VACUUM COATING UNIT MANUAL

INSTRUCTION MANUAL

ROTARY VACUUM PUMPS
'ED' SERIES

TÜV CERT
DIN EN ISO 9001:2000

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1.0 INTRODUCTION

HINDHIVAC Vacuum Coater-12A4D can perform a large number of industrial and laboratory applications like preparation of thin films for Optical and Electronic applications, preparation of specimens for Electron Microscope, etc. The basic unit consists of a cabinet containing a vacuum pumping system together with all the electrical components necessary for the coating process.

2.0 SYSTEM DESCRIPTION

A. VACUUM CHAMBER

The chamber is fabricated from electrochemically-polished stainless steel. Three circular glass windows enable visual inspection of the coating process. When the chamber is placed on the base plate it makes a vacuum tight seal with the base plate by means of an 'L' type neoprene gasket.

A Cooling water pipe line is coiled on the outer wall of the chamber to prevent overheating, and to reduce the outgassing by circulating the water. Alternatively a glass bell jar is supplied along with the unit.

B. PUMPING SYSTEM

The chamber is evacuated by a HINDHIVAC diff pack pump Model-114D and backed by a 250 liters per minute, double stage, direct driven, rotary vacuum pump, Model ED-15 with an overload protection.

THE SYSTM CONTAINS FOLLOWING VACUUM VALVES:

a. A hand operated high vacuum valve is fixed to a base plate of 13" dia. This valve isolated the chamber from the pumping system so that the chamber can be brought to atmospheric pressure without switching off the pumping system. A stainless steel wire mesh is fixed over the base plate opening to prevent foreign bodies from falling into the high vacuum valve

b. A single handle operated 3 way combination valve is used in roughing and backing line. The backing position is used to isolate the Diff pack pump from the rest of the system when roughing is in progress. The roughing and backing valves are interlocked and due to the single lever operation they cannot be opened simultaneously.

c. A 6mm RAV is fixed to the collar pipeline to release the chamber vacuum after each coating process cycle. A fine control needle valve is also provided on the collar for use during H.T discharge cleaning or sputtering is employed.

3.0 SAFETY DEVICES

a. An over load protection for rotary vacuum pump motor is provided by an air break direct line starter with a thermal overload relay.

b. The cooling coil of the Diff pack pump is equipped with a thermal switch, which isolates the power supply to the pump heater in the event of over heating.

c. A water flow switch is also incorporated in the outlet of the cooling water supply line to switch off the power to the Diff pack pump in case of failure of water supply or minimum recommended flow pressure.

d. A vacuum switch is incorporated in the roughing line and set to operate when the chamber pressure approaches atmospheric pressure and isolate the power supplies (HT, RH, LT). This prevents accidental switching 'on' of H.T. power supply when the chamber is exposed to atmosphere.

e. The LT supply for evaporation filaments or boats is obtained from a 230V input transformer by means of parallel or series connections in the secondary side of the transformer. The output rating may be either 20V 100 amps or 10V 200 Amps (continuous) or 10V 100 amps or 20V 50Hz amps intermittent (110 minutes). The standard unit is normally connected for 200 amps. Rating. The LT output from the transformer is fed through a current meter and through a selector switch to LT feed through and filament holders.

f. The doors of the coating unit cabinet are equipped with a switch to isolate the power supply of HT, RH & LT when door is removed (Refer circuit diagram enclosed).

g. The HT supply for glow discharge cleaning (Ion Bombardment) is obtained from a high reactance transformer rated at 3.5 KV 50mA (5 KV AC open circuit.)

h. The input voltage to the LT and HT transformers and the radiant heater are first selected with a Rotary switch on the electrical control panel and then fed to a manually operated variac controller on the coating unit cabinet. A circuit breaker in the return line is provided to protect the variac control from overload. A 0 to 10 amps AC primary current ammeter is also provided in the return line.

i. To measure evaporation current an ammeter is provided on the panel. It works in conjunction with a current transformer, which is connected to the secondary of the LT transformer. The ammeter is sealed 0-100 amps in black and 0-200 amps in red for 20V and 10V respectively.

j. A solid-state power pack to give a full wave rectified DC supply is provided for HT cleaning and cathode sputtering supply. The 0-10 amps AC primary current meter indicates the primary current of the HT transformer when HT cleaning of sputtering is in progress.

FUSES

F1	32A	MAINS
F2	32A	MAINS
F3	10A	ROTARY PUMP
F4	2A	ROTARY DRIVE
F5	4A	DIFUSSION PUMP
F6	2A	FE
F7	20A	HT,RH,LT MAINS
F8	2A	HT
F9	10A	LT
F10	10A	SH/RH .

VACUUM MEASUREMENT.

A Pirani operates in conjunction with two Pirani gauge heads, one mounted in the rotary vacuum pump pipeline and the other in the collar side. The Pirani gauge measures from 0.5m.bar to 1 x 10(-3)m.bar and the Pirani gauge is used to measure roughing and backing pressure.

The penning gauge head is mounted in the collar. The penning gauge head measures from 1 x 1-(-3)m.bar to 1 x 1-(-6) m.bar. The penning gauge is used to measure high vacuum in the chamber.

ELECTRICAL CONTROLS AND INDICATORS

The following are mounted on the panel and electrical control panel on the front of the cabinet

1. Rotary vacuum pump indication lamp
2. Diffusion pump indication lamp
3. HT (HT Cleaning) indication lamp
4. RH (Radiant Heater) indication lamp
5. LT indication lamp
6. Mains indication lamp

7. Primary current to the transformer (HT, LT and radiant heater) is indicated on 0-20 amps. Ammeter.

8. LT secondary current is indicated on 0-200 amps. Ammeter, i.e.100 Amps. used when the LT transformer secondary is connected for 10V operation.

9. A 0-500 deg.c digital indicates through a thermocouple the temperature below the radiant heater (i.e. at the substrate)
PD controller used for measure the temp. and controlling of substrate heater – (OPTIONAL)
(Accessories supplied along with the radiant heater or substrate heater 500° C)

10. A manually operated speed control is provided to the rotary drive motor (accessory.)

THREE ROTARY SELECTOR SWITCHES ARE LABELLED AS UNDER

1. OFF – Rot. Drive – Rot. Drive & Diff. Pump

2. OFF – HT. –R.H.-L.T.

3. EL1-EL2 – EL3 LT electrode selector **(optional)**

4. Green and Red/START/STOP Push buttons for Rotary pumps

CHAMBER GADGETRY (STANDARD)

A The chamber gadgetry comprises of a work holder ring, which has a diameter of 8". The work holder ring is supported by three pillars fixed to the base plate. A spherical work holder which is supplied unpierced along with the unit is mounted on the work holder ring for uniform coatings on plain area from a central evaporation source.

B A DC high-tension discharge cleaning system consisting of pure aluminum bar (Cathode)with suitable shielded to avoid electron contamination of the substrate.

C A source shutter swinging over the source position and operated by an external lever is provided on the top of the tabletop.

D A standard filament holder is fixed to the LT live electrode and an earth electrode. The filament is normally positioned vertically below the center of the work holder to give uniform distribution of the evaporation. Two sets of off-center filament holders and one set of center filament holder are supplied to fix them these three sets of LT electrodes for multi layer coatings on small plane areas where there are no uniformity. A 200 amps selection switch is provided in the door to select any one of the three LT electrodes.

E A baffle plate is provided within the tripod just above the base plate aperture. This also acts as a radiation shield when the radiant heater is used.

F A stainless steel wire mesh is provided over the base plate opening to prevent foreign bodies from falling into the baffle valve.

G A sputtering gadget of 3.1/2" dia, Copper cathode with an associated shielding is supplied. The cathode electrode is supplied un plated and necessary plating should be done by the customer. (Optional necessary)

4.0 ACCESSORIES (OPTIONAL)

1. ROTARY DRIVE

The rotary drive is useful for deposition of materials uniformly on large plane surface substrates. This comprises of a rotating work holder, which has a useful diameter of 6". The work holder ring is supported by three equally spaced ball bearings one of which is spring loaded, acting on the rim of the work holder. The work holder is rotated by a variable speed electric motor situated on a platform inside the coating unit cabinet. The speed of the rotary drive motor is controlled by a rider control fixed on the left side of the cabinet.

NOTE: Rotary drive is used along with the sector filament holder. Remove multi filament turret, spherical work holder & use flat work holder.

A. OFF SECTOR ION BOMBARDMENT

This is used in conjunction with the rotary drive. This high-tension discharge cleaning system consists of a super pure aluminum electrode bar. The bar is shielded to avoid electron contamination of the substrate during discharge cleaning.

B. SOURCE SHUTTER PLATE

This plate is designed to cover any one of the off sector filament holders meant for sequential evaporation when a rotary drive is used. The shutter plate is attached to a standard source shutter shaft when a rotary drive is used.

C. OFF SECTOR FILAMENT HOLDER

These filament holders are used in conjunction with the rotary drive. They are designed to distribute uniform evaporation on a rotating plane substrate held in the rotary work holder ring.

2. MULTI-FILAMENT TURRET:

This is designed to evaporate four different materials vertically below the center of the work holder ring without breaking the vacuum. There is no provision to evaporate from

off-sector to be used along with the rotary drive. This gadget is to be used with a spherical work holder for multi layer depositions.

This thermal evaporation system consists of a four-position vapor source turret constructed out of copper, permitting current loading up to 100 amps. The low tension earth brush is in permanent contact with the rim of the turret low tension earth plate and low tension life electrode brush will make the contact whenever that evaporation source comes to the firing position (i.e. to the center). The turret, which is supported on a circular plate, positioned 3" above the base plate (from base plate to filament) is rotated by an external hand wheel. The movement is transmitted into the vacuum system via a ¼" Wilson shaft seal and a chain drive. The evaporation is carried out from the vapor source positioned vertically below the center of the work holder ring. Each source can be adjusted to evaporation position by observing through the chamber window and that particular number of the source can be identified at the hand wheel indicator.

NOTE: When MFT is used LT Evaporation source holders are to be removed.

3 RADIANT HEATER

The radiant heater is fixed inside the chamber on top of the work holder ring. This is capable of heating the substrate up to a temperature range of 250'C to 275'C in about 30 minutes. The heating element is Inconal sheathed nichrome and the circuit is fused at 10 amps. To prevent overloading of the heater. Electrical connection is made via two feed through fixed through the base plate.

Temperature measurement is made using a chromel-Alumel thermocouple in conjunction with a 500'c. digital meter mounted on the front panel. The thermocouple leads are brought out of the vacuum system via a vacuum feed through in the base plate.

Note: Temperature indicator is common for both RH & SH.

4 ELECTRON BEAM GUN:

The electron beam gun is a vapor deposition source designed to produce thin films in high vacuum. The gun can achieve temperatures in excess of 3000'c. This is adequate to produce thin metallic and non-metallic films of refractory metals such as tungsten, tantalum and molybdenum. The material holder is water-cooled copper.

The gun consists of three principal parts, a water-cooled sample holder (Anode), a filament (Cathode) and a shield. In operation the filament is resistively heated by a filament power supply to a point where it admits electrons. One of the filaments is connected to the shield. This prevents electrons from being accelerated and striking the shield. The sample holder is held at several K.V. positive with respect to the filament and shield by high voltage supply. This causes the electrons, which have been emitted by the filament to accelerate towards and strike the sample in the

sample holder. On striking they give up energy gained during acceleration, heating the sample to the point where it evaporates. The shield prevents the evaporated material *from* leaving the gun in any direction other than through the port on the top shield. A power supply consisting of HT and LT with meters and controls will be supplementary with the gun.

NOTE: When EBG is used all LT Evaporation source holders, MFT, FE are to be removed.

5. FLASH EVAPORATION

The flash evaporation unit consisting of a suitable electro magnetic vibrator which is fitted inside the chamber to feed continuously on to a heated boat type thermal evaporation source for rapid evaporation of material .The rate of feed can be adjusted electrically from outside by changing the amplitude of vibration .It is completed with variable power supply.

NOTE: When FE gadgetry is used along with central evaporation Source holder. MFT, SH, Source shutter plates cannot be used.

6. COLD FINGER

Specimen cooling by liquid nitrogen is achieved by a cold finger which is introduced from the top view port of the stain less steel chamber after removing the standard view port glass. Liquid nitrogen has to be poured in to this finger which cools the specimen holder by conduction. Proper design of the cold finger eliminates excessive water condensation out side. The specimen has to be clamped directly to the cold finger, at the bottom, inside the chamber. The maximum specimen size which can be clamped to the cold finger will be about 1 square inch.
Note: When CF is used RH, SH & RD to be removed.

7. ELECTRO-PNEUMATICALLY OPERATED SOURCE SHUTTER.

The electro pneumatically operated source shutter is used to cover or uncover the evaporation source automatically, based on the signal from the digital thickness monitor .this consists of a pneumatic cylinder attached to a rotary shaft seal with shaft and shutter plate.
Note: When pneumatic shutter is used, manual shutter to be removed.

8. SPECIAL SUBSTRATE HEATER.

The special substrate heater for 500 degC temp. is basically a nichrome heater embedded between two stain less steel plates supported on stain less steel radiation shields. The substrate, which is to be heated, is placed on top of the heater. The temp. measurement and control is by means of digital PD controller

with K type thermo couple. The power to the heater is smoothly controlled by means of SSR power controller based on signal from digital PD controller.

Note: When substrate heater is used, RH, rotary work holder to be removed.

SERVICES REQUIRED

Power supply	230V AC single phase 50 Hz 15 amps.(see circuit diagram) Maximum power consumption about 3 KVA.
Cooled water at 20'c	Consumption 2 lts./min. for DP, metal bell jar and EB gun
Installation	The unit should be installed on an even level concrete floor.
Unpacking	The unit, in a dismantled condition, is packed carefully in several cases to avoid damage during transportation. On receipt of the unit, carefully unpack and check the components for damage.

ROTARY VACUUM PUMP

Before connecting the rotary vacuum pump to the coating unit, charge the oil to the pump as follows.

A Remove the oil pouring dummy of the rotary pump

B Fill the pump with oil to the level marked on the sight glass window in the pump wall, and replace the oil pouring dummy.

DIFFUSION PUMP

Charge the diffusion pump with 100 ml. Of the silicon oil/Hydro Carbon oil supplied as follows.

a Vent Air into the Diffpack pump

b. Before pouring the oil pre-heat the Diffpack pump for at least 10 minutes. and cool it about half an hour

c. Remove the knurled locknut on the diffpack pump

d. Slowly pour the 100 ml. Charge of diffpack pump oil into the diffpack pump oil port using a clean funnel

e. Re-position the dummy and tighten the joints carefully. (Make sure that you have replaced the 'O'ring properly).

5.0 INSTALLATION OF SPUTTERING GADGET

It is necessary to remove the filament holder and HT cleaning assembly to install the sputtering gadget.

A Remove the chamber

B Remove the work holder

C Remove the HT cleaning gadgetry by loosening the securing screw and by disconnecting the wires.

D Remove the external shield

E Remove the screws securing the filament to LT electrodes

F Slip the sputtering gadget on the tripod such that the electrical contact comes on top of the HT electrode and fix its position by tightening its screws.

G Make the electrical connection with an aluminum wire of 0.5 mm to 1mm dial and insulate it with porcelain beads.

INITIAL SETTING UP

Prior to starting a newly installed coating unit, carry out the following.

A Check the vacuum gauges in accordance with the relevant working instructions supplied. The operator should be thoroughly familiar with it before using the coating unit.

B Fix new filaments or evaporation boats to the filament holders. Whenever a new filament or boat is fixed the chamber must first be evacuated to 10(-4)m.bar and flushed the same to remove contamination etc. by passing slightly higher current than that is normally used for evaporation.

C. The rotary work holder if fitted can be operated by means of the rotary switch (on the electrical panel) and speed control.

D. Check DTM is in working condition or not, for further details

PLEASE REFER :DIGITAL THICKNESS MONITOR INSTUCTION MANUAL

PRE-OPERATIONAL CHECK (ROUTINE)

A The rotary vacuum pump oil level is correct

B All the manually operated valves are closed

C All the switches on the control panel are off

D All the coating unit cabinet doors are properly closed.

6.0 OPERATION

1 Switch on the main switch. Switch on the rotary vacuum pump

2 Switch on the Pirani gauge

3 On the first start of each day, check the rotary vacuum pump by means of gauge head-1 for its satisfactory operation and by closing the combination valve CV-25

4 Close the high vacuum valve

5 Turn the combination valve to backing position. The pressure should fall steadily to better than 0.05 m.bar as the diffpack pump is evacuated.

6 Allow the cooling water supply to flow.

7 Switch on the Diffpack pump by selecting rotary switch. The diffpack pump will take about 30 minutes to reach the operating temperature.

8 Remove the chamber after admitting air

9 Load the filaments or boats with the required material and fix the substrates on the work holder. Note down the materials that are loaded in the turret with the appropriate number of that particular filament or boat. Select the required filament or boat on turret (if turret is fitted).

10 Cover the filament or boat with source shutter

11 Replace chamber on the base plate.

NOTE: Clean the L-gasket sealing portion before placing the chamber and see that no foreign materials are left on the base plate where the chamber L-gasket sits.

12 After Diffpack pump is ready, close the chamber air admittance valve and needle valve.

13 Close the backing valve and open roughing valve slowly

14 Select gauge head-2 in Pirani

15 Wait until gauge head-2 shows better than 0.05 m.bar

16 Close the roughing valve and open the backing valve

38. Repeat the process with each filament if necessary. Zero the thyristor control before changing the filament selector switch each time.

39. When evaporation is complete shutter the source. Zero the thyristor control. Switch off the LT and CB – 1.

40. Switch off the penning gauge, close the high vacuum valve and allow the chamber temperature to come down to 50'c. or less in case the chamber is at higher temperature.

41. Open the air admittance valve till airflow ceases and then remove the chamber.

42. Unload the work holder. Handle the fresh films with care.

7.0. RE – CYCLING.

Re-load the work holder and vapor source when necessary and proceed as before from starting the unit from Sl. No – 9.

8.0 SHUTTING DOWN THE UNIT.

The operator is advised to leave the chamber under vacuum at all time when the unit is not in use in order to prevent exposure of the chamber interior to atmosphere.

1. Evacuate the chamber down to 10(-4) m.bar then close the high vacuum valve.
2. Switch off the penning gauge.
3. Switch off the diffpack pump.
4. Run the rotary pump for a period of 15 – 25 minutes keeping the backing valve open and close backing valve and switch – off the rotary vacuum pump.
5. Close the cooling water supply.
6. Switch off mains switch.

NOTE: Before attempting to re-open the chamber do not forget admit air first.

9.0 LEAK DETECTION

1. SPURIOUS LEAKS

If the equipment has been dismantled and re-assembled a longer pump down time must be allowed to deal with out gassing from the walls of the system and to pump.

Fluid. Similarly contamination of the system with vapor given off by dust, greases, etc., will prolong the pump down time and give the appearance of leakage. This can be avoided by paying strict attention to cleanliness and by keeping the work chamber under vacuum when not in use. Defective operation of the pump equipment will also cause prolonged pump down time and poor vacuum.

THE FOLLOWING ITEMS SHOULD THEREFORE BE CHECK:

A. The diffpack pump heater for open circuit.

B. The Quantity and condition of the oil in the diffpack pump.

C. The interior cleanliness of the chamber system. The state of chamber sealing gasket and sealing surface.

INDICATION OF LEAKS

A. LENS BLOOMING

After deposition the condition of the residual magnesium fluoride will give an indication of the chamber vacuum. A good vacuum will cause the residue to appear white or light gray. If it appears dark gray or black, air leakage should be suspected. The hardness of the film and leak or uniform color are further indications of poor vacuum.

B. EVAPORATED METAL FILMS

Here again lack of brightness and or hardness in the film is an indication of poor vacuum. Also under good vacuum conditions, the deposited metal, cast sharp shadows of objects on the work chamber since the molecules of metal vapor travels in straight paths. The mean free path of gas molecules at low pressure being sufficiently long to make collusions between them and the deposited metal negligible.

C. CONDITIONS OF FILAMENT WIRE

Both molybdenum and tungsten filaments appear bright after heating in good vacuum. Should the filament appear contaminated with a brownish deposit, leakage should be suspected.

INTRODUCTION

a. *General Description*

'HINDHIVAC' Direct Driven, Vane type vacuum pumps are double stage, oil sealed type and designed for a variety of basic vacuum pumping applications.

The pumps are similar in construction but of varying pumping speeds (nominal free air displacement) like 3(M^{-3})/hr, 6(M^{-3})/hr, 15(M^{3})/hr, 21(M^{-3})/hr and 30(M^{3})/hr. The direct drive to the pump is provided through a flexible coupling from a flange mounted motor which also drives the cooling fan. The pumps are provided with either single phase or three phase motors.

b. *Construction*

'HINDHIVAC' High Vacuum Pumps, ED-Series, are spring loaded Sliding Vane type, with vanes placed in the slots of the rotor. They are mounted eccentrically both in the first and second stage with inter connecting ports.

Both, the first stage which creates primary vacuum and second stage which creates the low pressure, are isolated with the introduction of an isolator in between and the two rotors are mounted eccentrically within respective stators.

The first stage end plate has a bearing and an oil seal for isolation from atmosphere. The second stage end cover also has a bearing for locating the shaft, which will give the closest possible tolerance and free movement within the stator and rotor for efficient performance of the pump.

This block is fixed to an aluminium assembly, called the Mounting Block. On one side of this is fixed the vacuum pump and the oil cover and on the other side the driving motor. A coupling joins this assembly to the motor for a smooth drive.

The oil pump housing is mounted on the rear end plate of the stator. This oil pump provides the lubrication to the pump and the oil flow to the stator. The pump functions in a similar manner as the vacuum pump. It has a vane, mounted in an excentric position in the bore and drives the oil under pressure. In the event of the pump stopping a spring - loaded flap valve is activated to seal the oil port of the oil pump, thereby preventing any backstreaming of oil in to the chamber because of difference in pressure.

A filter is provided on the oil pump housing through which oil is sucked in. This prevents any dirt or fibrous tissues from entering the pump and causing reduction in flow of oil and thereby seizure of moving parts.

Precautions should also be taken when these pumps are used in places where high water vapour tolerance is required. Chilled condensors are recommended for condensing water vapours. While handling water vapour, please run the pump with its gas ballast open.

Special care is to be taken when pumps are used where acidic vapours are present. Traps to neutralise these dangerous vapours must be used. Otherwise, they will damage the inner parts of the pumps.

For smooth functioning and noiseless operation, epoxy blades are used within the rotors. Chemicals prone to attack such resins should be specially taken care of and should not be allowed inside the pump. Otherwise, decomposition of the vanes will result in unsatisfactory functioning of the pump.

Occasional opening of oil tank and cleaning the filters is recommended to give trouble free service and assured low pressures.

c. *Working Principle*

During operation, the rotor vanes sweep the volume of the gas or air trapped in the crescent shaped gap formed by the rotor which is mounted eccentrically in the stator. As each vane passes the inlet port opening a known quantity of gas is introduced and subsequently trapped and compressed by the next vane following it and ejected via the exhaust flap valve mostly and via the interconnecting port to the II stage partially, when the inlet pressure is near atmospheric pressure. As the inlet pressure drops the I stage exhaust flap valve closes and all the air or gases pass to the II stage, where it is further compressed and discharged to atmosphere.

d. *Gas Ballast*

The Direct drive models are incorporated with a gas ballast facility to enable them to pump the condensable vapours without contaminating the pump oil. This is done by introduction of gas or air at atmospheric pressure through a manually operated valve into the volume between the second stage rotor vane and discharge valve, when the mixture of air and vapour in this volume is at low pressure. When the volume of gas (air)/vapour mixture is compressed prior to ejection, the discharge valve opens before the partial pressure of the vapour component is high enough to cause it to condense.

