TABLE OF CONTENTS

TRITON TECHNOLOGY, INC.

INTRODUCTION

This manual describes the function, theory of operation, and operating procedures for the System 6 Small Vessel Transit Time (SVT²) Flow Module.

Section 1 briefly describes the function of the SVT² Flow Module and its specifications. This section also describes and cross-references each control, indicator or connector, to a number keyed to the panel illustrations.

Section 2 discusses the basic SVT² principle, and provides a brief description about the operation of the SVT² Flow Module.

Section 3 provides information about additional equipment necessary to operate the SVT² Flow Module. This section also describes how to connect the transducer and chart recorder, how to calibrate the system, and how to perform an end-to-end test to ensure the system is ready for data collection.

The Table of contents provides easy access to information in the body of this manual (the manuals for each module type have their own table of contents).

The Appendix provides in depth information pertaining to application of the SVT² Flowmeter Module.

TRITON TECHNOLOGY, INC.

1. SVT² FLOW MODULE

1.1 FUNCTION

The SVT² flowmeter uses bursts of high frequency sound traveling across a blood vessel to measure blood flow in the vessels of experimental animal preparations. The Flowmeter generates an analog output voltage proportional to the volume flow (in mL/min).

The SVT² flowmeter module operates with a range of eleven reflector type transducers.

These probes are ideally suited for both acute and chronic implantation. At the time of purchase, the user selects a probe terminated with a bullet-type connector, a titanium skin button or a Fischer series 102 connector.

The SVT² module automatically recognizes the connected transducer size and adjusts its internal circuitry accordingly.

Four active filters are selectable by a front panel switch. They are all low pass types with corner frequencies of: .1Hz(mean), 10Hz, 30Hz and 100Hz.

The zero balance control is equipped with a counting dial so that individual probe offsets can be recorded.

A digital panel meter indicates flow in mL/min. when the instrument is in the RUN mode. In the calibration (CAL) mode, the display indicates the flow calibration in incremental steps. When the probe identification (ID) switch is pressed in the RUN mode only, the panel meter displays the size of the attached probe.

Signal quality is continuously monitored and displayed on the front panel. Acceptable signal quality is displayed as a green light, while a red light indicates received signal level is below the acceptable threshold.

A post amplifier is built into the module. Gains of x1, x10 and x20 are controlled by a front panel switch.

1.2 SPECIFICATIONS

ULTRASONIC FREQ — 5 MHz.

SAMPLE REPETITION FREQ (SRF) — Factory set at 2.000KHz.

TRANSMIT OUTPUT — 55V pulse into 50 OHM load from a single-ended source.

TRANSMIT PULSE BURST — The transmit burst is factory set at 15 pulses.

ANALOG OUTPUT — Bipolar; zero flow = zero volts; scale factor. Output may be offset +/- 10% using the front panel zero control.

Scale Factor	Gain
10mV/mL/min	x1
100mV/mL/min	x10
200mV/mL/min	x20

FILTERS — The output signal is available with any one of the four low pass active filters: 0.1Hz, 10Hz, 30Hz, and 100Hz at the "A" output jack.

1.3 FRONT PANEL CONTROLS

NOTE: The number preceding each item corresponds to its location on the SVT² FLOWMETER MODULE FRONT AND REAR PANELS illustration.

80

ID

The IDENTIFY (ID) button is a momentary push button switch that causes the display to indicate the size of connected probe in millimeters. An indication of "02.4" means that a 2.4mm probe is connected. The RUN/CAL switch must be in the RUN position to activate ID. If the ID Button is pressed with no transducer attached the display will indicate "6.5".

81

FILTER

82 The FILTER selects one of the four internal filters (0.1Hz, 10Hz, 30Hz, or 100Hz) that will condition the output signal at jack "A".

DISPLAY

83 A four digit liquid crystal display that indicates the measured flow, the calibrate values in the CAL mode and the probe size when the ID button is pressed in the RUN mode.

RUN/CAL

Select RUN for making measurements or CAL positions which cause the module to output calibrated steps from 1000 mL/min. The METER switch must be in the PHASIC position for viewing CAL settings.

84

METER

85 A switch selecting either the 0.1Hz (mean) or 100Hz (phasic) filter for the digital display. The switch is set to phasic for viewing CAL values.

86

POLARITY

This switch reverses the output voltage polarity sense.

87

ZERO

A 10 turn offset control that provides approximately +/-10% of full scale adjustment range.

SIGNAL

Green indicates a usable ultrasound signal for normal measurement. Red indicates inadequate signal level, check probe and connections.

