CTI-CRYOGENICS
HELIX TECHNOLOGY CORPORATION

CRYO-TORR® 100, 7, 8 and 8F HIGH-VACUUM PUMPS

(USED WITH 8300™ OR SC (AIR) COMPRESSOR)

Installation, Operation and Servicing Instructions

M8040240
Rev. A (9/91)

Revised September 1991

3750

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Manual Contents

This manual provides installation, operation and servicing instructions by major system component (cryopump, compressor, and controller) to simplify getting the world's finest high-vacuum pump into operation quickly and efficiently, meeting its designed capabilities.

Technical Inquiries

CTI-CRYOGENICS has a world wide system of customer support centers available to answer technical questions, or to assist you with installation, operation and maintenance of your product. All customer support centers have "rapid response" capabilities providing 24-hour technical support. In the Continental U.S.A. and Canada you may call toll free for assistance *24 HOURS A DAY, 7 DAYS A WEEK.*

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Your high-vacuum equipment is designed and manufactured to ensure a minimum of maintenance. However, should your unit require service or if you need technical assistance, contact the nearest customer support center. Have the following information available when placing the call so we may assist you quickly.

- Equipment Type
- Product Serial No.
- Product Part No.
- Product Application
- Hours of Operation
- Specific Problem Area

SAFETY CONSIDERATIONS

Your Cryo-Torr® High Vacuum Pump has been engineered to provide extremely safe and dependable operation when properly used. Certain safety considerations need to be observed during the normal use of your vacuum pump equipment. Warning blocks within the Manual text pinpoint these specific safety considerations. Warnings are defined as hazards or unsafe practices which could result in severe injury or loss of life.

⚠WARNING


TOXIC, CORROSIVE OR DANGEROUS GASES present in a cryopump could cause severe injury upon contact.

1. Always vent such gases to a safe location, using an inert purge gas.
2. Clearly identify such gases on containers used to store or ship equipment after such exposure.


FLAMMABLE OR EXPLOSIVE GASES present in a cryopump could cause severe injury if ignited.

1. Always vent such gases to a safe location, using an inert purge gas.
2. Do not install a hot-filament type vacuum gauge on the cryopump side of the roughing valve; it could be an ignition source of flammable gases in the pump.
3. Cryopumping oxygen/ozone requires special precautions and frequent regeneration. Ozone may be present as a by-product of oxygen processes.

HIGH VOLTAGE is present within the system and can cause severe injury from electric shock.

1. Disconnect the system from all power sources before making electrical connections between system components and also before performing Troubleshooting and Maintenance procedures.

HIGH GAS PRESSURE is present within the system and can cause severe injury from propelled particles or parts.

1. Do not modify or remove the pressure relief valves, either on the cryopump or within the helium compressor.
2. Always depressurize the adsorber to atmospheric pressure before disposing of it.
3. Always bleed the helium charge down to atmospheric pressure before servicing or disassembling the self-sealing gas half-couplings.

BEFORE INSTALLING, OPERATING OR SERVICING EQUIPMENT, READ THIS MANUAL WHICH CONTAINS IMPORTANT SAFETY INFORMATION.

CRYOPUMP OXYGEN PROCEDURES

⚠WARNING

COMBUSTION SUPPORTED BY OXYGEN IN THE PUMP COULD CAUSE SEVERE INJURY. WHEN OXYGEN IS USED AS A PROCESS GAS, SPECIAL PRECAUTIONS DESCRIBED IN THE TEXT BELOW SHOULD BE TAKEN.

When oxygen is used as a process gas, the following precautions should be taken.

1. Follow all cryopump operating instructions including:

   - Insure that there are no sources of ignition (e.g., hot filament vacuum gauges) on the cryopump side of the high vac valve operating during the warming or venting of the pump.

   - Perform inert gas purge regenerations at flow rates recommended for cryopumps.

2. Regenerate as frequently as practical to minimize the amount of oxidizer present in the cryopump.

3. It is standard practice in the vacuum industry that any system exposed to richer-than-air oxygen levels should be prepared for oxygen service per the manufacturer's recommendations, including use of oxygen service lubricating oils in roughing pumps.

⚠WARNING

EXPLOSION OCCURING FROM OZONE IN THE PUMP COULD CAUSE SEVERE INJURY. OZONE CAN BE PRESENT AS A BY-PRODUCT OF OXYGEN PROCESSES. IF OZONE IS PRESENT, SPECIAL PRECAUTIONS DESCRIBED IN THE TEXT BELOW MUST BE TAKEN.

Ozone may be unknowingly produced in an ionizing process (e.g., sputtering, etching, glow discharge). Explosive conditions may exist if ozone is present, especially during warming of the cryopump. Signs of ozone's presence are:

1. Crackling/popping sounds (as in electrical arcing) occurring within the first few minutes of regeneration.

2. Gas venting from the cryopump during regeneration may have a pungent smell, similar to that present in an arc welding operation or after an electrical storm.

NOTE: A change in process may increase the amount of ozone present.

If ozone is present, the following precautions must be taken.

1. All of the above oxygen precautions must be followed. The required regeneration frequency is dependent upon flow and process conditions. Daily regeneration may be required. Call CTI-CRYOGENICS for assistance.

2. Reduce the oxygen mixture to the lowest level the process will allow.

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Brooks
800-367-4887

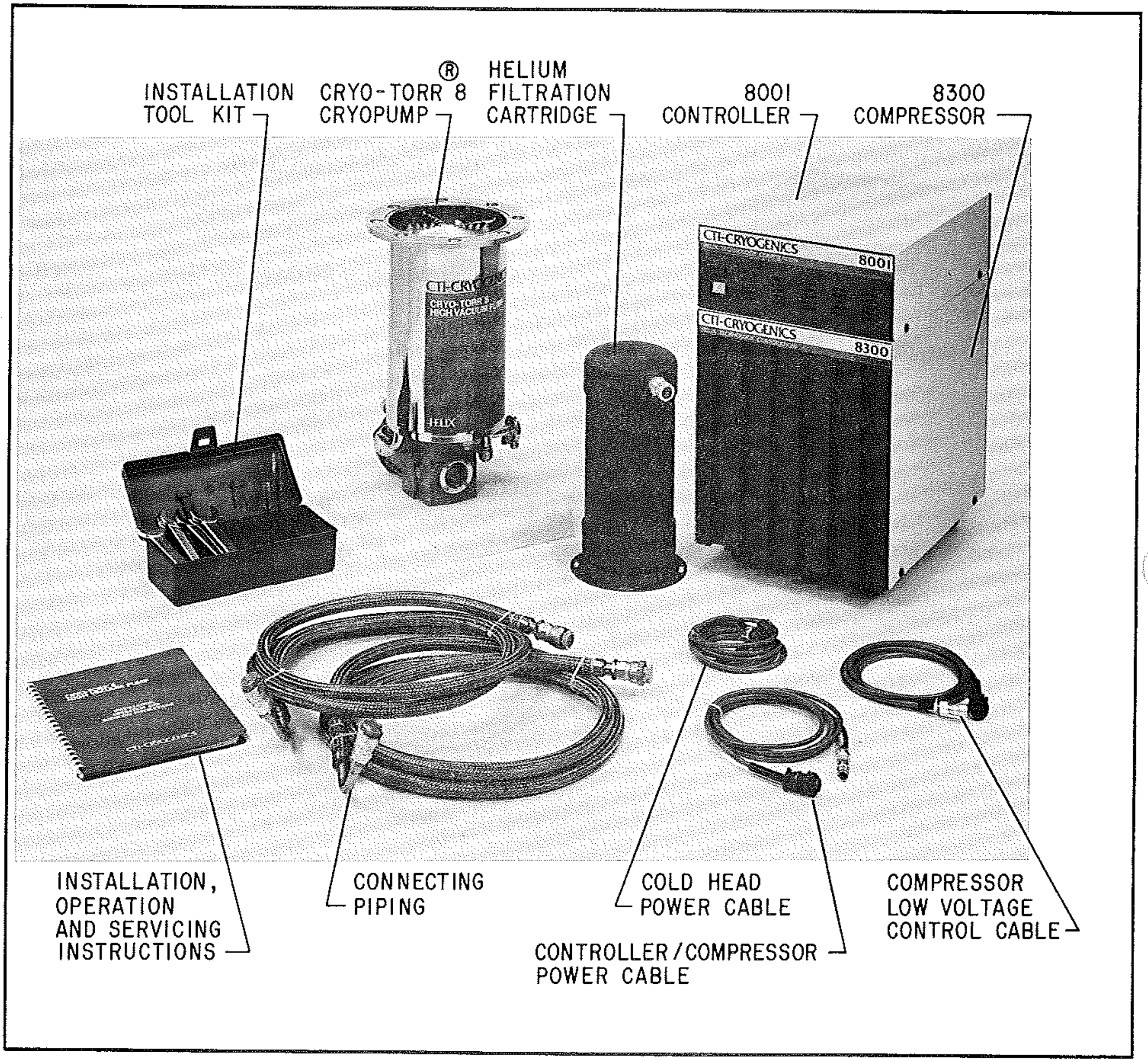


Figure 1.1 Typical Cryo-Torr® High-Vacuum Pumping System (Cryo-Torr 8 Cryopump and 8300™ Compressor shown)

Section 1: Introduction

1.1 General

This manual provides instructions for installing, operating and servicing the Cryo-Torr® 100, 7, 8 and 8F Cryopumps. If you are installing or operating a high-vacuum system you should also have available the Model SC Compressor or 8300™ Compressor and the manuals listed below that apply to your particular system.

	MANUAL REQUIRED	
SYSTEM COMPONENT	8300 COMPRESSOR	MODEL SC COMPRESSOR
Cryo-Torr 100, 7, 8 and 8F High-Vacuum Pump	M8040240	M8040240
8300™ Compressor	M8040242	------
Model SC Compressor	------	M8040243
8001™/8002™ Controller	M8040241	------

The manuals cover two basic components: The cryopump, compressor, and the controller where applicable. Each manual presents information for installation, operation and servicing of that component. A manual is shipped with each system component (cryopump, compressor, and controller).

When you purchase a system, you will receive the three manuals necessary for system installation, plus a loose-leaf binder with index tab separators allowing you to compile a complete indexed system notebook.

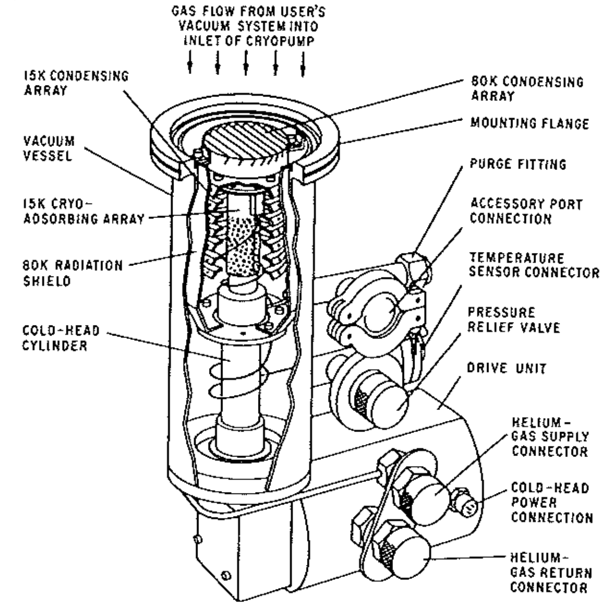
The Cryo-Torr High-Vacuum Pump System, shown in Figure 1.1, provides fast, clean pumping of all gases in the 10^{-3} to 10^{-10} torr range. It operates on the principle that gases can be condensed and held at extremely low vapor pressure, achieving high speeds and throughputs at the cryogenic temperatures of the operating cryopump.

The cryopump is a reliable rugged unit that requires a minimum of servicing. The cryopump exposes no moving parts, operating fluids, or backing pumps to the working vacuum; the possibility of contamination is eliminated.

