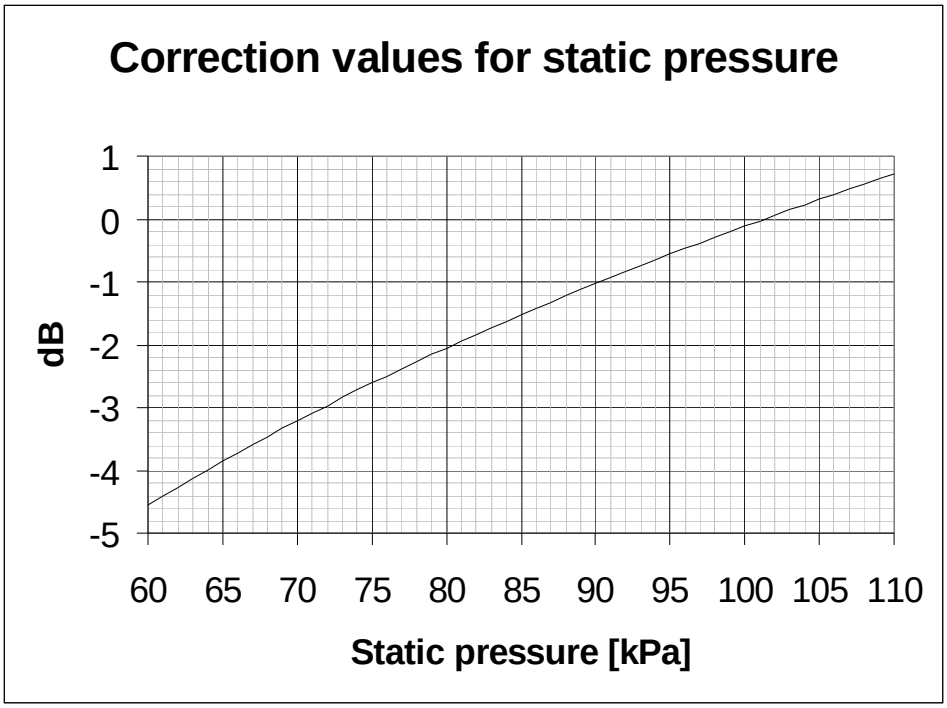

Fig. 9 Correction values for static pressure

Appendix B- Corrections for Humidity

For very precise calibrations, corresponding to IEC Standard 942 Class 0, it is necessary to correct the pressure in the Pistonphone for the influence of the air humidity. The humidity influence is a function of both the temperature and the barometric pressure. The curves in Figure 10 (see following page) give a correction value C, which takes into account the effect of temperature and humidity variations.

This value has to be corrected for the influence of the barometric pressure P_a. according to the equation:

$$\Delta LH = (P_r/P_a) * C + 0.0064\text{dB}$$

This correction factor has to be added to the other correction factors in equations 4, 5 and 6.

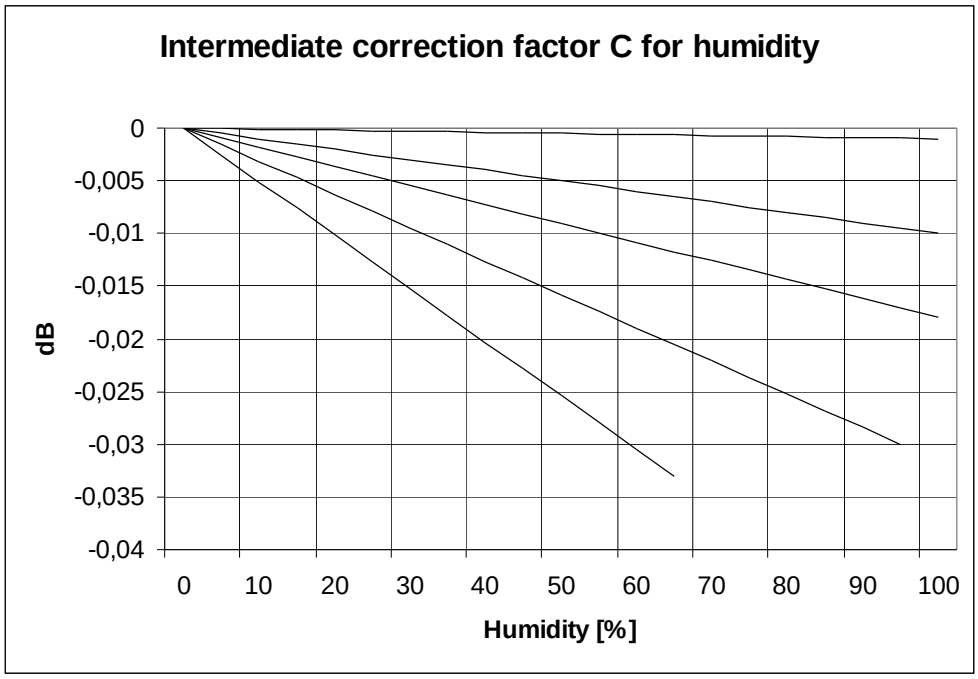

Fig. 10 Corrections for humidity

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A PCB GROUP COMPANY

ISO 9001 CERTIFIED

Manual Number: 21360
Manual Revision: A
ECN 20497

VIB-377 Manual – 08/04
Printed in the U.S.A.

