MEMORIAL UNIVERSITY

Wind Tunnel Revitalization Project

Work term 3 Fall 2006

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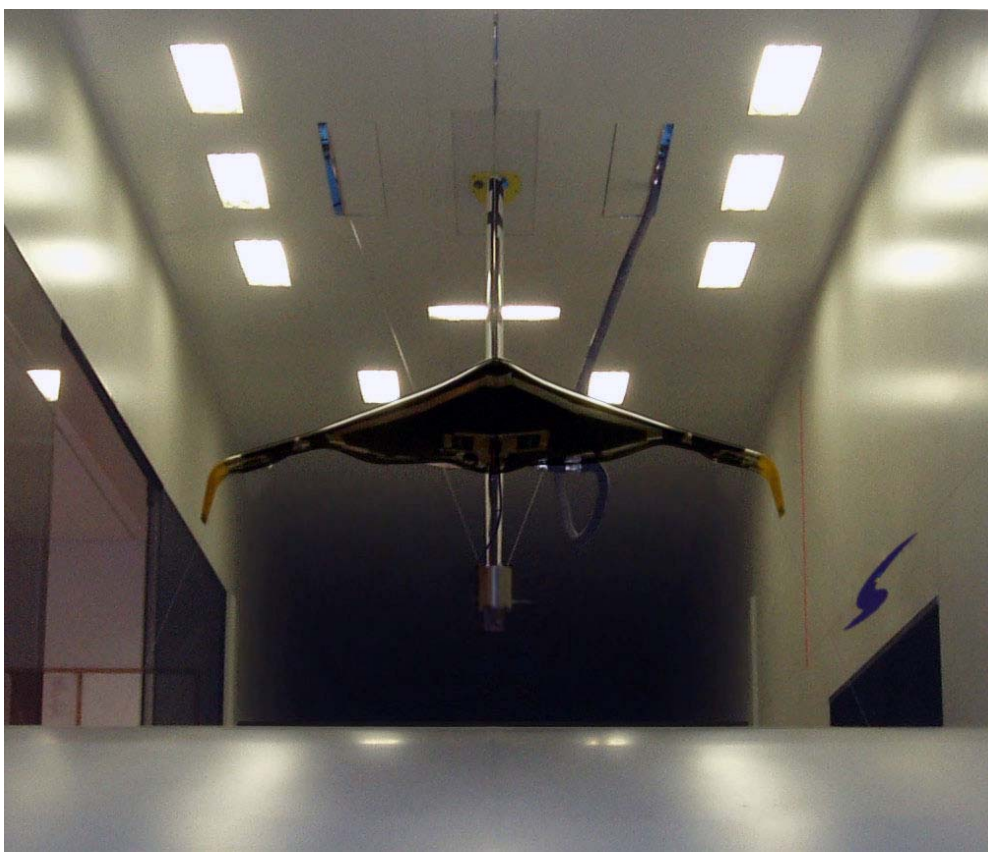
MUN # 200355337

Mechanical Engineering



Wind Tunnel Revitalization Project

Introduction

This project aims to fully put the wind tunnel of Memorial University back into service which requires equipping the tunnel with its old force balance and flow visualization equipment. The major part of the project will be the calibration and modernization of the force balance for force and moment measurements on the test model. The balance will be equipped with a data acquisition system and a computer to monitor and analyze the test results simultaneously. Also there will be some flow measurements across the test section and finally the smoke generator needs to be prepared and installed in the tunnel.

Acknowledgements

This project was completed on the wind tunnel of Memorial University under the guidance of Dr. Stephen Bruneau and with the help of the data acquisition technician, Tom Pike as well as with the cooperation of the lab manager, Darryl Pike. Thank you!

Table of contents

1- Pyramidal Force Balance

Introduction

Quote from: http://www.nasatech.com/Briefs/Oct03/LAR16020.html

"…A force balance is a complex structural spring element instrumented with strain gauges for measuring three orthogonal components of aerodynamic force (normal, axial, and side force) and three orthogonal components of aerodynamic torque (rolling, pitching, and yawing moments). Force balances remain as the state-of-the-art instrument that provides these measurements on a scale model of an aircraft during wind tunnel testing. Ideally, each electrical channel of the balance would respond only to its respective component of load, and it would have no response to other components of load. This is not entirely possible even though balance designs are optimized to minimize these undesirable interaction effects. Ultimately, a calibration experiment is performed to obtain the necessary data to generate a mathematical model and determine the force measurement accuracy."

There is an external 6 component pyramidal balance manufactured by Aerolab in the wind tunnel which is capable of measuring all the forces and moments on the test model. It is equipped with 6 load cells for Measuring**:**

1- Drag: The force Parallel to the wind flow and to the tunnel's walls

2- Lift: Upward/Downward force normal to Drag and Side force

3- Side force: Applied to the sides of the test model and normal to Drag and Lift

4- Yawing moment: Moment caused by Drag and Side force about an axis parallel to Lift

5- Pitching moment: Moment caused by Drag and Lift about an axis parallel to side force

6- Rolling moment: Moment caused by Lift and Side force about an axis parallel to Drag

* This force balance measures the moments applied about the balance virtual centre NOT about the models' center of gravity or centeroid.

Force and moment concepts

Figure 1

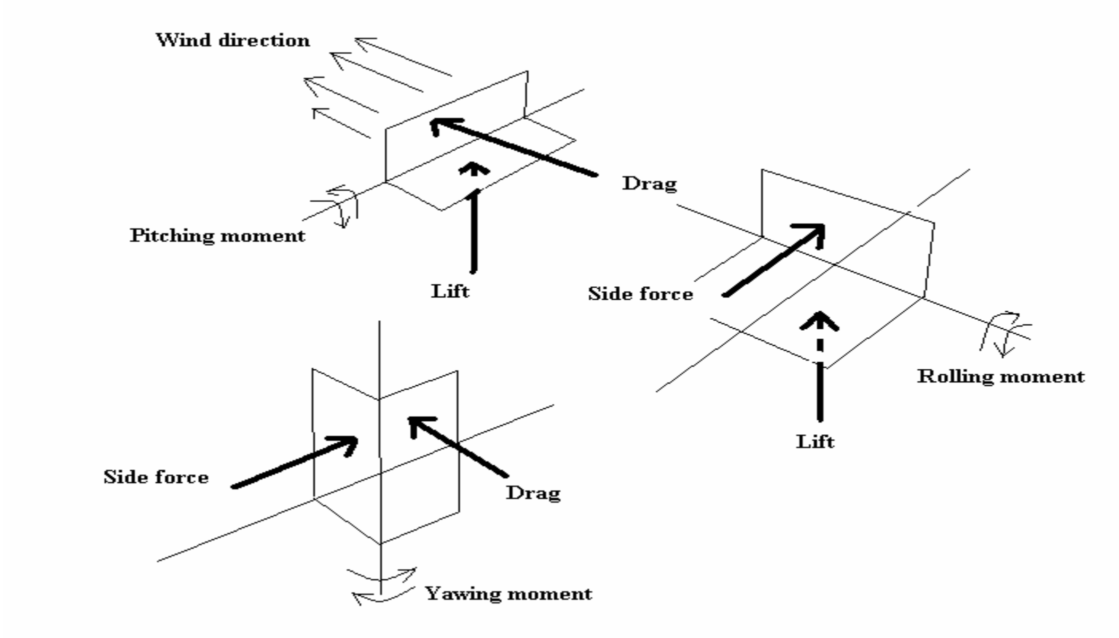
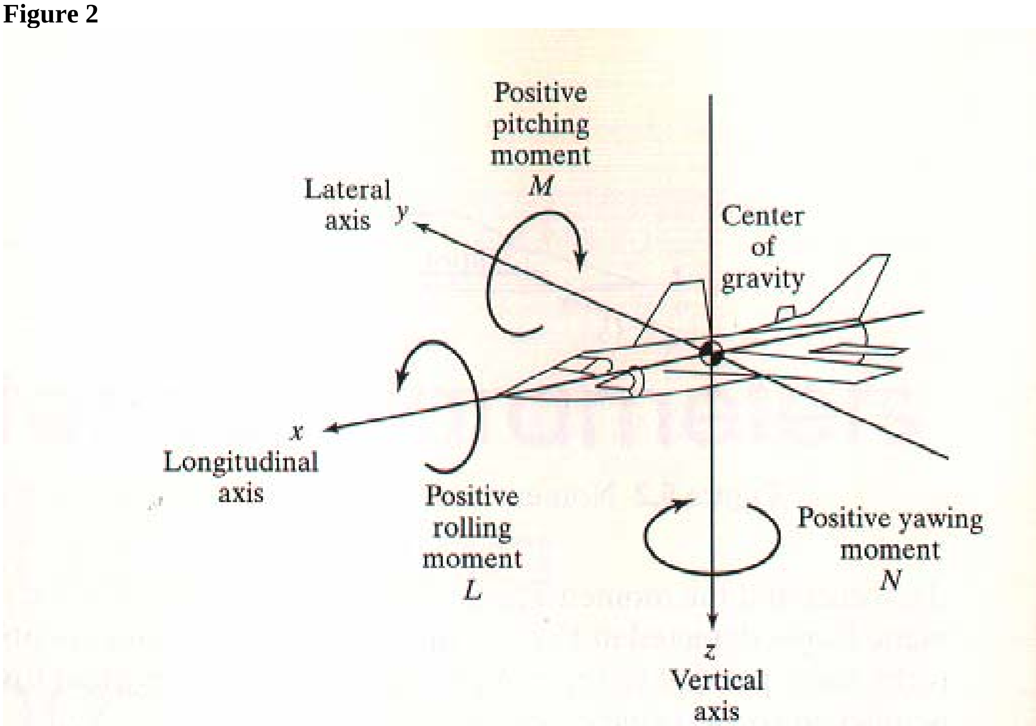


