INSTRUCTION MANUAL

MODEL CMH

CAPACITANCE MANOMETER

VACUUM GENERAL

TABLE OF CONTENTS

Dear Customer,

Congratulations on your choice of Vacuum General products for your measurement/control application.

Each Vacuum General product represents the culmination of many years of experience in the vacuum industry, complimented with proven design technology and superior manufacturing and quality assurance processes to ensure the user a long and reliable use of each device.

Please take the time to read this manual before installing your Vacuum General instrument, thereby insuring the best possible performance of your product with the least amount of inconvenience.

Thank you again for choosing Vacuum General and please don't hesitate to contact any of our offices for further product information or service.

Sincerely,

Vacuum General Inc.

Fig. 1 Model CMH Series Capacitance Manometer

This instruction manual covers the operation, installation and maintenance of the Model CMH Series Capacitance Manometers manufactured by Vacuum General Inc. The Model CMH Capacitance Manometer is intended to be operated in conjunction with Vacuum General's Model 80-6 Pressure Display Module which provides both a source of power and read out capability.

PRODUCT WARRANTY POLICY

Products manufactured by Vacuum General are warranted against defects in workmanship and materials under normal use and service for one year from the date of invoice, with the exception of lamps, fuses, and relays, which are specifically excluded. Special custom-made products may be subject to a different period of warranty.

Vacuum General will repair or replace products that prove defective during the warranty period provided that failure or damage has not been caused by accident, neglect, misuse, improper installation, abnormal operating conditions, alteration or repair by any person not authorized by Vacuum General. The only time that component replacement is acceptable is when plug-in provisions have been made.

If a malfunction or any portion thereof is determined by Vacuum General to have been caused by conditions not covered by this warranty, a repair-cost estimate shall be submitted to the purchaser for approval before repair work is started.

Liability under this warranty is limited to servicing, adjusting or replacing units returned to the factory or to an authorized repair facility.

The foregoing warranties are in lieu of all other warranties and conditions expressed or implied, including, but not limited to, those concerning merchantability and fitness for a particular purpose. Vacuum General is not liable for any special, consequential or indirect damages, including any caused by failure of the product to perform properly.

If a malfunction develops, notify Vacuum General, giving the name, model number and serial number of the equipment and the details of the problem. Service and/or shipping information will be provided on receipt of this information.

Should immediate assistance be desired, contact our Customer Service Department at (619) 571-1222. A customer-service engineer will provide advice to minimize equipment downtime.

WARRANTY AND CLAIMS

Warranty

Vacuum General warrants that each product manufactured by it is free from defects of material and workmanship under normal use and service. Vacuum General accepts liability under use warranty to adjust or service all defective products and /or replace any defective parts thereof. This warranty is in effect for one year after delivery to the original purchaser. Upon learning of a defect, the original purchaser may return the product (shipping charges must be prepaid) to Vacuum General or have it repaired by personnel authorized by Vacuum General to perform work. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. Should this be the case, Vacuum General will submit an estimate of the repair charges for approval before work will be started.

Vacuum General shall not be liable for any damages caused by the failure of said Vacuum General product to perform properly. Should Vacuum General be found to have such liability, that liability shall be limited to $1000 maximum. This warranty does not apply to any unit that has been subject to neglect, accident, misuse, improper installation or operation, or that in any way has been tampered with, altered or repaired by any person not authorized by Vacuum General to perform repair services. The only exception is in the case where Vacuum General has made plug-in provisions for replacement of components. Replacement of said components will not constitute tampering or alteration of the unit and will not result in termination of the warranty. Vacuum General will not honor this warranty in any unit bearing a serial number that has been altered, defaced or removed. This warranty is in lieu of all other warranties expressed or implied and no one is authorized to assume any liability on behalf of Vacuum General or impose any obligation upon it in connection with the sale of any device other than as stated above.

Please note: Some States do not allow the exclusion or limitation of implied warranties or consequential damages; so, the above limitations or exclusions may not apply to you. This warranty gives you specific legal rights, and you may also have other rights that vary from State to State.

Unpacking

While no special precautions are necessary, it is advisable to ascertain that all items on the packing list are accounted for and that there is no obvious damage. Units should be checked for damage to protruding items such as connectors, fuse holders, controls, etc. See section on claims for shipping damage if there are problems.

Claim for Shipment Damage

It is expected that equipment will be tested as soon as it is received. If damage has occurred in transit, a claim should be filed with the carrier.

A report should be made to the claim agent and then forwarded to Vacuum General in all correspondence with Vacuum General. Please be sure to include the model number and serial number.

