Model 8350
VELOCICALC
Air Velocity Meter

Operation and Service Manual

July 1989
P/N 1980014 Rev A

TSI Incorporated

Model 8350
VELOCICALC
Air Velocity Meter

Operation and Service Manual

July 1989
P/N 1980014 Rev A

TSI Incorporated
P.O. Box 64394
500 Cardigan Road
Saint Paul, MN 55164
USA

U.S.
Sales & Customer Service:
(800)777-8356 / (651)490-2711
Fax: (651)490-2874

INTERNATIONAL
Sales & Customer Service:
(1)651-490-2711
Fax: (1)651-490-2874

Address
TSI Incorporated/500 Cardigan Road/P.O. Box 64394/St. Paul, MN 55164/USA

Telex No.
6879024

Limitation of Warranty and Liability
TSI Incorporated (TSI) warrants that this product, under normal use and service as described in the Operation and Service manual, shall be free from defects in workmanship and material for a period of twelve (12) months from the date of shipment to the customer. This limited warranty is subject to the following exclusions:

1) Batteries are warranted for a period of 90 days from the date of shipment to the customer.
2) With respect to any repair services rendered, TSI warrants that the parts repaired or replaced will be in good working condition, under normal use, for a period of 90 days from the date of shipment to the customer.
3) The normal deterioration of replaceable or renewable parts, and replenishable supplies is not covered by this warranty.
4) Unless specifically authorized in a separate writing by TSI, TSI makes no warranty with respect to, and shall have no liability in connection with, any goods which are incorporated into other products or equipment by the Buyer.

The foregoing is IN LIEU OF all other warranties and is subject to the conditions and LIMITATIONS stated herein. **NO OTHER EXPRESS OR IMPLIED WARRANTY OF FITNESS FOR PARTICULAR PURPOSE OR MERCHANTABILITY IS MADE.**

THE EXCLUSIVE REMEDY OF THE USER OR PURCHASER, AND THE LIMIT OF THE LIABILITY OF TSI OR ANY OTHER SELLER FOR ANY AND ALL LOSSES, INJURIES, OR DAMAGE RESULTING FROM THE USE OF THIS PRODUCT (INCLUDING CLAIMS BASED ON CONTRACT, NEGLIGENCE, STRICT LIABILITY, OTHER TORT, OR OTHERWISE) SHALL BE THE RETURN OF THE PRODUCT AND THE REFUND OF THE PURCHASE PRICE, OR, AT THE OPTION OF TSI OR ANY OTHER SELLER, THE REPAIR OR REPLACEMENT OF THE PRODUCT. IN NO EVENT SHALL TSI OR ANY OTHER SELLER BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES.

The purchaser and all users are deemed to have accepted the terms of this LIMITATION OF WARRANTY AND LIABILITY, which contains the complete and exclusive limited warranty of TSI. This LIMITATION OF WARRANTY AND LIABILITY may not be amended or modified nor may any of its terms be waived except by a writing signed by an authorized representative of TSI.

Service Policy
Knowing that inoperative or defective instruments are as detrimental to TSI as they are to our customers, our service policy is designed to give prompt attention to any problems. If any malfunction is discovered, please contact your nearest sales office or representative, or call TSI's Customer Service department at (612) 483-4711.

Contents

About this manual 1

Introduction 3

Chapters

1 **Setup**
Unpacking 5
Parts identification 6
Preparing the instrument 6
Getting started 9

2 **Description of parts and functions**
Selecting the units of measure 13
The power switch: On/Off/Standby 14
Using the function keys 15
TIME CONSTANT key 16
STORE key 16
AVERAGE key 17
CLEAR key 17
VELOCITY key 17
TEMPERATURE key 17
Contrast control 18
Batteries 18
AC adapter 19
Velocity and temperature probe 19
RS-232C serial output 20
Interfacing the meter to a microcomputer 21

3 **Maintenance**
Probe tip 23
Cases 23
Storage 23
Recalibration 23
Calibration adjustment 24
Probe replacement 25

4 **Troubleshooting** 27

Appendices

A Theory of operation 29
B Standard velocity vs. actual velocity 31
C VELOCICALC serial interface connections 33
D Specifications 35

Tables

1 List of components 5
2 Metric vs. English display 13
3 Typical battery life 18
4 RS-232C output from the VELOCICALC 21
5 Troubleshooting the VELOCICALC 27

Illustrations

1 The VELOCICALC and accessories 5
2 Front of the VELOCICALC 6
3 Back of the VELOCICALC 6
4 Removing the battery access cover 7
5 Jumper in position J3 displays readings in English units 8
6 Jumper in position J5 displays readings in metric units 8
7 Using the VELOCICALC with the probe attached to the instrument 9
8 Using the VELOCICALC with the probe held in hand 10
9 The power switch and function keys 11
10 Moving the jumper 13
11 The power switch 14
12 The membrane keypad 15
13 Location of the AC adapter receptacle and the RS-232C connector 19
14 The orientation dot 20
15 The signal connections for the RS-232C connector 21
16 Potentiometer used for adjusting the calibration 24
17 The bridge circuit 29
18 25-pin, RS-232C serial interface connections 33
19 9-pin, RS-232C serial interface connections 33

About this manual

The MODEL 8350 *VELOCICALC Air Velocity Meter Operation and Service Manual* explains how to set up, operate, and maintain the VELOCICALC. Read it thoroughly before using the instrument.

- Chapter 1 lists the materials you received and briefly explains how to start using the VELOCICALC.
- Chapter 2 fully describes the functions of the VELOCICALC.
- Chapters 3 and 4 cover maintenance and troubleshooting procedures.

The appendices provide technical information about the VELOCICALC and its use. Appendix A describes the theory of operation. Appendix B explains the difference between standard air velocity and actual air velocity. Appendix C explains the signal connections for the VELOCICALC's serial interface. Appendix D lists the performance specifications of the instrument.

Formatting and Typography

Note that step-by-step instructions are numbered in boldface type: **1, 2, 3,** etc., set flush-left against the margin.

References to the front panel keys on the VELOCICALC, along with the instrument's displayed readout, are represented in this manual by the typeface called Helvetica Narrow. In addition to the different typeface, displayed messages appear in quotes.

When reference is made to other sections of the manual, the section title is italicized.

> Example: If you press the AVERAGE key before storing any values, the display reads "NO DATA" (from *AVERAGE key* in Ch. 2).

To call your attention to an important note or comment, a black, four-pointed star ✦ is used.

HELP!

If you need technical assistance with this instrument or if you have questions about the manual, please call TSI's Industrial Test Instruments Group at 612/490-2888. If your meter needs repair or recalibration, contact TSI's Customer Service department at 612/483-4711. ■

Introduction

The TSI MODEL 8350 VELOCICALC Air Velocity Meter is a hand-held, battery-operated meter that measures both air velocity and air temperature. The measurement technique used is constant-temperature hot-wire anemometry in which the sensor is held at a constant temperature by a control circuit. As the speed of the air flowing past the sensor increases, more electrical power is required to maintain the sensor's temperature. Thus, the power supplied to the sensor is directly related to the air velocity.

VELOCICALCs are temperature-compensated. This means that the effects of ambient temperature variations are automatically accounted for. See the appendices for more detail.

The calibration of the VELOCICALC is laser-verified. This means that the wind tunnels used to calibrate the instruments are verified using laser Doppler velocimetry to ensure the highest possible accuracy over the entire range of 30 to 9999 feet per minute. A certificate of traceability to the U.S. National Bureau of Standards is included with each instrument.

The VELOCICALC has been designed with many useful features, including a wide velocity range, high accuracy, calculated averages, RS-232C output and a variable time constant. This manual describes them all in full detail. ■

Chapter 1

Setup

This chapter guides you through unpacking, setting up, and getting started using your VELOCICALC. See chapter 2 for a detailed description of all operating functions.

Unpacking

Carefully unpack the instrument and accessories from the shipping container. Refer to figure 1 to identify the individual parts. Check them against the list of components in table 1; if any are missing or damaged, notify TSI immediately.

