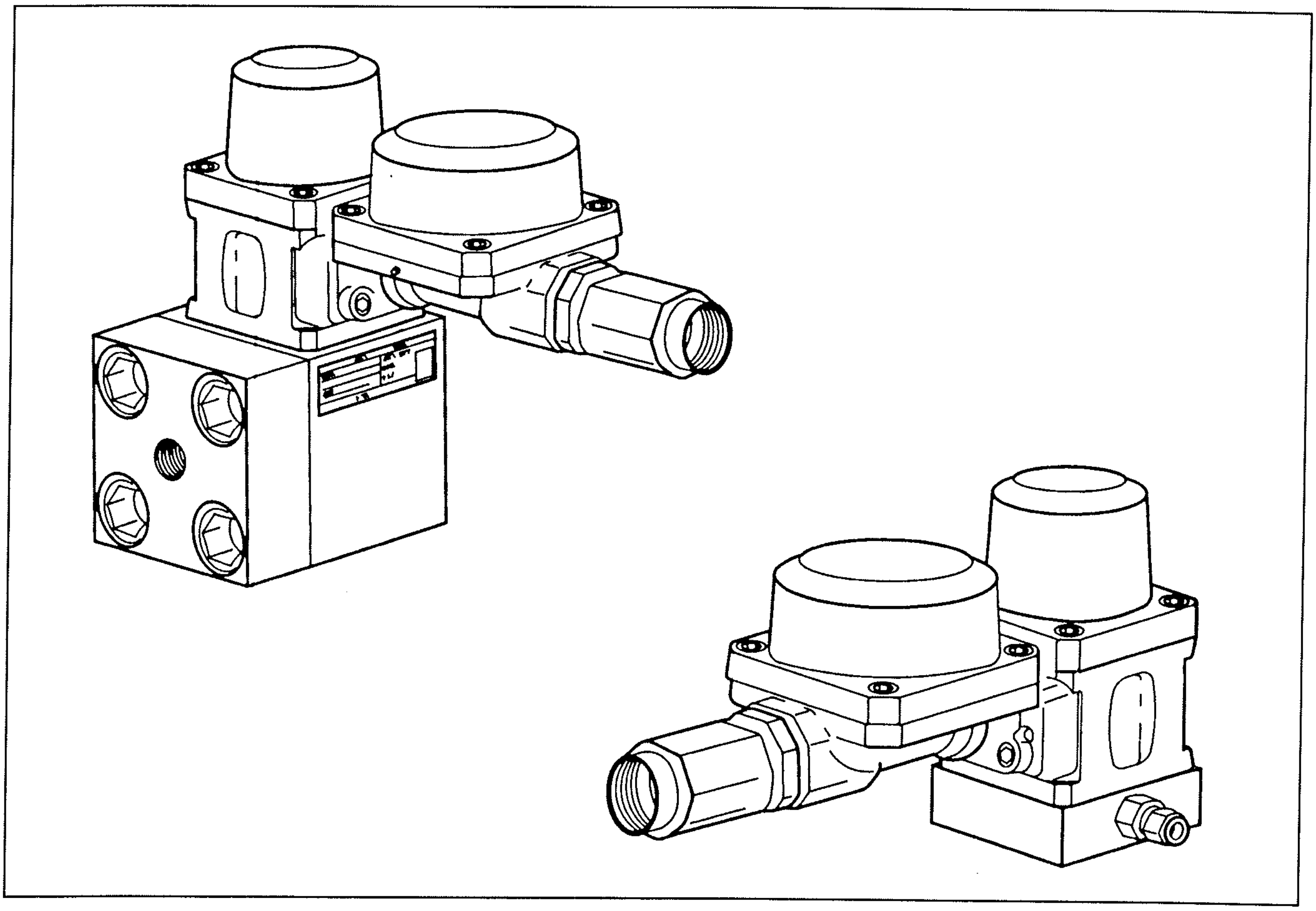
INSTRUCTIONS

OVAL

Ins.No. L-502-3-E

MASFLO-OVAL

Explosionproof Thermal Mass Flowmeter ..... F-330 Series



Every MASFLO-OVAL system is manufactured under stringent quality control and thoroughly tested and inspected before shipment from our factory. To expect the stated performance throughout its service life, please familiarize yourself with the instructions contained in this manual before use. Also retain it at the field location for quick reference.

C O N T E N T S

1. BEFORE YOU BEGIN

Before leaving the factory, every Oval product has been thoroughly inspected and tested and is shipped in first-class operating condition. When received, it should be carefully inspected for any indication of rough handling during transit. In this section, instructions necessary for handling your system are described. Make yourself familiar with these instructions. As for other instructions, refer to respective sections. If you have something to inquire, contact the nearest Oval authorized service station in your district.

1.1 Confirming the Quantities

Explosionproof-rated Masflo Oval systems may be configured more or less differently, depending on individual customer specifications, but basically each system consists of the following components. Make sure of their quantities upon receipt.

① Explosionproof Masflo Oval
② Readout unit (ROU)
③ C1 cable: Connects the ROU and the tie-point strip. (The cable is terminated with a round connector at the ROU end and loose at the other end).
④ C4 cable: Power cable to the ROU.
⑤ Output connector: Fits the ROU.
⑥ ROU panel hold-down fittings: Four (two) pcs. per unit. If you are to use it as a Masflo controller, a control valve is additionally provided.

1.2 Confirming the Nameplate

Every Masflo-Oval is assembled and adjusted to individual specifications. Ratings, such as acceptable fluids and flowrate, appear on the nameplate located on the outside of the housing. Make sure to see they conform to your particular specifications.

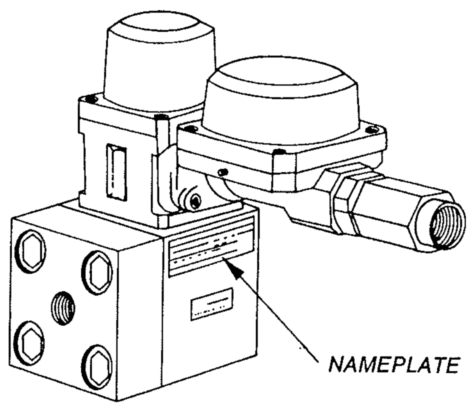


Fig. 1 Location of Nameplate

1.3 Transportation Considerations

To safeguard against damage during transit, it is suggested that the Masflo-Oval be transported to the installation location in its original package of shipment from the factory.

1.4 Storage Considerations

A Masflo-Oval that has been stored for extended periods of time from the date of shipment may possibly be involved in an unexpected accident. So if storage over extended periods of time is anticipated, bear in mind the following instructions:

(1) Keep the Masflo-Oval in its original package of shipment from the factory if circumstances permit.

(2) Select a storage location which meets the following requirements:

☆ Free from rain or water.

☆ Free from vibration and impact shocks.

☆ Temperature and humidity of room conditions (25 °C and 65 % R.H. approx.) if possible.

(3) In case of storing a Masflo-Oval which has once been placed in service for any length of time, purge it with clean air or N_2 gas to ensure freedom from residual gas of measurement in the measuring chamber of the flowmeter body. Good practice is to seal the gas inlet and outlet against contaminants.

2. GENERAL

The F-300 Series explosionproof Masflo Oval is a hydrogen explosionproof version of the F-100 Series general-purpose mass flowmeter for gas service. You can build an explosionproof mass flow controller by combining this F-300 Series with the F-400, a hydrogen explosionproof version in its control valve assembly of the F-200 general-purpose mass flow controller.