TECHNICAL SPECIFICATIONS

Sl. No	Pump Model	ED6	ED15	ED21	ED30
1	Nominal Pumping Speed:M^3/Hr	6	15	21	30
	Lit/Min	100	250	350	500
2	Ultimate Partial Pressure : (on Mcleod Gauge)				
	Gas Ballast Closed: (m.bar)	$5x10^{-4}$	$5x10^{-4}$	$5x10^{-4}$	$5x10^{-4}$
	Gas Ballast Opened: (m.bar)	$6x10^{-2}$	$6x10^{-2}$	$6x10^{-2}$	$6x10^{-2}$
3	Weight (kgs)	32	42	45	52
4	Maximum nominal power rating(KW)	0.25	0.37	0.55	1.1
5	Pump Rotational Speed (at no load r.p.m)	1340-1440	1340-1440	1340-1440	1340-1440
6	Oil Capacity (Lits)	2.0	2.75	2.75	3.0
7	Inlet Flange (ISO-KF)	KF-25	KF-25	KF-25	KF-25
8	Recommended Oil	HINDHIVAC Molecular Distilled Oil : Grade MD-504			

INSTALLATION

a. *Unpacking*

Unpack the pump and remove all protective covers and the protective cover on the inlet pipe. Check for any possible damage in transit. If found alright, proceed as given below. The handle of the pump which is packed separately is to be fixed with the two screws provided at the top of the pump.

b. *Pump Inlet Connection*

The vacuum inlet connection is a KF-25 Flange with an 'o' ring holder and 'o'ring. The free flange can be welded to a pipe or inserted into a rubber tubing.

c. *Pump Outlet Connection*

A plain nozzle of suitable size provided for the pump discharge connection.

The pump exhaust nozzle can be connected through a tubing to the outside of the building with a sump in such a way that condensed fluid from pipe should not flow back to the pump.

d. *Oil Charge*

During installation, initially pour 100ml of oil to the inlet of the pump. To facilitate Oil pumping. Remove the oil filling plug and fill oil to a level which is visible through the sight glass using the recommended grade of oil. The level of the oil is to be half the level of the oil sight glass. Replace the oil filling plug with the sealing gasket in position.

NOTE	**During normal running of the pump, the oil level will be visible in the sight glass**

e. *Electrical Connections*

The pumps are fixed with single phase 230V AC 50Hz motors of suitable rating. Three phase motors are provided on request at extra cost.

To connect the electrical supply leads, remove the terminal box cover and take the lead wires through and connect to the appropriate terminals.

The direction of rotation is clockwise when viewed from drive end. The motor is factory wired to run in the correct direction and requires no change while connecting power in case of single-phase motors.

OPERATION

NOTE	Never obstruct the pump outlet, this may cause dangerous pressure build-up inside the pump.

a. Before starting the pump check that the oil level, which is visible in the oil sight glass, is at the indicated level. The pump will operate satisfactorily at this level for normal use.

b. When pumping condensable vapours present in the system, the gas ballast facility must be utilised by introducing air into the pump by rotating the gas ballast valve in anti-clockwise direction. Before pumping vapours, the pump should be isolated from the system and allowed to run for approximately 20-30 minutes to warm the oil and assist in preventing vapour condensation in the cold pump. The gas ballast valve is to be closed when better ultimate vacuum (lower pressure) is required in the system after the vapours are removed.

c. When the pump is used for pumping large quantities of vapour, it is recommended that the pump is isolated from the system and run for atleast 30 minutes with the gas ballast valve open. This particularly applies after corrosive vapours have been pumped. If the pump is used in systems which produce heavy evacuation of vapours, particularly if vapours are of a corrosive nature, the gas ballast may not completely protect the pump. A suitable trap is recommended to reduce the harmful vapours carried over to the pump.

d. If the system connected to the pump has likelihood of solid particles present entering the pump, a dust filter should be incorporated in the line. (for details refer to accessories)

e. When measuring ultimate pressure (ultimate vacuum) it is to be taken note of, that the pump oil may have a vapour pressure which is higher than that of the permanent gases in the system being evacuated. Hence, while measuring the ultimate vacuum with gauges of Pirani or Thermocouple type, which measure the total pressure of the permanent gases and vapours, they will indicate differently from gauges of Mcleod or Manometer type which will only indicate the pressure of the permanent gases.

To obtain the highest possible vacuum when the pump is filled with a fresh charge of oil, it is recommended to run the pump with full gas ballast open for 10 to 15 minutes before measuring the ultimate vacuum or connecting it to the system. This has the effect of degassing the oil and improving the ultimate vacuum.

f. The retention of vacuum in the system when the pump is shut off for any reason is possible only if the gas ballast valve is closed. It is recommended to use a Solenoid Operated Isolation-cum-Air Admittance Valve at the inlet of the pump where greater system security is required, on large volumes which are evacuated where they create a negative drive on the pump by force of a large volume.

g. The pump is designed for long and trouble free operation provided the recommended operating and servicing procedures are adhered to. Before despatching the pump, each and every pump is inspected and tested for performance. Many cases of suspected failure and of poor pump performance are infact due to leakage in vacuum system, faulty due to wrong selection or not properly providing suitable accessories like traps, etc. Any such possibilities are to be checked with proper guidance by our design department while choosing pumps for different applications.

MAINTENANCE

The following routine servicing will be required :

a. Oil Level

Oil level to be checked daily.

b. Oil Pouring

To top the oil, remove the oil filler plug located on the top of the oil tank and fill with recommended grade of oil until the oil level is visible in the sight glass above the minimum required level. Replace the filler plug and ensure the gasket seal is in position.

c. Oil Filling

To change the oil proceed as follows :

d. Gravity Drain

Switch off the pump, place a clean suitable tray or container beneath the drain plug and remove the plug. Allow oil to drain completely. Switch on the pump for few seconds and throttle the exhaust nozzle with finger to ensure complete flushing of the oil. Switch off the pump immediately. Pour a small quantity of oil down the vacuum inlet and switch on the pump for rinsing the pump and flushing purpose. Switch off the pump. Drain the oil and replace the

	WARNING		**DO NOT completely restrict the pump outlet while flushing the oil under pressure as this may cause excessive high internal pressure build up resulting in pump oil tank rupture.If long pipes are connected to the pump exhausting out of air conditioned enviornments, please use sufficiently large diameter pipes to ensure no back pressure is built up on exhaust.**

SPARES & ACCESSORIES

A set of spares comprising of these items are recommended for trouble free maintenance.

1.	Springs & Pins for Vanes (1st & 2nd Stage)	:	1 set
2.	Oil seals	:	1 set
3.	Gaskets and 'O' Rings	:	1 set
4.	Filters	:	1 set
5.	'O' ring holder with `O' Ring	:	1 set
6.	K.F Clamp	:	1 set

A full range of accessories are available for direct drive pumps as listed below.

a. Inlet Filters (Dust Filters)

Inlet dust filters are recommended where fine abrasive dust particles are to be prevented from entering the vacuum pump. This filter incorporates a fine mesh filter which is supported by a frame. The inlet and outlet are of KF couplings.

b. Moisture Trap

The moisture trap is designed for use in systems where the requirement is for removal of limited quantities of moisture at low pressures. The phosphorous pentoxide (P2O5) dessicant is contained within the trap.

c. Foreline Trap

For use in clean pumping systems, it utilises the trapping properties of activated alumina to trap oil vapour and prevent back migration of pump oil vapour into the vacuum system.

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d. *Mist Filter*

The Exhaust Mist Filter is recommended on the outlet (exhaust) to capture oil mist which would be otherwise admitted into the environment while running on gas ballast or inlet open for long periods of time.

e. *Anti Vibration Mounting*

'U' shaped rubber cushion mounting for pumps installed on framed structures to avoid vibrations being transmitted to other parts. Flexible hoses or bellows between the pump and the system, are recommended.

f. *Isolation Valve:*

The Isolation valve is recommended for enhanced protection against backstreaming of vacuum pump oil into the system. This is incorporated directly on the inlet connection of the pump.

g. *Water Cooled Condenser*

The water cooled condenser is recommended where condensable vapours or gases are pumped by the pumping which may otherwise contaminate the pump oil. These are supplied with KF couplings to match the pump inlet.

WARRANTY CONDITIONS

Warranty of one year for any manufacturing or material defects, faulty workmanship from the date despatch of the pump.

If any fault occurs or parts are damaged contact the service department of

HINDHIVAC PRIVATE LTD.

BANGALORE

Or

Regional service centers

At

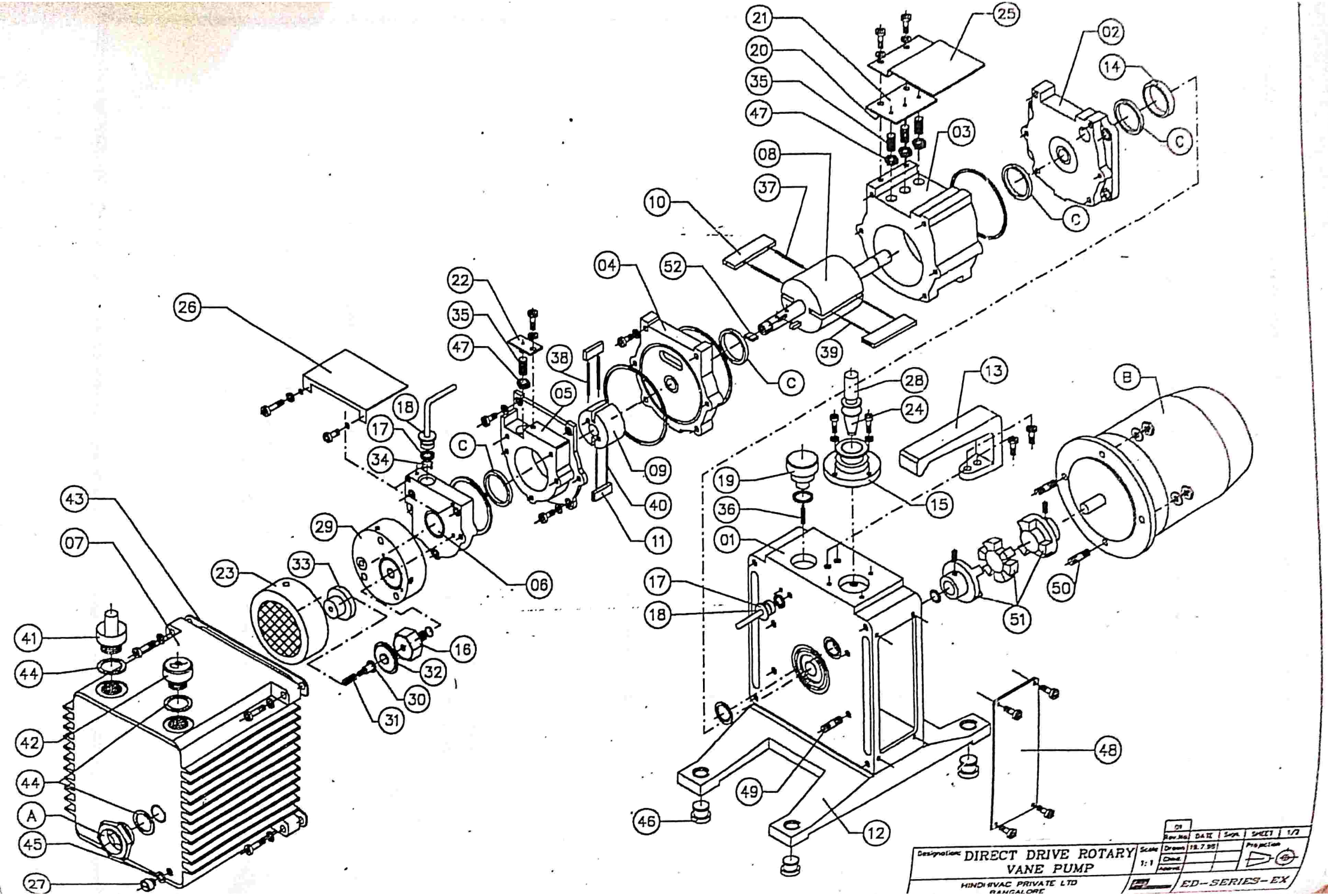
MUMBAI, DELHI, CHENNAI, HYDERABAD,

PUNE, AHMEDADABAD AND CALCUTTA,

Specifyling:

1. Model No. of the Pump.
2. Serial No. of the Pump.
3. Date of Purchase.
4. Nature of fault.

The service department will normally arrange for service personnel to call or for the faulty pump to be returned. No pump should be returned without prior agreement. The above procedure also applies to pumps damaged during transit, but both the carrier and Insurance Company on which the goods are insured to be notified within three days of receipt of goods.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DIRECT DRIVE ROTARY VANE PUMP
HINDHIVAC PRIVATE LTD BANGALORE
ED-SERIES-EX

ITEM NO.	DESCRIPTION	QTY
01	MOUNTING BLOCK	1
02	END COVER MOUNTING BLOCK SIDE	1
03	I STAGE STATOR	1
04	ISOLATOR	1
05	II STAGE STATOR	1
06	END COVER	1
07	OIL TANK	1
08	I STAGE ROTOR	1
09	II STAGE ROTOR	1
10	I STAGE VANE	2
11	II STAGE VANE	2
12	BASE PLATE	1
13	HANDLE	1
14	LOCATING BUSH	1
15	INLET CONNECTION	1
16	OIL PUMP HOUSING BUSH	1
17	G.B.CONNECTING PLUG	2
18	G.B.CONNECTING PLUG HOLDER	2
19	GAS BALLAST KNOB	1
20	GUIDE PIN	4
21	I STAGE EXHAUST PLATE	1
22	II STAGE EXHAUST PLATE	1
23	OIL FILTER	1
24	AIR INLET FILTER	1
25	I STAGE BAFFLE COVER	1
26	II SGATE BAFFLE COVER	1
27	OIL TANK DRAIN PLUG	1
28	INLET PIPE	1
29	OIL PUMP HOUSING	1
30	OIL PUMP HOUSING SPACER	1

ITEM NO.	DESCRIPTION	QTY
31	OIL PUMP HOUSING SPRING	1
32	OIL PUMP HOUSING FLAP	1
33	OIL PUMP HOUSING TOP COVER	1
34	FLOAT VALVE	1
35	I & II STAGE EXHAUST POPPET SPRING	4
36	GAS BALLAST SPRING	1
37	I STAGE VANE SPRING	2
38	II STAGE VANE SPRING	2
39	I STAGE VANE SPRING PIN	2
40	II STAGE VANE SPRING PIN	2
41	EXHAUST NOZZLE	1
42	OIL POURING PLUG	1
43	OIL TANK GASKET	1
44	WASHER (FOR OIL POURING PLUG & EXHAUST NOZZLE)	2
45	DRAIN PLUG WASHER	1
46	RUBBER GROMMET	4
47	EXHAUST POPPET	4
48	NAME PLATE	2
49	STUD (FOR END COVER MOUNTING BLOCK SIDE)	4
50	STUD (FOR MOTOR)	4
51	FLEXIBLE COUPLING SET	1
52	OIL PUMP VANE	1
A	OIL SIGHT GLASS	1
B	MOTOR	1
C	OIL SEAL	4

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			Rev.No.	DATE	Sign.	SHEET 2/2
Designation: DIRECT DRIVE ROTARY VANE PUMP		Scale 1:1	Drawn	19.7.98		Projection
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			Appvd.			
HINDHIVAC PRIVATE LTD BANGALORE						ED–SERIES–EX

"HINDHIVAC"

OIL DIFFUSION PUMP

OPERATION

AND

MAINTENANCE MANUAL

TÜV CERT

DIN EN ISO 9001:2000

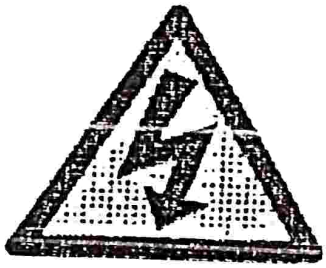
HIND HIGH VACUUM COMPANY PVT. LTD.,

No. 17, Phase I, Peenya Industrial Area, Bangalore, INDIA

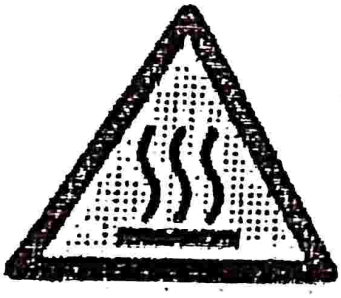
Phone: 91-80-41931000. Fax : 91-80-28394874

e-mail: info@hindhivac.com

The following warning symbols appear on the pump:

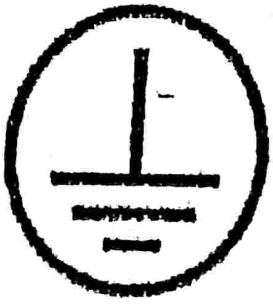


Warning – risk of electric shock



Warning – hot surfaces

Warning – Personal injury



PE Protective Earth

CONTENTS

1.0 INTRODUCTION

The HINDHIVAC Oil Diffusion Pumps are being manufactured in an extensive range to suit the varied needs of both industrial and laboratory users. These pumps are available with nominal bore sizes from a range of 1" to 36" diameter. While 1" pump gives 10 liters per second pumping speed the 36" pump gives 40-45000 lit/sec. with two to five stages (depending on size).

These water cooled Oil Diffusion Pumps are fabricated either from Mild Steel or Electroplated Aluminium or Stainless Steel. Two types of pumps are offered:

a. Fractionating diffusion pumps and

b. Non-fractionating pumps.

The superior pumping speed of the HINDHIVAC Diffusion pumps with other features make them an excellent choice for such high vacuum applications as Vacuum Furnaces, Space Research, Vacuum Coating of lenses, thin film deposition and several other industrial applications.

The HINDHIVAC Diffusion pumps produce much higher ultimate vacuum than any other type of vapour pumps like vapour ejector pump etc. Diffusion pumps are employed in the pressure range 10^{-1} to 10^{-7} m.bar and even lower pressure using the correct technique.

2.0 GENERAL DESCRIPTION

2.1 MAIN BODY

The diffusion pump body is cylindrical in shape which has a housing for the jet assembly and the charging fluid. This is provided with a metallic flange at the top which is either made of stainless steel or MS electro plated with suitable 'O' ring groove and securing bolt holes. This may be either fitted to the bottom flange or a suitable baffle valve or to the system to be evacuated.

Generally, all the pumps are fitted with a baffle valve or other type of baffles at the opening to avoid back streaming i.e., the migration of working fluid molecules into the system which ultimately lead to complete loss of the working fluid and contamination of the whole system.

Cooling water coil is soldered on the outer wall of the pump to cool the pump body.

2.2 JET

This consists of a set of metallic nozzles which are assembled around a central rod and housed in the main body of the pump. All the nozzles are oriented downwards at a certain angle towards the water cooled pump body and designed to give the best performance and maximum efficiency. The water circulated on the outer wall of the main body cools the vapour molecules which emerge from these nozzles striking the inner wall of the pump body.

Jet may be of a single or multi-stage depending on the size of the pump. In multi-stage the number of nozzles will be more than one. The jet accessories are made of stainless steel or electroplated aluminum. Diffusion pumps are manufactured in two types called the Standard Diffusion pump and Fractionating Diffusion Pump. The main difference between these two is in the fabrication and arrangement of the nozzles. The working of these two explained in the section "Working Principles" separately.

2.3 BOILER

This is a part of the main body where the working fluid is heated and evaporated. The boiler is designed to hold a certain specified quantity of the recommended working fluid to give maximum efficiency. Always care should be taken to see that working fluid is not exposed to atmosphere when in hot condition. Also the level of the working fluid in the boiler housing should be often checked and kept constant. The boiler is heated electrically with a heating element housed outside the main body.

2.4 HEATERS

This is housed at the bottom of the main body of the pump. The heating element is properly secured to the main body by a suitable arrangement. The heating coil is well insulated from the main body and the heater cover. The terminals are provided on the other side of the heater cover. The terminals are provided on the outer side of the heater cover to connect to the main power supply. So always only the specified input has to be fed to the heating coils. Any variation in the heater input due to voltage variations will affect the performance of the pump.

2.5 CARTRIDGE HEATERS

In Models with large diameters of diffusion pumps, cartridge heaters are used. In these pumps a burst free evaporation of the pump fluid is achieved by special heater construction and so, a pumping speed constant with time is obtained.

In this heating is achieved by an internal heater and consists of heater cartridges which are slid into tubes brazed on heat conducting fins. The Stainless Steel tubes are welded horizontally

in the pump body and located above the oil surface. The heat conducting fins which projects into the pump fluid is so chosen that an intensive but smooth evaporation of the pump fluid is obtained. The pump fluid receives additional energy from the parts of the conducting fins which stands above the surface. This special construction of the heater arrangement allows changing of the heater cartridges with pump still hot.

2.6 REPLACEMENT OF CARTRIDGE HEATERS

The cartridge heaters are made of either SS or brass sheathing which are ground on the outer surface to snugly fit in to the SS pipes welded to the pump body. Before inserting the cartridge heaters into the pipes clean inside surface of the pipes thoroughly and if necessary remove any burrs and dents with emery paper. Insert the heater completely into the pipe till it touches the covered end without any slackness. The electrical connections for the cartridge heaters are connected to 3 phase supply with each phase connected to the three heaters separately and neutral is given to the other terminals of the three heaters together. Details of the connections are given in the circuit diagram enclosed with this working instructions.

2.7 FORE ARM

The fore-vacuum connection also known as backing connection diffusion pump which is situated at the side of the pump body, a little above the heater cover will have a flange or coupling. This is connected to some type of backing pump usually a rotary vacuum pump. It is normally directed upwards and is cooled by water to avoid pump fluid being discharged to the atmosphere by the backing pump. Baffles are provided inside the fore-arm to avoid further loss of fluid.

2.8 COLD CAP RINGS

Cold cap baffles are designed in such a way that they can be mounted inside the pump body directly above the top jet of the high vacuum stage. Cold top jet baffles are used to reduce the oil back streaming through the high thermal conductivity metallic spider legs. The cold cap has good thermal contact with the cooled wall of the pump which means it is practically at the cooling water temperature or the room temperature.

2.9 THERMOSTAT

This is a safety device which is fitted on the side of the main body above the cooling coils. This acts as a safety device to cut off the power supply to the boiler heater in case the cooling water supply fails or the temperature of the body and the fluid exceeds a safe limit. The working principle is explained in the section "Safety devices and Accessories".

3.0 WORKING PRINCIPLE

The working principle of both the Standard and the Fractionating type of Diffusion Pumps are almost the same. They differ only a little and the principle is as follows.

The oil in the boiler is heated by the heater and converted into vapour. This rises in the concentric columns and is limited by the jets due to the comparative high pressure existing above the boiler in the jet system. The vapour is forced through jet aperture where it is deflected downwards by the jet deflectors while the tubular side jet discharges vapour into the backing system. The molecules issuing from the jet engulf gas molecules, diffuse into the vapour streams not being able to diffuse back due to the downwards deflected vapours. The gas molecules are finally removed to the atmosphere by the backing pump. The oil vapour impinging on the water cooled pump wall condenses and drains to the boiler where it is re-evaporated.

