PSC/ALC

HORIZONTAL

SUPERCONDUCTING MAGNET SYSTEM

HORIZONTAL SUPERCONDUCTING MAGNET SYSTEM

PROJECT NO : 29127

CUSTOMER : SWISS INSTITUTE FOR NUCLEAR RESEARCH

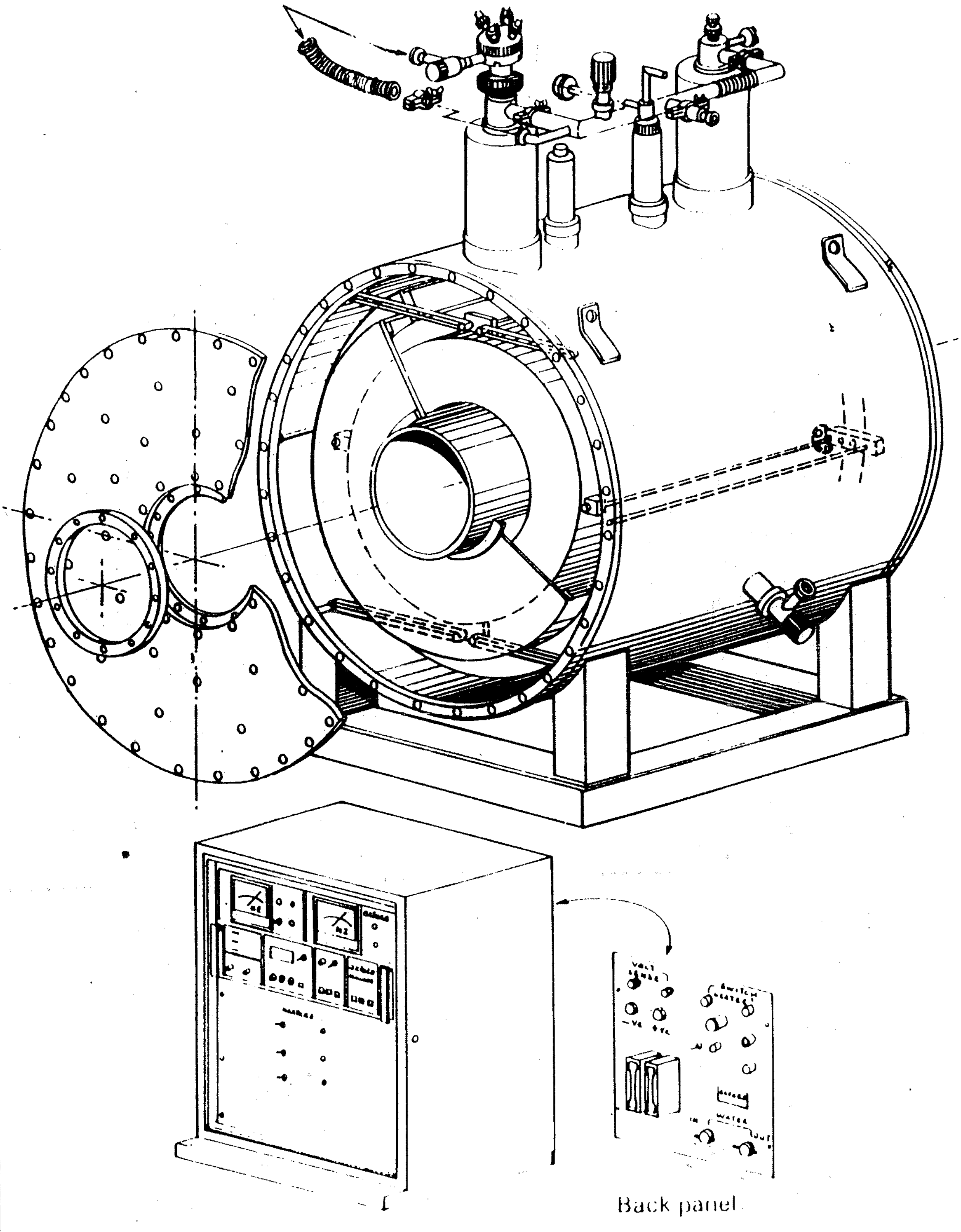
IMPORTANT

Please read the manual before commissioning the system. It is possible to damage the cryostat and magnet if the correct procedures are not followed.

Oxford Instruments cannot accept responsibility for damage to the system caused by failure to observe the correct procedures laid down in the instruction manual.

Quote the above project number in any communication with Oxford Instruments Limited.

If any problems are experienced with the magnet and/or cryostat, complete the questionnaire at the back of this manual and return it to Oxford Instruments Limited.



Back panel

HORIZONTAL SYSTEM
200mm. BORE; 5·1 TESLA.

OXFORD

SUPERCONDUCTING MAGNET SYSTEM

WARNING The warning sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death to personnel.

CAUTION The caution sign denotes a hazard, it calls attention to an operating procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product.

NOTE The note sign denotes important information. It calls attention to an operating procedure, practice, condition or the like which is essential to highlight.

PART I - UNPACKING AND REASSEMBLY INSTRUCTIONS

SECTION 1

1.1 Removal of Shipping Fixtures (transit bungs)

NOTE: It is strongly recommended that final assembly be done where the magnet is to operate. Movement of the cryostat after assembly can cause deterioration of performance.

To prevent damage during transit, the cryostat has its internal parts secured together by special fixtures. The existence of these "transit bungs" can be recognised by aluminium bungs, figure 1.

To get these transit bungs in position, nitrogen shield and outer vacuum chamber (O.V.C.) bore tubes, with their associated end flanges are removed and packed separately, also affording them extra protection during shipment.

The O.V.C. end flanges are retained in position to become an integral part of the shipping fixtures and also allow the cryostat to be evacuated and avoid moisture contamination during shipment.

Before putting the system into operation, these bungs must be removed, and the cryostat correctly assembled, figures 2 and 3.

Removal Procedure (shipping fixtures)

1. Release the vacuum to atmosphere with dry nitrogen, thus avoiding moisture contaminations of the superinsulation.
2. Unscrew the large bolt at each end of the cryostat.
3. Unscrew the M4 caphead screws at one end and remove the central bung and large 'O' ring.
4. Unscrew the M4 caphead screws at the other end and again remove the central bung and large 'O' ring.
5. Unscrew the 30 x M8 caphead screws and remove the large diameter O.V.C. flanges from each end to expose the cryostat internals and remaining transit bungs.
6. Remove the large horizontally positioned bracing member from each end complete with the axial spacers, sliding it away from the centre mandrel.
7. The centre mandrel can now be withdrawn from the bore of the helium can.
8. Mark all the transit bungs and store them. The centre mandrel and axial spacers are custom made for each system and each end. If the system is to be transported for any reason, the transit bungs must be replaced (reverse the procedure given above) and the cryostat evacuated.

1.2 Assembly of the Cryostat

The following equipment should be made available before assembly is started:

1) Assorted metric allen keys, screwdriver and sharp knife.

2) Silicone vaccum grease (e.g. Edwards, Silicone High Vacuum Grease).

3) Acetone or similar solvent.

4) Metal polish.

5) Clean cotton gloves and soft cloths for cleaning bore tubes.

6) Self adhesive aluminium tape (0.004" thick) and aluminised mylar tape.

7) Vacuum pumps with gauges sufficient to reduce the pressure to 10^{-5} torr at the pump.

8) Pumping lines from pump to cryostat, plus fittings.

Before replacing the bore tubes, the internal spacings must be set up correctly. Spacers are fitted (a + b in figures 2 and 3) consisting of adjustable glassfibre rods whose function is to centralise the two reservoirs about the bore tubes, thus avoiding a physical "touch" and a thermal short. The glassfibre rods are 3mm diameter and must therefore not be subjected to any undue strain (Torque). There are 6 spring washers which must be tightened until they are completely collapsed, this ensures that the rods remain light when the system is cooled down.

The radial spacers are set to position the helium reservoir in relation to the O.V.C. The spacers need only to be locked in position with the bolt and then the pin inserted on assembly. The nitrogen reservoir is spaced with nylon rings which are located on the end of the axial spacers.

Clean all the bore tubes and end flanges using a solvent; polish any areas that have dulled since leaving the factory. Avoid greasy finger marks by wearing clean cotton gloves, and finally buff the components with dry cloths.

Offer up the nitrogen shield end flange to end 'B' and hold in position with 4 x M6 countersunk screws, view down the bore end 'A' and observe the degree of concentricity for the horizontal plane, (some eccentricity will be evident in the vertical plane, but this will correct itself on cooldown and contraction of the neck tubes). The cryostat has been set to give the correct spacings and will need no further radial adjustment, but may need axial adjustment.

If concentricity is good, remove the end flange and offer up the nitrogen shield flange/bore tube from end 'A' and hold in position with 4 screws, view down the bore from end 'B' and again observe the degree of concentricity. If necessary adjust as with end 'B', until concentricity is good.

Once the spacers are set, replace the nitrogen shield bore tube and end flange, apply thermal conducting grease to the interface between the nitrogen reservoir and end flanges. Use all the countersunk screws to asemble the parts.

Check the concentricity by offering up the outer end flange 'A', hold with 4 x M8 screws and view down the bore from end 'B', adjust if necessary and repeat the procedure. Once set up, remove both end flanges and the bore tube.

Slide the room temperature bore tube into the cryostat. Clean all the 'O' rings and grease them. Ensure channels are clean and free from debris, then fit OVC end flanges using 30 x M8 caphead screws at each end. Finally screw in position the centre flanges and 'O' rings. The cryostat is now ready for evacuation and cooldown.

PART II - SHORT FORM INSTRUCTIONS - for quck reference only

SECTION 1

1.1 Magnet Specification and Operation Data

Central field	:	5 Tesla (max central field 5.1 Tesla
Tesla/Amp	:	0.06826
Expected current for central field	:	73.24 Amps at 5T, 74.71 Amps at 5.1T
Superconductor type	:	Multi filamentary Niobium Titanium
Room temp bore diameter	:	200 mm
Inductance	:	171 Henries nominal
Recommended power supply trip voltage (in constant current mode)	:	8 volts

Homogeneity
1×10^{-3} over 50 cm x 2 cm dia.
1×10^{-4} over 5 cm DSV

SWEEP GENERATOR

Mode	Amp/Min	Time Setting	From (Amps)	To (Amps)
Maximum charging rate:	2 1		0 50	50 field 5.0T or 5.1T
Constant current	0.5			5.0 - 5.1
Maximum discharge rate:				
Constant current	1 2		5.0T or 5.1T 50	50 0
Discharging current leads only	20		field	0
Charging current leads only	20		0	field

Mode	V at P.S.U.	V at magnet	From (Amps)	To (Amps)
Max charge rate constant volts	8 volts using std leads	7.1 volts	0	field
Max discharge				
constant volts	-8 V	8.9 volts	field	0
constant current	<10 V		field	0

Charge and discharge current leads by hand when no sweep generator is available.

1.1 System Test Summary

Project No : 29127 Date : 19/5/87

Field current at	5 Tesla	:	73.24 Amp
	5.1 Tesla	:	74.71 Amps

Time to reach field in constant voltage mode

from warm	+5V = 48 mins - 5.1T
subsequent	+7V = 29 mins - 5.1T

Persistence:

Nitrogen boil off	:	440 cc/hr
Helium boil off	:	428 cc/hr
Final hold time with 100% He	:	> 72 hr

With current in in leads (74 Amp):

Nitrogen boil off	:	440 cc/hr
Helium boil off	:	515 cc/hr

1.2 Cryogenic Short Form Instructions

NOTE - Use this section as a quick reference procedure/check list, if there is any doubt at all then refer to PART III.

1.2.1 Commissioning Cryostat (at room temperature)

It is assumed that the cryostat has been unpacked, the bore tubes inserted and the helium gas recovery system is ready for connection.

1) Evacuate the outer vacuum case (O.V.C.) to better than 5 x 10^{-5} torr. Use a fast rotary pump and diffusion pump.

2) Ensure that O.V.C. valve is closed over the pumping orifice.

3) Ensure that O.V.C. valve is closed and cover the pumping orifice.

4) Flush and pump the liquid helium tank several times with dry helium gas. The tank should quickly reach a pressure of 1 torr using a 50 l/min rotary pump (N.B. O.V.C. must be at vacuum).

1.2.2 Cooling to 4.2K

1) Fill the helium tank and nitrogen tank up the neck tubes until full with liquid nitrogen (LN_2).

2) After 1 hour completely refill the helium reservoir and leave overnight to precool. In the morining use dry helium gas to blow the liquid nitogen out (via tube inserted through syphon hole and into cone).

3) Allow helium gas to flow for a few minutes after LN_2 stops flowing.

4) Connect a capsule gauge, rotary pump and source of dry helium gas to helium tank.

5) Pump out and watch for a pause in the pressure in the range 80 to 100 torr, indicating liquid nitrogen.
   100 133 mbar

6) Flush and pump out, at least twice, until certain that no LN_2 remains (less than 5 torr). Then fill with helium gas and connect to recovery system.

7) Insert helium transfer suphon ensuring that it is firmly located in the cone inside the cryostat.

8) Gently transfer until liquid collects (approx 1 hour and 25 litres of liquid).

9) If the magnet is to be energised, transfer until 100% on level probe monitor.

10) Check that all air passages into the helium tank, except the recovery system, are blocked.

11) The final boil-off figure for the liquid helium will not be known until about three days after inital filling. This is a result of the long thermal time constant of the system.

1.2.3 Refilling with liquid helium

1) Insert the helium transfer syphon into the transport dewar (NOT into cryostat) which has been placed close to the cryostat.

2) Pressurise transport dewar and wait until liquid comes out of the syphon.

3) Insert syphon into cryostat, but stop when its end is about 50 mm above cone.

4) Transfer liquid.

5) Reduce pressure on transfer dewar and remove syphon.

6) Ensure that all air passages are closed.