88

GAIN

A three position switch selects the gain of an internal post amplifier.

x1 = 10mV/mL/min
x10 = 1000mV/mL/min
x20 = 200mV/mL/min

89

PROBE

Input connector for the probe or a Transition Cable to extend the probe length.

TRITON TECHNOLOGY, INC.

1.4 REAR PANEL OUTPUTS FOR SVT² MODULES

90

"A" FLOW OUT (PHONE)

The analog output voltage scaled with the GAIN switch and filtered. The front panel FILTER switch selects that conditions the output signal.

The analog output voltage scaled with the GAIN switch and properly conditioned by selecting the appropriate filter with the FILTER switch on the front panel.

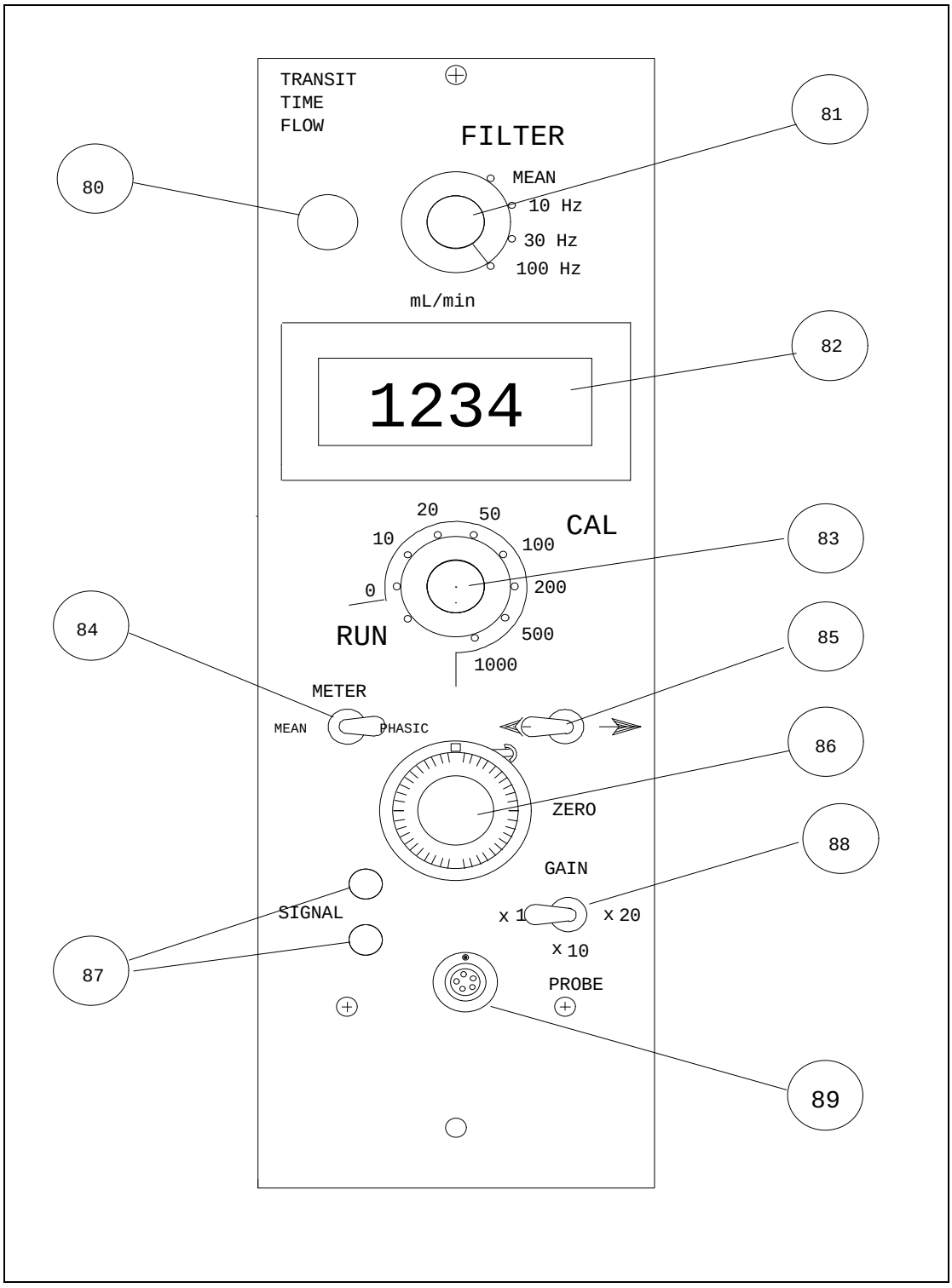


Figure 1 Flowmeter Module Front Panel