In the conventional oil vapour pump the ultimate vacuum achieved is little less than the Fractionating type. This is due to the comparatively high voltality of the light fractions which arrive at the top jet and prevents achieving an ultimate vacuum lower than the vapour pressure of these fractions. Where as in the Fractionating type Diffusion Pump the condensed oil returning to the boiler for re-evaporation on its path to the centre of the boiler evaporates progressively. The light fractions or low molecular weight fractions of the high vapour pressure travel to the side jet as its temperature rises rapidly and evaporates before it reaches the centre of the jet. The medium fractions of little lower vapour pressure travels still further towards the centre but vapourises before they reach centre and feed the intermediate jets. Finally the oil composed mainly of the heaviest and the lowest vapour pressure fraction reaches the pump centre and vapourises, feeding the top jet. The characteristic which is termed "Fractionating" pumps thus allow only stable and heaviest fractions of the pump fluid to reach first stage which results in the high performance of the pump.

The pumps are available in single stage and multi-stages. The number of stages depend on the number of nozzle openings. HINDHIVAC pumps are available from two to five stages.

4.0 INSTALLATION

On receiving the equipment unpack it and remove all the packing materials. Remove the covers over the flanges and clean them carefully with acetone or some other suitable solvent without damaging the 'O' rings.

Pumps are despatched with utmost care and if any damage is noticed in the jets or any other parts, they are to be immediately reported to us. All HINDHIVAC pumps are tested thoroughly for vacuum and high performance before it is despatched to the customer.

The pump jets are fabricated out of SS or Aluminium. Precautions have to be taken while tightening the centre rod at the bottom with nut. Over tightening results in jet ends getting damaged which in turn will reduce the gap between the jets thus affecting the performance of the pump.

The HINDHIVAC pumps are supplied with fluid charge required for the diffusion pumps. If the pump is exposed to atmosphere before being installed or if a fluid other than the recommended oil is to be used the whole pump has to be cleaned with an organic solvent like acetone.

4.1 VACUUM TIGHTNESS

The pump should be tested for vacuum tightness before the fluid charge is placed into the boiler as the outgassing from the fluid may render the subsequent testing difficult. For most purposes it is sufficient to test the system with the rotary backing pump and assess the overall vacuum tightness by the closeness with which the vacuum attained at the inlet or at the apparatus.

4.2 PUMP FLUID

An ultimate vacuum in the range of 10^{-5} m.bar to 10^{-7} m.bar can be obtained with HINDHIVAC Diffusion pumps using Dow Corning 702, 704 and 705 silicon fluids. These are chemically inert and free from impurities. The 704 fluid is specially recommended for use along with liquid air traps to attain such low pressures as 10^{-7} m.bar.

4.3 GENERAL PROPERTIES OF SILICON FLUIDS

Silicon fluids are not oxidized by air at operating temperatures. Their chemical resistance gives long life and eliminates frequent replacements, Silicon fluids being inert do not react with metal parts, Elastomer seals and gases such as Hydrogen and Carbon-Di-Oxide commonly found in high vacuum systems. Its radiation resistance is good because of high phenol contents. Silicon fluids will not break or decompose under operational conditions. In contrast all organic fluids undergo some cracking. Thermal stability of silicon fluids prevent decomposition.

There is no fouling of diffusion pump boiler surface and the jet with organic tar and hard carbon. Diffusion pumps using silicon fluids can operate against higher fore-pressures than those using most of other oils.

4.4 FLUID FILLING

It is recommended that only the oil charge specified by us are used to attain the maximum vacuum but other fluids of similar properties can be used. Whenever a different fluid is to be filled, the inner parts of the pump are to be cleaned thoroughly with acetone. On no account Mercury should be used.

The appropriate charge of oil specified in the instruction sheet for each pump is to be poured into the boiler. The charge may be poured down the inner wall of the pump body. Care must be taken that the fluid charge does not contact the upper stages of the jet assembly. The jet assembly is to be replaced properly after oil pumping as it was before taking enough care to see that the side opening of the bottom most jet should face the backing line opening provided in the main body. in case of diff stack pump oil is filling through oil drain

If the pump is fitted with an isolation baffle valve filling is done using a length of rubber or polythene tubing passed round the baffle plate when in the lifted position into the pump mouth. Insert tubing a little deep down into the body to avoid fluid coming into contact with top jets. The alternative method for charging the pump is by pouring oil into the backing opening after removing the vacuum union and its flanges. Also it is possible to use the side drain plug-cum-oil level indicator by attaching a length of suitable rubber or polythene tubing to the union of the drain plug and using the rotary pump to evacuate the diffusion pump thus sucking the fluid from the container into the boiler. This is possible in case of pump above 6" size. It is advised to check the oil level and the quality of fluid in the boiler periodically to obtain best performance. An easily accessible oil-cum-level checking device is fitted to all the pumps above 6" size.

4.5 VACUUM CONNECTION

The top flange of the pump may be secured to baffle valve (if used) or to any suitable mating flange of the system to be evacuated with a suitable 'O' ring groove. The backing connection provided on the side is connected to a suitable rotary pump with an ultimate vacuum better than the backing pressure required for the diffusion pump to operate. The coupling provided on the backing ejector pipe is coupled to a matching part of the coupling which is brazed to the pipe connecting the rotary pump. Care should be taken to clean the couplings with acetone and ensure that the 'O' ring is properly placed in the coupling. Pipe connecting the rotary pump to the backing connection should be of shortest possible length.

4.6 COOLING WATER AND CONNECTIONS

Connection should be made using flexible hoses to the cooling water pipe coupling provided so that the water flows downwards through the cooling coil. If a baffle valve is fitted the water should first flow through the baffle valve coil then through the vapour pump oil. The circulating water temperature should be kept as close as possible to 15 °C. The recommended minimum water flow for various sizes of pumps and inlet temperatures are given in the chart.

The heater must not be switched on without the cooling water flowing, as the oil may be lost or decomposed and cooling coil solder may also melt.

For effective condensation of the oil vapours cold water at 15°C, cooled water should be circulated around the diffusion pump through the coils. It is essential that the cooling water is dust free and tested for hardness to avoid formation of scales inside the cooling pipe line.

4.7 ELECTRICAL SUPPLY

The AC supply given to the pump heater should match the specified voltages for each pump mentioned in the chart. Connect the electric supply to pump heater via the two pin socket supplied along with the pump.

For OD-114 pump the power supply required for the heater will be of 1 phase 230V so that heater is connected to one phase as indicated in the circuit diagram enclosed. This will ensure proper voltage current supply to the pump heater for efficient heating. This can also be connected to 230V supply , , is given as indicated in the circuit diagram..

4.8 BACKING PUMP

A single stage or double stage rotary pump with a displacement not less than that is specified in the chart and capable of achieving a vacuum of 0.05 m.bar or better is recommended and connected to the diffusion pump by means of shortest possible length of pipe.

5.0 OPERATING PRINCIPLE

(Assuming that it has to be operated in conjuction with a fully valved system).

STARTING

This applies when the pump and the apparatus are at the atmospheric pressure:-

a. Close the high vacuum valve (baffle valve) air admittance valve of the pump as well as the chamber and all other openings connected to atmosphere.

b. Start the rotary pump and then open the backing valve. After reaching 0.05 m.bar or better pressure in Pirani gauge close the backing valve and open the roughing valve connecting the chamber to the system. This ensures that both the backing and roughing lines are in vacuum.

c. After ensuring that the backing pressure reaches 0.05 m.bar, and cooling water supply is provided, switch on the diffusion pump.

WARNING :

Diffusion pump should never be switched on without ensuring cooling water supply

After a warn-up period of 20-30 minutes open the high vacuum valve (baffle valve) to connect the chamber to the diffusion pump.

Before opening the high vacuum valve, be sure that the chamber has minimum pressure 0.05 m.bar or better. As otherwise the pump will not be able to handle the volume efficiently.

6.0 CLOSING DOWN

Close the high vacuum or baffle valve and switch off the pump heater. Allow the pump to cool. Close the backing valve after sometime (roughly 15-20 minutes) and open the rotary pump air admittance valve and switch off the rotary pump. If magnetic isolation cum air admittance valve is installed at the inlet of the rotary pump the procedure of allowing air into the rotary pump is automatically done when the rotary vacuum pump is switched off. After the pump is completely cooled down, close the water supply.

NOTE:

This method ensures that the vapour pump is under vacuum thus preventing the pump fluid from absorbing air or decomposing due to cracking when air comes into contact with hot fluid.

NOTE:

Never allow air into the hot diffusion pump. If allowed the costly working fluid will be lost in decomposition.

7.0 SAFETY DEVICES OR ACCESSORIES

Thermostat or the thermal switch is an electrical device to protect the pump from damage due to failure in cooling water supply system. If the temperature of the pump rises too high, the heaters are automatically switched off. The thermostat is secured to a mounting plate which is attached to the pump cooling coil, and in the event of temperature exceeding the prescribed limit, power supply to the pump heater is cut-off The 5 amps and 230V AC rated switch should be connected in series with supply to the pump heater.

8.0 MAINTENANCE

FLUID CHANGE :

If the pump ceases to give satisfactory ultimate vacuum the fluid must be drained and inspected (See page fluid filling).

NOTE:

Remove the jet assembly by unscrewing the top jet or nut over it and remove the complete jet assembly, and slowly pour out the fluid into a container. If it is badly charred or discoloured the pump must be thoroughly cleaned and re-charged with new fluid.

IMPORTANT

1. Choose an installation area with suitable power outlet and ample water supply and drain. The area should be free from strong drafts and dust.
2. Check the pump to be sure that the jet assembly is aligned properly.
3. Fill the pump with the correct measure of recommended oil after thoroughly cleaning with acetone if exposed to dust and atmosphere for a long time.

4. Always mount the pump in a vertical position so as to have reasonably equal level of oil in the boiler.

5. Make tight vacuum connections on the high vacuum and fore vacuum sides. These will be generally flanges or couplings connection with suitable 'O' rings or gaskets. Connection to the backing pump should be preferably flexible to avoid detrimental effects due to vibration.

6. Check and match the water flow rate with the specified ratings, without any obstruction.

7. Verify the readiness of the safety devices like thermostat and water flow switch.

8. Switch on the heater only after the cooling water circulation is on and the required fore vacuum is reached.

9. Check whether the heater is working properly. This is usually done by feeling the boiler or heater cover.

10. The pressure should drop rapidly when the pump has reached its operating temperature. If not check the system for any probable leakage.

11. While shutting down the diffusion pump, the important precaution to be taken are to avoid letting air into the diffusion pump while the fluid is still hot so as to prevent the damage to the pump oil due to cracking. Even silicon oils is decomposed to some extent by exposure to air when hot.

12. Check the heater input supply for proper voltage and wattage as specified.

13. Change oil depending on the nature of vacuum process to which the pump is to be used.

14. Check the condition of the oil and the oil level occasionally.

15. Set up a cleaning programme depending on the nature of usage of pump.

16. Whenever the performance of the pump comes down, clean the pump thoroughly and refill with new oil.

17. Do not use cheap substitute of fluid charge. Use only the recommended oil or its equivalent.

ACCESSORIES TO DIFFUSION PUMPS

Selection of appropriate accessories should be based on the kind of application the system is intended to be deployed, to achieve efficient utilization of the system.

A simple pumping system consisting of a diffusion pump backed by a rotary pump attached directly to the vessel to be evacuated enables the most efficient use of the available pumping speed. However the use of vapour diffusion pump of any type usually results in the presence to a considerable degree of the pump fluid into the system. This results in the loss of costly pumping fluids as well as contaminating the vacuum system and thus affecting the process involved.

The phenomena of the flight of the vapour molecules into the system from the pump inlet is called back streaming. The major source of back streaming is the top of the first jet.

Depending on the process to which vacuum is employed where high degree of cleanliness vapours is required a large variety of vacuum accessories for these diffusion pumps are designed and manufactured by HINDHIVAC PVT Ltd., to meet the user's requirements.

In order to eliminate this back streaming to a large extent it is advisable to use a cooled optically dense baffle or a trap which acts as a barrier to the migrating fluid. HINDHIVAC pumps are designed to give the overall performance with minimum back streaming but where complete back streaming is to be avoided and oil contamination is to be reduced to the minimum, the customer should choose some of the following accessories which can be directly fitted to the diffusion pump flange.

BAFFLE VALVE

HINDHIVAC water cooled baffle valve enables a working vapour pump to be isolated while the pumping system is at atmospheric pressure. The valve plate just on top of the diffusion pump acts as an effective baffle in preventing the migration of oil vapours.

These baffles are made in two basic versions:

1. In-Line type
2. Right Angle type

For further details on this please refer to the brochure on "Baffle Valves".

CHEVRON BAFFLES

These are optically dense baffles which are compact with maximum conductance and with effective trapping of back streaming vapours.

We offer two types, the first being "Water Cooled Chevron Baffle" and the second is "Refrigerated Chevron Baffles".

These can be easily installed on top flange of the diffusion pump and is fitted with a butterfly valve at the top or a gate valve for isolating the working pump when the top vessel is to be opened to atmosphere.

When a better oil free chamber is required the introduction of a refrigerated chevron baffle is recommended for on top of the vapour pump.

BUTTERFLY VALVES

HINDHIVAC Quarter swing type butterfly valves are compact and high conductance valves. Its compact dimensions help to reduce the height of the system. These are recommended for use as baffles in combination with a chevron baffle or with a liquid air trap.

LIQUID AIR / NITROGEN TRAPS

HINDHIVAC Liquid air traps are optically dense and constructed out of 304 non-magnetic stainless steel. These are used to trap pump fluid vapours migrating to the system.They are designed for liquid gas coolants such as liquid nitrogen, Liquid air or solid CO_2 with alcohol mixture. Highly polished interior surface reduces heat loss as by radiation. The above stated are some of the essential accessories for obtaining an ultimate and contamination free vacuum in the shortest possible time.

CRYO-COOLED LIQUID NITROGEN TRAP

Acryo-cooled liquid nitrogen trap is fixed at the side of the diffusion pump to avoid the back streaming and to achieve the clean ultimate vacuum.

This trap is giving good through put for vacuum pumping when compared with standard LN2 trap. It occupies less height for better operational height of the unit .Without reworking the pipe line setup, the trap either can be removed or fixed. The trap has a OFHC Cu baffle which is very effectiv and avoids back streaming of oil

13.0 TECHNICAL SPECIFICATIONS:

Parameters	OD-65	OD-80	OD-114D	OD-150D	OD-250	OD-250D	OD-350	OD-500
Nominal dia (mm)	65	80	114	162	250	250	350	500
Pumping Speed in (lit/sec)	120	240	280	700	3000	1700	6000	12000
Backing pump	ED-6	ED-6	ED-15	ED-21	CD-90	CD-45	CD-120	CP-250+ RA-375
Warm Up Time in minuts	15	15	15	15	15	15	15	15
Ultimate Vacuum (DC704)	$5x10^{-7}$	$5x10^{-7}$	$5x10^{-7}$	$5x10^{-7}$	$5x10^{-7}$	$5x10^{-7}$	$5x10^{-7}$	$5x10^{-7}$
Fluid Quantity(cc)	80	80	100	250	600-800	500	1200-1800	3000-3500
Heater Rating (Watts)	350	350	500	1350	2250	2250	3750	7500
Material Body	SS	SS	SS	SS	SS	SS	SS	SS
Material Jet Assembly	SS	AL	AL	SS&AL	AL	SS&AL	AL	AL
Cooling water required In lits/minute. at20to 25°C	2	Air Cooled	2	4	5-6	4	6-7	6-8

"HINDHIVAC"

MINI PIRANI STABILIZED GAUGE

MODEL - A6STM-D

OPERATION
AND
MAINTENANCE MANUAL

TÜV CERT
DIN EN ISO 9001:2000

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CONTENTS

1.0 INTRODUCTION

The HINDHIVAC mini pirani stabilised gauge model A6 STM is a pressure control instrument designed with the thermal conductivity type gauge head (Sensor). This provides all necessary bridge circuits and signal conditioned analog outputs. This instrument can accept range from 0.5 m.bar to 0.001 m.bar using a direct reading meter.This instrument works on the principle of change in resistance of material with a change in temperature.This can be used to measure vacuum from 0.5 m.bar to 0.001 m.bar anywhere in the vacuum system with a suitable adopter.This gauge is very much essential in the pirani controller to control vacuum(0.5 m.bar to 0.001 m.bar). Two gauge heads can be directly connected to this gauge to read fore vacuum and roughing vacuum of a vacuum system.

2.0 GENERAL DESCRIPTION

The mini Pirani gauge model A6STM is a modular front panel construction and forms 1/4 size of a standard 19" rack. This can be used as a bench standing type or as a panel mounting type. By using an appropriate rack adaptor, four numbers of such units can be mounted in a 19" rack having 133mm (5" - 1/4") height. (Ex: Penning STP4M-I,Pirani controller PRGC-1 and Penning Controller PNGC-1).

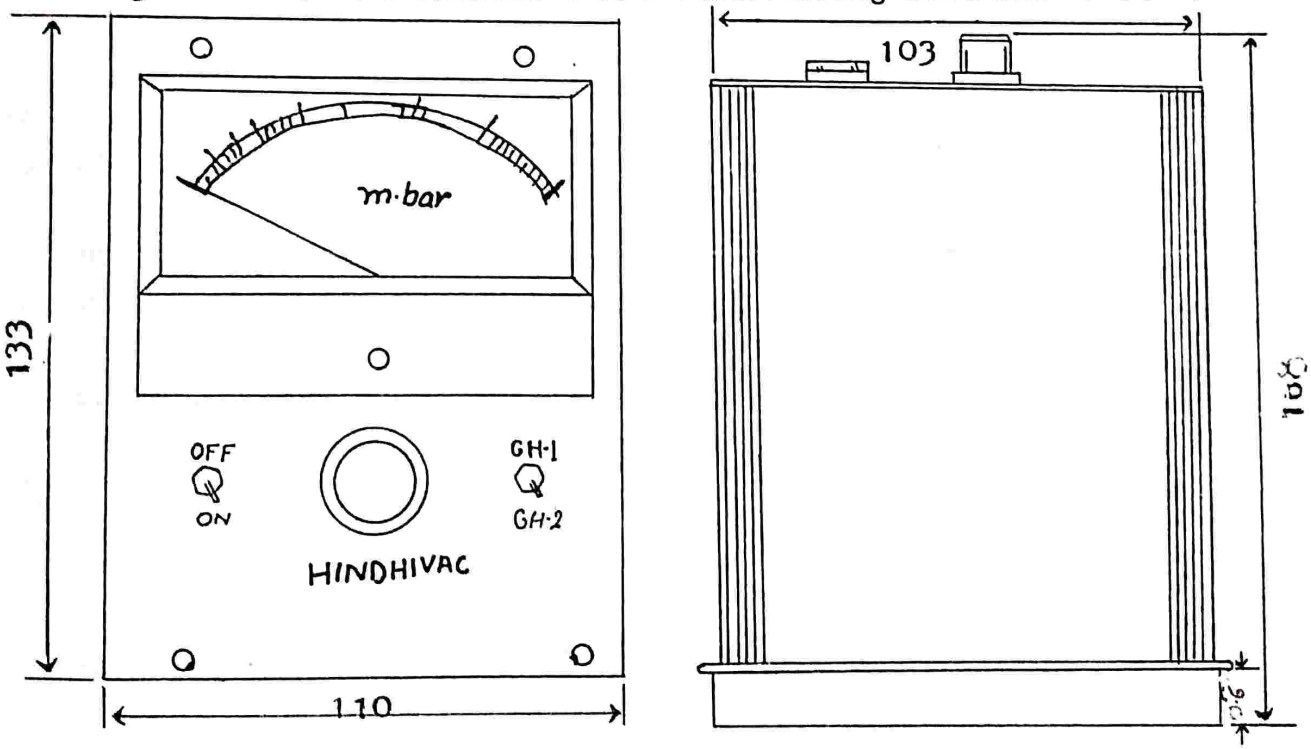


Fig. 1 Diagram of Pirani Gauge Outline

This instrument is constructed with light aluminium alloy frames, having detachable covers on all sides. This facilitates, easy accessability of all components mounted inside and the gauge makes the service more convenient. This gauge measures the pressure is the range of 0.5 m.bar to 0.001 m.bar using a direct reading meter. It operates with one or two HINDHIVAC Pirani Gauge heads, which facilitate the measurement of the fore vacuum and roughing vacuum in any vacuum system.

The gauge is calibrated for dry air but will be found accurate for most purposes under normal working conditions, where small quantities of other gases or vapours are present.

3.0 SPECIFICATIONS

ELECTRICITY SUPPLY	: 230V AC (+ OR -10%)
BRIDGE OUTPUT VOLTAGE	: 2V D.C. (+ OR -0.5%)
PRESSURE RANGE	: 0.5 m.bar TO 0.001 m.bar
NO. OF GAUGE HEADS	: TWO HINDHIVAC MODEL PR-1
FUSE	: 250 m.a. SIZE: 5 X 20 mm
GH1, GH2	: INPUT TO HINDHIVAC PIRANI CONTROLLER MODEL PRGC-1 FOR PRESSURE CONTROL.
SIZE IN MM	: 133H x 110W x 132D.(APPROXIMATELY).

4.0 UNPACKING AND PRE-OPERATIONAL CHECK

The control panel and gauge heads are carefully checked and packed before despatch. Prior to using the instrument carefully inspect the unit for any visual signs of transportational damages. Please remove the top cover by unscrewing the two round head screws on each side and slide the cover towards the back, visually inspect the inside of the unit for damages and displacement of components on the P.C.B that might have occured during transportation. check their sockets if all internal connections are in place and properly seated. Replace the cover in the same way as it was removed.

REMEMBER	When the top cover of the gauge is removed, remove the shorting terminal of the meter.

If any damage is observed, please report to HINDHIVAC and to the insurance to file a proper claim: Please send copy of change claim to HINDHIVAC Bangalore in order to expedite replacements or repair of the instrument.

If the unit fails to function properly contact our local office or please write to HINDHIVAC, Bangalore.

5.0 INSTALLATION

- Check that the supply voltage agrees with operating voltage of instrument.
- Check that the mains ON switch (SW1) is OFF in position.
- Check that the meter indicates zero if not adjust by the mechanical zero adjusting screw on the meter face.
- Plug the gauge heads 1 & 2 respectively into their sockets firmly at the rear panel.
- Connect the gauge head to the vacuum system. See that the O ring is properly placed in the male joint. Tighten the locknut with the hand properly, so that the O ring provides a leak tight joint.
- Switch on the control unit by switching on the toggle switch (S1). Now the neon lamp should glow indicating readiness of the power supply to gauge head.

6.0 CIRCUIT DESCRIPTION

The 230V AC (± 10%) mains supply is given to the primary part of the transformer (T) through a fuse (F) and mains switch (SW1) located on the front panel. The mains indication lamp (PL) is connected across the primary part of the transformer (T) and it glows when the instrument is switched on under normal working condition.

The output from the secondary part of the transformer is rectified by diodes D01 to D04 and smoothened by capacitor C01. The rectified voltage is fed to an integrated circuit voltage stabiliser, the output of which can be adjusted to +2V by adjustment of a preset (P01). A capacitor C02 is connected across the output of the regulator to reduce ripples. Resistors R02 and R03 form two arms of a bridge net work and the other two arms are formed by the Pirani Gauge Head.

Potentiometer P2 is used for adjusting the initial setting of zero at atmospheric pressure and potentiometer P3 is provided for calibration of the gauge head P2 and P3: They are located inside the gauge heads.