1.2.4 Warming up the cryostat

1) Insett transfer syphon into cone, close off recovery system and transfer as much liquid as possible to a transport dewar by pressurising the helium tank with dry, compressed helium gas. (Tank pressure < 0.5 Atm).

2) Insert a tube into the nitrogen tank and blow out the LN_2 using helium gas applied to the other tube. (< approx 0.5 Atm).

CAUTION DO NOT overpressurise.

3) Circulation of dry warm helium gas round the magnet will accelerate the warm up.

4) For fast warm up soften the O.V.C. with dry nitrogen gas and warm the outside using a 1 kW fan heater.

NOTE: 5) If the cryostat temperature rises above 77K then the O.V.C. MUST be repumped to better than 5×10^{-5} torr.

1.3 Magnet Short Form Instructions

(If in doubt refer to Part III).

1.3.1 Running the magnet up from zero

1) Check that the helium and nitrogen levels are adequate.

2) Check for continuity of all leads, see check list.

3) Connect power supplies and set all currents to zero.

4) Decide upon final magnet current.

5) Choose constant voltage or constant current mode of energising.

6) Find the helipot setting to give the final current.

7) Follow instructions for mode of energising.

8) Check that main current is initially zero.

9)) Begin to increase the current.

WARNING: SHORT THE MAGNET TERMINALS BEFORE DISCONNECTING THE MAIN LEADS OR BEFORE SWITCHING THE POWER SUPPLY OFF IF POWER SUPPLY IS TO BE REMOVED.

1.3.2 Running down an energised magnet

1) Set current to rundown in the required mode and at the recommended rate (sweep to zero button).

1.6 General Precautions

1.6.1 Magnet

NOTE: 1) Ensure that the 10-pin seals 'A', 'B' and 'C' are connected to the correct cables.

2) Do not attempt to refill the cryostat with liquid helium when the magnet is energised with less than 10% (on meter) of helium.

1.6.2 Cryostat

NOTE: Removal of precooling nitrogen.

It is important to ensure that ALL liquid ntrogen is removed from the helium can after the precooling stage, any traces left will severely impair the speed of transferring helium and may prevent the magnet operating, due to the presence of frozen nitrogen.

The recommended procedure is as follows:

(a) Blow liquid nitrogen out using pure helium gas. Ensure that the nitrogen blow-out tube is firmly located in the cone, (max pressure 8 p.s.i.g.).

(b) After the liquid stops issuing from the tube stop blowing helium gas and wait at least 15 minutes.

(c) Re-start blowing helium gas and watch if any more liquid appears. Repeat this procedure until NO liquid appears on re-blowing the system.

(d) Continue blowing helium gas for five minutes after the nitrogen stops.

(e) Pump and flush the helium can at LEAST TWICE before attempting to transfer liquid helium. With a capsule type vacuum gauge fitted any pause in pressure between 80 to 100 torr indicates the presence of liquid nitrogen.

CAUTION Warming up the cryostat

It is improtant never to open the vacuum valve to air while the system is cold, even if all cryogens have been removed. Condensed water vapour will extend the pump out time considerably and will severely contaminate the superinsulation, eventually destroying the aluminised réflecting surfaces of the superinsulation and polished aluminum internals.

Always soften the cryostat with dry nitrogen gas to part of full atmospheric pressure and close the valve.

Always store the cryostat under vacuum.

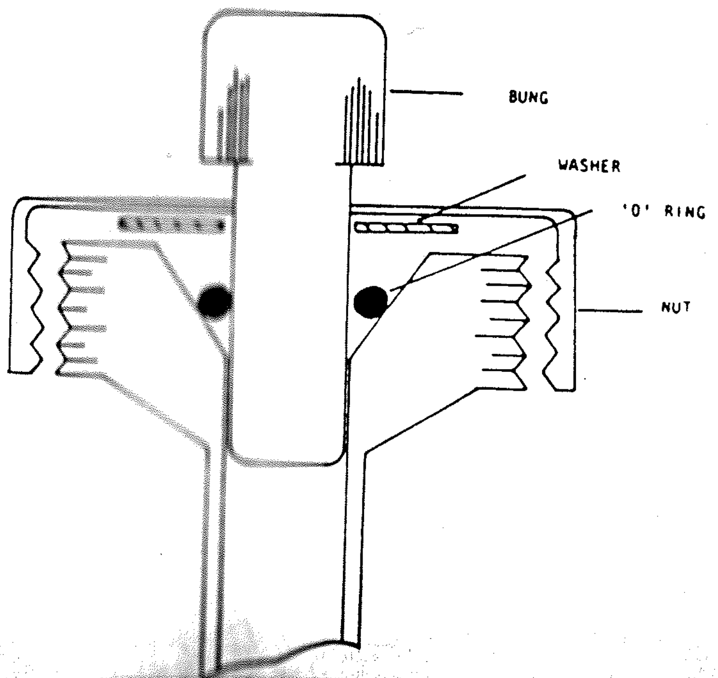
Dry nitrogen

The simplest method of obtaining dry nitrogen gas is to immerse a tube into a liquid nitrogen storage dewar below the surface of the liquid, connect and seal the tube to the vacuum valve using suitable fittings. On slowly opening the vac valve, liquid will be forced into the cryostat where it will immediately vaporise to form dry gas - having not had the opportunity to be contaminated with moisture.

1.6.3 Safety procedures

CAUTION The following procedures must always be followed to ensure efficient and safe operation of the cryogenic system.

1) Assemble the syphon bung correctly, that is the rubber 'O' ring should be below the washer, see below. The demountable lead entry fitting should be sealed in the same way. Ensure 'O' rings are fitted to the 10 pin connectors alongside the syphon entry fitting, and ensure all manifold 'O' rings are fitted and the clamps tightened, otherwise icing up will occur in the necks.



2) Icing up

It is important to ensure that the helium and nitrogen necks do not ice up by air migration, particularly where boil-off rates are low. Total blockages may occur and lead to pressurised reservoirs and if this goes unoticed the pressure may rise to a point where it ruptures the wall of the can, allowing liquid to spray out and gasify rapidly, causing considerable damage to virtually every component in the cryostat.

3) Periodically check the helium level, excessive boil-off could indicate a leak into the vacuum space which may require running down the magnet and warming the cryostat before a cure can be effected.

4) Do not let the level of liquid nitrogen fall below about 20%.

Regularly inspect for icing up in the nitrogen fill vents, or prevent this by pushing over them lengths of rubber of plastic tube, say 12 inches long, and connect the helium manifold to a long exhaust line, preferably to a recovery system.

If in doubt contact your local Oxford Instruments Agent.

1.7 General Maintenance

1.7.1 Cryostat

The cryostat once assembled and cooled should require little maintenance apart from the periodic topping up of the cryogen liquid levels.

There are several routine checks and procedures which should be observed to ensure trouble free long term operation.

i) Proper assembly of 'O' rings.

This applies particularly to the 'O' rings around the manifold. Incorrectly assembled 'O' rings may lead not only to the leaking of valuable helium to the atmosphere, but over a period of time will allow air into the cryostat where it will freeze and cause constriction. If allowed to continue unchecked this could result in the complete blocking of exit ports for the exhausting gas and the consequent increase in pressure in the helium can. In the worst case explosion of the helium can could result.

Syphon and demountable lead entry ports.

The 'O' ring should be assembled below the washer so that on tightening the nut the 'O' ring is compressed against the tube or plug.

ii) Boil off check valve

If the system is not supplied with a low pressure (approximately 0.5 psi) check valve on the exhaust then a simple bunsen valve can be very effective. A bunsen valve is made from a 6 inch piece of rubber tube, typically $^1/_2$" O.D. and 1/16 wall. One end is blocked off with a bung and a split is made in the tube. This valve when placed over the exhaust port will act as a non-return valve.

Some form of non-return valve <u>must</u> be fitted to the cryostat if it is not exhausting to a helium recovery system. When atmospheric pressure changes it is possible for a negative differential pressure to exist between atmosphere and the helium can, air will then enter the helium can and this must be prevented.

iii) Periodically, every few days, check that some boil off is occurring. An apparant zero boil off could imply a blockage which must be attended to at once. A steadily increasing boil off over a period of time could indicate a small leak into the vacuum space and consequent deterioration of the vacuum. The vacuum space cannot be pumped while liquid helium is in the helium can unless special precautions are taken such as a liquid nitrogen trap on the diffusion pump to prevent the cryostat from cryopumping the diffusion pump oil.

iv) Precooling the syphon

The phase separator must be used with the syphon while topping up liquid helium. During topping up of the liquid helium it is important to pre-cool the syphon before attempting to introduce liquid into the cryostat. This is done by inserting the syphon leg into the transport dewar and pressurising it so that gas escapes through the syphon to air. After five minutes or so the escaping gas will get colder as the syphon cools. Eventually a dense blue plume of cold gas will be seen, at this stage the syphon can be gradually introduced into the cryostat while still transferring. The syphon should be lowered to within 2 inches of the syphon cone over a period of five minutes. Do not push down completely.

Failure to pre-cool properly could result in the superconducting switch opening and the magnet discharging through the protection circuit or, in a severe case, quenching.

v) During topping up of liquid helium the increased flow of cold helium can supercool the liquid nitrogen and stop it boiling. During this period there is a possibility that ice will form in the nitrogen exhaust ports. Check the nitrogen ports regularly.

WARNING:

vi) REMOVAL OF SYPHON AFTER TRANSFER.

Loosen the knurled nut at the cryostat then gently rotate the syphon before trying to remove it from the cryostat, then gently lift up out of the cryostat.

NOTE All of the electrical diagnostics to the cryostat enter the cryostat via a plug which is located at the base of the neck fixed to the syphon cone. Care must be taken not to disconnect the plug and socket when removing the transfer tube. The pins on the plug are fragile and care must be taken not to damage them.

1.7.2 Magnet

i) If for any reason the magnet should begin to discharge e.g. by attempting to transfer helium without pre-cooling the syphon. The magnet should be left to discharge completely before any action can be taken, this will take approximately 2 minutes. It is advised that Oxford Instruments be contacted as soon as possible.

ii) Magnet quench

Under normal operating conditions it is extemely rare for a quench to occur. Generally a slightly increased risk of quenching occurs on running the magnet to field from warm (training quench) or on topping up the liquid helium level where the syphon has not been pre-cooled and/or a very low helium level exists in the helium can.

A quench is a result of part of the superconductor temporarily becoming a normal resistive metal, heat is generated and propogates through the whole magnet. The result is that all the stored energy of the magnetic field is converted to heat which rapidly boils off the remaining liquid.

A quench can be alarming but not dangerous. Keep clear of the cold exhausting gas, and if in a small unventilated room open doors and windows to allow fresh air into the room as the helium gas may displace the oxygen in the room.

After a quench when the cold gas has stopped issuing from the cryostat liquid helium can be re-introduced into the helium can and the magnet run back to field. Contact your service engineer to do this if the engineer would normally refill the system.

PART III - DETAIL INSTRUCTIONS

SECTION 1

1. General Principles of Operation

1.1 The magnet

The magnet is wound from superconducting wire which is NbTi alloy in a protective maxtrix of copper. It consists of long solenoid section together with a series of trim coils. The latter cancel the second and fourth order axial gradients which result from the finite length of the solenoid sections. All the sections are connected in series.

The circuit diagram, figure 4, shows the arrangement of the various coils and protection.

The protection consists of low value resistors across each coil section. In the event of the magnet quenching (becoming resistive) these resistors prevent the development of high voltages which could cause insulation break down. They also dissipate some energy during the quench and thus reduce the energy dissipated in the magnet windings.

1.2 The Cryostat

The magnet is operated at a constant temperature of 4.2K, obtained by immersing it in a bath of liquid helium-4 which is boiling at normal atmospheric pressure.

The liquid helium is held in the cryostat which is shown schematically in figure 2. The helium vessel containing the magnet is suspended by two neck tubes which also provide service access. Lateral support is given by radial struts at the ends of the helium tank. The helium vessel is surrounded by a gas cooled shield and then by a liquid nitrogen tank and shield, which is in turn enclosed by the outer vacuum case. The helium tank, gas cooled shield and nitrogen tank are all superinsulated.

Above the magnet at the top of the helium can and below one of the stacks there is a plate which carries the demountable lead connector, below the other neck a second plate supports the syphon cone and connections to the helium level sensors.

1.3 Cryostat Services

The arrangement of the fittings on top of the cryostat is shown on G.A. Drawing 2. The neck tubes, which project above the top of the main cryostat body, carry the inlets for the liquid helium transfer tube and demountable current lead.

All electrical contacts to the magnet are made via this demountable lead which carries a multiway plug on its lower end. The plug mates with a socket thus allowing repeated insertion and removal. The wiring details are shown on the wiring diagram.

The cryostat also has two fill/vent tubes for the liquid nitrogen reservoir and the valve for evacuating the outer vacuum case (O.V.C.) This valve incorporates an over-pressure relief valve which opens at approximately 0.1 atmosphere over pressure. valve.

1.4 Cryogen Level Sensors

1.4.1 Helium Level Sensor

In order to monitor the level of helium around the magnet, three independent level sensors are mounted inside the helium can. Two are of the pulsed superconductor type; one is monitored continuously by the HLM2 meter, the other remains as a standby, should the first one fail for any reason. In the extremely unlikely event that both should fail, a third method of monitoring is available, consisting of a series of carbon sensors, these will indicate whether they are immersed in liquid or gas and can be monitored by custom built electronics supplied by Oxford Instruments upon request.

1.4.2 Nitrogen level sensor

This is of the capacitive type, monitoring the full volume of the nitrogen can (50 litres). The associcated probe electronics are mounted on the cryostat above one nitrogen fill/vent tube to eliminate capacitive effects of a long lead. The small tube spacing the electronics away from the vent prevents them suffering icing and condensation problems. The nitrogen is monitored continuously by the NLM3 meter and relates to the following volumes:

NLM2 Meter Reading	Litres	
100%	50	
90%	45	
80%	40	
70%	35	
60%	30	
50%	25	
40%	20	Refill level
30%	15	
20%	10	
10%	5	
0%	0	

See separate operating manual for further information.