GENERAL INSTRUCTIONS

Receiving Inspection Procedure

Your instrumentation was shipped to you fully assembled, in packing that is designed to protect it against all normal shipping hazards. We suggest that you first inspect the exterior of the shipping container for any visible damage. Then verify that your shipment includes all instruments and accessories listed on the packing slip, which also will indicate whether the shipment was partial or complete. Check to see that the equipment received matches the equipment ordered. Then remove the instrumentation from the shipping case and test its functional operation, following the instructions in the applicable protions of this manual. If shipping damage is noted, keep all forms, invoices and shipping materials and file a claim with the shipping carrier's claim department, sending a copy to Vacuum General. Be sure to include the instrument's name, model number, and serial number on all correspondence. We will advise you as soon as possible regarding repair or replacement.

If your shipment is not correct for any reason, or if you would like to expedite the repair or replacement of damaged equipment, telephone our Customer Service Department at (619) 571-1222.

General Safety Instructions

The following safety instructions are general in nature and should be followed for safe utilization of your equipment. These precautions should be understood and adhered to during all phases of operation, service and repair of this instrumentation.

Grounding	All instruments are equipped with a three-conductor AC power cable that must be plugged into an approved three-conductor electrical outlet with proper ground. The instrument power outlet and power cable meet the International Electrotechnical Commission (EC) safety standards.
Explosive Atmosphere	Operation of an electrical instrument in the presence of flammable gases, fumes, or other types of explosive environments is a critical safety hazard and must be avoided.
Internal Examination	Removal of instrument covers for adjustment or troubleshooting must be done only by qualified maintenance personnel, not by operating personnel. Do not replace components without first disconnecting the power cable and discharging the circuits before touching them.
Part Substitutions and Modifications	Substituting non identical parts or modifying an instrument in any way not only voids the warranty but could cause a safety hazard and should be avoided. Repair work, if possible should

be done at the Vacuum General factory or a factory-authorized service center.

WARNING The warning blocks in this manual precede potentially dangerous procedures. These WARNINGS must be heeded.

Return Shipment Procedure

As part of your evaluation of possible equipment malfunction, we ask that you disengage our instruments from your main system. Follow the preliminary bench check and troubleshooting procedures in this manual to localize any malfunction. Verify that the problem is in our equipment and not somewhere else in your system.

If you determine that equipment must be returned to Vacuum General for any reason, notify the Customer Service Department either by mail or by telephone and request a return authorization (RA) number and shipping instructions. Please note that:

- Claims for damage must be filed immediately.
- We cannot accept a return shipment without an RA number.
- A written explanation, giving specific details regarding any problem, must accompany the return shipment.
- For Warranty Returns: Transportation charges to return equipment to Vacuum General are the responsibility of the purchaser. Transportation charges for shipment back to the purchaser will be paid by Vacuum General unless the purchaser requests special handling, which will be at the purchaser's expense. If material is sent to Vacuum General collect, charges for return will be billed to the purchaser. Customs and freight charges on shipments to and from foreign countries to Vacuum General are the responsibility of the purchaser.
- For Non-Warranty Returns: All transportation and custom charges are the responsibility of the purchaser.

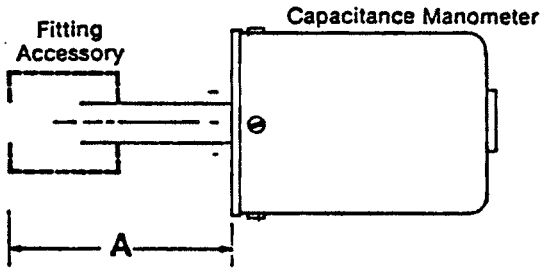
Model numbers for capacitance manometers are composed of designations for series, fittings, and pressure range.

For example: CM -01 -100

SERIES	FITTINGS	PRESSURE RANGE
CM	01 No fitting (standard ½" OD tubulation)	1 1 torr (CMT/ CMH only)
CML	02 KF-10 flange with seals and clamps	10 10 torr
CMT	03 Mini-Conflat flange with mates	100 100 torr (CM/CML only)
CMH	04 CAJON ULTRATORR flange	1000 1000 torr (CM/CML only)
	05 CAJON 8 VCO flange	
	06 CAJON 8 VCR flange	
	07 2¾" Conflat flange with mates	

Figure 2. Model Number Identification

NOTE: All capacitance manometers come with 1/2 inch outside diameter tubulation as standard (01) designation. Additionally, the manometers are available with a variety of fittings that are attached to the 1/2 inch tubulation. Figure 3 describes the model number and fitting and gives dimension "A" for mounting purposes.