Figure 2



Components and load cells configuration

Figure 3

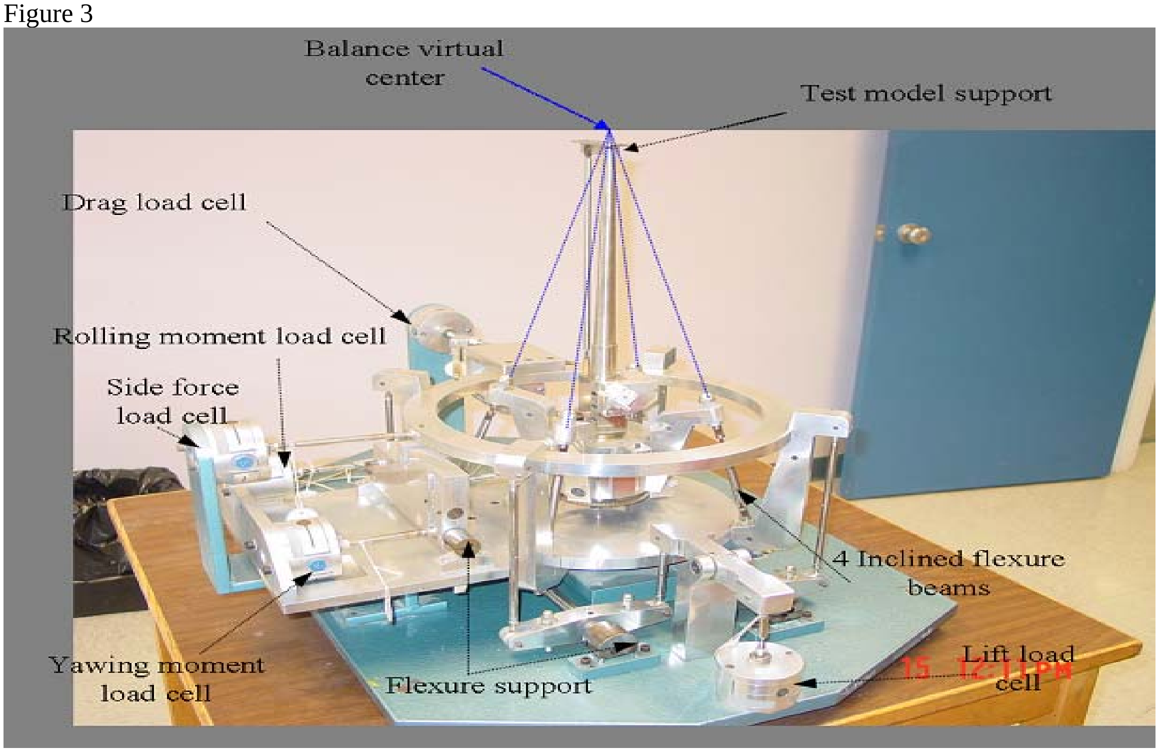
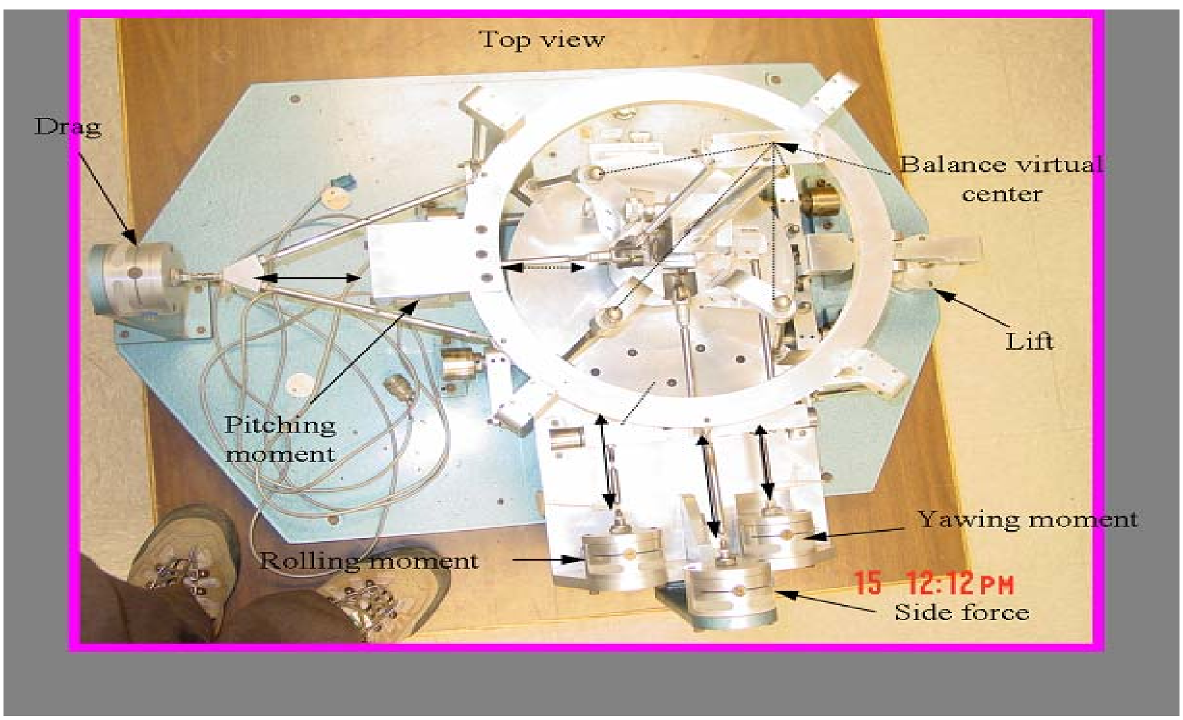


Figure 4



1.1 Dusting and cleaning

The balance seemed to have not been used for a long time and as a result it was dusted and dirty. I dusted and cleaned it thoroughly with cleaners and ensured that all the joints are clear of any dust or dirt as they would adversely affect the performance and precision of the balance. Extreme care was taken in handling the balance.

1.2 Collecting information on its physical and mechanical structure

Since there was no manufacturer's manual or any brochures available on the balance, I searched the web and looked up pages containing any information on it. There are a few websites which have some information on this type of balance which I found very helpful. Also the text book: Low-speed wind tunnel testing / Jewel B. Barlow, William H. Rae, Alan Pope, 3rd edition 1999 available at the QEII library is very helpful. There are some Aerodynamics books which are helpful too when studying the wind tunnel. The Aerolab webpage has very little info on their products and as I inquired, a hard copy of the manual would cost us $110 USD to order, which we did not. The manufacturer also has a new National Instrument's DAQ software and hardware as well as the LabView for upgrading the balance.

As you see in Figure 3 and figure 4, there is a point called "Balance virtual center" at which all four inclined struts meet. This is the point about which all the three moments are measured. The structure of the balance needs to be sturdy and rigid to dampen any vibrations created during the testing; therefore it is quite heavy and needs at least to persons to handle it. The rods, beams, and joints used in the balance are flexure types which are designed to transfer forces and moments with minimal friction and to avoid "hysteresis effect" in the system. The hysteresis effect would lower the accuracy of the readings from the load cells.

1.3 Providing a data acquisition system to replace the old electronic one

The electronic part of the balance, which has become obsolete, was a box containing all those small electronic parts plus a few analog meters with knobs and switches on both the front and the back panels. We upgraded the balance with a NI signal conditioning board (SC- 2043) and a NI DAQmx PCI 6024E board with an external 10V DC power supply. The DAQ system requires a fast computer to process all the data read from the 6 load cells, unfortunately all the PC's available in the lab were slow and could not support the DAQ system. We got a 1700 MHz Pentium 4 that can process this vast amount of data read from the balance. It took us about a week to configure and debug the NI DAQ system.

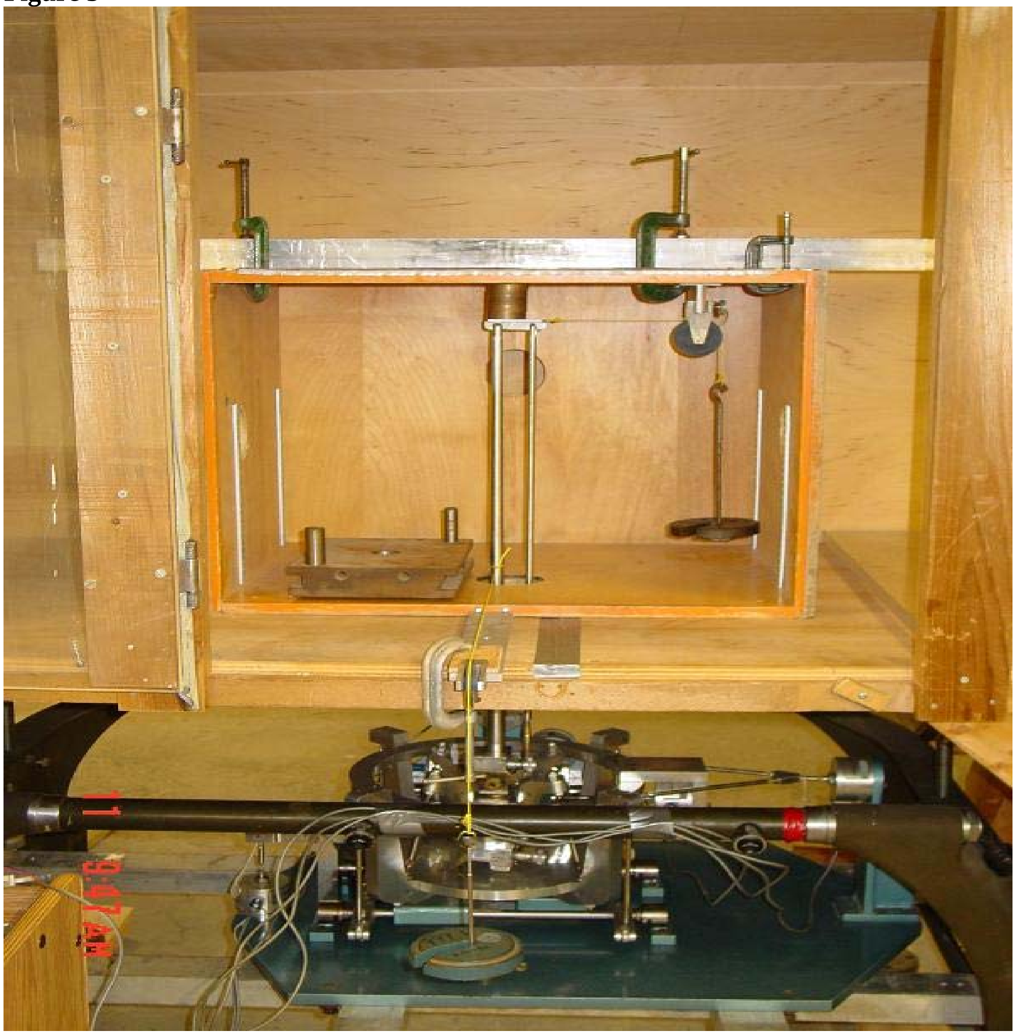
1.4 Testing all six load cells for functionality

There was a little doubt as to whether or not the balance was still functional, therefore we tested all load cells for functionality by sending an excitation voltage to them and observing the response while pushing or pulling on the respected one. All 6 were responding good, however, we were not sure about their accuracy, so I erected a temporary calibration apparatus with a few pulleys and some strings to test them by applying some known loads and observing the responses and it turned out all 6 were working.

1.5 Preparing and erecting a calibration rig in the test section

We needed a rigid structure to mount the pulleys on and to hang loads of up to 25 lbs during the calibrations process. So I came up with the following structure (figure 5) and with some modifications we could have a rigid rig. The rig needs to be aligned with the tunnel's side walls and balanced as well.

Figure 5



1-6 Installing the balance under the tunnel

The calibration has to be very precise and accurate; accordingly we installed the balance underneath the tunnel right at the test section. As for the external balances, it is strongly recommended that the calibration be completed with the balance in place. This would ensure the alignment of the balance with the tunnel and consequently having more accurate results, therefore the balance must be aligned and balanced horizontally at all times.

1.7 Calibration

Introduction

Calibration is simply applying some known loads to a load cell and recording the voltage responses from it, by doing so, we can get a linear curve of the response voltage versus applied load from the data points (this could be conveniently done in Microsoft Excel). The plot's equation can then be used for determining any unknown loads by just knowing the response voltage from the load cell.

Quote from page 258 of the book: Low-speed wind tunnel testing / Jewel B. Barlow, William H. Rae, Alan Pope, 3rd edition 1999

"… Let us start by making clear the immensity of a wind tunnel balance calibration: with a competent crew the first calibration of a new balance will take three months at least. This time frame supposes that adequate shop facilities for all sorts of changes are available and recognizes that the first "calibration" will almost inevitably involve many adjustments. Many balances have, however, subsequently served very well for decades with modest additional calibration efforts."