Superconducting type

The level sensors do not monitor the full depth of the helium can only the major part of the useable volume. The following table relates the HLM2 meter reading to the actual volume of helium:

HLM2 Meter Reading	Litres	
Max vol	79	
100%	65	
90%	60	
80%	54	
70%	50	
60%	45	
50%	42	
40%	40	
30%	38	Recommended Refill Level (30%)
20%	32	
10%	26	
0%	20	Minimum Operating Level

See seperate operating manual for further information.

If the level falls to 10% on the meter refilling is still possible but there is danger of quenching the magnet; it is recommended that the magnet be de-energised in the standard manner before refilling.

Carbon resistor type

There are four carbon sensors mounted around the periphery of the magnet end flange and are positioned to relate to the following volumes:

1st carbon sensor	:	79	litres
2nd carbon sensor	:	56	litres
3rd carbon sensor	:	48	litres (40% on level meter)
4th carbon sensor	:	25	litres

Each sensor is a standard Allen Bradley resistor with most of the insulation removed - this greatly improves its response time and it can detect the difference between liquid and cold gas.

Use a constant current source set at 2mA and connect to each resistor separately (see figure 7). Measure the voltage across the same resistor; there should be approx 100mV difference between liquid and cold gas.

The four carbon sensors are wired to the multi pins connected at the bottom of the service neck. See diagram.

1.5 Demountable Electrical Connector and Syphon Cone Assembly

The three 10 pin seals on this neck connect with the 2 helium level probes, Allen Bradley carbon sensor.

NOTE:

Removing this connector should only be attemped when the cryostat is warm. The procedure of removing the plug should be undertaken with extreme care as the pins are very delicate.

This lead is not designed to be frequently removed and replaced. It should only be removed if damage has occured to the leads or further leads are required to be mounted to the socket at the base of the neck tubes.

Removal of Demountable Electrical Connector

1. Remove the exhaust manifold from the stack top fitting.

2. Remove the four scews holding the 'top hat'. Firmly but carefully lift the 'top hat' vertically upwards, taking particular care as the plug exits the neck, not to damage the pins.

3. Carry out repairs as necessary to the wiring (see wiring diagrams and instructions) if any wiring is to be replaced, it is important to use 40 SWG solid copper insulated wire to prevent an unnecessary heat leak into the cryostat.

4. Replacement: Before replacing the assembly make sure it is clean and that the 'O' ring has been greased and is in position then using the screwed rod provided which can be passed through the syphon entry at the top of the demountable electrical connector and also screw into the cone at the plug end.

   Slide the tube or rod through the connector and screw into the syphon cone at the bottom of the cryostat neck.

   Lower the whole asembly gradually - when the plug reached the socket, slowly rotate the whole unit until you feel the large locating pin mate with the larger hole in the socket. Position the stack top fitting and push it firmly downwards to securely locate the pins at the same time the central rod that was used for initial location may be unscrewed then slid vertically out of the top.

   NOTE:

   Great care must be taken to ensure that the orientation of the pins are correct.

   With the plug firmly located in its socket the 4 screws holding the 'top hat' can be replaced and tightened.

1.6 Current Leads

1.6.1 Current Lead

The current lead has been modified at customers request. The modfication consisted of permanently soldering in the four current leads to the magnet. The top of the lead has been used to terminate the wiring at the top of the service neck, there is an 'O' ring seat at this point as the current leads are soldered to the terminals at the top of the neck and to the magnet in the helium vessel.

WARNING

The 'O' ring seal must not be opened at any time without first contacting Oxford Instruments and quoting the Project Number which is at the front of this manual, as serious damage could occur to the current leads in the neck.

1.6.2 Demountable electrical connection and syphon entry

This demountable connection which interfaces to the internal wiring loom with a 35 pin plug, the socket is rigidly and permanently sighted at the bottom of the other helium neck to the current lead. The position of the socket is such that the exhausting helium gas is allowed to escape vertically through the neck tube and current lead tube, thus using the available enthalpy of the gas to cool both neck tubes, and also the copper current leads and electrical connections, intercepting the conducted heat to the helium can.

At the bottom the 35 pin plug has an extra large diameter pin, it serves no electrical requirement but it is a locating pin that mates with a hole in the socket and aligns the other 35 pins prior to engagement. No maintenance is required other than to check for shorts between pins and ground. (See wiring diagrams and check list).

2. Cryogenic Fluids and Cooldown Procedure

2.1 Liquid helium and liquid nitrogen

The cryogenic fluids used with this system are liquid helium and liquid nitrogen. The relevant properties of these liquids are in table 3.

(a) Liquid nitrogen is a colourless liquid obtained from the liquefaction of air. It is generally stored in vacuum insulated containers but its relatively high latent heat of evaporation permits short term storage in foamed plastic vessels. It may be transferred from one container to another by pouring, or by the use of a rubber or plastic tube. The following safety precautions should be observed.

i) Flexible materials become brittle when cooled to liquid nitrogen temperature. Rubber tubes used for transferring liquid nitrogen will break easily if strained.

ii) Open vessels containing liquid nitrogen should be kept covered to prevent frost formation by the condensation of water vapour from the atmosphere and also to prevent oxygen enrichment by condensation from the air. This can present a fire risk.

iii) Vessels containing liquid nitrogen should not be sealed so that evaporating gas can escape and prevent a pressure build-up.

iv) Liquid nitrogen spilled on vacuum or cryogenic equipment will freeze 'O' rings and cause loss of vacuum. Care should be taken when pouring to prevent excessive spillage.

v) Liquid nitrogen spilled on the body will cause tissue damage, similar to a severe burn. Rubber gloves and boots should be worn where necessary.

(b) Liquid helium is a colourless liquid produced from the naturally occuring gas deposits in the earth. The density of the gas is so low that the concentration in the atmosphere is minute. Where possible evaporated gas should be recovered and re-liquefied, both to economise in operating costs and to conserve the earth's resources.

Liquid helium is stored in vacuum insulated containers which also include some form of radiation shield to intercept thermal radiation from the room temperature environment. It is transferred between storage vessels, or from a storage vessel to a cryostat by means of a vacuum insulated transfer tube (sometimes called a syphon).

2.2 Evacuating the outer vacuum case

It is not recommended that this be done if the cryostat is below room temperature.

CAUTION WARNING NEVER PUMP HELIUM CAN WITHOUT A VACUUM IN THE O.V.C. (Failure to observe this rule may result in collapse of the helium reservoir).

In order to maintain the thermal isolation of the liquid helium it is necessary that a high vacuum be obtained in the outer case of the cryostat (O.V.C.). Traces of air will be condensed when the cryostat is filled with liquid helium, but helium gas will spoil the vacuum. Over a long period of time helium gas may percolate past 'O' rings from the atmosphere. The O.V.C. should not need pumping if the cryostat contains liquid helium.

A slow increase in the boil-off rate of liquid helium indicates that the dewar is going soft (helium has entered the O.V.C.).

If the O.V.C. goes soft, de-energise the magnet (Part II), warm up the cryostat and try to locate the leak. Assuming that the problem was helium gas diffusion, pump out the O.V.C. and follow the usual commissioning procedures.

The pumping equipment should consist of an oil diffusion pump of 50mm (2 in) diameter fitted with a liquid nitrogen cold trap. The diffusion pump should be backed by a rotary pump of speed not less than 25 l/min. The rotary pump should have a gas ballast facility. If plastic or rubber link tubes are used these must NOT have been used previously to carry or pump helium.

(a) Connect the valve on the cryostat to the pumping equipment using a short tube of not less than 15mm ($^3/_4$ in.) internal diameter. Using the rotary pump evacuate the cryostat (O.V.C.) until the pressure is less than 1 torr then admit an atmosphere of DRY nitrogen gas and pump out again - repeat several times. Finally pump to less than 0.05 torr.

(b) Switch over to the diffusion pump and evacuate the cryostat to less than 5 x 10^{-5} torr and continue pumping for at least 24 hours (preferably at least 48 hours) before sealing the O.V.C. valve. This ensures that residual gas trapped in the superinsulation is removed and cannot impair the reflecting properties of the superinsulation. (On filling the cryostat with cryogenic liquids, the pressure should fall to less than 10^{-6} torr). Place a dust cap over the pumping port.

It has been assumed that the evacuation procedure started from atmospheric pressure. If the cryostat is already evacuated and it is desired to inspect the pressure only, the pumping tube should be already evacuated and the diffusion pump operating before the O.V.C. valve is opened.

The recommended equipment for evacuating the outer case is shown in figure 12.

2.3 Filling the liquid nitrogen container

Connect the fill tube of the liquid nitrogen container to a storage vessel using flexible plastic pipe. Transfer the liquid nitrogen by pressurising the storage vessel to approximately 0.25 atm (4 p.s.i.g.). Violent boiling will occur initially until the radiation shield has cooled down. When liquid nitrogen sprays out of the fill tubes release the pressure on the storage vessel to stop the transfer.

The storage vessel can be pressurised using a high-pressure gas cylinder fitted with reducing valve. By using an electrically operated valve between the gas cylinder and the storage vessel, the liquid nitrogen container can be filled and the level maintained using a Liquid Nitrogen Level Controller.

Inspect the liquid nitrogen level daily.

The problems caused by ice formation in the filling tubes can be prevented by slipping 0.25m (10 in.) lengths of plastic tubing over them. These tubes also prevent any overflow of liquid nitrogen from cooling the top flange and its 'O' ring. This can be important if an autofilling system fails to stop the nitrogen transfer when the tank is full.

2.4 Precooling the magnet

Before filling the cryostat with liqiud heluim the magnet must be cooled to a temperature below 100K. To do this completely fill the liquid helium container with liquid nitrogen. Use a length of 10mm (3/8 in.) diameter stainless steel tubing inserted into the transfer tube entry port, but not pushed fully down into the cone. Allow the liquid nitrogen to remain for one or two hours and then fill it completely again. Leave the system overnight to precool correctly and then remove it as follows.

Insert the 10mm stainless steel tube into the transfer entry fitting and ensure that it is firmly fitted into the cone above the magnet. Blow out all the liquid nitrogen by pressurising the liquid heluim container to not more than 0.25 atm. (8 p.s.i.g.).

It is important that all the liquid nitrogen is removed. Failure to do this properly will make filling with the liquid helium difficult and may impair the performance of the magnet. Evacuate the liquid helium container using a rotary pump, (if during pump down a pause is seen in the range 80-100 torr then liquid nitrogen is still present) and then fill it with helium gas. Repeat this procedure at least two times in order to thoroughly purge the magnet of nitrogen. As an indication that all the liquid nitrogen has been removed, check that it is possible to evacuate the liquid helium container to a pressure less than 10 torr. = 13 mbar

The recommended equipment for performing this operation is shown in figure 13.

106 – 133 mbar

2.5 Initial filling with liquid helium

Connect the cryostat to the helium recovery system or put a one-way valve on the cryostat exhaust tube. Position the liquid helium storage vessel so that the transfer tube can be inserted easily. Ensure that the transfer tube is not blocked by blowing heluim gas through it.

Remove the plug from the cryostat tube entry port and also from the top of the storage vessel. Insert the transfer tube slowly, allowing it to cool gradually. Ensure that the end of the transfer tube is fitted into the cone above the magnet. In this way, liquid is introduced at the bottom of the magnet which is then cooled by the enthalpy of the gas as well as by the latent heat of evaporation.

Start transferring the liquid helium by pressurising the storage vessel. (This is generally done by gently squeezing a rubber bladder attached to the vessel). The transfer rate should be such that the vent pipe is frozen for not more than 2m (6ft) of its length. The initial transfer rate should be equivalent to about 10 litres of liquid per hour. This rate can be increased as the magnet cools.

When the magnet resistance drops to zero the transfer rate can be further increased in order to fill the liquid helium container. This should occur when 15 to 30 litres of liquid have been transferred, further liquid is then required to fill the cryostat.

When the liquid helium reservoir has been filled stop the transfer by releasing the pressure in the storage vessel. Remove the transfer tube and replace the plug.

Inspect the liquid heluim level at least daily.

2.6 Refilling with liquid helium

The cryostat should be refilled when the level reaches the 30% mark. If refilling care should be taken not to evaporate the liquid in the cryostat with the hot gas which initially comes through the transfer tube.

NOTE: Failure to take care can cause the magnet to quench

The correct procedure is as follows:

(a) Insert one leg of the transfer tube into the storage vessel, but leave the other one outside the cryostat. Pressurise the transport dewar in the normal way, as if transferring helium. After about a minute liquid will issue from the transfer tube, indicated by a blue tongue of vapour. (Prior to this a white vapour plume will have been seen for about 20 seconds).

(b) Quickly release the pressure in the transport dewar and insert the open end of the transfer tube into the cryostat.

(c) Lower the transfer tube until it reaches the bottom of the neck tube. DO NOT push the tube into the cone above the magnet. Transfer helium in the usual way.

If the helium level has fallen below 10% and the magnet is still energised there are two causes of action open.

i) DE-ENERGISE THE MAGNET, refill and then re-energise the magnet.

ii) If the magnet is to remain energised the cryostat may be topped up but take care as the syphon is introduced and as the transfer starts. Use the gas/liquid deflector supplied with the transfer tube to direct the helium away from the magnet.

2.7 Closing down and warming up the cryostat

Having de-energised the magnet the system can simply be allowed to run out of liquid helium and nitrogen and left to warm up. If a rapid warm up is desired either transfer the helium out of the cryostat into a transport dewar or insert the blowing-out tube into the transfer tube entry port and gently pass DRY helium gas through it. This will boil-off the remaining liquid. Remove the liquid nitrogen by passing a stainless steel tube through the straight filler tube and seal the joint with a piece of rubber hose, pressurise the container through the other filler tube and blow-out the liquid into a storage dewar.