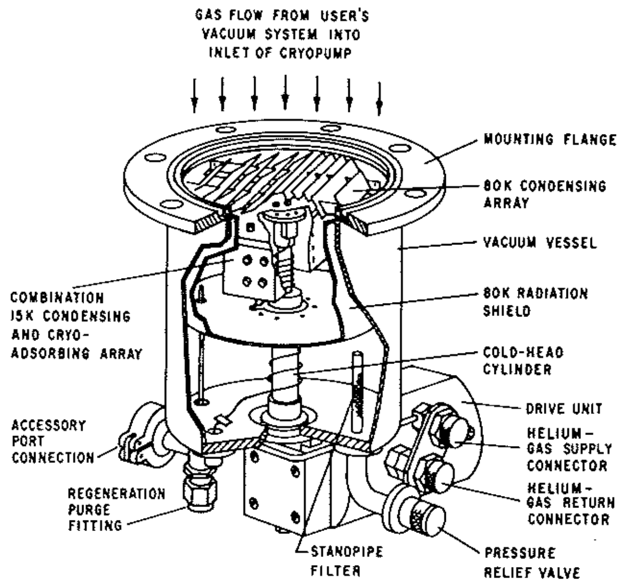
Figure 1.2 shows cutaway views of the cryopumps. The CT-8F cryopump is virtually identical in operation to the CT-8 and is of a flat pump design that offers a dimensional alternative when vertical space is limited. The CT-8F cryopump is available with gas and electrical connectors facing in either a left or right direction to match your piping and electrical interface.

1.2 Installation, Operation and Servicing Instructions

Installation, Operation and Servicing Instructions for your Cryo-Torr vacuum pump provide complete and easily accessible information. All personnel with installation, operation, and servicing responsibilities should become familiar with the contents of these instructions to ensure safe, reliable, and efficient cryopump performance.



CT-100



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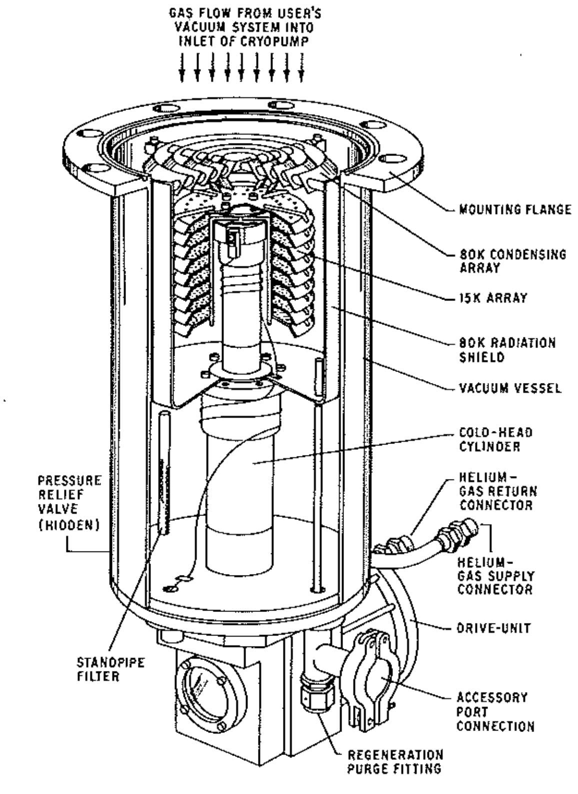

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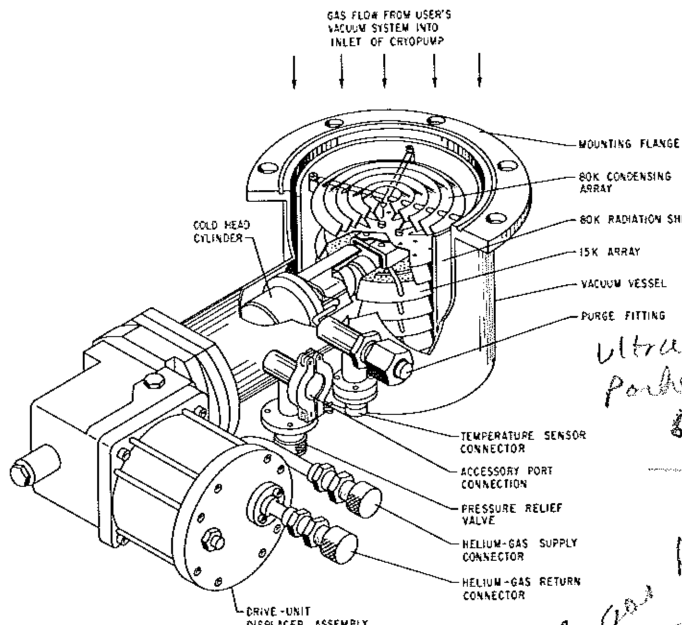


CT-8F

Figure 1.2 Cutaway views of Cryo-Torr Cryopumps

Table 1.1 Cryopump Specifications

WEIGHT (APPROXIMATE)				
			SHIPPING WEIGHT	
CRYOPUMP	LBS	KG	LBS	KG
CT-100	22	10	30	11
CT-7	25	11	32	14.5
CT-8	45	20	50	23
CT-8F	42	20	47	21

PUMPING SPEEDS (LITER/SECOND)				
CRYOPUMP	WATER	AIR	HYDROGEN	ARGON
CT-100	1,000	350	480	285
CT-7	3,600	1,000	1,000	850
CT-8	4,000	1,500	2,500	1,200
CT-8F	4,000	1,500	2,200	1,200

CROSSOVER (MAXIMUM GAS BURST)	
CRYOPUMP	TORR-LITERS
CT-100	40
CT-7	50
CT-8	150
CT-8F	150

CONDENSABLE GASES CAPACITY (ARGON, NITROGEN, OXYGEN, ETC.)		
CRYOPUMP	STANDARD LITERS	TORR-LITERS
CT-100	90	68,400
CT-7	350	266,000
CT-8	1,000	760,000
CT-8F	1,000	760,000

Table 1.1 Cryopump Specifications (Cont.)

Capacity:

HYDROGEN GAS CAPACITY			
CRYOPUMP	HYDROGEN PARTIAL PRESSURE (TORR)	STANDARD LITERS	TORR-LITERS
CT-100	5×10^{-8}	1	760
CT-100	5×10^{-6}	2	1,520
CT-7	5×10^{-8}	2	1,520
CT-7	5×10^{-6}	4	3,040
CT-8	5×10^{-8}	6	4,560
CT-8	5×10^{-6}	12	9,120
CT-8F	5×10^{-8}	4	3,040
CT-8F	5×10^{-6}	8	6,080

ARGON THROUGHPUT (MAXIMUM)		
CRYOPUMP	SCC/MINUTE	TORR-LITERS/ SECOND
CT-100	75	0.95
CT-7	75	0.95
CT-8	700	8.9
CT-8F	700	8.9

Interface connections

Helium supply and return piping
10 ft. (3 m) each with 1/2-inch self-sealing couplings. (Longer lengths, elbows and tees available.)

Cold-head power cable
10 ft. (3 m). (Longer lengths available.)

Temperature sensor
(a) Hydrogen-vapor-pressure gauge
(b) Diode temperature sensor connector mates with Amphenol P/N 48-16R-10-55/48-23-41

Accessory port connection (Roughing)
Supplied by CTI
NW-25 ISO-KF flange
(with clamp and blank flange)

Regeneration purge fitting
Supplied by CTI
Parker CPI ULTRASEAL SIZE 6
(with plug and nut)

Note:
The cryopump may be operated in any position.

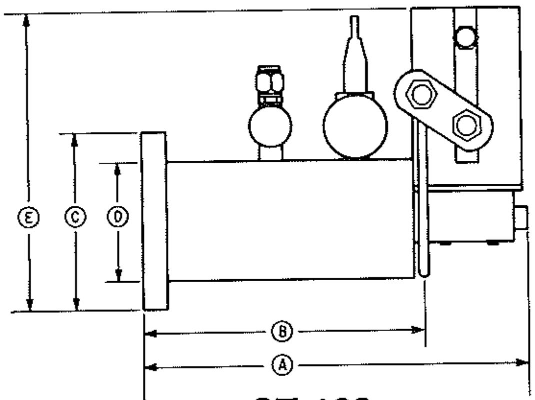
Table 1.1 Cryopump Specifications (Cont.)

Interface dimensions:

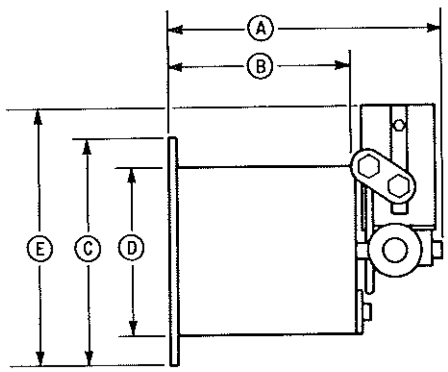
Note: The dimensions present below are basic interfacing dimensions required for cryopump installation. If additional dimensions are required, contact your sales representative or the Order Processing Department to obtain an interface drawing for your particular cryopump.

DIMENSIONS					
CRYOPUMP	A (in./mm)	B (in./mm)	C (in./mm)	D (in./mm)	E (in./mm)
CT-100					
(MET.SEAL)	12.9 (328)	9.4 (240)	6 (152)	3.9 (99)	10 (256)
(ISO)	12.8 (323)	9.3 (235)	5.12 (130)	3.9 (99)	10 (256)
CT-7					
(ISO)	13.25 (337)	9 (229)	9.5 (130)	7.9 (200)	11.8 (300)
(ANSI)	13.25 (337)	9 (229)	11 (279)	7.9 (200)	12.6 (320)
(UHV)	13.25 (337)	9 (229)	10 (254)	7.9 (200)	12 (307)
CT-8					
(ANSI)	20.7 (526)	13.8 (351)	11 (279)	8 (203)	14.5 (370)
(MET.SEAL)	20.7 (526)	13.8 (351)	10 (254)	8 (203)	14.5 (370)
(UHV)	20.7 (526)	13.8 (351)	10 (254)	8 (203)	14.5 (370)
(ISO)	20.7 (526)	13.8 (351)	9.5 (240)	8 (203)	14.5 (370)
CT-8F					
(ANSI)	22.6 (574)	15.8 (402)	11 (279)	8 (203)	14.5 (370)
(ISO)	21.8 (555)	15 (381)	9.5 (240)	8 (203)	14.5 (370)

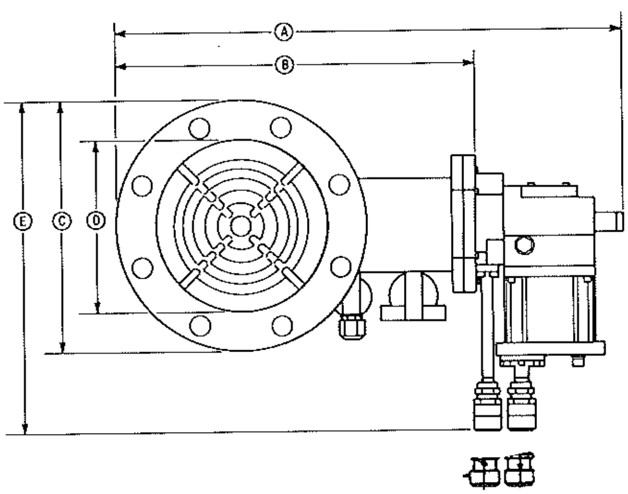
**Note:* CT-8F depth dimensions is 7.1 in. (179.6 mm) approximate



CT-100



CT-7



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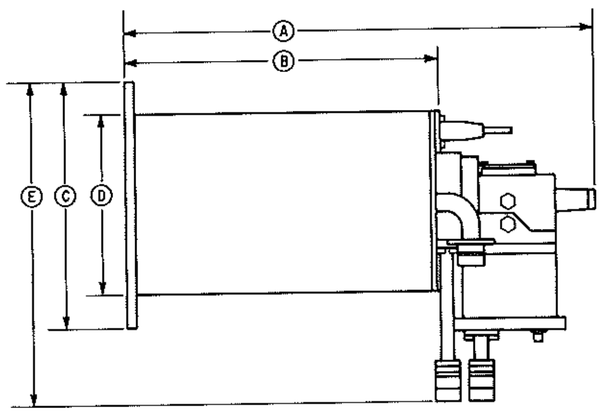


CT-8

Section 2: Inspection

2.1 Packaging of the System

A Cryo-Torr High-Vacuum Pump System is packaged in three or four separate cartons, depending upon whether an 8300 or Model SC Compressor is used. Listed below are the contents of each carton, as they relate to these two compressor applications. Note that an Installation, Operation, and Servicing Manual is included in cartons for the high-vacuum pump, compressor and controller; each manual covers the component packaged in that carton.

