TELEDYNE HASTINGS INSTRUMENTS

INSTRUCTION MANUAL

HASTINGS 200 SERIES FAST RESPONSE MASS FLOWMETERS

TELEDYNE INSTRUMENTS
Hastings Instruments
A Teledyne Technologies Company

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KEMA CERT 10192.01
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Accredited by the Registrar Accreditation Board (RAB)

Manual Print History

The print history shown below lists the printing dates of all revisions and addenda created for this manual. The revision level letter increases alphabetically as the manual undergoes subsequent updates. Addenda, which are released between revisions, contain important change information that the user should incorporate immediately into the manual. Addenda are numbered sequentially. When a new revision is created, all addenda associated with the previous revision of the manual are incorporated into the new revision of the manual. Each new revision includes a revised copy of this print history page.

Revision B (Document Number 126-082000) ..... August 2000

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Visit www.teledyne-hi.com for WEEE disposal guidance.

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Hastings Mass Flowmeters are designed to accurately measure mass flow without corrections or compensations for gas pressure and temperature. Due to a linear electrical output signal, the flowmeters are ideal for use with totalizers and recorders. Hastings Mass Flowmeters do not require any periodic maintenance under normal operating conditions with clean gases. No damage will occur from the use of moderate overpressures or overflows.

The standard flowmeter calibration is for air. Special calibrations for most other gases such as oxygen, nitrogen, hydrogen, and carbon monoxide are available on special order, or by use of a gas multiplier. These instruments are calibrated with air at the factory, then the output is adjusted using gas correction factors.

1.1 Features

Hastings Fast Response HFM Flowmeters have response times of less than two seconds to 98% of a 0-100% step change with less than 2% overshoot.

Fast Response HFM Flowmeters are available with a 15-pin "D" connector and are pin for pin compatible with most other manufacturers' thermal mass flowmeters with 20-pin connectors.

HFM Models incorporate a removable/replaceable sensor which virtually eliminates long down time due to clogging, the most common cause of failure in the industry.

Each flowmeter has a shunt which can be quickly and easily adjusted in the field to different ranges, however, recalibration is normally required.

A 100 micron filter is located upstream of the shunt and sensor to eliminate most of the larger impurities in the system which tend to plug thermal mass flowmeters.

The Model HFM Flowmeter comes in 15 standard ranges from 0-10 SCCM to 0-500 SLPM. Special ranges are available upon request.

Model HFM Flowmeters are constructed of 300 series stainless steel.Viton is standard for O-rings & seals. Neoprene and Kalrez are available upon request, for use with corrosive gases.

1.2 Specifications

- Response Time ..... (to 98% of 0-100% step change)Less than 2 seconds
- Accuracy & Linearity ..... ±1% (F.S.)
- Repeatability ..... ±0.2% (F.S.)
- Std. Pressure Rating ..... 500 psig
- High Pressure Option ..... 1000 psig (proof tested to 1500 psig)
- Pressure Coefficient ..... (0-500 psig N_2) 0.01%/psi
- Leak Integrity ..... 10^{-9} sccs
- Temperature Coefficient of Span ..... <0.1% per °C
- Power ..... ±15VDC @ ±50mA
- Flow Signal ..... 0-5.00VDC (inherently linear)
- Wetted Material ..... 316 SS,Viton Seals, Gold/ Nickle Braze
- Connector ..... 15 pin D connector
- FittingsHFM-229, ... 1/4" Swagelok ™
  HFM-230, 1/2" Swagelok ™
- Weight (approx)HFM-229, ... 1.8 lbs.
  HFM-230, 3.3 lbs.

1.3 Accessories

1.3.1 Power Supplies

Hastings' Power Supplies are designed as combination power supplies and digital readout monitors. They can simultaneously power a combination of different Hastings Flow Instruments. The front panel (9.47"H X 3.47"W) allows mounting of two units in a standard 19" rack. A terminal strip on the rear panel provides the user with continuous analog outputs from all channels. All power supplies have a 3-1/2 LCD display.

Models 200 and 400 Power Supplies can accommodate up to two or four Hastings Flow Instruments, respectively, and the Model 40 is for use with flowmeters only, powering up to 4 simultaneously. The Model 40 also features user-adjustable gas conversion factors for direct reading when changing gases. For more information, request Product Bulletin No. 544.

1.3.2 Alarms

The Model AL-1 Flow Alarm is available as an attachment suitable for use with any 0-5.00 VDC input signal. Calibrated digital dial precision pots determine the low and high set points as a percent of full scale. This permits use with any range flowmeter or other instrument having a 0-5.00 VDC linear output signal. Control action is within 0.2% of scale. The AL-1 is available in the panel mount J package.

1.3.3 Totalizer

The Hastings TR-1 Flow Totalizer integrates the 0-5.00 VDC signal generated by the flowmeter to give a total flow reading. Count rates from 0-999 counts per minute are selectable by internal setting. The TR-1 is available in the panel mount J package.

1.3.4 4-20 mA Current Converter

The Hastings Model CC-420 Series Current Converter is an option available with Hastings Mass Flowmeters. The CC-420 produces a 4-20 mA signal from the 0-5.00 VDC output of the flowmeter. The CC-420 is available in the panel mount J package.

This section is designed to assist in getting a new flowmeter into operation as quickly and easily as possible. Please read the following thoroughly before attempting to install the instrument.

2.1 Receiving Inspection:

Carefully unpack the Hastings Flowmeter and any accessories that arrive with it. Inspect it for any obvious signs of damage due to shipment. Immediately advise the carrier who delivered the shipment if any damage is suspected.

Compare each component shipped against the packing list. Ensure that all parts are present (i.e. flowmeter, power supply, cables, etc.). Optional equipment or accessories will be listed separately on the packing list (see Section 1.4 - Accessories). There may also be one or more OPT- options on the packing list. These normally refer to special ranges or special gas calibrations. They may also refer to special helium leak tests or high pressure tests, or special modifications such as high temperature or special O-ring materials. In most cases these are not separate parts, but rather special options or modifications built into the flowmeter or power supply.

2.2 Power Requirements:

All HFM Model Flowmeters require ±15VDC @ ±50 mA max . The 15VDC can vary between 14.25 VDC and 15.75VDC. The supply voltage should be regulated with no more than 50 mV ripple. Surge suppressers are recommended to prevent power line spikes from feeding through to the instruments. These power requirements are satisfied by the Hastings Power Supply described in Section 1.4 - Accessories.

2.3 Output Voltage:

The output of the flowmeter is a 0-5.00VDC signal proportional to the flow rate. The output is sent to the display and is available at terminals at the rear of the Hastings Power Supply. If a Hastings supply is not being used, the output is available on pin 6 of the D connector. It is recommended that the load resistance be no less than 2k Ohms.

2.4 Mechanical Connections:

The transducer may be oriented in any position, as long as the direction of gas flow through the transducer follows the arrow marked on the bottom of the label. The preferred orientation is with the inlet and outlet fittings in a horizontal plane with the connector pointing up.

The smallest passageway encountered on the Hastings HFM Flowmeter is .012" ID, therefore steps should be taken to ensure proper filtering that prevents blockage of these passageways.

There are two 8-32 threaded holes 1/4" deep in the bottom of the transducer that can be used to secure it to a mounting bracket, if desired.

The standard inlet and outlet fittings for the HFM-229 Flowmeter are 1/4" Swagelok. For the HFM-230, the fittings are 1/2" Swagelok. Optional VCR and VCO fittings are available from the factory. Viton O-rings are standard with all fittings; Kalrez and Neoprene O-rings are optional and can be ordered from the factory.