Having removed all the cryogenic liquids the system can be warmed up by softening the vacuum. Leave for 1 hour to let the magnet warm towards 77K. Slowly allow DRY nitrogen gas into the O.V.C. until 1 atmosphere is reached - close the valve to prevent any moisture contaminating the superinsulation. The nitrogen gas can be obtained from the neck of a container of quickly boiling liquid nitrogen. Non-preferred method: With the vacuum valve closed blow some helium gas into the pipe attached to the valve. Place a rubber bung on the end of the pipe then open the valve and close it again. This technique ensures that only a small amount of helium gas enters the vacuum space so that the warming up process is not too violent. Ensure that the relief valve is unobstructed. This technique is very effective but afterwards great care must be taken to flush the helium out of the superinsulation.

CAUTION Never open the valve to air when the cryostat is cold condensed water vapour will eventually destroy the silvering of the superinsulation.

2.8 Helium Gas Recovery

The use of a gas recovery system is desirable for four reasons.

i) Financial saving.

ii) Conservation of the earth's supply of helium.

iii) Prevention of the cryostat becoming contaminated with ice and air.

iv) Prevention of the air becoming contaminated with helium gas to the detriment of vacuum seals.

A typical recovery system consists of low-pressure gas storage, in the form of a gas-holder, or gas-bag, connected to the cryostat vent; a compressor, and high-pressure gas storage. The compressor should be specifically made for helium because of the large amount of heat produced when compressing this gas.

NOTE: To prevent air entering the cryostat the recovery system should be maintained slightly above atmospheric pressure. A pressure of a few centimetres of water is sufficient.

Failure to observe this precaution may lead to ice and solid air forming on the connectors for the demountable leads preventing reinsertion of the leads.

2.9 Over-Pressure Relief Valve

This device is intended to protect cryostats against a large increase in pressure which could arise should a superconducting magnet quench. When used as a relief valve it forms a positive seal preventing the flow of gas in either direction unless the internal pressure exceeds approximately 2 p.s.i.

3 Magnet Operation

3.1 Connect the flexible leads to the current supply, observing the polarity and ensuring that all connections are tightly clamped.

3.2 Energising the Magnet

Constant Voltage Mode

When using an Oxford Instruments, or similar, power supply to run the magnet up from zero field the supply can be used in its constant voltage mode. This provides a smooth charging rate which decreases at higher currents as the voltage drop down the leads subtracts from the set voltage level on the supply. Operating current and charging voltages are given in Part II. Small changes in current are best made with the fine current control on the power supply. Set all the supply controls to zero.

(a) Set the positive voltage limit control of the supply to maximum. Set the "FINE" current control to mid-range. Increase the current to the desired value using the "COARSE" current control.

(b) Wait for one minute then measure the voltage at the supply terminals. Add to this the recommended magnet charging voltage (Part II) and note this total voltage, V_T.

(c) Now turn the voltage limit control to zero leaving the current control set at the desired level. The output current will now fall to zero.

(d) Open the superconducting switch by switching on the heater supply.

(e) Wait for 30 seconds and then set the voltage control to V_T. The magnet current will now increase at a rate determined by:

$$\frac{LdI}{dt} = V_T(R_L I)/(1+R_L R_S)$$

where I is the magnet current (not equal to the supply current I_O).

R_L is the lead resistance

L is the magnet inductance

R_S is the combined resistance of the switch and the protection resistors, 2 to 6 ohms.

(Note - this system does not have any switches therefore R_S = protection resistance Ω 7 Ω.

After the supply reverts to the constant current mode the magnet current will come to equilibrium with a time constant L/R_s seconds. Thus a few minutes' wait is necessary before any other action is taken.

(f) Reduce the current slowly by hand down to the operating value. Wait several minutes and then close the superconducting switch.

(g) Wait a few more minutes then smoothly reduce the power supply current to zero.

WARNING: Short the terminals on top of the cryostat current terminals and disconnect the flexible leads from the power supply.

Constant current mode

In this mode the power supply current is changed by external means - either manually or using a sweep generator. The magnet will only charge at the programmed rate if the "set voltage" level (at the output terminals of the supply) is large enough to overcome the back e.m.f. of the magnet. Set all the controls to zero. (It is assumed that an external sweep unit is used).

(a) Set the sweep unit output to maximum. Set the positive voltage limit to maximum, then increase the power supply control until the full current is flowing in the leads. Lock the control in this position.

(b) Reduce the sweep unit output to zero and check that the main current falls to zero. Wait one minute.

(c) Set the sweep rate to the value shown in Part II and begin the sweep. Change the sweep rate at the specified current values.

(d) Stop the sweep at the full field current and wait for a few minutes. Reduce the current to the operating value (either by hand or on the slow sweep rate).

WARNING: Short the terminals on the cryostat current lead and disconnect the flexible leads from the power supply.

3.3 Discharging the Magnet

On this system there are no superconducting switches so the external (room temp) current lead must remain attached to the system while there is current in the leads. To discharge the magnet:

1) Set the current setting to zero and using the cosntant current mod sweep the current to zero using the rates given in the tables.

2) Use the sweep to zero button on the power supply.

Discharge the main solenoid by running down its current at the rate specified in Part II. This can be done in constant voltage or current modes. Wait until the power supply terminal voltage falls to zero before disconnecting the leads.

Disconnect all power supplies.

3.4 <u>Alternative emergency discharge</u>

The magnet possess high stray fields which may cause unexpected attraction of large ferrous objects, in doing so arms and legs could become trapped. The magnet can be quenched using the quench heaters (see wiring diagram for pin numbers). <u>Damage may or may not occur</u> to the magnet. This method of running the magnet down should only be used in an emergency.

4. Trouble Shooting

4.1 Cryogenic Operation

High impedance pumping line	-	Shorten line or use large bore tubing.
Defective pump	-	rectify or replace
Condensable vapours in vacuum space	-	pump on gas ballast until clear. Warming the outer case may help.
Leak into vacuum space	-	prove and locate leak by connecting helium mass spectrometer leak detector to the vacuum valve. Leak located in nitrogen or helium vessels by evacuating the vessel in question, when leak rate should diminish and then filling with helium gas when leak rate will increase.
Leak in outer case	-	Inspect 'O' rings and replace as necessary or consult Oxford Instruments Limited.
Leak in nitrogen or helium vessels	-	Consult Oxford Instruments Limited.

<u>Vacuum case pressure does not decrease on filling with liquid nitrogen</u>

Leak into vacuum space	-	see above

<u>Vacuum case pressure does not decrease on filling with liquid helium</u>

Diffusion pump back streaming	-	disconnect pump
Leak into vacuum space	-	see above.

<u>Magnet does not pre-cool</u>

Nitrogen vessel empty	-	fill

<u>Difficulty in transferring liquid helium</u>

Magnet not adequately pre-cooled	-	see part III 2.2.4
Transfer tube blocked	-	remove, allow to warm up and blow helium gas through it.
Storage vessel empty	-	replace
Transfer rate too high	-	recover pipes excessively frosted. Frost for 1m indicates adequate transfer rate.

Excessive heat leak	-	see "excessive evaporation rate" below.
Thermal oscillations in helium vessel neck	-	Place ear to top of cryostat-oscillations can sometimes be heard. Move transfer tube up or down until oscillations disappear.
Syphon does not reach to	-	when cooling the magnet down bottom of magnetto 4.2K it is essential to transfer liquid to below the magnet so that the enthalpy of the gas, is used for cooling. Ensure that the transfer tube is inserted into the extension socket on top of the magnet.

<u>Excessive liquid heluim evaporation rate</u>

Leak into vacuum space	-	indicated by condensation of water vapour or frost on the cryostat's outer wall.
Helium vessel touching	-	indicated by reduction in radiation shield evaporation rate. Consult Oxford Instruments Company.
Radiation shield insufficiently	-	either the liquid nitrogen vessel codis empty - refill, or the radiation shield is touching the outer case indicated by a cold spot on the outer case - consult Oxford Instruments Limited.

N.B. Normal liquid helium evaporation rate is given in Part II. This is with the magnet in persistent mode and the leads removed. The evaporation rate will be higher than this immediately after transferring.

<u>Syphon entry port blocked with ice</u>

Remove the top cap from chimney and cover the aperture. Warm and dry the cap.

