FV156-871
Respiratory Flow Integrator

I N D E X

LIST OF ILLUSTRATIONS

1-1. DESCRIPTION

The Model FV156-871 is an electronic integrator specifically designed for respiratory volume measurement. It accepts an electrical flow signal from a pneumotach signal-conditioner and integrates this signal to provide an electrical output proportional to volume. Two simultaneous outputs are available; one is proportional to total volume, and the other can be switch-selected to show either inspired or expired volume. Input signal range is ±10 Vdc, and the output signal range is ±10 Vdc at 10 mA, which is sufficient for most data recording equipment.

A typical respiratory test setup utilizing Validyne physiological instrumentation is shown schematically in Figure 1.1. An MP45-871 variable reluctance pressure transducer, range ±2 cm H_2O, is used to measure the pressure difference developed by the air flow through the pneumotach. The electrical output of this transducer is fed to a CD19-871 carrier demodulator, where it is demodulated and amplified to provide two Dc output signals proportional to flow-rate. One of these is fed directly to the strip-chart recorder and the X-Y plotter, which is used if flow-volume loops are to be recorded. The other output signal is fed to the FV156-871 Integrator, which provides two volume signal outputs. The A Output is a 0 to ±10 Vdc signal which is proportional to the total volume. The B Output is a 0 to ±10 Vdc signal, switch-selectable for either Expired or Inspired volume. These two outputs are fed to the recorders as shown. The other MP45-871 Transducer is connected to the input of the pneumotach for mouth-pressure measurement. Its output is connected to a second CD19-871 Carrier Demodulator, whose 0 to 10 Vdc signal output is used to measure and record airway resistance.

The integrator scaling can be adjusted to any point between 0.1 Volt/second per Volt input to 1.1 Volt/second per Volt input. Integration continues until the front-panel HOLD/RESET switch is actuated or