When installing a Cryo-Torr High-Vacuum Pump System, CTI recommends that as you unpack a component; you then perform an inspection and the necessary tasks for system installation for the component according to the manual (included with the component). Final system installation and operation will be performed following procedures in the cryopump manual (M8040240).

2.2 The Cryopump

On receipt, remove the cryopump from its shipping carton and inspect the cryopump for evidence of damage. Report any damage to the shipper at once. Also, retain the shipping cartons for use in storage or return shipment.

Inspect the cryopump for damage by examining the following:

1. Overall exterior.
2. Mounting flange and its sealing surfaces after removing the protective cover.
3. Louver assembly of the 80K condensing array. Replace the protective cover.

For Your Information --

If you are already familiar with the details of cryopump installation, proceed directly to Section 3 so your cryopump can be made operational quickly. If not, proceed to Section 4 for detailed installation procedures.

	COMPRESSOR USED		
CARTON LABEL	8300	MODEL SC (AIR)	MANUAL NO.
CRYO-TORR®	Cryopump	Cryopump	M8040240
Compressor	8300 Compressor -----	----- SC (Air) Compressor	M8040241 M8040243
Accessories	Maintenance Tool Kit and Accessories, P/N 8032040G013	Maintenance Tool Kit and Accessories P/N 8032040G004	-----
Controller	8001 or 8002 Controller	-----	M8040241

Section 3: Quick Installation and Startup

Many Users are already familiar with the details of cryopump, controller, and compressor installation, and basic operation. This section presents the installation and startup steps in summary form so that the cryopump can be made operational quickly. Table 3.1, and Figure 3.1, present summary procedures for quick installation and startup. Each step in the table is followed by a reference to the location in the Manual where detailed information is given.

This Section is merely designed to get your system "running". No attempt is made here to present detailed procedures for installing and operating your system. Detailed information is covered in Section 4 and Section 5.

Table 3.1 Summary of Procedures for Quick Installation and Startup

STEP	PROCEDURE (See Figures 3.1 and 3.2)	REFER TO REFERENCE FOR DETAILS
	⚠CAUTION 1. DO NOT connect the controller or cryopump to its power source until all connections have been made between the components of the high-vacuum system. 2. The switch(es) on the front of the controller or compressor must be in the OFF position before making any and all electrical connections.	
1.	Mount the cryopump to the vacuum system.	Section 4.1, page 4-1
2.	Connect roughing system, purge gas system and vent pipe to cryopump.	Section 4.2, thru 4.4 pages 4-1 and 4-2
3.	Connect the helium-gas supply and return lines between the cryopump and the compressor.	Section 4.5, page 4-2
4.	Electrically connect the compressor and controller. (Model 8300 Compressor) a. Connect compressor control cable between controller and compressor. b. Connect controller to compressor power cable.	Section 4.6, page 4-3
5.	Connect cold-head power cable from the cryopump to the controller or compressor.	Section 4.6, page 4-3
6.	Connect the controller or compressor main power cable to the power source.	Section 4.6, page 4-3
	YOUR SYSTEM IS NOW READY FOR OPERATION.	
7.	Start the system by using the system power ON/OFF switch. (On SC Compressor also turn on the cold head switch.)	Section 5.3, page 5-2

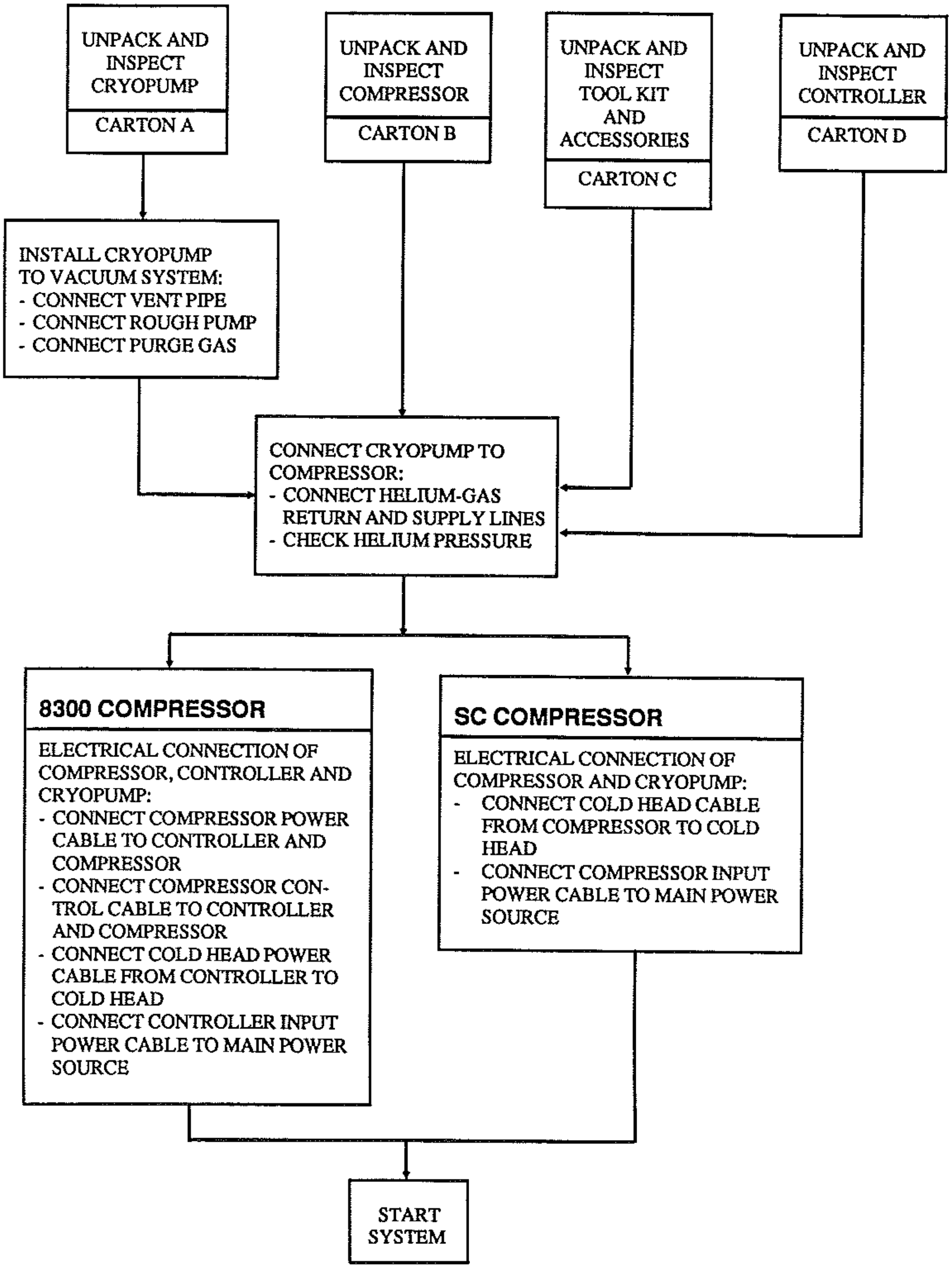


Figure 3.1 Block diagram for system installation

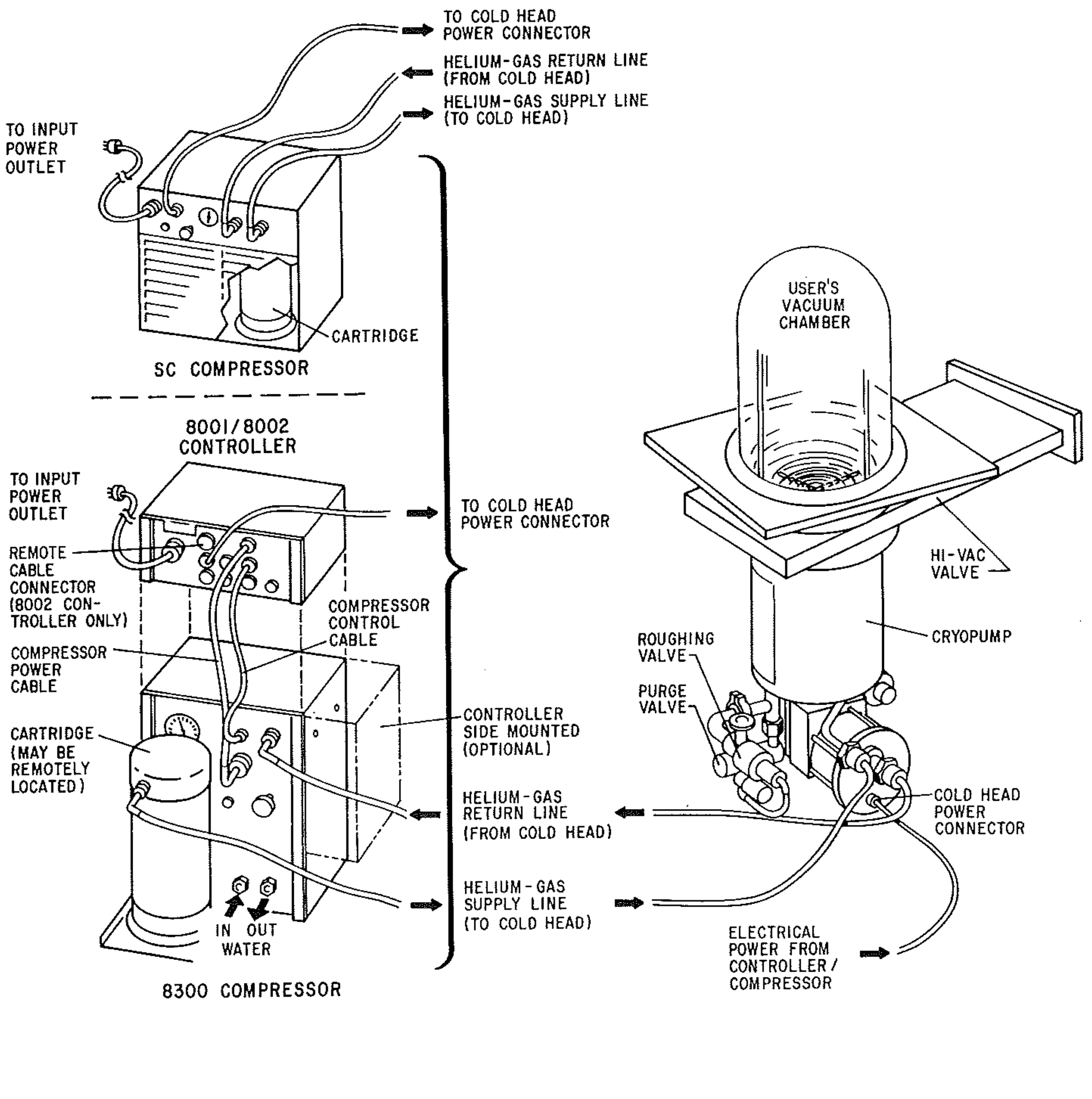


Figure 3.2 Cryopump Interconnection

Section 4: Installation

4.1 Mounting the Cryopump to the Vacuum System

Your cryopump may be installed in any orientation.

Before mounting the cryopump to a vacuum system, an isolation valve (Hi-Vac valve) must be installed between the cryopump and vacuum chamber as a means to isolate the cryopump from the chamber.

To install the cryopump to the vacuum system, refer to Figure 3.2, page 3-3, and proceed as follows:

1. Remove the protective cover from the main flange of the cryopump.
2. Clean all sealing surfaces and install the O-ring or metal seal gasket as appropriate.
3. Mount the cryopump to the Hi-Vac valve or vacuum chamber mounting flange. Be sure all mounting bolts are secure.

4.2 Connecting to Roughing Pump

The roughing pump system connects to the cryopump accessory port. The port will accept an ISO NW-25 flange.

Connect the roughing pump system to the accessory port of the cryopump using a roughing line with the largest inside diameter possible to minimize the roughing time required during startup procedures prior to normal operation.

⚠WARNING

Do not install a hot-filament-type vacuum gauge on the cryopump side of the roughing valve; it could be a source of ignition for flammable gases.

The installation of a DV6M thermocouple (TC) gauge is acceptable providing you install the roughing valve and the TC gauge between the roughing pump system and cryopump. Install the TC gauge and roughing valve as close as possible to the cryopump. A distance of 4 to 6 inches from the cryopump accessory port is desirable.