FIGURE 1   TRANSIT BUNGS

HORIZONTAL SECTION THROUGH CRYOSTAT

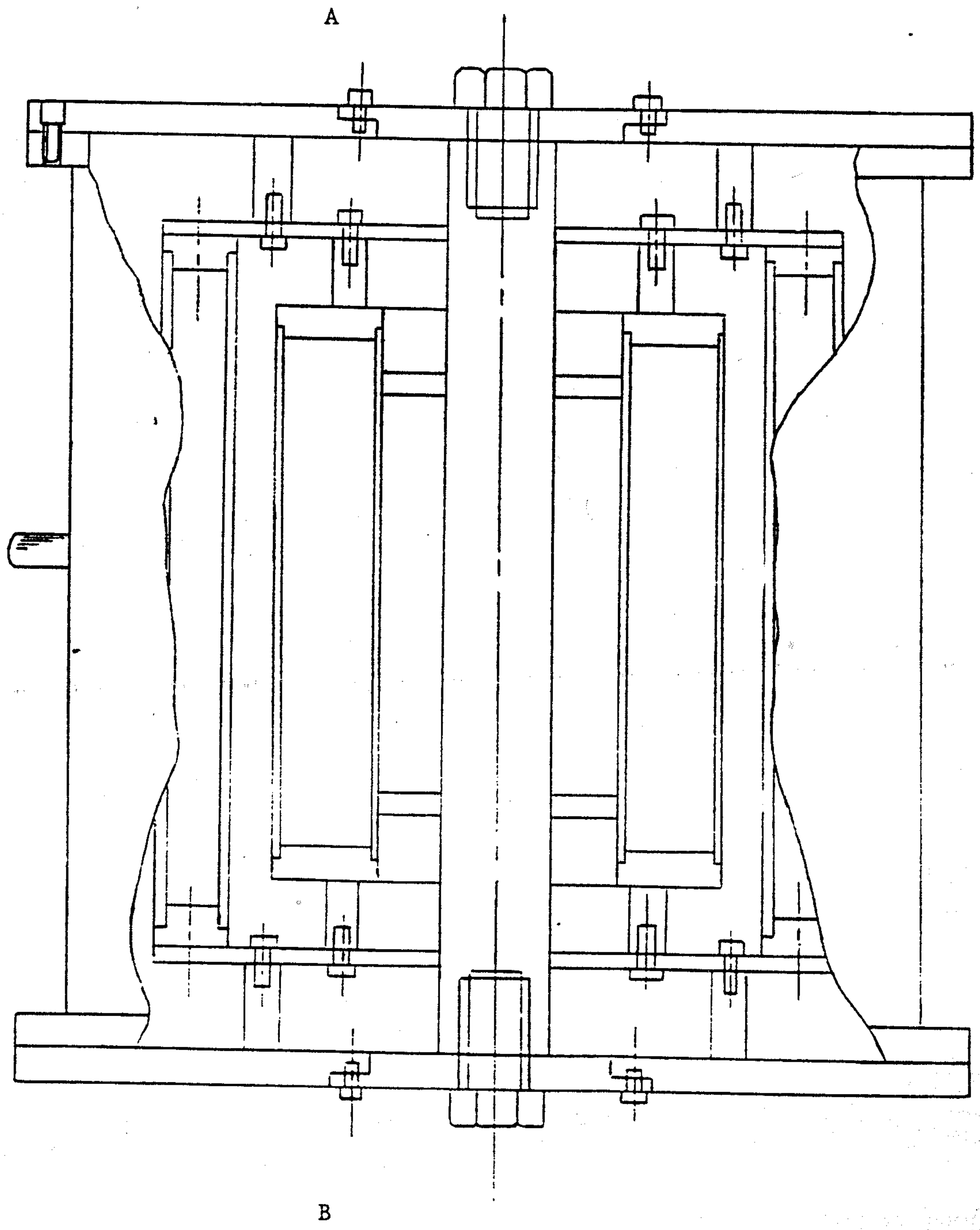


FIGURE 9 NITROGEN PROBE

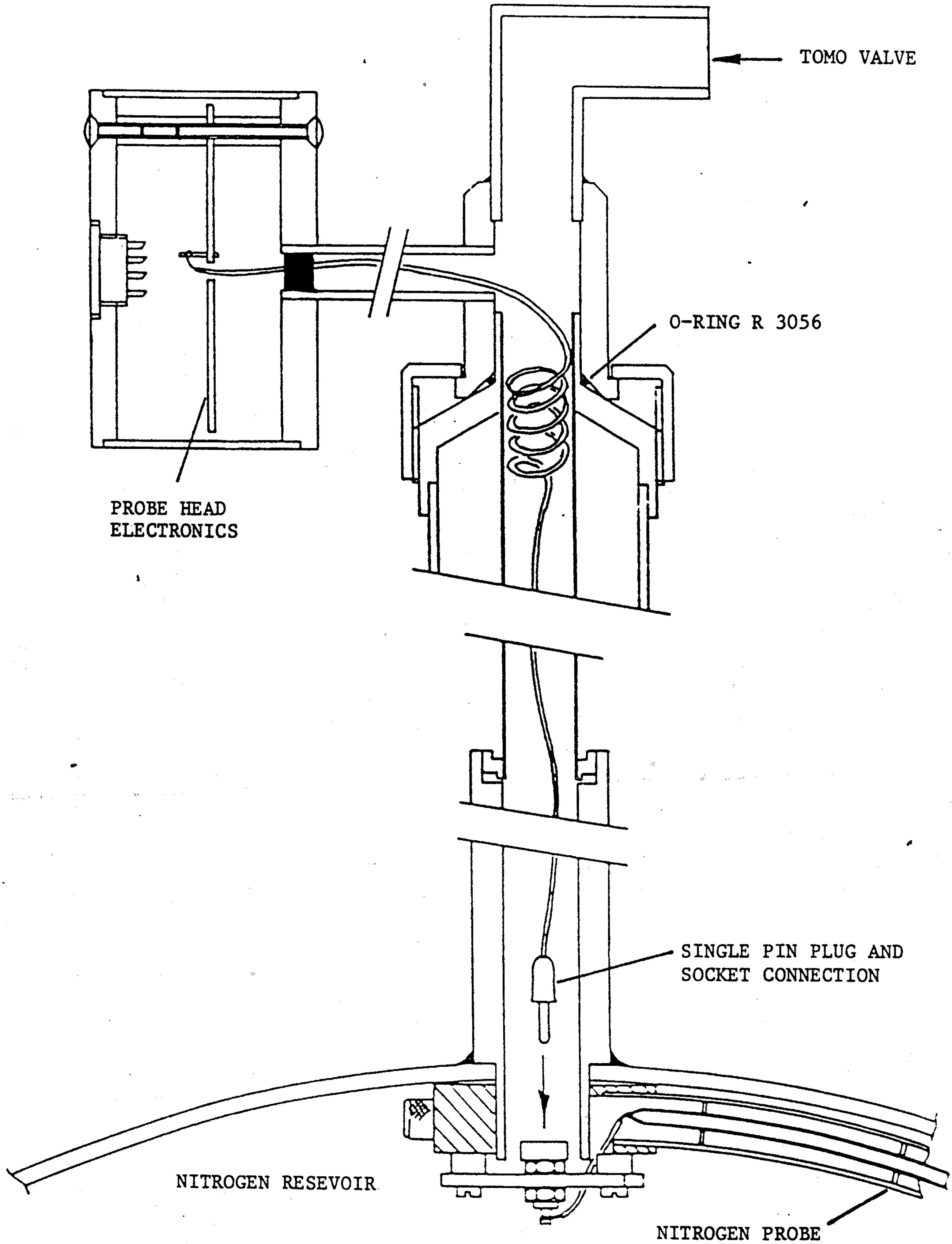


FIGURE 8. ELECTRICAL CONNECTIONS TO HELIUM LEVEL PROBE AND EMERGENCY DISCHARGE FACILITY

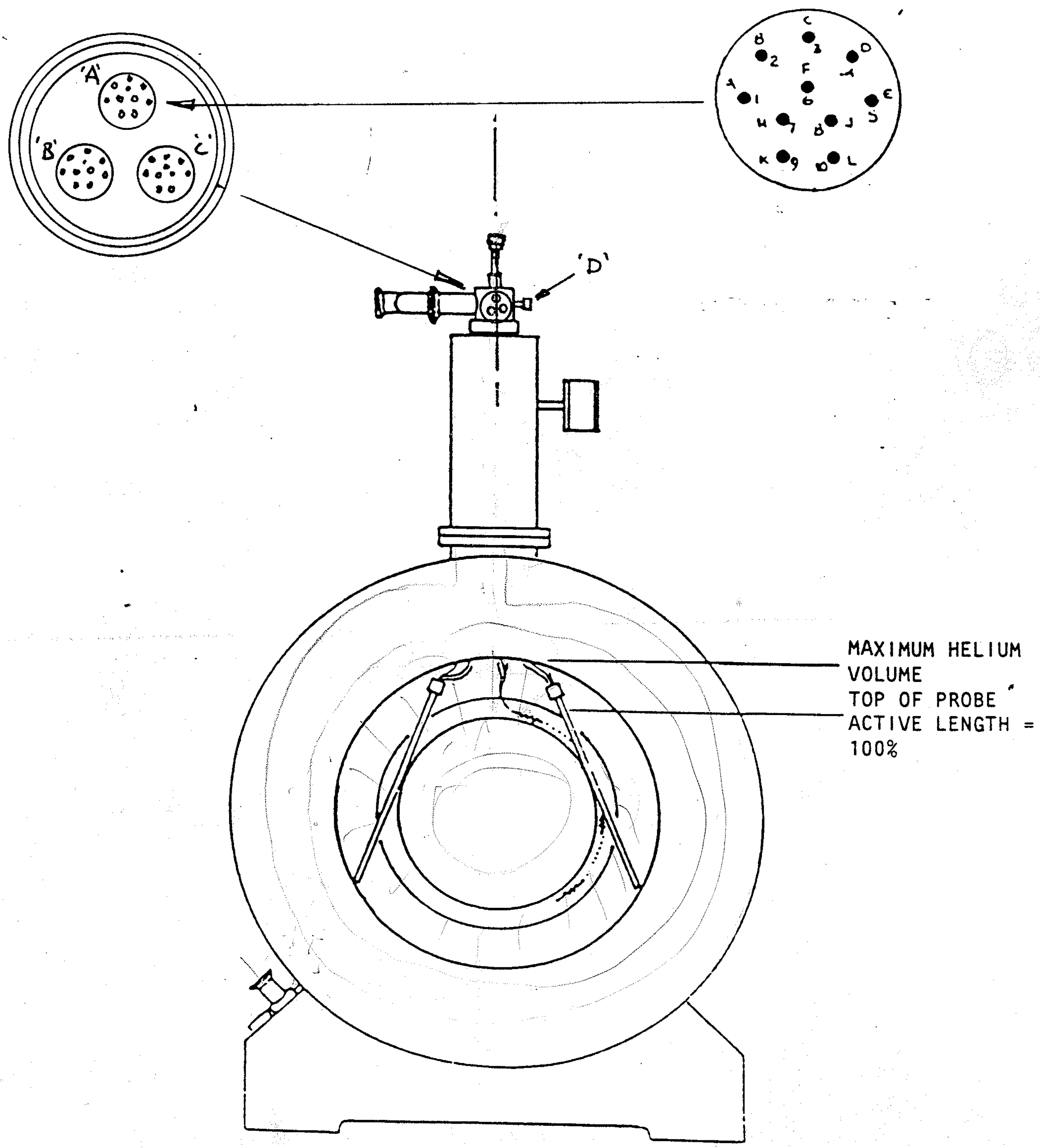
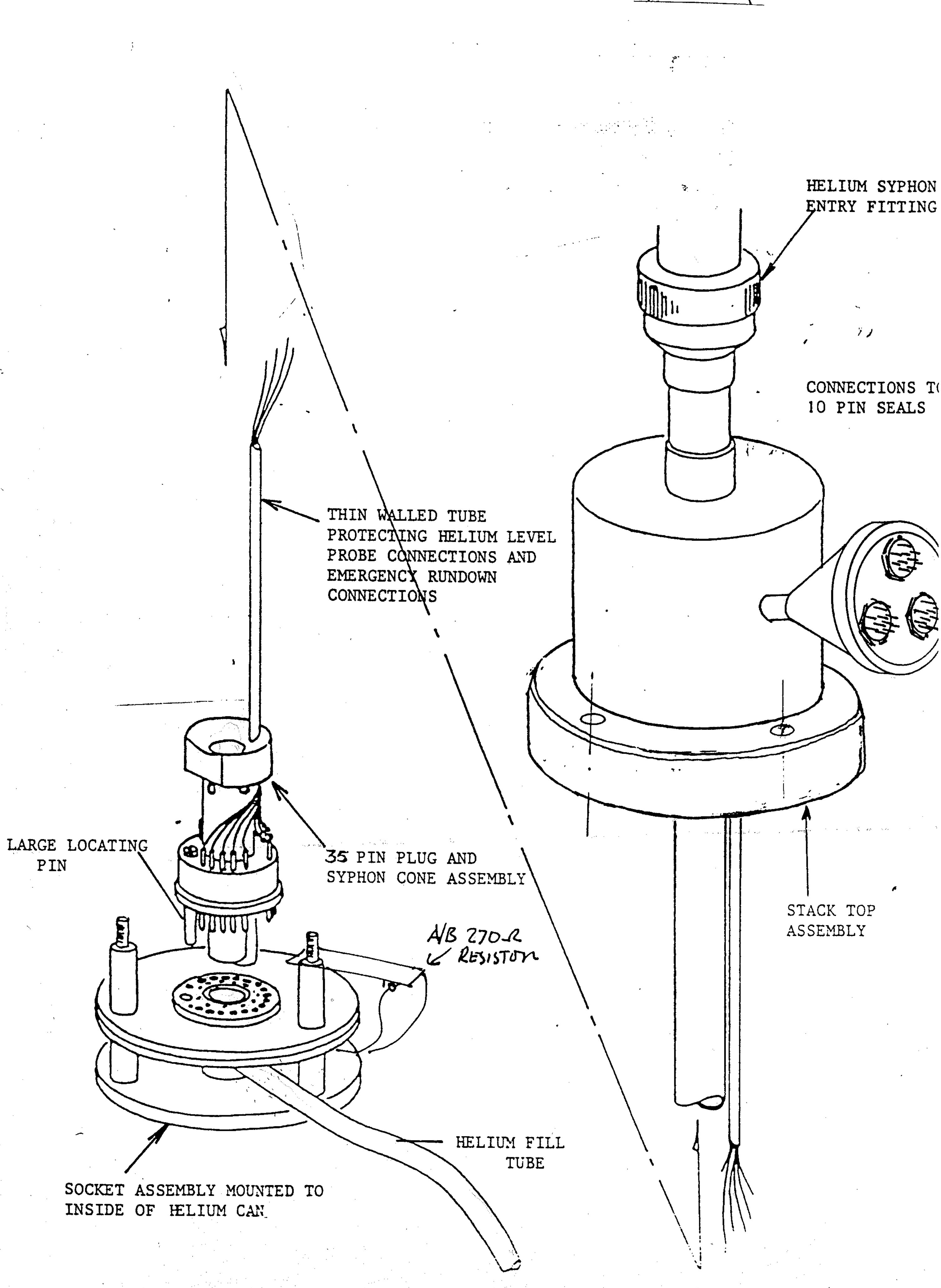
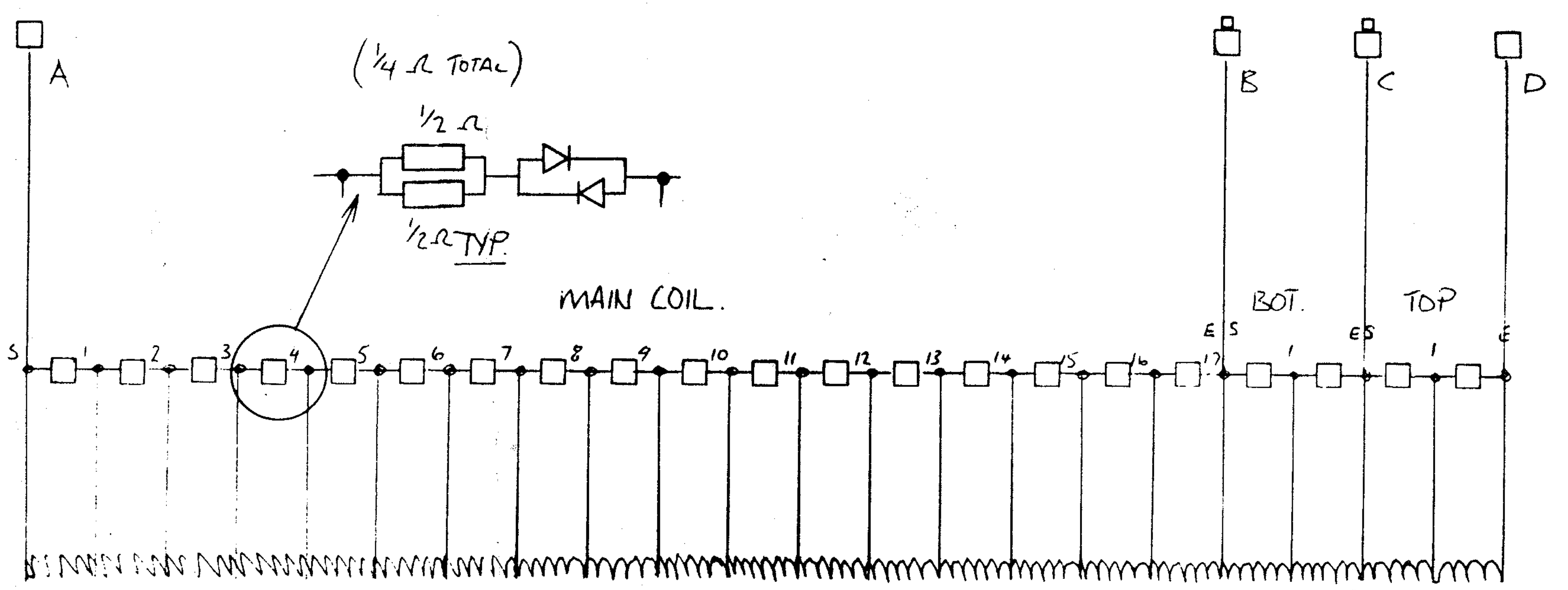
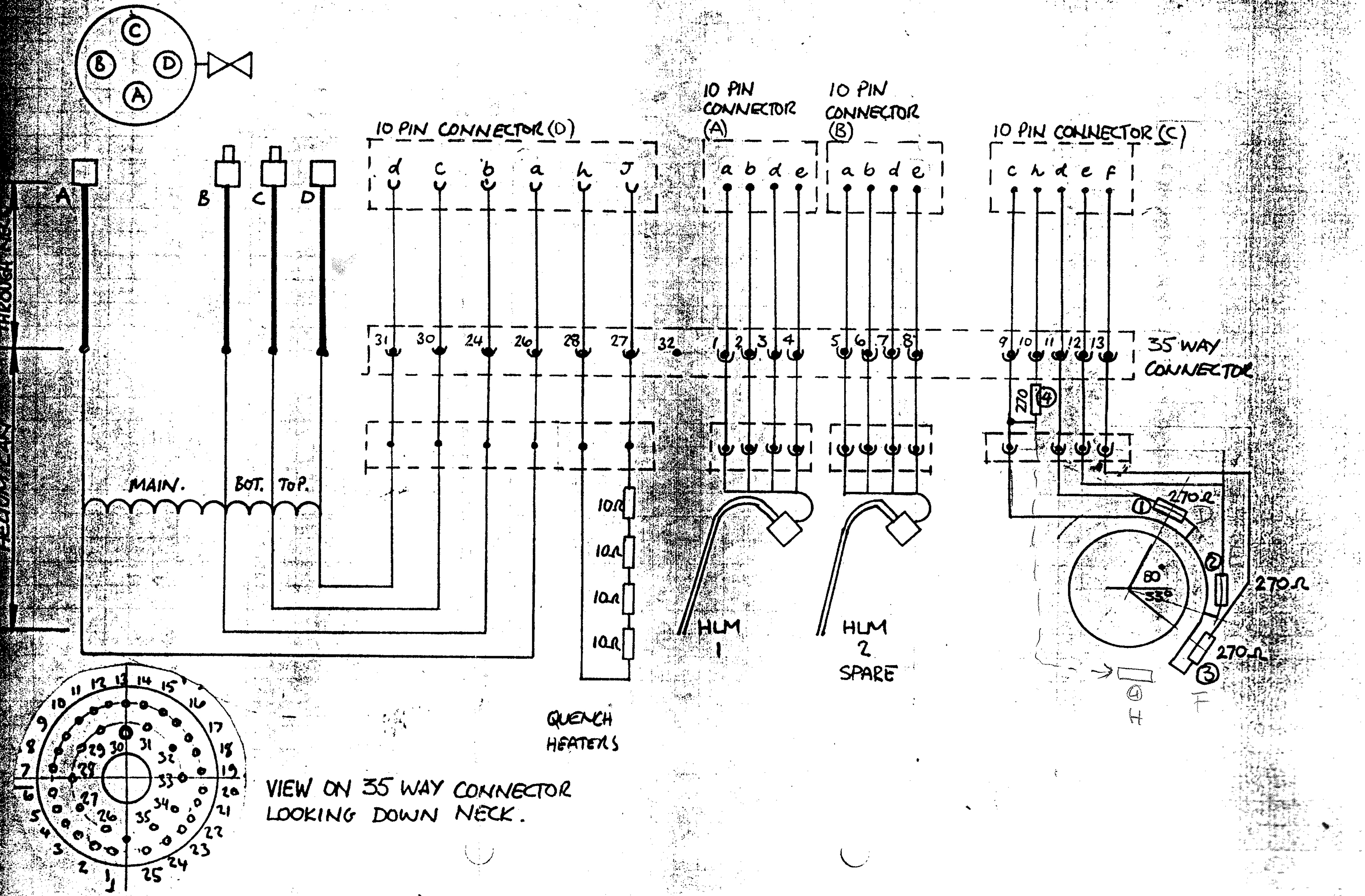