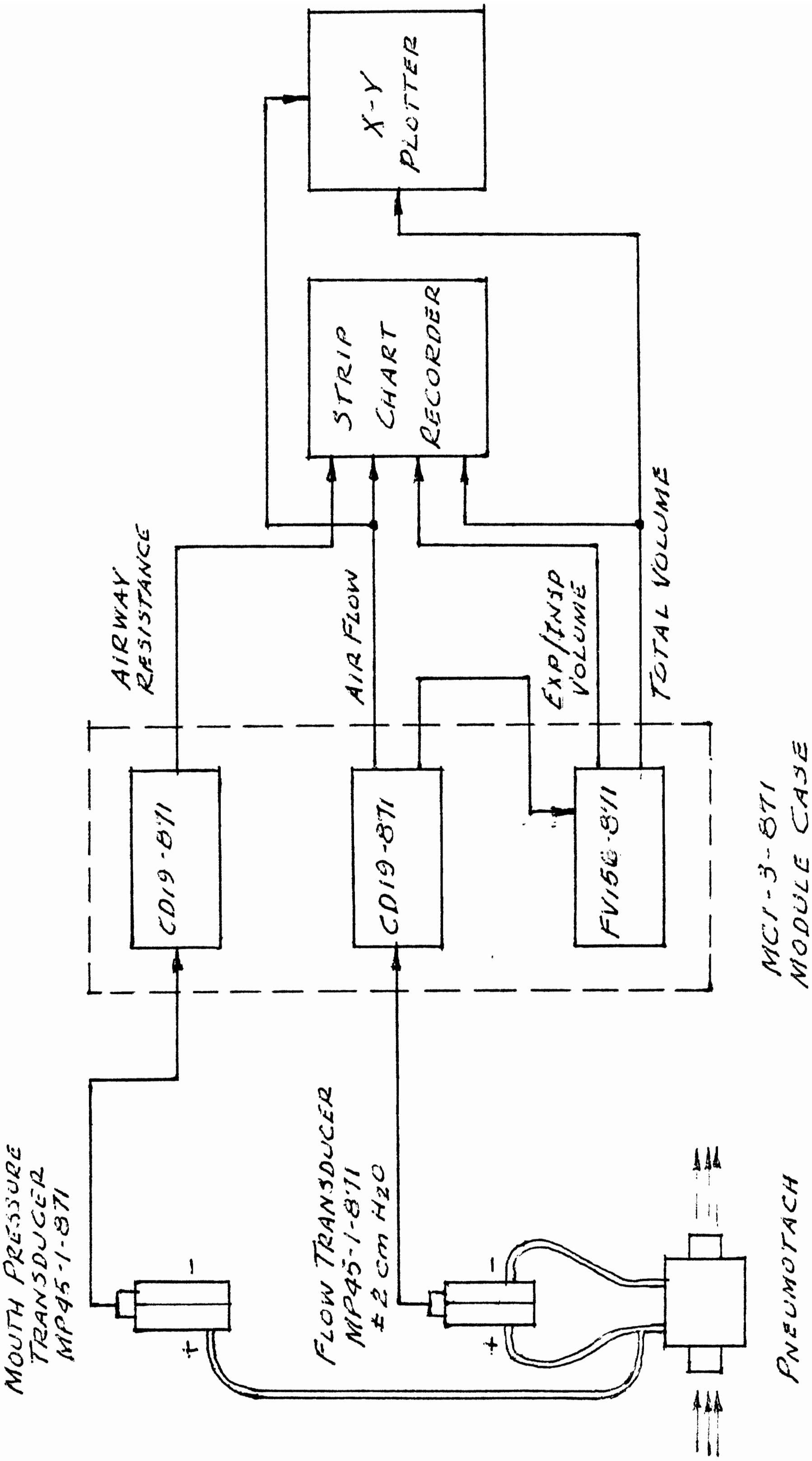


FIG. 1.1 Typical Instrumentation System

until the output reaches 10 Vdc. For example, if a steady airflow through the pneumotach produces a 1 Volt flow signal input to an FV156-871 with its front panel FLOW SPAN dial set at 1000 (representing a scaling of 1V/sec/Vin), the FV156 A Output will reach +10 Vdc in 10 seconds. The B Output, which can be adjusted from 0 to 100 percent of the A Output, has its own reset circuit, which can be switch-selected for reset at the end of each Expiration or Inspiration cycle or at the +10V output level.

The FFV156-871 is a plug-in module for the MC1-3-871, MC1-333-871, and MC1-10-871 Module Cases. The module case supplies the operating power and the connections between the module and the input/output connectors on the rear of the module case.

See Figure 4.1 for identification and location of front panel and internal controls.

1.2 FUNCTIONAL BLOCK DIAGRAM

Figure 1.2 presents a functional block diagram of the FV156-871. The control functions are described in Section 4.1.