3. GENERAL SPECIFICATIONS

Table 1

Item	Description
Flow Range	Max. at full scale: 15N LM, 100N LM, 500N LM (controller 15N LM and 100N LM)
Max. Operating Pressure	39.2MPa
Operating Temperature	0 to +50°C (for reasons of explosionproof construction)
Heater Coil Temperature	Ambient temperature + 40°C
Average Temp. Coeff.	0.1% of F.S. (full scale)/°C
Average Press. Coeff.	0.1%of F.S. (full scale)/0.1MPa at N_2
Accuracy (Linearity incl.)	± 1% of F.S. (in actual gas calibration)
Repeatability	± 0.2% of F.S.
Response	1.0 sec. approx. (time constant). Response time 3 sec. or less when used as a controller (± 2% of setting)
Power Supply	± 15V DC
Sensor Current Drain	+15V DC ± 10%: 75mA − 15V DC ± 10%: 25mA
Valve Current Drain	+15V DC ± 10%: 250mA (F-400 series)
Output Signal	0 - 5V DC (stabdard) 1 - 5V DC, 0 - 20/4 - 20mA DC (options)
Load Resistance	Minimum: 2k Ω at 5V output Maximum: 375 Ω at 20mA output
Zero Stability	Long term error: 1% max./year Temperature drift: 0.05%/°C
Explosionproof Rating	Flameproof construction; d3aG4
Installation Location	Standard: Indoors. Outdoors permissible (Avoid direct exposure to the sun and rain.)
Physical Orientation	Horizontal installation
Electrical Connections	Conduit connection: G3/4" internal threads, Class A (standard) Pressuretight gasketed lead-in fitting: Cable O.D. ϕ 8 to ϕ 16mm (option). Specify cable O.D. Internal connections: Terminal block (screw connections)
Explosionproof Hsng. Finish	Munsell 2.5PB5/8
Materials	Body: Stainless steel (standard) Explosionproof housing: Aluminum casting
Seals	Viton (standard), Carrets, etc.
Process Connections	Biting type (standard), vacuum coupling, etc.
Helium Leak	$< 2 \times 10^{-8}$ NmL/s
△ Press. Req'd for Control V.	20% min. above the supply pressure (In case supply pressure is below 6.28MPa)
Control Valve	Applicable range of Kv value: 3.2×10^{-6} to 7.7×10^{-2}
Control Range	2 - 100%
Setting Signals	0 - 5V DC (standard, 1 - 5VDC, 4 - 20mA DC

Table 2 (Model, Flow Range, and Connections)

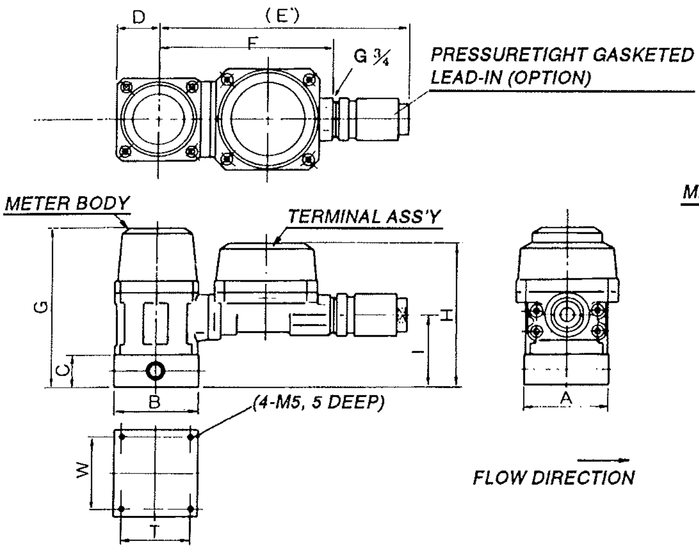
Full Scale Flow Range NLM {L/min (normal)}	*Mass Flowmeter (F-300 Series)*	*Control Valve (F-400 Series)*	*Combination with Controller*	*Connections (Biting connectors)*	
	Max. Operating Pressure 39.2MPa			*Standard*	*Option*
Minimum 0 - 0.005	*F-330*	*F-430*	*F-330 + F-430*	*1/8"*	*1/8"*
Maximum 0 - 15	*F-331*	*F-431*	*F-331 + F-431*	*1/4"*	*6mm*
Minimum 0 - 15 *Maximum 0 - 100*	*F-332*	*F-432*	*F-332 + F-432*	*1/2"*	*1/4"* *6mm*
Minimum 0- 100 *Maximum 0 - 500*	*F-333*	----	----	*3/4"*	*1/2"* *12mm*

➡ *NOTES: 1. The flow range shows flowrates with N_2.*
For use with gases other than N_2, all you do is to divide the operating flowrate with the conversion factor of the gas used, reducing it into the flowrate of N_2 and, using Table 2, choose the model compatible with that flow range.
When you change the kind of gas with another, you may make conversions using conversion factors before and after the alteration of gas kind, a greater meter error may result. For precise measurement, recalibration is required.

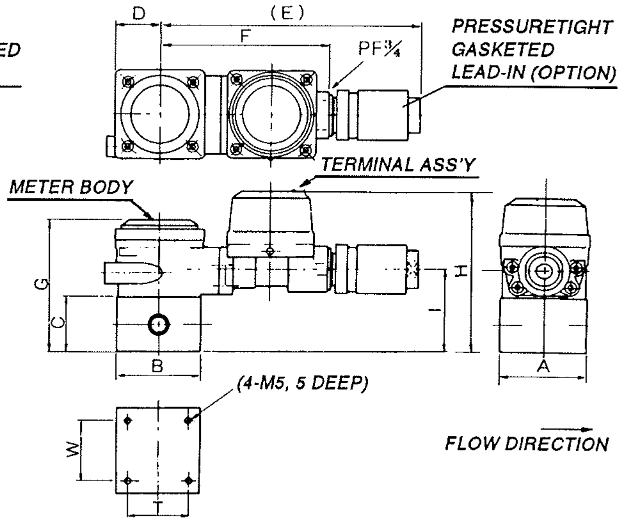
2. The flow control range of control valve depends on the flowrate factor (Kv value).
Max. $Kv = 7.7 \times 10^{-2}$ ($Cv \fallingdotseq 9 \times 10^{-2}$)

4. OUTLINE DIMENSIONS

Mass Flowmeter



Control Valve



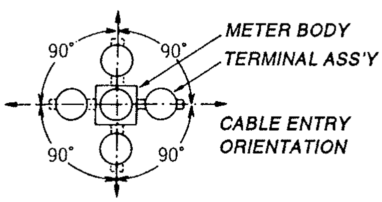
● Dimensions Table

ALL DIMENSIONS IN MILLIMETERS

	Model	A	B	C	D	(E)	F	G	H	I	T	W	Mass, kg
Masflow Meter	F-330/F-331	82	82	30	41	245	168	153	132	68	60	60	4.5
	F-332	106	82	67	41	245	168	190	169	105	60	60	7.4
	F-333	128	100	100	50	245	168	223	202	138	90	70	12.1
Control Valve	F-430/F-431	70	70	45	37	222	144	109	132	68	50	50	3.3
	F-432	70	70	45	37	222	144	109	132	68	50	50	3.3

➡ NOTES: 1. Dims. E show the dimensions with pressuretight gasketed lead-in for external conductors.
2. Dims. A show standard dimensions. True max. dimensions depend on the size of the connector used.

● Cable Entry Orientation



◎ The orientation of cable entry can be specified in increments of 90 degrees through 360 degrees. It cannot be changed in the field. Be sure to specify when you order.