A molecular sieve roughing trap to minimize oil backstreaming from your roughing pump system may be installed in the roughing pump line near the roughing pump. The trap must be properly maintained.

4.3 Connecting Purge Gas

Connect your purge gas supply to the purge gas heater and purge valve. Adjust the supply pressure to operating pressure of 40 psig minimum and a maximum operating pressure of 100 psig maximum, this will allow for the desired purge gas flow rate for the most efficient regeneration.

4.4 Connecting a Vent Pipe

The cryopump pressure relief valve (shown in Figure 1.2) may be vented directly into the room or can be connected to a vent pipe.

⚠WARNING

- If toxic, corrosive, or flammable gases are pumped, a vent pipe must be connected to the cryopump relief valve and directed to a safe location.
- When connecting a vent pipe to your cryopump, a 1.30 inch diameter x 1.38 inch long volume around the relief valve must remain open.

(Vent pipe adapters are available from CTI-CRYOGENICS (CTI P/N 8080250K008).

4.5 Connecting the Cryopump to the Compressor

Make the connections between the cryopump and compressor. Refer to Figure 3.2, page 3-3, while making the component interconnections.

1. Remove all dust plugs and caps from the supply and return lines, compressor, and cryopump. Check all fittings.
2. Connect the helium-gas return line from the compressor helium-gas return connector to the helium-gas return connector on the cryopump.
3. Connect the helium-gas supply line from the compressor helium-gas supply connector to the helium-gas supply connector on the cryopump.
4. Attach the supply and return line identification decals (CTI supplied) to their respective connections.
5. Verify proper helium static pressure by confirming that the helium pressure gauge on the compressor reads 245-250 psig (1690-1725 kPa) in an ambient temperature range of 60 to 100°F (16 to 38°C).

If the indicated pressure is higher than 250 psig (1725 kPa), reduce the pressure as follows:

1. Remove the flare cap from the gas charge fitting located on the rear of the compressor.
2. Open the gas charge valve very slowly. Allow a slight amount of helium gas to escape until the helium pressure gauge reads 250 psig (1725 kPa).
3. Close the gas charge valve and reinstall the flare cap.

If the indicated pressure is lower than 245 psig, (1690 kPa), add helium gas as described in Section 7.4, page 7-2.

4.6 Connecting Power Cables

> **⚠CAUTION**
>
> 1. The switch(s) on the front of the controller or compressor must be in the OFF position before making any and all electrical connections.
> 2. Do not connect the controller or compressor to its power source until all connections have been made between the components of the high-vacuum pump system.

1. Check to insure the following electrical cables are properly connected between the controller and the compressor: (8300 Compressor only)
   a. The compressor control cable between the controller and compressor.
   b. The compressor power cable.
2. Check to insure the cold-head power cable is properly connected to the cold head.
3. Check to insure the controller or compressor main power cable is properly connected to the main power source.
4. Your system is now ready to operate.

4.7 Multi-Cryopump Installation Using 8300 Compressor

> **For Your Information --**
>
> Contact the CTI-Application Engineering Department for specific hardware and gas pressure requirements before installing your multiple cryopumps and 8300 Compressor. If you have installed your cryopumps and desire to establish the static pressure for your system refer to procedures in this section.

To establish the appropriate gas charge pressure of a multiple (2) cryopump (CT-100) and 8300 Compressor installation using interconnecting lines totaling more than 10 feet (on either the supply or return side) proceed as follows:

1. Connect the multiple cryopump system as shown on Figure 4.1. This figure depicts a typical multi-cryopump installation with an 8300 Compressor and 8002 Controller. Note that the cable is connected from the controller to each cold head; also, the components are helium connected in parallel (all supply fittings piped together).
2. Check the static charge of the system and add or discharge helium gas as required to bring the static pressure to 245-250 psig (1690-1725 kPa). (Follow the procedures as descirbed in Section 7.4 to add helium or procedures in Section 4.5 to discharge helium).
3. Start the system.
4. Approximately 10 minutes after start-up, note the pressure on the return gauge on the helium compressor. Adjust the pressure by adding or discharging helium to 85-95 psig (585-655 kPa).
5. Allow the system to run until both cryopumps have attained a temperature less than 20K.
6. Again adjust the pressure as in step 4 above, until the return gauge in the compressor is reading 105-115 psig (725-780 kPa).
7. Shut off the system and allow it to reach room temperature (approximately 3 hours without regeneration). Note the static pressure in the system. It should not exceed 255 psig (1755 kPa). This then becomes the static pressure of your multiple cryopump installation.

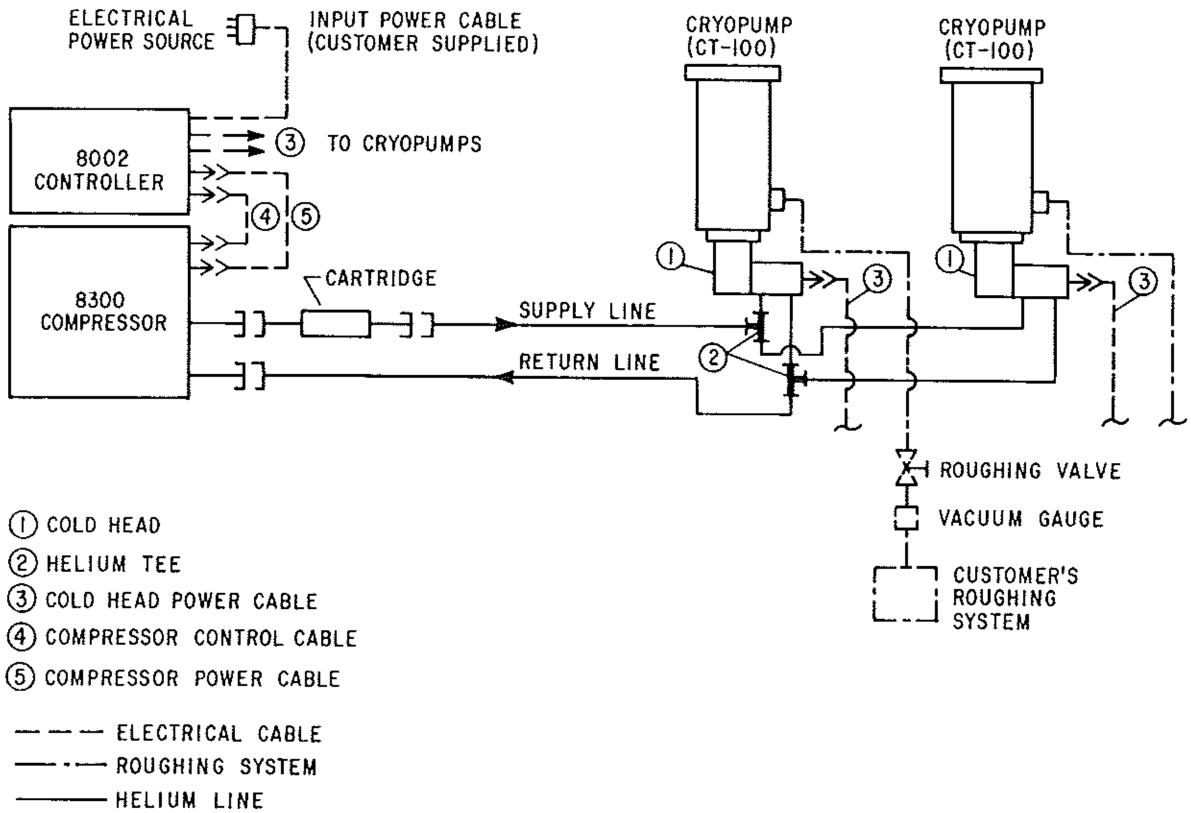


Figure 4.1 Multiple cryopump installation with 8300 Compressor powered by 8002™ Controller

Section 5: Operation

5.1 Before Startup

Before beginning system operation make certain all the steps in the inspection and installation procedures have been completed and confirmed.

Operating Log

It is advisable to create and maintain an operating log. The record will assist in troubleshooting should problems arise. The log should include as a minimum the following data: the cooldown time to 20K; the roughing time to 50μ; the time to base pressure at crossover; the time between regeneration; and, the compressor pressure reading. These recorded values are useful for future performance reference.

5.2 Rough Pumping (Preliminary Vacuum Pumping)

It is not necessary to rough pump the cryopump to very low pressures. Experience has shown that a roughing pressure between 50 and 75 microns is all that is required. This pressure can be measured with a DV-6M thermocouple (TC) gauge mounted as close as possible to the roughing port.

5.3 Rate of Rise (ROR)

Rate of pressure rise in a newly installed cryopump is an important measure of the tightness of your installation. This is obtained by closing the roughing valve (see Figure 3.2, page 3-3) when the pressure has reached 50-75 microns. Observe the rate of pressure rise over the five-minute period. A rise of less than 10 microns/minute over a five-minute period (50-microns total) is an indication of the integrity and cleanliness of the cryopump. If the total ROR is greater than 50 microns, repurge the cryopump, check for evidence of leaks, and repeat the roughing cycle and ROR.

Note: Such a procedure may be adapted to quickly check the integrity/cleanliness of your process chamber.

5.4 Startup and Cooldown

1. Before startup confirm the following:
   a. That the Hi-Vac valve to your vacuum chamber is closed.
   b. That the pressure in your cryopump is approximately 100 microns.
2. Turn on the system power ON/OFF switch on the controller/compressor.
3. Note the helium pressure and temperature reading during the initial cooldown. Typical values during cooldown are given in Table 5.1. If the cryopump has not achieved a second stage temperature of 20K or less in the time specified in Table 5.1 with the Hi-Vac valve closed, refer to the Appendix A, Troubleshooting the Cryopump.
4. When the cooldown temperature of 20K or less is reached, the cryopump is ready for normal vacuum operation. An additional 30 minutes will often permit the cryopump to reach "bottom-out" temperature.
5. Record the time that was required to reach 20K in your log; also record the compressor return gas pressure at 20K. This value can be useful for future evaluation of cryopump performance.

Table 5.1 Typical Pressure Variations During Cooldown and Normal Operation (All Values Nominal)

CRYOPUMP MODEL (QTY. USED)	COMPRESSOR MODEL (CONTROLLER) MODEL	TIME	NOMINAL HELIUM PRESSURE PSIG (kPa)*	TEMPERATURE INDICATOR READING (k)	H_2Vp READING (psia)
CT-7 or CT-100 (1)	8300 (8001, 8002)	Before startup **60 mins. after startup**	250 (1725) 95 (655)	300 20	--- $\leq$ 20
CT-8 (1) or CT-8F (1)	8300 (8001, 8002)	Before startup **90 mins. after startup**	250 (1725) 105 (725)	300 20	--- $\leq$ 20
CT-100 (2)	8300 (8002)	Before startup **60 mins. after startup**	250 (1725) 95 (655)	300 20	--- $\leq$ 20
CT-100 (1)	SC	Before startup **120 mins. after startup**	225 (1550) 250 (1725)	300 10-20	--- $\leq$ 20
CT-7 (1)	SC	Before startup **90 mins. after startup**	225 (1550) 250 (1725)	300 10-20	--- $\leq$ 20
CT-8 or CT-8F	SC	Before startup **90 mins. after startup**	247 (1707) 280 (1930)	300 10-20	--- $\leq$ 20

*Center point of needle swing

5.5 Normal Operation

The Cryo-Torr high-vacuum pump system is designed to operate without operator assistance.

As an aid to evaluating performance it may be advantageous to record basic parameters at a regularly scheduled period. An ideal time is to coordinate this practice with other maintenance items or whenever regeneration is required. On new systems record this data at least on a monthly basis.

5.6 Cryopump Oxygen Procedures

⚠WARNING

Combustion supported by oxygen in the pump could cause severe injury. When oxygen is used as a process gas, special precautions should be taken.

When using oxygen as a process gas, it is strongly recommended that as a minimum, the following precautions be taken.

1. Follow all cryopump operating instructions including:
   - Insure that there are no sources of ignition (e.g., hot filament vacuum gauges) on the cryopump side of the Hi-Vac valve operating during the warming or venting of the pump.
   - Perform inert gas purge regenerations at flow rates recommended for cryopumps.
2. Regenerate as frequently as practical to minimize the amount of oxidizer present in the cryopump.
3. Provide proper and appropriate venting for the cryopump relief valve to vent exhaust gases.
4. Any system exposed to richer-than-air oxygen levels should be prepared for oxygen service per the manufacturer's recommendations, including use of oxygen service lubricating oils in roughing pumps.