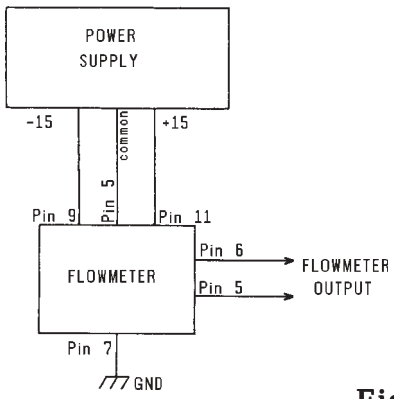


Fig.2.1

The standard inlet and outlet fittings for the HFM-229B Flowmeter are NPT thread in the size of the pipe listed on the drawing on page 22, for sizes up to 3" laminar. On the 4", 6", and 8" laminars, flange fittings are standard. Smooth tubulation is optional on all sizes.

It is suggested that all connections be checked for leaks after installation. This can be done by pressurizing the transducer (do not exceed 500 psig unless the transducer is specifically rated for higher pressures) and applying a diluted soap solution to the flow connections.

2.5 Electrical Connections:

If a power supply was purchased from Hastings Instruments, installation will consist of connecting the cable, purchased separately from the power supply, from the rear of the supply to the top of the flowmeter. If a Hastings supply was not purchased, follow the instructions below to connect up the flowmeter.

The power supply used must be capable of supplying ±15VDC at ±50mA . These voltages must be referenced to a common ground.

Refer to Fig. 2.1. Connect -15VDC to pin 9 and +15VDC to pin 11. Pin 5 is common and must be connected to the common connection at the power supply. Pin 7 is the case ground and it should be connected to the cable shield if available, and to AC ground of the power supply. Pin 6 is the output signal from the flowmeter. This output will be 0-5VDC, 5VDC being 100% of rated or full flow.

2.6 Operation:

2.6.1 Power Supply Operation

Do not connect transducers while the power supply is energized. The display may read either percent of full scale or actual flow rate, depending on the power supply purchased. To read flow rate, turn display switch to desired channel.

2.6.2 Ambient Temperature

In order to maintain the accuracy of the flowmeter with changes in ambient temperature, it is necessary to keep the temperature of the transducer between 0°C and 50°C. Since some of the temperature shift results in a slight zero offset, better results are obtained if the flowmeter is re-zeroed at the operating temperature. The flowmeter calibration may change by a factor up to 0.1%/°C. Hastings Mass Flowmeters are for *GAS* flow, so *DO NOT* let the temperature and/or pressure of the gas reach a point that would cause the gas to change to a liquid state, or erroneous indications will result.

2.6.3 Zero Check

Turn the power supply "ON". Allow the flowmeter 10 minutes to warm up. Stop all flow through the transducer and check electrical zero.

CAUTION: Do not assume that all metering valves will completely shut off flow. Even a slight leakage through a valve will cause an indication on the meter which will falsely appear to be a zero shift.

If necessary, adjust the "ZERO" potentiometer, located on the lower inlet side of the transducer, until the meter indicates zero. This zero should be checked periodically during normal operation.

2.7 Range Changing:

The range of the flowmeter can be changed in the field if recalibration facilities are available. The instructions to change the flow range can be found in Section 4.5. In order to change the range of a Model HFM-230 Flowmeter, a new laminar flow element must be purchased from the factory.

This section contains an overall functional description of Model HFM Flowmeters. Detailed schematics and parts lists can be found at the end of the manual in Section 6.0. In this section and other sections throughout this manual, when a power supply is mentioned, it is assumed that the customer has a Hastings Power Supply. These sections are not applicable if another type of power supply is used.

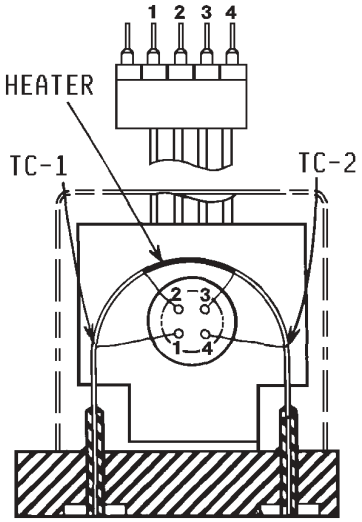


Fig.3.1

3.1 Overall Functional Description

The HFM Flowmeter consists of a sensor, electronic circuitry, and a shunt. The sensor measures the flow rate from 0 to 10 sccm of the gas to be metered. The shunt divides the flow such that the flow through the sensor is a precise percentage of the flow through the shunt. The flow through the sensor and the shunt is always laminar. The circuit board amplifies the sensor output to 5.00 VDC and sends it to the power supply to display. All of these components working together result in a fast, stable flowmeter.

3.2 Sensor

The Hastings Model HFM Mass Flowmeter operates on a unique thermal electric principle whereby a metallic capillary tube is heated uniformly by a resistance winding attached to the mid-point of the capillary (see Figure 3.1). Thermocouples TC-1 and TC-2 are welded at equal distances from the mid-point and develop equal outputs at zero flow.

When flow occurs through the tubing, heat is transferred from the tube to the gas on the inlet side, and from the gas back to the tube on the outlet side creating an asymmetrical temperature distribution (see Figure 3.2). The thermocouples sense this decrease and increase in the capillary tube temperature, and produce a millivolt output signal proportional to that change.

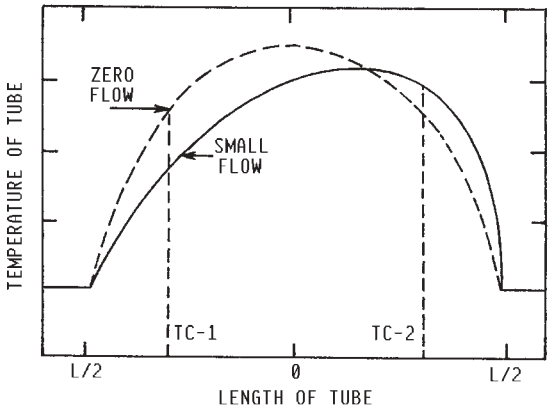


Fig.3.2

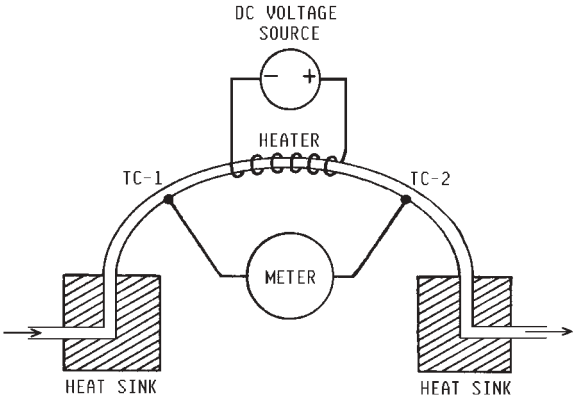


Fig.3.3

For a constant power input, the differential thermocouple output is a function of the mass flow rate and the heat capacity of the gas. Since the heat capacity of many gases is relatively constant over wide ranges of temperature and pressure, the flowmeter may be calibrated directly in mass units for those gases. Changes in gas composition usually only require application of a simple multiplier to the air calibration to account for the difference in heat capacity, and thus the flowmeter is capable of measuring a wide variety of gases.

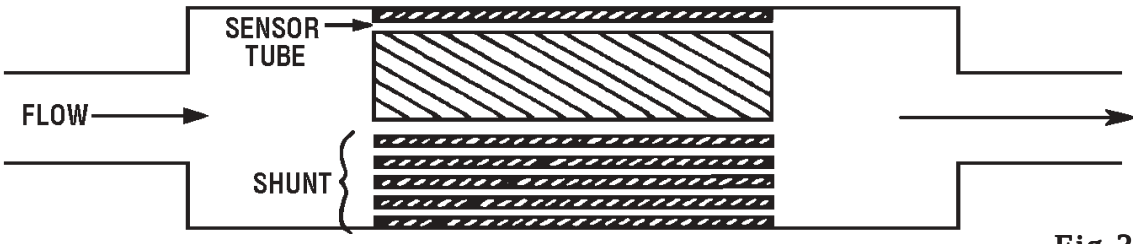


Fig.3.4

3.3 Electronics

The Fast Response Model HFM uses a thermal flow sensor to measure flow through a capillary tube, which is a fixed percentage of the total flow through the instrument. This sensor develops an output signal proportional to flow which is approximately 0.8 mv full scale magnitude (see Figure 3.3). This signal is amplified by the meter circuitry until it is 0-5.00 VDC. This 5 volt output is sent back to the power supply and to the flowmeter circuitry, if applicable. At the power supply the 5 volt output is sent to the terminals on the back and to the decoding circuitry in the display which converts it to a 3-1/2 digit output.