Fig. 2

5. PRODUCT CODE EXPLANATION

	PRODUCT CODE NUMBER															DESCRIPTION	E MFM	E CV
	①	–	②	③	④	⑤	–	⑥	–	⑦	⑧	–	⑨	⑩	⑪			
Type	F	–														Thermal mass flowmeter/Controller		
Model			3													Flameproom flowmeter	○	
			4													Flameproof control valve		○
Pressure				3												Max. operating pressure 39.2MPa	○	○
Capacity					0											5 NmL/min.	○	○
					1											10 NmL/min. to 15 NL/min.	○	○
					2											15 to 100 NL/min.	○	○
					3											100 to 500 Nl/min.	○	
Functions						S	–									Standard Model	○	○
Output								A	–							0 - 5V DC (standard)	○	
								B	–							1 - 5V DC	○	
								C	–							0 - 20mA DC	○	
								D	–							4 - 20mA DC	○	
								N	–							Control valve		○
								Z	–							Other than above	○	
Method of Connections										1						Biting type (standard)	○	○
										2						Rc adaptor provided	○	○
										3						Vacuum coupling	○	○
										9						Other than above	○	○
Inlet/Outlet Connections											1	–				Coupling pipe O.D. 1/8" (applicable model: F-□30, F-□31)	○	○
											2	–				Coupling pipe O.D. 1/4" (applicable model: F-□30, F-□31, F-□32)	○	○
											3	–				Coupling pipe O.D. 6mm (applicable model: F-□30, F-□31, F-□32)	○	○
											4	–				Coupling pipe O.D. 12mm (applicable model: F-□32, F-333)	○	○
											5	–				Coupling pipe O.D. 1/2" (applicable model: F-□32, F-333)	○	○
											6	–				Coupling pipe O.D. 3/8" (applicable model: F-□31, F-□32)	○	○
											7	–				Coupling pipe O.D. 3/4" (applicable model: F-333)	○	
											Z	–					○	○
Body Material													1			Stainless steel	○	○
													9			Other than above		
Seal Material														1		Viton	○	○
														2		Neoprene	○	○
														3		Carrets	○	○
														4		EPDM	○	○
														9		Other than above	○	○
Setting Input															A	0-5V DC	○	
															B	1-5V DC	○	
															C	0-20mA DC		
															D	4-20mA DC	○	
															N	Setting input not required	○	○
															Z	Other than above	○	

6. SYSTEM DESIGN AND OPERATING CONSIDERATIONS

(1) The Masflo Meter/Controller is serviceable only for clean and dry gases. (A dew point of −20 °C under atmospheric pressure is the condition required for dry gases.)

(2) A 50μm filter built in the gas inlet coupling keeps dust out. But in applications where dust and mist are anticipated in the line, system design considerations should be taken to preclude them in early stages, for example, with the provision of a 5μm filter. If dust and mist inclusion is also expected by back flows from downstream, a filter of 5μm approx. should be provided downstream of the equipment.

(3) Provide a stop valve both upstream and downstream of the Masflo Meter/Controller, with which to shutoff or starting the flow. In the Masflo Controller, in particular, its control valve which is "normally closed" should not be used as a stop valve. This control valve, similar to other control valves in general, may leak slightly in its closed position.

(4) As for pipe diameter upstream and downstream of the Masflo Meter/Controller, use the same connection diameter as that of the body as long as circumstances permit. In the Masflo Controller, in particular, which uses a control valve, a large difference in diameter could cause its performance to suffer.

(5) Every Masflo Controller which uses a control valve is individually adjusted to optimum conditions according to particular customer specifications. For this reason, system design should be such that upstream and downstream pressures are held within the specification to the extent possible.
For example, if pressure differential is excessively small from specification, the system could fail to manage the desired flowrate relative to the Cv value of the valve. To facilitate control, system design should also be such that pressure variation is held small or moderate in the rate of change. Sharp pressure variations could cause the control valve to hunt.

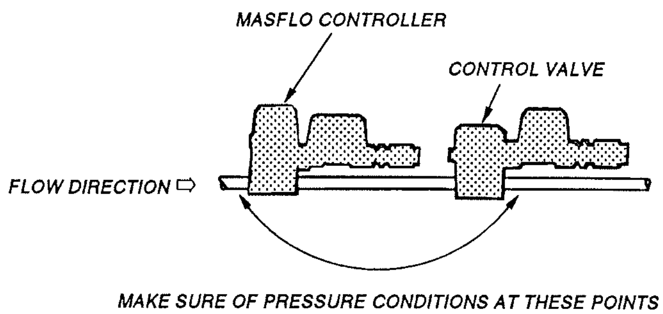


Fig. 3

(6) For large flowrates, a piping assembly with small pipe I.D. should be avoided. Or resultant jet flows at the inlet would cause a loss of accuracy. Also for large flowrates, sharp bends close to the inlet or outlet of the Masflo Meter/Controller should be avoided. It should be located at least 10 times the pipe I.D. away from a bend.

(7) A reducing valve should not be connected immediately upstream of the Masflo Meter/Controller. But there is no problem if the Masflo Meter/Controller is connected through a pipe section. Precautions should be taken particularly with Masflo Meter/Controller for large flowrate service.
Also provide a buffer upstream and downstream of the equipment, conforming to the following formula:

$$V \geqq \frac{0.15d^2}{\sqrt{\rho}}$$

where V = Capacity [L]
d = Control valve orifice diameter [mm]
ρ = Gas density [kg/Nm^3]

[Example]
With 500NL/min air and 4mm orifice dia., find the ratings of a buffer required for stable control.

$$V \geqq 0.15 \times 4^2/\sqrt{1.29} = 2.1 \text{ [L]}$$

And the capacity of a reducing valve required for it is at least twice the flowrate to be controlled.
That is 2 × 500 = 1,000 NL/min.

(8) System purge
Before installing the Masflo Meter/Controller, be sure to purge the piping assembly. For making measurement of highly reactive gases, like silane family, in particular, it is required that purging with inert gas be made thoroughly before allowing the gas. Furthermore, if it is desired to remove the process connection, allowing it to be exposed to the atmosphere, thorough purging is required before removing the process connection.

⚠ **CAUTION**

In general processes which use the Masflo Meter/Controller, it is necessary that their piping be clean. Cutting oil used for thread cutting, dust and other foreign matter must be thoroughly removed (using a solvent, such as triethane). Also due consideration must be taken to ensure that there is no seal tape extruding into the pipe interior.

7. INSTALLATION

7.1 Installation Location of Meter Body

① The explosionproof Masflo Meter/Controller is intended for installation outdoors but installation locations exposed to the direct sun and rainwater should be avoided. We recommend well ventilated installation locations with least temperature variation.
② Avoid installation locations with high temperature and humidity.
③ Leak check of the piping assembly and line purge must be performed without fail.
④ Provide a line filter on the power source side if a potential source of electrical noise exists near by.
⑤ To prevent entry of impurities produced from pipeline, etc., a gas filter (5 μm) should be provided.
⑥ The Masflo-Oval is calibrated at 0 °C and 1 atmospheric pressure (standard-condition: normal).
⑦ Dedicated power supplies, programmers, indicators and interconnect cables are available from OVAL.
⑧ For cable runs 30 meters and longer, use CVVS 1.25—2 sq. in conductor area.
⑨ For cable runs 30 meters and longer, use a 4—20mA dc output.
⑩ The maximum transmission length is 300 meters.

7.2 Meter Body Installation

① Install using the two fitting screw slots (M4) located on the bottom of the body block. (See the OUTLINE DIMENSIONS.)

Screw size: M5, 7mm long

② At installation, ensure that its physical orientation is horizontal. Also, do not make a mistake in the direction of gas inlet and outlet.

③ A vent opening is located under the flowmeter amplifier housing (casting). It should be free from rainwater.

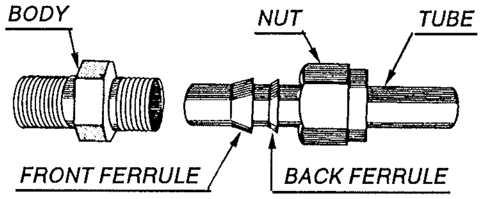
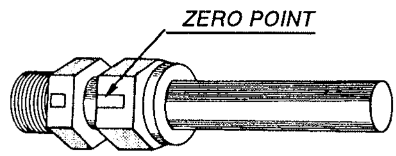
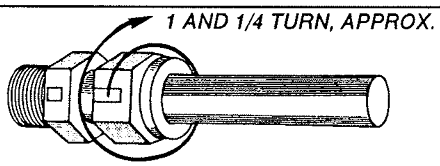
④ For ease of maintenance, proper working space should be secured to provide access to the cover of amplifier compartment and that of terminal box.