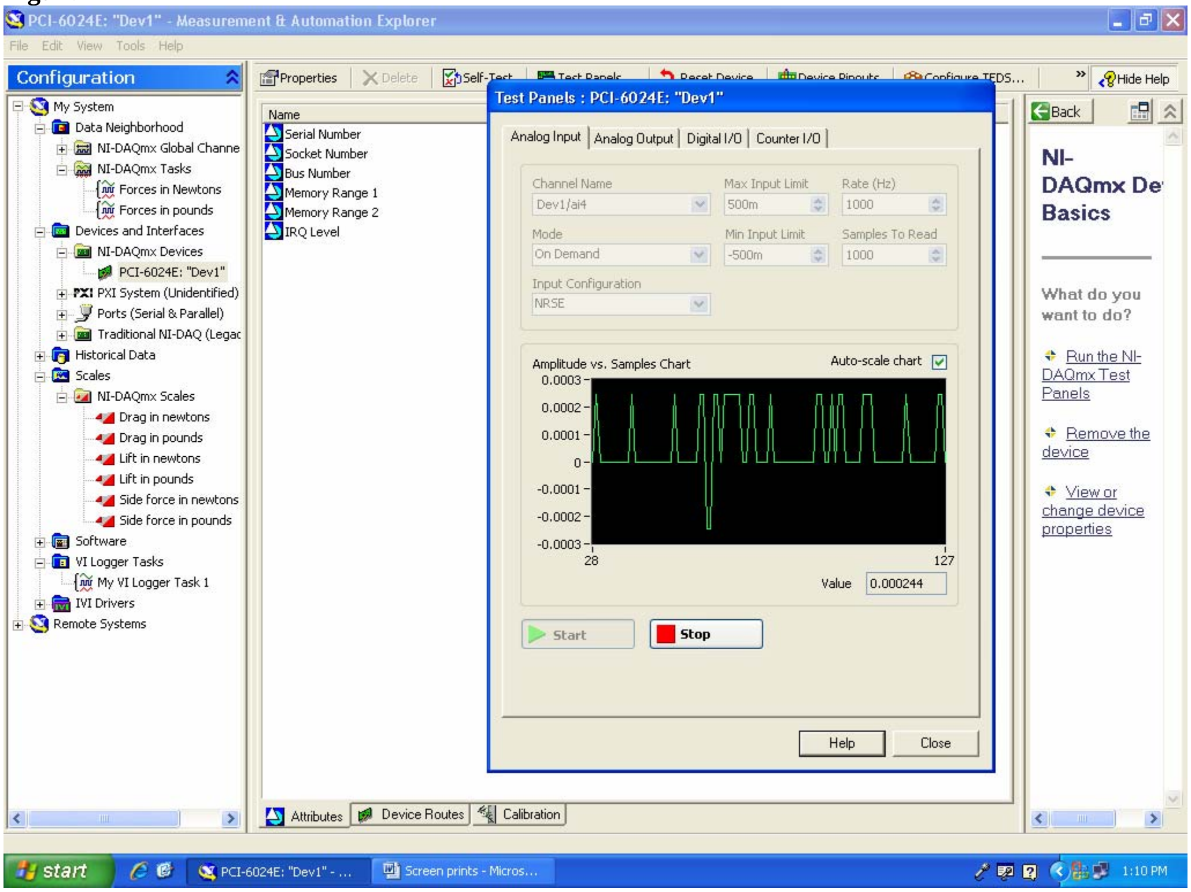
Figure 6 shows the balance and the calibration rig in the tunnel.

Figure 6

1.7.1 Configuring the NI Measurement & Automation Explorer

Table 1 represents the data points obtained from the calibration of the drag. We then plot them in Microsoft Excel to obtain the equation of the linear curve (see figures 8 and 9). To obtain the data in Table 1: Open Measurement & Automation Explorer → Configuration → My system → Devices and interfaces → NI-DAQmx Devices → PCI-6024E (Right click) → Test panels: Channel name from 0-7(select the channel being calibrated) ; Mode: on demand; Input Configuration: NRSE; Max input limit: 500m; Min: -500m → Apply a known load to the load cell and click the Start.

Figure 7



The reading 'Value' from figure 7 is the response voltage from the load cell which is proportionate to the applied known load. Repeat this procedure to have a set of data points like those of the Table 1.

Table 1

Calibration of Drag		
Applied load (lb)	Response voltage (V)	Applied load (N)
0	0.000244	0.00
0.44	0.000977	1.96
0.878	0.00195	3.91
1.316	0.00269	5.86
1.754	0.00366	7.81
2.192	0.00439	9.77
2.648	0.00537	11.80
0.444	0.000977	1.98
2.652	0.00537	11.81
4.866	0.00977	21.68
5.444	0.0107	24.25
7.652	0.0152	34.09
9.866	0.0195	43.95
10.444	0.021	46.53
10.882	0.0215	48.48
11.32	0.0226	50.43
11.759	0.0234	52.39
12.198	0.0243	54.34
14.406	0.0287	64.18
15.444	0.0308	68.80

Figure 8

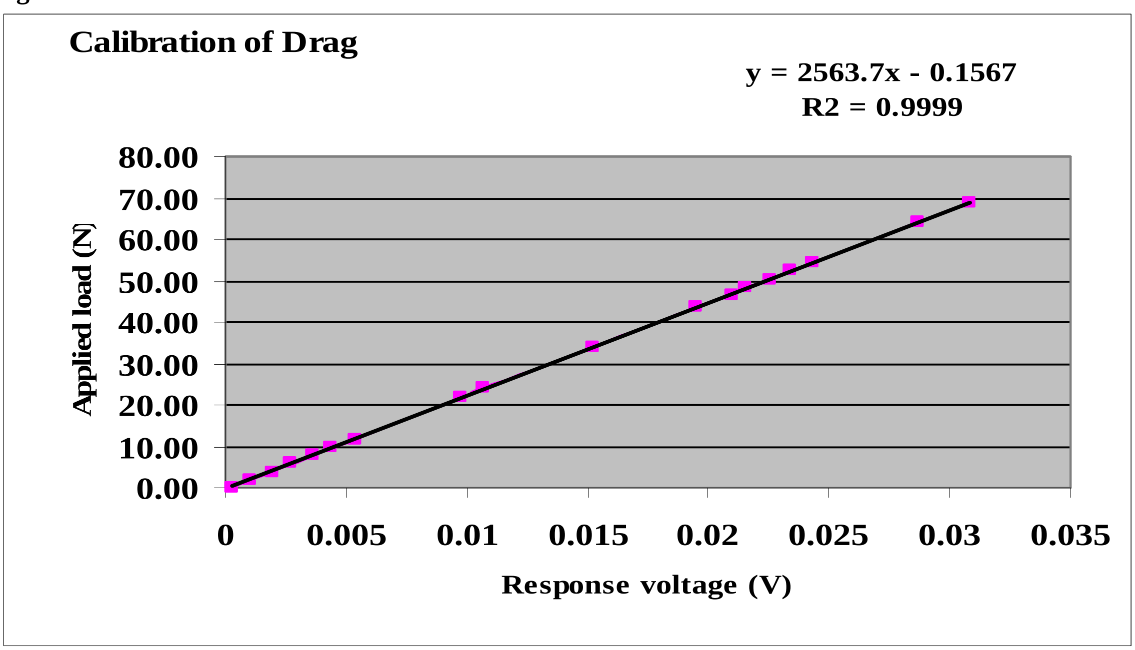
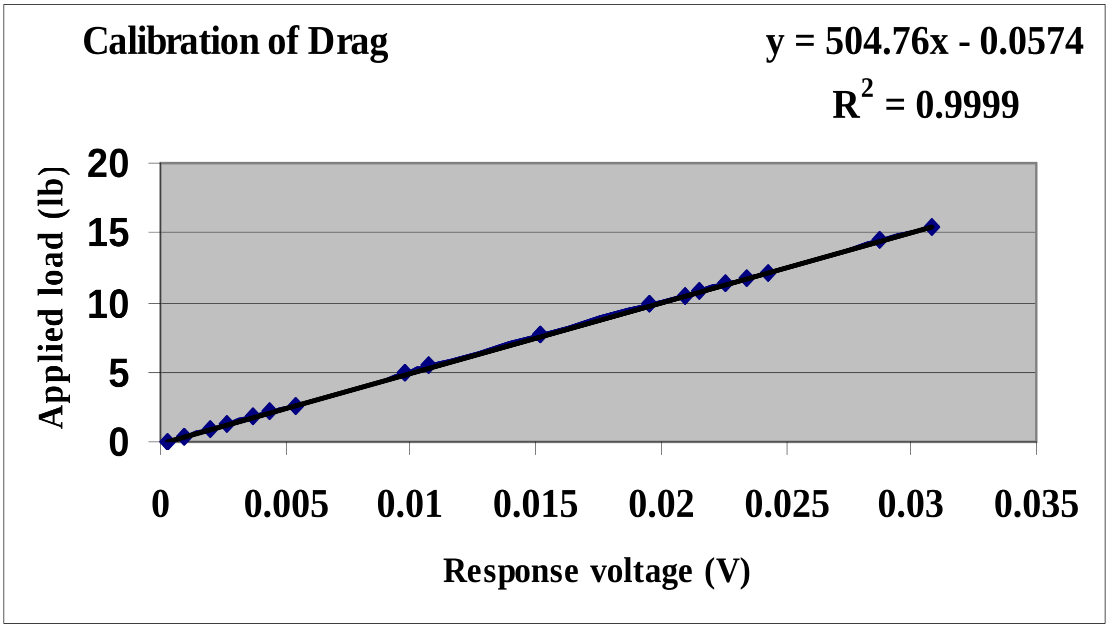
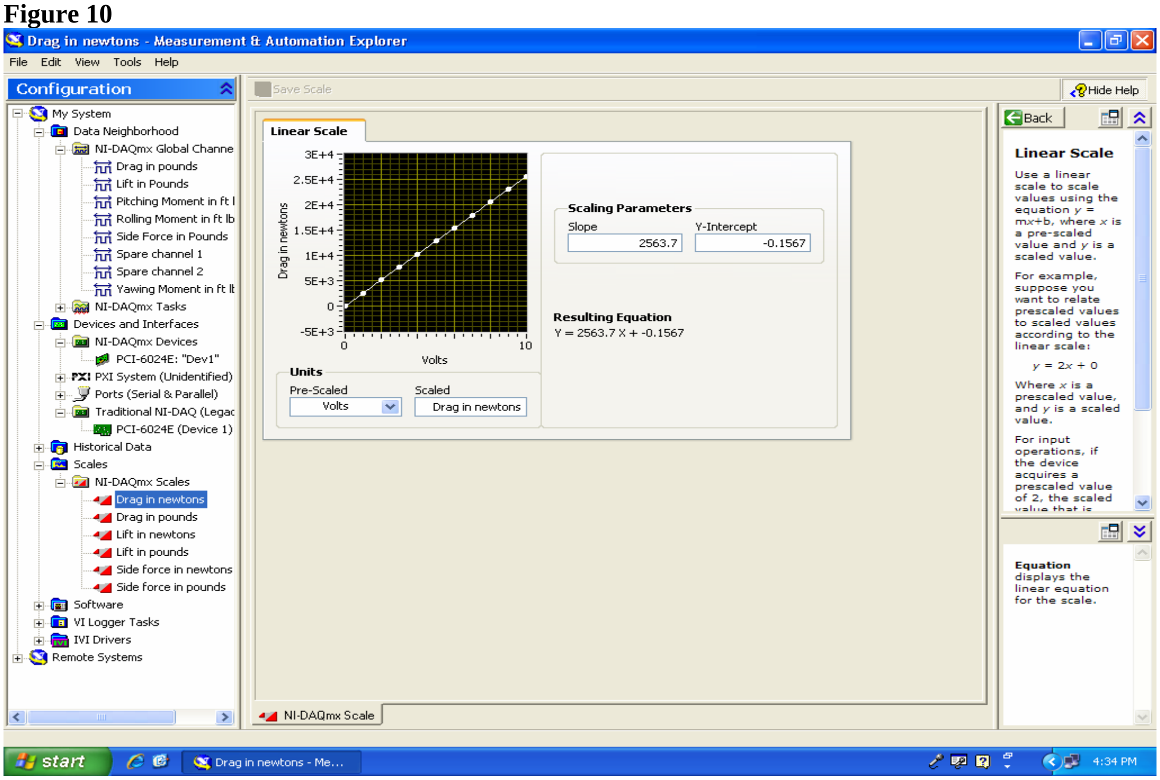