TABLE 1. List of components

Qty	Item	Part No.
1	VELOCICALC Model 8350	1080545
1	Carrying case	1319026
4	AA Alkaline batteries	1208013
1	AC Adapter	2613033 (115 VAC) or 2613037 (220 VAC)
1	Operation and Service Manual	1980014

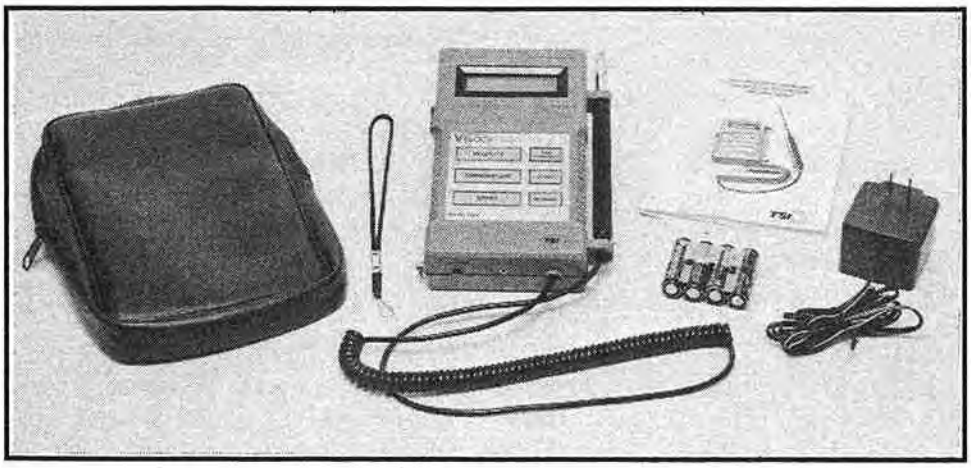

Figure 1. The VELOCICALC and accessories

Included with every manual is a registration card; look for yours at the front of this manual. Please fill it out and mail it promptly; it allows TSI to inform you of product updates.

Parts identification

Figures 2 and 3 identify the main parts of the VELOCICALC. Become familiar with them before proceeding with the setup.

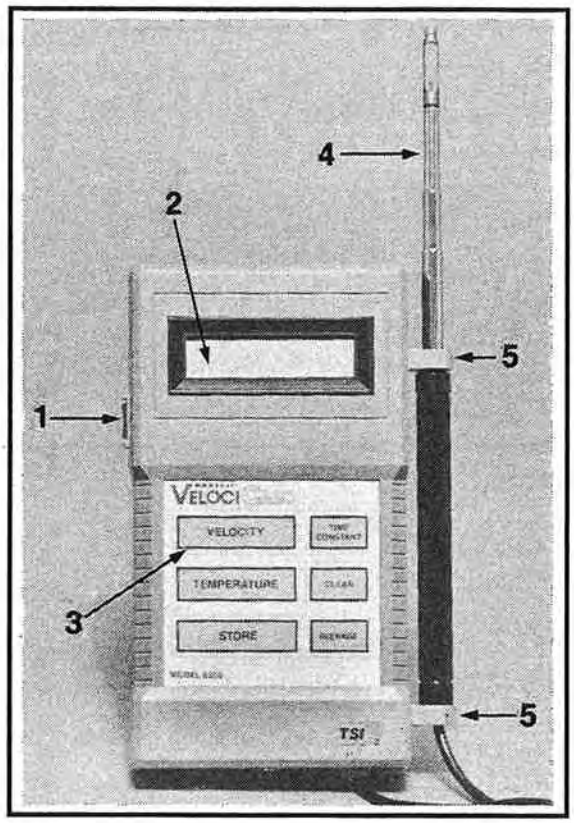

Figure 2. Front of the VELOCICALC

1. On/Off switch
2. Display
3. Function keys
4. Telescoping probe
5. Probe mounting brackets

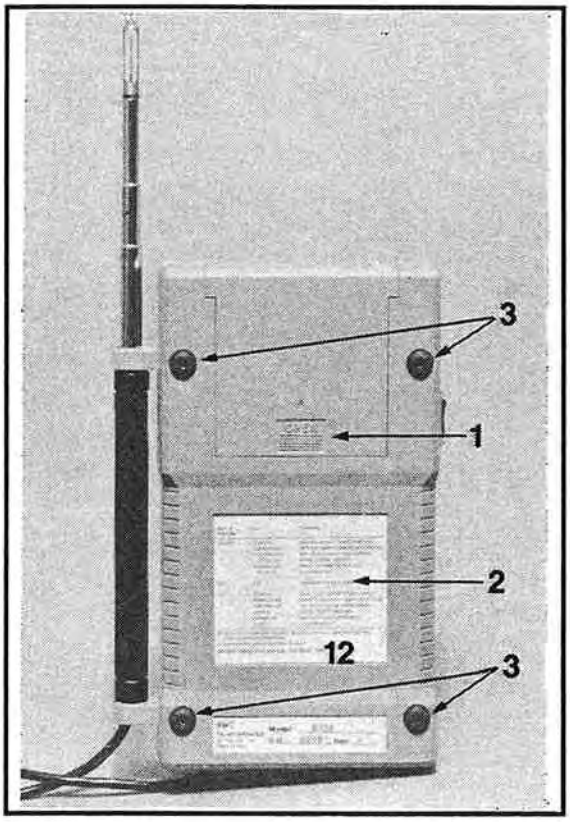

Figure 3. Back of the VELOCICALC

1. Battery access cover
2. Operating instructions
3. Rubber feet

Preparing the instrument

This section briefly explains how to install batteries into the VELOCICALC and how to get started taking air velocity and temperature measurements.

Installing the batteries

Before you operate the instrument, follow these three steps to install the batteries:

1 Slide out the battery access cover as shown in figure 4; where the cover is marked "OPEN" press down and forward to disengage the retaining clip.

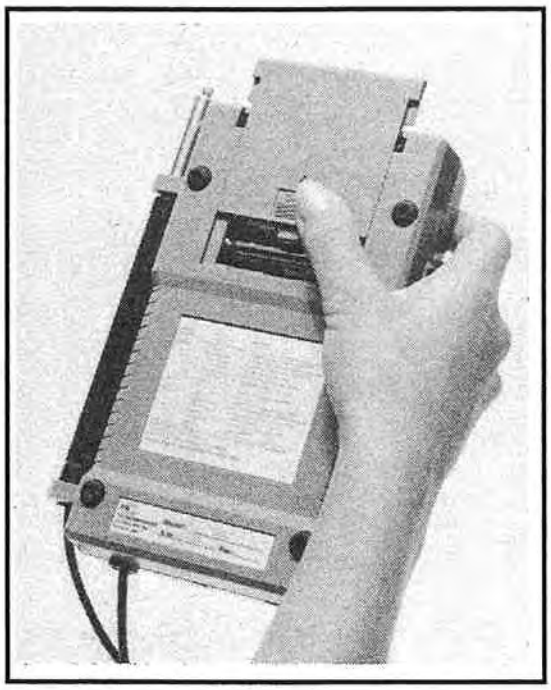

Figure 4. Removing the battery access cover

2 Install the four AA alkaline batteries provided with the instrument. Be sure to match the polarities marked on the battery holder.

3 Replace the battery access cover.

Selecting the units of measure

As shipped from the factory, the VELOCICALC displays velocity readings in units of feet per minute (FPM) and temperature readings in degrees Fahrenheit (°F). But the VELOCICALC can also display readings in units of meters per second (m/s) and degrees Centigrade (°C). To change units on the display, follow these four steps:

1 With the unit switched off, open the instrument case by removing the four Phillips-head screws inside the rubber feet on the back cover.

2 Locate the movable jumper just below the battery case as shown in figure 5. (The instrument is shipped with the jumper in position J3.)

3 Using a needle-nose pliers, move the jumper from position J3 to J5.

4 Replace the cover and reinstall the four screws and rubber feet.

The VELOCICALC now displays values in m/s and °C.