MODEL	FITTING DESCRIPTION	DIMENSION "A"	
		Inches	Centimeters
01	No fitting (standard ½" OD tubulation)	1-13/16	4.60
02	KF-10 flange with seals and clamps	2-1/8	5.40
03	Mini-Conflat flange	1-13/16	4.60
04	CAJON ULTRATORR flange	2-5/8	6.67
05	CAJON 8 VCO flange	2-1/4	5.72
06	CAJON 8 VCR flange	2-15/16	7.46
07	2¾" Conflat flange	1-13/16	4.60

Figure 3. Fitting Accessories and Mounting Information

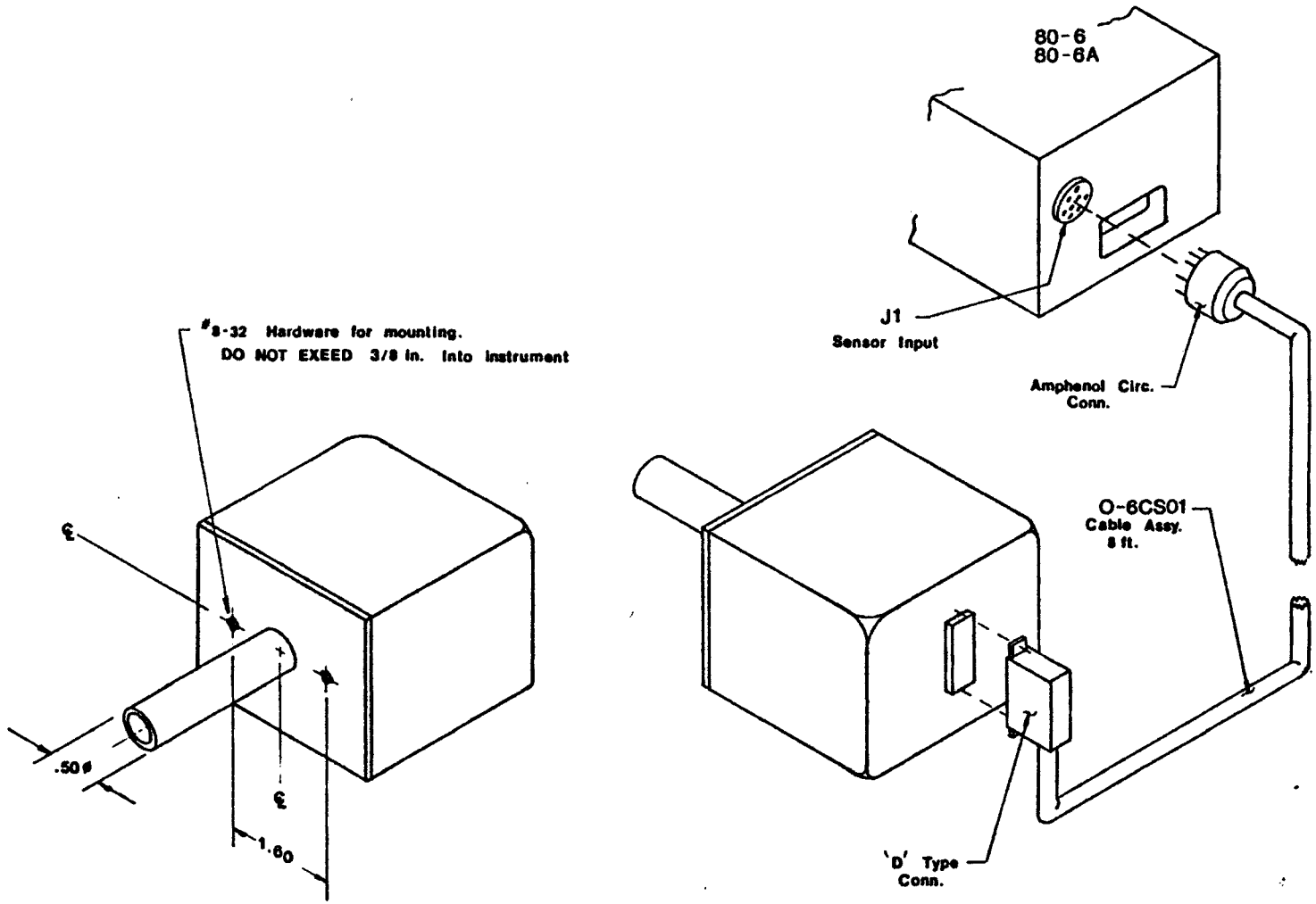


Fig. 4 Outline and Mounting Details

OPERATION

Capacitance manometers employ a tensioned metal diaphragm that is positioned perpendicular to the pressure input tube. Pressure on the input side displaces the diaphragm toward two electrodes that are located behind the diaphragm. Diaphragm displacements as small as .0000002 of an inch are sensed by capacitance measurement between the electrodes and the diaphragm.

Capacitance manometers provide an output voltage of 0 to +10 volts DC, which is proportional to a pressure from zero to the maximum range of the manometer. The pressure can be read directly on a digital voltmeter. The voltmeter's decimal placement should be adjusted according to the range of the manometer used. Alternately, Vacuum General provides a range of digital readouts/power supplies specifically for its capacitance manometer instrument range.