6.1 BRIDGE VOLTAGE

The bridge voltage is set at the factory and should require no further adjustment. However, before a control unit is used for the first time, check the voltage as described below with the gauge heads connected.

a. Remove the top plate of the chassis.

b. Connect the gauge to the mains voltage supply.

c. Allow 10 minutes to warm up.

d. Measure the output voltage of the regulator on the printed card across R02 and R03.

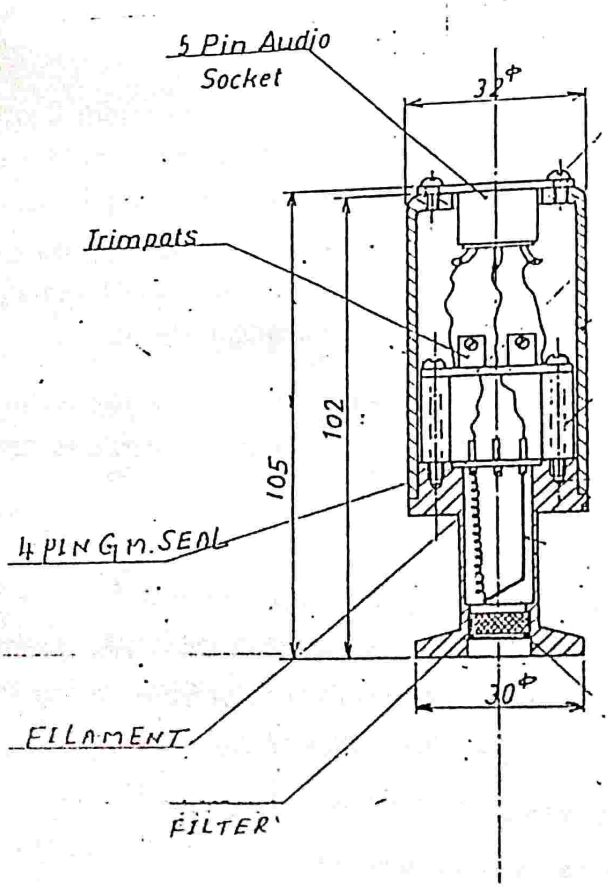
e. Use a D.C. voltmeter with the range of 0-2.5V DC (Avometer 8 x is suitable).

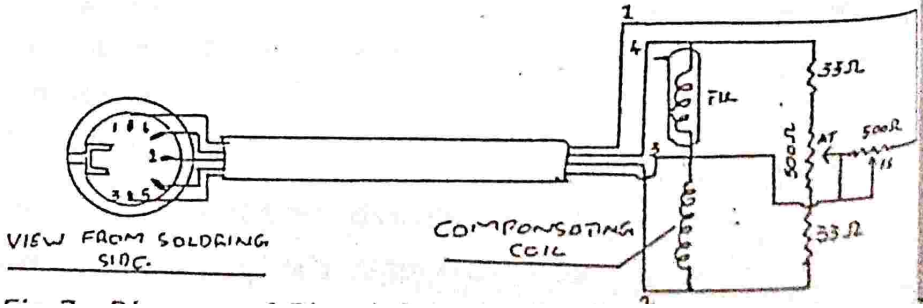
The meter should read 2V DC. If the voltage is not correct adjust (P01) until it reads 2V DC.

7.0 PRINCIPLE OF OPERATION

Change of pressure in the vacuum system brings about a rise or fall in number of gas molecules present and hence a rise or fall in thermal conductivity of the gas. Thus the heat loss of the constant voltage electrically heated filament in the system varies with the pressure.

The pirani gauge head filament has high temperature co-efficient of resistance. So a slight change in the system pressure brings about useful change in the filament resistance resulting in an out of balance current which can be read as pressure on the meter. The Pirani gauge head indicates the total pressure of combined gases and condensable vapours in the system as the heated wire can lose heat. (both gas and vapour molecules.)





7.1 OUTPUT FOR VACUUM CONTROLLER

Two electrical signals which are proportional to the meter reading are provided on the back panel corresponding to GH1 and GH2 and marked as GH1 COM GH2. Any one of these signals can be connected to the HINDHIVAC pirani controller Model PRGC-1, which works in the range of 0.5 m.bar to 0.001 m.bar to actuate any external electrical gadgets depend upon the preset vacuum.

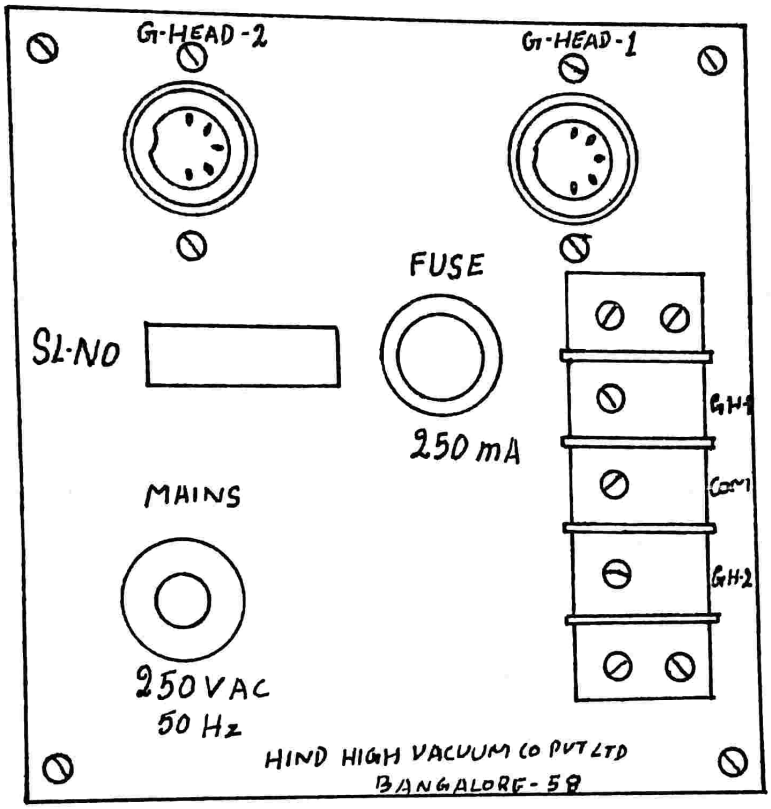


Fig.4 Diagram of Pirani Gauge Back Panel

8.0 OPERATION PROCEDURES

a. Connect the 2 gauge heads at the rear panel.

b. Switch ON the instrument by operating the mains ON switch.

c. Keep SW2 in GH1 position.

d. The meter should indicate 'AT' on the meter scale. If not, adjust (P02) the thick wire potentiometer inside the gauge head until to reads 'AT'.

e. Keep SW2 in G. Head-2 position. Similarly adjust the meter to read 'AT' by using a corresponding potentiometer. (Inside gauge head 2). Now the instrument is ready for vacuum measurement. Evacuate the system and observe the reading on meter scale.

8.1 LEAK DETECTION

The Mini Pirani Gauge can be used to locate coarse leaks such as leaks through 'O' ring seals, door flanges, windows, leak in shaft seals or valve diaphragm. hydrogen is ideally suitable as a probe gas in leak detection; Due to high rate of diffusion through the leak, the pirani gauge senses almost immediately. Moreover the thermal conductivity of hydrogen at low pressure is almost twice that of dry air so that a pirani gauge calibrated for dry air is twice as sensitive to hydrogen at the same absolute pressure.

The leak detection is to be carried on as follows:

Fit a hydrogen cylinder with a pressure reducing valve. An air gun nozzle or a piece of glass tubing of 1/8" diameter at one end and a small hole at the other end is recommended as a probe to direct a fine jet of hydrogen to the suspected leak area. Begin at the highest point in a vacuum system and work slowly and systematically downwards, observing the pirani gauge for fluctuations and sealing each leak as it is found. In equipments with two or more gauge heads, select the gauge head nearest to the path of the gas between the probe area and the pumps for observation. Very small leaks require specialised leak detection apparatus.

PRECAUTION 	Hydrogen is an explosive gas, necessary precautions should be taken while handling it. Alternatively, other safer gases can be used with reduced sensitivity which depends upon their thermal conductivity.

.0 MAINTENANCE

Servicing of the gauge apart from the adjustments described should be undertaken only by an Electronic engineer familiar with ICs and Transistor circuits.

For voltage and current measurements use an AC/DC multi range meter having a sensitivity of at least 20,000 ohms per volt.

9.1 RECONDITIONING OF THE FILAMENT

The gauge head behaves erratically if it is filled with any contaminants, the gauge head has to be flushed out with suitable organic solvents such as Petroleum, Ether, Benzene, Carbon tetrachloride or Acetone and then thoroughly dried.

Apply 10V AC or DC to pin No.1 and 4 of the gauge head plug for two minutes. This flashes the filament and volatises the deposits over the filament.

9.2 REPLACEMENT OF GAUGE HEAD TUBE

To replace the gauge head tube, remove the screws of the gauge head and take out the top cover. Now the metal body, compensating coil and potentiometers (P02,P03) are accessible. Desolder the leads of the metal gauge head from the cable and potentiometers (P02, P03) shorting point, introduce the new gauge head tube and reverse the procedure.

9.3 GAUGE CALIBRATION

When a new gauge head tube is replaced, it is necessary to calibrate the unit. The gauge is to be calibrated for dry air against a Mcleod gauge with all the necessary traps etc., For accurate calibration, the unit has to be sent to the factory. However, for a rough calibration, the following procedure is to be adopted.

1. Follow procedure of operation procedures a,b,c,d and e
2. Evacuate the gauge head to pressure below 0.001 m.bar.
3. Select SW2 switch to G.Head-1 position and adjust potentiometer P02 (FS) (marked on the gauge head). Until the meter reads 0.001 m.bar on the scale.
4. Select SW2 switch to G.Head-2 position and adjust potentiometer P02 (FS) (marked on the gauge head) until the meter reads 0.001 m.bar on the scale.

PRECAUTION	The filament must be flashed only when the pressure in the gauge head is below 1 micron.

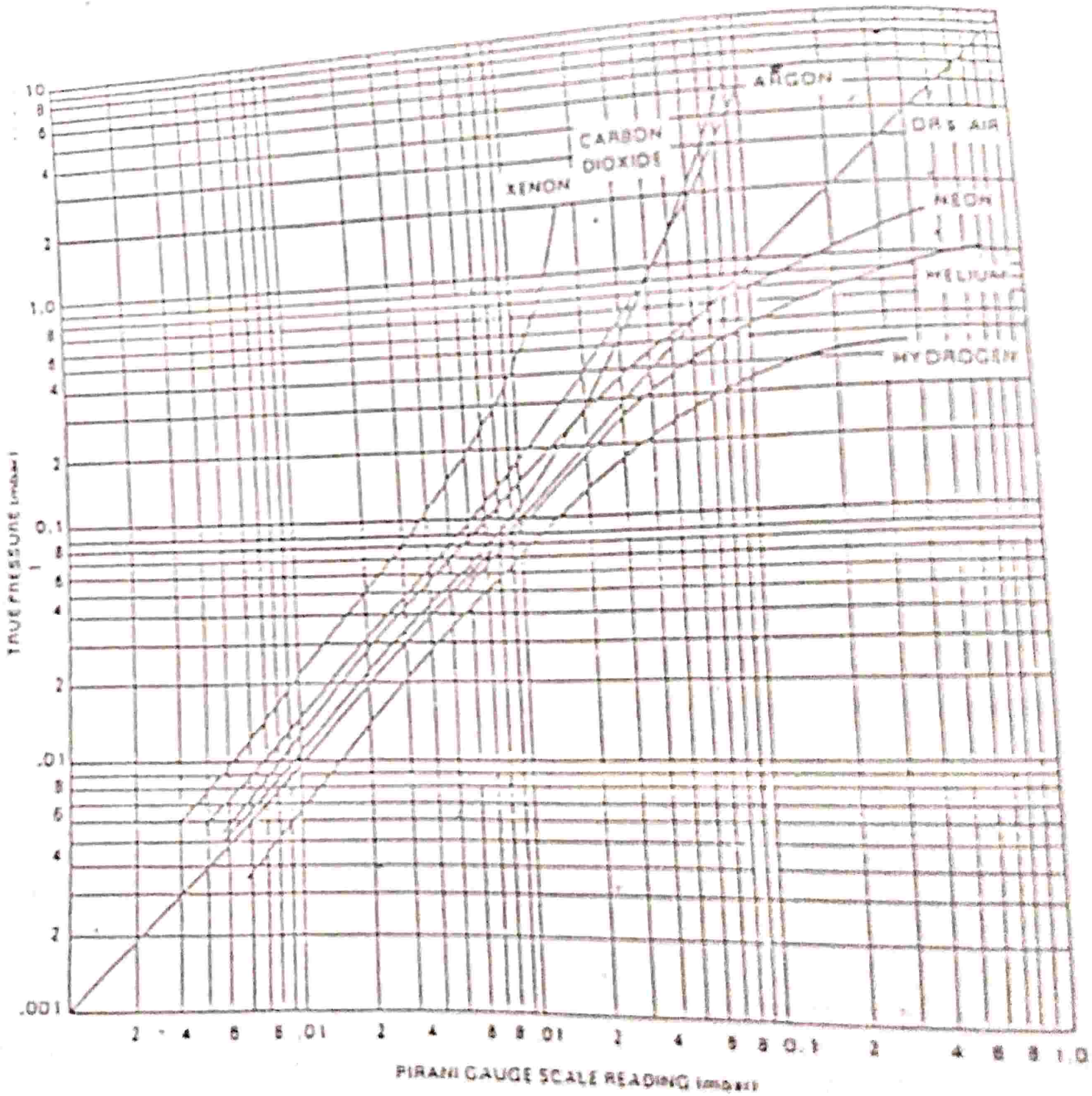
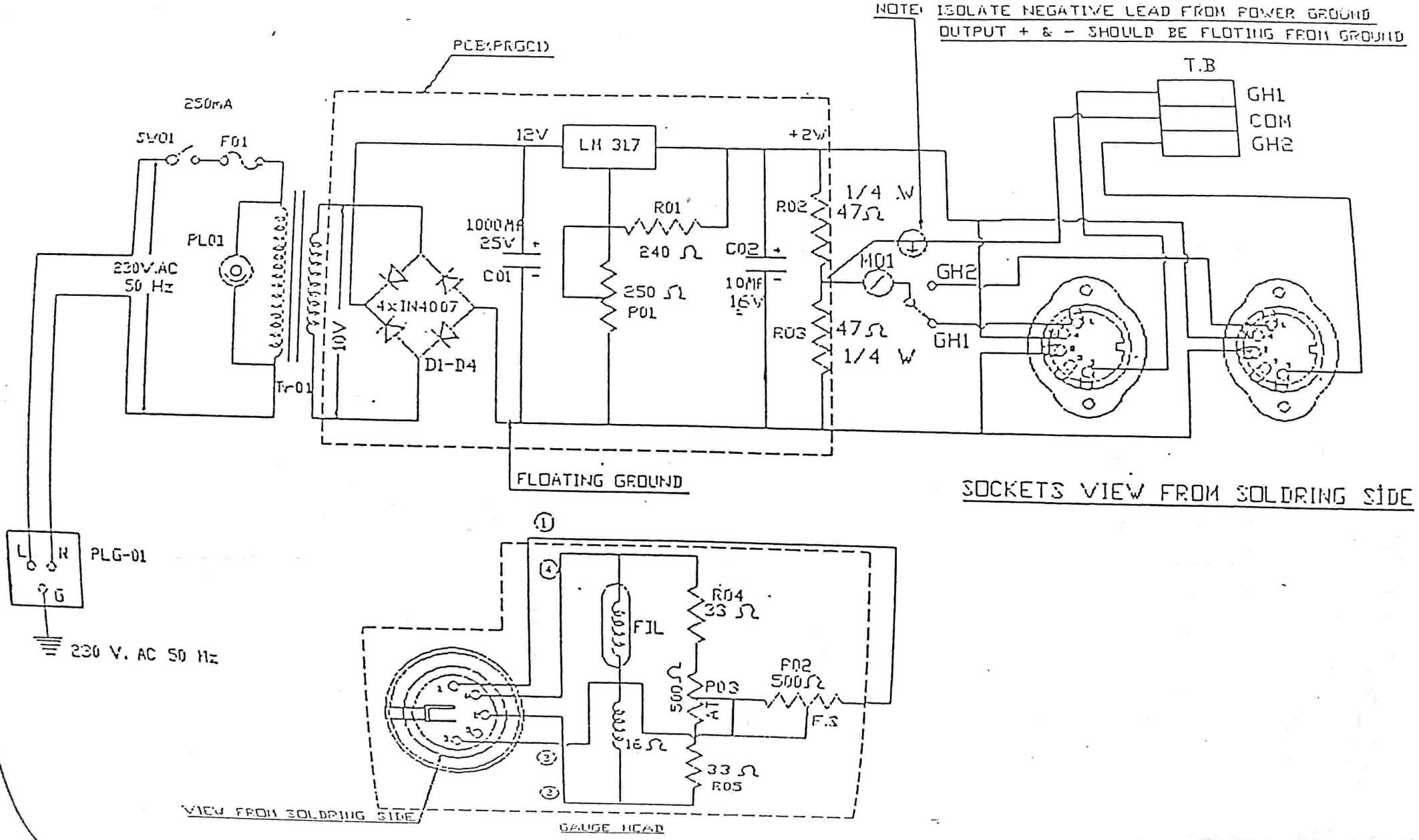


Fig. 5. Calibration Chart

10.0 TROUBLE SHOOTING

SL. NO.	TROUBLE	CAUSE	REMEDY
1.	Mains indicator lamp not glowing	Electricity supply has failed. Lamp PL has failed.	Check supply voltage fuse-F power chord mains plug, switches SW1.
2.	Bridge voltage is too high.	IC is not working properly.	Check & replace.
3.	Bridge voltage is too low.	D01,D02,D03 & D04 are faulty.	Check & replace
4.	Meter reads F.S.D. connection.	Open gauge head or replace filament.	Repair the gauge head
5.	Pressure reading erratic.	Gauge socket contacts are loose or dirty.	Tighten or clean.
6.	Calibration suspect.	Bridge voltage set incorrectly.	Carry out bridge voltage adjustment.
7.	No meter reading.	Pressure at Atm. or gauge head not plug -ged in or 500 ohms (F.S) potentiometer Opened.	Check & Replace.


NOTE: ISOLATE NEGATIVE LEAD FROM POWER GROUND
OUTPUT + & - SHOULD BE FLOTING FROM GROUND
PCB(PROG1)
250mA
SW01
F01
PL01
230V.AC
50 Hz
Tr01
10V
4xIN4007
D1-D4
12V
LM 317
+2V
1000MF
25V
C01
R01
240 Ω
250 Ω
P01
C02
10MF
16V
R02
1/4 W
47Ω
R03
47Ω
1/4 W
MO1
T.B
GH1
COM
GH2
FLOATING GROUND
SOCKETS VIEW FROM SOLDRING SIDE
L
N
G
PLG-01
230 V. AC 50 Hz
FIL
R04
33 Ω
P03
500Ω
P02
500Ω
F.S
16Ω
33 Ω
R05
VIEW FROM SOLDRING SIDE
GAUGE HEAD

"HINDHIVAC"

MINI PENNING STABILISED GAUGE

MODEL - STP 4M-D

OPERATION

AND

MAINTENANCE MANUAL

TÜV CERT
DIN EN ISO 9001:2000

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CONTENTS

1.00 INTRODUCTION

The HINDHIVAC mini penning stabilised gauge model STP4M-D is a pressure control instrument designed with the cold cathode type gauge head (Sensor). This provides all necessary circuit and signal conditioned analog output. This instrument can accept a range from $1x10^{-3}$ to $1x\ 10^{-5}$ (Top scale) and from 2×10^{-5} to 1×10^{-6} (Bottom scale)

This gauge covers a pressure range of 1×10^{-3} to 1×10^{-6} m.bar in two ranges with instant range changing provided by a toggle switch. No manual adjustment is required and pressure is indicated in a clear front meter directly calibrated in m.bar.

2.00 GENERAL DESCRIPTION

This mini penning model STP4M-D is modular front panel construction and form 1/4 size of a standard 19" rack. This is designed using the principle of emission of electron from a cold cathode with a high voltage mode. Just solid state power supply circuit is mounted on attachable printed board. The mains fuse (F) the mains chord, the penning gauge head socket and control output terminals are provided at the rear of the unit. A two metres long power chord is supplied as part of the unit. A high voltage cable is supplied along with the gauge head to connect the gauge head to the control units. This gauge covers a pressure range of 1×10^{-3} to $1x10^{-6}$ m.bar in two ranges with instant range changing provided by a toggle switch. No manual adjustment is required and pressure is indicated in a clear front meter constructed from light aluminium alloy frames, having detachable cover on all sides. This facilities easy accessibility of all components mounted inside and this makes services more convenient. This can be used as bench standing type or panel mounting type. By using an appropriate rack adapter,

3.00 APPLICATION

This instrument sensor is having a wide range of applications in high vacuum system for measuring high vacuum. This instrument can be used in high vacuum like coating unit, Sputtering units and many other applications. Having a wide range this instrument can also be used as vacuum impregnation unit, Epoxy mixing and casting units and similar processing equipment operating in range of 10^{-3} to 10^{-6} m.bar

4.00 SPECIFICATIONS

ELECTRICITY SUPPLY	:	230V AC 50Hz (± 10%)
OUTPUT VOLTAGE	:	2.2 KVDC (± 5%)
PRESSURE RANGE	:	Range-1: 1 x 10^{-3} to 1 x10^{-5} (Top scale)
	:	Range-2: 2 x $10^{-5}$to 1 x 10^{-6} (Bottom scale)
FUSE	:	500 ma size 5Dia x 20 mm
GAUGE HEAD	:	HINDHIVAC Model PNG-2.
CONTROL	:	Input to HINDHIVAC penning controller model PNGC-1 for pressure control.
SIZE IN MM	:	98H x 98W x 180D. (Approximately).

5.00 UNPACKING AND PRE-OPERATIONAL CHECK

The control panel and gauge head are carefully checked and packed before despatch. Prior to using the instrument carefully inspect the unit for any visual signs of transportation damage. Remove the top cover by unscrewing the two round head screws on each side and slide the cover towards back, visualy inspect the inside of the unit for damages and displacement of components on P.C.B that might have occured during transportational. check their sockets, all internal connections are in place and properly seated. Replace the cover in the same manner as it was removed.

CAUTION

When the top cover of the gauge is removed, remove the shorting terminal of the meter.

If any damage is observed, report to HINDHIVAC and the insurance to file proper claim, sent copy of change claim to HINDHIVAC Bangalore to assist the expediting replacements or repair of the instrument.

If the unit fails to functions properly contact our local office or write to HINDHIVAC Bangalore.

6.00 INSTALLATION:

1. Check that the electricity supply voltage agrees with the operating voltage of the instrument.
2. Check that the meter indicates zero. If not adjust by the mechanical zero adjusting screws on the meter face.
3. Connect the gauge head to the vacuum system. See that the O ring is properly placed in the male joint. Tighten the locknut with hand properly so that the O ring provides a leak tight joint.
4. Connect the high voltage cable from the gauge head to the control unit, supplied alongwith the gauge head.
5. Evacuate the system to better than 10^{-3} m.bar.
6. Switch on the control unit by switching on the toggle switch [S1] Now the neon lamp should glow indicating the readiness of the power supply to gauge head.