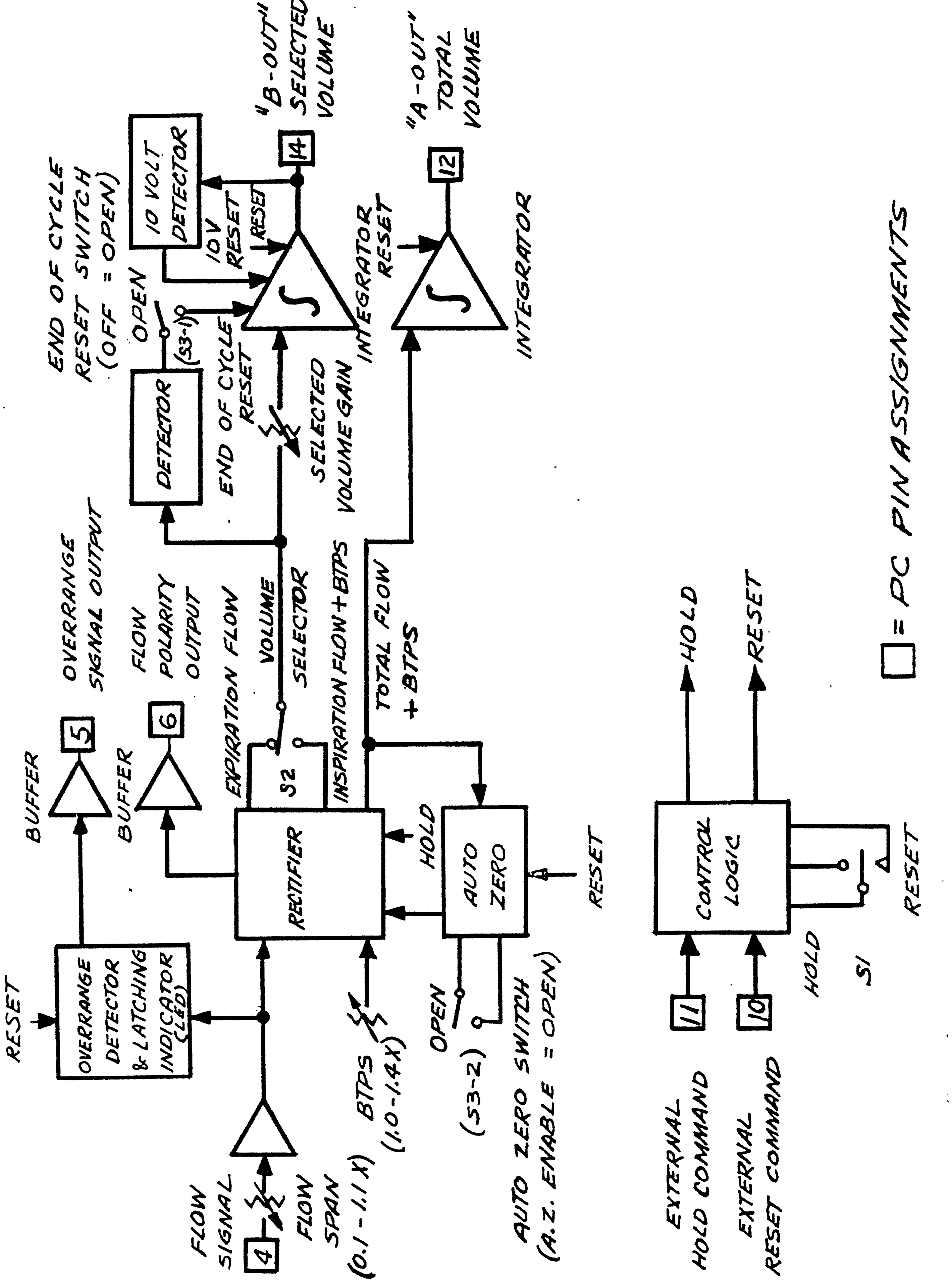


FIG. 1.2, FV156-871 Block Diagram

SECTION 2.0
SPECIFICATIONS

2.1 ELECTRICAL

Input Range:	±10V DC
Input Impedance:	11K Ohms
Integrator Scaling:	0.1 V/sec to 1.1 V/sec output per volt of input (sensitivity).
Exp/Insp Volume:	May be adjusted, from 0% to 100% of Total Volume Output Level
B.T.P.S. Correction:	Adjustable 1.0 to 1.4X
Drift:	Typical ± 15mV/minute referred to output
Temp. Drift, 40°F-120°F	Typical ± 1mV/Sec.
Hold Drift:	Typical ± 15mV/minute referred to output
Reset:	Exp/Insp Volume selectable at end of cycle or automatic at maximum of +10VDC; front panel manual, and remote reset available
Reset Rates:	End of cycle: 1msec typical; Auto reset at +10V: 20msec nominal
Output A: Output B:	0 to ±10V DC at 10mA 0 to +10V DC at 10mA
Output Impedance:	10 Ohms maximum
Remote Hold:	(TTL compatible) hold on low
Remote Reset:	(TTL compatible) reset on low
Flow Polarity Output Signal:	(TTL compatible) low on inspiration
	NOTE: "LOW" refers to Logic Level of 0-+0.8 Volts, Sink 1mA.
Flow Overrange Indicator:	Front panel mounted light emitting diode, latching; release on reset.

2.1 ELECTRICAL (continued)

Flow Overrange Ouput Signal:	(TTL compatible) high when indicator lights
Temperature Range:	40°F to 120°F (5°C to 50°C)
Power Requirements:	±15V DC from MC1 Module Case

2.2 MECHANICAL

Size:	3.7"H x 1.6"W x 5.75"D (9.4cm x 4cm x 14.6cm)
Weight:	10 ozs. AVDP (283 grams)

3.1 INSTALLATION

The FV156-871 is mechanically designed as a plug-in unit to any MC1 System Module Case. The plug-in unit derives all necessary operating voltages from the module case and, in turn, supplies all connections, through its pc board connector, to the external input/output connectors on the rear panel of the module case.

Any position of the MC1 case may be used as there is no interaction between plug-in modules. No damage will result when units are installed or removed without turning off system power.

3.2 ELECTRICAL CONNECTIONS

3.2.1 INPUT

All inputs to the FV156-871 are made through the Cannon WK-4-32C receptable marked "INPUT" or "TRANSDUCER INPUT" on the rear panel of the MC1 Module Case. The receptable pin assignments are as follows:

Pin 1 External HOLD signal input (See Section 3.2.3)
Pin 2 FLOW signal input
Pin 3 Input common (circuit ground)
Pin 4 External RESET signal input (See Section 3.2.3)

When the flow signal is derived from a Carrier Demodulator plugged into the MC1 Module Case, it is only necessary to connect one lead from the demodulator output to Pin 2 on the WK4 input connector matching the FV156 as the circuit ground pin (Pin 3) is internally connected to the carrier demodulator output circuit ground. The flow signal input range is 0 to ±10 Vdc.

3.2.2 OUTPUT

Output "A" - The Total Volume output is obtained from the XLR-3-32S receptable marked "OUTPUT A" on the rear panel of the MC-1 Module Case with the following pin assignments:

Pin 1 Total Volume output signal
Pin 2 Signal ground
Pin 3 Chassis ground

The total volume output signal range is 0 to ±10 Vdc; the signal polarity is the same as that of the input flow signal.