7.3 Pipe Connections

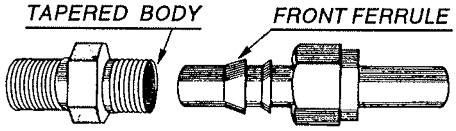
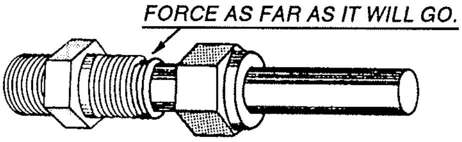
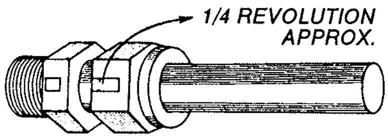
(1) Process connection is made with biting-type coupler. Tighten connections firmly to prevent leaks, observing the following instructions:

- Pipes less than 1/8″
  Following tightening up with fingers, tighten an additional 3/4 revolution with wrench.
- Pipes greater than 1/8″
  Following tightening up with fingers, tighten an additional 1 and 1/4 revolutions with wrench.

(2) Tightening Procedure (Fig. 4)

1		Make sure to see that members of the coupling are fitted in proper order as shown in the figure.
2		Insert the tube end deep enough to hit the body shoulder, tighten the nut firmly with fingers, and mark the body and nut with a match mark. This point is referred to as zero point.
3		Starting from the zero point, tighten the nut one and a quarter revolutions with wrench. Tightening is now complete.

(3) Retightening Procedure After Uncoupling (Fig. 5)

1		Before installation, make sure the tapered face of the body and front ferrule are free from foreign matter.
2		Insert the front ferrule deep enough to hit the tapered face of the body and then tighten the nut firmly with fingers.
3		Tighten the nut by an additional 1/4 rev. approx. with wrench. Tightening is now complete. ➡ ***NOTE:*** *After tightening up, it should be at the original position or at a position somewhat advanced from there.*

7.4 Electrical Connections

(1) Wiring from Read-out Unit to Masflo Meter

It is recommended that a tie-point strip be provided inside the panel of the read-out unit.

> *Use the C1 cable between the read-out unit and the tie-point strip.*
> ★ *C1 cable is terminated with a round connector at the read-out unit end and loose at the other end.*

> *Use CVVS or CEVS cable between the tie-point strip and the Masflo meter.*
> ◆ *Cable Specifications* ◆
> ① *When combination with a control valve is desired*
> *8-conductor: Finished O.D. ϕ8mm to ϕ16mm*
> ② *Standalone*
> *5-conductor and larger: Finished O.D. ϕ8mm to ϕ16mm*

(2) Electrical Work at Masflo Meter Cable Entry

① Cable entry is of G3/4 internal threads (Class A threads).
② If you are to use pressuretight gasketed connection fittings, we supply them.
③ For conduit work, piping with Class A threads is recommended.

➡ **NOTE:** In the explosionproof rating d3aG4, it is mandatory to use Class A threads.

(3) Wiring Connections at Masflo Meter Terminal Block

The terminal block is of screw connection type. Prepare wire ends as shown below.

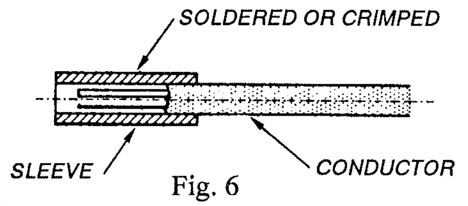


Fig. 6

(4) Masflo Meter Terminal Block Identification

Terminal No.	Description	Signal Direction
1	5V DC voltage output	MFM ⇨ ROU
2	Flowrate signal output	MFM ⇨ ROU
3	Flowrate setting signal	ROU ⇨ MFM
4	Valve 0V	
5	Valve control signal	MFM ⇨ ROU
6	Power − 15V DC	ROU ⇨ MFM
7	Power +15V DC	ROU ⇨ MFM
8	Common 0V	

1. MFM: Masflo meter
   ROU: Read-out unit
2. If Masflo meter is used singularly (without Oval control valve), wiring connections to terminals 1, 3 and 5 in the table above are not necessary.
3. In making wiring connections at power terminals 6, 7 and 8, ensure correct connections in the terminal box, on the tie-point strip, etc.
   Faulty wiring connections at these points could ruin your equipment.

(5) Typical Example of Wiring Connections

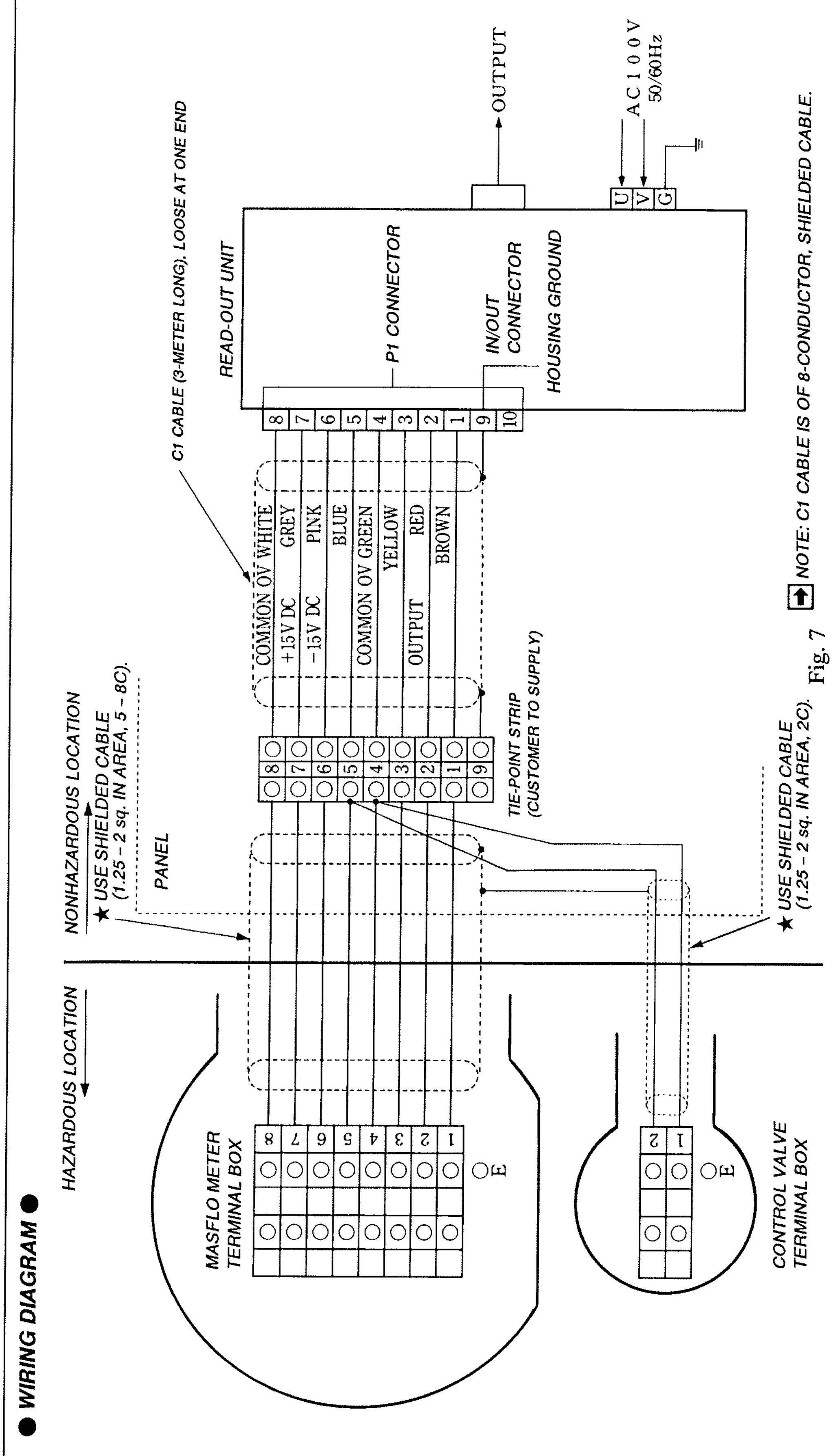


Fig. 7

⚠ PRECAUTIONS

The clearance between the Masflo meter's terminal box and its cover is confined to 0.1mm max. due to the restrictions imposed on explosionproof construction. Be extremely careful about deep scratches following repeated cover removal and installation. The cover may resist to opening: when you remove or install the cover on the amplifier assembly, it is good practice to remove the blind plug for air vent located on the meter body and remove pressuretight gasketed connection fitting on the terminal box assembly before attempting to remove or install the cover.