NOTE:

Sometimes the ionisation phenomena by which the Penning gauge works will not initiate as soon as the range 1 position is selected. It takes few seconds to initiate the discharge. So keep it in the same position in case it does not initiate immediately. After the discharge initiates the meter needle moves from right to left showing the correct pressure in the chamber.

7.00 CIRCUIT DESCRIPTION

The penning gauge with gauge head operate as follows.

When the penning gauge is connected to the power supply, the 230 VAC is given to primary of the transformer (T1) through fuse (F) and mains ON/OFF switch (SW1) located on front panel. The mains indication Neon lamp is connected across the primary of the transformer through a series resistor to indicate mains on in normal condition.

The out put from secondary of the transformer is rectified and filtered and fed to regulator + 12V to get 2.2 KV for penning gauge head.

The penning gauge head power supply circuit operates on the principle of inverter [DC to DC] to obtain 2.2 KV DC.

To generate 2.2 KV, the supply is derived from line power transformer through secondary winding of 18V at 250mA. The A.C voltage is rectified, filtered and regulated to generate +12 VDC using 7812 IC regulator.

[Comprising of D101-D104, C101-C102 and I C 101]

The regulated 12V is then applied to high gain push pull amplifier which acts as an oscillator from transient current under regenerative feedback action at around 50 KHz along with ferrite core transformer.

[Comprising of R101, R102, & R103, C103,Tr101 & Tr102]

Since the core of the transformer material is ferrite and low hysterisis which has got high magnetic permeability, the E.M.F induced in primary winding C1, C2 and B1 B2 are stepped up to about 480 VAC [measured using AVO meter] in the secondary winding at around 50 K Hz.

This voltage is then applied to voltage quadruple [Comprising of D105-D108, and C104 - C107] which rectifies, multiplies and gives 2.2 KVDC $\pm$ 10%. This voltage is then applied to anode and cathode of gauge head through 1 meg Ohm (R105) resistor as current limiting resistor.

Here the negative of 2.2 KV is grounded through R104 and the cathode of the gauge head is also grounded.. Hence the current flowing through R104, is directly proportional to the change in the gauge head pressure.

8.00 PRINCIPLE OF OPERATION:

The electrons emitted from the cathode [gauge head body] of the gauge head are deflected by means of magnetic field applied at right angles to the plane of the electrodes and are made to take helical path before reaching the anode loop. Thus following very long path, the chance of collision with gas molecule is high even at low pressures. The secondary electrons produced by ionisation themselves perform similar oscillations and the rate of ionisation increases rapidly. Eventually the electrons are captured by the anode and equilibrium is reached when the number of electrons produced per second by ionisation is the sum of positive ion current to the cathode and the electron current to the anode and is used to measure the pressure of the gas.

The gauge head is completely made up of metal for more reliability. It contains one anode bend made out of non magnetic stainless steel wire which is fixed to the top flange with a glass to metal seal to resist electrical and vacuum leaks. Complete assembly of the gauge head is shown in the drawing which is supplied along with the instrument. Here cathode is an aluminium body to which magnet is fixed permanently. The complete assembly is enclosed in a PVC cover with a rubber gasket. The gauge head is leak tested upto the range of 10^{-10} std.cc/sec leak rate by the Mass Spectrometer leak Detector before sending for despatch. The lower pressure limits of this gauge is 10^{-6} m.bar.

9.00 OPERATING PROCEDURE

This is a cold cathode Ionisation gauge head consisting of two electrodes anode and cathode. A potential difference of about 2.3 KV is applied between anode and cathode through current limiting resistor. A magnetic field is introduced at right angles to the plane of the electrodes by a permanent magnet having nearly 800 gauss magnetic field which will increase the ionisation current. The pressure measuring range of this gauge head is 1×10^{-3} m.bar to 1×10^{-6} m.bar.

METER:

This is a Micro ammeter connected in the cathode circuit of the Penning gauge head to measure the discharge current of the gauge head. The discharge current is directly proportional to the pressure in the system. The meter is directly calibrated in m.bar [mm Hg] Separate potentiometers are provided for each range for calibration purpose.

9.01 OUTPUT FOR VACUUM CONTROLLER

The analog signal, which is proportional to pressure in the gauge head is provided on back panel corresponding to (+) common ground and (-) floating. The signal is approximately 2.0 volts full scale corresponding to 1×10^{-3} m.bar, and 6 m.v corresponding to 1×10^{-6} m.bar.The signal can be connected to Hi-Tech penning controller model PNGC - 1, which works in the range of 10^{-3} to 10^{-6} m.bar to actuate any external device depend upon the preset vacuum level.

10.00 MAINTENANCE

10.01 MAINTENANCE OF CONTROL UNITS:

Servicing of the control unit apart from the adjustments, should be taken by an Electronic Engineer.

10.02 TEST EQUIPMENT:

For voltage and current measurement use a multimeter having a sensitivity of at least 20,000 ohms/volt in DC (AVO Model SZ is suitable).

10.03 MAINTENANCE OF GAUGE HEAD:

The electrodes [ANODE AND CATHODE] of the gauge head must be cleaned for efficient functioning. Contamination of gauge head is a common reason for unstable pressure readings or for the failure of initiation of discharge.

When the gauge head is operated in a high pressure for a long time. Sputtering takes pla and forms a thin deposit of metal on the cathode. These deposits by themselves a harmless. But eventually they may cause electrical leakage between the electrodes.

If the gauge head is operated for considerably long period in organic vapours, decomp sition of vapour causes carbonaceous deposits and form insulating layers on t cathodes. This reduces the sensitivity of the gauge head and thus effects the pressu reading.

If the contamination of gauge head is suspected, carry out an insulation test with megger between the anode and cathode terminals. The resistance should be infinite.

10.04 CLEANING OF PENNING GAUGE HEAD:

Oscillations developing in the penning gauge meter usually indicate a contamination o the gauge head.

When it has been determined that the Penning gauge head is contaminated, the following procedure could be adopted.

1. Switch off the penning gauge control unit of the power supply.
2. Remove the gauge head from vacuum system after venting the system to atmosphere with appropriate valves closed.
3. Disconnect the connector at the gauge head, carrying the power supply cable from control unit.
4. Unscrew top two Nos. of screws and remove Top cover protecting the gauge head.
5. After removing the Top cover the top flange fixing screws are accessible.
6. Remove the four cheese head screws and take out the top flange straight upward until the anode is cleared out of the cathode assembly.
7. Place the anode assembly carefully keeping the anode without any strain as the anode loop is supported on a fragile glass to metal seal.
8. Usually when the gauge head is contaminated the anode loop & the cathode loop are discoloured and thin layer of deposits are formed on them.
9. The anode loop and cathode liner are made of SS and non- magnetic type.
10. If facilities are available for chemical cleaning of SS the anode loop and cathode liner can be cleaned with following solution. 20-30% HND (Nitric acid) and 2-3% HF (Hydroflouric acid) at 140 deg.F for 20 minutes.

11. If the facilities for chemical cleaning is not available, use very fine abrassive by holding carefully the anode loop without straining the seal portion and clean allround the loop wire.

12. Use some abrasives to clean the shield also to remove the deposits.

13. Clean the anode loop and the shield with acetone and dry it throughly. Check the insulation between center conductor and flange for any leakage.

14. When the cathode liner is cleaned with an abrasive it need not be removed from the body. Clean carefully on the inner surfaces to remove the contamination without making any scratches on the surface.

15. Clean with acetone on internal surface and dry it throughly.

16. Introduce the anode loop keeping exactly in the centre parallel to cathode with sealing 'O' ring in place after smearing with a little of high vacuum grease.

17. Tighten the four cheese head screws diagonally opposite so that uniform tightness is achieved.

18. Place the top cover and tighten the fixing screws and introduce the bottom rubber cup.

19. Fit the gauge head into the vacuum system and operate for a few minute or two when roughing the system for self cleaning of the gauge head.

20. Initially there may be still some fluctuations because of trapped gases which will be cleared off after some continuous use in high vacuum.

11.00 TROUBLE SHOOTING

	TROUBLE	CAUSE	REMEDY
1.	No mains indication lamp.	Open power cord lead	Check & Replace
		Open fuse	Check & Replace
		Faulty switch	Check & Replace
		Faulty lamp	Check & Replace
2.	No. H.T.DC Voltage	Faulty transformer	Check & Replace
		Faulty diodes	Check & Replace
		Faulty capacitors	Check & Replace
3.	Unstable pressure readings	Gauge head contaminated	Clean the Gauge head.

PRECAUTIONS

1. DANGER HIGH VOLTAGE:

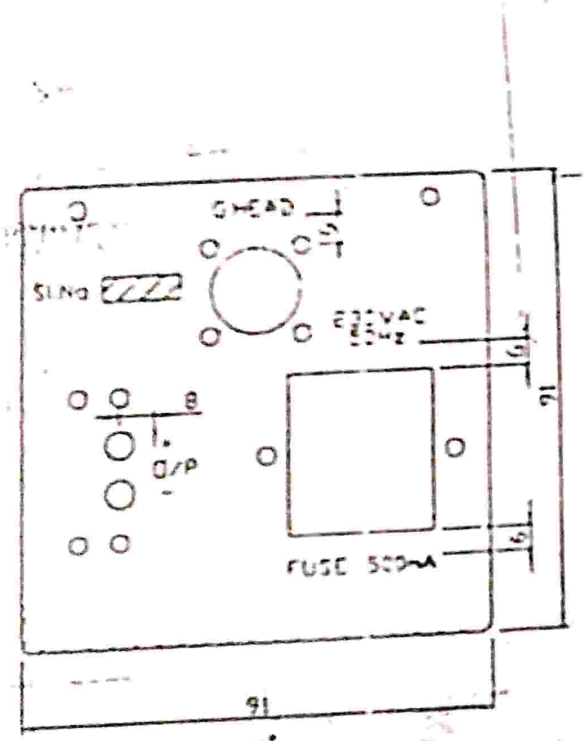
The high voltage can be lethal. Hence before trying to attempt any service on the instrument or while removing the gauge head cable care must be taken to avoid any contact with live wires even after switching off the instrument. The capacitors in the doubler circuit are not discharged through any bleeder and hence voltage will appear even after switching off the unit for quite some time. Hence, to make sure, discharge the capacitor by shorting the central conductor of the gauge head socket to ground after removing the gauge head cable by a piece of well insulated wire. Never attempt to disconnect the coaxial plug at the gauge head side, without disconnecting first from the control panel.

2. Never switch on the gauge head in high pressure (above 10^{-3} m.bar) for a long time.
3. Never select range 2 when system pressure is above 2×10^{-5} m.bar.
4. Keep the gauge head away from magnetic fields.

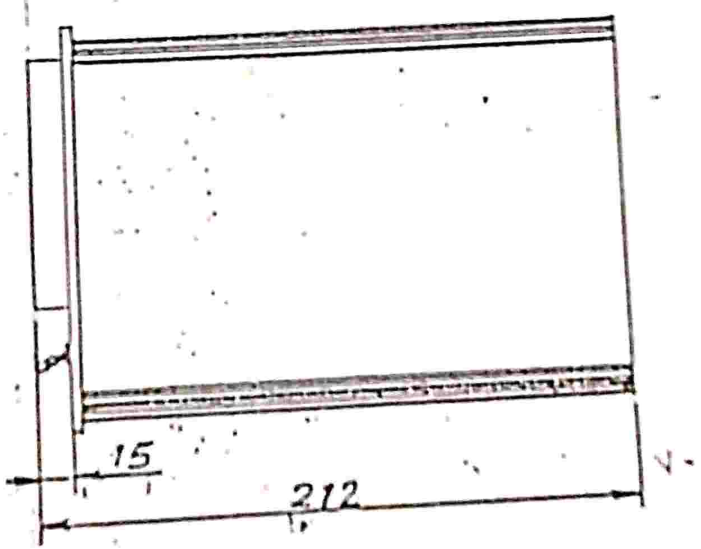
12.00 LIST OF ENCLOSURES

Mechanical Dimensions of penning gauge
Diagram of penning gauge front panel
Diagram of penning gauge outline
Diagram of penning gauge back panel
Schematic Diagram of penning gauge head
Circuit diagram of penning gauge

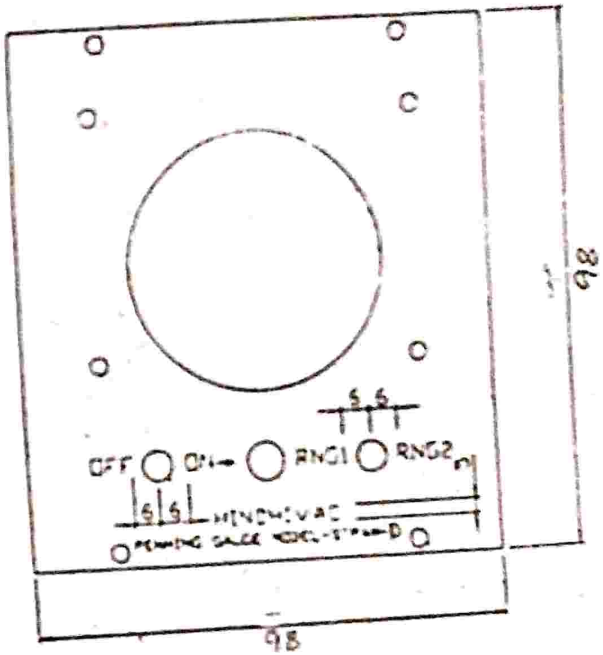
MECHANICAL DIMENSIONS OF PENNI . GAUGE



REAR VIEW



SIDE VIEW



FRONT VIEW

DIAGRAM OF PENNING GAUGE OUTLINE

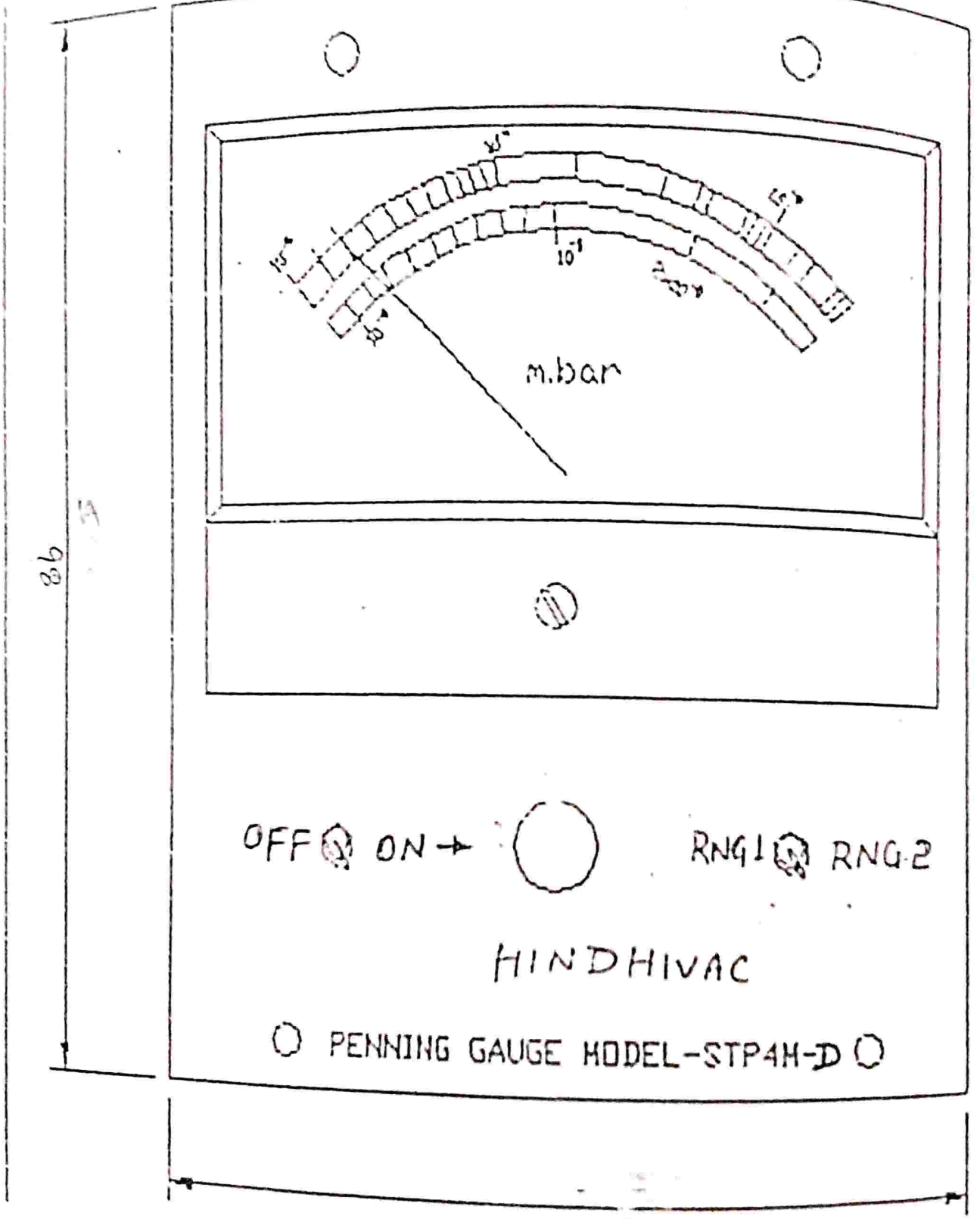
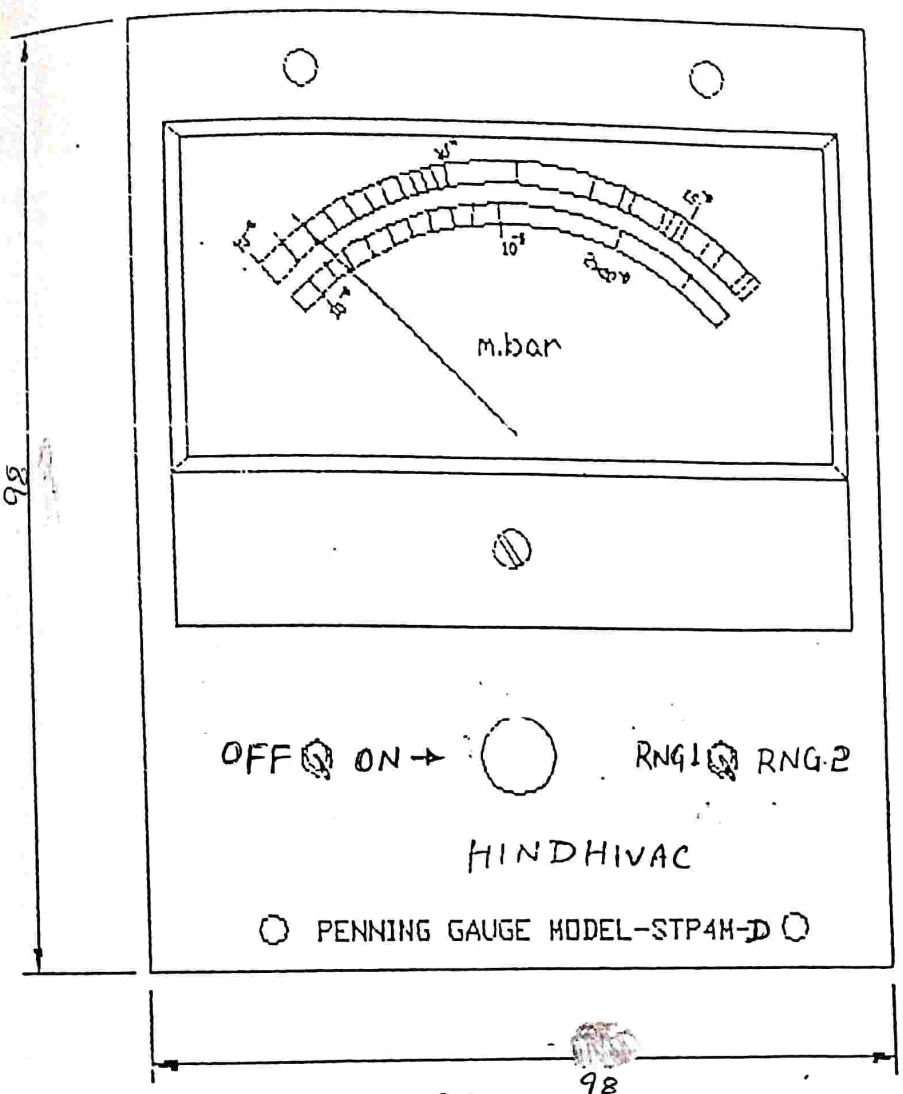
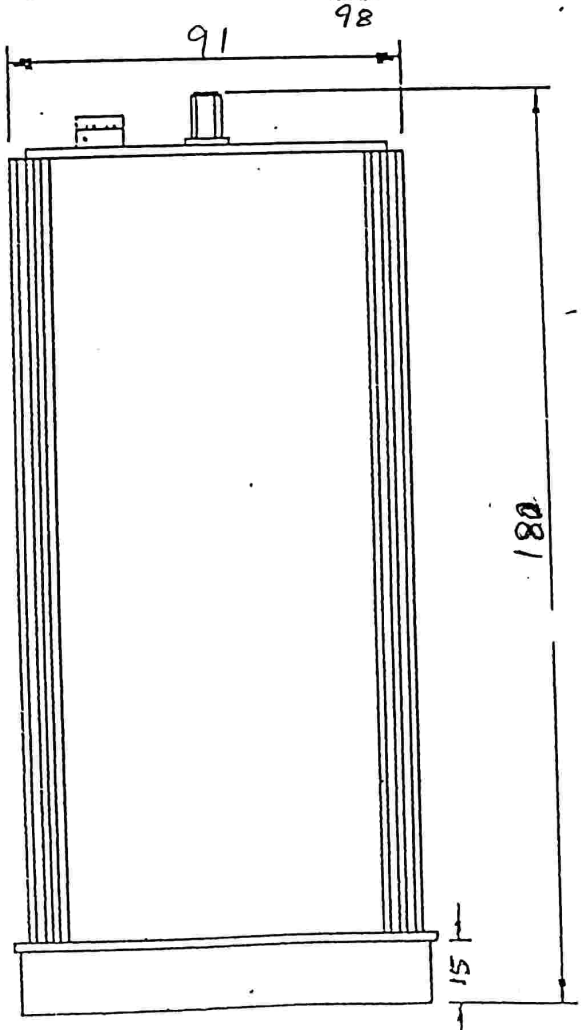