Figure 9



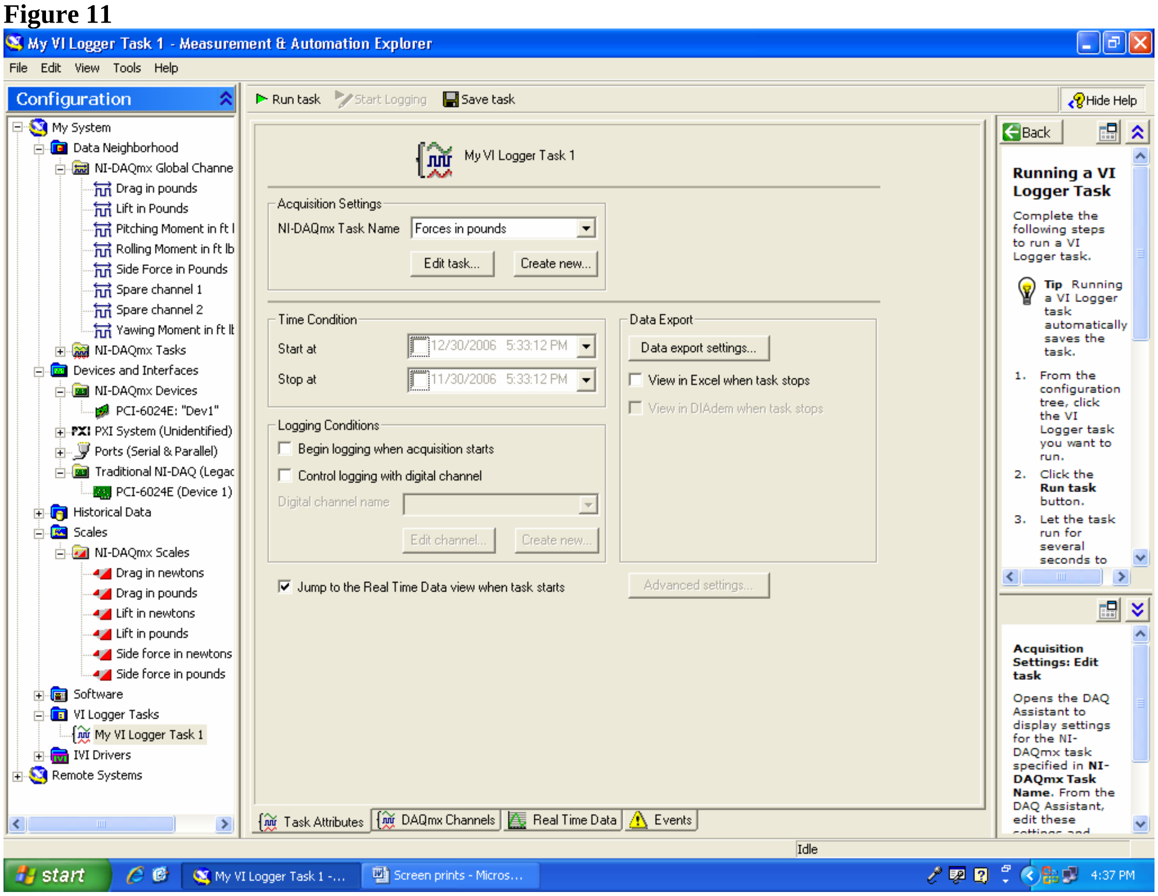
The equations obtained form figure 7 and 8 are then used in the NI Measurement & Automation Explorer to create a scale for the respected load cell (see figure 10).

Figure 10



In the VI Logger Task → My VI Logger task 1 → Task Attributes → Acquisitions settings → NI-DAQmx Task Name → Create new → Analog input → Voltage → Choose a Channel (channels are from 0 -7 on the SC-2043 board).

Figure 11



After that, in the VI Logger Task → Task Attributes → Acquisitions settings → NI-DAQmx Task Name → Edit task → Voltage Input Setup → Settings → Input Range (-100 to +100 for a typical force in newtons). Terminal Configuration NRSE and the Custom scaling → Choose the desired scale → Save task. Refer to figure 12 and figure 13.

Figure 12

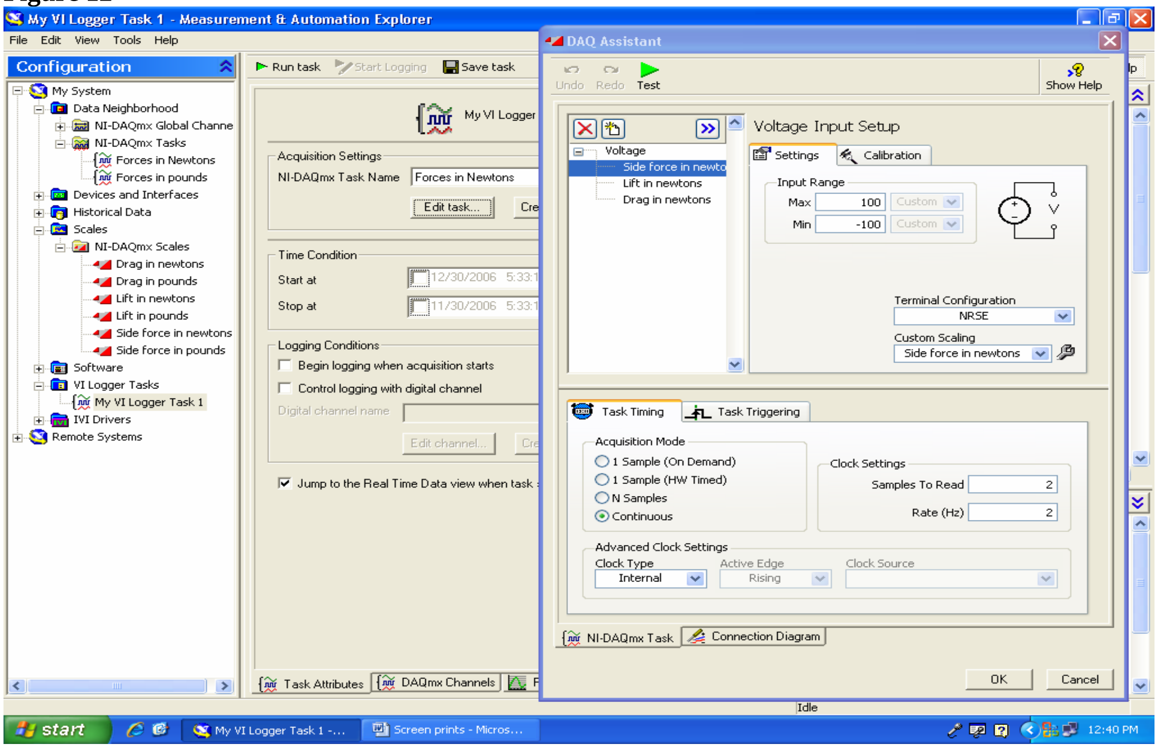
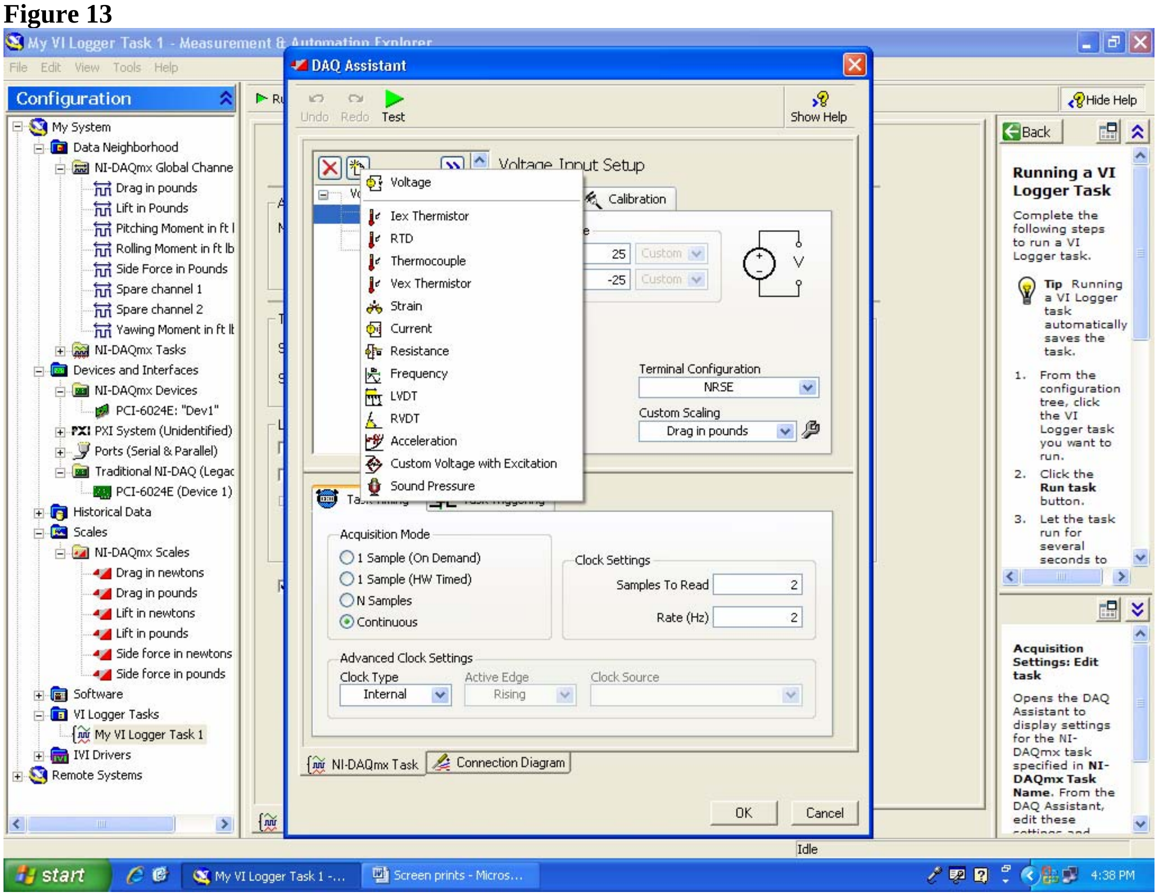
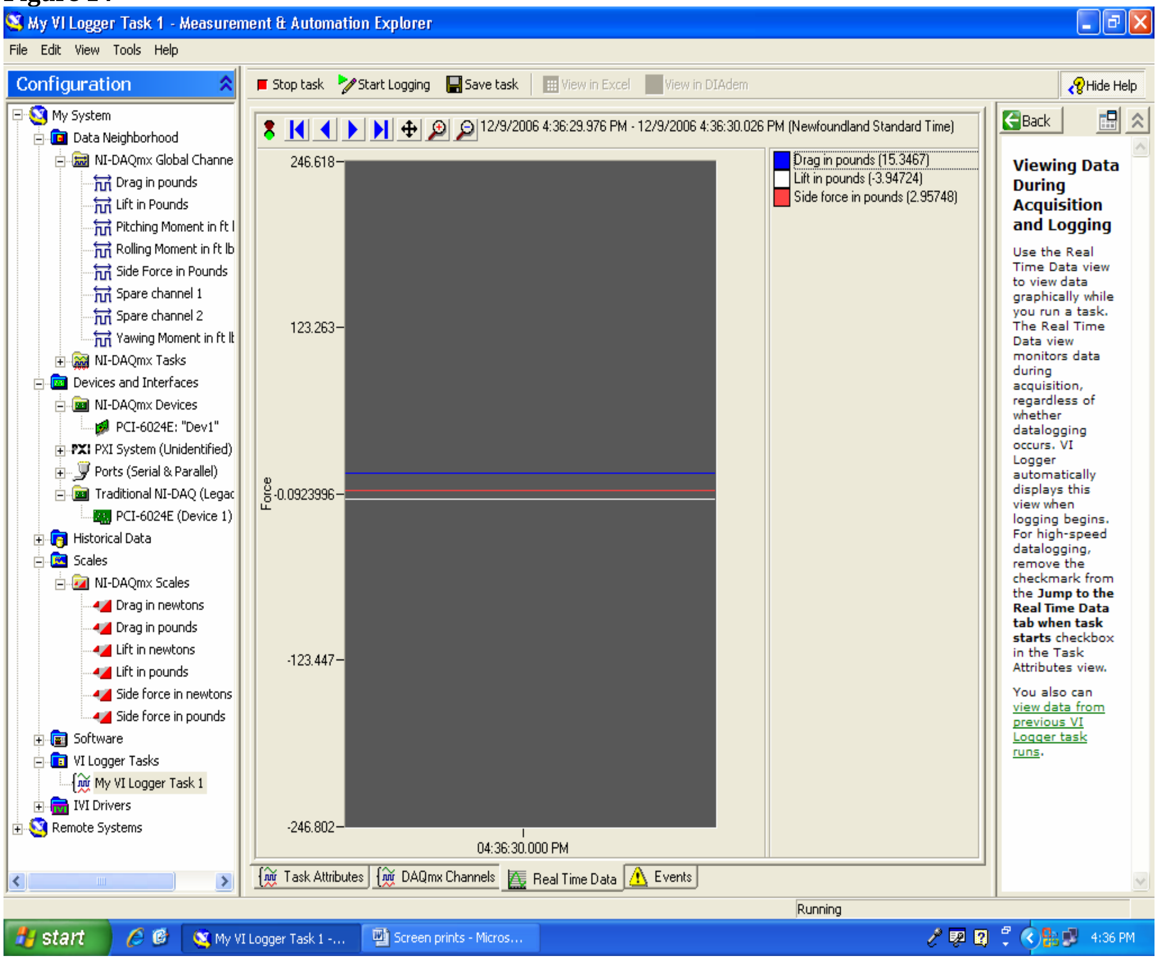