⚠WARNING

Explosion occurring from ozone in the pump could cause severe injury. Ozone can be present as a by-product of oxygen processes. If ozone is present, special precautions described in the text below must be taken.

Ozone may be unknowingly produced in an ionizing process (e.g., sputtering, etching, glow discharge). Explosive conditions may exist if ozone is present, especially during warming of the cryopump. Signs of ozone's presence are:

1. Crackling/popping sounds (as in electrical arcing) occurring within the first few minutes of regeneration.
2. Gas venting from the cryopump during regeneration may have a pungent smell, similar to that present in an arc welding operation or after an electrical storm.

   Note: A change in process may increase the amount of ozone present.

If ozone is present, the following precautions must be taken, in addition to those already mentioned.

1. The required regeneration frequency should be increased depending upon flow and process conditions. Daily regeneration may be required. (Call CTI-CRYOGENICS for assistance.)
2. Reduce the oxygen mixture to the absolute lowest level the process will allow.
3. Be sure that the system is properly vented to a scrubber or to a safe area preferably outdoors.

5.7 Determining Crossover Pressure

Crossover is that point in time when the pumping of a vacuum chamber is switched from "rough" pumping to "high-vacuum" pumping. Rough pumping brings the vacuum chamber pressure from one atmosphere (760 torr) down to a pressure of about 0.5 torr. At crossover the roughing valve is closed and the high-vacuum valve opened bringing the vacuum chamber down to a pressure typically less than 10^{-6} torr. This momentary "pulse" of gas and water molecules is cryo-condensed on the arrays of the cryopump.

To determine the maximum permissible CROSSOVER PRESSURE (CP) perform the following calculation using the CROSSOVER VALUES (CV) for your Model cryopump shown in the table below and the actual VOLUME OF YOUR CHAMBER (VC).

CROSSOVER VALUES (CV)	
CRYO-TORR	TORR-LITERS
CT-100	40
CT-7	50
CT-8	150
CT-8F	150

Example: (For CT-8/8F)
(Volume of chamber = 100 liters)

$$CP = \frac{CROSSOVER\ VALUE}{VOLUME\ OF\ CHAMBER} = \frac{CV}{VC}$$

$$CP = \frac{150\ torr\text{-}liters}{100\ liters} = 1.5\ torr$$

For Your Information --

The calculated crossover pressure may not be optimized for your system. To help prevent any back streaming during the roughing of the vacuum chamber, you should stop roughing at as high a pressure as possible. The optimum crossover pressure for a vacuum chamber should cause a very slight rise in temperature with a rapid recovery. Increase the roughing pressure in small increments (15 to 20%) until this rise in temperature is noted; then drop the value by a small amount (10%), this will be the optimum pressure for that vacuum chamber.

5.8 Determining Cryopump Capacity for Condensable Gases

Cryopump capacity is defined as the total standard liters of a gas that can be accomodated within a cryopump prior to regeneration. The number of hours between regeneration cycles can be easily calculated in the case of a continuous gas flow of a known gas species:

$$A = \frac{16.6 \times C}{B}$$

A = Duration of operation with a continuous gas flow (hours)
B = Gas Flow (scc/min.)
C = Cryo-Torr capacity for the particular gas species being flowed (std liters); refer to the following Table.

CONDENSABLE GASES CAPACITY (ARGON, NITROGEN, OXYGEN, ETC.)		
CRYOPUMP	STANDARD LITERS	TORR-LITERS
CT-100	90	68,400
CT-7	350	266,000
CT-8	1,000	760,000
CT-8F	1,000	760,000

Example: (For CT-8/8F)
For a sputtering application of continuously flowing argon gas at 70 scc/min., the duration of continuous operation with this gas flow (between regenerations) would be:

$$A = \frac{16.6 \times 1000\ (std\ liters)}{70\ (scc/min.)} = 237\ hours$$

5.9 Determining the Number of Crossover Cycles

The number of crossover cycles between regenerations can also be easily calculated when the crossover pressure and vacuum chamber volume are known:

$$N = \frac{760{,}000 \text{ torr liters}}{P \times V}$$

N = *Number of crossover cycles*
V = *Volume of vacuum chamber (liters)*
P = *Pressure of vacuum chamber prior to crossover (torr) (roughing pressure)*

Example:
For a vacuum chamber of 100 liters and a roughing pressure of 1.5 torr, the number of crossover cycles between regenerations would be:

$$N = \frac{760{,}000 \text{ torr liters}}{1.5 \text{ (torr)} \times 100 \text{ (liters)}} = 5{,}060 \text{ cycles}$$

5.10 Cryopump Shutdown Procedures

Typically a cryopump can be left in operation continuously if you are not processing or not using the vacuum chamber, by simply closing the Hi-Vac valve to isolate the cryopump from your vacuum chamber. You are now able to load, unload, repair or replace components in the chamber and the cryopump will be available for restart of the process as necessary.

If you are planning to shut down the cryopump it is recommended that the cryopump be shut off and a gas purge be initiated and continued until the cryopump has reached room temperature. At this point it can be held under positive pressure, and rough pumped prior to startup.

5.11 Cryopump Storage

If the cryopump is stored while still attached to your vacuum system, the cryopump vacuum vessel should be kept at slight positive atmospheric pressure with dry nitrogen or argon.

If the cryopump is removed from your vacuum system, install the protective cover on the mounting flange of the cryopump vacuum vessel inlet before storage.

The remaining components of your Cryo-Torr high-vacuum pump systems are fully protected during storage if kept under positive helium pressure and all component connections left connected. Periodically check the helium supply pressure gauge on the compressor. If the gauge reads below 245 psig (1690 kPa) or 220 psig (1515 kPa) for CT-100/7, add helium as described in Section 7.4, page 7-2.

5.12 Hazardous Materials

⚠WARNING

If the cryopump has been used to pump toxic or dangerous materials, you must take adequate precautions to safeguard personnel. If such a cryopump is shipped to a Product Service Department, clearly mark on all storage cartons the identity of the toxic or dangerous materials to which the cryopump has been subjected. All shipped equipment that contains hazardous/toxic materials must conform to DOT regulations.

Section 6: Regeneration

6.1 Introduction

The cryopump periodically requires regeneration to return it to its original operating capabilities.

Gases captured from a vacuum chamber and trapped in the cryopump through condensation and cryo-adsorption are held primarily in an ice-like form. Regeneration removes trapped gases through a process similar to defrosting a refrigerator freezer compartment.

During regeneration the cryopump is warmed to room temperature or higher, allowing trapped gases to change from a solid state to a gaseous state and are thereby released from the cryopump through the pressure relief valve to the atmosphere.

⚠WARNING

Toxic, corrosive, or flammable gases must be safely vented to prevent harm to personnel and to avoid equipment damage. If a large amount of oxygen has been cryopumped, refer to Section 5.6, page 5-3.

6.2 When to Regenerate

The need to regenerate the Cryo-Torr high-vacuum pump as a result of saturation is a function of the cryopump capacity and the process gas throughput.

If the cryopump becomes incapable of maintaining a high-vacuum (typically an increase in your vacuum chamber base pressure by a factor greater than 10, even though the cold head and compressor unit are operating satisfactorily), the cryopump requires regeneration.

It is recommended that your cryopump be regenerated on a regular schedule coinciding with system maintenance, weekend system shutdown, etc. A suitable time interval between regenerations can be determined by experience.

Data aiding calculation of gas saturation levels may be obtained in Section 5.8, page 5-4, Determining Cryopump Capacity for Condensable Gases.

Extended loss of electrical power (10 minutes or longer), system vacuum failure, such as venting with a partially open vacuum isolation valve, and operator error may necessitate cryopump regeneration.

Note: Short term electrical outages of up to 10 minutes should not result in the need to regenerate your cryopump.

6.3 Assisted Regeneration

Regeneration incorporating the use of heated dry inert purge gas (nitrogen/argon) is the preferred method of regeneration and will overcome the unassisted regeneration technical difficulties by:

1. Minimizing the required time to bring the condensing and cryo-adsorbing arrays to room temperature.
2. Reducing the time required to rough the cryopump because the dry inert purge gas will minimize the amount of residual water vapor in the 15K array.
3. Diluting hazardous gases and ensuring their removal from the cryopump housing.

REQUIRED ACCESSORIES FOR ASSISTED REGENERATION	
DESCRIPTION	**PART NUMBER**
Purge gas heater	8080250K020
Purge gas solenoid valve	8080250K023

To accomplish assisted regeneration with heated dry purge gas:

1. Close the Hi-Vac isolation valve.
2. Shut off the cryopump using the system power ON/OFF switch on the controller or the compressor.
3. ***Immediately*** introduce heated dry purge gas through the vacuum vessel purge fitting at approximately 150°F (66°C) and at a flow rate of 1-2 cfm. Allow the purge gas to vent through the "poppet" relief valve.

flow ~ 1/2 hr

4. Halt the gas purge when the condensing arrays reach 80°F (26°C) (300k).
5. When the condensing arrays reach ambient temperature, rough the cryopump to an initial starting pressure, usually between 50 and 100 microns. After roughing, you can perform a simple check (1) to ensure that your cryopump regeneration has been thorough, and (2) that no air-to-vacuum leaks are present. The check is called a "rate of rise" (ROR).

   Upon completion of your roughing cycle (to 50 or 100 microns), close the roughing valve and observe the "rate of pressure rise" (ROR) over a five-minute period. The ROR should be less than 10 microns/minute over a five-minute period (50-microns total). If the ROR is greater than 50 microns, repurge the cryopump, check for evidence of leaks, and repeat the roughing cycle and ROR.

6. Close the cryopump roughing valve and start the cryopump.
7. The cryopump is ready for use when the second-stage array reaches a temperature of 20K or lower.

Section 7: Maintenance Procedures

7.1 Scheduled Maintenance

The only scheduled maintenance required on the Cryo-Torr High-Vacuum Pump System is the annual replacement of the cartridge P/N 8080280K001 (for 8300 Compressor) or P/N 8080255K001 (for SC Compressor).

The procedures for removing and replacing the cartridge are included in the Compressor Manual.

7.2 Unscheduled Maintenance

There are several maintenance items that may arise on an unplanned basis. These items generally do not occur frequently but when they do, some specialized procedures are necessary. They are as follows and are listed in their general order of frequency of occurrence.

1. Cleaning or replacing the cryopump arrays.
2. Adding helium gas.
3. Decontaminating the helium circuit.

Suggested Maintenance Equipment

It is advisable to have available the equipment and disposable supplies listed below.

1. Helium, 99.999% pure.
2. Indium gasket 0.005-inch thick, 3" x 3" sheet, P/N 3543738P001.
3. Maintenance manifold, P/N 8080250K003*.
4. Pressure regulator (0-3000/0-400 psig).
5. Helium charging line terminating in a 1/4-inch female flare fitting (P/N 7021002P001).
6. Installation Tool Kit, P/N 8032040G013. Supplied with Cryo-Torr High-Vacuum Pump.
7. Lint-free gloves and cloth.
8. Oakite or equivalent detergent soap.
9. Denatured alcohol.
10. Apiezon™ vacuum grease, P/N 579847*.
11. Torque wrench, 0 to 30 inch-pounds.

*Available from stock; consult the factory or your sales representative.

7.3 Cleaning the Cryopump

⚠WARNING

If the cryopump has been used to pump toxic or dangerous materials, you must take adequate precautions to safeguard personnel.

The arrays or other interior surfaces of the cryopump vacuum vessel seldom require cleaning because dust buildup does not affect performance, and the special alloy copper cryo-condensing arrays are nickel plated for corrosion resistance. Cryopump performance in most cases can be recovered by regeneration. In case of a system malfunction, (i.e., backstreaming of a rough pump oil or "dumping" of a process chamber) saturation or contamination of the 15K cryo-adsorbing array (charcoal) may require more than regeneration. The charcoal array, if not severely contaminated, may be recovered by following the vacuum baking procedures in this section.

If you wish to clean the arrays and other interior surfaces, follow the procedures below. Refer to Appendix B, Illustrated Parts Breakdown while performing these disassembly and reassembly procedures.