ADJUSTMENTS AND ZEROING OF CAPACITANCE MANOMETERS

The capacitance manometer has a zero adjustment that has been set at the factory. The zero should be checked at the time of installation and reset if necessary. Prior to zero check or reset, the capacitance manometer must be pumped down thoroughly and outgassed. Begin the zero setting procedure by cycling the manometer two or three times from atmospheric pressure to a pressure of 1×10^{-5} torr or lower. This cycling will release any temperature stresses in the diaphragm.

With the system at high vacuum (1×10^{-5} torr), check the zero of the capacitance manometer by using a digital voltmeter with at least four digits. Connect the voltmeter across the "Signal Out" (+) and "Signal Rtn." (-) of the manometer's connector. While monitoring the voltmeter's output, adjust the "zero adjust" potentiometer until the meter reading indicates zero. The instrument has now been nulled and is ready for operation.

OPERATION

Maximum Pressure at Port

16 PSI or 125% of full scale, whichever is greater.

Orientation

Preferred orientation is port facing down, alternative recommendation is port horizontal.(See Figure 5.)

NOTE: We do not recommend orientation with port facing up. But if orientation is absolutely required, you must use an inline filter.

Zero Adjust

The zero is set at the factory at room temperature. If a precision zero is required, connect the sensor to a vacuum port at 1 x 10^{-4} TORR or below and adjust the zero control located near the connector on the side of the sensor. If the sensor is used with a readout such as the Vacuum General 78-6A and 70-10A, the zero may be set at the front panel of the readout.

Environmental Operation

Operation in an environment conatining severe electro magnetic interference should not present a special problem. A heavy braided ground strap to the port may be necessary.

NOTE: This instrument should only be serviced by Vacuum General. Any attempt at so doing by others will void the warranty. Also, damage resulting from over pressure, over voltage input, over heating, water damage, misuse or improper installation are not covered by warranty.

Input Voltage

$\pm$ 15 volts DC $\pm$ .3 volts DC @ 250 MA

Normal Operating Temperature Range

+10°C to 45°C (temperature controlled range = 19° - 30° C)

Signal Output

"0" to 10 volts DC

Minimum Load Resistance

5,000 Ohms

INSTALLATION

Mounting the CMH Capacitance Manometer

Capacitance manometers normally are mounted by means of their inlet tubulation or with the use of one of the fitting accessories listed in Figure 3. The CMH also can be directly mounted with 8-32 screws. See Outline and Mounting Details, Figure 4.

Other recommendations when mounting the capacitance manometer are:

1. Do not put any strain on the manometer's inlet tubulation.
2. Ensure that there is a leak-proof seal around the inlet tubulation.
3. Keep the end of the manometer's inlet tubulation within 2 inches of the work chamber's wall.
4. If you are connecting tubing between the chamber and the manometer, keep the tubing diameter equal to or larger than the diameter of the inlet tubulation.
5. Do not put any strain on the manometer's connecting lead wires.
6. Do not use in-line filters between the work chamber and the manometer's port.

COMMENTARY

*The rationale for the preceding recommendations includes the following:

1. If particles enter the sensing port, they can affect the manometer's functioning--a condition that is likely to occur if the manometer's port is facing upward. For installations that require a vertical connection to the bottom of a chamber, we suggest that you mount the manometer horizontally and install a 90° elbow between the port and the chamber.
2. In-line filters and distance between the manometer and the chamber both introduce time delays that will reduce the speed of measurement and system response to fluctuations in pressure. Not using filters and keeping the manometer's port within 2 inches of the chamber will optimize both manometer and system performance.
3. Using connection tubing of smaller diameter than the manometer's sensing tube also is not recommended because it restricts gas movement and may increase response time.

Install the capacitance manometer as close as possible to the area of the vacuum chamber where you want to monitor pressure. Although the transducer can be installed with the end of the tube inside or flush mounted to the vacuum chamber or remotely on an extension tube, the closer the manometer is to the vacuum chamber, the more responseive it will be to fluctuations in system pressure.

Installation orientation for this transducer is not critical as long as the transducer is not mounted with the port facing up. Mounting with the port facing down is preferable, and mounting with the port facing sideways is PERMISSIBLE.