FIGURE 11 35 PIN DEMOUNTABLE ELECTRICAL CONNECTOR AND SYPHON CONE ASSEMBLY



MAGNET PROTECTION WIRING





10 PIN CONNECTOR (D)
d c b a h J
10 PIN CONNECTOR (A)
a b d e
10 PIN CONNECTOR (B)
a b d e
10 PIN CONNECTOR (C)
c h d e f
31 30 24 26 28 27 32 1 2 3 4 5 6 7 8 9 10 11 12 13
35 WAY CONNECTOR
A B C D
MAIN. BOT. TOP.
THROUGH NECK
HELIUM CAN
10Ω 10Ω 10Ω 10Ω
QUENCH HEATERS
HLM 1
HLM 2 SPARE
270Ω 270Ω 270Ω 270
80° 33°
VIEW ON 35 WAY CONNECTOR LOOKING DOWN NECK.

CIRCUIT CHECK LIST

Current Leads

		Pin No	300K (ohms)	77K (ohms)
START MAGNET ______	START BOTTOM COMP	A-B	: 4.25K	: 593Ω
START MAGNET ______	START TOP COMP	A-C	: 4.61K	: 644Ω
START MAGNET ______	END OF MAGNET	A-D	: 5.02K	: 705Ω
Magnet to ground			: >15M	: ∞

10 pin connector (A) Helium level probe

Probe 1

Pin No	300K (ohms)	77K (ohms)
A-B	: 21.8	: 17.3
A-D	: 96.3	: 86.1
A-E	: 90.4	: 82.5
A-Grd	: ∞	: ∞
A-Mag	: ∞	: ∞

10 pin connector (B) Helium level probe

Probe 2
(spare)

Pin No	300K (ohms)	77K (ohms)
A-B	: 22.5	: 16.7
A-D	: 97.5	: 85.9
A-E	: 91.7	: 82.6
A-Grd	: ∞	: ∞
A-Mag	: ∞	: ∞

10 pin connector (C) Level sensors

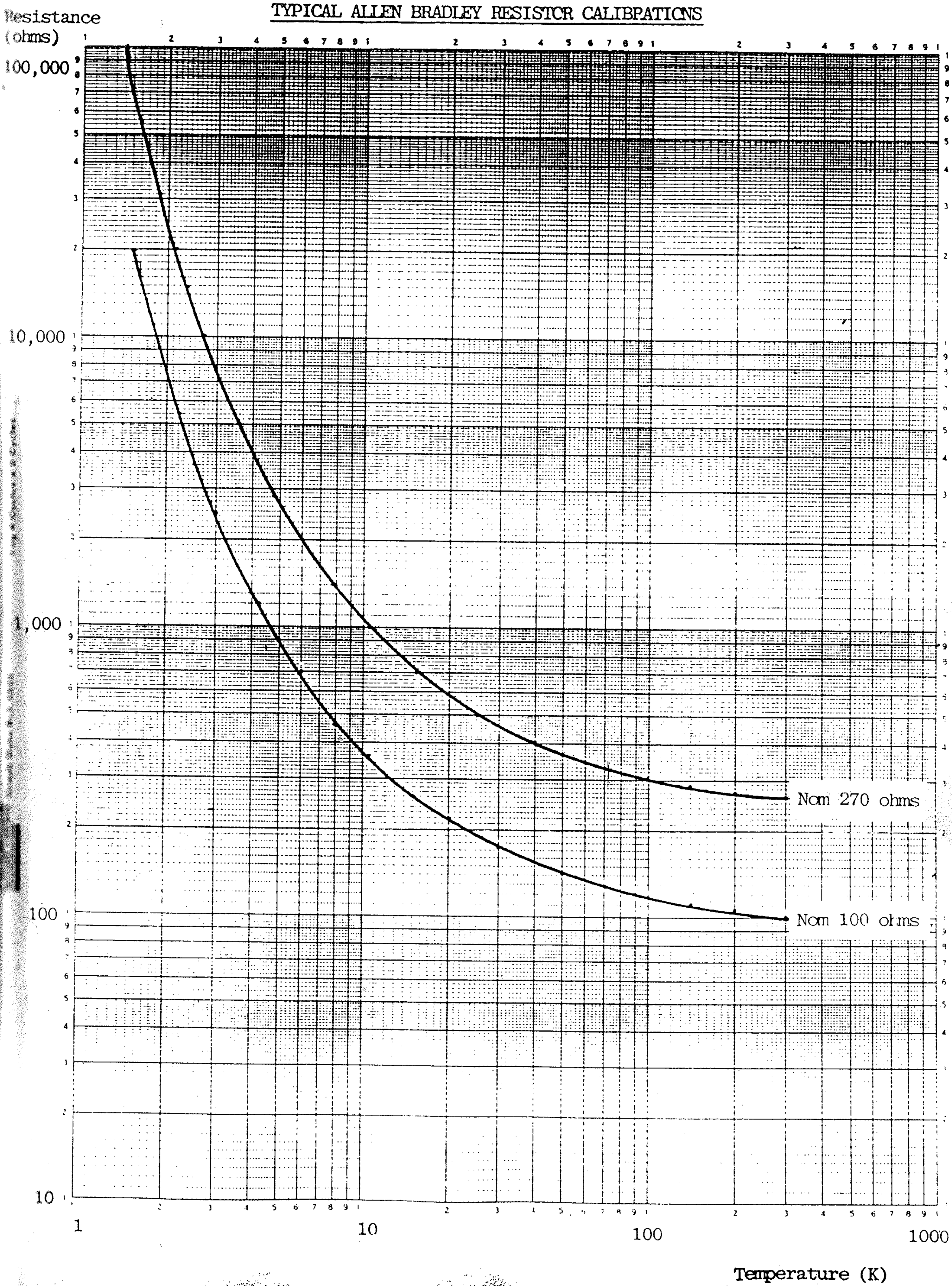
	A/B	Pin No	300K (ohms)	77K (ohms)
Allen Brădley Resistors	1	C-D	: 308	: 371
270Ω nom.	2	C-E	: 301	: 364
See chart for calibration at low temp	3	C-F	: 308	: 373
100% Full Sensor -	4	C-H	: 308	: 372
		C-Grd	: ∞	: ∞
		C-Mag	: ∞	: ∞

(Note - on use of chart, the sensors are wired with constantan wire so subtract wire resistance, example: wire Rw = 308 - 270 = 38Ω)

10 pin connector (D) Potential taps to magnet coils

	Pin No	300K (ohms)	77K (ohms)
	A-D	: 5.10K	: 733
	A-C	: 4.70K	: 677
	A-B	: 4.30K	: 619
	A-Grd	: 5.2M	: 20M
Quench heaters	H-Mag	: ∞	: ∞
	H-Grd	: ∞	: ∞
Heaters	H-J	: 77.4Ω	: 80Ω