Figure 13



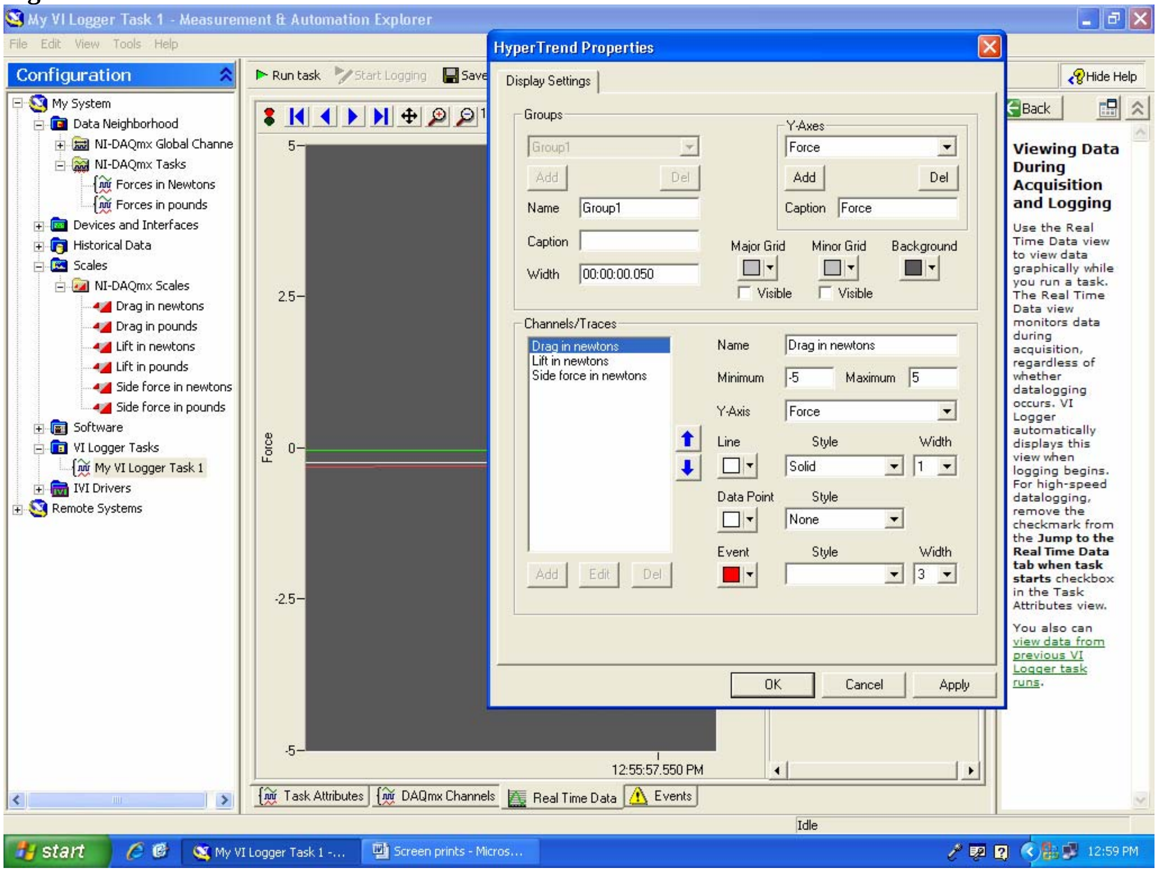
Back to: VI Logger Task → My VI Logger task 1 → Real Time Data → Run task (wait a few seconds). See figure 14.

Figure 14



To configure and make changes to the display screen, simply right click on the graph → properties → Display Settings → Apply → OK. See figure 15.

Figure 15



*Note: During testing it is observed that there are some noises interfering with the readings, making them to fluctuate rapidly and as a result errors appear in readings. Since the response voltage is very small then that small amount is multiplied by a large number (i.e. 2500) to be converted to force in pounds or newtons, a small amount of noise or unwanted fluctuations would convert into a significant amount of error in readings. Therefore, the user should take the average of the data as a stable reading is impossible to obtain. To eliminate this problem, one solution could be refurbishing the balance with a new set of load cells which would cost at least $3000.

2- Smoke Generator

In the Aerolab smoke generator, the smoke-producing fluid (paraffin oil) is forced through an electrical heater which turns the liquid into vapour or ‘smoke’. The device is hooked up to the air pressure as well as to a power supply. The air pressure can be adjusted by turning a screw located on top of the air tank to regulate the pressure. An operating pressure of about 40-50 psi is recommended by the manufacturer.

Connecting and sealing the missing fluid transfer lines

After dusting and cleaning the device, I provided the device with two fluid lines which were missing, a 12 m long hose for air and a 1.5 m small diameter tubing for the fluid transfer line.

How to operate

1- Open the main air pressure valve

2- Adjust the pressure to 40-50 psi

3- Open the fluid valve (located on the fluid reservoir) until fluid starts dripping from the tip of the smoke probe

4- Turn the power switch to 2 or 3 (3 for normal operation, see Appendix C)

5- Turn the power on

6- Make necessary adjustments to increase or decrease the fluid flow

7- To safely shut the machine down, ensure power is turned off first, then the fluid.

8- Shut the main air pressure valve off

*During testing, wear protective gloves as the probe tends to get too hot.

Figure 16 and 17 show the flow visualization on the test model using the smoke generator.