1. Confirm that an adequate supply of indium gasket material, P/N 3543738P001, is available.
2. Carefully disassemble the components in the vacuum vessel.
3. Clean the components as follows:

⚠CAUTION

Do not clean the 15K cryo-adsorbing array (charcoal) because you will contaminate it in the cleaning process. Use the vacuum baking procedure to recover a 15K cryo-adsorbing array that is not severely contaminated.

   a. Wash each item in strong soap or detergent solution and hot water.
   b. Rinse the items in <u>clean hot water</u>.
   c. Air or oven dry at 150°F (66°C) maximum.

4. To clean a 15K cryo-adsorbing array (charcoal) that is not severely contaminated by oil backstreaming or dust particles covering its surfaces, vacuum bake it at a temperature of 150°F (66°C) for at least 2 hours.

   Note: It is good practice to perform this vacuum baking procedure on the 15K array on a regular basis to insure continued efficient cryopump operation.

5. If the 15K cryo-adsorbing array does not require vacuum baking, the array surfaces may be dusted using a lint-free cloth lightly moistened with denatured alcohol. Allow the array to air dry before assembly.
6. Wearing lint-free gloves, reassemble the cryopump. Replace any indium gasket damaged during disassembly.
7. Hold the torque on all screws that compress indium gaskets for a minimum of 5 seconds to allow proper gasket seating.

SCREW THREAD	TORQUE (INCH-POUNDS)
No. 4-40	11
No. 6-32	20
No. 10-32	30

7.4 Adding Helium Gas

⚠CAUTION

If the compressor helium pressure gauge reads less than 30, decontamination is required. Refer to decontamination procedures on page 7-4 or contact the Product Service Department.

There are two conditions that require the addition of helium gas:

1. Compressor not operating; helium pressure gauge reads 245 psig (1690 kPa), or below.
2. Compressor operating; helium pressure reads below that specified in the following Table.

Typical Pressure During Normal Operation (CT-100, 7, 8 and 8F)

CRYOPUMP (NO. USED)	HELIUM PRESSURE PSIG (kPa)*	
	8300 COMP.	SC COMP.
CT-100 (1) CT-100 (2)	95 (655) 115 (790)	250 (1725) 280 (1930)
CT-7 (1)	95 (655)	250 (1725)
CT-8 (1)	105 (725)	280 (1930)
CT-8F (1)	105 (725)	280 (1930)

*Center point of needle swing

If you need to add helium more than once every 6 months, check for leaks caused by improperly connected self-sealing connections on interconnecting components or any mechanical joint within the compressor.

A User-supplied helium charging line terminating in a 1/4-inch female flare fitting, and a two-stage pressure regulator rated at 0-3000/0-400 psig is required for this operation.

Use only 99.999% pure helium gas.

To add helium gas:

1. Attach a two-stage regulator (0-3000/0-400 psig) and charging line to a helium bottle (99.999% pure). DO NOT OPEN THE BOTTLE AT THIS TIME. Purge the regulator and charging lines as instructed in steps a through d below. Do *not* use helium gas that is *less than 99.999% pure.*

   a. Open the regulator a small amount by turning the adjusting knob clockwise until it contacts the diaphragm, then turn approximately 1/8 to 1/4 turn more, so that the regulator is barely open.

   b. Slowly open the bottle valve, and purge the regulator and line for 10 to 15 seconds. Turn the regulator knob counterclockwise until the helium stops flowing.

   c. Loosely connect the charge line to the helium pressure regulator.

   d. Purge the charge line again, as in step a, for 30 seconds, and tighten the charge line flare fitting onto the helium pressure regulator while the helium is flowing.

This procedure is required to ensure that both the regulator and the charging line will be purged of air and that the air trapped in the regulator will not diffuse back into the helium bottle. For best results, CTI suggests a dedicated helium bottle, regulator, and line, which are never separated, for adding helium.

2. Remove the flare cap of the gas charge fitting on the rear of the compressor.

3. Attach the charging line from the helium pressure regulator to the 1/4-inch male flare fitting installed on the helium charge valve.

4. Set the helium pressure regulator to 300 psig (2070 kPa). Depending on the compressor operating state, add helium gas:

   a. If the compressor is running under normal operating conditions, slowly open the helium charge valve on the rear of the compressor. When the helium pressure gauge rises to that specified in the Table above, tightly close the charge valve.

   b. If the compressor is not running, slowly open the helium charge valve. When the helium pressure gauge rises to 245-250 psig (1690-1725 kPa), tightly close the charge valve.

5. Ensure that the helium charge valve on the compressor is tightly closed. Shut off the helium pressure regulator on the helium bottle and remove the charging line from the male flare fitting. Reinstall the flare cap.

7.5 Helium Circuit Decontamination

Contamination of the helium-gas circuit is indicated by sluggish or intermittent operation (ratchetting) of the cold head drive mechanism. With severe contamination the cold head drive may seize and fail to operate. One of the major sources of contamination is using helium gas of less than the required purity. When performing the decontamination process, use only 99.999% pure-helium gas, and the regulator and charging line must be properly connected and purged.

This decontamination procedure will remove contaminants from the cold head and/or compressor, thereby restoring system performance. The cold-trapping of contaminants inside the cold head during this procedure also decontaminates the compressor if the contamination is not severe. (Separate decontamination of the compressor is required whenever the compressor has been opened to atmosphere, or the pressure dropped to zero.)

7.5.1 Cryopump Decontamination Procedures

1. Cool down the cryopump and operate it for one to three hours. (If the system will not cool down, proceed to step 2.) Operating the cryopump will isolate the contaminants by coldtrapping them in the cold head. The longer the cryopump is operated beyond the one-hour period, the greater is the amount of contamination that becomes isolated inside the cold head.
2. Shut down the cryopump per Section 5.10, page 5-5.
3. Immediately disconnect the helium-gas supply and helium-gas return lines from the gas-supply and gas-return connectors at the rear of the compressor. Leave them attached to the cold head.
4. Attach the maintenance manifold (P/N 8080250K003) to the disconnected ends of the helium-gas return and helium-gas supply lines.
5. Reduce the pressure in the cold head to a level of 45 psig by using the maintenance manifold.
6. Allow the second stage of the cold head to warm up to room temperature. Warmup time can be reduced by purging the cryopump with warm dry argon or nitrogen gas. Using the gas heater, CTI P/N 8080250K020, will reduce warm-up time about 50 percent, and will maintain the gas temperature below the 150°F (66°C) limit.
7. Once the cryopump has reached room temperature, attach a two-stage regulator (0-3000/0-400 psig) and charging line to a helium bottle (99.999% pure). DO NOT OPEN THE BOTTLE AT THIS TIME. Purge the regulator and charging lines as instructed in steps a through d below. Do *not* use helium gas that is *less than 99.999% pure*.
   a. Open the regulator a small amount by turning the adjusting knob clockwise until it contacts the diaphragm; then turn approximately 1/8 to 1/4 turn more, so that the regulator is barely open.
   b. Slowly open the bottle valve, and purge the regulator and line for 10 to 15 seconds. Turn the regulator knob counterclockwise until the helium stops flowing.
   c. Loosely connect the charge line to the 1/8-inch valve on the maintenance manifold.
   d. Purge the charge line again, as in step a, for 30 seconds, and tighten the charge line flare fitting onto the valve while the helium is flowing.

This procedure is required to ensure that both the regulator and the charging line will be purged of air. For best results, CTI suggests a dedicated helium bottle, regulator, and line, which are never separated, for adding helium.

8. Perform in sequence:
   a. Backfill the cold head with helium to a static charge pressure of 245-250 psig (1690-1725 kPa), by adjusting the regulator to the required pressure, and opening the valve on the manifold. Close the valve when the pressure is correct.

b. Depressurize the cold head by *slowly* opening the ball valve and allowing the helium to bleed out slowly. Do *not* reduce the pressure to *less than* 30 psig or the cold head may be further contaminated.

c. Perform flushing steps a and b three more times.

d. Pressurize the cold head to the static charge pressure of 245-250 psig (1690-1725 kPa) and run the cold head drive motor for 10 to 30 seconds by actuating the controller ON/OFF switch.

e. Perform steps b through d three more times for a total of 20 flushes and a total of 4 drive-motor runs.

9. Verify that the cold head is pressurized to the static charge pressure of 245-250 psig (1690-1725 kPa).

10. Disconnect the maintenance manifold from the helium-gas return and helium-gas supply lines.

11. Reconnect the helium-gas return and helium-gas supply lines to the return and supply connectors at the rear of the compressor. The cryopump is now ready for operation.

7.5.2 Compressor Decontamination Procedures

The procedure to decontaminate a compressor is similar to the above procedure with certain exceptions.

- There is no need to operate the cryopump before decontaminating the compressor.
- The maintenance manifold and flex lines will be connected to the supply and return fittings on the compressor.

1. Depressurize the compressor (if pressurized) SLOWLY to 30 psig by opening the ball valve on the maintenance manifold and allowing the helium to bleed out.
2. Charge the compressor slowly to approximately 250 psig (1725 kPa) by opening the 1/8-inch valve on the maintenance manifold.
3. Run the compressor for about 30 seconds.
4. Repeat steps 1 and 2, one more time.
5. Disconnect the maintenance manifold from the helium-gas return and helium-gas supply lines.
6. Reconnect the helium-gas return and helium-gas supply lines to the return and supply connectors on the cold head. The compressor is now ready for operation.

For Your Information --

After connecting the compressor to the cryopump, and operating the system for a period of time, it may be necessary to decontaminate the cryopump as some residual contamination from the compressor may become trapped in the cold head. If the entire system were reduced to zero psig (a broken flex line for example), then the cryopump and compressor would have to be decontaminated according to the decontamination procedure section, beginning on page 7-4.

Appendix A:
Troubleshooting Procedures

A.1 Troubleshooting the Cryopump

The primary indication of trouble in a vacuum pumping system is a rise in the base pressure of your vacuum chamber. A rise in the base pressure may be caused by a leak in the vacuum system or by a fault in the cryopump i.e., saturation of the 15K cryo-adsorbing charcoal array. (Regeneration may be necessary). If the cryopump temperature is below 20K it must pump at rated capacity; a high base pressure is usually caused by an air-to-vacuum leak in the system.

If you suspect a leak in your vacuum system, isolate the cryopump by closing the Hi-Vac valve and leak check your vacuum chamber. If no leaks are found, a leak may be present below the Hi-Vac valve (cryopump). Leak checking below the Hi-Vac valve should be performed with the cryopump shut off and at room temperature. Leak checking while the cryopump is operating may mask leaks that are present (due to the ability of the cryopump to pump helium). If no leak is found, refer to the cryopump troubleshooting procedures summarized in Table A.1.

The problems presented in the Troubleshooting Table are followed by possible causes and corrective actions. The causes and corresponding actions are listed in their order of probability of occurrence. 1) is most likely, 2) is next most likely, etc.

Maintaining a log of certain parameters during normal operation can be a valuable tool in troubleshooting the cryopump. The parameters included in the log should include as a minimum the following: the cooldown time to 20K; the roughing time to 50μ; the time to base pressure at crossover; the time between regeneration; and the compressor pressure reading.

A.2 Technical Inquiries

Please refer to page ii of this manual for a complete list of the CTI-CRYOGENICS' world wide customer support centers.

Table A.1 Troubleshooting the Cryopump

Problem	Possible Cause	Corrective Action
1) High base pressure of vacuum system; cryopump temperature below 20K.	1) Air-to-vacuum leak in vacuum system.	1) Check the following: a. Vacuum chamber and Hi-Vac valve for leaks. b. Cryopump for leaks. c. Cryopump relief valve for leaks.
	2) High partial pressure of non-condensables (helium, hydrogen, or neon) within the cryopump because the 15K array has reached full capacity.	2) Regenerate the cryopump.
	3) A leak through a roughing valve, purge valve, or other accessory.	3) Check all valves to insure proper seating.
2) High base pressure of vacuum system, and a cryopump temperature *above* 20K.	1) Decrease in cryopump cold head performance.	1) Check compressor gauge for low helium charge pressure. Add gas as necessary.
	2) High partial pressure of non-condensables (helium, hydrogen, or neon) within the cryopump.	2) Regenerate the cryopump.
	3) Excessive thermal load on frontal array.	3) Reduce the thermal radiation load by: a. Shielding the cryopump. b. Lowering the temperature of the radiating surface.