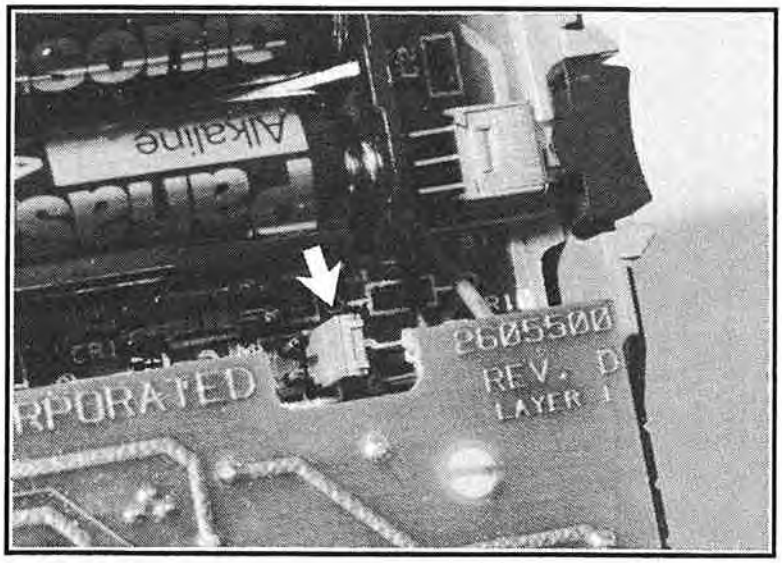

Figure 5. Jumper in position J3 (as shipped from the factory) displays readings in English units

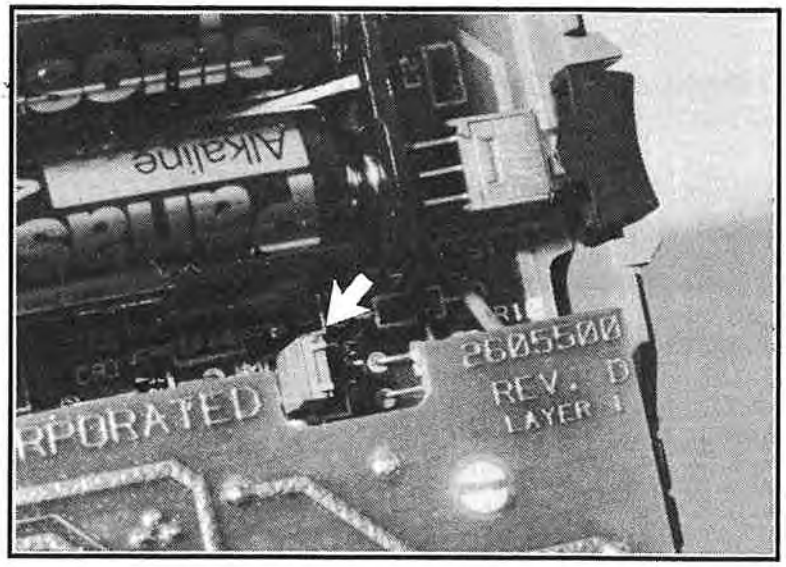

Figure 6. Jumper in position J5 displays readings in metric units

Getting started

Now that you have installed the batteries and selected the measurement units, the VELOCICALC is ready to use.

Preparing to make a measurement

The telescoping probe, mounted on the side of the VELOCICALC, contains the velocity and temperature sensors; it is shipped fully retracted to protect the sensors. You can use the probe either mounted on the VELOCICALC (fig. 7) or held in your hand (fig. 8). However, in either case, you must first extend the probe to expose the sensor in order to make measurements.

Figure 7. Using the VELOCICALC with the probe attached to the instrument

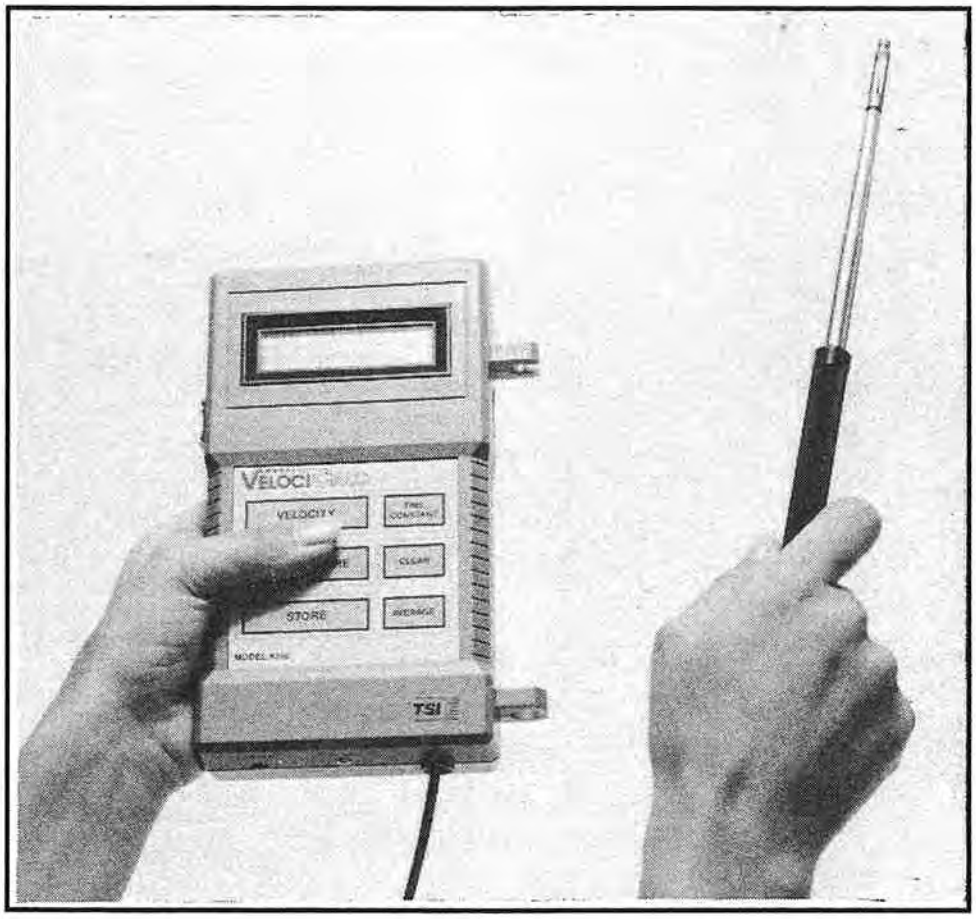

Figure 8. Using the VELOCICALC with the probe held in hand

To remove the probe from its mounting brackets, first pull the top of the probe out of the upper mounting bracket, away from the body of the instrument; then lift the probe out of the lower bracket.

To extend the probe, hold its handle in one hand and pull on the knurled tip with the other hand. Do not hold the cable while extending or retracting the probe; this prevents the probe from moving.

Switching on the power

Set the power switch to the ON position (see figure 9). Since the VELOCICALC automatically starts up in the velocity mode, the word "VELOCITY" immediately appears on the display. Within seconds, the instrument displays velocity measurements in units of FPM or m/s, depending on the position of the units jumper.

Locate the sensor where you want to measure velocity. Make sure the sensor window is fully exposed and that the red orientation mark at the tip of the probe is directed *toward* the flow. The VELOCICALC is now ready to measure velocity.

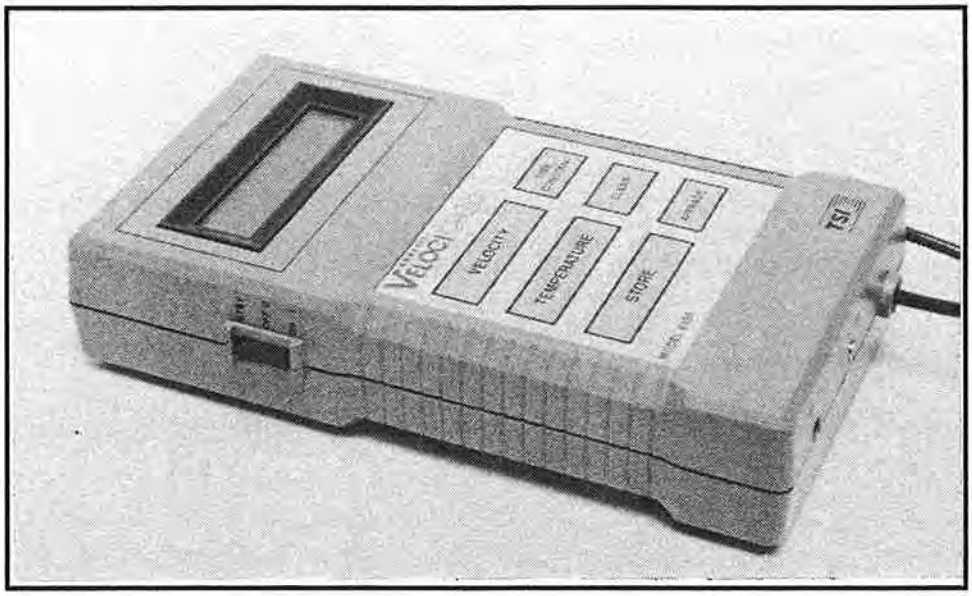

Figure 9. The VELOCICALC power switch and function keys

Selecting the time constant

The normal time-constant value is 1 second; this value works well when measuring velocities in steady air flows. However, longer time constants of 2, 5, 10, 15 and 20 seconds are available to provide a steady, time-averaged display, even in situations where the flow is unsteady. If a longer time constant is required to smooth out velocity fluctuations, press and hold the TIME CONSTANT key until the desired value appears on the display. Release the key to select the displayed value.