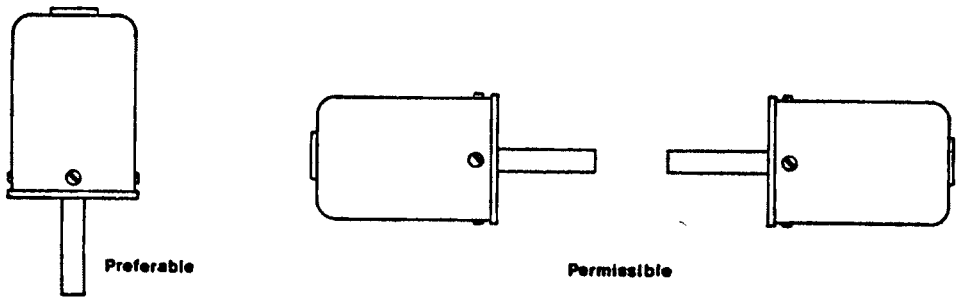


Figure 5. Installation Orientation

WIRING THE CMH CAPACITANCE MANOMETER

CAUTION:

The CMH Capacitance Manometer manufactured by Vacuum General is designed for a plus 15 volt DC and minus 15 volt DC supply. Reversal of these supplies may cause serious damage to the equipment and is to be avoided. When using the Vacuum General Model 80-6 power supply and readout module, specify the Model 0-6CS01 cable to assure porper connections. If using an alternate power supply and/or readout module, observe the following table for connecting the equipment.

J1 PINOUT		DESCRIPTION
1.	Signal out (+)	This is the positive side of the 0-10VDC output signal.
2.	Not Used	This connection is not presently used.
3.	RT. Factory only	This is reserved for Vacuum General use only. DO NOT USE this terminal.
4.	+15V Power	Must be connected to the plus side of the power supply (250 mA min.).
5.	-15V Power	Must be connected to the negative side of the power supply (250 mA min.).
6.	Case Ground	The case ground is isolated from signal and power supply common.
7.	Not Used	This connection is not presently used.
8.	Signal Ground	Is isolated from case ground by 100KΩ resistor and a 0.1μF capacitor.
9.	Power Ground	Return line for positive and negative of 15 volt power supply.

TABLE 1. J1 PINOUT

PRINCIPLE OF OPERATION

Introduction:

"CAPACITANCE MANOMETER" is the term given to a measuring instrument that utilizes the deflection of a diaphram and the resultant change in capacitance between the diaphram and a fixed electrode to sense pressure. Capacitance manometers are characterized by high zero stability, high accuracy and wide dynamic range. Although these instruments are inherently differential, they are commonly employed as absolute gauges by means of a hermetically sealed vacuum reference on one side of the diaphram.

Diaphragm:

Central to the proper operation of a capacitance manometer is the diaphragm (see figs 5&6). The diaphragm provides isolation between the measured medium and the reference cavity containing the sensing electrodes. It performs the function of the moving electrode when under pressure and thereby provides a change in capacitance proportional to the change in pressure.

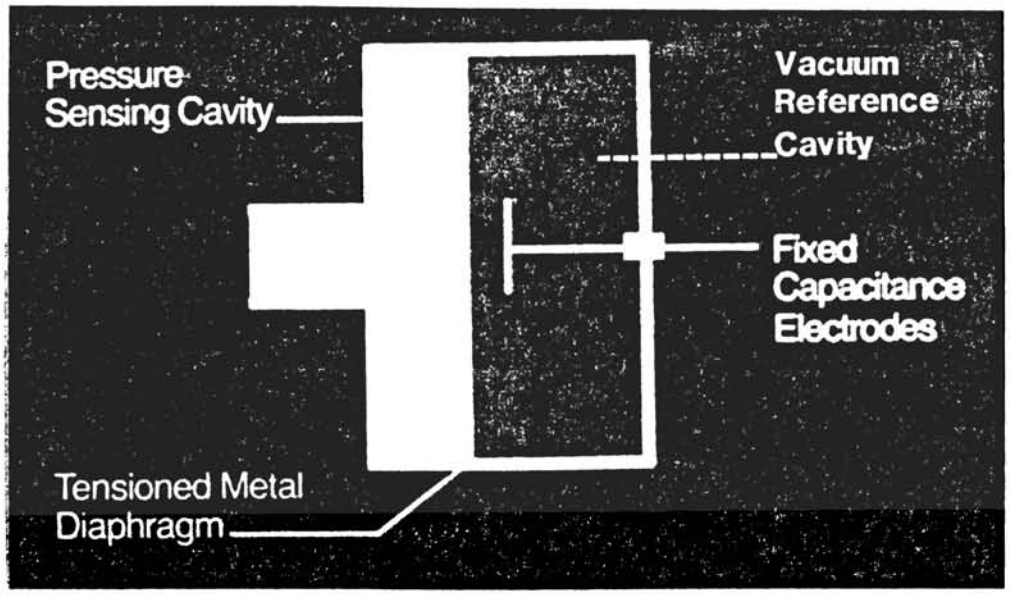


FIG. 5 BASIC SENSOR AT EQUILIBRIUM.