Figure 16

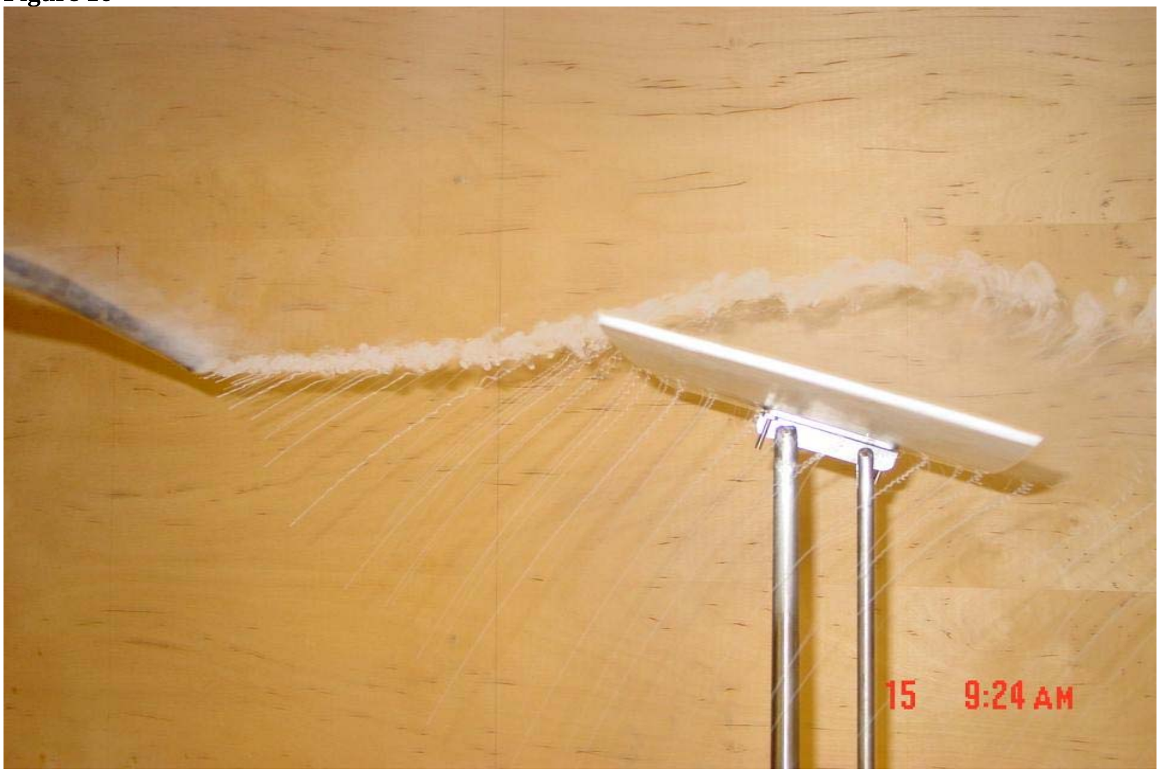
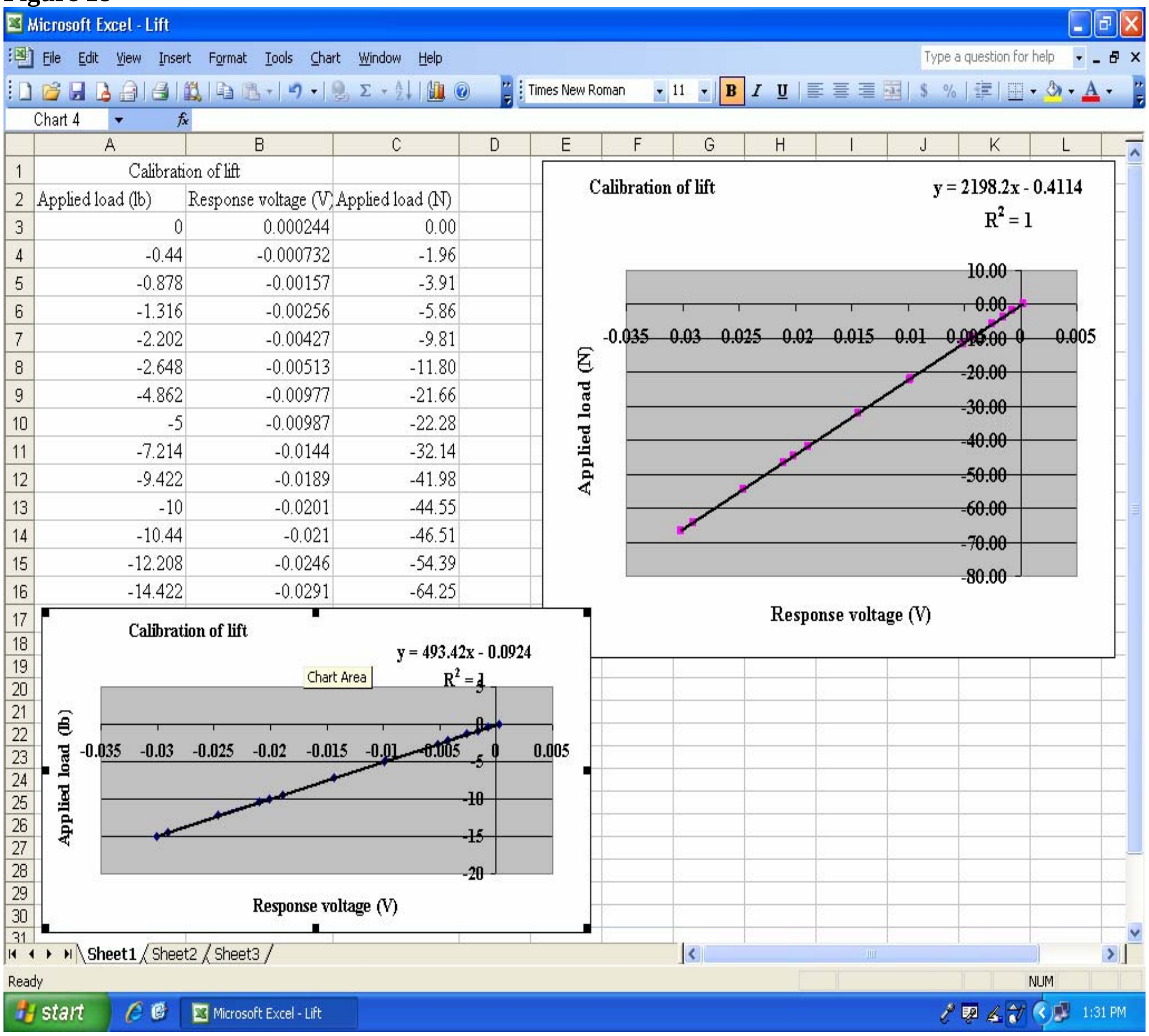


Figure 17

Appendix A

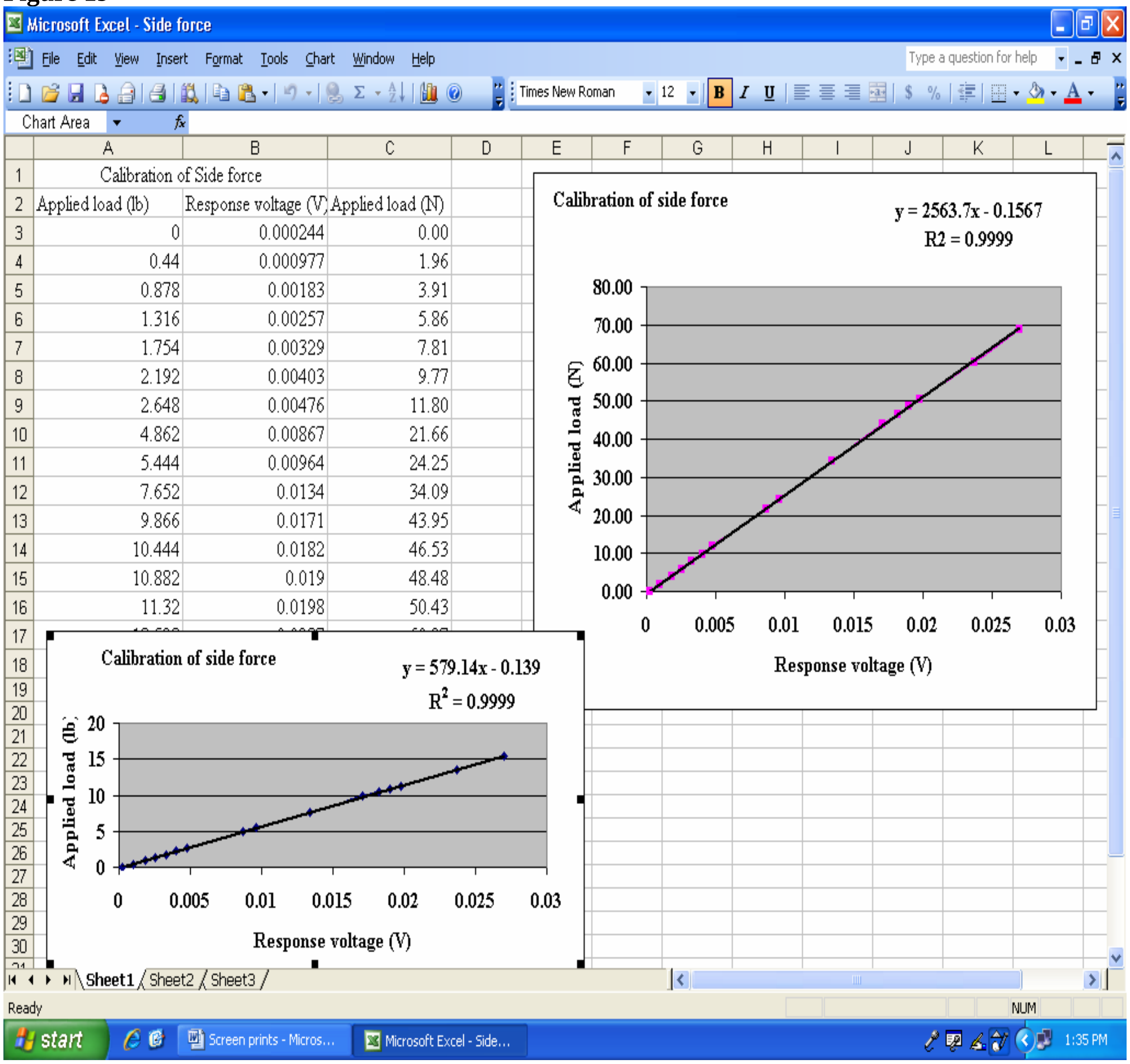
Lift (figure 18) and side force (figure 19) calibration data points.

Figure 18



Calibration of lift		
Applied load (lb)	Response voltage (V)	Applied load (N)
0	0.000244	0.00
-0.44	-0.000732	-1.96
-0.878	-0.00157	-3.91
-1.316	-0.00256	-5.86
-2.202	-0.00427	-9.81
-2.648	-0.00513	-11.80
-4.862	-0.00977	-21.66
-5	-0.00987	-22.28
-7.214	-0.0144	-32.14
-9.422	-0.0189	-41.98
-10	-0.0201	-44.55
-10.44	-0.021	-46.51
-12.208	-0.0246	-54.39
-14.422	-0.0291	-64.25

Figure 19


Microsoft Excel - Side force
Calibration of Side force
Applied load (lb)
Response voltage (V)
Applied load (N)
0 0.000244 0.00
0.44 0.000977 1.96
0.878 0.00183 3.91
1.316 0.00257 5.86
1.754 0.00329 7.81
2.192 0.00403 9.77
2.648 0.00476 11.80
4.862 0.00867 21.66
5.444 0.00964 24.25
7.652 0.0134 34.09
9.866 0.0171 43.95
10.444 0.0182 46.53
10.882 0.019 48.48
11.32 0.0198 50.43
Calibration of side force
y = 2563.7x - 0.1567
R2 = 0.9999
Applied load (N)
Response voltage (V)
Calibration of side force
y = 579.14x - 0.139
R2 = 0.9999
Applied load (lb)
Response voltage (V)
Sheet1
Sheet2
Sheet3
Ready
NUM
start
1:35 PM