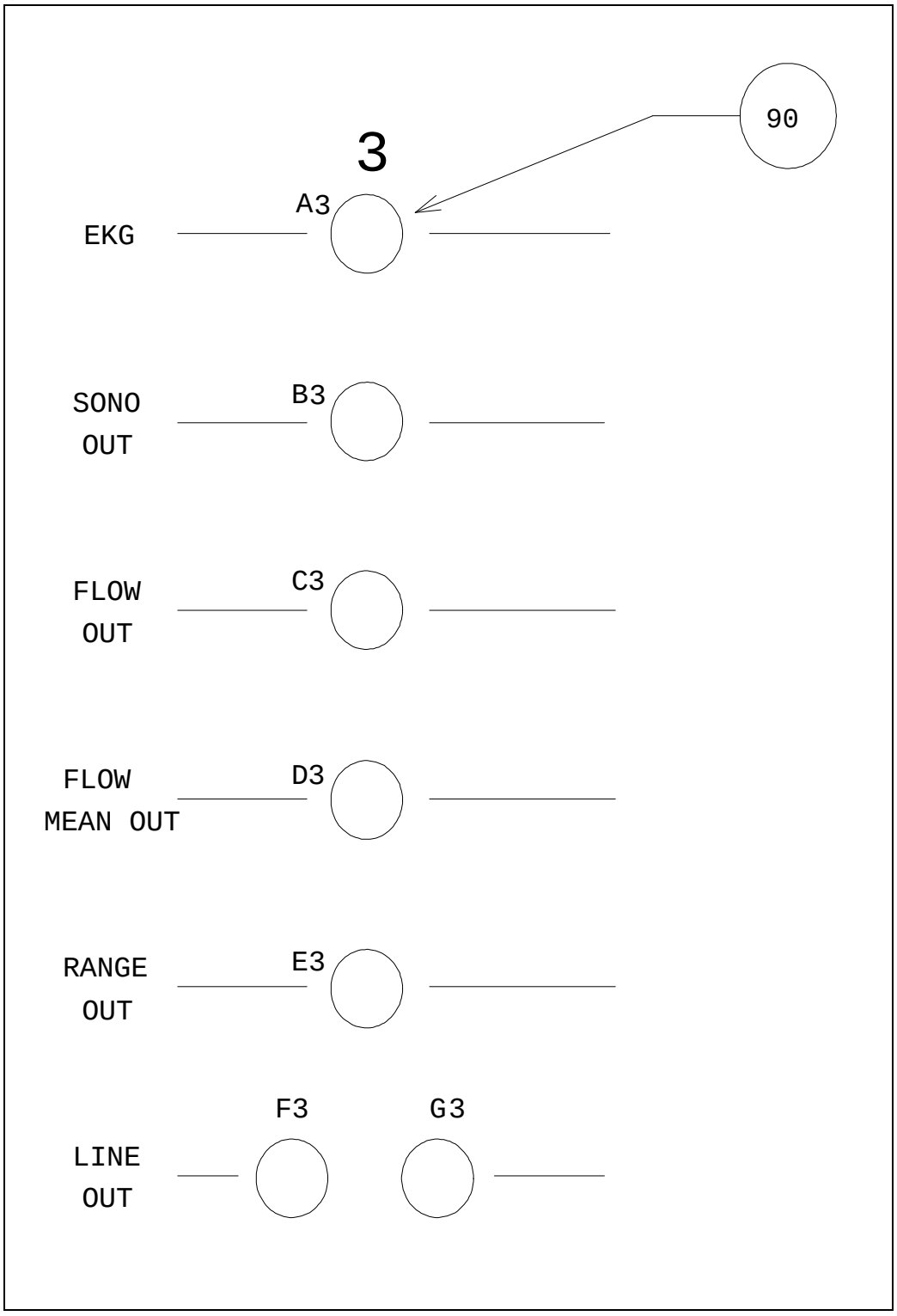


Figure 2 System 6 Rear Panel

2. THEORY OF OPERATION

OPERATING PRINCIPLE

The probes are designed so that ultrasound originating at a piezo crystal is projected through the vessel at a 45 degree angle to a reflector on the opposite side of the vessel where the sound is reflected back through the vessel at 45 degrees ending at a second crystal. Sound is made to travel both ways along this path so that there is an upstream path and a downstream path. The transit time for the upstream path is longer than the transit time for the downstream path because the flow velocity component is added algebraically to the sound velocity.