You can check the current time constant without changing it. Simply press the TIME CONSTANT key and release it as soon as a value appears. The first value displayed is always the current time constant.

Storing and averaging

To compute the average of a number of readings, use the STORE and AVERAGE keys. When the instrument displays a reading you want to include in the average, press and hold the STORE key until the display reads "STORE". A number (from 1 to 255) accompanies the "STORE" message to indicate how many readings are currently in memory. When you want to display the average of these values, press the AVERAGE key. The message "AVG" appears first, along with a number (between 1 and 255) to indicate how many values you have accumulated for averaging. The average value is then displayed for 1 second. To keep the value on the display, hold down the key.

You can store additional readings even after an average has been displayed: just press the STORE key when the instrument displays a reading you want to include. The additional values are then averaged with those already

accumulated. If you want to average a completely new set of readings, first press the CLEAR key and then start the storage process once again.

Measuring temperature

To measure temperature, press and hold the TEMPERATURE key until the display reads "TEMP". The VELOCICALC is now ready to measure temperature. The display reads either XXX.X °F or XX.X °C.

After switching to the temperature measurement mode, allow about 45 seconds for the temperature reading to stabilize .

To store and average a set of temperature values, follow the procedure given above for averaging velocity values.

✦ Temperature readings are accumulated separately from velocity readings. You can switch back and forth between velocity and temperature modes without losing any readings. ■

Chapter 2

Description of parts and functions

While chapter 1 gave you an overview of the instrument and its operation, this chapter thoroughly describes the various parts and functions of the VELOCICALC.

Selecting the units of measure

You can select English or metric display units by moving an internal jumper. (Be sure to switch off the VELOCICALC before moving the jumper.) Figure 10 shows the jumper being moved. Metric units are displayed when the jumper is in the J5 position and English units are displayed when the jumper is in the J3 position. Table 2 gives the format of the display for the two measurement modes.

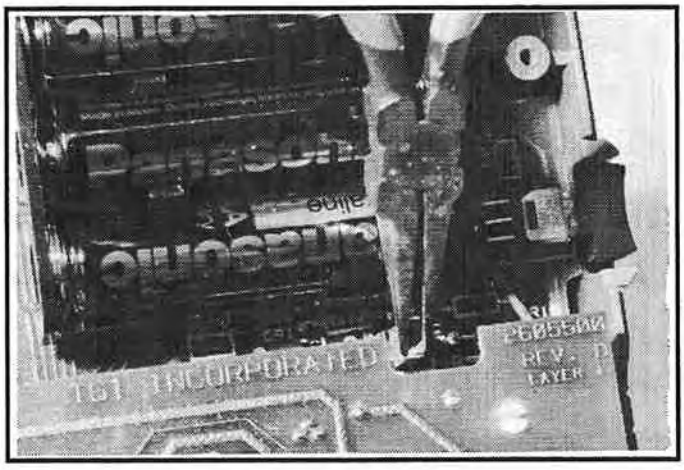

Figure 10. Moving the jumper

TABLE 2. Metric vs. English display

	ENGLISH	METRIC
VELOCITY	XXXX FPM	XX.XX m/s
TEMPERATURE	XXX.X °F	XX.X °C

The power switch: ON/OFF/STANDBY

The power switch on the left side of the VELOCICALC has three positions and functions: ON, OFF, and STANDBY (indicated by the letters STBY, see figure 11).

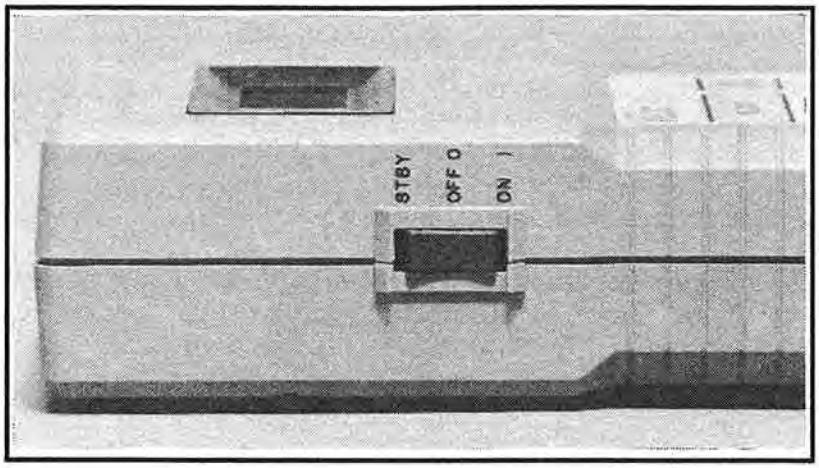

Figure 11. The power switch

Use the ON position to measure velocity or temperature continuously. (When you switch on the VELOCICALC, it starts up in the VELOCITY mode.) If you leave it in the ON position, the VELOCICALC operates until the battery voltage drops below 4.7 volts. The display then reads "LOW BATT" and you should install a set of fresh batteries. If the voltage falls below 4.6 volts the display goes blank.

In the OFF position, the microprocessor and associated electronics are without power; all stored values are lost.

The STANDBY mode conserves battery life. In this mode, velocity or temperature readings are displayed only when you press and hold the VELOCITY or TEMPERATURE key respectively. When you release the key, the VELOCICALC displays readings for 30 seconds, and then returns to "STANDBY". "STANDBY" means that the VELOCICALC has switched to its low-power mode: no power is drawn by the sensor and the instrument uses only enough power to run the microprocessor and retain stored data.

All functions work in the STANDBY mode (STORE, AVERAGE, CLEAR and TIME CONSTANT). However, they work only when temperature or velocity values are displayed. Stored values are retained until you clear them or switch off the VELOCICALC.

If you accidently switch on the VELOCICALC or leave it in the VELOCITY mode during storage, the instrument's Auto Idle feature will conserve battery life. When the VELOCICALC measures zero flow for 10 minutes in the continuous VELOCITY mode (ON), power is cut off from the sensor and the message "IDLE" is displayed. Typically, the Auto Idle feature is activated only when the probe is fully closed and not in use. To reactivate the instrument, either press the VELOCITY or TEMPERATURE key, or switch the unit off and then on again.

The Auto Idle feature does not work when the VELOCICALC is in the STANDBY mode.

Using the function keys

The VELOCICALC is easy to operate. To select a function, press and hold the desired key until the name of the selected function is displayed. For example, to store a displayed value for later averaging, press and hold the STORE key until the display momentarily indicates "STORE".

For the layout of the membrane keypad refer to figure 12.

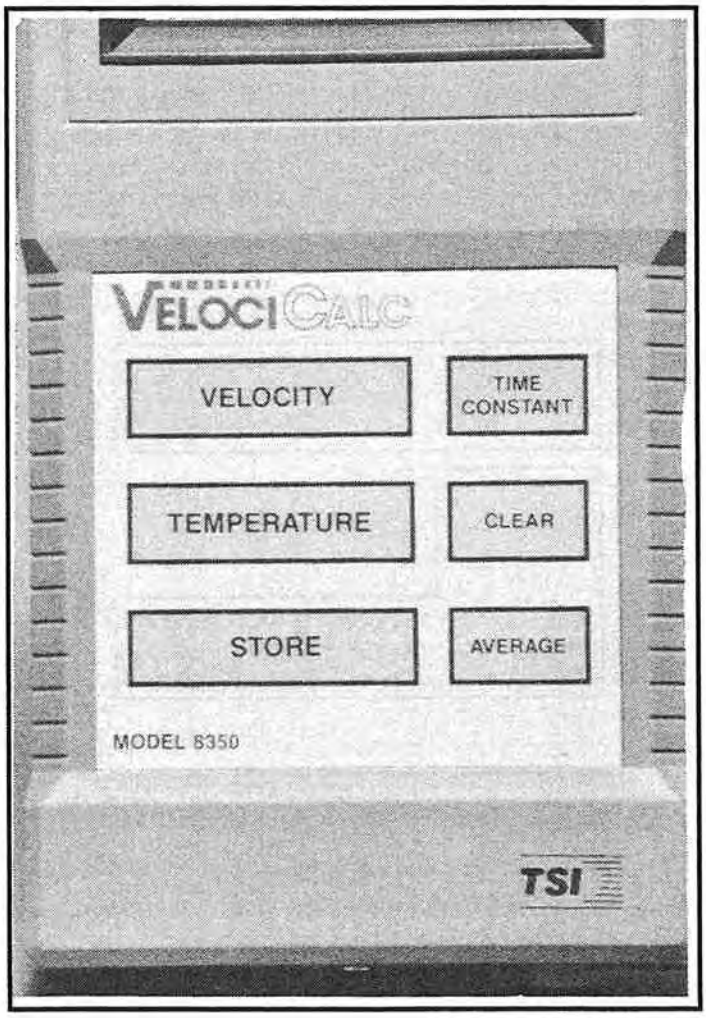

Figure 12. The VELOCICALC membrane keypad

✦ For ready reference, the back of the VELOCICALC offers brief instructions for operating the instrument.