Capacitance manometers generally employ a highly pretensioned, thin metal diaphragm. Used in this fashion, the diaphragm can be considered more as a membrane than a plate because the diaphragm is linear at deflections many times its thickness. The increase in tension due to deflection can be made small, compared to the initial tension. Because the pressure is supported by the pretension, hysteresis and creep are reduced to the point of being negligible in the better embodiments of the technique. As the pressure magnitude across the diaphragm increases, thicker diaphragms are needed and the practicality of obtaining sufficient pretension diminishes. Thus, the higher the pressure range, the greater the deviation from pure membrane action and the poorer the elastic performance.

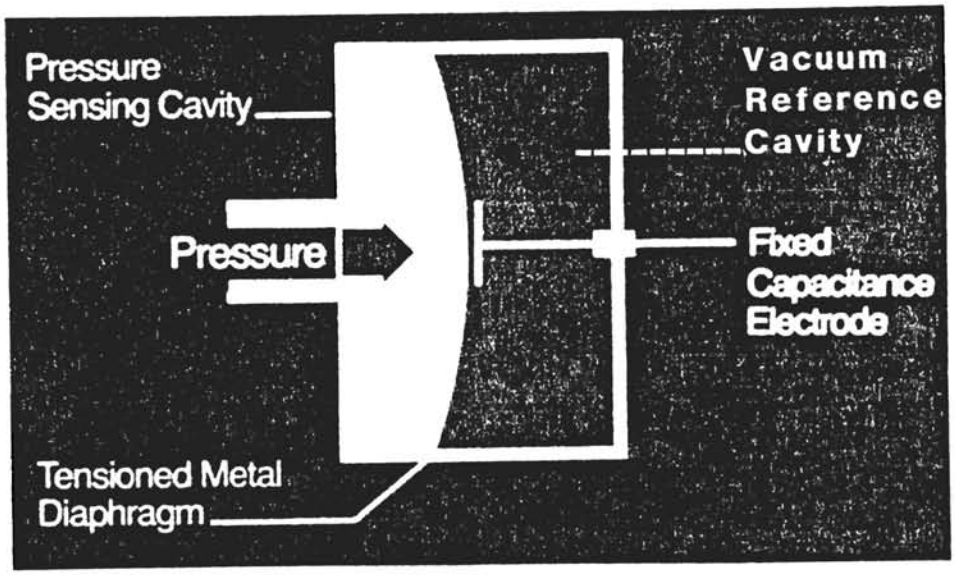


FIG. 7 BASIC SENSOR UNDER PRESSURE

The Capacitance Technique:

Many measuring instruments suffer from frictional effects, which cause hysteresis and non-repeatability. Frictional forces reverse direction when the deflection reverses direction. Such forces are necessarily variable in nature, due to their dependence on the level of vibration at any instance of time. The use of capacitance sensing allows a non-contacting scheme which is relatively easy to employ.

The use of capacitance as a sensing technique yields infinite resolution in the commonly employed sense and high output voltage with little or no power dissipation.

Gas capacitors can be excited with hundreds of volts, and measuring circuits can output at these levels, as opposed to other measuring techniques, which generally yield in the millivolt range before amplification. This high output voltage is significant in allowing a good signal-to-noise ratio. This in turn, is absolutely necessary when attempting to make meaningful measurements over a dynamic range of several decades.

Circuitry Considerations:

In order to realize the full potential of the mechanical portion of the capacitance manometer, it is necessary to utilize an electrical circuit which satisfies the particular application. In general, these circuits are periodic, and, due to the small capacitances involved, the frequency is generally high to keep the impedance at manageable levels.

The major elements of the Model CMH Series Capacitance Manometer are composed of the following blocks (refer to fig.9).

1. Mechanical Sensor
2. Oscillator Circuit
3. Follower Circuit
4. A.C. Amplifier
5. Demodulator
6. D.C. Amplifier
7. Square Wave & Voltage Source For Follower
8. Zero Circuit
9. Cut-off Circuit
10. Heater Circuit
11. Power Supply Circuit

A brief description of the system follows:

1. Mechanical Sensor.

As previously discussed the mechanical sensor provides the

interface between the medium under measurement and the generation of an electrical signal proportional to pressure. It accomplishes this by measuring the capacitance change caused by deflection of the diaphragm due to the difference in pressure between the reference cavity and the medium under measurement. (See fig. 7.)