The Fast Response Model HFM uses additional electronics to achieve fast response characteristics by amplifying the rate of change of the input signal, and adding it to the amplified input signal. The electronics are adjusted to provide response times of less than two seconds to 98% of a 0-100% step change with less than 2% overshoot. The electronics also maintain the ouput signal above 5.00 VDC when the flowrate exceeds the full scale flow of the flowmeter.

NOTE: *The output signal will continue to increase above 5.00 VDC as the flow rate exceeds full scale flow, however, the output above 5.00 VDC is non-linear and should not be used for flow measurement.*

3.4 Shunt

Higher measurement of flow rates is achieved by dividing the flow with a fixed ratio shunting arrangement, as is illustrated in Figure 3.4. This is accomplished by placing the measuring capillary tube parallel with one or more dimensionally similar channels, called a laminar flow element (LFE). Therefore, the sensor only needs to heat the gas passing through the capillary tube resulting in low power requirements, while retaining all the mass measuring characteristics.

The HFM-229 has two possible shunts. The low range shunt consists of tubes inserted into a cylindrical base. This shunt is adjustable for ranges from 0-10 sccm to 0-250 sccm (see Figure 3.5). The higher range shunt consists of a corrugated stainless steel ribbon wound into a coil and fused. The higher range shunt is adjustable from 0-0.3 slpm to 0-30 slpm ranges (Figure 3.6).

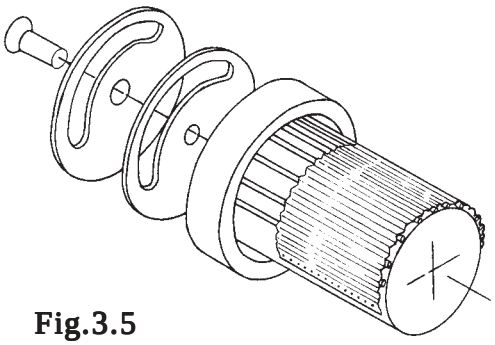


Fig.3.5

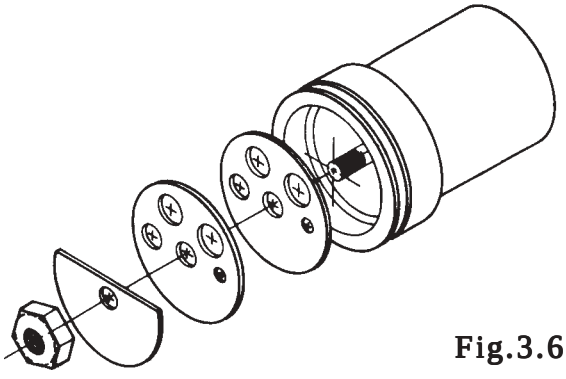


Fig.3.6

The HFM-230 uses a shunt which is a corrugated and fused shunt similar to the shunt used in the lower flow range instruments (see Figure 3.7). This highest range shunt is adjustable from 0- 50 slpm to 0-500 slpm.

The HFM-229B Series uses an external laminar flow element instead of an internal shunt, because the necessary size for the element exceeds the body size of the flowmeter. This laminar flow element is made of a corrugated and fused stainless steel ribbon similar to the one used in the Model HFM-230.

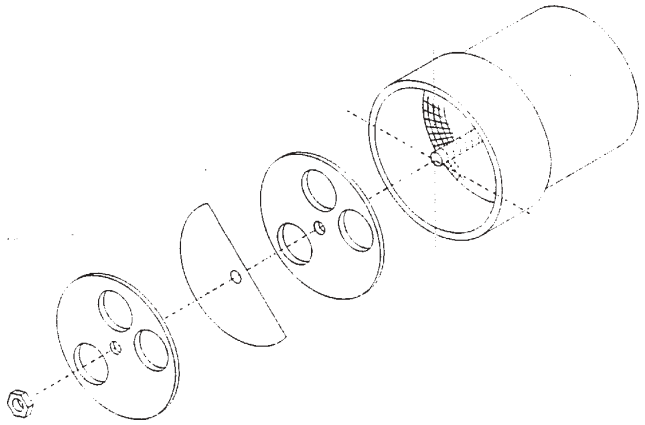


Fig.3.7

4.1 Introduction:

This section contains service and calibration information. Some portions of the instrument are delicate. Use extreme care when servicing the flowmeter. The potentiometer positions and the electrical components referred to in the troubleshooting section can be found in Section 6.0 on the electrical component layout drawing.

4.2 Authorized Maintenance:

With proper care in installation and use, the flowmeter will require little or no maintenance. If maintenance does become necessary, most of the instrument can be cleaned or repaired in the field. Some procedures may require recalibration. Do not attempt these procedures unless facilities are available. Entry into the sensor or tampering with the printed circuit board will void warranty. Do not perform repairs on these assemblies while unit is still under warranty.

4.3 Adjustments:

4.3.1 Calibration Procedure

1. Connect power cable to D connector as specified in Section 2.5. Allow instrument to warm up for 30 minutes with all flow shut off.

2. Set ZERO potentiometer for 0.000 VDC output at pin 6 on the D connector or flow output pin on the rear of the Hastings Power Supply.

3. Turn on air supply to inlet of instrument. Adjust flow rate to 100% according to flow reference.

4. Adjust SPAN pot until the flowmeter indicates full scale flow (5.000 VDC). NOTE: Perform this step only if a calibrated reference flowmeter is available.

5. Record flowmeter and flow reference outputs for flow rates of 20%, 40%, 60%, 80%, and 100%.

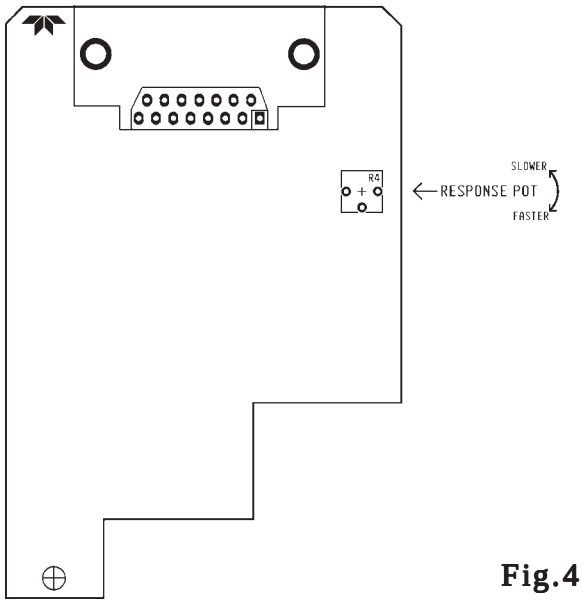


Fig.4.1

4.3.2 Response Time Adjustments

Readjustments of the fast response circuit should not be necessary unless changes in the range or sensor have been performed. The flowmeter should be calibrated before setting the response time.