TIME CONSTANT key

The VELOCICALC offers a variable time constant that allows you to obtain a steady velocity reading in a fluctuating flow. To select a time constant (1, 2, 5, 10, 15 or 20 seconds), simply press and hold the TIME CONSTANT key. From that point on, each velocity value that appears on the display is an average of velocities measured during the averaging time you selected: 1, 2, 5, 10, 15, or 20 seconds. One second is the default value when you switch the instrument to ON or STANDBY.

To check the current value of the time constant without changing it, press and hold the TIME CONSTANT key until the value appears on the display (for example, "TC=1"). To change this value, press and hold the TIME CONSTANT key until the desired value appears and then release the key. The new value is used until you select a different time constant or until you switch off the VELOCICALC.

When you select a time constant longer than 1 second, it is important to allow the new period of time to elapse before using a velocity reading. This time allows the values on the display to become a true average of velocities over the selected time period; displayed values are not valid averages until at least one time-constant period has elapsed.

Each time you change the time constant, its new value is transmitted via the RS-232C connector to any serial device you may have connected to the VELOCICALC. Refer to Table 4; it identifies the serial output from the VELOCICALC.

STORE key

The STORE key performs three functions.

First, it accumulates multiple velocity and temperature readings for averaging. This is useful, for example, in determining the average velocity in a duct or in calculating the average face velocity in a fumehood. To accumulate readings for an average, place the probe where you want to make your first measurement. Once a value is displayed, then press the STORE key. Reposition the probe and repeat. Up to 255 values can be stored in both the velocity and temperature modes. If you try to store more than 255 readings, the message "ERROR" appears on the display and the VELOCICALC will not accept additional readings.

- ✦ When you press the STORE key, the message "STORE" is displayed with a number (from 1 to 255) that indicates how many readings are accumulated in memory. The value being stored is then displayed for 1 second or until you release the key. To avoid storing the same reading twice, wait at least 2 seconds before pressing STORE again.

Second, since the display holds the reading as long as you depress the STORE key, you can also use the STORE key to maintain a value on the display.

Third, the STORE key automatically transmits the value on the display through the RS-232C interface if you have a serial device connected to the VELOCICALC (see *RS-232C serial output* later in this chapter). The value transmitted is also stored for averaging.

AVERAGE key

Press the AVERAGE key to display the average of the readings stored via the VELOCITY or TEMPERATURE function. Before the average is displayed, the message "AVG" appears with a number (from 1 to 255) that indicates how many values you have accumulated for averaging.

- ✦ Displaying an average does not affect the storage register. Additional values (up to 255 in both the temperature and velocity modes) can be stored for further averaging.

Pressing the AVERAGE key also holds the average reading on the display until you release the key.

If you press the AVERAGE key before storing any values, the display reads "NO DATA". You must store at least one value to enable the AVERAGE function.

With a serial device connected to the VELOCICALC, the average is transmitted through the RS-232C interface whenever you press the AVERAGE key (see *RS-232C serial output* later in this chapter).

CLEAR key

Press the CLEAR key to erase the values in the storage register (either velocity or temperature values). For example, to erase the stored values in the VELOCITY register, set the VELOCICALC to the VELOCITY mode and press CLEAR.

Each time you press the CLEAR key, the message "CLEAR VEL" or "CLEAR TEMP" is transmitted through the RS-232C interface. For example, when a printer is connected and you press the CLEAR key, the message "CLEAR VEL" or "CLEAR TEMP" is printed to indicate which storage register has been cleared.

VELOCITY key

When you are in the TEMPERATURE mode, press the VELOCITY key to switch the VELOCICALC from TEMPERATURE to VELOCITY.

In the STANDBY mode, press the VELOCITY key to initiate velocity readings or to switch from TEMPERATURE to VELOCITY. Velocity readings will continue to be displayed for 30 seconds after you release the key.

In the IDLE mode, press the VELOCITY key to re-activate the VELOCICALC and begin taking velocity readings.

TEMPERATURE key

When in the VELOCITY mode, press the TEMPERATURE key to switch the VELOCICALC from VELOCITY to TEMPERATURE.

In the STANDBY mode, press the TEMPERATURE key to initiate temperature readings or to switch from VELOCITY to TEMPERATURE. Temperature readings will continue to be displayed for 30 seconds after you release the key.

In the IDLE mode, press the TEMPERATURE key to re-activate the VELOCICALC and begin taking temperature readings.

Contrast control

You can adjust the contrast of the instrument's LCD display to improve its readability when viewed at an angle. The contrast control is on the right-hand side of the VELOCICALC opposite the power switch. To access the contrast control, you must first remove the probe from the mounting brackets. As you adjust the contrast, be sure to hold the unit at the same angle you intend to use it.

Batteries

The VELOCICALC is powered by four AA-size batteries. TSI ships the instrument with alkaline batteries, but nickel-cadmium rechargeable batteries may be used. Keep in mind that battery life is a function of the velocity being measured: the higher the velocity, the shorter the life. Table 3 shows typical battery life for both alkaline and nickel-cadmium batteries at three velocities.

TABLE 3. Typical battery life* at three velocities

AIR VELOCITY (FPM)	(m/s)	ALKALINE LIFE (hrs)	NICKEL CADMIUM LIFE (hrs)
100	0.5	7.0	5.0
1000	5	4.4	3.5
9000	45	2.4	2.4

* at 20°C

The VELOCICALC continuously monitors its battery supply voltage. When the voltage falls below 4.8 volts DC, the measurement units on the display ("FPM", "m/s", "°F", or "°C") blinks on and off. This indicates a low battery condition and means you should install fresh batteries.

✦ Once the blinking begins, you still have a few minutes to complete the measurement you are making. While the units are blinking, all functions (STORE, AVERAGE, CLEAR and TIME CONSTANT) operate normally.

When the battery voltage falls below 4.7 volts DC, the message "LOW BATT" is displayed. None of the functions operates and all accumulated readings and averages are lost.

If you do not install fresh batteries and the voltage falls below 4.6 volts, the display goes blank.

AC Adapter

The AC adapter supplied with the VELOCICALC allows you to power the instrument directly from an AC wall outlet. Since power from the AC adapter bypasses the batteries, it does not matter what type of batteries are installed or whether batteries are installed at all. The AC adapter provides 6 volts DC at 300 milliamperes to the instrument. The polarity of its connector is negative (–) on the outer contact and positive (+) on the inner contact. Figure 13 shows the location of the AC adapter receptacle on the VELOCICALC.

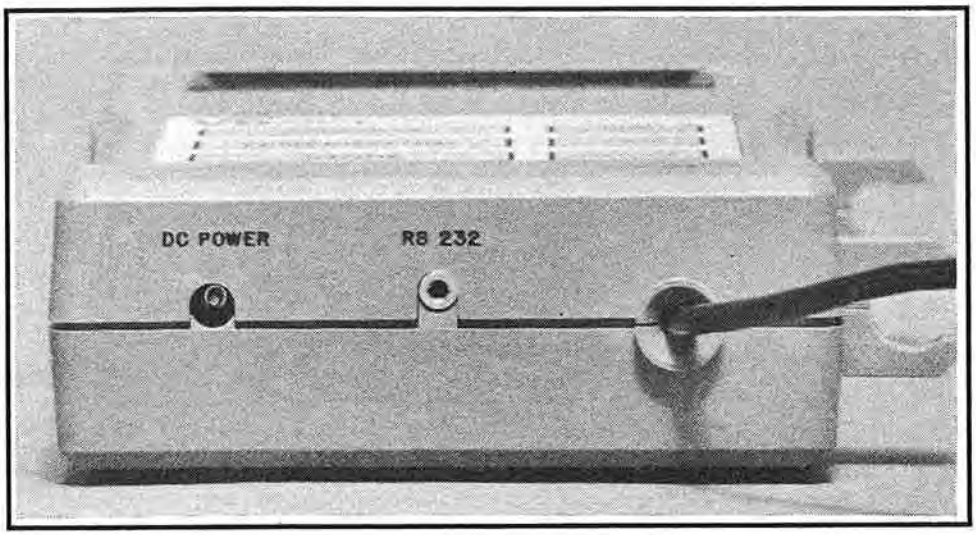

Figure 13. Location of the AC adapter receptacle and the RS-232C output connector

✦ The AC adapter supplied with the VELOCICALC is not a battery charger; its power bypasses the batteries. You can use the AC adapter while nickel-cadmium batteries are installed, but they will not be recharged. You must recharge nickel-cadmium batteries externally.