Table A.1 Troubleshooting the Cryopump (Cont.)

Problem	Possible Cause	Corrective Action
3) Cryopump fails to cool down to the required operating temperature; takes too long to reach temperature (20K).	1) Low helium pressure in compressor.	1) Check compressor gauge for low helium charge pressure. Add gas as necessary.
	2) Helium-gas supply/return line incorrectly attached; self-sealing couplings not fully tightened.	2) Check that helium-gas supply line is connected to supply connector and all self-sealing couplings are fully seated.
	3) Vacuum leak in vacuum system or cryopump.	3) Check the following: a. Vacuum chamber and Hi-Vac valve for leaks. b. Cryopump for leaks. c. Cryopump relief valve for leaks.
	4) Incomplete regeneration may not have fully cleaned the adsorbing array. High rate of rise.	4) Regenerate the cryopump.
	5) Compressor problems.	5) Refer to compressor trouble-shooting procedures in Table A.1 of compressor manual.
4) The cryopump makes a growling noise (Model 8300 Compressor).	1) Incorrect position of frequency selector switch S3, or of the voltage selector switch S2.	1) Measure and confirm incoming voltages with values in Table 1.1, of the controller manual; also, confirm correct selector switch settings as described in Section 3.2, page 3-3.

BASIC OPERATING INFORMATION			
CRYOPUMP (NO. USED)	HELIUM PRESSURE PSIG (kPa)* (NORMAL OPERATION-STEADY STATE)		HELIUM STATIC PRESSURE PSIG (kPa)
	8300 COMP.	SC COMP.	
CT-100 (1) CT-100 (2)**	95 (655) 115 (790)	250 (1725) 280 (1930)	245-250 (1690-1725)
CT-7 (1)	95 (655)	250 (1725)	245-250 (1690-1725)
CT-8 (1) CT-8F (1)	105 (725)	280 (1930)	245-250 (1690-1725)

*Center point of needle swing **Powered by 8002 Controller

Appendix B
Illustrated Parts Breakdown

Legend: Figure B.1

ITEM NO.	PART NO.	DESCRIPTION	NO. REQ'D.
--	---	Cryo-Torr 100 Cryopump	1
1	8080006K001	80K Condensing Array	1
2	---	Cap Screw, Hexagon Socket Type, SSTL,#4-40 x 3/8" Lg.	2
3	---	Lockwasher, Split Type, SSTL, #4	6
4	---	Washer, Flat, SSTL, #4	6
5	8080006K003	15K Condensing Array	1
6	---	Cap Screw, Hexagon Socket Type, SSTL, #4-40 x 1/2" Lg.	4
7	---	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 3/8" Lg.	7
8	---	Lockwasher, Split Type, SSTL, #6	7
9	---	Washer, Flat, SSTL, #6	7
10	8080006K004	80K Radiation Shield	1
11	---	Screw, Flat Head, SSTL, #4-40 x 3/8" Lg.	3
12	8080006K003	15K Cryo-Adsorbing Array	2
12A	---	Temperature Sensor	1
13	---	Vacuum Vessel	1
14	---	O-Ring, #600-V1, Viton, Parker	1
15	---	Plug	1
16	---	Nut	1
17	---	Centering Ring	1
18	---	O-Ring, Alcatel	1
19	---	Flange, Blank	1
20	---	Clamp	1
21	8080250K045	Pressure Relief Valve	1
22	---	O-Ring, #2-037, Viton, Parker V337-9	1
23	8080250K010	Drive-Unit-Displacer Assembly	1
24	---	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1/2" Lg.	2
25	---	Lockwasher, Split, SSTL, #10	2
26	---	Cover	1
--	505013	Indium Sheet, 3" x 6" x 0.005" Thick	1

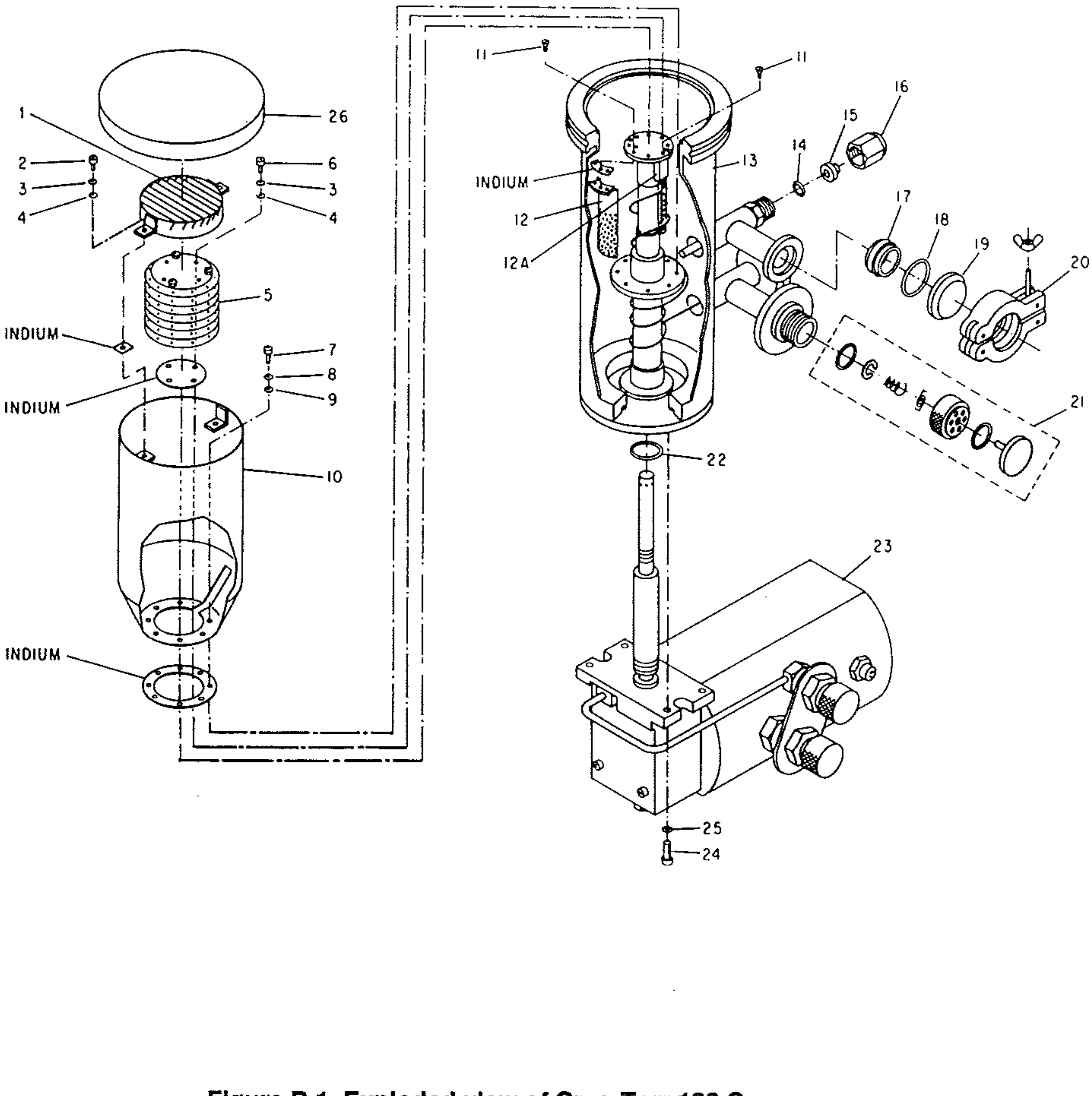
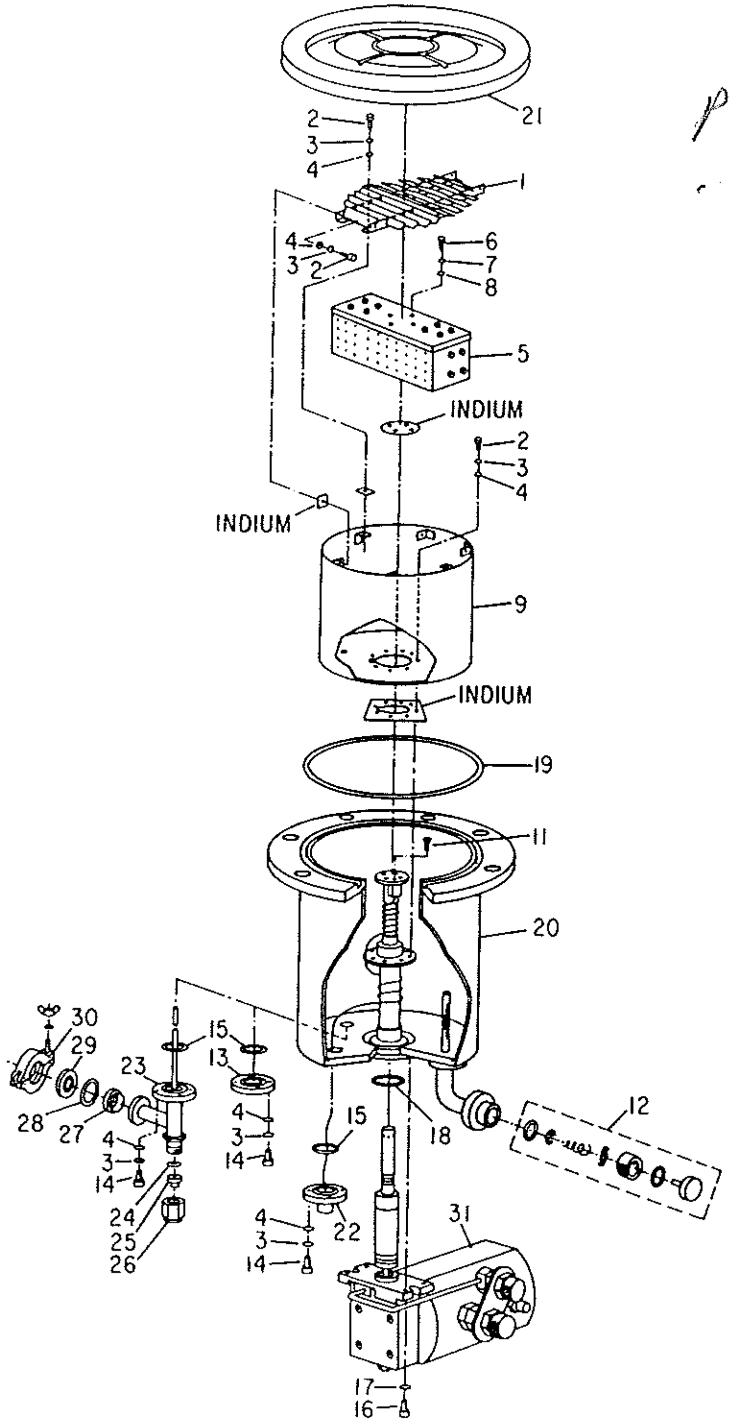


Figure B.1 Exploded view of Cryo-Torr 100 Cryopump

Legend: Figure B.2

ITEM NO.	PART NO.	DESCRIPTION	NO. REQ'D.
--	---	Cryo-Torr 7 Cryopump	1
1	8080001K001	80K Condensing Array	1
2	---	Cap Screw, Hexagon Socket Type, SSTL,#6-32 x 3/8" Lg.	14
3	---	Lockwasher, Split Type, SSTL, #6	22
4	---	Washer, Flat, SSTL, #6	22
5	8080001K003	15K Cryo-Adsorbing Array	1
6	---	Screw, Round Head, Brass, #4-40 x 1/2" Lg.	4
7	---	Lockwasher, Split Type, SSTL, #4	4
8	---	Washer, Flat, SSTL, #4	1
9	8080001K004	80K Radiation Shield	1
10*	8080250K006	Hydrogen-Vapor-Pressure Gauge (Optional)	1
11	---	Screw, Flat Head, Brass, #2-56 x 1/8" Lg.	1
12	8080250K045	Pressure Relief Valve	1
13	8080250K004	Accessory Port Cover	1
14	---	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 1/2" Lg.	8
15	---	O-Ring, #2-20, Viton, Parker, 77-545	2
16	---	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1/2" Lg.	2
17	---	Lockwasher, Split, SSTL, #10	2
18	---	O-Ring, #2-037, Viton, Parker, V337-9	1
19	586441	O-Ring, #2-267, Viton, Parker, V377-9	1
20	---	Vacuum Housing	1
21	---	Cover	1
22	8042033	Diode Temperature Sensor	1
23	8044042G001	Regeneration Purge Fitting	1
24	---	O-Ring, #600-V1, Viton, Parker	1
25	---	Plug	1
26	---	Nut	1
27	---	Centering Ring	1
28	---	O-Ring, Alcatel	1
29	---	Flange, Blank	1
30	---	Clamp	1
31	8080250K010	Drive-Unit-Displacer Assembly	1
--	---	Indium Sheet, 3" x 6" x 0.005"	1