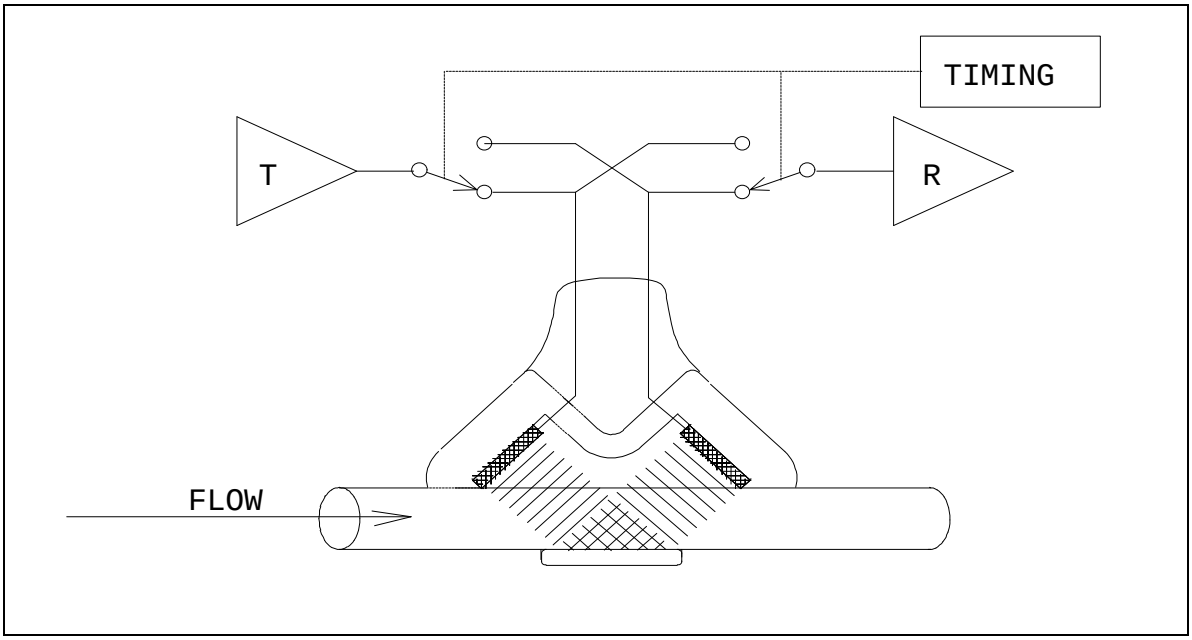


Figure 3 Ultrasound Paths

The difference in transit time between a single upstream path and a single downstream path is very small; therefore the upstream and downstream measurements consist of 15 circuits of the same path. The 15 pass measurements are occurring at 2000 measurements per second. The total times for 15 passes in each direction is stored and compared differentially, yielding a signal that is proportional to volume flow.

This signal is further processed by amplification appropriate for each probe size and filtering selectable by front panel control.

CALIBRATE MODE

Calibration voltages are derived from an internal precision reference and are routed to the output and display via the same path as the flow signal when the RUN/CAL switch is moved through the CAL positions. Voltages equal to 10, 10, 50, 100, 200, 500 and 1000mL/min are selectable. In the GAIN

setting of x1, the scale factor is 10mV/mL/min. When the GAIN switch is x10, the scale factor is 100mV/mL/min and in x20 the scale factor is 200mV/mL/min.

Important: The meter switch should be placed in the "phasic" position for viewing CAL settings.

SIGNAL QUALITY MONITOR

The received signal for each measurement sample must be greater than a fixed minimum threshold and meet other requirements before further processing is allowed. The results of these tests are displayed by the signal indicators; green = good; red = low signal, check connections and insure that air is not trapped in the probe. In the CAL positions the signal indicators have no significance.

PROBE SENSING

Each probe size is uniquely coded so that the module can recognize what size probe is attached and configure the measurement parameters for that size. It is important to verify that when the ID button is depressed in the RUN mode, the correct size is displayed.

SCALING,OFFSET, AND FILTERS

The prime flow signal is scaled for each probe size to 10mV/mL/min.. This signal may be superimposed on a fixed offset signal. The offset signal may be balanced to zero with the ZERO control. Each probe will exhibit some offset that remains essentially constant, therefore the counter dial readings on the ZERO control for each probe can be recorded for future reference.

The scaled/offset balanced signal is simultaneously applied to the inputs of four active low pass filters having cutoffs at: 0.1Hz(MEAN), 10Hz, 30Hz and 100Hz(PHASIC). The outputs of the filters are selected by the front panel FILTER switch and directed to the input of the POST Amplifier.

The Post Amplifier provides additional gains of x10 and x20 to aid in setting levels for external data recording and processing equipment. The output of the Post Amplifier is directed to the "A" output of the System 6 Chassis or the "A" output of the Twin Pack.