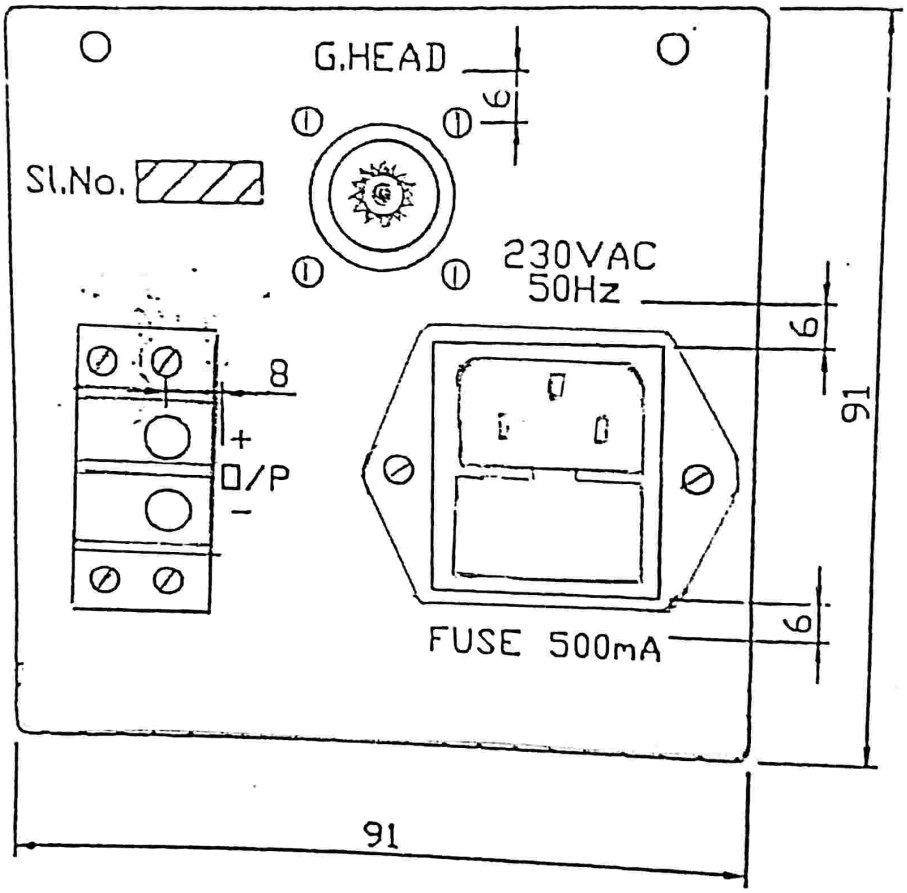
DIAGRAM OF PENNING GAUGE OUTLINE



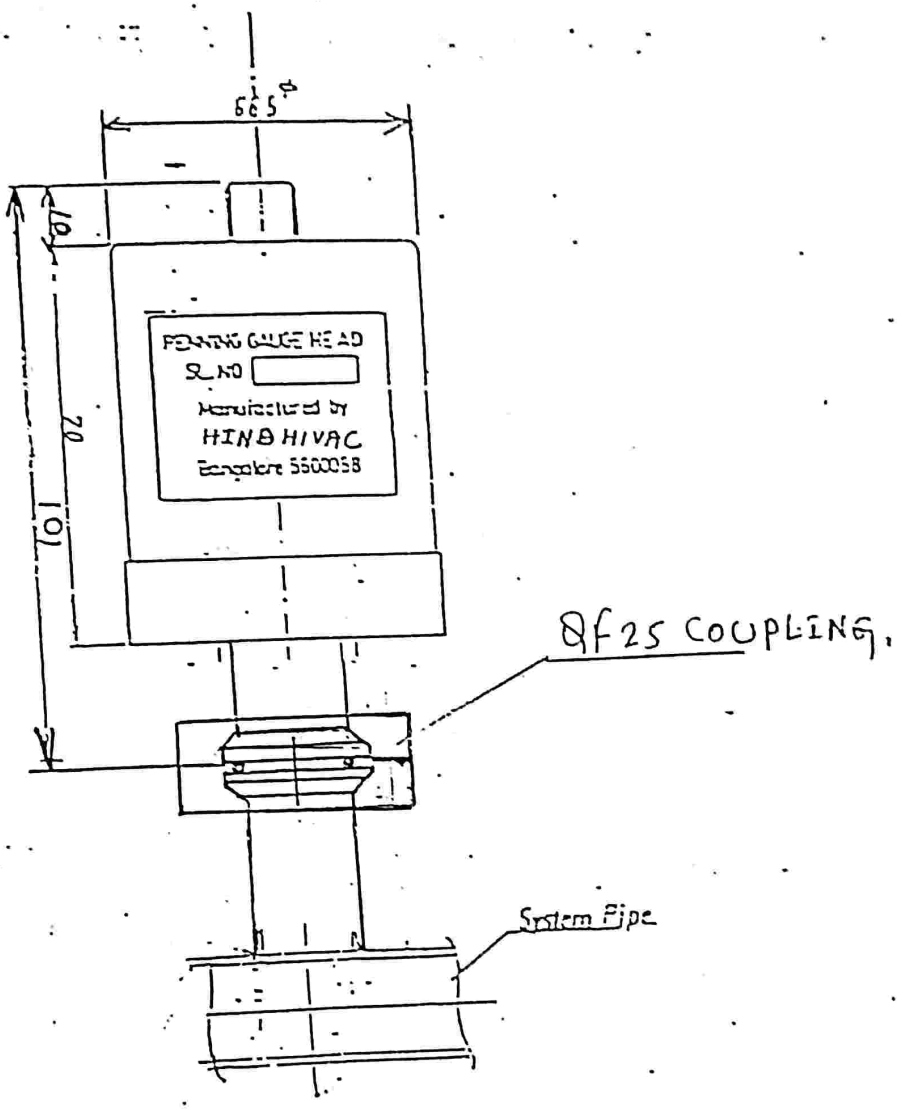


FILENAME

BACK PANEL FOR PENNING GAUGE

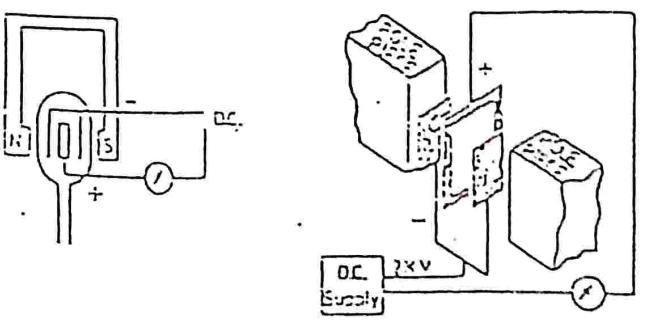


SCHEMATIC DIAGRAM OF GAUGE HEAD



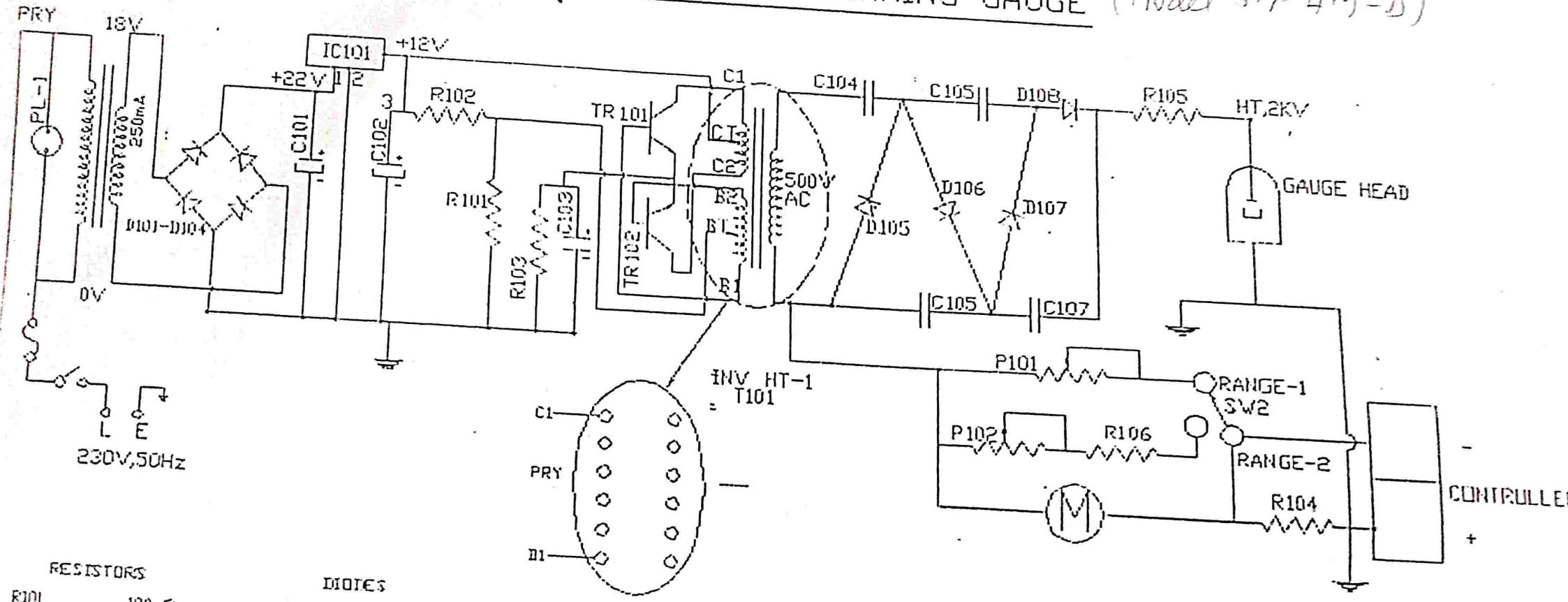
Note: 1) All Dimensions are in mm.

2) X: Max 25mm.



DRC-NO: ST-26 Rev-2

CIRCUIT DIAGRAM OF PENNING GAUGE (Model STP 4M-D)



RESISTORS

R101	100 Ω
R102	1.3K Ω
R103	12 Ω
R104	3.3KΩ
R105	1M Ω 2 W
R106	680 Ω

CAPACITORS

C101	1000 MF/40V
C102	10MF/25V
C103	330PF
C104	0.01MF
C105	0.01MF
C106	0.01MF
C107	0.01MF

TRANSISTORS

DIODES

D101	IN4007
D102	IN4007
D103	IN4007
D104	IN4007
D105	DR 150
D106	DR 150
D107	DR 150
D108	DR 150

POT

P101	250 Ω
P102	25K Ω

IC

IC 101	7812

T - FERRITE CORE TRANSFORMER
PRIMARY C1-C2 - 16 TURNS - 27 SWG WITH CENTRE TAP
PRIMARY B1-B2 - 8 TURNS - 37 SWG WITH CENTRE TAP
SECONDARY 365 TURNS - 37 SWG.

"HINDHIVAC"

DIGITAL THICKNESS MONITOR

MODEL - DTM - 101

OPERATION

AND

MAINTENANCE MANUAL

TÜV CERT
DIN EN ISO 9001:2000

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DRAWINGS

APPENDIX

1.0 GENERAL DESCRIPTION

The **Thickness Monitor** allows improved manual control of the vacuum film deposition process by providing a direct display of film thickness and deposition rate during deposition.

Semi automatic control of film thickness can be accomplished by utilization of the shutter control relay in the Monitor. The shutter control relay allows for direct operator control of the system shutter and will also automatically close the shutter when the deposition thickness equals a preprogrammed value. The DTM-101 has two shutter control relays which can be programmed to close on two separate set points.

The Monitor requires 4 operator supplied parameters in order to provide direct read out and shutter control. Entry, modification and display of these parameters is easy and straight forward. Parameter storage is not dependent on continuous AC power. Internal, self charging, Ni-Cad batteries provide parameter storage for a minimum of 60 days without external power.

1.1 FEATURES

- **Independent Film Density and Tooling Factor Parameters.**

The tooling factor parameter allows the Monitor to compensate for deposition geometry effects such as different source to sensor and source to substrate distances which result in proportional but not equal film thickness at the sensor and the substrates. By utilizing the tooling factor, the Monitor can calculate and display film thickness and rate at the substrate rather than at the sensor.

- **Acoustic Impedance Correction**

The monitor corrects the thickness reading for acoustic impedance mismatch between the crystal and film material by taking into account the operator supplied acoustic Impedance Parameter for the film. If not corrected for, errors result as the film thickness builds up on the sensor crystal. The sensitivity of quartz crystals to material build up changes with the amount of material on the crystal if the deposited material has an acoustic impedance significantly different than that of quartz. With some materials this effect can lead to differences between indicated and actual thickness of up to 20% as material builds up on the sensor crystal.

- **Parameter Display**

The film Density, Tooling Factor and Acoustic Impedance parameters are instantly viewable on demand for quick reference at any time.

- **Autoranged Display**

All parameter displays and Rate and Thickness displays are fully autoranged.

- **Long-term Parameter Storage**

Parameters entered into the monitor are maintained in memory for a period of at least 60 days without power. Short term power loss will not require parameters to be re-entered.

- **High Update Rate**

The monitor utilizes a dynamic updating scheme which provides an update rate of 5 measurements/sec at high deposition rates where response is important while still maintaining a static resolution of 0.01 microgram/sq.cm (1 Angstrom of material with density one) at low deposition rates.

- **Output Protection**

The Monitor incorporates output protection on both the shutter relay output and the DAC output in order to minimise the possibility of damage to the monitor due to external system faults or miswiring.

- **DAC Output**

A digital to analog converter output provides data for recording of the deposition process. Either rate or thickness data is selected for the DAC output.

- **Universal Applicability**

The Monitor is designed to accept 6MHz sensor crystals and nominal A.C. line voltages of 200 through 240VAC

- **Built in Test**

The monitor incorporates built in test functions to guarantee its operational integrity and to aid in fault isolation in the event of an internal failure.

1.2 SPECIFICATIONS

Measurement Range	:	Transducer Limited Typically 5,000 microgram / sq cm as much as 20,000 gram/sq cm for well behaved materials (1.0 Microgram/sq cm 37 A

Rate Display	:	3 Digit LED Autoranging from 00.0 to 999.Ang/sec.
Thickness Display	:	4 Digit LED Autoranging from 0.000 to 999.9 K Ang
Update Rate	:	Automatically Varied -.4 to 5 updates/sec.
Static Thickness Resolution	:	1 Ang at minimum update rate
Input Parameter	:	Tooling factor, Density and Acoustic Impedance inputs allow readout directly in Angstroms.
Film No.	:	DTM - 101 allows input parameters for 1 to 100 films to be entered.
Tooling Factor	:	1.0 to 999.9%
Film Density	:	0.800 to 99.99 gm/cubic sec
Film Acoustic Impedance	:	5.000 to 99.99 x 10 gm/cm sec
Shutter Control	:	Dedicated relay. Internal 3 Amp fuse protection, two relays.
Thickness Set Point	:	0.000 to 999.9 K Ang, shutter Closes when displayed thickness equals or exceeds set point.
Start Control	:	Zero thickness and opens shutter
Stop Control	:	Close Shutter.
Shutter position indicator	:	LED on indicates that shutter relay is activated.
Crystal Compatibility	:	6 Mhz.
Crystal Test Display	:	Type of Crystal Being used.
Crystal Health	:	Percentage of crystal life remaining.
Crystal Frequency	:	6 Mhz.

Analog Output	:	0 to +5 ± .25 V full scale corresponding to last 2 or 3 digits of selected display.
Output Control	:	Rate or thickness select Decade Select selects for conversion of last 2 or 3 digits of display. Full scale and zero scale output. Useful in calibrating recording equipment.
Self Test	:	Automatic Detection and indication of : Oscillator Failure Power line Failure Internal failure (Thickness Monitor)
Power Requirement	:	230 V AC ± 10% 50Hz 15 V.
Size	:	203 width x 209 deep Height 85.
Operating temperature range	:	0 to 45°c.

2.0 UNPACKING AND INSPECTION

Carefully inspect your monitor and its shipping container for evidence of possible shipping damage or loss. If such evidence is present, a report should be filed with the carrier as soon as possible. Keep the shipping container as evidence if shipping damage is present or for possible future return of the unit. Check the material received against the packing list to be certain that all material is accounted for. The following items should have been included with your monitor:

1 DTM 101

1 Operator's Manual

1 Power Chord

1 3 Pin Connector

1 Oscillator Box

1 Crystal Holder with water feedthrough

2 Connecting Cables

2.1 BENCH CHECK-OUT

If there is no evidence of damage, the monitor can be bench checked. Make sure that the input power voltage requirement is correct for your installation.

Power is applied to the monitor via the rear panel rocker switch. When power is first applied to the monitor it goes through a short internal test routine during which time all of the numeric displays will show 8's and all decimal points will be lit. These conditions lasts for 3 seconds after which time the monitor will begin to flash a P FAIL message indicating that Power has been interrupted for more than 250 m sec. You may see an E FAIL or I FAIL message for a short time, this is normal. If the display stops on either of the messages an internal fault has been detected and the unit will remain inoperative util the fault has been corrected. Further details of error message can be found in TEST FAILURE DETECTION.

If power has been OFF for more than 60 days, the monitor may display self flashing C FAIL message, indicating that the unit has lost all or part of its stored parameters. This fault may be cleared by pressing the STOP button. If C FAIL flashed for each film number selected, the same may cleared by pressing the stop button.

Pressing the stop button will also present the parameters as follows:

SET POINT	- 10.00
DENSITY	- 1.000
ACOUSTIC IMP	- 8.830
TOOLING	- 100

Clearing this fault should result in a flashing O FAIL message indicating that the sensor oscillator has failed, in this case because the oscillators is not hooked up.

If your monitor responds as described above it is probably OK and is ready to be installed. If not, return the monitor for repair or replacement.

If an oscillator feedthrogh and sensor head are available, you may wish to bench check the total system at this time. Obviously good vacuum practice should be observed when handling those items which will later be installed in the vacuum system. Be careful not to touch the surface of the sensor crystal installed in the Crystal holder. Connect the various components as follows: Use the 10 coaxial cable to connect the monitor to the OUTPUT end of the oscillator. Use the 6" coaxial cable to connect the INPUT end of the Oscillator to the atmosphere side of the feedthrough. Use the 30" miniature coaxial cable to connect the vacuum side of the feedthrough to the sensor

After all the components have been connected pressing the STOP button should clear the O FAIL message.

Depressing the START button will set the thickness display to zero. Breathe lightly on the sensor crystal surface. The displayed thickness should increase due to condensed water vapour on the crystal. The O FAIL message may be reactivated if excessive water on the crystal causes it to fail. The message should clear itself as soon as sufficient water has evaporated allowing the crystal to recover. The displayed thickness should then decrease as additional water vapour evaporates from the surface. If operation seems abnormal check to see that the stored parameter values are reasonable.The following parameter values are suggested

Set Point Thickness	10.00 K Ang
Material Density	2.650 gm/cubic cm
Acoustic Impedance	8.830
Tooling Factor	100.0%

If everything responds as described above the total system is OK. If not refer to TROUBLESHOOTING.

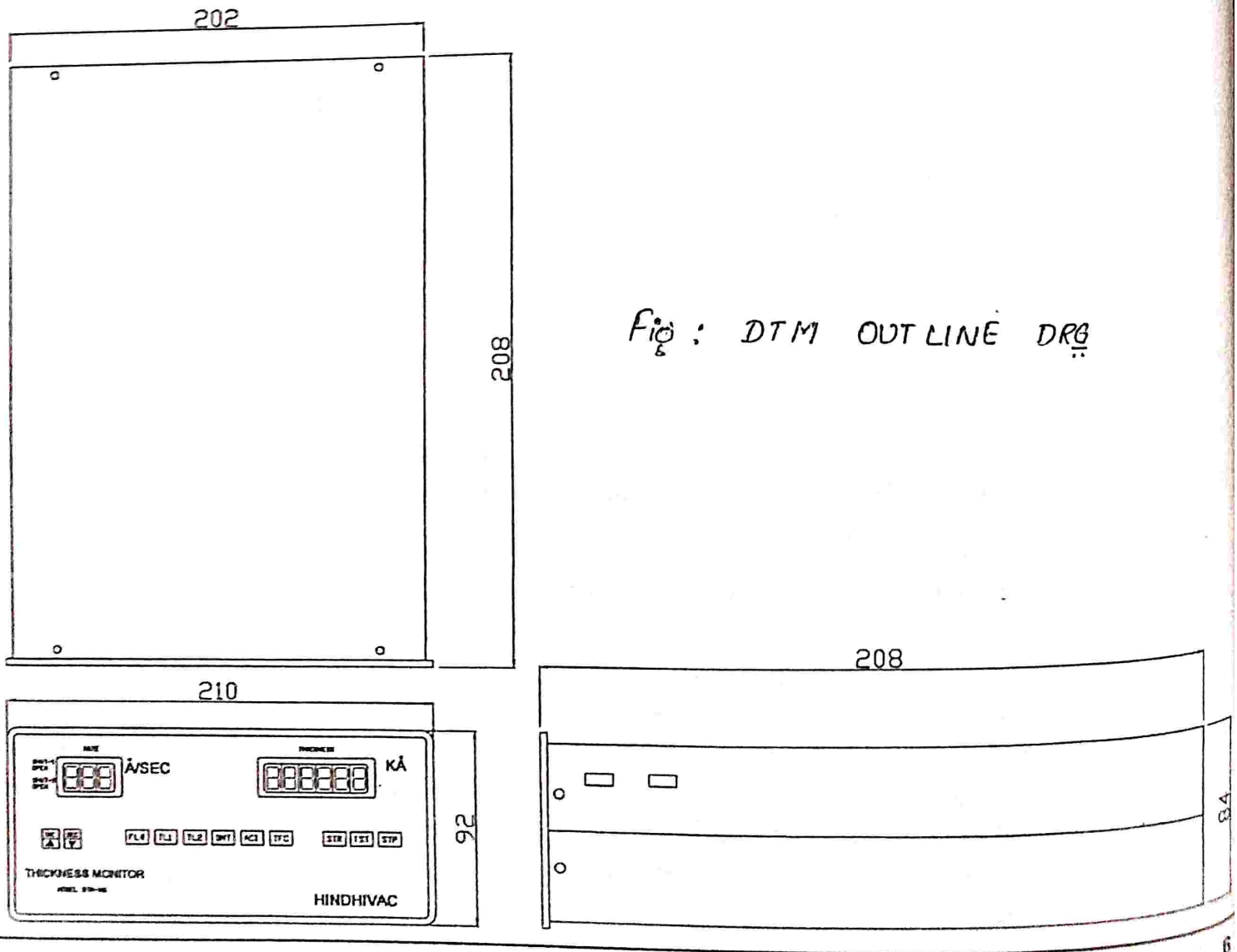
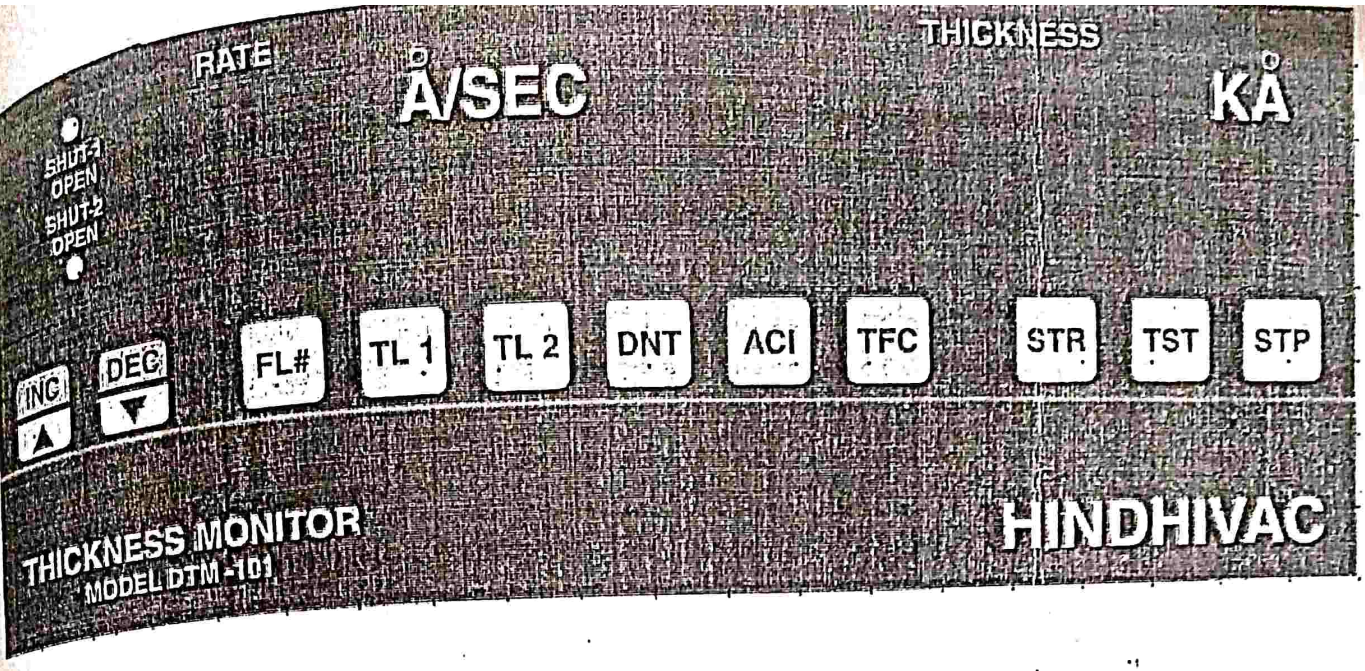