8. INSPECTION POINTS IN TROUBLESHOOTING

◆ When trouble is found, the following points should be inspected before you seek our service.

8.1 Around Masflo Meter/Controller

(1) Is the flow direction in conformity?
(2) Is dust and mist completely removed?
(3) Are Masflo Meter/Controller specifications in agreement with the status of the existing line?
(4) Isn't there any high frequency noise source near by?

8.2 Read-out Unit

Uncouple connectors furnished and turn on power. Inspect connector pins for the Masflo. (Exercise care not to short out pins.)

(1) Measure the voltage across pins ⑦ and ⑧. (Negative polarity at pin ⑧.) Verify that +15VDC is produced.
(2) Measure the voltage across pins ⑥ and ⑧. (Negative polarity at pin ⑧.) Verify that -15VDC is produced.
(3) If the Masflo Meter/Controller provides a voltage output, apply a DC voltage within a range 0 – 5V across pins ② and ⑧. (Negative polarity at pin ⑧.) Does any reading appear on the front panel digital indicator? (If the total counter is provided, does the counter advance?)

⚠ **CAUTION**

In paragraph (3) above, there may be cases where the Masflo Meter/Controller provides a voltage output but the signal is converted into a current output in the read-out unit. So careful attention should be paid to the model code number of your Masflo Meter/Controller.

F – ○○○ S – A – ○○
└─ Voltage output 0 - 5V DC
B: 1 - 5V DC

F – ○○○ S – D – ○○
└─ Current output: 4 - 20mA DC
C: 0 - 20mA DC

If voltage output is the case, inspect according to paragraph (3) above.

8.3 Cables

Inspect for opens. The connector pins to the Masflo Meter are numbered pin-to-pin compatible with those to the read-out unit.

8.4 Masflo Meter, Controller

(1) **When the fluid flow is interrupted.**
(upstream and downstream shut off with stop valves).
There may be cases where the flow indicator registers 0.2 or 0.3％. This is by no means any indication of a fault.

(2) **While there is a gas flow.**
With Masflo Controller, the flowrate hunts and fluctuates, or the Controller fails to reach the full scale.

① Make sure that the pressure upstream and downstream of the Masflo Controller conforms to the specification.
② Make sure that the pressure above does not fluctuate excessively.

(3) **Despite a uniform flow, there is a dispersion in flowrate readings.**

① The influence of noises is among possible causes. If this is suspected, verify whether or not it is a noise source by removing power to the suspected equipment.

If the troubles is identified to be other than above or if the conditions described in Paragraph (2) do conform to the specification, the Masflo Meter/Controller itself is suspected to have a fault.

8.5 Troubleshooting

Symptom	Possible Causes	Remedy
1. Fails to produce an output signal.	a. ± 15V power is not supplied. b. Same as above. c. A short is in the output stage. d. Supply pressure too high or pressure differential too great. e. Control valve is clogged. f. Screen filter in the inlet connection is clogged. g. Capillary sensor is defective.	1a. Inspect power supply. 1b. Inspect cable connections. 1c. Return PC board to factory for replacement. 1d. Adjust supply pressure to specification. 1e. Connect a 0 – 15VDC adjustable power supply, apply supply pressure and slowly increase supply voltage progressively. Valve should open at 7V ± 3V. If it fails to open, wash clean the inner walls of the valve and make valve adjustment. (This adjustment requires experience and skill).) 1f. Clean screen filter with trichloroethane or Freon. 1g. Return to factory for repair.
2. Excessive output signal.	a. Output stage is at fault. b. Capillary sensor is faulty	2a. Return to factory. 2b. Return to factory.
3. Output signal very low with respect to the setting signal. Or it fails to reach the flow rate setpoint.	a. Screen filter dirty and clogged. b. Laminar flow device dirty and clogged. Or moisture is present in the flowmeter. c. Orifice in the valve is dirty and clogged. d. Valve interior damaged (bulged plunger seat). e. A gas of different specification or of different pressure.	3a. Wash clean screen filter. 3b. Remove laminar flow device and clean. Dry by purging with air or N_2. 3c. Wash clean orifice in the valve. 3d. Remove plunger assembly, replace plunger and make valve adjustment. Or return to factory. 3e. Use meter under design specifications.
4. Flowrate decreases progressively.	a. Liquefied hydrocarbons, such as C_3H_8, C_4H_{10} and NH_3. b. Valve out of adjustment with time.	4a. Decrease supply pressure or warm the meter. 4b. Refer to 1e.
5. Oscillation.	a. Supply pressure is too high. Or differential pressure is too great. b. Pipe run between reducing valve and MFC is too short. c. Reducing valve is oscillating. d. Valve sleeve or interior is damaged.	5a. Decrease pressure. 5b. Increase upstream pipe diameter or its length. 5c. Replace reducing valve. Implement 5b. 5d. Replace damaged components and make valve adjustment. Refer to 1e or return to factory.
6. Slight flow at setting zero .	a. Valve leaks due to damaged plunger or dirty orifice. b. Pressure too high or too low.	6a. Wash clean orifice and adjust plunger assembly after replacement. Refer to 1e. 6b. Supply pressure of specification.
7. Large flow at setting zero.	a. Diaphragm is damaged (diaphragm type control valve only).	7a. Replace diaphragm.
8. Gas leaks from O-ring at connections.	a. O-ring is deteriorated. Or coupling or body is damaged.	8a. Replace O-ring or coupling. If body is damaged, return to factory.

9. CHANGING THE GASES USED

9.1 Running a Gas Other Than Calibration Gas

Every Masflo Meter/Masflo Controller is individually calibrated according to the type of gas to be used and flowrate. If, therefore, a gas other than the one specified on the meter nameplate is used, inconsistency in the actual flowrate with the indicated flowrate may result.
To find the actual flowrate, calculate it with a conversion factor.
The output signal to mass flowrate relationship is generally expressed by

$$V = K \cdot Cp \cdot Qm = K \cdot Cp \cdot \rho \cdot Q_v$$

where V: Output signal
K: A constant
ρ : Gas density
Cp: Gas specific heat
Qm: Mass flowrate
Q_v: Volume flowrate

Accordingly, when the specific heat and density of the gas to be measured have changed, it is necessary that the output be compensated for.
The conversion factor C to compensate for this is expressed by:

$$C = \frac{Cp1 \cdot \rho 1 \cdot 1/N1}{Cp2 \cdot \rho 2 \cdot 1/N2}$$

where Cp: Specific heat
ρ : Density under normal condition
N: A coefficient depending on the molecular structure of the gas
(1) Calibrated gas
(2) Gas to be metered

Coefficients depending on the molecular structure of the gas
N=1.03 Monoatomic gases (Ar, He)
N=1.00 Biatomic gases (N_2, O_2, C_o, Air)
N=0.94 Triatomic gases (CO_2, SO_2)
N=0.88 Polyatomic gases (NH_3, CH_4)

Based on this formula, conversion factors are tabulated by determining their relationship with N_2 gas.

Example:

The meter is calibrated with N_2. When CO_2 is measured at a rate 200NmL/min. and the output signal is 80%, then

$$\text{Actual } CO_2 \text{ flowrate} = 80.0 \times \frac{0.74}{1.000} = 59.2\%$$

It follows that

$$\frac{59.2}{100} \times 200 = 118.4 \text{ NmL/min.}$$

In case of mixed gases, their conversion factors can be determined by the formula

$$\frac{1}{Cmix} = \frac{V1}{C1} + \frac{V2}{C2} + \frac{V3}{C3} + \cdot \cdot \cdot \frac{Vn}{Cn}$$

where Cmix = Conversion factor of the mixed gas
Cn = Conversion factor of gas n
Vn = Volumetric ratio the gas n occupies in the mixed gas

⚠ **CAUTION:** With Masflo Controller, if conversion factors of applicable gases remain about the same but their densities are considerably different, the Controller may fail to manage the stated flowrate relative to the C_v value of the valve.