AUDIBLE ALARM

An analog window comparator continuously monitors the output of the Post Amplifier. If the output of the Post Amplifier exceeds +/- 12 volts the alarm is activated. The alarm is deactivated when the output signal returns to within +/- 12 volts.

SYNCHRONIZING

When the module is operated in the System 6 Chassis its sound transmission occurs during the time slot allocated for the position in which it is installed. When two modules are installed in a Twin Pack, they will synch to each other and alternate their transmissions. Individual operation in a Twin Pack is asynchronous.

TRITON TECHNOLOGY, INC.

3. FIRST TIME START-UP AND OPERATION

3.1 EQUIPMENT REQUIRED

1 chart recorder (or A/D converter)

1 cup water

1 transition cable (see Appendix A)

1 chart recorder cable

1 SVT² transducer

NOTE: Figure 2 shows outputs when the module is installed in position 3.

3.2 INITIAL SETUP

The initial setup ensures a standard starting point for operating the SVT² Flow module. The System 6 or Twin Pack comes from the factory with the SVT² modules installed. However, you may wish to change module positions to suit your application, or add other modules at a later time.

This procedure will guide the new user through the initial setup, verification of operation, and calibration.

*******CAUTION*******
DO NOT REMOVE OR INSTALL MODULES WITH THE POWER ON

3.2.1 MAINFRAME OR TWIN PACK REAR-PANEL SETUP

- These instructions ensure proper power-up.

1. Connect the power cable to the appropriate power mains.
2. Connect the chart recorder input cable to the A output jack at the position where the transit time module is plugged in.
3. Turn the power switch ON.
4. The LED power indicator light on the System 6 should light. If it doesn't, check the power cord, fuse, voltage selector, and mains receptacle. Contact Triton Technology if problem cannot be resolved.
5. Return the power switch to OFF.

3.2.2 MAINFRAME FRONT-PANEL SETUP

1. The mainframe controls are not used with transit time flow measurements.

3.2.3 SVT² FLOW MODULE FRONT-PANEL SETTINGS

- Set the selected Flowmeter module front panel controls as listed below in Table 4.

CONTROL	POSITION
FILTER	100 Hz
RUN/CALIB	CAL 0
METER	PHASIC
POLARITY	LEFT
ZERO	CENTER
GAIN	X1

Table 1 SVT² Front-Panel Initial Settings

3.3 CALIBRATION

3.3.1 CHART RECORDER SETUP

1. Turn the chart recorder power ON with the paper drive off. Turn System 6 or TwinPack power ON.

2. Set the chart recorder to a DC gain level appropriate for a 2 volt deflection.

3. Verify the transit time module display reads "000".

4. Use the chart recorder position or offset control to position the pen at the bottom of the chart tracing.

3.3.2 CALIBRATE CHART RECORDER (or A/D CONVERTER)

- After performing the setup above, the chart recorder can be calibrated to a full scale level appropriate for the expected maximum flow. In this example a full scale of 1000 mL/min. will be used.

1. Rotate RUN/CALIB switch to "1000".

2. The chart pen should deflect upward, if it does not, verify the cable connections and recorder controls.

3. Rotate the CALIB switch to "0" and adjust the recorder zero or offset control to place the pen at the zero reference line on the chart.

4. Rotate the CALIB switch to "1000". If the pen has deflected beyond the top of the chart paper, the chart recorder gain must be decreased. Decrease the chart gain until the pen is at the desired chart line. Conversely, if the chart gain is too low, it will have to be increased until the pen is at the desired level for 1000 mL/min..

5. Rotate the CALIB switch back to zero to ensure the pen returns to the correct zero level. If it does not, repeat steps 3 and 4 until the pen positioning for 0 and 1000 mL/min. are correct. It may be necessary to run the chart recorder at slow speed to final check these levels.

6. Rotate the CALIB switch to "500". The pen should deflect to a position 50% of full scale.

7. Set the CALIB switch to zero and start the chart paper at slow speed. Slowly rotate the RUN/CALIB switch clockwise, forming a stair step on the chart recorder as shown in Figure 4.

NOTE: There may be overshoot as the signal transitions between steps.