IMPORTANT: Response time cannot be tested with a simple shutoff valve. Pressure builds up behind the valve, and when opened creates a surge flow in excess of the calibrated flow rate. What must be used is a two-way valve or a fitting which can be quickly connected and provide a leak-free seal to the flowmeter inlet. The reference flow is vented to atmosphere, and switches through the flowmeter when the valve is operated or fitting is connected. The valve or fitting should be close coupled to the flowmeter inlet to reduce pneumatic time delays. The response pot is not accessible from the exterior of the flowmeter. The cover must be removed to make any adjustments. See Fig. 4.1.

Using a voltmeter, strip chart recorder, or oscilloscope connected to the flow output voltage, switch flow through the flowmeter and observe output voltage. Adjust response pot to increase or decrease response time. The response pot is a single turn pot and a small pot adjustment produces a large response time change. Remove flow from flowmeter and allow output voltage to reach zero volts. Repeat test until response time is set.

4.3.3 Miscellaneous Adjustments

Periodically, during normal operation, the ZERO should be checked and adjusted when required.

4.4 End Cap Removal

The end cap on the inlet side must be removed to gain access to the filter or shunt assembly. First shut off the supply of gas to the instrument. Disconnect the Swagelok fitting on the inlet and outlet sides of the instrument. Remove the four hex bolts holding the end cap to the instrument (see Figure 4.2). Carefully remove the end cap, filter, wave spring and shunt, noting their order and proper orientation. NOTE: The Model HFM-230 does not include a wave spring. The shunt can be severely damaged if dropped. Examine the filter and shunt. If either is dirty or blocked, clean or replace as applicable. Reassembly is the reverse of the removal procedure.

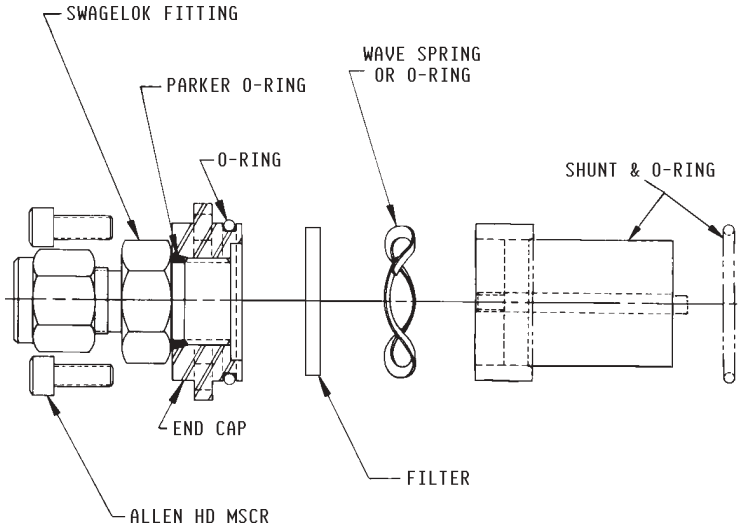


Fig.4.2

NOTE: When reinstalling the small range shunt, ensure that corrugated side is down.

4.5 Range Changes

Remove end cap and shunt assembly per Section 4.4 above. The 0-10 sccm to 0-300 sccm range shunt has tubes, while the medium range shunt is built from a coil of corrugated stainless steel foil. The medium range shunt has a disk assembly with two large, one medium, and one small hole. To change ranges, the disc on the inlet of the shunt should be loosened, turned and retightened to expose the number of holes or tubes as listed below for the range desired.

SIZE	RANGE	SHUNT SETUP
SMALL	0-10 sccm	0 tubes
	0-30 sccm	1 tube
	0-50 sccm	2 tubes
	0-100 sccm	4 tubes
	0-250 sccm	10 tubes
MEDIUM	0-.3 slpm	smallest hole
	0-1 slpm	medium hole
	0-3 slpm	1 large and small hole
	0-5 slpm	both large holes
	0-10 slpm	half-washer
	0-30 slpm	washer removed
LARGE	0-50 slpm	1 hole
	0-100 slpm	2 holes
	0-150	slpm3 holes
	0-300	slpmwasher removed
	0-500	slpm washer removed

***NOTE**: These ranges are for Air at Standard Temperature and Pressure.*

4.6 Printed Circuit Board Replacement

In the unlikely event that the PC board fails, it is easily removed from the instrument and replaced with a spare to minimize instrument downtime. Replacement of the PC board will require the instrument to be recalibrated per Section 4.3.1.Unplug the power cable from the top of the transducer. Remove the two screws on the side of the cover. Lift off the cover and unplug the four-wire sensor plug noting the orientation prior to removal. Remove the screw that holds the PC board to the sensor. Troubleshoot or replace as applicable. Installation is the reverse of the above procedure. Recalibrate if any components were changed or if any potentiometers were adjusted.

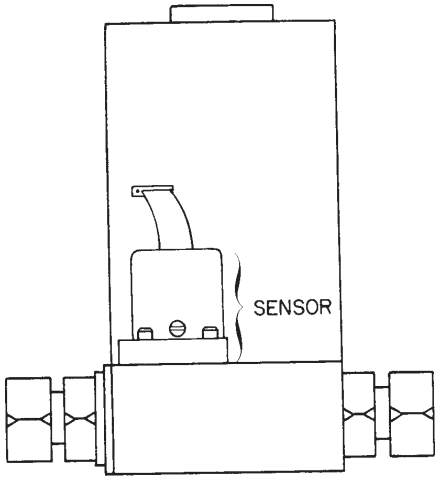


Fig.4.3

4.7 Sensor Replacement

If the sensor fails or becomes plugged it can be removed. Remove the cover and the PC board per Section 4.6 above. Remove the three bolts holding the sensor to the instrument base. Remove the sensor from the base noting the two O-rings (Parker 2-005, V884-75) between the sensor and the base. See Figure 4.3. If the sensor is plugged it can be cleaned by running a fine wire (approximately 0.008" diameter) through the tube. If sensor needs replacement, obtain another from the factory and install it. Ensure that O-rings are clean and intact. Install O-rings on seating surface, then carefully place sensor over O-rings, and tighten down the three screws evenly. Replacement of sensor will require recalibration per Section 4.3.1.

4.8 Troubleshooting

SYMPTOM: Output reads 40% of flow with no flow. Zero pot has no effect.

CAUSE: Power supply locked up or shorted out.

ACTION: Turn off power supply for a few seconds, then turn back on. If this proves ineffective, disconnect the unit from the power supply. If power supply display does not return to zero, then a regulator chip in the power supply is probably burned out.
Check supply voltages and replace faulty regulator. If display returns to zero after disconnecting the power supply from the unit there is a short in the unit to ground. Check capacitors C11 & C13 first.

SYMPTOM: Output of unit is proportional to flow but extremely small and not correctable by span pot.

CAUSE: Sensor is not being heated.

ACTION: Unplug sensor from PC board (Fig. 4.3). Pins on sensor are numbered from left to right. Begin counting with second pin from left (see Fig. 4.4). Check the resistance between pins 2 & 3 of the sensor. This will read between 2450 & 2550. Check the resistance between pins 1 & 4 of the sensor. This should read approximately 2.3 ohms. If this reads open circuit, sensor was probably plugged into PC board improperly and one of the thermocouples has been destroyed. Replace sensor. Check the resistance between pin 2 and the base of the sensor. This should be an open circuit. Repeat for pin 3 and the base. If resistance readings are correct but sensor is not indicating flow, the sensor is probably plugged; clean or replace as applicable.

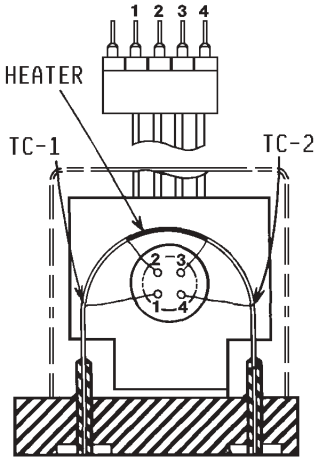


Fig.4.4

SYMPTOM: Sensor has proper resistance readings, but little or no output with flow.