If you desire to run different kinds of gases, seek our assistance in advance if possible.

9.2 About Conversion Factors

Every Masflo Controller is calibrated and adjusted according to the type of the gas used and its flowrate.
Basically, different kinds of gases are unacceptable. If it is desired to measure a different kind of gas, correction of readings with conversion factor is required.

(1) With reference to N_2 being 1.0, conversion factors of different gases are determined.
These factors are used for convenience sake; you should remember that the simple process of conversion does not necessarily give you definite accuracy. We should take them as guidelines.

(2) The flowrate of a different gas is determined by the formula:

$$\text{Flowrate of gas used} = \text{Calibration gas flowrate} \times \frac{\text{Conversion factor of gas used}}{\text{Conversion factor of calibration gas}}$$

10. CALIBRATION PROCEDURE *(Calibration with wet gas meter)*

10.1 Masflo Oval Calibration Procedure *(See Flow Chart in Sec. 10.2.)*

① Complete the piping and wiring; conduct a leak test to ensure freedom from leaks (see Fig. 9).

➡ **NOTE:** Test instruments of good accuracy should be used. Instrument accuracy has a direct influence upon the error of measurement.

② Remove the aluminum housing cover of the amplifier, providing access to adjustment trimmers (L, M and H) on the printed circuit board.

③ Supply power and provide a warm-up period for at least 20 minutes.

④ Carefully allow the gas until the pressure gage P1 reaches the service pressure specified.

➡ **NOTES:** (1) The MFC is a mass flow controller but, strictly speaking, it is influenced by changes in pressure as the specific heat of fluid changes with pressure. For this reason, the inlet pressure should be as close to the design pressure as possible.

(2) Because this MFC is provided with a control valve, excursions from the design pressure may result in unsatisfactory control or failure to allow the maximum flowrate.

(3) The reducing valve used should also have sufficient flow capacity. Otherwise unsatisfactory control might result.

⑤ Install a wet gas meter on a level plane.

⑥ Allow the fluid into the wet gas meter to break in (5 pointer revolutions min.).

⑦ Align the wet gas meter pointer with "0" position and make a liquid level adjustment. For other information, refer to the instruction manual for the wet gas meter.

⑧ Give a 2.5V DC (or 10mA for current) programming signal to the MFC from the ROU potentiometer or an external source (CPU or current/voltage generator) to allow the fluid to run. With MFC of 0-5V (0-20mA) output, the flowrate is at 50 %; with MFC of 1-5V (4-20mA) output, the flowrate is at 37.5 %. The programming signal and output signal are of the same type and without converters, such as V/V, V/I or I/V (see Fig. 13).

⑨ When stability in flowrate is reached, measure with a stopwatch or similar instrument the time required for the delivery of a specific volume of fluid, observing the pointer of the wet gas meter.

➡ **NOTES:** (1) The duration of time measurement should be long enough to neglect the error of measurement.

(2) The volume of measurement by the wet gas meter should be a multiple of integers of one pointer revolution. For example, with a wet gas meter of 2 liters per revolution, the errors of measurement at 1.5 liters per revolution and at 2 liters will be too great with too much dispersions. For this reason, the volume of measurement should be 2, 4, 6, 8, ··· 2n (liters).

⑩ In the course of measurement, take average readings of temperature and absolute pressure of the wet gas meter.

⑪ Determine the flowrate of the wet gas meter and find the error with respect to the flowrate output of the MFC:

$$Q = \frac{V \times 60}{t} \quad \text{(L/min.)}$$

$$Q_n = \frac{273.15 \times P_a \times Q}{760 \times (T_a \times 273.15)} \quad \text{(NL/min.)}$$

$$E = \frac{Q_s - Q_n}{QF} \times 100 + E_0 \quad \text{(\% of FS)}$$

where Q: Actual flowrate of the wet type (NL/min.)
V: Volume measured (l)
t: Duration of time measurement (sec.)
Q_n: Normal flowrate of the wet type (NL/min.)
P_a: Absolute pressure of the wet type (kPa [Abs])
T_a: Temperature of the wet type (°C)
E: Error of MFC (% of FS)
Q_s: Flowrate of MFC (NL/min.)
QF: Full scale flowrate of MFC (NL/min.)
E_0: Instrumental error of the wet type (%)

⑫ If error is held within 1 % of FS, go to Step ⑬. If error exceeds +1% of FS, turn the adjust trimmer "M" counterclockwise (flowrate increases); if the error falls below −1% , turn the adjust trimmer "M" clockwise (flowrate decreases) and go back to Step ⑨.

➡ **NOTES:** (1) Turning the adjust trimmer "M" clockwise causes the error to go positive; turning it counterclockwise causes the error to go negative.
(2) while you make adjustments, exercise care not to allow the screwdriver or other tool to come into contact with other component parts.

⑬ Set the flowrate to 0% .

➡ **NOTE:** (1) In spite of having diminished to zero flow, the display and output may not agree with true zero under certain circumstances. But this doesn't mean any indication of a fault.
(2) At zero flow, monitor the wet gas meter and verify that no flow is running. Valve leaks around 0.1% are tolerable.

⑭ If it is roughly in agreement, make fine adjustments (see the description that follows) and go down to Step ⑮.
Rotating the adjust trimmer "L" clockwise decreases the output; rotating it counterclockwise increases it. If it is a negative-polarity voltage, adjust it with "L" until it is +0.01V or so. If it is not a negative-polarity voltage, rotate the "L" clockwise until it arrives at a point it will not decrease any more. If rotating the "L" clockwise no longer causes the voltage to change, rotate it counterclockwise until it arrives at a point from which the voltage begins to rise. If you find it necessary to make a major adjustment, go back to Step ⑧.

➡ **NOTES:** (1) If errors are large, repeat Steps ⑧ through ⑮ several times. But if errors are within 2 or 3% , a single adjustment may be enough.
(2) Moving the trimmer "L" to an extent of 1 to 2% does not cause a significant shift of the 50% (37.5%) point of flowrate.

⑮ By giving the MFC a programming signal, allow a 25% flowrate.
⑯ Take Steps ⑨ through ⑪ and determine the error.
⑰ If the error falls within ± 1% of FS, go down to Step ⑱. If the error is below −1% , by raising the error at 50% (37.5 %) flowrate toward the positive (+); or if the error exceeds +1.1% , by moving the error at 50% flowrate toward the negative (−), bring the error at 25% flowrate to be held within ± 1% of FS. To do this operation, therefore, go back to Step ⑧.
⑱ By giving the MFC a programming signal, allow a 100% flowrate.
⑲ Take Steps ⑨ through ⑪ and determine the error.
⑳ If the error falls within ± 1% of FS, go down to Step ㉑. If the error exceeds +1% , rotate the adjust trimmer "H" counterclockwise (flowrate increases); if the error is below −1% , rotate the adjust trimmer "H" clockwise (flowrate decreases) and go back to Step ⑲.

➡ **NOTE:(1)** Similar to "M", turning the adjust trimmer "H" clockwise moves the error toward the positive; turning it counterclockwise moves the error toward the negative.

㉑ By giving the MFC a programming signal, allow a 75% flowrate.

㉒ Take Steps ⑨ through ⑪ and determine the error.

㉓ If the error falls within ±1% of FS, go down to ㉔. If the error is below −1%, by raising the error at 100% flowrate toward the positive (+); or if the error exceeds +1% , by moving the error at 100% flowrate toward the negative (−), bring the error at 75% flowrate to be held within ±1% of FS. To do this operation, therefore, go back to Step ⑱.