Fig : DTM OUTLINE DRG



3.0 MONITOR INSTALLATION

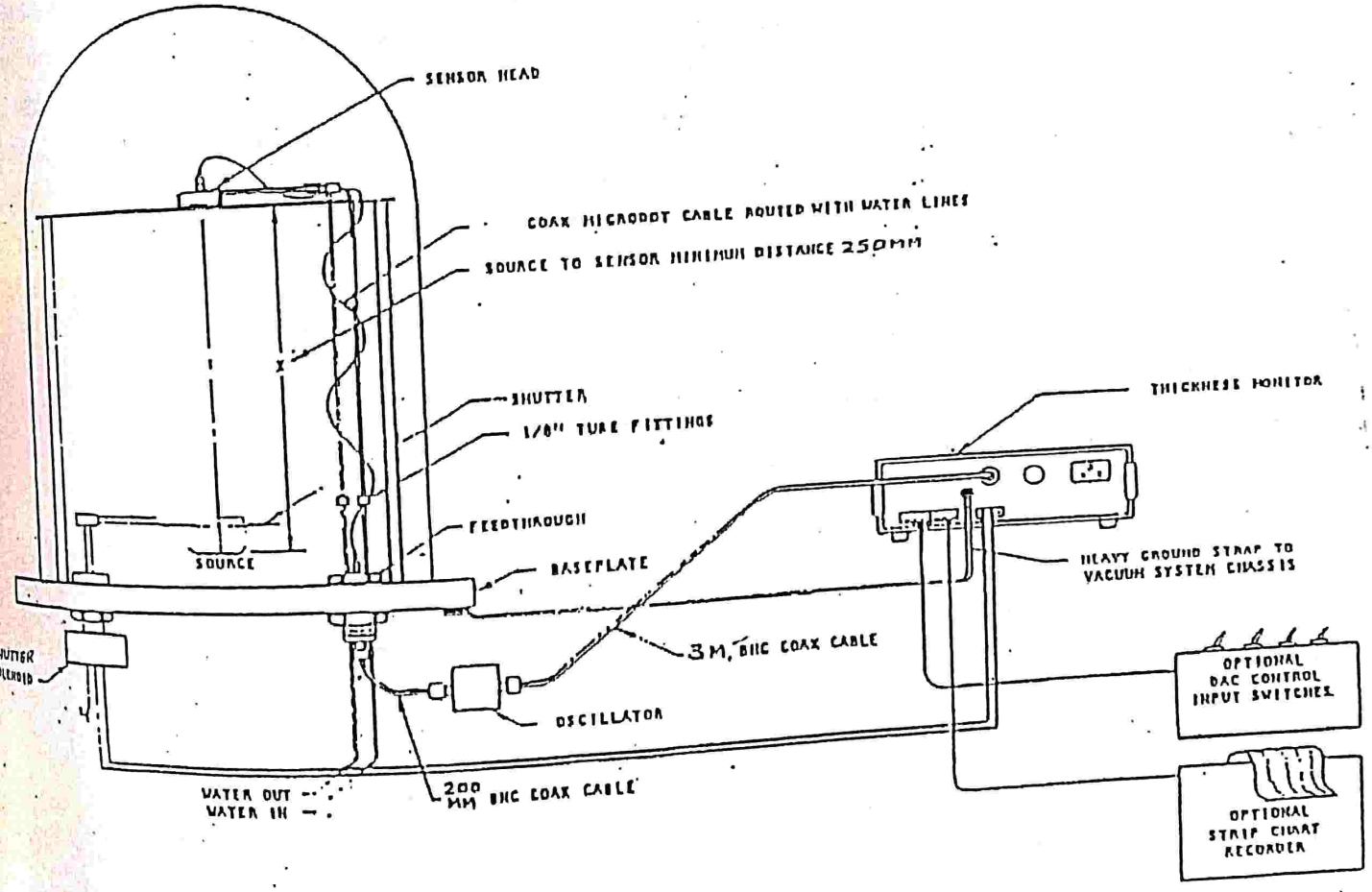


FIG. 3. Typical Vacuum System Installation

3.1 MONITOR INSTALLATION PRECAUTIONS

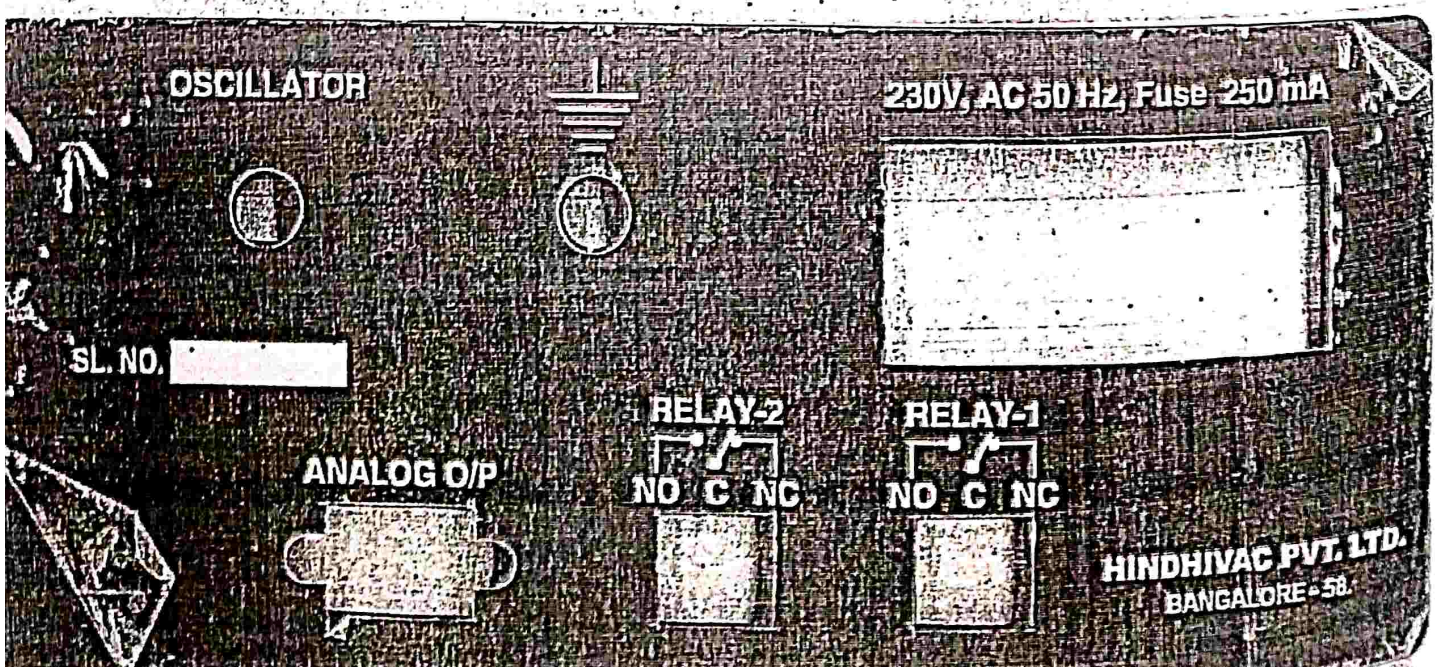
- **PROPER GROUNDING**

The monitor is designed to operate in electrically noisy environments. In many cases no special grounding precautions will be required. Where noise susceptibility is suspected, use a short length wire, wire braid or copper strap is recommended, to connect the monitor to the equipment on which or in which, the unit is mounted. Use the grounding lug provided on the back of the monitor for this purpose. If trouble still persists, make sure that the equipment on which the monitor is mounted, or the equipment rack in which the unit is mounted is adequately grounded to the vacuum frame. Use short copper straps or braid. It is a good idea to use several grounding straps attached to widely separated points on the vacuum system and equipment frame in order to minimise the inductance of the ground path.

- **HEAT DISSIPATION**

Your monitor dissipates very little heat. Even so, the heat that is generated must be allowed to dissipate or the Monitor will overheat. Most of the heat generated in the monitor is routed to the rear panel which is cooled by convection and radiation. Make sure that there is adequate clearance around the unit to allow air flow. If the unit is mounted in an enclosure, make sure that the air flow is enough to maintain a maximum temperature environment of 50 degrees centigrade for the monitor. Overheating of the Monitor will ultimately cause functional failures and may cause permanent failures.

3.2 REAR PANEL CONNECTIONS



OSCILLATOR CONNECTOR

A BNC connector is provided on the rear panel of the monitor for connection to the sensor oscillator. The monitor's oscillator input buffer is designed to operate with coaxial cable of 50 ohm impedance. Cable lengths upto 10 mtr. may be installed using RG 58 cable or an equivalent. Cable lengths longer than the 3 mtr length supplies are available upon request. Refer to sensor, feedthrough and oscillator installation instructions.

SHUTTER CONNECTION

A 3 pin powermate connector is provided on the two connectors on the monitor's rear panel for connection to a shutter activating device. The shutter relay provides a form C contact closure (SPDT, break before make). The contacts are rated for 24 VDC/AC. A 3 Amp fuse is mounted inside the monitor to protect the internal circuitry from possible damage due to miswiring. A mating connector and pins are supplied for connection to the rear panel connector. The pins can be crimped or soldered to the wires leading to the shutter actuator, refer to shutter wiring schematic for connecting a shutter solenoid. Using this connection scheme results in the shutter closing in the event of power loss.

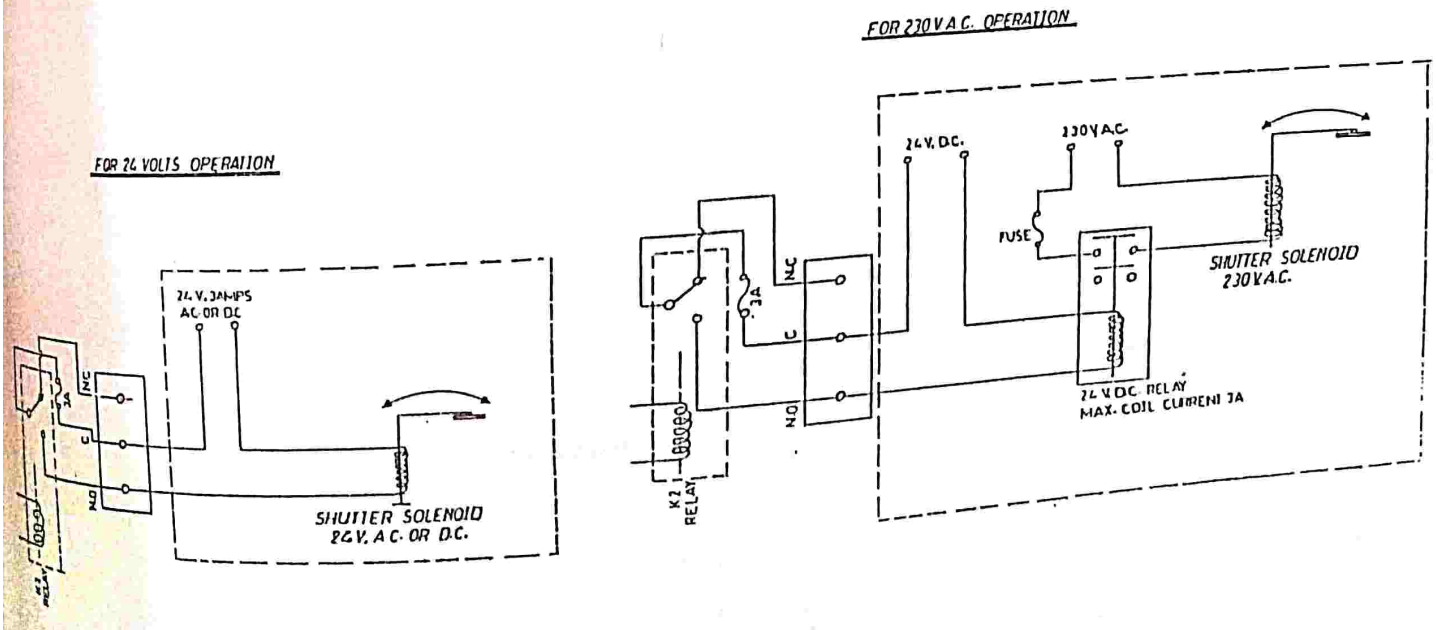


Fig. 5 Diagram of shutter wiring schematic

DIGITAL TO ANALOG CONVERTOR (DAC) CONNECTION

A nine pin connector is supplied on the monitor rear panel for connection to the DAC.

The following list describes the DAC connector pin assignments.

Pin Number

1. Logic Signal Return.
2. Full scale Calibration Input
3. Zero scale Calibration Input
4. 2 or 3 Decade Select Input
5. Thickness or Rate select Input
6. Analog Signal Return
7. Analog Signal Output
8. Not used
9. Not used

A suggested wiring diagram for connecting a strip chart recorder to the DAC output is shown. It is suggested that the control switches be mounted near the recorder for convenience. Even though the Logic Signal Ground and the Analog Signal Return are tied to the Monitor ground internal to the Monitor it is suggested that the Analog Signal Output and Return be handled as a signal pair. In order to minimise noise pickup at the recorder it may be necessary to use a twisted, shielded pair for this signal.

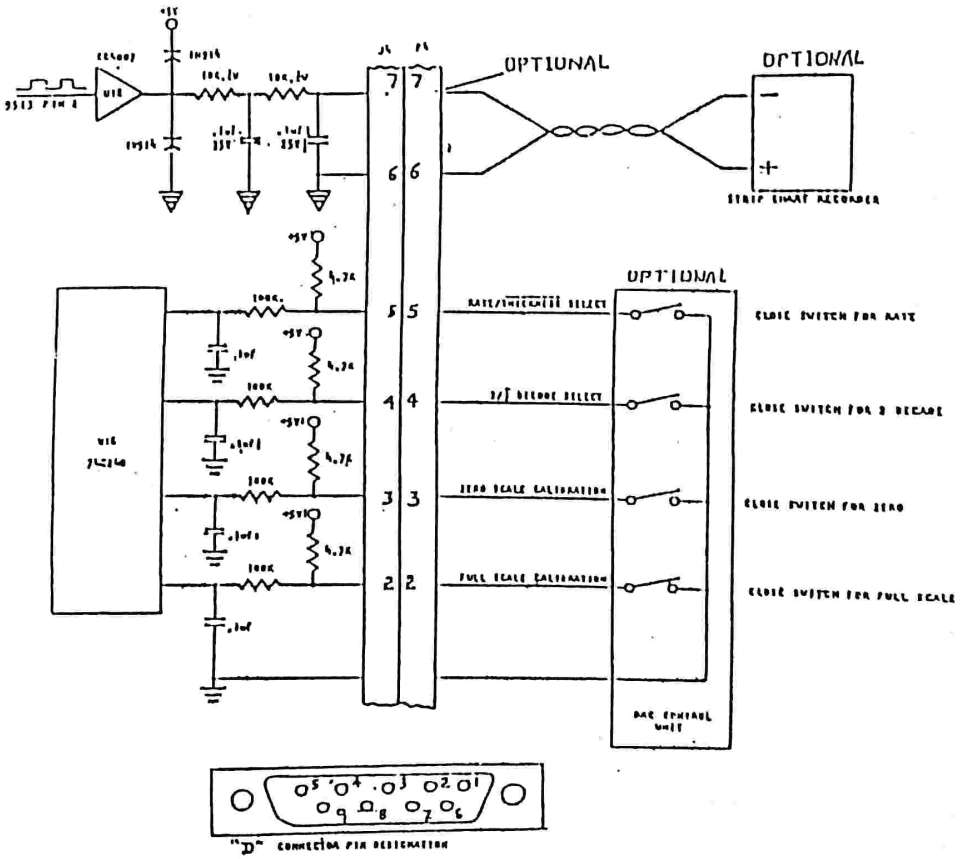


Fig. 6 DAC Wiring Schematic

CAUTION	Under no circumstances should the monitor cover be removed without first removing the line cord as dangerous voltages are present inside the case.

The cover of the monitor is secured by 4 screws which are located in the feet on the bottom of the unit. The 2 rear screws are located under the soft rubber pads which plug into the plastic feet. Remove the 4 screws, grip the unit by the sides with the front panel facing you and carefullypush the top cover up off the front panel with your thumbs. When the top edge of the front panel becomes visible, turn the unit around and do the same thing with the back cover facing you. The cover is tight and you will have to work it off slowly.

To reinstall the cover slide it down over the front and rear panels and into the side panels. Installation of the front two feet which constrain the bail is most easily accomplished by installing them with the bail in its extended position.

CAUTION	Be careful not to over tighten the screws as it is possible to pull the insert out of the cover.

SENSOR, FEEDTHROUGH AND OSCILLATOR INSTALLATION

4.1 SENSOR HEAD INSTALLATION

The sensor head can be installed in any appropriate location in the vacuum chamber. Preferably, the sensor should be located at least 250 mm from the evaporation source and as close as possible to the center of the substrate area. The distance from the vapour source to the substrate is the recommended distance between the vapour source and the sensor crystal surface. Make sure there is adequate clearance to allow for easy removal of the crystal drawer.

The microdot cable connects the sensor head to the dual water/electrical feedthrough. It is a good idea to wrap the coaxial cable loosely around the water cooling tubes. Teflon is used as the insulator in the coaxial cable and therefore will in many cases need no further shielding. However, if substrate heating is used or the system operates above 300°c for any other reason, the cable and water lines may be wrapped together in aluminium foil to extend the cable's useful life.

The mounting tabs on the sensor head may be used to install a radiation shield to specifically protect the microdot cable connector at its attachment point to the head.

Water cooling of the sensor head should always be provided except during short depositions at low temperatures. In all cases, sensor head temperature should not exceed 100 degrees centigrade. Sufficient cooling for thermal environments of upto 300°C. can be provided by a water flow of approximately 0.5 litre per minute. Excessively cold water may result in condensation of water on the crystal holder and crystal when the system is vented. Excessive moisture may cause the crystal to cease operating. This condition is only temporary and the crystal will function properly as soon as the moisture evaporates. Ideal water temperature is between 10°C and 25°C.

Use a shutter to shield the sensor head during initial soak periods to protect the crystal from any sputtering that may occur. If a small droplet of molten material hits the crystal, the crystal may be damaged and oscillation will cease.

4.2 INSTRUMENTATION FEEDTHROUGH INSTALLATION

The feedthrough is installed in the vacuum chamber through a base plate hole. The sensor head is connected to the BNC connector by a teflon coaxial cable. Connect the small co axial cable to the feedthrough's external BNC connector and the sensor oscillator's TRANSDUCER BNC connector. Water line connections to the feedthrough's external BNC connector and the sensor oscillator's TRANSDUCES BNC connector. water line connection to the feedthrough may be accomplished by brazing or vacuum coupling.

4.3 COMBINATION SENSOR/FEEDTHRU INSTALLATION

With the combination Sensor/feedthru, the coaxial cable is already attached. Merely pull the coils apart to desired length. Maximum expansion is 30 inches.

4.4 SENSOR OSCILLATOR INSTALLATION

Use the 6 inch coaxial cable with BNC connectors to connect the Transduce end of the oscillator to the feedthrough.

Use the 10 foot cable to connect the other end of the oscillator to the Monitor. Be careful to route the cable away from any high voltage or RF lines and away from hot or moving surfaces.

For a complete description of the oscillator see Appendix A-2.

There are eleven switches on the front panel. The two switches on the left and six in the middle are used for display and modification of parameters. Their use in described under Display and Modification of Parameters .

The three switches on the right form the normal operating controls. Depressing one of these switches causes the following action:

START (STR)

Set the thickness display to zero and opens the shutter.

STOP (STP)

Closes the shutter. Also used to clear certain error conditions such as power FAIL and Oscillator FAIL.

FILM NUMBER (FL ##)

Selects a film from 1 to 100. When depressed, display the current film in the rate display and can be incremented or decremented within 3 seconds of activation by depressing the increase or decrease buttons. Each film can be individually programmed by setting the film number and programming as per paragraph 6.3.

NOTE	Failure mode must be cleared in order to advance to the next film.

TEST (TST)

Used to determine crystal health. While depressed, causes crystal data to be displayed in both the rate and thickness displays. Causes no other action. Display returns to normal upon release of button.

6.3 DISPLAY AND MODIFICATION OF PARAMETERS

Display of the parameter values stored in the monitor is accomplished by depressing one of the appropriate buttons within the group of 6 parameter buttons. The valve of the parameter is displayed in the thickness display area for as long as the button is depressed and for a display hold period of approximately 3 seconds after it is released. The layer No. is displayed in the Rate Display area.

At any time during the display of the parameter it can be increased or decreased by depressing one of the INCREASE or DECREASE buttons.

The parameter button need not be simultaneously pressed as pressing the increase or decrease buttons will hold the current parameter display for the normal parameter display hold period. If the increase or decrease button is kept depressed the rate at which the parameter varies gradually increased. Thus the longer the button is kept depressed the faster the parameter changes. When the button is released and then depressed again the rate returns to its initial slow value. With a little practice this allows parameters to be set to the necessary accuracy while keeping the time to go from one extreme value to another within reasonable limits.

The Increase and the Decrease buttons are only active when a parameter is being displayed. The rate display continues to display deposition rate independent of parameter displays. The parameters may be changed before, during, and after a deposition. Only during a failure condition will the parameters be viewable but unchangeable.

6.4. THICKNESS SET POINT SHUTTER CONTROL (TL - 1 & TL - 2)

The thickness set point establishes the film thickness at which the shutter closes. As described above, depressing the START button zeros the Thickness Display and opens the shutter. The shutter is then automatically closed when the Thickness Display equals or exceeds the Thickness Set Point. The shutter can also be closed manually by depressing the STOP button. In this way complete manual control of the shutter, as may be required for servicing the source, is available through use of the START and STOP button. This eliminates the need for a separate OPEN,CLOSE,AUTO switch and eliminates the possibility of leaving such a switch in the open or close position when it should be in the auto position. If auto control of the shutter is not desired the Thickness Set Point parameter can be programmed at a value much greater than can reasonably be achieved. The Thickness Set Point-2 may be used to activate a second shutter relay to allow two materials to be sequentially deposited to two preset thicknesses or to operate other electrical or electrical-mechanical devices.

6.5 CRYSTAL TEST

When the TEST button is depressed the normal displays are replaced with crystal test information.

The normal Rate Display is replaced with a three digit number the leftmost digit of which is 6 indicating the type of sensor crystal the Monitor is set up for. The Monitor is compatible with 6 MHz sensor crystals.

The rightmost 2 digits display the crystal health. Crystal health is indicated as a percentage of crystal life remaining. See Appendix A.5. A new crystal will have a health of 98 to 99%. The health decreases as material is deposited on the crystal sensing surface.