CAUSE: Plugged sensor.

ACTION: Shut off gas supply and power supply. Remove cover and PC board from unit. Remove sensor assembly and examine. If sensor has evidence of plugging, clean or replace as applicable.

SYMPTOM: Flowmeter reads other than 0.00 VDC with no flow, or there is a small flow when flowmeter reads 0.00 VDC.

CAUSE: ZERO potentiometer is out of adjustment.

ACTION: Shut off all flow. Adjust ZERO potentiometer until output reads 0.00 VDC.

SYMPTOM: Flowmeter out of calibration and non-linear.

CAUSE: Leaks in gas inlet or outlet fittings.

ACTION: Check all fittings for leaks by placing soap solution on all fittings between gas supply and final destination of gas. Check flowmeter for leaks. Replace "O" rings if required or recalibrate as necessary.

5.0 REPLACEMENT PARTS

The following is a list of the available replacement parts and their factory stock numbers. The HFM-229, HFM-229B, HFM-200, HFM-200B, and the HFC-202 shunts and filter discs are interchangeable. The HFM-230, HFM-201, and the HFC-203 shunts and filter discs are also interchangeable. The same sensor module is used on all of the above models.

STOCK NO.	DESCRIPTION	AIR RANGE
81-102L	LOW RANGE SHUNT	10, 30, 50, 100, 250 SCCM
81-102H	MED RANGE SHUNT	0.3, 1, 3, 5, 10, 30 SLPM
81-102B	HIGH RANGE SHUNT	50, 100, 150, 300, 500 SLPM
65-140E	LFE Model LS-2, 2.0" NPTM	0-750 SLPM
65-140G	LFE Model LS-3, 3.0" NPTM	0-1500 SLPM
65-140J	LFE Model LS-4F, 4.0" Flange	0-3000 SLPM
65-140K	LFE Model LS-6F, 6.0" Flange	0-6000 SLPM
65-140L	LFE Model LS-8F, 8.0" Flange	0-15,000 SLPM
39-02-003	SMALL FILTER DISC	HFM-229, HFM-229B, AND HFC-202
39-02-002	LARGE FILTER DISC	HFM-230 AND HFC-203
81-105	SENSOR MODULE	ALL MODELS
65-595	FAST RESPONSE HFM ELECTRONICS CARD	D CONNECTOR
81-115	VITON O-RING KIT FOR HFM-200 and 200B	
81-116	VITON O-RING KIT FOR HFM-201	
81-146	KALREZ™ O-RING KIT FOR HFM-200 and 200B	
81-147	KALREZ™ O-RING KIT FOR HFM-201	
81-150	NEOPRENE O-RING KIT FOR HFM-200 and 200B	
81-151	NEOPRENE O-RING KIT FOR HFM-201	

***NOTE**: Ranges listed are for same standard temperature and pressure.*

To place an order or to obtain information concerning replacement parts, contact the factory or our local manufacturer's representative in your area. See below, or this manual's last page for the address or phone number. When ordering, include the following information:

- Instrument model number
- Part description
- Hastings part number

Warranty Policy

Hastings Instruments warrants this product for a period of one year from the date of shipment to be free from defects in material and workmanship. This warranty does not apply to defects or failures resulting from unauthorized modification, misuse or mishandling of the product. This warranty does not apply to batteries or other expendable parts, nor to damage caused by leaking batteries or any similar occurrence. This warranty does not apply to any instrument which has had a tamper seal removed or broken.

This warranty is in lieu of all other warranties, expressed or implied, including any implied warranty as to fitness for a particular use. Hastings Instruments shall not be liable for any indirect or consequential damages.

Hastings Instruments will, at its option, repair, replace or refund the selling price of the product if Hastings Instruments determines, in good faith, that it is defective in materials or workmanship during the warranty period. Defective instruments should be returned to Hastings Instruments together with a written statement of the problem and a Return Material Authorization (RMA) number. Please consult the factory for your RMA number before returning any product for repair.

Non-Warranty Repair Policy

Any product returned for a non-warranty repair must be accompanied by a purchase order, RMA form and a written description of the problem with the instrument. If the repair cost is higher, you will be contacted for authorization before we proceed with any repairs. If you then choose not to have the product repaired, a minimum will be charged to cover the processing and inspection. Please consult the factory for your RMA number before returning any product for repair.

TELEDYNE HASTINGS

804 NEWCOMBE AVENUE

HAMPTON, VIRGINIA 23669 U.S.A.