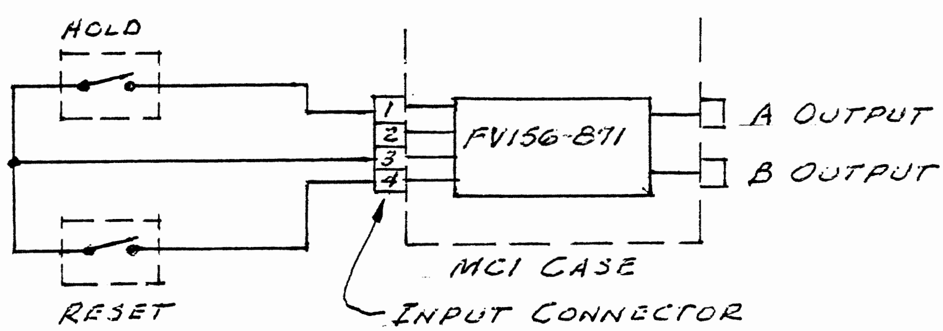
Output "B" - The front panel selected Expired or Inspired output is obtained from the XLR-3-32S receptable marked "OUTPUT B" on the rear panel of the MC1 Module Case, with the following pin assignments:

Pin 1 Expired/Inspired output signal
Pin 2 Signal ground
Pin 3 Chassis ground

This output signal range is 0 to +10 Vdc; the signal polarity is positive for both Expired or Inspired outputs.

3.2.3 REMOTE CONTROL

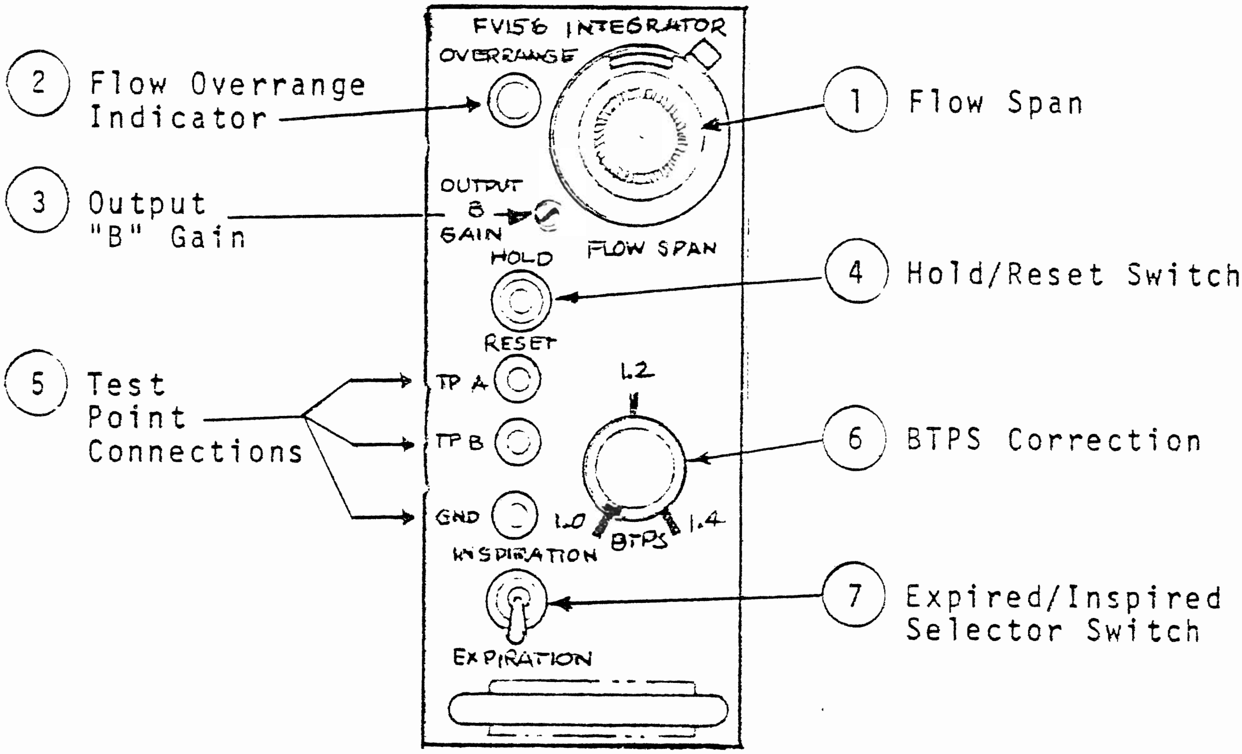
The FV156-871 has provisions for remote control of the HOLD and RESET functions. The control signal to actuate either function is low logic level (<0.8 Vdc), and can be generated by a computer-controlled data acquisition system, if used, or by the use of external foot-operated switches, as shown below:



The FV156-871 also provides TTL compatible overrange and flow polarity signal outputs should these be desired when the FV156 is used as part of a digital data acquistion system. Access to these signals requires wiring connections to the module connector inside the MC1 module case; wiring can be run through the extra hole on the rear of the MC1 case. Connections are as follows:

Overrange Signal - This TTL compatible signal is available from pin number 5, counting from the top, of the pcb connector for the FV156. TTL high logic level (>2.4 Vdc) indicates an overrange condition.