㉔ The circuitry is so designed that the characteristics below 50% (37.5%) remain unaffected by positions of adjust trimmer "H". However, to complete calibration, inspect errors at points 50% , 25% and 0% to verify that errors are held within ±1% of FS at all points. If not, repeat Steps from ⑧.

➡ **NOTE: (1)** In the case of 1-5V (4-20mA) output, an inspection at 50% is the last one since the point "M" is the point of 37.5% flowrate. If the error at 50% point fails to be held within ±1% of FS, adjust the trimmer "H" until errors, including 75% point, are held within ±1% of FS.

The explanation above centered around the Masflo Controller (MFC) but the same procedure applies to the Masflo Meter.

10.2 Masflo Oval Calibration Flowchart (Calibration with wet gas meter)

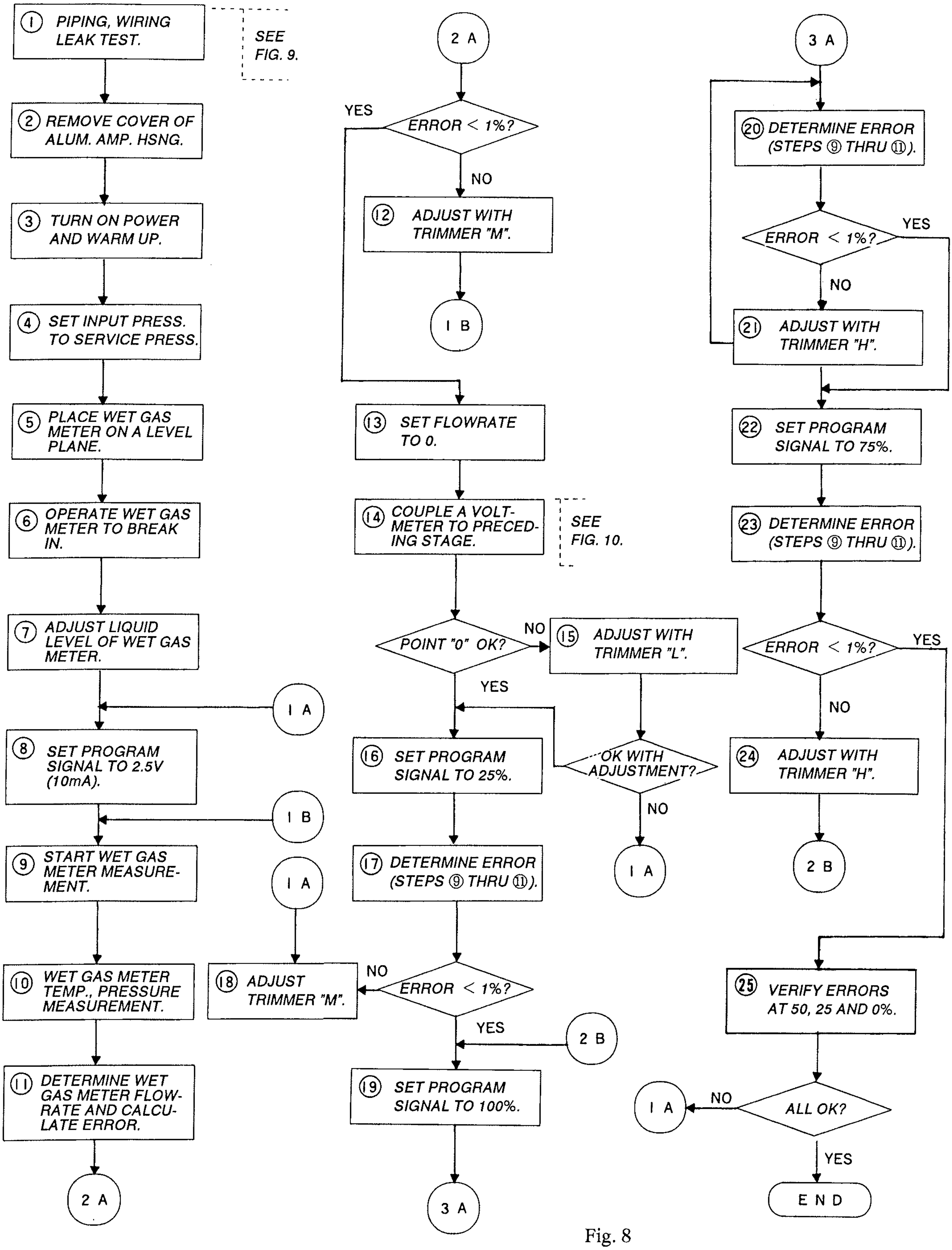


Fig. 8

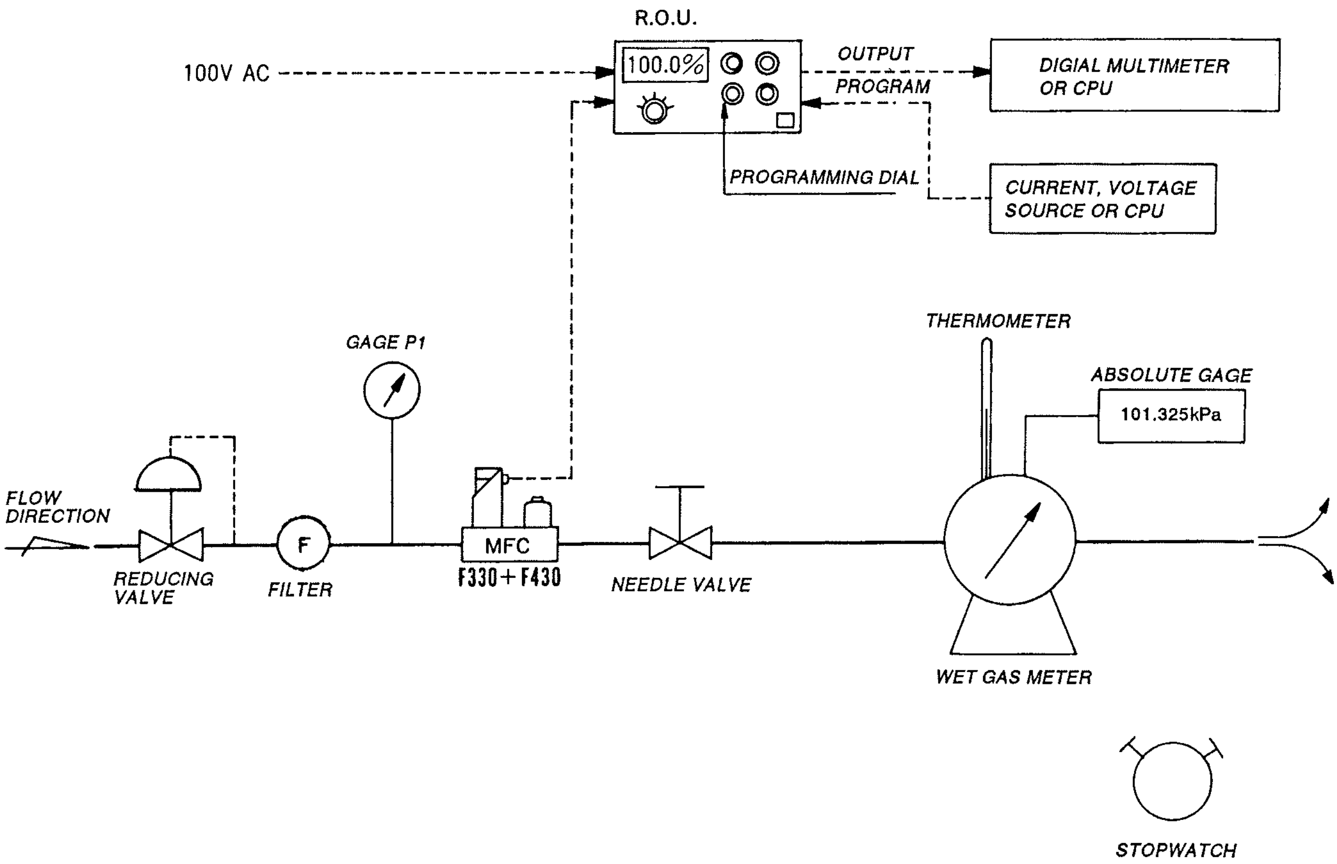
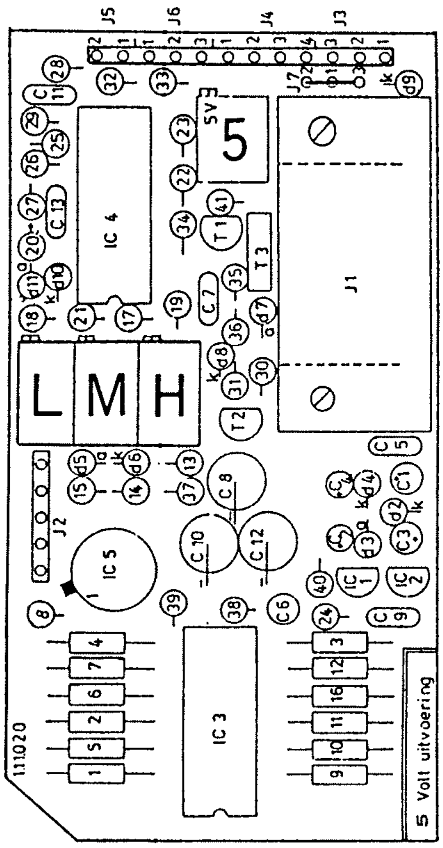