Velocity and temperature probe

The probe supplied with the VELOCICALC is used for both velocity and temperature readings. You can make measurements with the probe either mounted on the VELOCICALC or held in your hand. Note that when the probe is mounted on the VELOCICALC, an alignment key on the bottom of the probe handle prevents the probe from rotating.

To remove the probe from its mounting brackets, first pull the top of the probe out of the upper mounting bracket, away from the body of the instrument; then lift the probe out of the lower bracket. To replace the probe, reverse the procedure.

✦ Since the bottom of the probe handle is keyed, it fits in the lower mounting bracket only one way. Be sure the key at the base of the probe handle faces away from the case.

To extend the telescoping probe, hold the probe handle in one hand and pull on the knurled tip of the probe with the other hand. Do not hold the cable while extending or retracting the probe – this prevents the probe from moving. When fully extended, the probe measures 21 inches from the cable-end of the handle to the end of the knurled tip.

When using the probe, make sure the sensor window is fully exposed and the red orientation dot is directed toward the flow. Figure 14 shows the location of the dot at the tip of the probe.

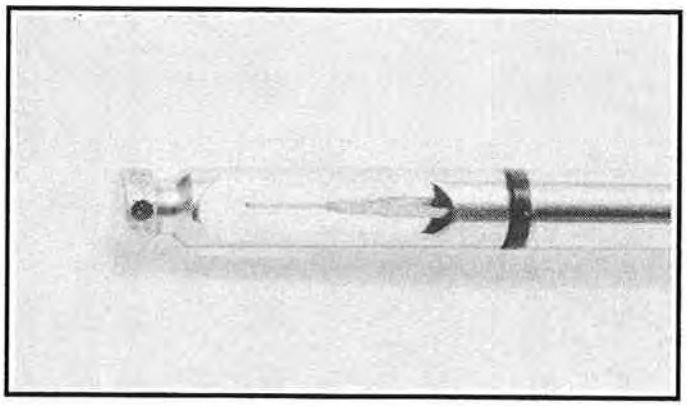

Figure 14. Keep the orientation dot toward the flow when making measurements

To retract the probe, point the tip of the probe up and let the cable hang down freely. As you press down on the knurled tip to collapse the probe, the cable will slide out of the handle on its own.

As you handle the probe, take care not to bump it against duct walls or other objects. The probe has been made as rugged as possible, but it can be damaged by careless handling.

RS-232C serial output

The serial output port on the VELOCICALC is used to interface to a printer, computer, digital data logger, or other serial device (see figure 13). For a listing of the serial communications parameters, refer to Appendix C, *VELOCICALC serial interface connections*, and Appendix D, *Specifications*.

The connector required for the RS-232C port on the VELOCICALC is a standard 2.5-millimeter-diameter mono audio plug. Figure 15 shows the plug's signal connections.

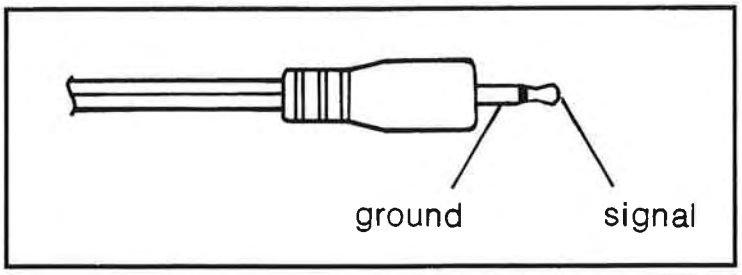

Figure 15. The signal connections for the RS-232C connector

The serial output from the VELOCICALC is transmitted in ASCII format. Table 4 lists the output generated for each function and the corresponding display on the instrument.

TABLE 4. RS-232C output from the VELOCICALC

MODE	KEY PRESSED	DISPLAY	SERIAL OUTPUT	
VELOCITY	CLEAR	CLEAR	CLEAR VEL	
	STORE	XXXX FPM	STORE(XXX)	XXXX FPM
		XX.XXm/s	STORE(XXX)	XX.XXm/s
	AVERAGE	XXXX FPM	AVG(XXX)	XXXX FPM
		XX.XXm/s	AVG(XXX)	XX.XXm/s
	TIME CONSTANT	TC=XX	TC=XX SECONDS	
TEMPERATURE	CLEAR	CLEAR	CLEAR TEMP	
	STORE	XXX.X °F	STORE(XXX)	XXX.X DegF
		XX.X °C	STORE(XXX)	XX.X DegC
	AVERAGE	XXX.X °F	AVG(XXX)	XXX.X DegF
		XX.X °C	AVG(XXX)	XX.X DegC

Interfacing the meter to a microcomputer

To connect the VELOCICALC to an IBM or IBM-compatible microcomputer (equipped with an RS-232C interface port), use the model 8917 interface cable. However, the microcomputer cannot read the VELOCICALC serial interface unless the computer's RS-232C port is properly initialized.

You can initialize the computer's RS-232C port in two ways; both require an interface cable (model 8917 or equivalent as described in Appendix C). One method is accomplished with a BASIC language computer program and the OPEN command. Before VELOCICALC communications begin, execute the following BASIC statement:

```
OPEN "COM1:1200,N,8,1" AS #1
```

The other method uses the DOS MODE command. Before VELOCICALC communications begin, execute the following DOS command:

```
MODE COM1:1200,N,8,1
```

The following sample BASIC program reads the VELOCICALC output and displays it on the computer screen:

```
10    '*** PROGRAM TO READ AND DISPLAY VELOCICALC OUTPUT ***
20    '
30    CLS                                   'CLEAR SCREEN
40    OUT 1021,96                           'CLEAR STATUS PORT
50    OPEN "COM1:1200,N,8,1" AS #1          'OPEN COMMUNICATIONS
60    INPUT #1,A$                           'INPUT DATA IN STRING
                                             FORMAT
70    PRINT A$                              'PRINT RESULTS
80    GOTO 60                               'LOOP BACK FOR MORE DATA
```

If you plan to write your own programs to communicate with the VELOCICALC, keep in mind that no handshaking takes place between the microcomputer and the instrument. This means that the VELOCICALC transmits data whenever an appropriate key is pressed, regardless of the microcomputer's readiness to receive data. To make certain no data is lost, be sure that the program is *receiving* when the VELOCICALC is *transmitting*. This is fairly easy to do since the instrument transmits only when certain keys are pressed. ■

Chapter 3

Maintenance

The VELOCICALC requires very little maintenance to keep it performing well.

Probe tip

Periodically inspect the probe tip to ensure that it is clean. Dust and oil deposits on the tip and sensor decrease the accuracy of the VELOCICALC.

✦ Caution: The VELOCICALC must be switched off for cleaning. Do not use high-pressure air, strong solvents, or brushes to clean the sensor tip; damage to the sensors could result.

To remove dust, blow it off with a gentle stream of air or rinse it off with a gentle stream of water. To remove a combination of dust and oil, rinse the probe tip in isopropyl alcohol and then blow it off with a gentle stream of air. Never use heat to dry the probe.

Cases

If the instrument case or storage case needs cleaning, wipe it off with a soft cloth and isopropyl alcohol or a mild detergent.

Never submerse the VELOCICALC.

Storage

When storing the VELOCICALC for more than a month, it is recommended that you remove the batteries to prevent damage due to leaking.

Recalibration

To maintain a high degree of accuracy in your velocity and temperature measurements, TSI recommends that you return your instrument to the factory for annual recalibration. For a nominal fee, we will recalibrate the unit and return it to you with a certificate of calibration and NBS traceability. Our standard policy is to complete repairs and recalibrations within five business days. This 'annual checkup' assures you of consistently accurate readings; it is especially important in applications where strict calibration records must be maintained.

Calibration adjustment

The calibration of the VELOCICALC can be adjusted. This capability is helpful to users who can establish known velocities to verify calibration accuracy.

To adjust the VELOCICALC's velocity calibration, follow these six steps:

1 Align the probe in an airflow of known standard velocity (see Appendix B *Standard velocity vs. actual velocity*). Choose a velocity that is in the middle range of your normal velocity measurements.