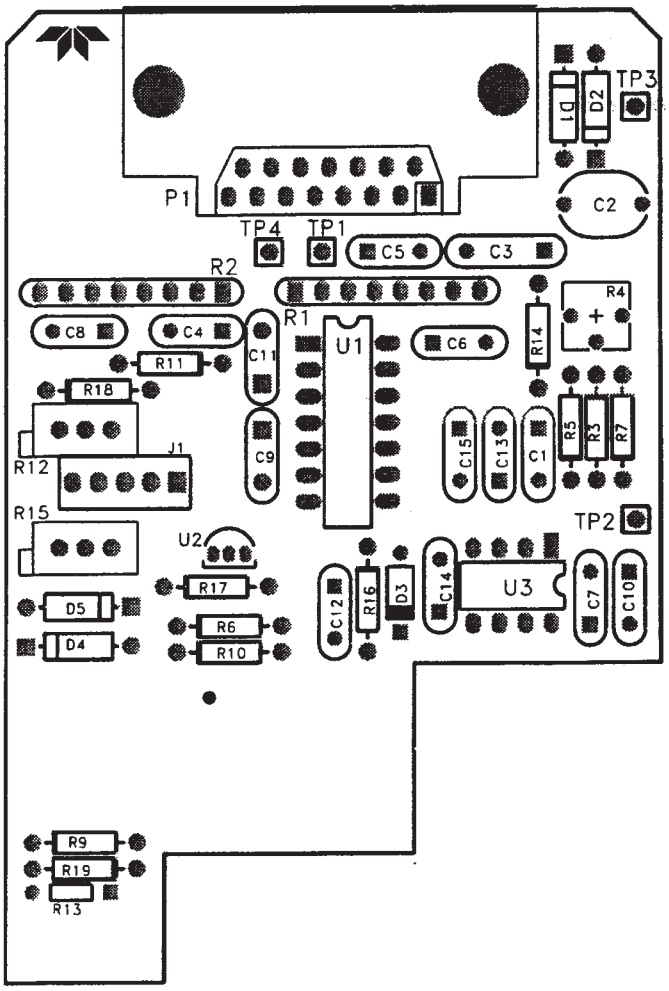
ATTENTION: REPAIR DEPARTMENT

TELEPHONE	(757) 723-6531
	1-800-950-2468
FAX	(757) 723-3925

7.0 Diagrams and Drawings

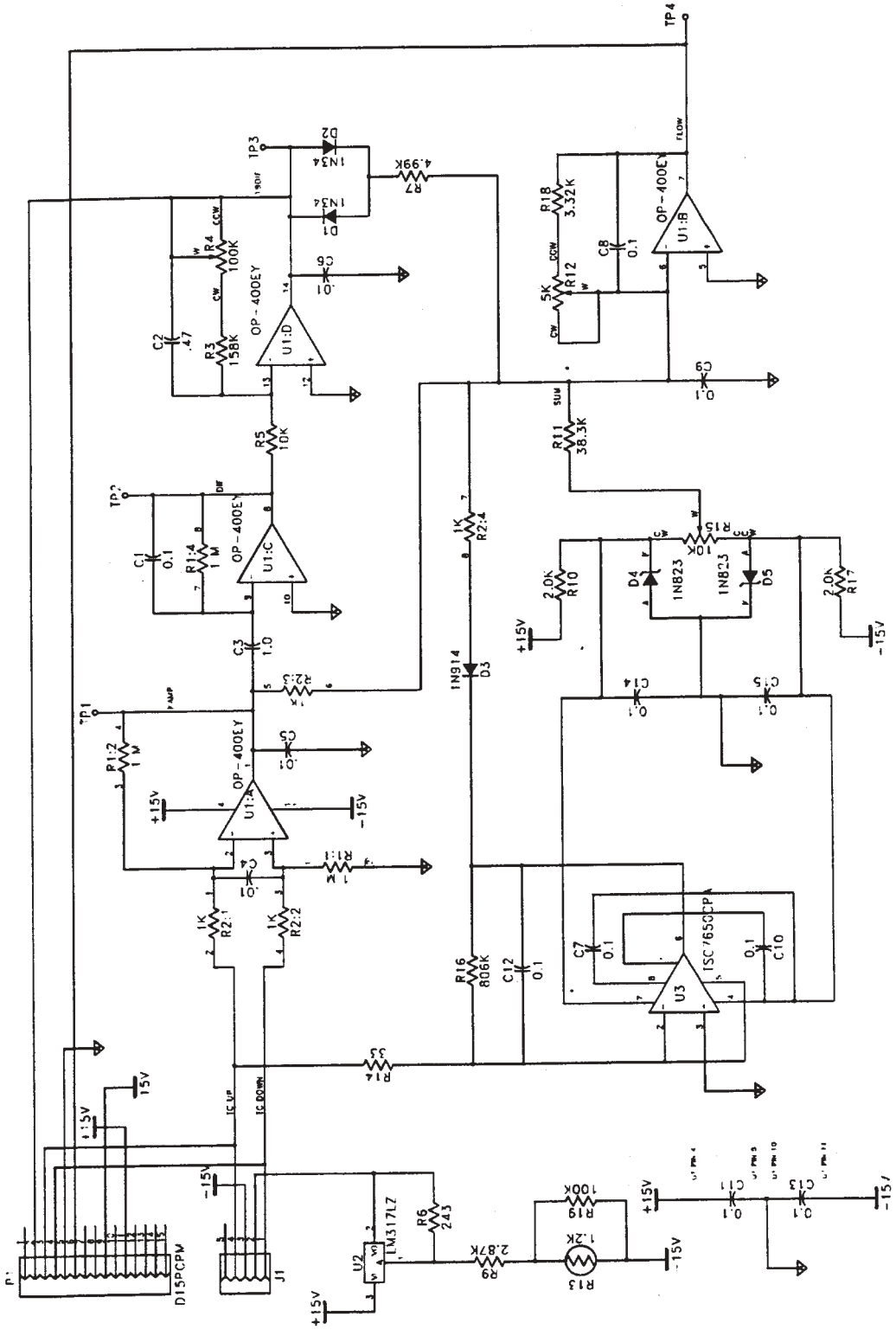
NOTES

1. STATIC SENSITIVE COMPONENTS. HANDLE ONLY AT APPROVED ESD WORKSTATION.



ITEM NO	QTY REQD	FSCM NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	REF/DWG NO.
[illegible]	1	[illegible]	18-01-380	RES. 3.32 KOHM, 1/8 WATT, 1%	R15
[illegible]	[illegible]	[illegible]	18-01-301	RES. 158 KOHM, 1/8 W, 1%	R3
[illegible]	[illegible]	[illegible]	56-02-084	IC OP-400FJ QUAD OPP AMP	U1
[illegible]	[illegible]	[illegible]	56-01-086	IC TSC7650CPA CHOPPER AMP	U3
[illegible]	[illegible]	[illegible]	56-02-076	IC LM317LZ VAR REG TO92 CASE	U2
[illegible]	[illegible]	[illegible]	40-01-011	TEMPSISTOR [illegible]K OHM 7000PPM TCR	R13
[illegible]	4	[illegible]	28-10-100	TEST PT,2A,TP103-03,COMP CORP	TP1,2,3,4
[illegible]	[illegible]	[illegible]	26-04-810A	PC-810 BARE ETCHED BOARD	30836
[illegible]	[illegible]	[illegible]	19-05-[illegible]	POT 100K OHM 1 1/4 SQ ONE TURN	R4
[illegible]	[illegible]	[illegible]	19-05-[illegible]	POT 10K OHM 3/8 SQ SIDE ADJUST	R15
[illegible]	[illegible]	[illegible]	19-05-044	POT 5K OHM 3/8 SQ SIDE ADJUST	R12
[illegible]	1	[illegible]	18-36-002	RES NETWORK (4) 1M OHM ISOLATED	R1
[illegible]	1	[illegible]	18-36-001	RES NETWORK (4) 1K OHM ISOLATED	R2
[illegible]	1	[illegible]	18-02-498	RES CARB 33 OHM 1/4 WATT 5%	R14
[illegible]	1	[illegible]	18-01-363	RES 243 OHM 1/4 WATT 1% MTL FLM	R6
[illegible]	1	[illegible]	18-01-341	RES 100K OHM 1/8 WATT 1%	R19
[illegible]	1	[illegible]	18-01-334	RES 2870 OHM 1/8 WATT 1%	R9
[illegible]	1	[illegible]	18-01-340	RES 806K OHM 1/8 WATT 1%	R16
[illegible]	2	[illegible]	18-01-274	RES 2000 OHM 1/8 WATT 1%	R10,R17
[illegible]	1	[illegible]	18-01-273	RES 4990 OHM 1/8 WATT 1%	R7
[illegible]	1	[illegible]	18-01-272	RES 10K OHM 1/8 WATT 1%	R5
[illegible]	1	[illegible]	18-01-261	RES 38.3K OHM 1/4 WATT 1% AXLD	R11
[illegible]	[illegible]	[illegible]	16-28-014	CONN MALE "D" 15 PIN RT ANGLE	P1
[illegible]	1	[illegible]	16-20-046	SOCKET STRIP 20 POS SS-120-T-2	J1
[illegible]	[illegible]	[illegible]	13-01-110	DIODE IN914	D3
[illegible]	2	[illegible]	13-01-080A	DIODE IN-823 ZENER MOT.	D4,D5
[illegible]	2	[illegible]	13-01-073	DIODE IN34A ITT	D1,D2
[illegible]	10	[illegible]	11-09-062	CAP 1MFD 50V	C1,C7-C15
[illegible]	1	[illegible]	11-09-064	CAP 47MFD 50V	C2
[illegible]	3	[illegible]	11-01-169	CAP .01UFD 25V DISC	C4,C5,C6
[illegible]	1	[illegible]	11-09-063	CAP SM 1MFD	C3

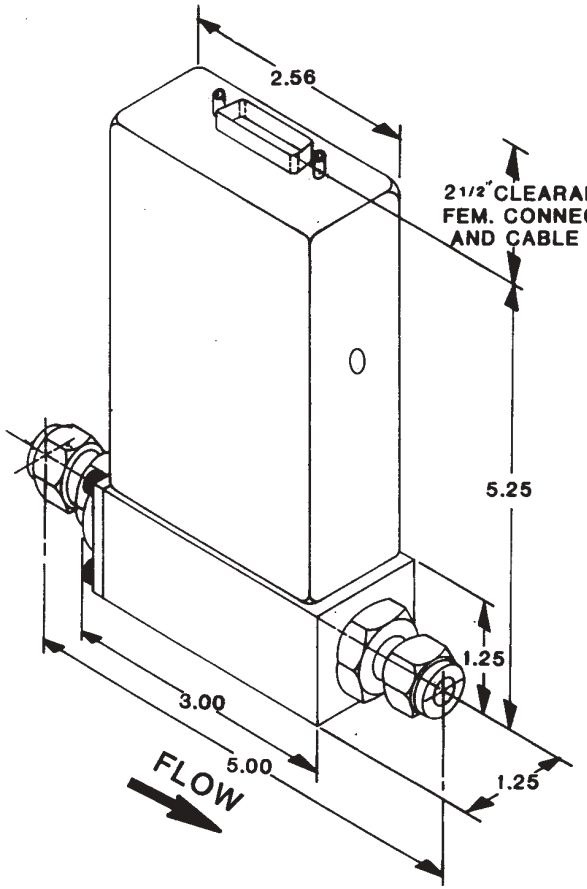
PARTS LIST

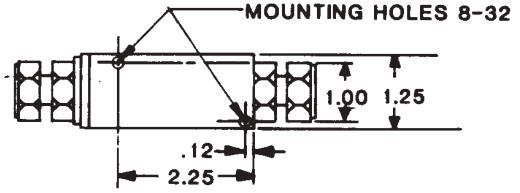


PC-810 Schematic

(Information from Hastings drawing 30837 rev. F)