Flow Polarity - This TTL compatible signal is available from pin number 6, counting from the top of the pcb connector for the FV156. TTL high logic level indicates EXPIRED flow; TTL low (<0.8 Vdc) indicates INSPIRED flow. Pin 9 or 15 (circuit ground) can be used for signal return.



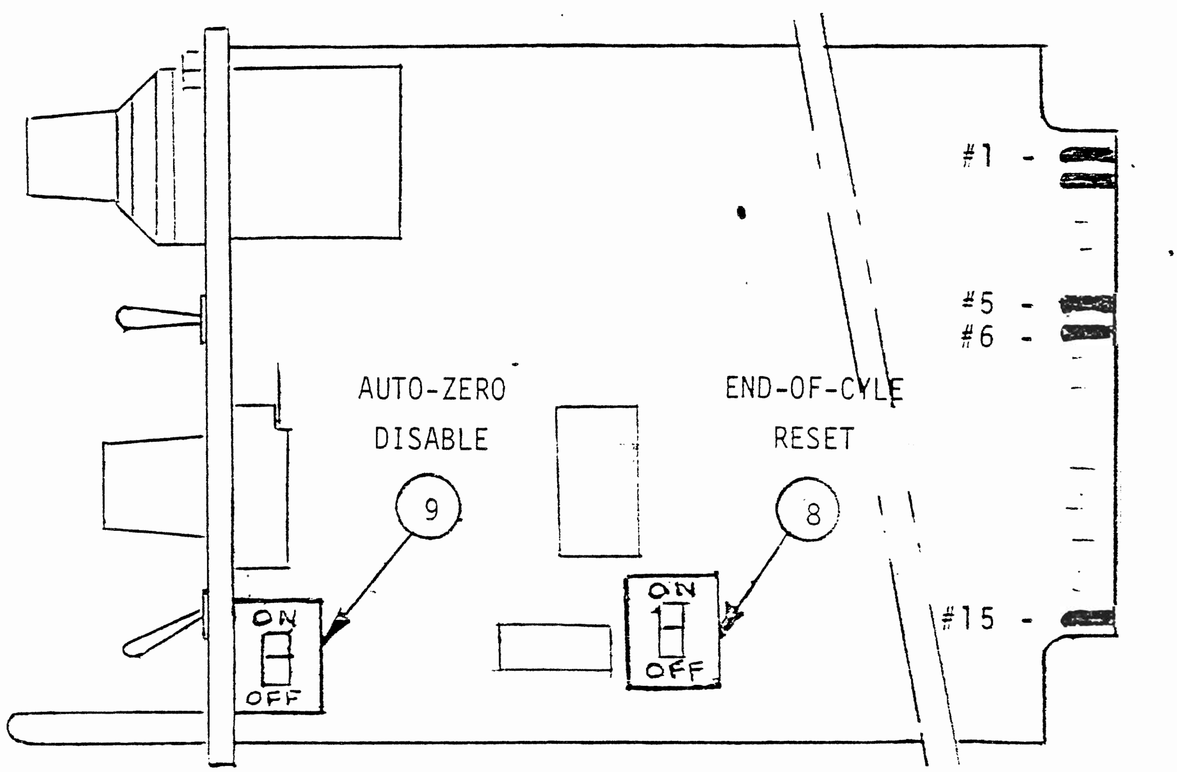


Fig. 4.0 Control Locations

See Figure 4.0 for location and identification of controls.

4.1 CONTROL FUNCTIONS

(1) Flow Span - Provides scaling of both volume outputs simultaneously. The 10-turn dial is graduated from 100 to 1100 divisions allowing the outputs to be adjusted from 0.1V/sec. (100 divisions) to 1.1V/sec. (1100 divisions) per volt of flow signal input.

(2) Flow Overrange Indicator - An LED (light emitting diode) which indicates (turns on) when a flow input signal of 12 volts has been exceeded, with the flow span control at 1100. The overrange light can be extinguished by rescaling the input flow signal to be 10 volts at full scale flow, and operating the reset switch. The overrange indicator also latches "ON" if the input flow signal exceeds ±0.12 V during "RESET" when the auto-zero mode is in use. To prevent this form of overrange triggering, one must manually adjust the flow null signal to less than ±0.12 V before "Resetting" the FV156.

(3) Output "B" Gain - A multi-turn screw driver adjustment allowing the Expired/Inspired volume output to be independently adjusted from 0% to 100% of the Total Volume output. This adjustment has no effect on the "A" (Total Volume) output signal level.

(4) Hold/Reset Switch - A three position switch which is normal in the center position. The HOLD position maintains the volume signals at the level of that moment and holds the level until the switch is taken out of that position. In the RESET position, a momentary (down) position, the integrators, and therefore both volume outputs, are reset to zero.

(5) Test points - Front panel test points provide access to the output "A" signal (TP-A), the output "B" signal (TP-B) and signal GND.