Appendix B

Flow control mechanism

Appendix C

Smoke generator's manual

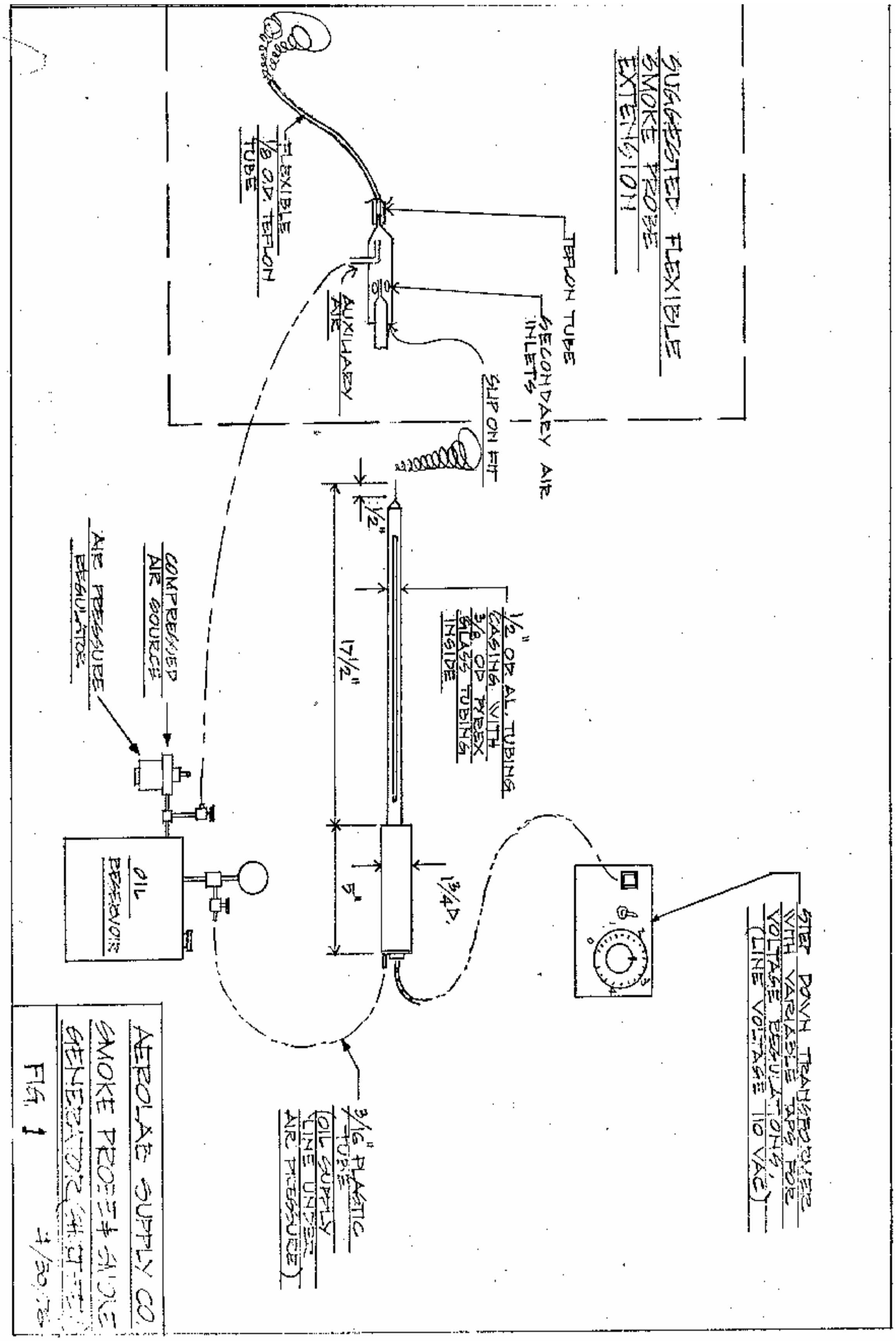
AEROLAB

INSTRUCTIONS ON AEROLAB SMOKE GENERATOR
FOR MEMORIAL UNIVERSITY OF NEWFOUND LAND

April 1976

In the Aerolab Smoke Generator, a smoke-producing liquid is forced through a small bore stainless steel tube which is resistance heated by the passage of a low voltage electric current. A layout of the system is presented as Figure 1.

The 'smoke' liquid is forced through the vaporizing tube by air pressure exerted on the surface of the liquid contained in the fluid reservoir. The air pressure is adjusted by turning the square-headed screw at the top of the Conoflow regulator and filter (Instructions are presented as Figure 2). The air input pressure must be no greater than 125 psi and may be as low as 60 psi. The regulated pressure is adjustable over the range 0-60 psi. Variable electrical input is obtained by a tapped step-down transformer housed inside a metal enclosure. In-coming voltage of 115 BAC 60 or 50 cycles single phase may be varied to values of 14, 28, 42 and 56 volts by adjusting a rotary switch to positions 1-4 inclusive. An on-and-off switch and a fuse are provided for operational convenience and safety. The probe is connected to a rubber-covered cable with a connector that mates with the receptacle in the enclosure. Obviously, the probe should never be directly connected to a 115 volt power outlet or it will burn out immediately. The '4' setting (56 volts) is rather high and should only be used with a maximum flow of oil.


SUGGESTED FLEXIBLE SMOKE PROBE EXTENSION
TEFLON TUBE
SECONDARY AIR INLETS
SLIP ON FIT
FLEXIBLE 1/8 OD TEFLON TUBE
AUXILIARY AIR
1/2"
17 1/2"
5"
1 3/4 D.
1/2" OD AL. TUBING CASING WITH 3/8 OD PYREX GLASS TUBING INSIDE
COMPRESSED AIR SOURCE
AIR PRESSURE REGULATOR
OIL RESERVOIR
STEP DOWN TRANSFORMER WITH VARIABLE TAPS FOR VOLTAGE REGULATIONS (LINE VOLTAGE 110 VAC)
3/16" PLASTIC TUBE OIL SUPPLY LINE UNDER AIR PRESSURE
AEROLAB SUPPLY CO.
FIG. 1
4/30/78

FOREMOST IN FINAL CONTROL ELEMENTS
PLANT AND OFFICES • BLACKWOOD, NEW JERSEY 08012

INSTRUCTIONS AND PARTS LIST
NO. FH-60
DATE: 1/10/69

INSTRUCTIONS

MODEL FH-60 AIRPAK FILTER-REGULATOR COMBINATION

AIRPAK INSTALLATION

Unit has four ¼" N.P.T. connections. The upstream inlet is stamped "IN" and the aspirated outlet is stamped "OUT" directly underneath the connections. The two remaining taps (stamped "G") are reduced pressure outlets which can be used as gauge connections.

AIRPAK MAINTENANCE

All air connections should be periodically checked for leakage. Adjusting knob (12) should be kept lubricated with dry lubricant.

FILTER

To clean filter (8), remove cap nut (24) and slide off bowl (9). Remove nut (10), filter plate (22) and filter (8). Filter element may be cleaned by rinsing in a solvent such as gasoline, naphtha, carbon tetrachloride, etc. and blowing dry with air stream directed on inside of filter cylinder.

To replace filter (8), put retaining plate (20) against body (18), and install filter (8) and filter plate (22) by threading nut (10) on bolt (21). Inspect "O" rings (19 & 23) for defects and replace if necessary. Attach bowl (9) by threading cap nut (24) on bolt (21). An effective seal will be made by merely making cap nut (24) finger tight.

At periodic intervals, the dripwell should be cleared by opening draincock (11) while unit is in line under pressure.

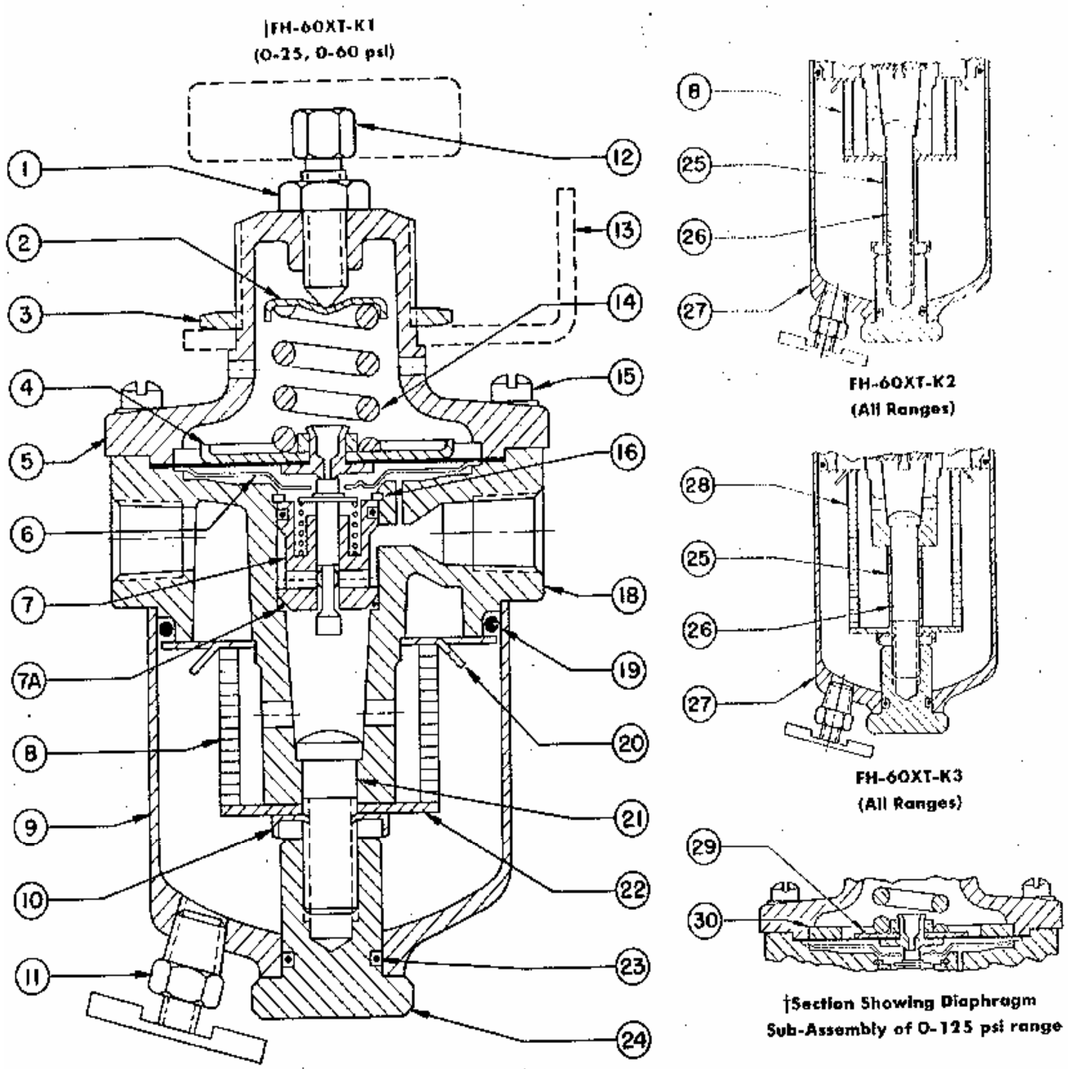
DIAPHRAGM AND NOZZLE REPLACEMENT

Periodic replacement of diaphragm assembly (4) and nozzle assembly (7) is recommended for service where unit is on stream continuously and consistent, high accuracy regulation is required. Frequency of replacement will depend on the nature of the service, cleanliness and moisture content of the air, etc.

To replace diaphragm assembly (4), loosen adjusting knob (12) until spring (14) tension is relieved, remove eight screws (15) and lift off bonnet (5), spring plate (2), spring (14), and diaphragm assembly (4). Place new diaphragm assembly (4) on body (18) with diaphragm plate up, and reassemble.

To replace nozzle assembly (7), remove diaphragm assembly (4) as above, and filter as described in section entitled "Filter". Remove baffle plate (6) and retaining ring (16). Then, by pushing up bolt (21), entire nozzle sub-assembly (7) will come out. Before installing nozzle sub-assembly (7), inspect "O" rings (7A) and replace if necessary. Push in nozzle sub-assembly (7), replace retaining ring (16) and baffle plate (6). Replace diaphragm sub-assembly (4) and filter as previously described.

Fig 2-A.