2 With the unit switched off, open the instrument case by removing the four Phillips-head screws inside the rubber feet on the back cover.

3 Find potentiometer RA3 on the printed circuit board. It is located near where the probe cable enters the case (see figure 16).

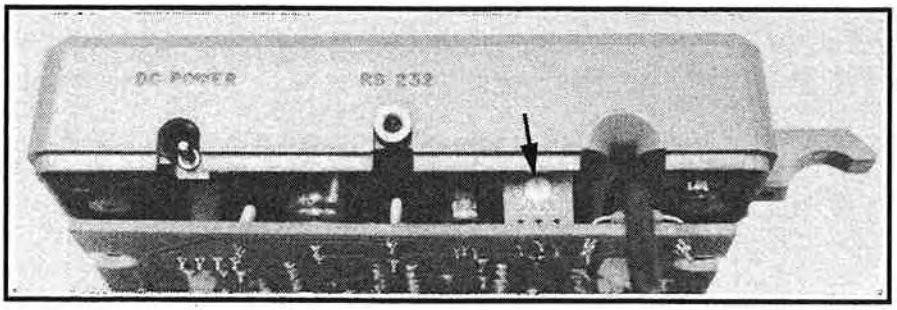

Figure 16. Potentiometer used for adjusting the calibration

4 Switch on the instrument.

Caution:	To prevent electronic damage to the instrument, avoid contact with any of the exposed solder joints and components on the printed circuit boards.

5 Allow a few seconds for the velocity reading to stabilize and then note the velocity indicated on the display. If that velocity differs from the established velocity, adjust the potentiometer (RA3). Turn the potentiometer clockwise to increase the indicated velocity, counter-clockwise to decrease it. The adjustment range is typically ±8 percent of velocity.

6 Switch off the VELOCICALC. Replace the cover and reinstall the four screws and rubber feet.

✦ An adjustment of the calibration will have a nearly equal percent-of-velocity effect over the entire range of the instrument. For example, a 5 percent of velocity adjustment made at 500 FPM will result in approximately a 5 percent of velocity change in the same direction at 100 FPM, 2000 FPM, 9000 FPM, etc.

Probe Replacement

If your probe is damaged, you can replace it with a new, pre-calibrated probe. To obtain a replacement probe kit, contact your local sales representative or contact TSI directly. ■

Chapter 4

Troubleshooting

Table 5 lists the symptoms, possible causes, and recommended solutions for common problems encountered with the VELOCICALC. If your symptom is not listed, or if none of the solutions solves your problem, please contact TSI.

TABLE 5. Troubleshooting the VELOCICALC

Symptom	Possible Causes	Corrective Action
No display	Unit not switched on.	Switch on the unit.
	Low or dead batteries.	Replace the batteries or plug in the AC adapter.
	Dirty battery contacts.	Clean the battery contacts.
Display is blinking	Batteries are low.	Replace or recharge batteries.
Display reads "IDLE"	The Auto Idle feature has been activated.	Press the VELOCITY or TEMPERATURE key.
Display reads "LOW BATT"	Low or dead batteries.	Replace the batteries.
	Wrong AC adapter.	Replace with the correct AC adapter.
	Low AC line voltage.	Correct the AC line voltage or use batteries.
	Dirty battery contacts.	Clean the battery contacts.
Temperature reads high when first read	Temperature sensor is still warm from velocity mode.	Allow about 45 seconds before reading temperature.

Display reads "ERROR"	You are trying to enter more than 255 readings.	Read or record the average; clear the storage register and proceed.
Wrong function displayed	Two keys have been pressed at the same time.	Press only one key at a time.
Velocity reading fluctuates badly	The flow is fluctuating.	Reposition the probe in a less turbulent section of the flow or use a longer time constant.
Velocity reading displays "OVER FPM" or "OVER m/s"	The velocity is over 9999 FPM or 50 m/s.	Use an alternate method to measure the velocity.
Temperature reading displays "OVER °F" or "OVER °C"	Temperature is above 200°F or 93.3°C.	*Remove the probe immediately: excessive heat can damage the sensor.* Use an alternate method to measure the temperature.
Temperature reading displays "UNDER °F" or "UNDER °C"	Temperature is below 0°F or –17.8°C.	Use an alternate method to measure the temperature.

Appendix A
Theory of Operation

The Model 8350 VELOCICALC Air Velocity Meter is a constant-temperature thermal anemometer. It uses two sensors: an air velocity sensor and a temperature compensation sensor. The velocity sensor is heated to an elevated temperature (relative to the surrounding air) by means of the control electronics. The temperature compensation sensor senses the ambient air temperature and forces the velocity sensor to stay at a constant "overheat" above the ambient.

The sensors form two legs of a Wheatstone bridge (figure 17). The bridge circuit forces the voltage at points A and B to be equal by means of the operational amplifier. Air flowing past the velocity sensor tends to cool the sensor, thus driving down its resistance. The operational amplifier responds by immediately delivering more power to the top of the bridge to maintain voltage equality at points A and B. As more air flows past the sensor, more power is required to maintain a balanced bridge. Thus, the power going into the top of the bridge is related to the velocity of the air flowing past the sensor. This is the principal of operation of all constant-temperature thermal anemometers.

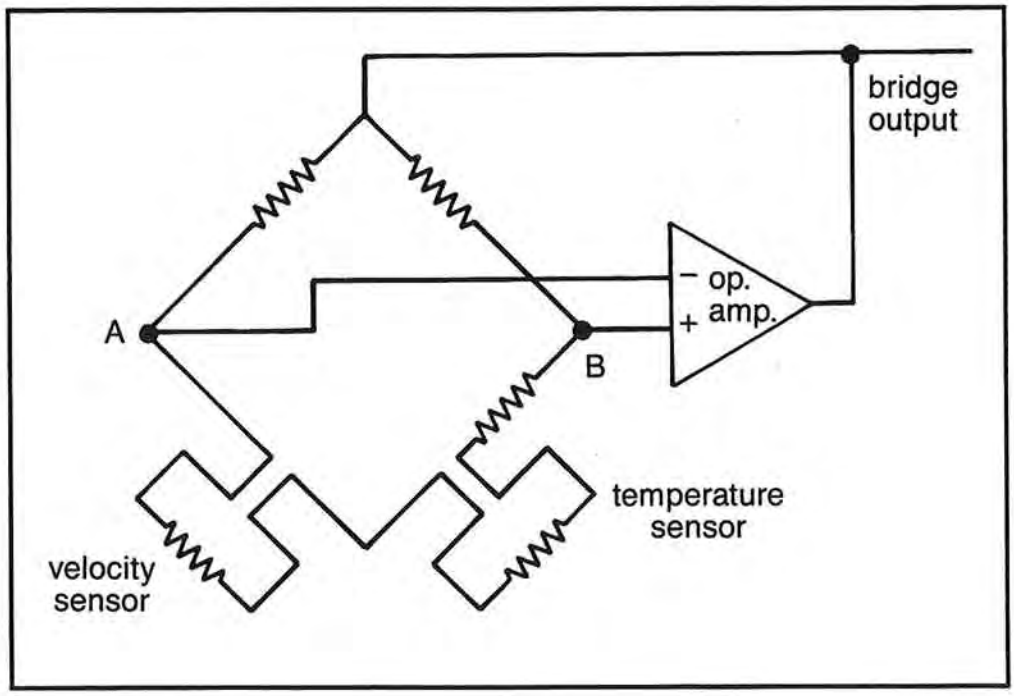

Figure 17. The bridge circuit

When measuring temperature, the temperature-sensitive element is used as a resistance thermometer. The velocity sensor is not heated in this mode.

The VELOCICALC automatically compensates for any density changes caused by temperature and pressure variations. All velocity measurements are given in standard feet per minute (or standard meters per second). TSI defines standard conditions as 70°F (21.1°C) and 14.7 psia* (101.4 kPa+).

* psia = pounds per square inch, absolute
+ kPa = kiloPascals

Appendix B
Standard Velocity vs. Actual Velocity

Since thermal sensors are sensitive to changes in air density and air velocity, all thermal anemometers indicate velocities with reference to a set of standard conditions. For TSI instruments, standard conditions are defined as 70° F (21.1° C) and 14.7 psia (101.4 kPa). Other manufacturers may use different values.

Standard velocity is the velocity the air would be moving if the temperature and pressure were at standard conditions. It is usually the most useful measure of airflow because it defines the heat-carrying capacity of the air.

Actual velocity is the velocity at which a microscopic particle of dust would be traveling if it were in the airstream.