(6) BTPS Correction - Provides additional flow signal gain up to 40% of additional Inspired flow to balance total volume output. This adjustment facilitates closed flow-volume loops. The BTPS control must be at 1.0 (full CCW) if BTPS correction is not desired.

(7) Expired/Inspired Selector Switch - The volume output "B" represents the volume from Inspired flow (up-position) or Expired flow (down position).

(8) End-of-Cycle Reset Switch - A single-pole GREEN DIPSWITCH mounted on the pc board near the center at the bottom edge. Pushing the rocker to the "ON" position causes the "B" Output to be reset whenever the flow drops to zero or reverses direction.

(9) Auto-Zero Enable/Disable Switch - A single-pole GREEN dipswitch mounted on the backside of the front panel near the bottom. Moving the rocker to the "ON" position disables the auto-zero function. When the switch is in the "OFF" position, the auto-zero circuit will, whenever reset is actuated, drive the flow amplifier output to zero. When the reset is removed, the auto-zero circuit will supply a signal to null up to ± 100mV input offset, which may appear at the flow input when the actual flow is zero. If the offset exceeds ± 100mV, the overrange light will indicate when the reset is released.

4.2 CALIBRATION

The FV156-871 can be calibrated as an individual module or included as part of the total system calibration. The following sections outline the procedures for either case.

4.2.1 MODULE CALIBRATION

If the FV156-871 input signal is known in terms of volts per unit flow, use the following procedure:

1. Determine the output signal desired in terms of volts per unit volume; this depends on the recorder input required for full-scale recording span.

2. Adjust the FLOW SPAN dial to provide the desired output volume signal. The dial setting (between 100 and 1100) will be:

$$\text{Dial Set} = \frac{\text{"A" Output Voltage}}{\text{Input Signal Voltage}} \times 1000$$

The B Output Voltage will be the same as the A Output if the B Output Gain is turned fully clockwise. The B Output can be adjusted to any lower value without affecting the A Output by turning the B Output Gain Control counter-clockwise.

EXAMPLE

The output of a CD19 connected for airflow measurement through a pneumatach is 5 V/Liter/sec. This signal is to be processed through an FV156-871 for strip-chart recording of flow volume. The desired recorder input is 1 V/Liter. The FV156 B Output is set at 100% of the A Output.

Find the FLOW SPAN dial setting by:

$$\text{Dial Set} = \frac{1V}{5V} \times 1000 = 200.$$

The integrator scaling of the FV156 is now set at 0.2 V/sec per volt of input. As the result:

(a) For the A Output (Total Volume), a steady expired airflow of 1 Liter/sec (5 Volt input) will produce an output increase at the rate of 1 V/sec; at the end of one second the output will be 1 V, at the end of two seconds the output will be 2 V, and so on. An inspired airflow of 1 Liter/sec will produce an output decrease at the rate of 1 V/sec. The A Output can only be reset by using the front panel RESET switch.

(b) If the B Output selected for EXPIRATION is recorded at a flow rate of 1 Liter/sec, the B output will increase at the rate of 1 V/sec only during the expiration cycles, with no change during the inspiration cycles. As the B Output is additive for successive expiration cycles, this output will automatically reset when it reaches 10 V. Thus, for successive expiration cycles of 1 Liter each, the B Output will reset at 10 cycles (10 Liters).

(c) If the B Output selected for INSPIRATION is recorded, the B Output will increase only during the inspiration cycles until it reaches the 10 V reset point. Note that the

B Output voltage increases (positive polarity) during either the EXPIRATION or INSPIRATION modes.

(d) The B Output can be set to automatically reset to zero at the end of each expiration or inspiration cycle (as determined by the position of the EXP/INSP selector switch). For this, the internal END-OF-CYCLE RESET switch must be in the ON position. (See Figure 4.0 Control Locations).

It is important to note that the integrators will continue to integrate any signal at the input, including any zero offset at no-flow conditions. This appears as a steady drift in the integrator output. To minimize this drift, the flow transducer output at zero flow must be zero-balanced as well as possible. For instance, a flow-signal zero offset of 0.050 V in the foregoing example will integrate at the rate of 0.2 V/sec/Vin, which will result in an output drift of 0.01 V/sec, or 0.6 V/minute. Improving the input signal null balance to 0.01 V will cut the integrator drift by a factor of five.

The above discussion on drift assumes that the internal AUTO-ZERO DISABLE switch is in the ON position (see Figure 4.0, Control Locations). If this switch is placed in the OFF position (auto-zero enabled), the input auto-zero circuit will recognize an input offset up to ±0.1 V and supply a compensating voltage to drive the integrator input to zero. This effectively eliminates output drift due to a fixed input zero offset, but it does not compensate for flow transducer zero instability due to hysteresis or temperature. As the auto-zero offset storage consists of a capacitor, it is useful mainly for test durations on the order of two or three minutes. Resetting the integrators resets the auto zero.