TYPICAL ALLEN BRADLEY RESISTOR CALIBRATIONS



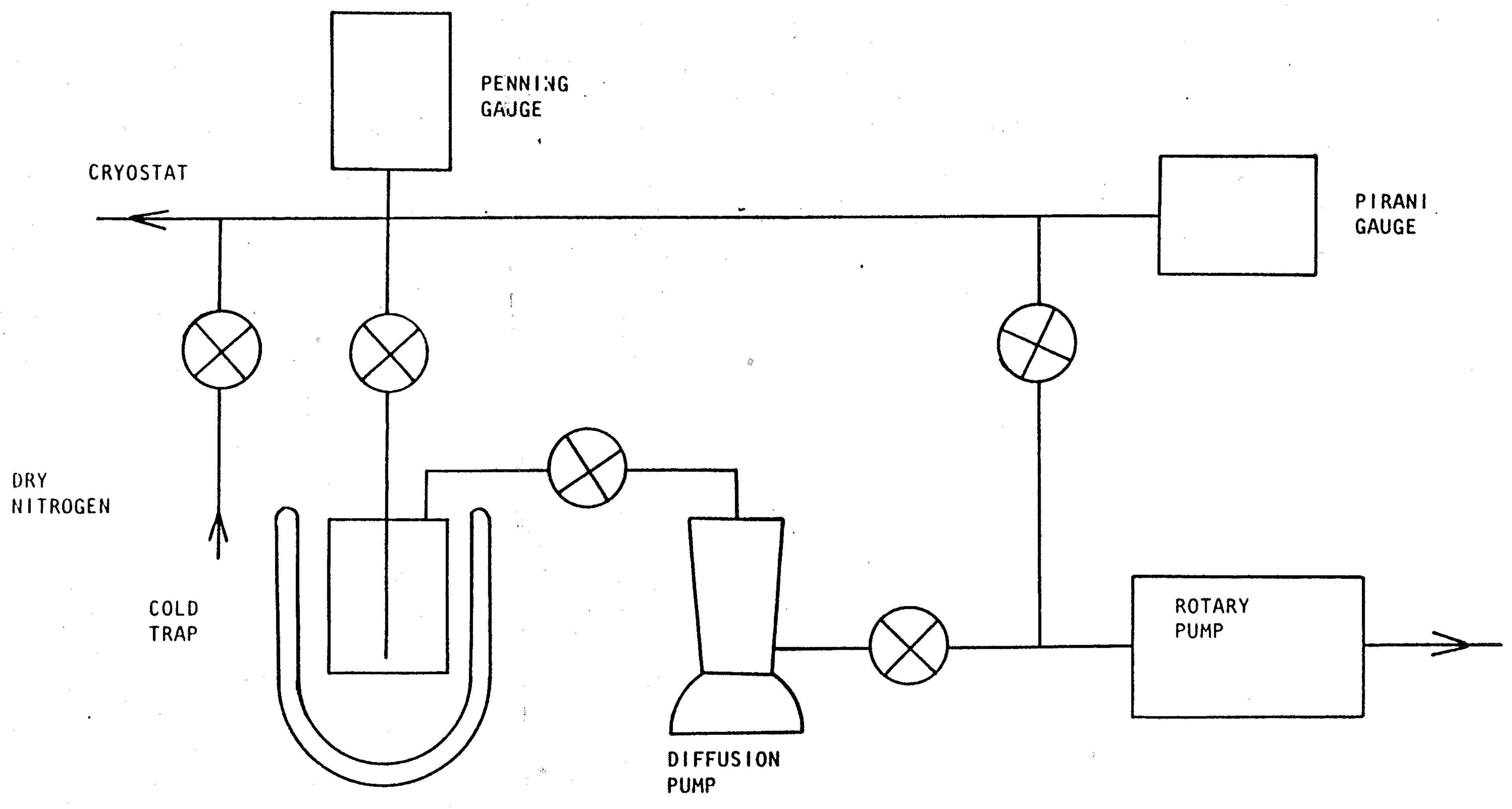


FIGURE 12 CRYOSTAT PUMPING SYSTEM

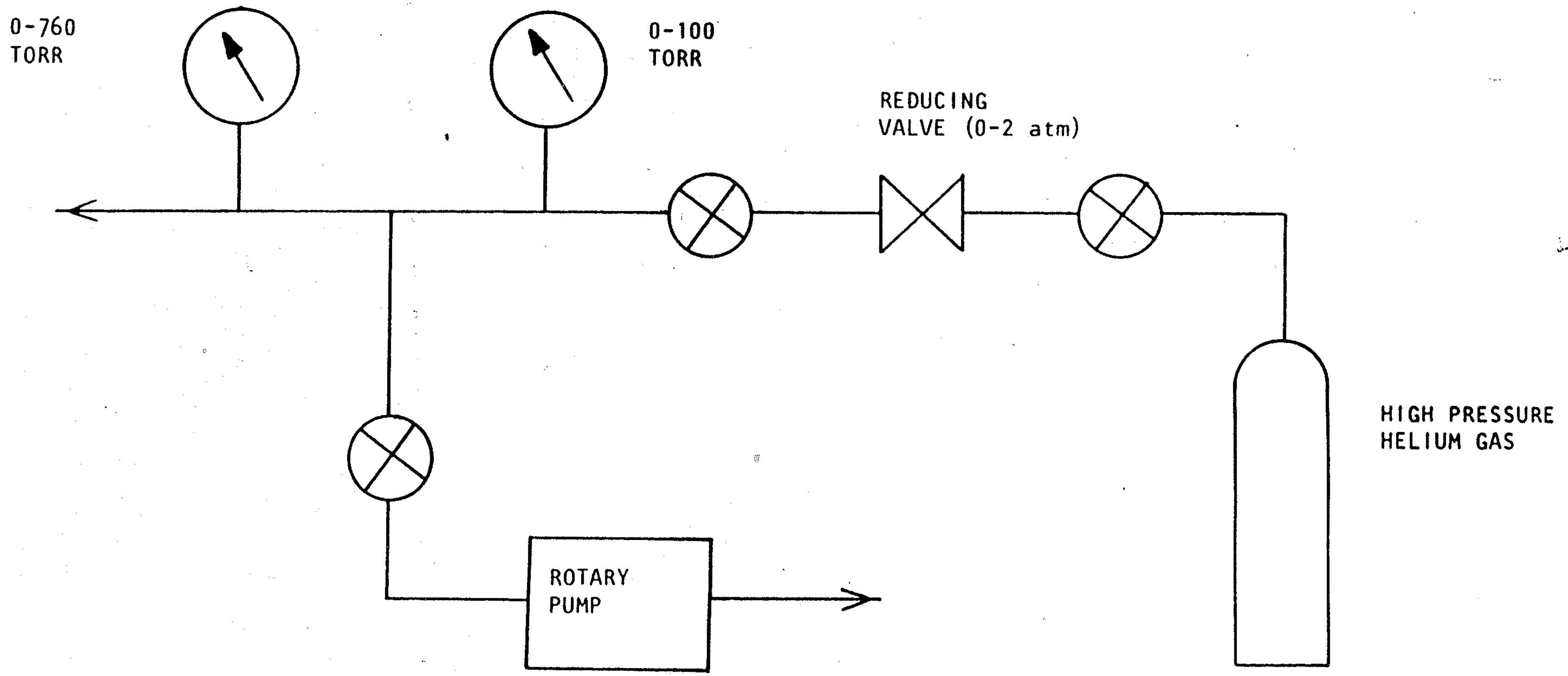


FIGURE 13 FLUSHING AND NITROGEN "BLOW-OUT" SYSTEM

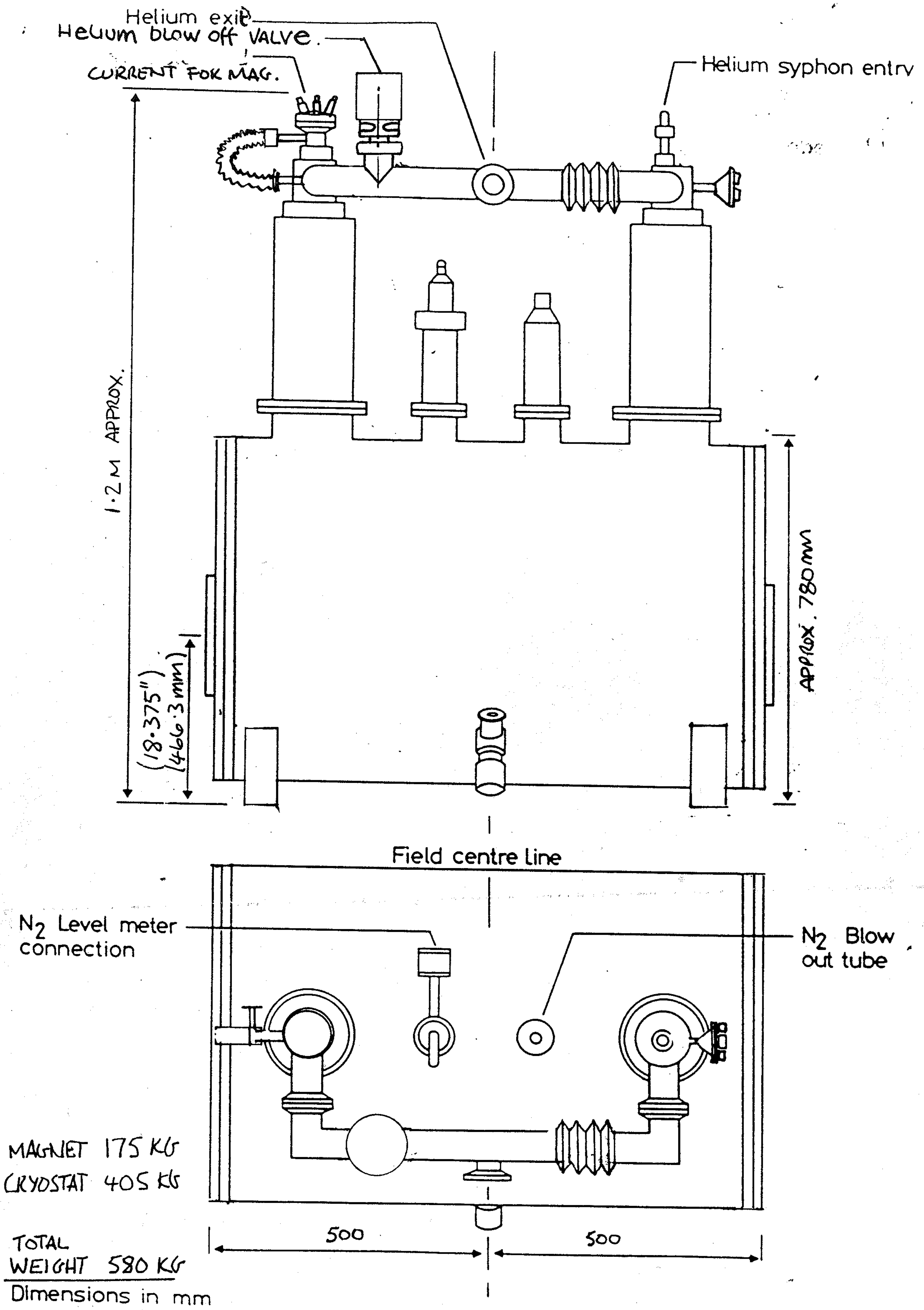
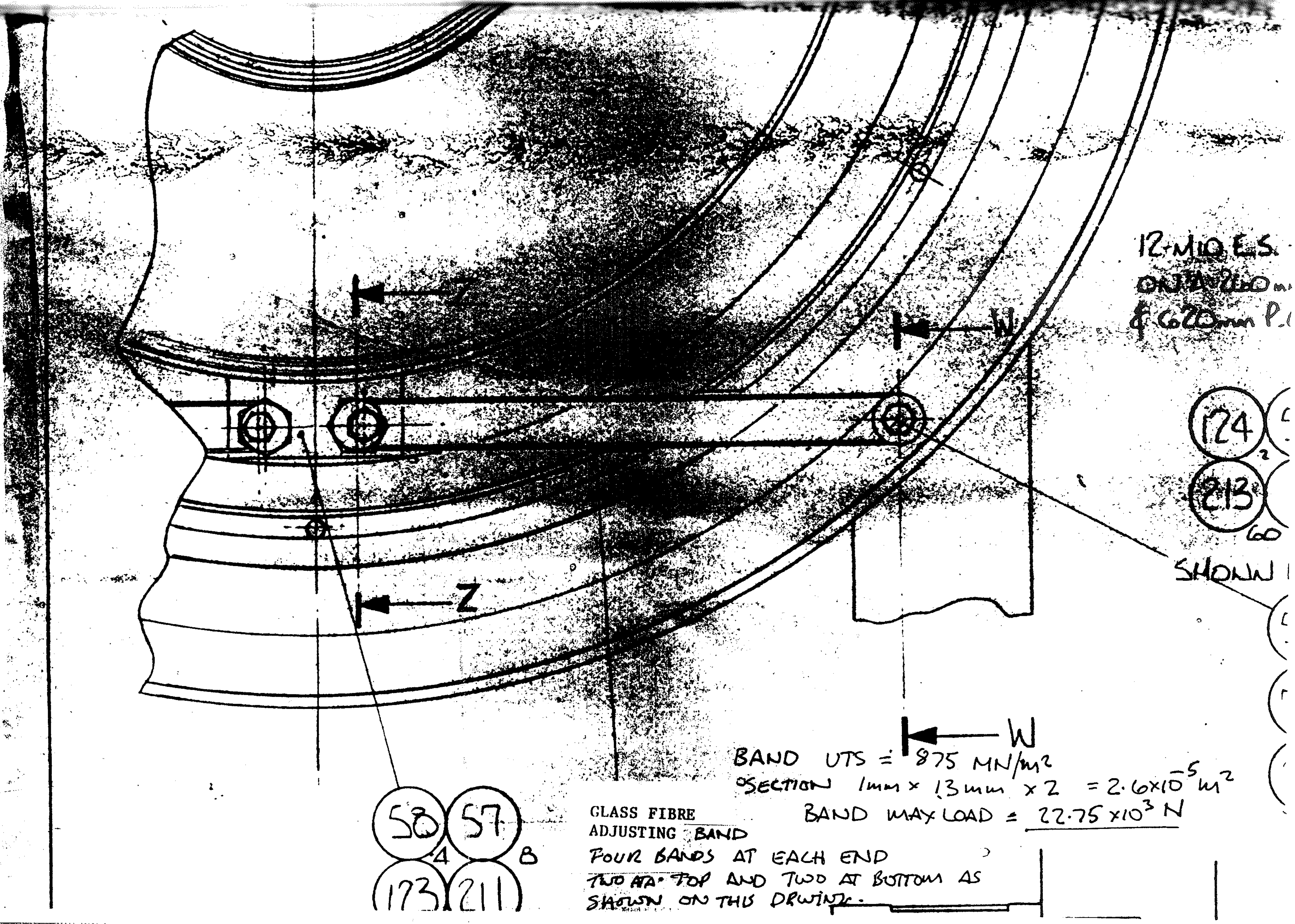
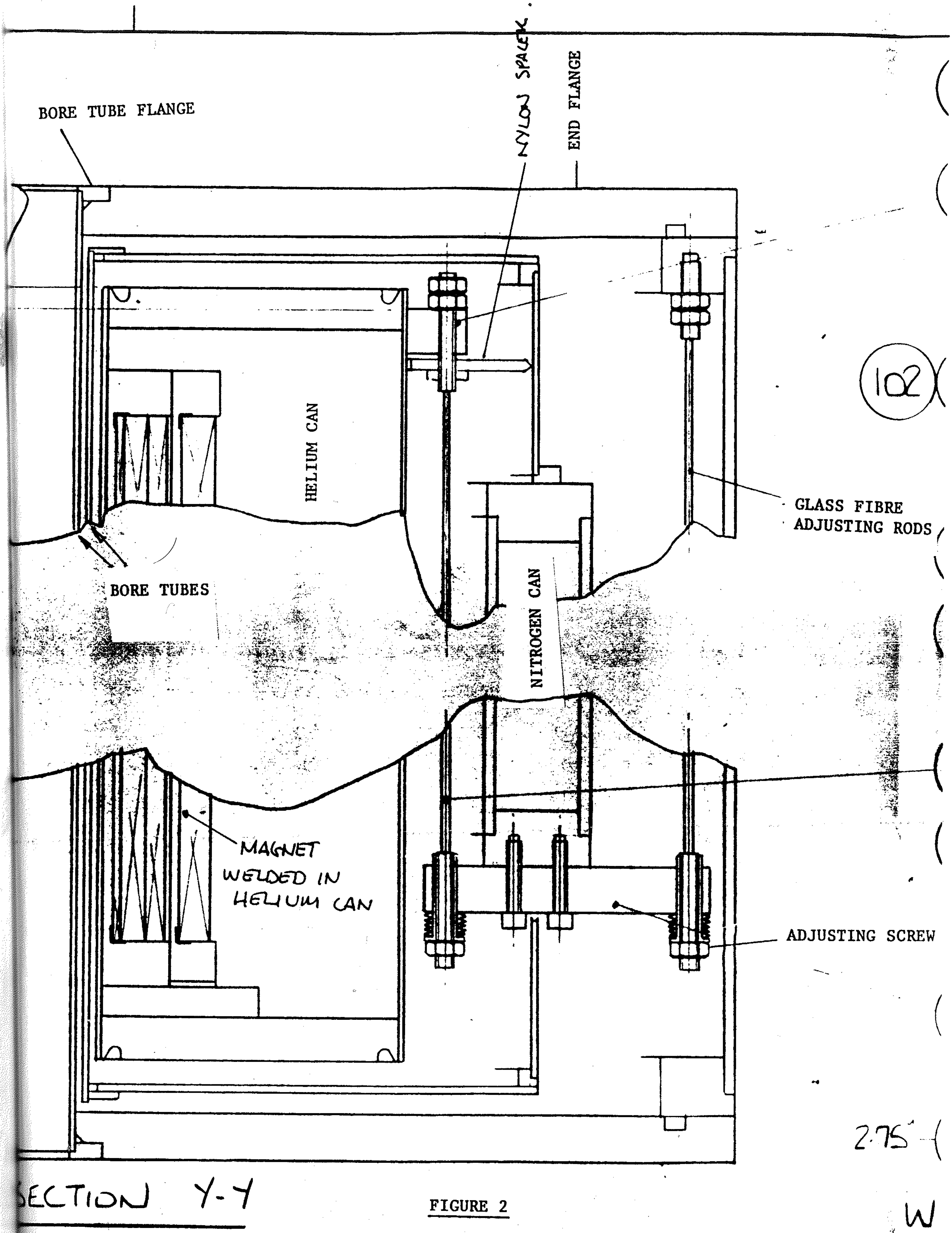


FIGURE 5 CRYOSTAT SCHEMATIC


12-M10 E.S.
Z
Z
W
W
124
213
60
SHOWN
BAND UTS = 875 MN/m²
SECTION 1mm × 13mm × 2 = 2.6×10⁻⁵ m²
BAND MAX LOAD = 22.75×10³ N
58
57
4
B
173
211
GLASS FIBRE
ADJUSTING BAND
FOUR BANDS AT EACH END
TWO AT TOP AND TWO AT BOTTOM AS
SHOWN ON THIS DRWING.