PARTS LIST

ITEM NO.	NO. REQ'D	DESCRIPTION	PART NO.
1	1	Hex. Jam Nut (FH-60XT-K only)	5/16"-24
2	1	Spring Plate	H-610
3	1	Locknut	H-29-1
*4	1	Diaphragm Sub-Assembly (0-25, 0-60 psi) consisting of: Diaphragm, Seat, Seat Nut, Plate	H-696
5	1	Bonnet	H-606
6	1	Baffle Plate	H-693
*7	1	Nozzle Sub-Assembly consisting of: Item 7A, plus Plug, Plug Spring, Spring Button, Retaining Washer, Nozzle	H-698
7A	2	"O" Ring	05-10-015
*8	1	Filter (FH-60XT-K1 & 2)	07-15-01
9	1	Bowl (FH-60XT-K1)	H-645
10	1	Nut	04-45-03
11	1	Draincock	H-648
12	1	Knob (FH-60XT-K) Handwheel (FH-60XT-H)	H-321 H-328
13	1	Wall Mounting Bracket	H-411
14	1	Spring (0-25 psi) Spring (0-60 or 0-125 psi)	H-172 H-76
15	8	Fillister Head Screw	10-32x5/8" lg.
16	1	Retaining Ring	04-68-01
18	1	Body	H-603
*19	1	"O" Ring	05-10-227
20	1	Retaining Plate	H-649
21	1	Bolt (FH-60XT-K1)	H-639
22	1	Filter Plate	H-622
*23	1	"O" Ring	05-10-015
24	1	Cap Nut	H-624
25	1	Spacer (FH-60XT-K2 & 3)	H-667
26	1	Bolt (FH-60XT-K2 & 3)	H-639-1
27	1	Bowl (FH-60XT-K2 & 3)	H-645-1
*28	1	Filter (FH-60XT-K3)	07-15-02
*29	1	Diaphragm Sub-Assembly (0-125 psi) consisting of: Diaphragm, Seat, Seat Nut, Plate	H-697
30	1	Restricting Plate (0-125 psi)	H-629
31	2	Pipe Plug (Not Shown)	1/4" N.P.T.
32	1	Gauge (Not Shown) 0-30 psi 0-60 psi 0-160 psi	07-16-02 07-16-03 07-16-05

*Recommended Spare Parts

CONOFLOW CORPORATION • BLACKWOOD, NEW JERSEY 08012

Fig 2-B

Page 2

Printed in U.S.A.

AEROLAB	INSTRUCTIONS ON AEROLAB SMOKE GENERATOR FOR MEMORIAL UNIVERSITY OF NEWFOUNDLAND page 2

The most important operational requirement is to make certain that liquid is flowing into the tube before the electricity is turned on and that the electricity is turned off before the liquid.

There are a variety of settings of pressure and voltage setting which will produce satisfactory results and some experimentation is suggested. However, it may be helpful to offer some suggestions as follows:

> Fill the tank to within about 1 inch of the top and adjust the regulator to about 40 psi. Turn the liquid control valve until the liquid comes out the probe in a fast drip (just short of a continuous stream)and turn the electrical knob to the #1 position. Then, if more smoke is desired, the liquid valve can be opened until liquid comes out with the smoke and the electrical knob turned to #2 position and the procedure repeated to setting #3.

An electrical setting of 4 is seldom, if ever, used.

The stainless capillary tube is encased in Ceramic beads with an outside aluminum tube for protection. Overheating of the capillary tube is indicated when the tube becomes red-hot. Immediate reduction of voltage setting or increase of liquid flow rate is required.

The smoke producing liquid supplied with the equipment is paraffin oil purchased from a local paint store. An alternate choice is 'Instant Fog Juice' which may be purchased from a theatrical supply house (at a higher price).

Aerolab in its own operating experience or in reports from its customers has not learned of any detrimental effects to humans resulting from breathing or exposure to paraffin vapor. However, we have not run tests and suggest that dense accumulations be avoided both for possible physiological or explosive hazards.

A 4-tube rake is supplied. This may be placed over the smoke-emitting tube to produce streamlines.

If it is desired to pipe the smoke through a flexible tube to some point on a model it will be found that simply connecting a teflon tube to the smoke producing outlet will not work. What is required is a simple ejector driven by auxiliary air which carries the smoke through the tube, as indicated by the sketch on Fig. 1.

Appendix D

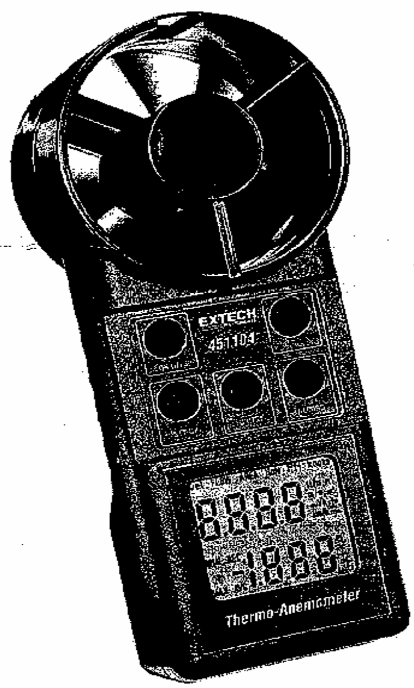
Vane anemometer's manual

User's Manual

EXTECH INSTRUMENTS

Vane Anemometer

MODEL 451104



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451104 3/00 Ver. 1.3

WARRANTY

EXTECH INSTRUMENTS CORPORATION warrants the basic instrument to be free of defects in parts and workmanship for one year from date of shipment (a six month limited warranty applies on sensors and cables). If it should become necessary to return the instrument for service during or beyond the warranty period, contact the Customer Service Department at (781) 890-7440 ext. 210 for authorization. **A Return Authorization (RA) number must be issued before any product is returned to Extech.** The sender is responsible for shipping charges, freight, insurance and proper packaging to prevent damage in transit. This warranty does not apply to defects resulting from action of the user such as misuse, improper wiring, operation outside of specification, improper maintenance or repair, or unauthorized modification. Extech specifically disclaims any implied warranties or merchantability or fitness for a specific purpose and will not be liable for any direct, indirect, incidental or consequential damages. Extech's total liability is limited to repair or replacement of the product. The warranty set forth above is inclusive and no other warranty, whether written or oral, is expressed or implied.

CALIBRATION AND REPAIR SERVICES

Extech offers complete repair and calibration services for all of the products we sell. For periodic calibration, NIST certification or repair of any Extech product, call customer service for details on services available. Extech recommends that calibration be performed on an annual basis to insure calibration integrity.

Tech Support Hotlines
781-890-7440 ext. 200
extech@extech.com

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Introduction

Congratulations on your purchase of Extech's Vane Anemometer, Model 451104. The Model 451104, measures the speed (velocity) at which air is flowing. It also measures temperature in both Centigrade and Fahrenheit degrees via a thermistor built into the air velocity sensor housing. The 451104 Anemometer monitors and displays in the following units: Feet per minute (ft/min), meters per second (m/s), kilometers per hour (km/hr), miles per hour (mph), and nautical miles per hour (knots). Vane Anemometers offer low price and easy visual inspection of the rotating sensor's movement which aids in air duct and fume hood applications. Here are a few of the applications for anemometers:

Specifications

General Specifications

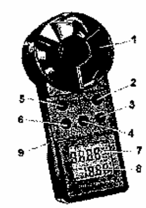
Display type and size	LCD display (9999 counts) 1-1/4 x 1-5/8in (37 x 42mm)
Operating Temperature	-10 °C to 50 °C (14 °F to 122 °F).
Operating Humidity	Max. 80% RH.
Meter Power	DC 9V; 100 hours continous battery life (with 20 min. auto-power OFF)
Weight	680g / 1.5 lb
Size	Instrument: 183 x 76 x 45 mm with cover
Sensor Diameter	3 in. (70mm)
Accessories	9V battery, hard carry case and instruction manual

Range, Resolution, and Accuracy Specifications

Range	Resolution	Accuracy (%FS)
80 - 5900 ft/min	1	+/-3%
0.4 - 30 m/sec	0.01	
0.9 - 68 mph	0.1	
0.8 - 58 knots		
1.4 - 108 km/hr		
-10 to 50°C	0.1°	+/-0.6°
14 to 122°F		+/-1°

Meter Description

1. Air velocity sensor and Temperature sensor
2. Data Hold key
3. Min/Max Record key
4. On/Off Reset key
5. Units select
6. Set-up key
7. LCD air velocity display
8. LCD temperature display
9. RS232 PC port



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Operating Instructions

Power Up

Press the ON/OFF key to power the meter. The LCD will illuminate all display indicators for approximately 2 seconds as it initializes. The meter will display "Vel" in the upper left hand corner of the LCD when it is ready for use.

Selecting Measurement Ranges

To select a measurement range after power-up, press the UNITS key. The meter powers up in ft/min mode. Press the UNITS key until the desired range appears on the LCD [mi/h (mph), knots (km/hr)].

Types of Measurements

1 **Standard Measurement Mode:** This is the default mode in which the meter powers up. Measurements will appear for air velocity and temperature on the LCD as they are measured. Other measuring modes are discussed next.

2 **"Continuous Running Average" Measurement Mode:** This Anemometer has the ability to record data for up to 2 hours while displaying the "running" average. Power the unit, place the vane sensor in front of the air source to be measured, press the RECORD key, and the meter will begin displaying the running average. Data is recorded once per second, and the user has up to 2 hours before the meter memory is full.

3 **" MIN/MAX/AVG" Measurement Mode**

To measure the minimum, maximum, and average readings in a given period of time perform the following steps:

1. Power the unit
2. Place sensor in front of air source
3. Press the RECORD key . The meter begins to take readings.
4. Press the HOLD button

BEFORE moving the sensor away from air source.

5. Press the RECORD key once to display the reading when HOLD was pressed.
6. Press RECORD again to display MIN reading
7. Press RECORD a third time to display the MAX reading.
8. Press RECORD a fourth time to display the AVG reading.
9. To clear all four of these stored readings, remove power from the meter or press and Hold RECORD until the meter beeps twice, then release the key.

AUTO-POWER OFF (SLEEP MODE)

1 This meter is equipped with an automatic shut-off function. After 20 minutes of non-use, the meter automatically shuts down after giving three warning beeps. Press the ON key while the warning beeps are sounding to provide another 20 minute window.
To avoid wasting batteries by leaving the meter unattended and powered up, this feature goes a long way in prolonging not only battery life, but meter life as well. However, In the event that you desire to defeat the Auto Power Off mode, follow these steps:

2 Disable Auto-Power OFF Function

1. Remove power from meter.
2. Press and hold the "ON" and "Hold" keys simultaneously.
3. Release the "ON" key while continuing to press the "Hold" key.
4. An "n" will appear on the LCD indicating "non-Sleep Mode".
5. Release the "Hold" key
6. The unit's Auto-Power OFF feature has been defeated meaning that it will not power down until the user powers down deliberately by pressing OFF button.
7. Auto Power OFF will be re-activated the next time the meter is powered.

CHANGING THE DEFAULT SETTINGS

It is possible to change the default air velocity and temperature display units and RS232 baud rate. The default air velocity units are ft/min and the default temperature units are degrees F. To change the default units to m/sec for air velocity and degrees C for temperature, perform the following steps:

1. From a power down condition, press and hold the "SET-UP" key.
2. Press and release the "ON" key and at the second beep release the "SET-UP" key .
3. The LCD will indicate wind speed units (ie."ft/min") in the upper right hand corner and temperatue units (ie. "°F") in the right lower corner.
4. Press the "Hold" key to set the air velocity units to m/sec (and temp to deg. C) or the "SET-UP" key to set the air velocity units to ft/min (and temp. to deg. F).
5. Press the "RECORD" key and an "S" will appear on the meter's LCD.
6. Press the "HOLD" key to save the setting.
7. "1200" or "2400" will appear on the LCD. This is the RS232 baud rate.
8. Press the "HOLD" key to set 1200 or the "SET-UP" key to set 2400.
9. Press the "RECORD" key and an "S" will appear on the meter's LCD.
10. Press the "HOLD" key to save the setting and return to the normal operating mode.