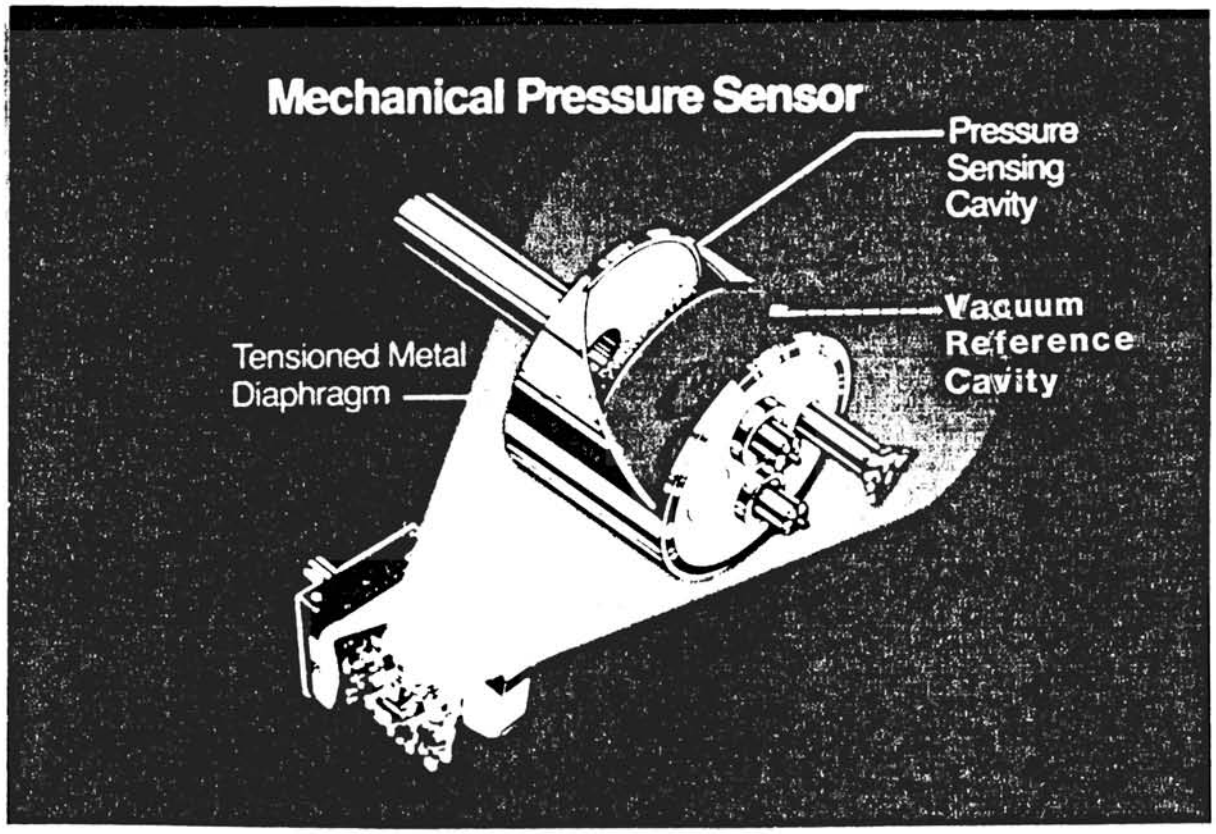
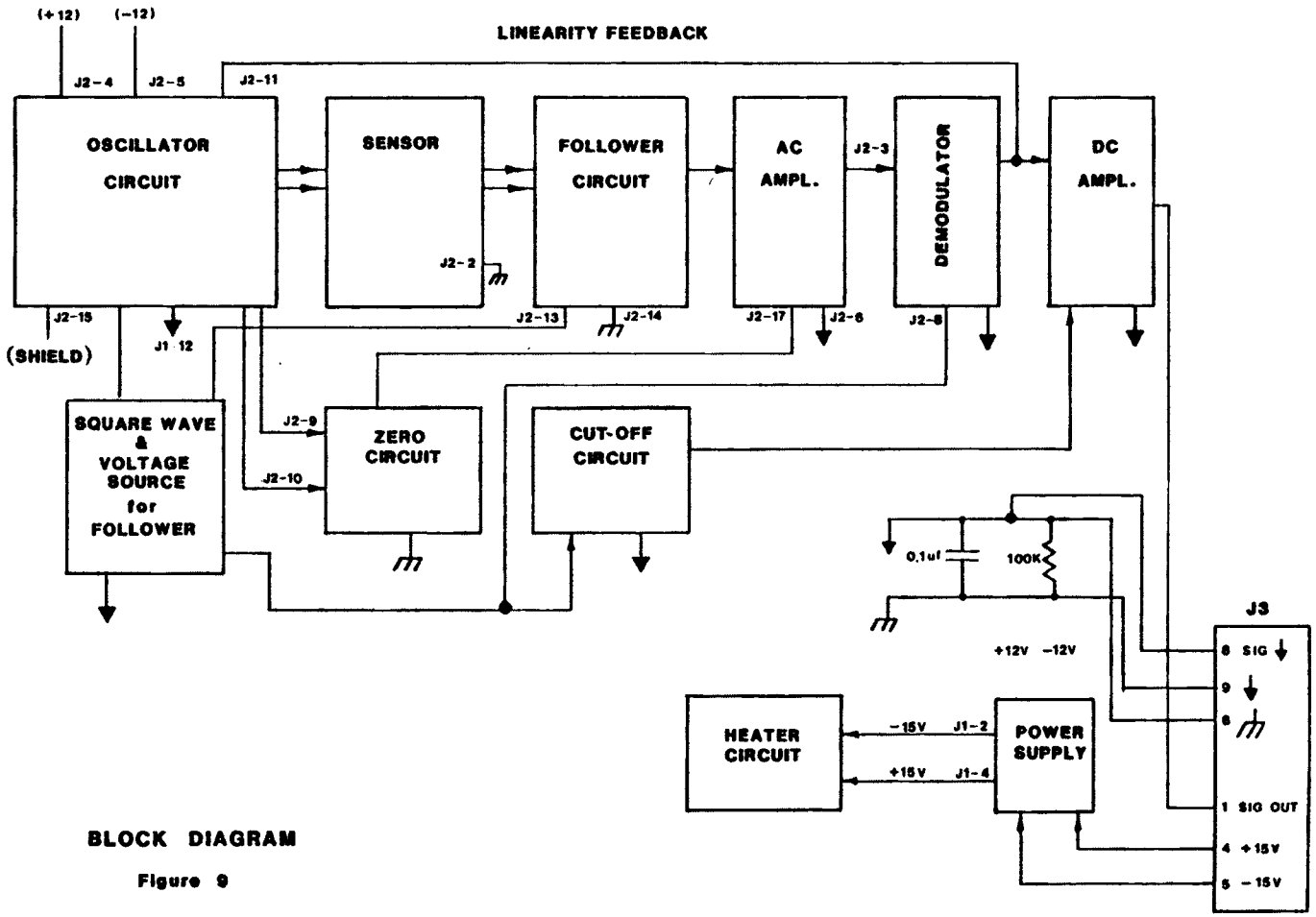