Model Number	PISTONPHONE	Revision: A
394A40		ECN #: 20497

Performance	ENGLISH	SI	
Operating Frequency (± 0.5 %)	250 Hz	250 Hz	
Output (± 0.08 dB) (Sound Pressure Level)	114 dB re 20 µPa	114 dB re 20 µPa	[3]
Distortion	<1.5 %	<1.5 %	
Environmental			
Temperature Range (Operating)	14 to +131 °F	-10 to +55 °C	
Barometric Pressure Coefficient	0.09 dB/kPa	0.09 dB/kPa	
Electrical			
Settling Time	15 sec	15 sec	[1]
Internal Battery (Type)	AA	AA	[2]
Internal Battery (Quantity)	4	4	
Battery Life	20 hours	20 hours	[1][2]
Physical			
Size (Height x Width x Length)	1.38 in x 1.38 in x 6.89 in	35 mm x 35 mm x 175 mm	
Weight	11.3 oz	320 gm	

All specifications are at room temperature unless otherwise specified.
In the interest of constant product improvement, we reserve the right to change specifications without notice.

ICP® is a registered trademark of PCB Group, Inc.

OPTIONAL VERSIONS

Optional versions have identical specifications and accessories as listed for the standard model except where noted below. More than one option may be used.

NOTES:

[1] Typical.
[2] Alkaline type recommended for longest service life.
[3] At ambient pressure

SUPPLIED ACCESSORIES:

Model 079A22 Adaptor for 1/4 inch microphones. (1)
Model RA0069 Adaptor for 1/8 inch microphone. (1)
Model ZC0002K Barometer (1)

OPTIONAL ACCESSORIES:

Model RA0023 1 inch microphone coupler. (1)
Model RA0025 Octopus coupler (1/4 inch mics) (1)

Entered: CCR	Engineer: CCR	Sales: WDL	Approved:	Spec Number:
Date: 8-30-04	Date: 8-30-04	Date: 8/30/4	Date:	21194

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VIBRATION DIVISION
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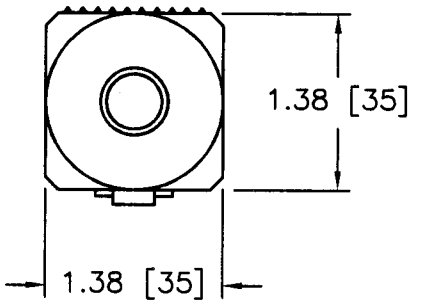
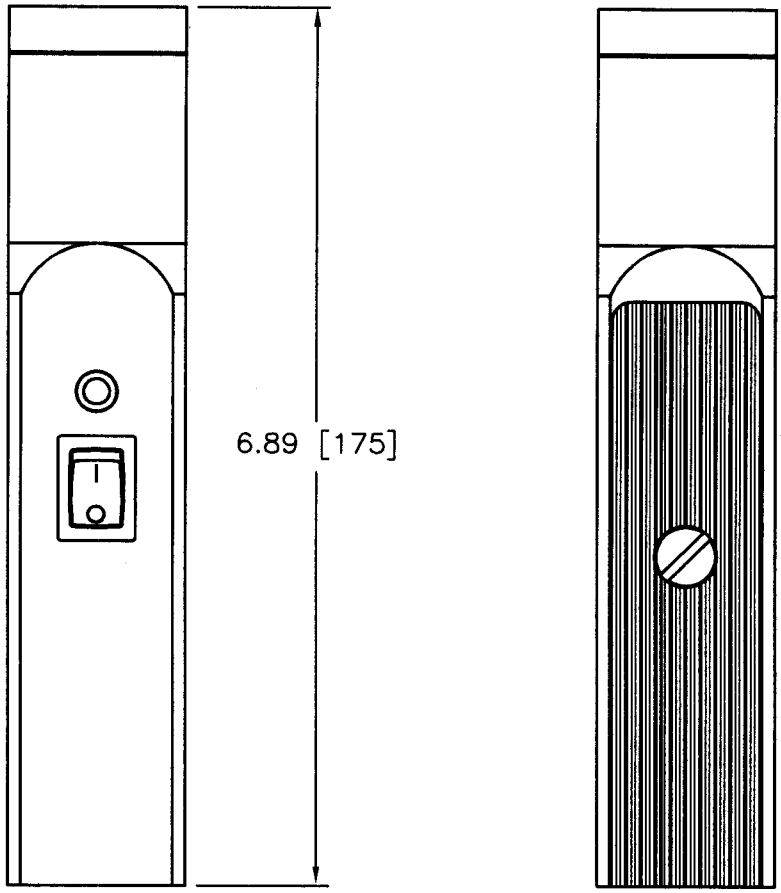
APPLICATION		
NEXT ASS'Y	USED ON	VAR

REVISIONS				
REV	DESCRIPTION	ECN	DATE	APP'D
NR	RELEASED TO DRAFTING		11/13/02	DM 11/14/02

21338





UNLESS SPECIFIED TOLERANCES	
DIMENSIONS IN INCHES DECIMALS XX ±.01 XXX ±.005 ANGLES ±2 DEGREES	DIMENSIONS IN MILLIMETERS [IN BRACKETS] DECIMALS XX ±0.3 XXX ±0.13 ANGLES ±2 DEGREES
FILLETS AND RADII .003 – .005	FILLETS AND RADII [0.07 – 0.13]
DD011 REV. B 03/13/98	

DRAWN	[illegible]	11/13/02	MFG	AL	11/14/02
CHK'D	DM	11/13/02	ENGR	DS	11/14/02
APP'D	[illegible]	11/14/02	SALES	WZ	11/14/2

TITLE
OUTLINE DRAWING
MODEL 394A40
PISTONPHONE CALIBRATOR

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SCALE: 1:1.5 | SHEET 1 OF 1