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
A	NEW ISSUE	10/19/87	AC Guinto
B	PER CAR #00283	11/16/87	AC Guinto
C	PIN 12 TO N/C, ECN 247	10/9/89	REG
D	REVISED PER ECN 435	9-7-91	WWA

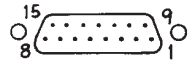




FLOW

MOUNTING HOLES

(BOTTOM VIEW)



PIN NO.	SIGNAL
1	N/C
2	N/C
3	INPUT TC
4	OUTPUT TC
5	COMMON
6	OUTPUT SIGNAL
7	SHIELD
8	N/C
9	-15V DC
10	N/C
11	+15V DC
12	N/C
13	N/C
14	N/C
15	N/C

NOTE:
PINS #3 AND #4 ARE FOR MFG. AND PLANT TESTING ONLY.

QTY REQD	FSCM NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL SPECIFICATION

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS ± DECIMALS .XX ± .XXX ± ANGLES ±

MATERIAL

FINISH

DO NOT SCALE DRAWING

CONTRACT NO.

APPROVALS	DATE
DRAWN S.M. KIRBY	10-19-87
CHECKED C. GUINGONA	10-19-87
ISSUED	10-19-87
	10/19/87

NEXT ASSY | USED ON

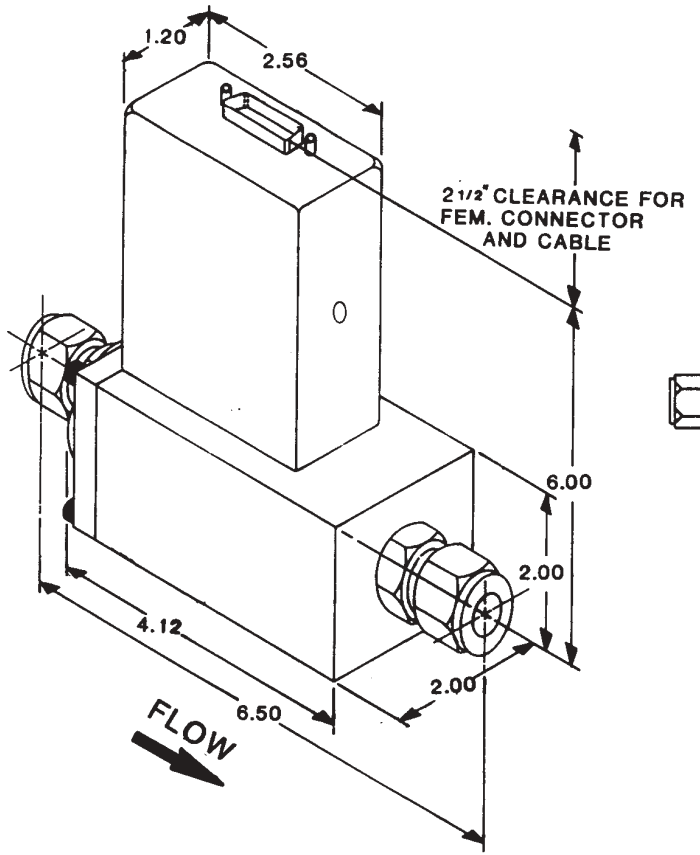
APPLICATION

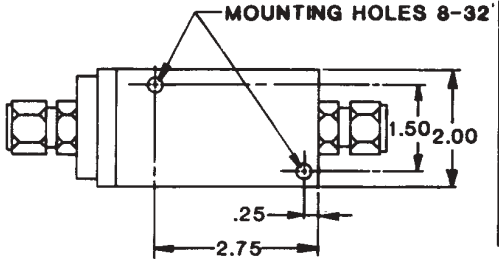
OUTLINE DWG. HFM-200 FLOW METER

SIZE	FSCM NO.	DWG. NO.	REV.
B		30369	D

SCALE NONE | SHEET 1 OF 1

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
A	NEW ISSUE	10/19/87	[illegible]
B	PER CAR #00283	10/19/87	[illegible]
C	PIN 12 TO N/C, ECN 247	10/9/89	[illegible]
D	REVISED PER ECN 435	7-4-91	[illegible]

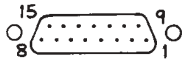




FLOW

MOUNTING HOLES

(BOTTOM VIEW)



PIN NO.	SIGNAL
1	N/C
2	N/C
3	INPUT TC
4	OUTPUT TC
5	COMMON
6	OUTPUT SIGNAL
7	SHIELD
8	N/C
9	-15V DC
10	N/C
11	+15V DC
12	N/C
13	N/C
14	N/C
15	N/C

NOTE:
PINS #3 AND #4 ARE FOR MFG. AND PLANT TESTING ONLY

QTY REQD	FSCM NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL SPECIFICATION

PARTS LIST

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS ± DECIMALS .XX ± .XXX ± ANGLES ±

MATERIAL

FINISH

DO NOT SCALE DRAWING

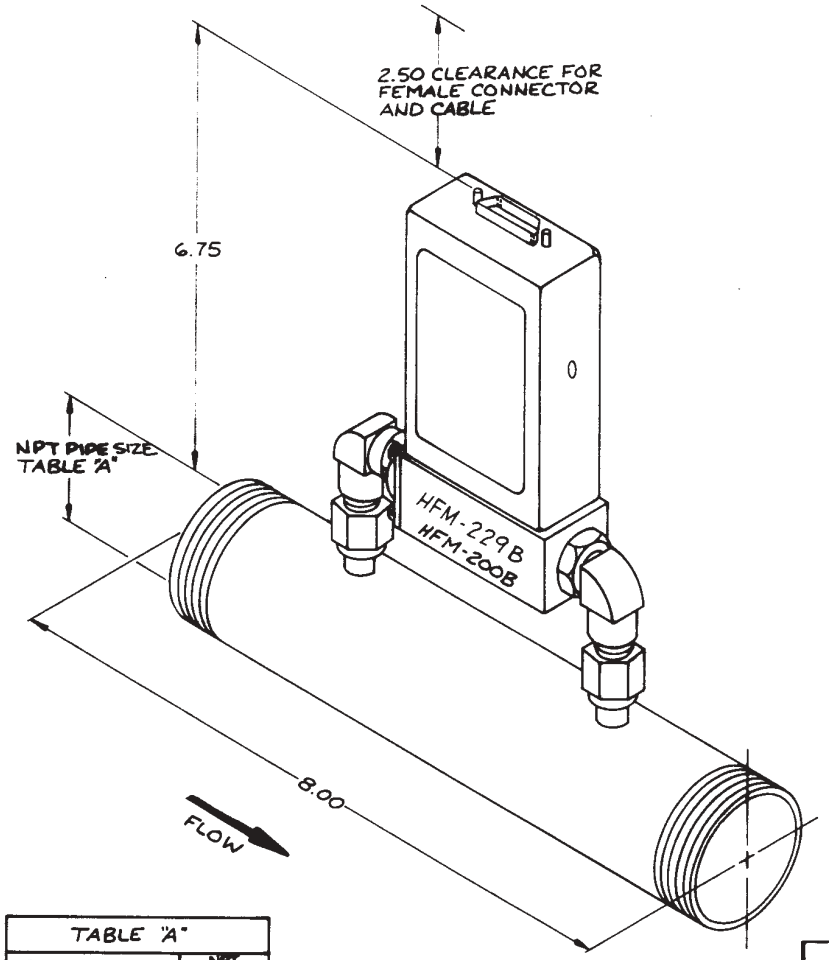
CONTRACT NO.