102

2.75

FIGURE 2

W

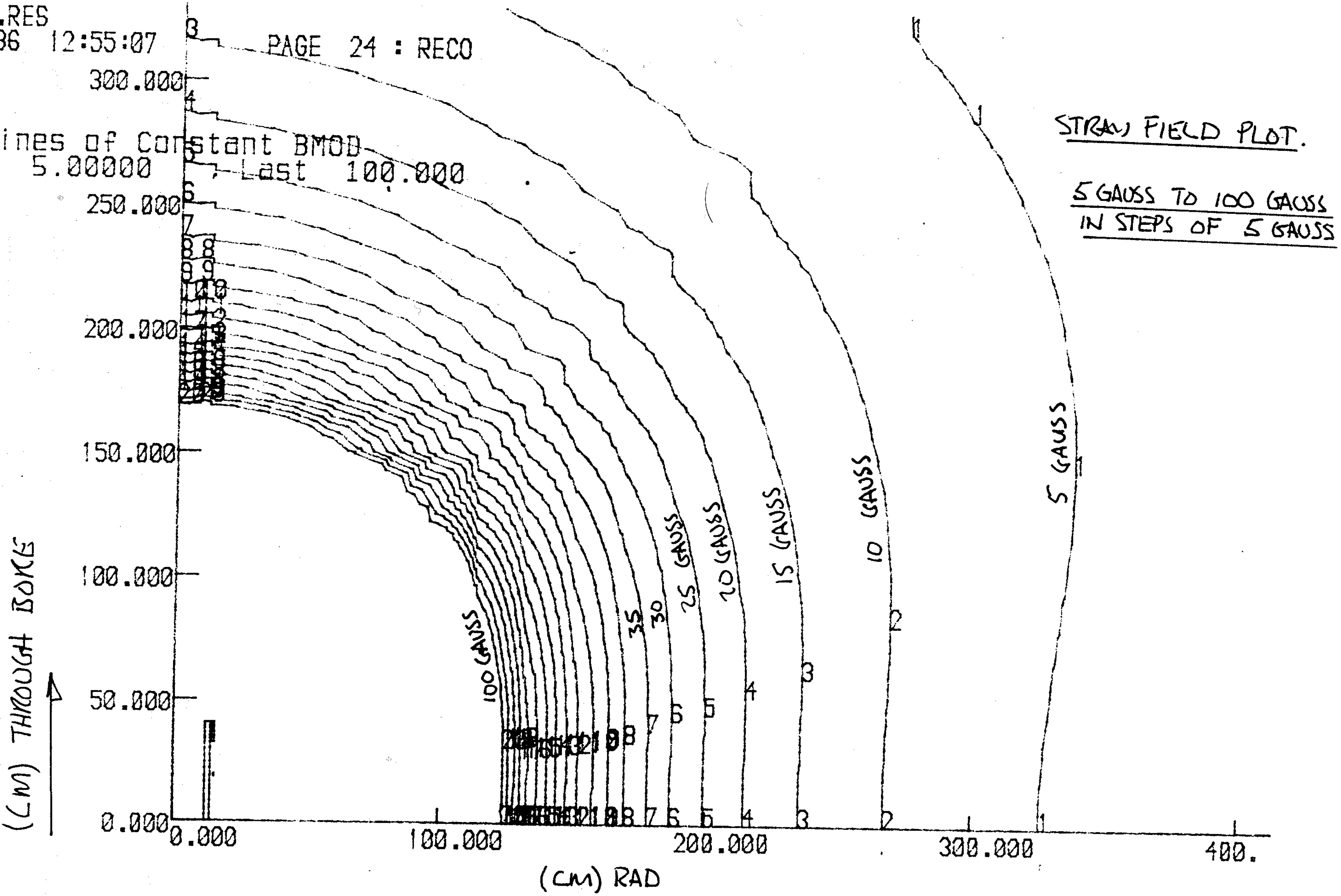
52

Cryogen	Normal Boiling Point (K)	Latent Heat (Joules/g)	Amount of Liquid Evaporated By 1 Watt (L/hour)	Liquid Density (g/ml)	Gas Density at NTP (g/ml)	Liquid to NTP Gas Volume Ratio	Enthalpy Change (gas) B.P to 77K (J/gm)	Enthalpy Change (gas) 77 to 300 (J/gm)
Liquid Helium	4.2	20.9	1.38	0.125	1.79×10^{-4}	1 : 700	384	1157
Liquid Hydrogen	20.39	443	0.115	0.071	8.99×10^{-5}	1 : 790	590	2900
Liquid Nitrogen	77.55	198	0.023	0.808	1.25×10^{-3}	1 : 650	-	234
Liquid Oxygen	90.19	212.5	0.015	1.14	1.43×10^{-3}	1 : 797	-	From BP 193

TABLE 3

TACQU1.RES
22/10/86 12:55:07

OK
CONT
20 Lines of Constant BMOD
First 5.00000 Last 100.000
OK



ELEM=LINE SYMM=AXI SOLN=AT

Static Solution Mesh 2527 Elements 31 Regions

PE2D

SYSTEM PROBLEM/RETURN FORM

If any difficulty is experienced in operating the system, the following details should be given to the Project Manager, Magnet Systems Group or his appointed representative. In the event that the system is returned to the works for repair, then this written form should be completed and addressed to:- Magnet Systems Manager, Oxford Instruments Ltd., Osney Mead, Oxford. OX2 0DX England. Telephone (0865) 41456.

System Type ....

System Project No. ....

Magnet No. ....

Cryostat No. ....

Date first received ....

Who commissioned the system ....

Briefly describe the problems/symptoms experienced with the system.

If other equipment such as power supply, sweep generator, temperature controller etc. is faulty, please give details:-

Equipment ....

Model ....

Serial No. ....

Date first received ....

Customer .... Date ....

Address ....

....

....

4.2 Magnet operation

Magnet discharges spontaneously

Helium level low	-	refill and re-energise
Helium level indicator faulty	-	disconnect and check. (Applies when level indicator is interlocked to switch heater unit).

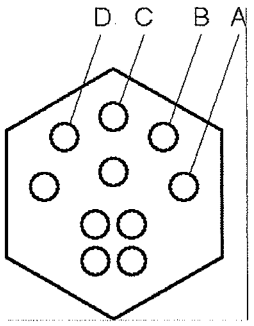
Magnet quenches

Helium level low	-	refill, check magnet and safety mechanisms
Leads replaced with incorrect polarity	-	refill, and check magnet

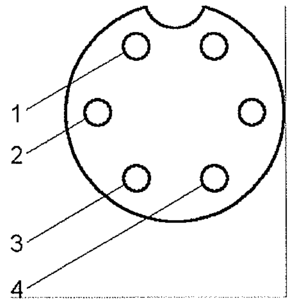
Belegung von LN_2 und LHE Kabel

Für Oxford Level Meter

Stickstoffkabel LN_2, lötseitig



A: blau
B: gelb
C: rot
D: grün od. klar

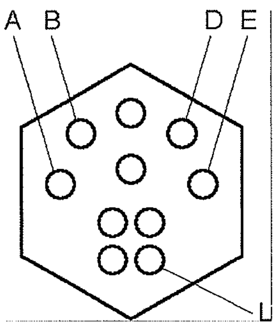


1: rot
2: blau
3: grün od. klar
4: gelb

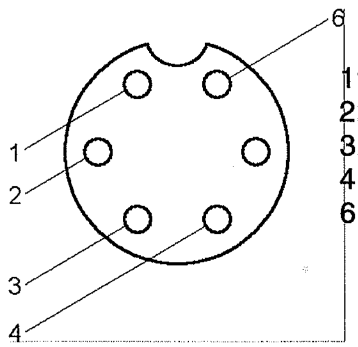
Oxford PCZ 0008 10-pin plug (male)

Kupplung 6-Polig Farnell Bestnr. 314-420

Heliumkabel LHE, lötseitig



A: blau
B: grün od. klar
D: gelb
E: rot
L: schwarz
(keine Signalbedeutung, wahrsch. Schirm)



1: rot
2: blau
3: grün od. klar
4: gelb
6: schwarz

Oxford PCS 0002 10-pin socked (female)

Kupplung 6-Polig Farnell Bestnr. 314-420

Christoph Boo, 24.03.2004

ALC

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Manual zum Kühlen des PSC Magneten, P.H. 4. Mai 00

Ablaufbeschrieb:

1.) Abkühlen des Helium-Tankes auf LN_2 Temperaturen

Temperaturmessung über Widerstand C-E, welcher sich oben am Tank befindet, 20° (Grad Celsius) = 294 Ω, LN_2 Temperatur = 365 Ω, (LHe Temp: ca. 4.5 kΩ).
Für den LN_2 Transfer in den He Tank hat Leo Simons einen geeigneten Heber mit 16er Flansch, welcher sich auf der Hinterseite des Bruno Werkzeugracks befindet. Das Verbindungsstück zum regulären LN_2 Transferschlauch liegt im PSC Schrank.

2.) (ev. parallel): LN_2 Transfer in Stickstoff Tank

3.) Nach ca. 12 - 24 h LN_2 aus He Tank entfernen

Einführen des Rohres mit dem kurzen PVC Schlauch am oberen Ende zur Befestigung des 16er Flansches. Dieser Flansch erlaubt die Verwendung eines regulären LN_2 Transferschlauches, welcher im gebogenen Zustand nicht durch Stress zerbirst, für die restliche Rücktransferstrecke kann wieder PVC verwendet werden.

Bei der LN_2 Entleerung muss darauf geachtet werden, dass das Rohrstück fest im PSC Konus sitzt (! Achtung: Kontraktion des Rohres durch dessen Abkühlung, d.h. Rohr um ca. 3 mm nachschieben). Das Rohr mittels der Schraube dicht befestigen und das LN_2 mit ca. 0.25 bar Überdruck "rauspumpen". (Bem: Der Simons'sche Transferheber ist zu dünn für den Rücktransfer (Druckaufbau nicht möglich). Je nachdem wie stark der He Tank mit LN_2 gefüllt wurde sind 20 bis 50 l LN_2 zu entfernen (bei Kühlung bis zu C-E = 365 Ω ca. 50 l, bei C-E = 350 Ω ca. 20 l.)

Nachdem der He Tank vom LN_2 befreit ist, kurz mit N_2 Gas flushen und danach auspumpen. Falls alles LN_2 entfernt ist, sollte der Druckabfall auf logarithmischer Skala linear verlaufen, ca. 20 mbar nach 6 Minuten mit 10-l-Vorvakuumpumpe (470 mbar nach 1 Min, 260 nach 2, 140 nach 3, 75 nach 4, 40 nach 5 Minuten, siehe Logbuch).

Nach 6 Min. mit **He** Gas "belüften" und Prozedur 2 mal wiederholen.

4.) LHe Transfer, ca. 200 Liter

Während des Abkühlprozesses können im Isoliervakuum kleine Vakuumeinbrüche auftreten. Das Isoliervakuum sollte deshalb während des Abkühlprozesses ab und zu gepumpt werden.

Dec. 3 1999

11^{00} Starting to pump down isolation vacuum
status: magnet at room temperature

15^{00} Problems with turbo pumping unit
→ exchanged with larger Pump assembly (Leo's big Pumpstand)
→ small pumpstand at vacuumgroup

19^{00} $P_{iso\ backsides} = 9 \cdot 10^{-4}$

Dec. 4 1999

13^{30} $P_{iso\ backs} = 1.5 \cdot 10^{-4}$
→ if everything goes well PSC will be LHe-cool bey wednesday afternoon

16^{00} $P_{iso} \approx 10^{-4}$

Dec 5, 1999

17^{00} $P_{iso} \approx 5\ 10^{-5}$

Dec 7, ~~[illegible]~~ 1999

12^{00} $P_{iso} \approx 4 \cdot 10^{-5}$
flushing LHe-LN_2 tank with N_2

13^{30} & Start LN_2 into LHe tank
C-E = 293.9 Ω

14^{30} C-E = 296.9 Ω

15^{10} C-E = 316.8 Ω

15^{30} C-E = 1335 "

17^{25} C–E = 363 Ω stop LN_2 transfer into LHe tank
Start filling LN_2 - ~~vessel~~ tank

19^{40} LN_2 vessel full
tank

close isolation vacuum value during the night $P_{iso} = 4 \cdot 10^{-7}$

08^{00} $P_{iso} = 2 \cdot 10^{-5}$ C–E = 365 Ω
→ pumping (probably "to cold")

08^{50} starting to remove LN_2 out of LHe tank

09^{25} 4½ vessels LN_2 out
seems to be all!

flushing with N_2

9^{55} flushing with He

10^{15} stop flushing
start pumping LHe tank

min	P [mbar]
0	930
1	470
2	260
3	142
4	78
5	43
6	24

10^{30} again pumping down

0	940
1	~~265~~
2	265
3	147
4	
5	44
6	25

10^{50} start LHe transfer

C - E = 361 Ω

11^{05} C - E = 402 Ω

11^{13} 482 Ω

11^{45} 1025 Ω

change of Vessel

11^{55} 4.5 kΩ

→ starting to fill reservoir

12^{30} LHe tank full