Because actual air density is rarely equal to air density at standard conditions, actual velocity usually differs from standard velocity.

In some instances, actual air velocity rather than standard velocity may be of interest. To obtain the value for actual velocity, multiply your standard velocity readings (as indicated by the VELOCICALC) by the following density correction factor:

$$\text{Actual velocity} = (\text{standard velocity}) \times \frac{(460 + T)}{(460 + 70)} \times \frac{14.7}{P}$$

Where

T = Ambient temperature in degrees Fahrenheit

P = Ambient pressure in psia

If you use metric units, the equation becomes:

$$\text{Actual velocity} = (\text{standard velocity}) \times \frac{(273 + T_m)}{(273 + 21.1)} \times \frac{101.4}{P_m}$$

Where

T_m = Ambient temperature in degrees Centigrade

Pm = Ambient pressure in kPa

Example No. 1:

You want to measure the actual velocity in a duct. The air temperature in the duct is 55°F and the pressure is 14.24 psia. You take a measurement and the display reads 1200 feet per minute (FPM).

$$\text{Actual velocity} = 1200 \times \frac{(460 + 55)}{(460 + 70)} \times \frac{14.7}{14.24} = 1203.7 \text{ FPM}$$

Example No. 2:

You need to measure the actual velocity in a plenum. The air pressure is 99.4 kPa and the temperature is 27°C. The display reading on the VELOCICALC is 2.30 meters per second (m/s).

$$\text{Actual velocity} = 2.30 \times \frac{(273 + 27)}{(273 + 21.1)} \times \frac{101.4}{99.4} = 2.39 \text{ m/s}$$

Appendix C
VELOCICALC Serial Interface Connections

The interface cable that connects the VELOCICALC to the microcomputer must be properly wired to allow communications. The following two figures show the proper configurations for IBM PC® and IBM-compatible microcomputers. Figure 18 shows the serial interface connections for 25-pin, RS-232C connectors; figure 19 shows the connections for 9-pin connectors.

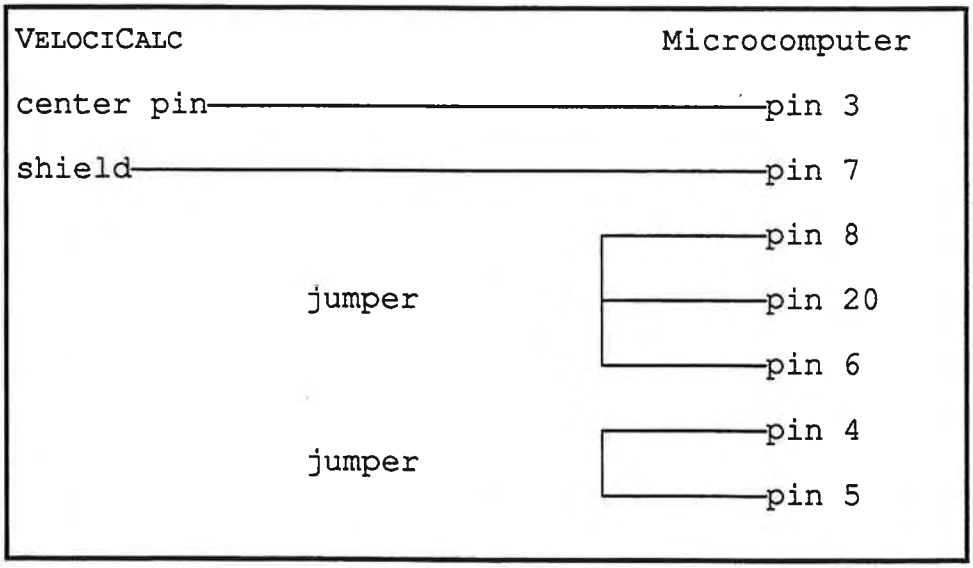

Figure 18. 25-pin, RS-232C serial interface connections

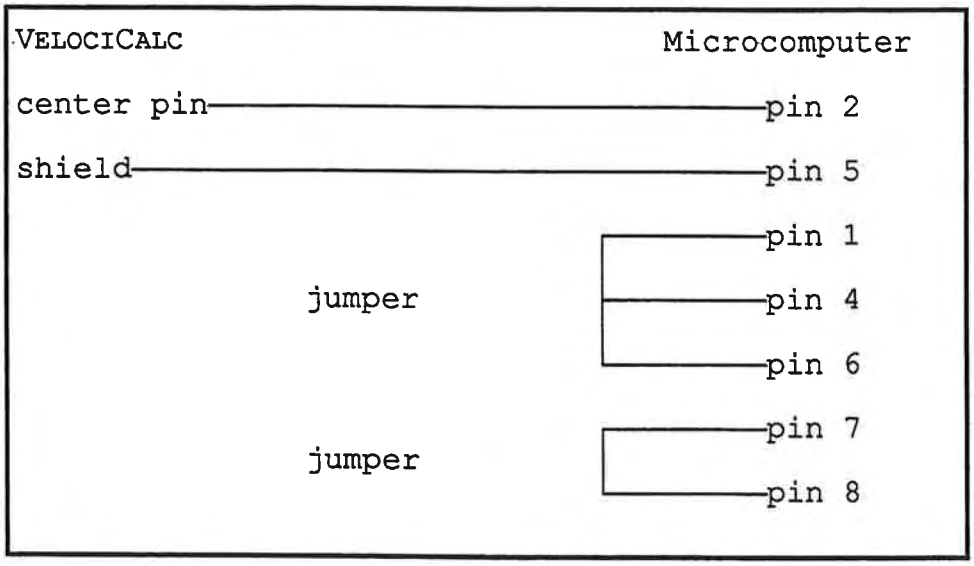

Figure 19. 9-pin, RS-232C serial interface connections

Appendix D
Specifications

DISPLAY — 8-character LCD dot matrix; 0.28-in. character height, 4-digit display plus 3 characters for units

OPERATING TEMPERATURE RANGE

Instrument: 40°F to 125°F (5°C to 52°C)
Probe: –30°F to 200°F (–34°C to +93°C)

VELOCITY

RANGE — 15 to 9999 FPM (0.08 to 50.00 m/s)

	30 to 500 FPM	500 to 2000 FPM	2000 to 6000 FPM	6000 to 9999 FPM
RESOLUTION	1 FPM	5 FPM	10 FPM	20 FPM
ACCURACY*	2.5% rdg** ±2 FPM	2.5% rdg ±10 FPM	2.5% rdg ±50 FPM	2.5% rdg ±100 FPM

	0.15 to 2.5 m/s	2.5 to 10 m/s	10 to 30 m/s	30 to 50 m/s
RESOLUTION	0.01 m/s	0.03 m/s	0.05 m/s	0.1 m/s
ACCURACY*	2.5% rdg** ±0.01 m/s	2.5% rdg ±0.05 m/s	2.5% rdg ±0.2 m/s	2.5% rdg ±0.5 m/s

* Temperature compensated over an air temperature range of 40°F to 150°F (5°C to 65°C)

** rdg: of reading

TEMPERATURE	
MEASUREMENT RANGE	0°F to 200°F (–17.8°C to 93.3°C)
RESOLUTION	0.1°F (0.1°C)
ACCURACY	±0.5°F (0.28°C)*
BATTERIES	Four AA-size, alkaline or nickel-cadmium
INSTRUMENT DIMENSIONS	1.5 x 4.1 x 7.4 in. (38 x 105 x 190 mm) not including the probe mounting brackets
WEIGHT WITH PROBE	1.1 lb. (0.5 kg)
CARRYING CASE	1.75 x 6 x 9.5 in. (45 x 152 x 241 mm)
PROBE DIMENSIONS	telescoping, 7 to 21 in. (178 to 533 mm), 0.235-in.-dia. (6-mm-dia.) at tip
SERIAL INTERFACE	RS-232C Baud rate: 1200 Serial data format: 1 start bit; 8 data bits; 2 stop bits; no parity
Voltage levels:	Logic "1" = – 4.5V logic "0" = + 4.5V
AC ADAPTER	6 Vdc, 0.3 A

* Accuracy with instrument case at 77°F (25°C). Add uncertainty of 0.125°F/°F (0.075°C/°C) for change in instrument temperature.

Specifications are subject to change without notice.

TSI Incorporated
Industrial Test
Instruments Group
500 Cardigan Road
P.O. Box 64394
St. Paul, MN 55164
Telephone: **1-800 876 9874**
or 612 490 2888
Telex: 6879024
Fax: 612 490 2874