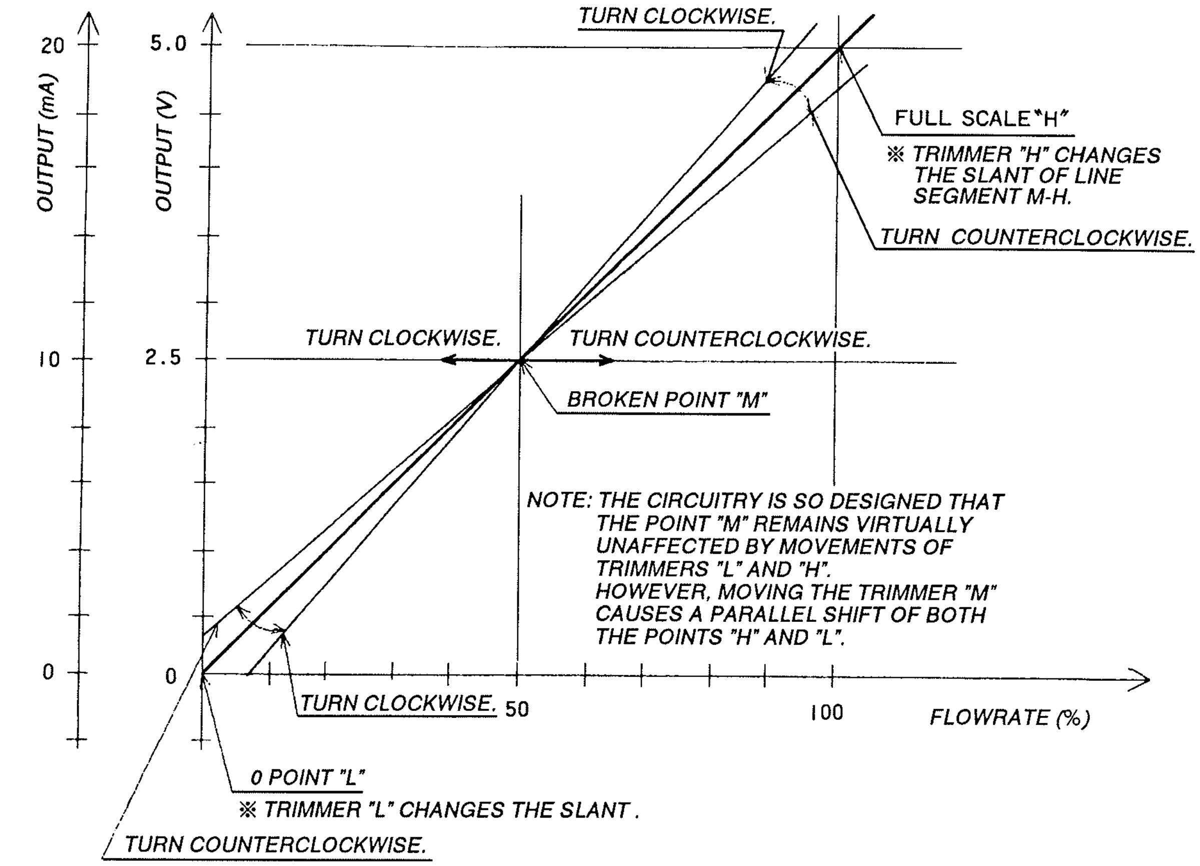
Fig. 9 Piping and Wiring Diagram



J 5 : Output of the preceding stage
J 3 : Common

Fig. 10 Component Locations on the Printed Circuit Board

ⓐ ***0 − 5V, 0 − 20mA Output***



ⓑ ***1 − 5V, 4 − 20mA Output***

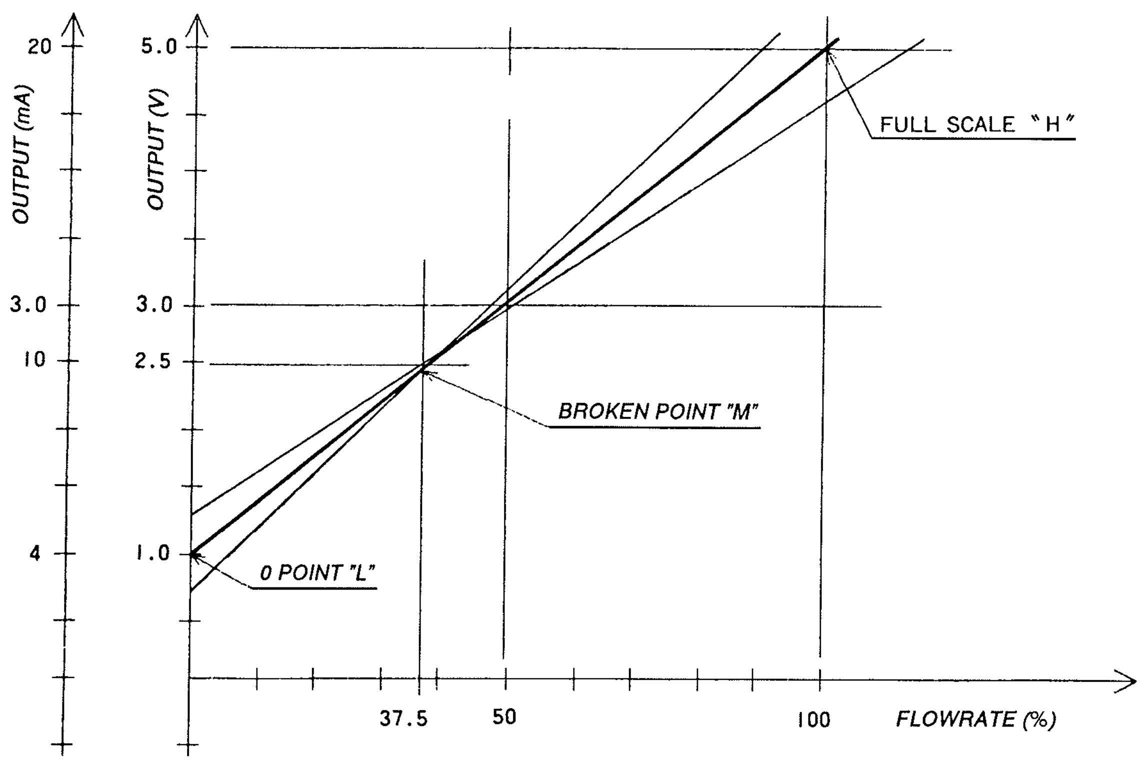


Fig. 11 Broken Point vs. Output

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