8. Stop the chart recorder and return the RUN/CALIB switch to zero.

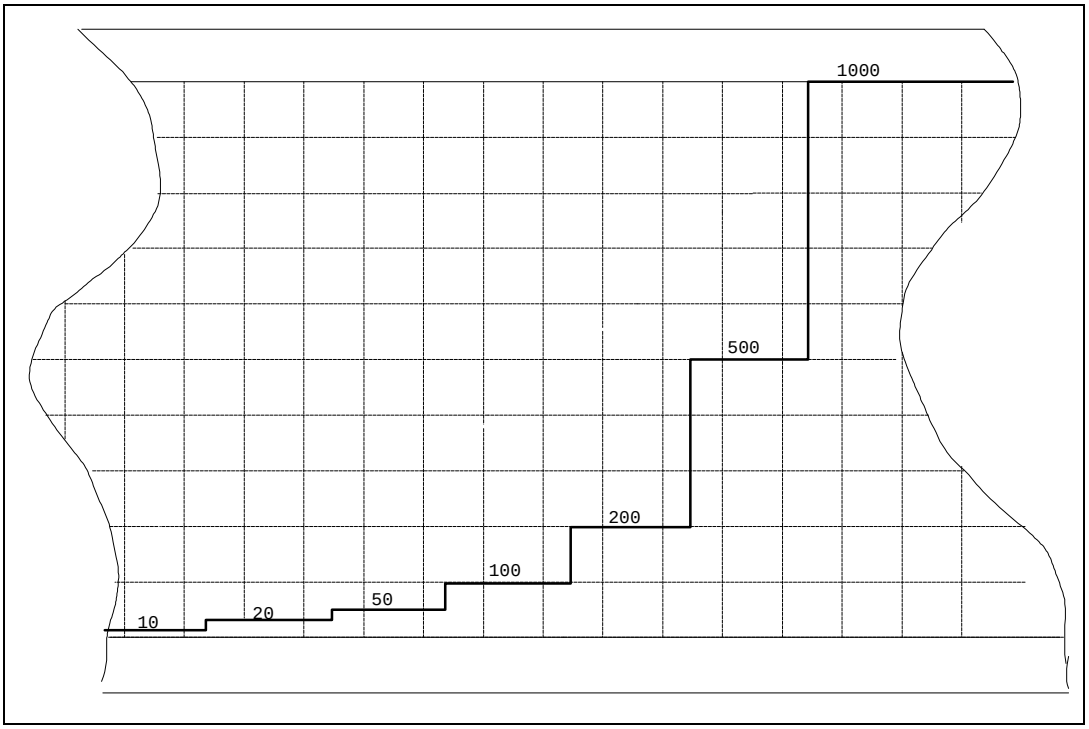


Figure 4 Chart Calibration

3.4 FINAL SETUP AND TEST

Now that the chart recorder is calibrated to the Transit Time Flowmeter it may be configured for operation in the RUN mode as follows:

3.4.1 CONNECT TRANSDUCERS

- These instructions describe how to connect the appropriate flow probe to a module.

3.4.2 TRANSDUCER BENCH TEST

- This test ensures that the flowmeter, transducer, and chart recorder are working together as a volume measuring system.

1. Submerge the transducer body in the container of water. Gently shake the probe to clear any trapped air bubbles.

2. Switch the RUN/CALIB switch to the RUN position and verify a green signal indicator is displayed.

3. Depress the ID button in the RUN mode; the display should indicate the probe size to the closest 1/10mm. (i.e. 02.4 if a 2.4mm probe is connected.