The normal thickness display is replaced with a display of the current operating frequency in megahertz of the sensor crystal.

The crystal test display reverts to normal after the TEST button is released. The crystal test function does not affect the normal operation of the Monitor. In particular, both Thickness and Rate continue to be calculated and the normal operation of the Thickness Set Point is not affected.

6.6. CRYSTAL FAIL INDICATION

As material builds up on the sensor crystal, a point will be reached at which the crystal will no longer be able to support oscillation. At this point the crystal has failed. The monitor indicates crystal failures by alternately flashing on O FAIL message and the last valid thickness reading prior to the failure. The shutter closes and the Shutter Indicator LED is turned off.

There are two possible types of a crystal failure: a short term failure and a permanent failure. If the crystal recovers within 2 seconds the monitor will regard it as a short term failure, in which case the display returns to normal, the Shutter is reopened, and Shutter indicator is turned back on. If the crystal is failed for more than 2 seconds the Monitor regards the failure as a permanent failure. In this case the Shutter and shutter Indicator LED are turned off and WILL NOT be turned back on if the crystal recovers at a later time. A permanent O FAIL condition must be cleared by pressing the STOP button. A crystal which has failed at any time should be replaced. For obvious reasons crystals should normally be replaced well before they are likely to fail. See Section 5 for the procedure on replacing spent crystals.

6.7 POWER FAIL INDICATION

The monitor is designed to tolerate short duration power failures of less than 250 milliseconds. During a deposition, if the power is disrupted for less than 250 milliseconds the Shutter closes and reopens when power returns. However, because the monitor is designed for possible unattended operation it does not reopen the Shutter if the power failure lasts for more than 250 milliseconds as a process disruption of this duration could seriously affect the deposition. Instead the Monitor retains the value of the film thickness at the time of power failure and flashes the P FAIL message to indicate to the operator that power was down during his absence. The operator then has the option of continuing the deposition if desired by restarting the Monitor.

6.8. DAC OPERATION

The DAC provides for the conversion of either Rate or Thickness to an analog voltage suitable for recording with a strip chart recorder or other recording device. The DAC converts the last two or three digits of the selected quantity to a zero to 5 volt analog voltage. If a three digit conversion is selected, the last three digits of the quantity are converted. Thus a thickness of 0.999 KA ng would correspond to the maximum analog output of 999/1000 times the full scale value. Since the full scale value is nominally 5.0 volts, a thickness valve 0.999 kAng would correspond to a nominal output of 4.995 volts.

At a thickness of 1.000 KAng the output would be zero corresponding to a value of zero for the last three digits. Since full scale corresponds to 1000 counts the DAC scale factor is 5.0 millivolt per Angstrom. A thickness of 1.020 would convert to a value of 0.1 volts.

If a two digit conversion is selected, the last two digits of the quantity are converted. Thus a thickness of 0.099 KAng would correspond to the maximum analog output of 99/100 times the full scale value of 5.0 volts for a nominal output of 4.95 volts. During two digit conversion the DAC scale factor is 50.0 millivolt per Angstrom.

When converting rate, the basic resolution is 0.1 Angstrom/sec. Thus a rate of 55.0 Ang/sec would be converted to 550/1000 times 5.0 volts or 2.75 volts if three digit conversion were selected and 55/100 times 5.0 volts or 2.50 volts if two digit conversion were selected.

A rate of 150. Ang/sec would be converted to 500/1000 times 5.0 using 3 digit conversion and 00/100 times 5.0 using 2 digit conversion. The use of 2 digit conversion of rate at a deposition rate of 150.Ang/sec.would be unusual but would allow the recorded rate to be easily resolved to a resolution of 0.1 Ang/sec. If the rate is increased to 151. Ang/sec the DAC output would increase to 10/100 x 5.0 or 0.5 volts.

DAC

The DAC output converts either rate or thickness to an analog voltage suitable for recording with a strip chart recorder or other recording devices. The DAC converts the rightmost two or three digits (which are selected by the operator) of the selected quantity to a zero to 5VDC analog voltage.

When converting thickness of the DAC scale factor is 2.5 MV/A deg. for three digit conversions and 25 MV/A deg. for two digit conversions. The zero reference level is 2.5V DC. For positive values the output increases toward +5V DC. For negative values the output decreases toward zero volts. When

converting rate, the DAC scale factor is 2.5 MV/0.1A deg/sec for three digit conversion and 25.MV/0.1A deg./sec for two digit conversion.

To calibrate, ground the appropriate pin on J4. To monitor thickness, pin 5 is open to monitor rate, pin 5 is grounded, for 2 decade selection pin 6 is open, for 3 decade selection pin 6 is grounded. for full scale positive calibration pin 2 is grounded for full scale negative calibration pin 8 is grounded, for full scale negative calibration pin 8 is grounded, for full scale negative calibration pin 7 is grounded, for zero calibration pin 7 and 8 are grounded simultaneously.

The output is monitored through pin 1.

ESTABLISHING THE DEPOSITION PARAMETERS

The following is a guide to establishing the deposition parameters. Valid reasons may occur to deviate from the recommendations and these reasons of course would take precedence.

7.1 TOOLING FACTOR (T F C)

The tooling factor parameter compensates for geometric factors in the deposition system which result in a difference between the deposition rate on the substrates and the rate on the sensing crystal. This parameter is entered in percent units and 100% corresponds to equal rates at the substrate and at the sensing crystal. For initial approximation the tooling factor can be calculated using the following equation.

$$\text{Tooling \%} = (\text{dcry} / \text{dsub})^2 \times 100\%$$

where dcry = Distance from the source to the crystal.
dsub = Distance from the source to the substrate.

Empirical calibration of the tooling factor is described in Section 7.4.

7.2 DENSITY (D N T)

The density parameter provides the Monitor with the density of the material being deposited so that it can calculate and display the physical film thickness. If the film density is known, it should be used. A list of the more commonly used film densities is presented in Table 7.1. As a first approximation, bulk material density can be used in programming, this parameter. Empirical calibration of this parameter is described in Section 7.4.

7.3. ACOUSTIC IMPEDANCE (A C I)

The shear wave acoustic impedance of the deposited film is required by the Monitor in order to accurately establish the sensor scale factor when the sensor crystal is heavily loaded. If the acoustic impedance of the film material is known, it can be entered directly in units of 100.000 gm/sq. cm sec. In most cases the acoustic impedance of the bulk material can be used and can be obtained from the Handbook of Physics or other sources of acoustic data. The shear wave acoustic impedance can be calculated from the shear modulus or the shear wave velocity and the density by using the following equations:

$$\text{Acoustic Impedance} = PC = PG$$

Where P Density (gm/cubic cm.)
C Transverse (shear) wave velocity (cm/sec).
G Shear modulus (dynes/sq. cm)

A list of the acoustic impedance and density of the more commonly deposited material is presented in Table 7.1 and a technique for empirically determining this parameter is presented in section 7.4.

In many cases, and particularly if the sensor crystal is not heavily loaded, sufficient accuracy can be achieved by using the acoustic impedance of quartz: 8.83 x 100.000 qm/sq. cm sec.

7.4 EMPIRICAL CALIBRATION

The known film density and acoustic impedance of many film materials is sufficiently accurate to be used directly without empirical calibration. A list of the density and Acoustic Impedance of the more commonly deposited materials is presented in table 7.1.

If the values of the density and acoustic impedance are not known, the Monitor can be calibrated empirically as described below.

The monitor is designed so that the density, tooling, and acoustic impedance parameters can be modified after the film is deposited and the effect of the new parameter value on the indicated thickness will be immediately displayed.

Using this feature, a trial deposition can be made, and if the displayed thickness does not agree with the independently measured thickness on the test substrates because of an error in one of the parameters, the parameter can be corrected by modifying its value until the displayed thickness is affected by all three of the above parameters, it is important that the effects of the individual parameters be properly isolated.

To calibrate the monitor, film density, tooling factor, and acoustic impedance must be established. If the approximate values of the parameters are known they should be used initially. If the acoustic impedance is not known, use the value for quartz, 8.83.

The film density can be established by depositing a trial film on several test substrates placed around, in the same plane, and as close as possible to the sensor crystal. The trial deposition should be thick enough to be measured with adequate precision using an optical inter ferometer or surface measuring device.

When making the trial deposition, use a fresh crystal and do not reset the final thickness reading obtained on the monitor. If the acoustic impedance parameter has been accurately established previously, a fresh crystal will not be required.

Determine the average film thickness on the test substrates. If the average measured thickness differs from that displayed by the Monitor,increase or decrease the programmed film density until the displayed thickness agrees with the measured thickness. The programmed film density will now be correct for that particular film. next, the tooling factor should be established. Place several test substrates at representative locations in the deposition fixture. Again, deposit a trial film, as above, using a known film density. Use a fresh crystal if the programmed acoustic impedance is not know to be correct. Do not reset the monitor after the deposition. Measure the average film thickness on the test substrates. If the average thickness differs from the displayed thickness, adjust the tooling factor until they agree.

To establish the acoustic impedance, the crystal must be heavily loaded. Deposit on the sensor crystal until the crystal health approaches 50% or until the crystal is approaching the end of its useful life. Using the loaded crystal, deposit another trial run as above and this time use the acoustic impedance parameter to bring the displayed thickness into agreement with the measured thickness. This calibrates the acoustic impedance parameter.

The monitor is now fully calibrated for the particular film material and should produce consistent and accurate films.

TABLE 7.1

DENSITY AND ACOUSTIC IMPEDANCE VALUES FOR SELECTED MATERIALS

MATERIAL	SYMBOL	DENSITY	IMPEDANCE
Aluminum	Al	2.70	8.17
Antimony	Sb	6.62	11.49
Arsenic	As	5.73	9.14
Beryllium	Be	1.85	16.26
Bismuth	Bi	9.8	11.18
Boron	B	2.54	22.70
cadmium	Cd	8.64	12.95
Cadmium sulfide	Cds	4.83	8.66
Cadmium telluride	CdTe	5.85	9.01
Calcium fluoride	CaF_2	3.18	11.39
Carbon (Diamond)	C	3.52	40.14
Chromium	Cr	7.20	28.95
Cobalt	Co	8.71	25.74
Copper	Cu	8.93	20.21
Copper (I)Sulfide (alpha)	Cu_2S(alpha)	5.6	12.80
Copper (I)Sulfide (beta)	Cu_2S(beta)	5.8	13.18
Copper (II) Sulfide	CuS	4.6	10.77
Dysprosium	Dy	8.54	14.72
Erbium	Er	9.05	11.93
Gadolinium	Gd	7.89	13.18
Gallium	Ga	5.93	14.89
Gallium Arsenide	GaAs	5.31	5.55
Germanium	Ge	5.35	17.11
Gold	Au	19.30	23.18
Hafnium	Hf	13.09	24.53
Holnium	Ho	8.8	15.22
Indium	In	7.30	10.50
Indium Antimonide	InSb	5.76	11.48
Iridium	Ir	22.40	68.45

MATERIAL	SYMBOL	DENSITY	IMPEDANCE
Iron	Fe	7.86	25.30
Lanthanum	La	6.17	9.59
Lead	Pb	11.30	7.81
Lead sulfide	PbS	7.50	15.60
Lithium fluoride	LiF	2.64	11.41
Magnesium	Mg	1.74	5.48
Magnesium Oxide	MgO	3.58	21.48
Manganese	Mn	7.20	23.42
Manganese (II) Sulfide	MnS	3.99	9.39
Mercury	Hg	13.46	11.93
Molybdenum	Mo	10.20	34.36
Nickel	Ni	8.91	26.68
Niobium	Nb	8.57	17.91
Palladium	Pd	12.00	24.73
Platinum	Pt	21.40	36.04
Rhenium	Re	21.04	58.87
Rhodium	Rh	12.41	42.05
Samarium	Sm	7.54	9.92
Scandium	Sc	3.0	9.70
Selenium	Se	4.82	10.22
Silicon	Si	2.32	12.40
Silicon (II) Oxide	SiO	2.13	10.15
Silicon Dioxide (fused Quartz)	SiO_2	2.20	8.25
Silver	Ag	10.50	16.69
Silver Bromide	AgBr	6.47	7.48
Magnesium Fluoride	Mgf_2	3.1	8.83
Silver Chloride	AgCl	5,56	6.69
Sodium Chloride	NaCl	2.17	5.62
Tantalum	Ta	16.60	33.70
Tantalum(IV)Oxide	Ta_2O_5	8.2	29.43
Tellurium	Te	6.25	9.81
Terbium	Tb	8.27	13.38
Thallium	T1	11.85	5.70

MATERIAL	SYMBOL	DENSITY	IMPEDANCE
Tin	Sn	7.30	12.20
Titanium	Ti	4.50	14.06
Titanium (IV)Oxide	TiO_2	4.26	22.07
Tungsten	W	19.30	54.17
Tungsten Carbide	WC	15.60	58.48
Uranium	U	18.70	37.10
Vanadium	V	5.96	16.66
Ytterbium	Yb	6.98	7.81
Yttrium	Y	4.34	10.57
Zinc	Zn	7.04	17.18
Zinc Oxide	ZnO	5.61	15.88
Zinc Selenide	ZnSe	5.26	12.23
Zinc Sulfide	ZnS	4.09	11.39
Zirconium	Zr	6.51	14.72

8.0 TROUBLE SHOOTING

This section is included to help isolate, as rapidly as possible, any failures which may occur in the Thickness Monitor setup.

The monitors internal self test features allow for quick isolation of both system installation faults and failures internal to the monitor unit itself. However, please note that in-field service of the monitor unit is NOT recommended and may indeed void the warranty.

Section 8.1 Self Test Failure Detection describes the Monitor's failure messages, which are referred to in all subsequent sections.

Section 8.2 and 8.4 are troubleshooting guides which may be used to help in isolating both external and internal faults to the Monitor.

Section 8.5 gives the operator the necessary background to understand the Monitor circuitry when internal troubleshooting is necessary.

8.1 SELF TEST FAILURE DETECTION

The Monitor's self test features detect several system failures. The specific failures are described below. Upon detection of a failure the appropriate

message is displayed. There are basically two types of system failures; failures which may not be reset by the operator and those that may. The E FAIL and I FAIL messages are NOT resetable. They may be cleared only by the replacement of the defective components. These failures are displayed continuously and ALL OTHER SYSTEM OPERATIONS ARE DISABLED. For these Internal failures, it is recommended that the unit be returned to the factory for repair. On failures that may be reset, the front panel display alternates the particular failure message and the rate and thickness values prior to the failure. The display continues to alternate the failure until the fault has been reset. The following is a summary of detected failures, the displayed messages and the necessary actions to reset them.

Detected Failure	Failure Message	Reset by
ROM Failure	E FAIL	Replacement of defective ROM(s)
RAM Failure	I FAIL	Replacement of defective RAM(s)
Invalid parameters	C FAIL	Press STOP button, parameter values will be preset.
Power Failure	P FAIL	Press STOP button
Oscillator Failure	O FAIL	If less than 2 seconds: Self clearing If greater than 2 seconds: Press STOP button.

Any long term failures will cause serious thickness errors if they occur during a run. To save any materials which may be in process the shutter is automatically closed. The process can be continued only after the above. If there is more than one failure, the other failure will then be displayed. When no failure exist only current rate and thickness values will be displayed. A description of the conditions of the individual failures follows.

- **POWER FAILURE**

Since power interruptions may seriously effect your run, indication of any significant A.C. line disruptions if provided by the P FAIL message. The shutter is automatically closed if a run was in process. It may be continued. Once all other equipment is functioning normally again, by depressing the STOP switch.

Note that it is normal for the power failure message to flash when the unit is first turned on. Press the STOP button to clear this message.

- **OSCILLATOR FAILURE**

An Oscillator Fail message indicates an improper or missing signal from the oscillator. The problem is most likely with the sensor crystal. However,

failures in the oscillator, coaxial cables, feedthrough, or sensor head can also generate this failure message. The oscillator failure message will be cleared automatically when the monitor receives a proper signal from the sensor oscillator if the failure lasts for less than 2 seconds. Failures of more than 2 seconds require the pressing of the STOP button to clear.

- **INVALID PARAMETERS**

The deposition parameters tooling factor, Acoustic Impedance, Material Density, and Thickness Set Point are numbers that must be stored in the monitor through periods of up to 60 days without A.C. power connected. If the integrity of these numbers is lost then the C FAIL message will be flashed when the monitor is turned on. This warns you of a possible internal failure. The C FAIL message can be cleared by pressing the STOP switch. The clearing of the failure message also results in the presetting of the parameters as defined in section 2.1. If there are no other failure message indicated then it is possible that the Monitor Ni-cad batteries simply require recharging. The batteries are automatically recharged when the monitor is connected to A.C. power. If after an overnight charge your monitor still does not retain the parameters intact (flashes C FAIL after periods of power down) then your monitor should be returned for service.

NOTE	EMERGENCY OPERATION

If your monitor does not maintain the parameters for the rated 60 hours but does for several hours or more, (make sure no other failure messages, except the P FAIL,flash on power up) it may be possible to reprogram your monitor and continue depositing as long as the A.C power is not removed. Return the Monitor for service as soon as possible.

- **RAM FAILURE**

In the case of a failure in the monitor's data memory, RAM, the I FAIL message will be displayed. The shutter is automatically closed since reliable operation of the Monitor is impossible until it is serviced. To confirm the RAM failure cycle the AC power to the unit. The monitor will recheck its memory and if failed, will again display the I FAIL message. If the I FAIL message is not displayed on power up the second time, the problem may be intermittent, it is recommended that your monitor be returned for service.

ROM FAILURE

In the case of a failure program memory, ROM, the E FAIL message is displayed. A ROM failure is treated in exactly the same manner as a RAM failure. Read the above section. 8.1.4 for details.

8.2 TROUBLE SHOOTING AIDS TO ISOLATE INSTALLATION FAULTS

The following table describes possible problems that could occur when interfacing the Monitor with a vacuum system. With each symptom is a list of probable causes.

If you should decide to remove the monitor cover read Section 3.3 and 8.3 carefully before doing so.

TABLE 8.1

Trouble shooting Aids for External Problems

Symptom	1. Front Panel Displays never illuminate
Probable causes	Voltage selector PC board is in the wrong position. Line fuse is blown F3 Rear Panel fuse holder
Symptom	2. Random P FAIL occurrence
Probable causes	Low A.C. line voltages. Intermittent A.C. line connection.
Symptom	3. Random O FAIL ocarinas.
Probable causes	Defective sensor crystal. Defective Crystal holder. Defective sensor oscillator. Intermittent oscillator cable connections. Defective coaxial cables (in particular the vacuum chamber cable). Thickness Monitor not properly grounded to the vacuum system. Wrong crystal selection.

	4.	Shutter never activated.
Symptom		
Probable causes		Shutter fuse is blown, F1 or F2. Internally mounted on P.C. board. Defective shutter wiring. Ref. Shutter Connection Defective shutter solenoid. No shutter solenoid power Defective Shutter Relay. Thickness set point is 0.
Symptom	5.	Faulty DAC output including no response from control inputs.
Probable causes		External recording equipment puts on excessive load on DAC output. Excessive resistance in DAC control input lines. Improper DAC wiring Ref. Digital to Analog convertor (DAC) connection

8.3. HANDLING PRECAUTIONS

Please follow these guidelines any time it is necessary to open the Monitor package and handle internal circuitry or components.

CAUTIONS	Disconnect the A.C. line power before disassembling the thickness monitor.

CMOS integrated circuits can be damaged by static discharge to their inputs. This discharge is the same phenomenon that produces the unpleasant shock when one grabs a door knob after walking across a carpet. The likelihood of static buildup is proportional to the dryness of the air and can be particularly troublesome in cold, dry climates, or hot desert climates.

In order to minimise the chances of discharging body charge into the IC inputs, always handle circuit boards by the edge. When moving a board from one surface to another, always touch the new surface or location before laying down or inserting the board, so that you, the board, and the surface or equipment are all at the same electrical potential. In dry climates, it is always wise to minimise the amount of movement when handling or replacing ICs in circuit boards. When handing a circuit board or IC to another person, always touch the person first.

Wood and paper are the most forgiging surfaces to work on. Plastic should be avoided. Metal is acceptable as long as the metal is always touched with the hands prior to laying down the ICs or circuit boards.

If the above precautions are observed, the chance of damage will be minimal.

CAUTION	The main P.C board contains nickle-cadmium batteries. This board should never be placed on a metal surface or wrapped in metal foil. Fusing of the printed circuit etches may result from shorted batteries.

8.4 TROUBLESHOOTING AIDS TO ISOLATE INTERNAL MONITOR FAULTS

The following table describes possible problems that could occur with the Monitor due to internal component failures. In the event of a thickness monitor failure it is recommended that the unit be returned to the factory with a description of the problem for maintenance. In-field service may void the warranty.

If in-field service is deemed necessary and the facilities and expertise are available, then reference to the Block Diagram description of section 8.5 will help in understanding the general circuitry areas referred to below.

If you should decide to open the Monitor read Section 8.3 on handling precautions carefully and Section 3.3 on cover removal.

TABLE-8.2

Trouble -shooting Aids for Internal Problems

Symptom	1.	Unit blows the line fuse (Rear Panel fuse holder).
Probable causes		Defective power supply circuit. Short on P.C.board
Symptom	2.	Front Panel Displays never illuminate.
Probable causes		Line fuse is blown, F3. Rear Panel fuse holder. CPU failure, see Symptom 14 below. Defective voltage regulator, VR1. Defective power monitor, U8. Defective Display Controller, U11.

Symptom	3.	Meaningless Display Information.
Probable causes		Defective board connector on main p.c.board. Defective 7 Segment Display, DS1-DS7. Defective Display Controller, U11. CPU failure, see Symptom 14 below.
Symptom	4.	Random P FAIL occurrence.
Probable causes		Loose fuse holder connections,F3 Defective power monitor,U8.
Symptom	5.	Random O FAIL occurrence.
Probable causes		Wrong crystal selections. J5 Defective monitor buffer. Q5
Symptom	6.	E FAIL message.
Probable causes		Defective EPROMS, U4 and U7.
Symptom	7.	I FAIL message.
Probable causes		Defective RAM, U3.
Symptom	8.	Shutter never activates but Indicator LED works.
Probable causes		Shutter fuse is blown, F1,F2. Internally mounted on P.C. board. Defective relay circuitry, K1,K2.
Symptom	9.	Indicator LED does not light but shutter operates.
Probable causes		Defective LED,DS8. Defective resistor, R32,R31. Defective board connector on main P.C board J1.

Symptom	10.	Shutter and Indicator LED do not operate.
Probable causes		Defective output latch, U9. Defective transistor, Q4, Q3.
Symptom	11.	Faulty DAC output including no response from control inputs.
Probable causes		Defective input buffer circuitry, U16. Defective output driver, U18.
Symptom	12.	Loss of keyboard entered data. C FAIL.
Probable causes		Aged or defective RAM batteries, BT1 and BT2. Defective RAM battery charger, Q1 and Q2. Defective power monitor, U8.
Symptom	13.	No response from keyboard buttons.
Probable causes		Defective front panel push buttons. Defective board connector on main P.C. board,J1. Defective input buffer,U5. CPU failure, see Symptom 14 below.
Symptom	14.	CPU failure.
Probable causes		Defective Z-80. U12. Improper clock signal,TP-20,U13,U14, and U15. Defective memory, U3, U4, and U7. Defective address decoders, U1 and U2. Thickness monitor not properly grounded to the vacuum system.