APPROVALS	DATE
DRAWN S.M. KIRBY	10-19-87
CHECKED C. GUINGONA	10-19-87
ISSUED [illegible]	10-19-87
[illegible]	10-19-87

OUTLINE DWG. HFM-201 FLOWMETER

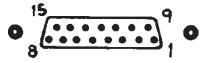
SIZE B | FSCM NO. | DWG. NO. 30370 | REV. D

SCALE NONE | SHEET 1 OF 1



REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
A	INITIAL ISSUE	5/2/89	
B	PIN 12 TO N/C. ECN 247	10/9/89	
C	REVISED PER ECN 435	7-4-91	
D	REVISED PER ECN 579	1-21-93	
E	REVISED PER ECN 662	3/2/93	

PIN NO.	SIGNAL
1	N/C
2	N/C
3	INPUT TC
4	OUTPUT TC
5	COMMON
6	OUTPUT SIGNAL
7	SHIELD
8	N/C
9	-15V DC
10	N/C
11	+15V DC
12	N/C
13	N/C
14	N/C
15	N/C



NOTES:
1. PINS 3 AND 4 ARE FOR MANUFACTURER'S AND PLANT TESTING ONLY.
2. THESE ARE SMOOTH-END VERSIONS OF STANDARD FLANGED LAMINARS. OVERALL LENGTH = 10.00 ± .25"

TABLE "A"	
FLOW RANGE	NPT PIPE SIZE
450-750 SLPM	2"
850-1500 SLPM	3"
* 3000 SLPM	4"
* 6000 SLPM	6"
* 15000 SLPM	8"

* SEE NOTE 2.

	QTY REQD	FSCM NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION / MATERIAL SPECIFICATION
				PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:
FRACTIONS ± N/A DECIMALS .XX ± .01 .XXX ± .005 ANGLES ± 2°
MATERIAL
FINISH
DO NOT SCALE DRAWING

STOCK NO.

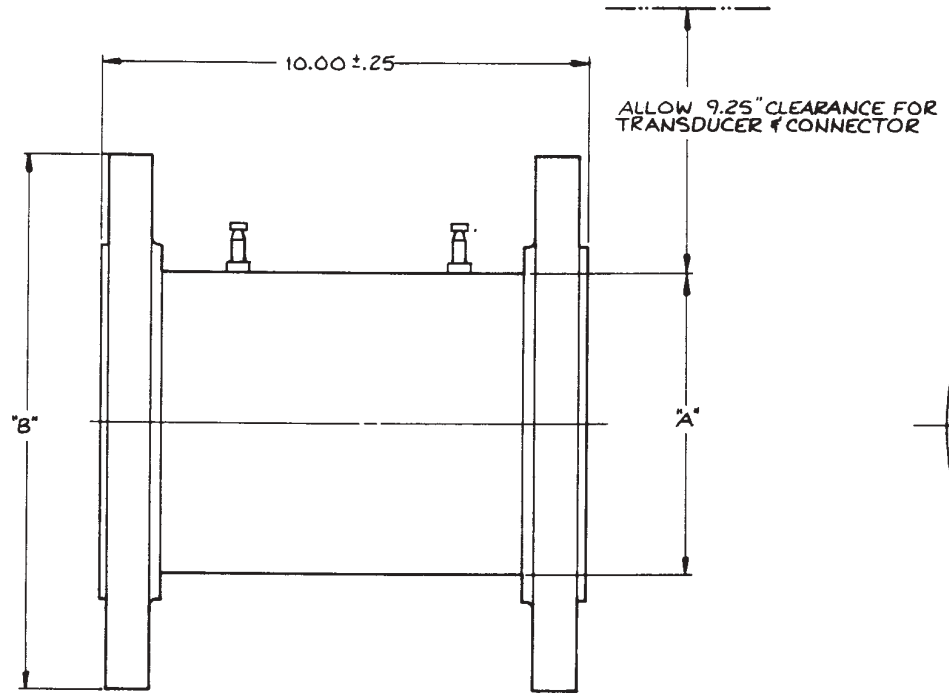
APPROVALS	DATE
DRAWN W.J. Pittsley	7-26-89
CHECKED	8-2-89
PROJ ENG	
ENG MGR	8/2/89

OUTLINE DIAGRAM - LAMINAR FLOW ELEMENT
HFM 200B - HFM 229B

SIZE B | FSCM NO. | DWG. NO. 30175 | REV. E
SCALE NTS | SHEET 1 OF 1

NEXT ASSY	USED ON
APPLICATION	

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
A	INITIAL ISSUE	5/2/89	



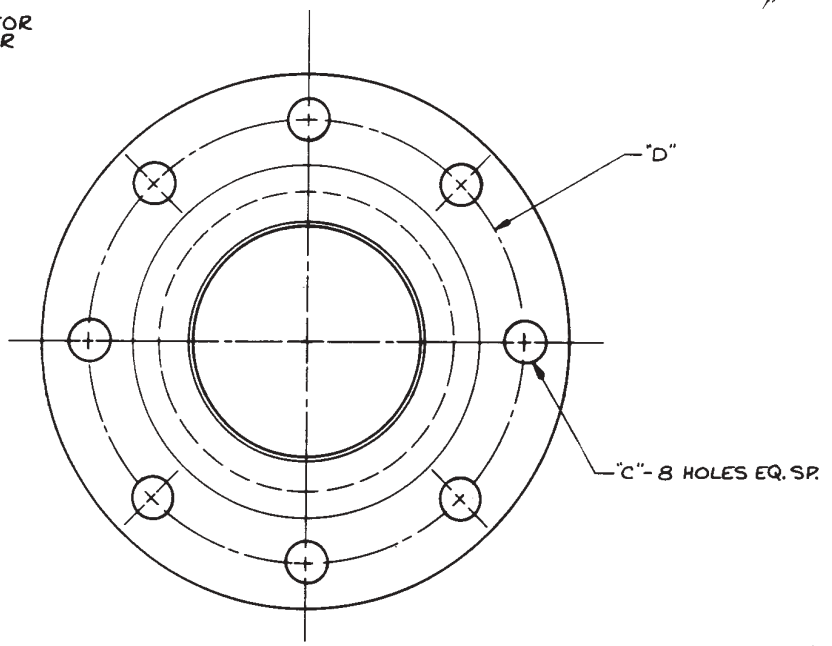


TABLE "A"

STOCK NO.	MODEL NO.	FLOW RANGE	"A" PIPE SIZE	"B" FLANGE O.D.	"C" HOLE DIA.	"D" BOLT CIRCLE
65-140J	LS-4F	3000 SLPM	4"	9.00"	.688, 8 PL	7.500"
65-140K	LS-6F	6000 SLPM	6"	11.00"	.813, 8 PL	9.500"
65-140L	LS-8F	15000 SLPM	8"	13.50"	.813, 8 PL	11.750"

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS ± N/A DECIMALS .XX ± .01 .XXX ± .005 ANGLES ± 2°

MATERIAL

FINISH

DO NOT SCALE DRAWING

STOCK NO. SEE TABLE "A"

APPROVALS	DATE
DRAWN	7/31/89
CHECKED	8-2-89
PROJ. ENG.	8-2-89
ENG. MGR.	8-2-89

OUTLINE DIAGRAM
LAMINAR FLOW ELEMENT
"LS" SERIES FLANGED

SIZE	FSCM NO.	DWG. NO.	REV.
B		30180	A

SCALE NTS SHEET 1 OF 1