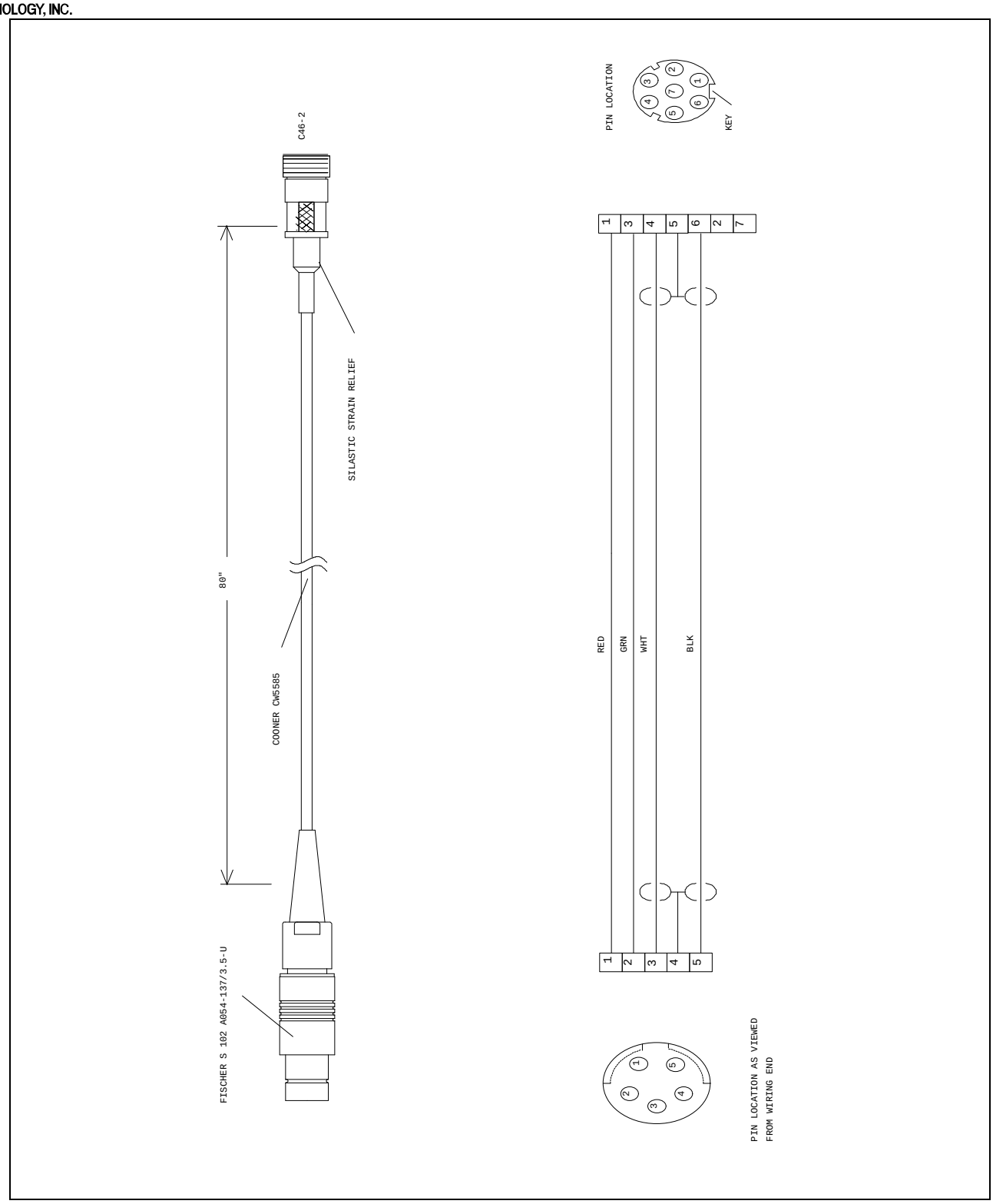
4. Lift the probe out of the water. The red signal indicator should be displayed indicating a loss of signal due to air in the sound path.

5. Return the probe as in Step 1, clearing any trapped air.

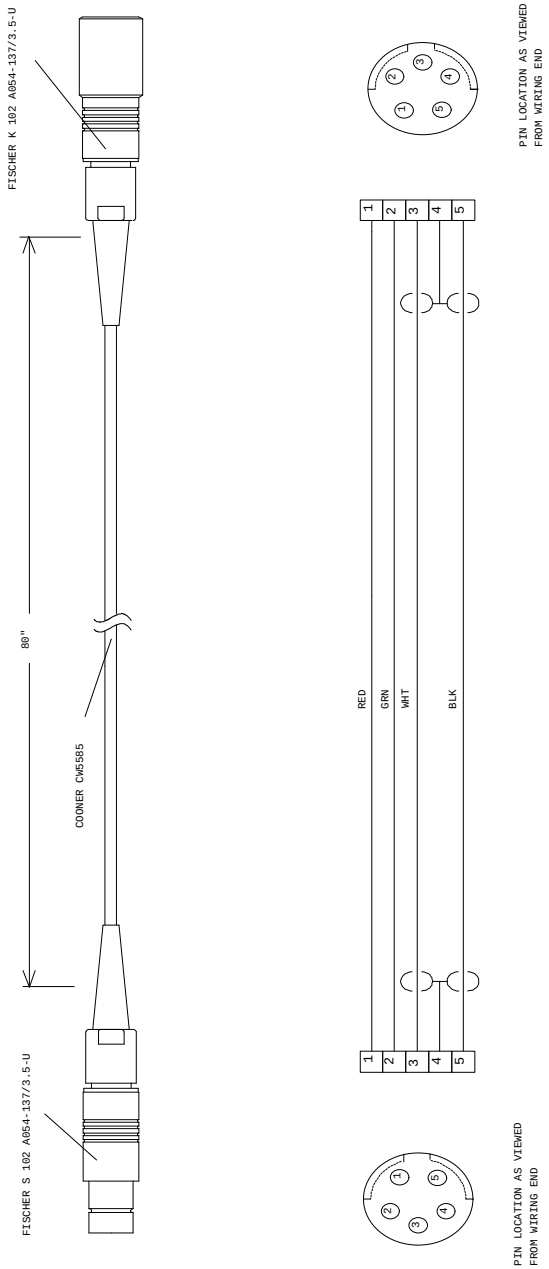
6. With the probe motionless in the container of water, adjust the ZERO potentiometer until the display reads 000. The polarity (-) indicator will come on when the offset is negative.