FIG. 8 MECHANICAL PRESSURE SENSOR

2. Oscillator Circuit.

An audio frequency carrier signal produced by a precision amplitude controlled sine wave generator, drives the transformer bridge containing the capacitance sensing electrodes of the mechanical sensor. The oscillator also drives a floating power supply which is used to isolate circuite ground from earth ground.



BLOCK DIAGRAM

Figure 9

3. Follower Circuit.

   The output of the transformer bridge, which is the carrier signal amplitude modulated by the sensor's pressure induced capacitance change, is fed into the follower circuit to provide a high impedance match prior to further amplification.

4. A.C. Amplifier.

   The a.c. amplifier provides amplification of the sensor signal and is transformer coupled to the output of the follower circuit. The output of this amplifier is also transformer coupled to the following demodulator stage.

5. Demodulator.

   The demodulator is carrier switched by a square wave signal from the floating supply and provides full wave synchronous demodulation of the amplified sensor signal and filtering. The resultant d.c. voltage signal, which is proportional to the change in capacitance of the sensor electrodes, is then sent to the d.c. amplifier.

6. D.C. Amplifier

   The d.c. voltage from the demodulator is fed to a single stage d.c. amplifier with a variable gain potentionmeter for full scale calibration.

7. Square Wave & Voltage Square

   This circuit provides the source of regulated floating supply to drive the sensor electronics. This circuit provides a regulated d.c. supply voltage for the voltage follower. It also supplies a square wave carrier reference signal for the demodulator.

8. Zero Circuit.

   A variable carrier frequency signal is applied in series with the output of the voltage follower to provide a method of zero adjustment.

9. Cut-off Circuit.

   When the capacitance manometer's full scale pressure is exceeded there is a potential that the sensor diaphragm will short-out the capacitor elements. This would result in no signal from the capacitance bridge and a zero output from the demodulator. To differentiate this ambiguous fold-back effect, the cut-out circuitry reacts to sensor capacitor shorting by providing a signal which drives the output to full scale.

10. Heater Circuit.

    The incoming ±15 volt supply is used directly to power the heater circuit. This circuit contains a Wheatstone bridge to monitor the enclosure temperature and provide a source of proportional power to drive a heater element which in turn precisely regulates the temperature of the enclosure. A lead-lag network is contained in the feedback loop to ensure stable operation of the heater.

11. Power Supply Circuit.

    Unregulated ±15 volt inputs are passed through wrong polarity protection diodes to three terminal semiconductor voltage regulators which provide ±12 volts regulated for internal circuitry.

12. All active inputs and outputs are passed through RFI filters to minimize RFI emissions and, equally as important, to prevent external RFI fileds from affecting system performance.