4.2.2 SYSTEM CALIBRATION

A physical system calibration is generally the best method for setting up the full test system. This means the application of a known flow input to the pneumotach and adjusting each component of the system to produce a calibrated test recording. The following procedure may be helpful in making such a calibration for a system consisting of a pneumotach connected to a Validyne pressure transducer for measuring airflow, a CD19 Carrier Demodulator for signal-conditioning the transducer output, an FV156-871 for integrating the flow rate signal from the CD19, and a two-channel strip-chart recorder for recording flow rate and flow volume.

(a) Connect the pressure transducer to the pneumotach with plastic tubing, with the pressure port marked + to the mouth end off the pneumotach. Connect the transducer cable to the appropriate INPUT connector for the CD19 in the MC1 Module Case.

(b) Connect the lead or cable from the OUTPUT A connector of the CD19 to the INPUT connector of the FV156, (see Section 3.2.1). Connect a cable from OUTPUT B to a recorder input; this is for flow rate recording.

(c) If Total Volume is to be recorded, connect a cable from OUTPUT A of the FV156 to a recorder input. If Expired or Inspired Volume are to be recorded, connect OUTPUT B of the FV156 to the recorder input, (See Section 3.2.2). Both Total Volume and Expired/Inspired Volume can be simultaneously recorded on a two-channel recorder, but this eliminates recording of flow rate.

(d) Set the CD19 GAIN dial to 1000, the GAIN switch to 25 mV/V, the CALIBRATE switch to OFF, the internal FREQ RESPONSE switch to 10 Hz. Connect a digital voltmeter to the OUTPUT and GRD test jacks on the front panels and, with no flow through the pneumatach, adjust the front-panel R Balance Control for the best possible output zero reading. This is important to minimize integrator output drift. See the CD19 Instruction Manual for more detailed zero-balance instructions.

(e) Connect a one-liter syringe to the pneumotach and empty it as steadily as possible. Note the number of seconds taken, and note the CD19 output during this flow. This is the empirical flow calibration in Volts/Liter/Time in seconds. Adjust the CD19 Gain Controls to make this 5 V/Liter/second. As Output B of this CD19 is connected to one channel of the recorder, adjust the recorder span for a convenient calibration value, such as 25 mm/liter/sec. Other values than these given here can be used, as long as the result is a known relation between the recording span and the flow rate. Although the recorder alone can be used for the CD19 zero and span adjustment, a voltmeter is recommended for making the zero adjustment. When performing this flow calibration, care should be taken not to exceed the laminar flow range of the pneumotach, this can cause internal flow turbulence and significant calibration error.

(f) If Total Volume is to be recorded, connect Output A of the FV156 to the recorder. Set the FV156 FLOW SPAN dial to 1000, the HOLD/RESET Switch to its center position, and the BTPS knob to 1.0 (fully CCW). Set the internal AUTO-ZERO DISABLE Switch to the ON position. With the syringe, apply one liter volume and check the recorder span, which now indicates a flow volume of one liter. Adjust the recorder as necessary for a convenient volume scale. If the input to the recorder is too high, it can be attenuated by:

(1) reducing the gain of the CD19; changing this will also change a corresponding change in the calibration of the flow rate recording;

(2) reducing the setting of the FV156 A FLOW SPAN dial; changing this will not affect the flow rate calibration.

This volume calibration will require some repetition, along with experimentation with the control settings and recorder speed, to arrive at the desired record format. If the front panel Output B Gain is set at 100% (fully CW), this procedure also calibrates Output B.

(g) If Expired/Inspired Volume is to be calibrated, connect Output B of the FV156 to the recorder. Turn the Output B Gain screwdriver control on the front panel fully CW. Set the EXP/INSP Selector Switch to the EXP position, and follow the procedure given in paragraph (f). If the internal END-OF-CYCLE RESET switch is in the OFF position, the recorded volume will be additive with each expiration cycle until the integrator reset point (10V output) is reached, at which time the recording will reset to zero. If this switch is in the ON position, the recording will automatically reset whenever the flow drops to zero or reverses direction. Calibration of Output B under expiration automatically calibrates the output under inspiration and vice versa. With the Output B Gain at 100% (fully CW), this procedure also calibrates Output A. As Output B Gain is an uncalibrated screwdriver adjustment, the use of a voltmeter connected to the front panel output test jacks is recommended.

4.3 FLOW/VOLUME LOOP RECORDING

Recording the flow/volume respiratory loop requires an X-Y Plotter, which utilizes the flow rate output from the CD19-871 and the total volume output from the FV156-871. The flow signal may be taken from either the A or B Output of the CD19-871 and is connected to the X axis of the plotter. The total volume output is taken from the A Output of the FV156-871 and is connected to the Y axis of the plotter. An expirational flow (+ signal) moves the plotter pen to the right, and an inspirational flow (-signal) moves the pen to the left. Expirational volume moves the pen up, and inspirational volume moves the pen down. The plotter is thus used to draw a closed-loop diagram of the breathing cycle for diagnostic use.