7. While keeping the probe submerged, move the probe back and forth creating relative motion of water through its lumen. The display should become active showing alternately positive and negative values. (The METER switch must be in PHASIC). The chart recorder should follow both positive and negative directions of flow, if the chart "zero" is placed mid-scale.

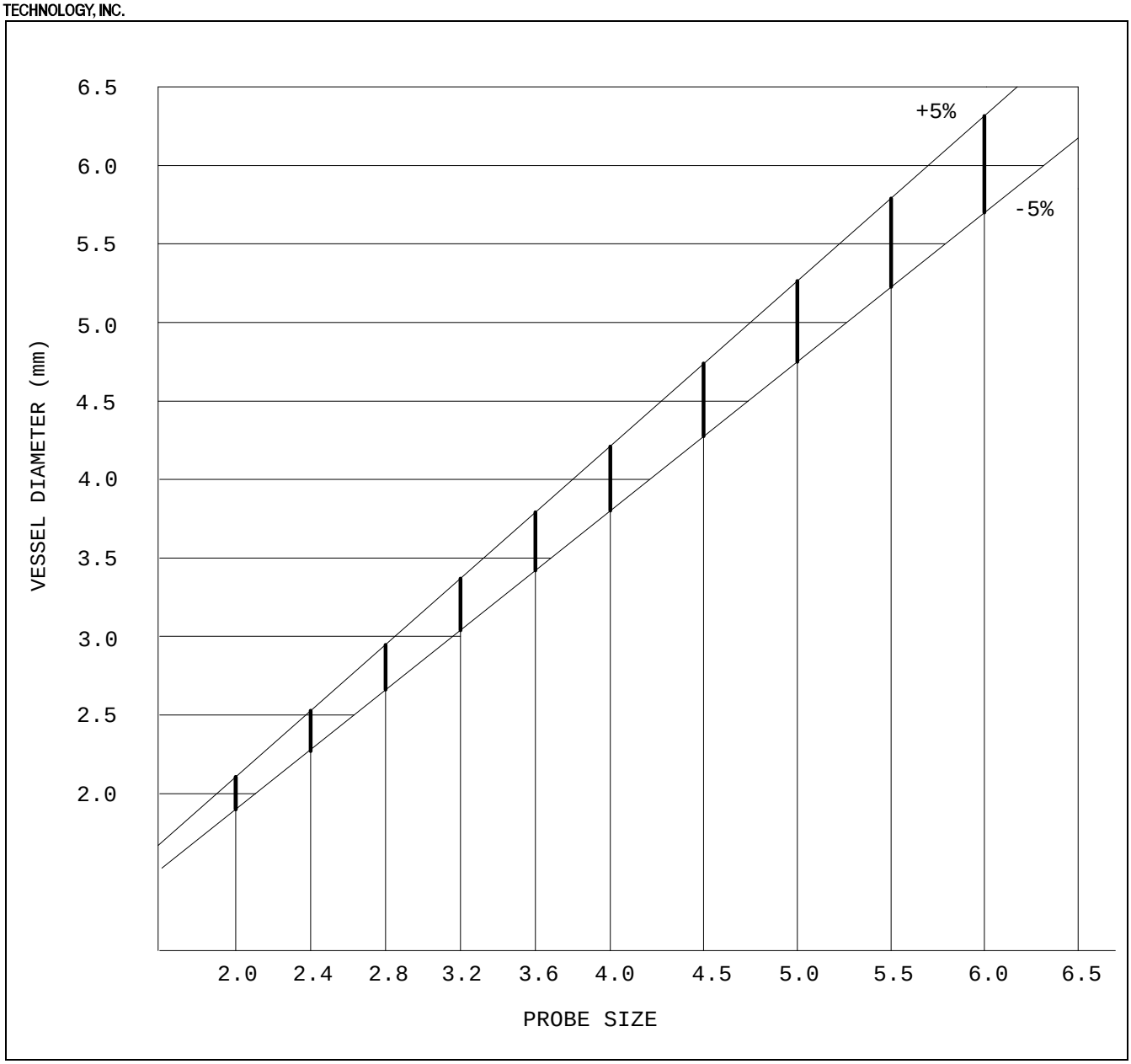
This completes the calibration and verification tests. The unit is now ready for use.



Appendix A -- Transition Cable - Konigsberg C46 (P/N#200-397)



Appendix A -- Transition Cable-Fischer (P/N#200-388)



Appendix B -- Probe Size Graph