However, the loop does not fully close because of body-induced temperature and pressure difference in the inhaled and exhaled air. To close the loop, a BTPS (Body Temperature Pressure Standard) correction is required. This is provided by the BTPS control on the FV156 front panel; this control allows the inspirational flow signal to be increased up to 40% in order to close the loop. The control is roughly graduated from 1.0 to 1.4, and is adjusted as required to meet the individual loop correction requirement.

5.1 MAINTENANCE

The FV156-871 should require no maintenance except for a periodic inspection for dust or other residue on the circuit board and contacts. If dirt or residue are found, this should be removed with a low-residue solvent such as Freon.

If a periodic maintenance program is in effect, the FV156-871 integrator scaling may be confirmed by the following procedure. Test equipment required consists of a precision 1.00 Vdc source, digital voltmeter, and stopwatch.

(a) Set the FLOW SPAN dial to 1000, the BTPS Control to 1.0 (fully CCW), the B Output Gain to 100% (fully CW), the internal AUTO-ZERO switch to ON, the internal END-OF-CYCLE switch of OFF.

(b) Connect the voltmeter to the front panel A Output and GRD test jacks. Connect the precision +1.00 Vdc voltage to the signal input (+ to pin 2, return to pin 3 of the MC1 Input Connector).

(c) Hold the RESET switch in the reset position; the voltmeter should read zero. Simultaneously, start the stopwatch and release the reset switch.

(d) At exactly 10 seconds, place the HOLD/RESET switch into the HOLD position. The voltmeter should read +10.00 ± 0.25 Vdc. If it does not, adjust the FLOW SPAN dial and repeat (c) and (d) until the proper reading is obtained.

(e) If at the end of the preceding steps, the FLOW SPAN dial reading is not 1000 ± 30, the dial reading may be adjusted by loosening the Allen set-screw in the knob, turning the dial to the proper reading and tightening the set-screw.

(f) Connect the voltmeter to the front-panel B Output test jack, and set the EXP/INSP switch to the EXP position.

(g) Repeat steps (c) and (d). The B Output voltage should be within ± 0.25V of the A Output voltage previously checked.

(h) Set the EXP/INSP switch to the INSP position. Reverse the polarity of the test input voltage so that -1.00 Vdc is the input.

(i) Repeat step (g). Note that the output will be +10 V for a -1 V input.

5.2 REPAIR

Should malfunction occur, we recommend that the unit be returned to the factory for prompt replacement or repair in accordance with the Validyne warranty.

5.3 CIRCUIT SCHEMATIC

Drawing 8364, attached, provides a circuit schematic of the FV156-871.

WARRANTY

VALIDYNE ENGINEERING CORPORATION warrants equipment of its own manufacture to be free from defects in material and workmanship under normal conditions of use and service.

VALIDYNE will rework or replace any item found to be defective on as return to VALIDYNE within the time specified below:

1. Pressure Transducers and Pressure Transmitters (including transducers supplied as part of Digital Manometer Systems) within three (3) years of its original purchase.

2. Electronics products (Transducer Indicators, Carrier Demodulators, plug-in SignalCondioners, Module Cases, etc.) within one (1) year of its original purchase.

3. OEM Transducers within one (1) year of its original purchase.

Buyer is requested to secure authorization of VALIDYNE, and to describe defect prior to return of equipment under warranty. Shipment to VALIDYNE shall be at Buyer's expense, with return at VALIDYNE's expense. NON-VERIFIED problems or malfunctions, whether warranty or not, are subject to a $100.00 evaluation charge.

The warranty carries no liability, either expressed or implied, beyond our obligation to rework or replace, at VALIDYNE's option, the unit which carries the warranty to the original purchaser. Prices, specifications, and designs are subject to change without notice. This warranty is void if the product is subjected to misuse, accident, neglect, or improper application or operation.

Out of Warranty Rework

Units returned to VALIDYNE for rework which are out of warranty will be subject to the following conditions:

1. A description of the problem or malfunction shall accompany the unit returned for rework, or be communicated to VALIDYNE prior to shipment. Otherwise there will be a minimum evaluation and/or calibration charge of $100.00.

2. Unit will be reworked automatically if the charge is less than 65% of current list price, unless other specific instructions are received. Above 65% VALIDYNE will request authorization by Buyer.

3. If a quotation is required before proceeding with rework, unit should be accompanied by a document so stating, or communicated to VALIDYNE prior to shipment. A $100.00 evaluation charge will be invoiced for this service.

4. Shipping charges in both directions are the responsibility of the Buyer for all out of warranty returns.

Warranty on Rework

Warranty coverage on rework is 90 days on work done, or to the end of the original warranty period, whichever is longest.

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