*Not shown in Figure B.2



poppet
· 40 & 80 psi

Figure B.2 Exploded view of Cryo-Torr 7 Cryopump

Legend: Figure B.3

ITEM NO.	PART NO.	DESCRIPTION	NO. REQ'D.
--	---	Cryo-Torr 8 Cryopump	1
1	8080002K001	80K Condensing Array	1
2	---	Cap Screw, Hexagon Socket Type, SSTL,#6-32 x 1/2" Lg.	12
3	---	Lockwasher, Split Type, SSTL, #6	22
4	8080002K010	15K Array Assembly	1
5	---	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 3/8" Lg.	10
6	---	Washer, Flat, SSTL, #6	18
7	8080002K004	80K Radiation Shield	1
8	8080250K045	Pressure Relief Valve	1
9	---	O-Ring, #2-20, Viton, Parker V337-9	2
10*	8080250K006	Hydrogen-Vapor-Pressure Gauge	1
11	8080250K009	Diode Temperature Sensor	1
12	8044043G002	Regeneration Purge Fitting	1
13	---	Cap Screw, Hexagon Socket Type, SSTL, #2-56 x 1/2" Lg.	2
14	---	Lockwasher, Split, SSTL, #2	2
15	8080002K005	Drive-Unit-Displacer Assembly	1
16	---	O-Ring, #2-140, Buna-N, Parker N219-7	1
17	---	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1/2" Lg.	2
18	---	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1-1/4" Lg.	4
19	---	Protective Cover	1
20	586441	O-Ring, #2-172, Viton, Parker V377-9	1
21	---	Vacuum Housing	1
22	---	O-Ring, #600-V1, Viton, Parker	1
23	---	Plug	1
24	---	Nut	1
25	---	Centering Ring w/O-Ring (Alcatel)	1
26	---	Flange, Blank	1
27	---	Clamp	1
28	---	O-Ring, #2V1-84-8A116, Cryolab	1
--	---	Indium Sheet, 3" x 6" x 0.005" thick	1

*Not shown in Figure B.3

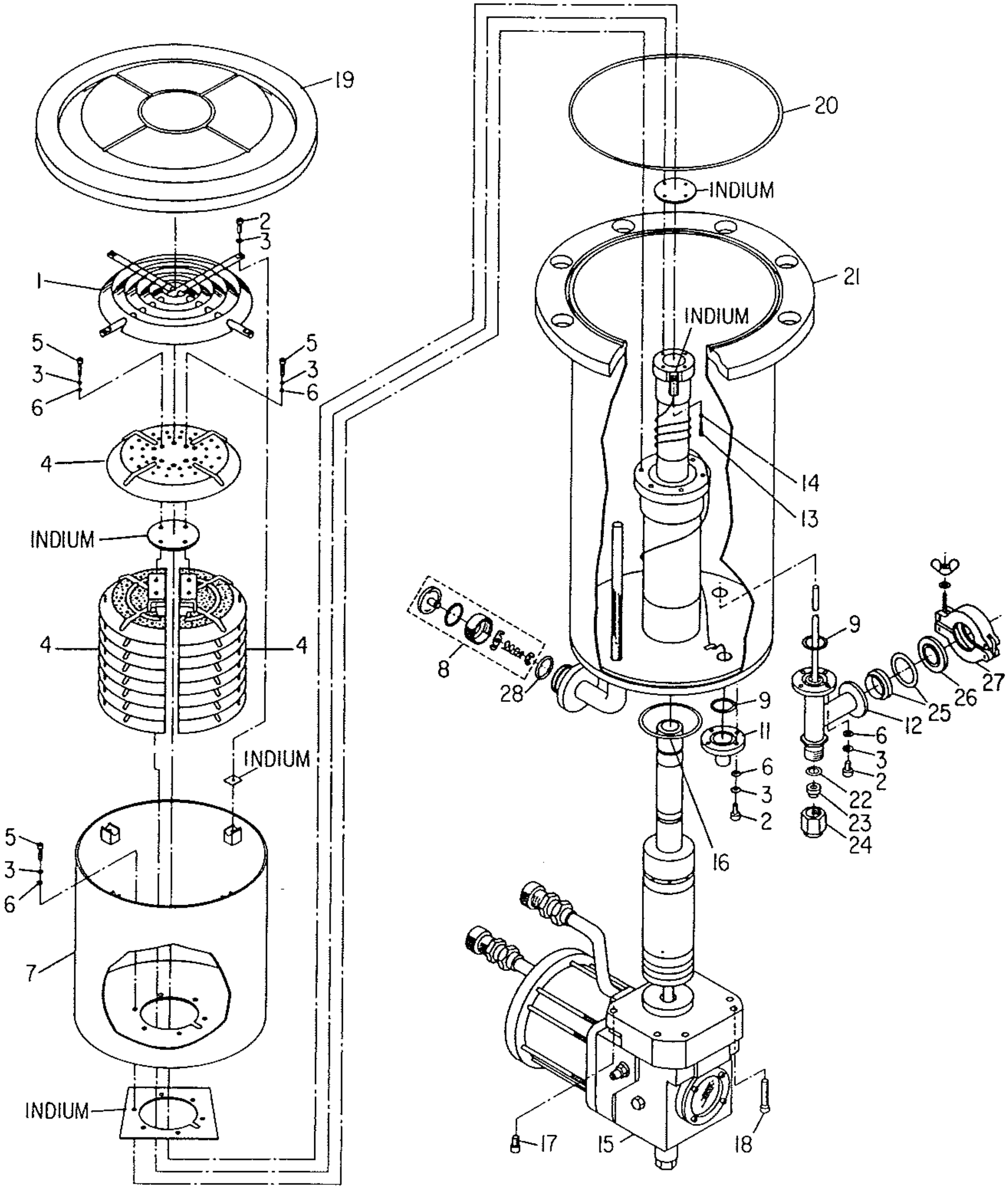


Figure B.3 Exploded view of Cryo-Torr 8 Cryopump

Legend: Figure B.4

ITEM NO.	PART NO.	DESCRIPTION	NO. REQ'D.
--	---	Cryo-Torr 8F Cryopump	1
1	8080002K001	80K Condensing Array	1
2	---	Cap Screw, Hexagon Socket Type, SSTL,#6-32 x 1/2" Lg.	8
3	---	Lockwasher, Split Type, SSTL, #6	18
4	---	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 3/8" Lg.	10
5	---	Washer, Flat, SSTL, #6	10
6	8080007K003	15K Array Assembly	1
7	8080007K004	80K Radiation Shield	1
8	---	Vacuum Housing	1
9	---	O-Ring, V747-75, #2-157 Viton	1
10	---	Cylinder, Refrigerator	1
11	---	O-Ring, #2-140, Buna-N, Parker N674-70	1
12	---	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1" Lg.	8
13	---	Lockwasher, Split Type, SSTL, #10	8
14	---	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1-1/4" Lg.	4
15	---	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1/2" Lg.	2
16	8080002K005	Drive-Unit-Displacer Assembly	1
17	8080250K045	Pressure Relief Valve	1
18	---	O-Ring,	1
19	---	Connector Assembly	1
20	---	Wire, Silicon Diode (72 in. length)	1
21	---	Diode Temperature Sensor	1
22	---	Nut, Hex #4-40	1
23	---	O-Ring, V709-90, 2-020	1
24	---	Clamp	1
25	---	Flange, Blank	1
26	---	Centering Ring with O-Ring	1
27	---	Nut	1
28	---	Plug	1
29	---	O-Ring, #6Q0-V1, Viton, Parker	1
30	---	Protective Cover	1
--	---	Indium Sheet, 3" x 6" x 0.005" thick	1
--	8080250K012	Temperature Sensor Replacement Kit,	1
--	---	consisting of:	
--	---	Wire, Silicon Diode (item no.20)	1
--	---	Diode Temperature Sensor (item no. 21)	1

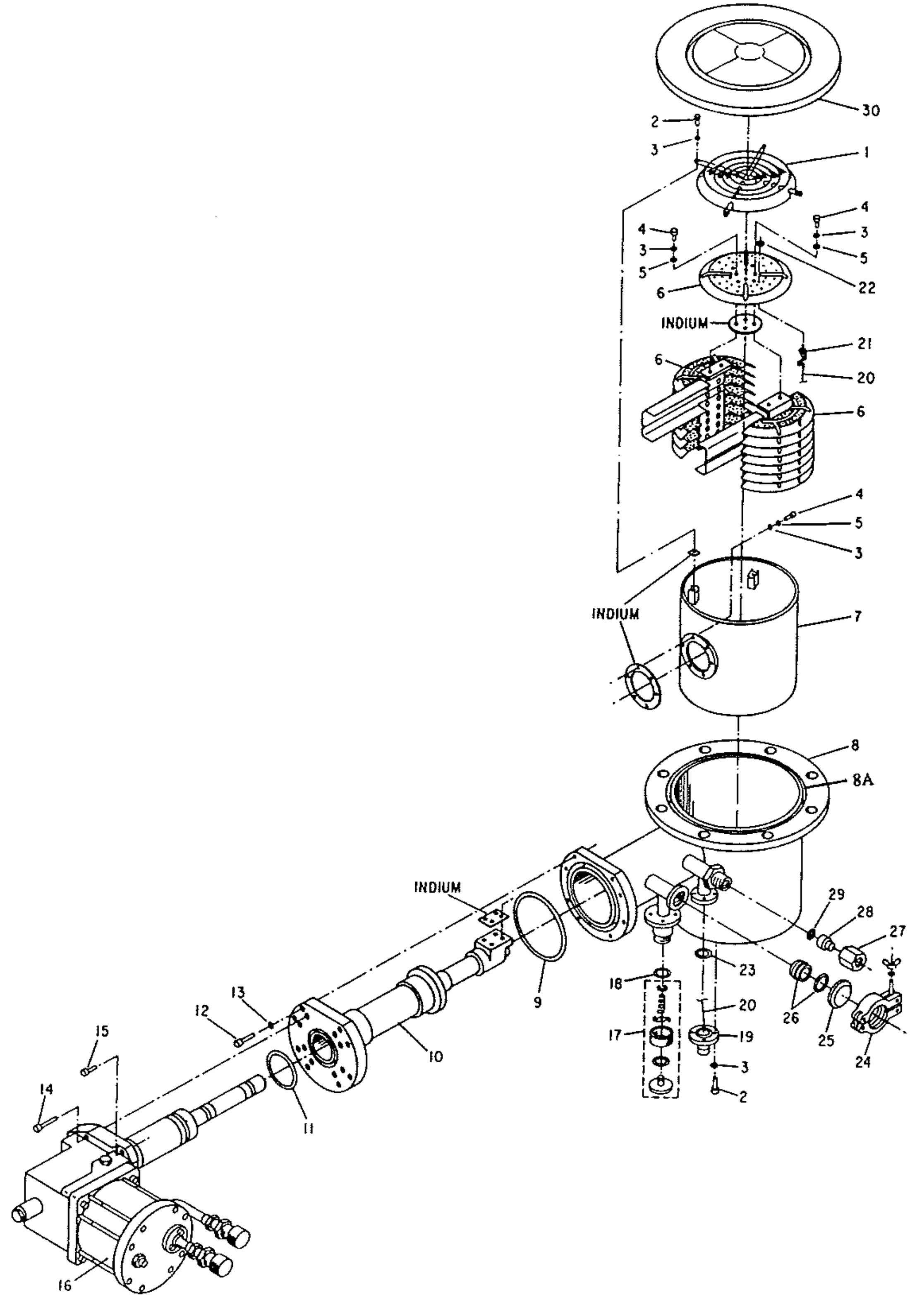


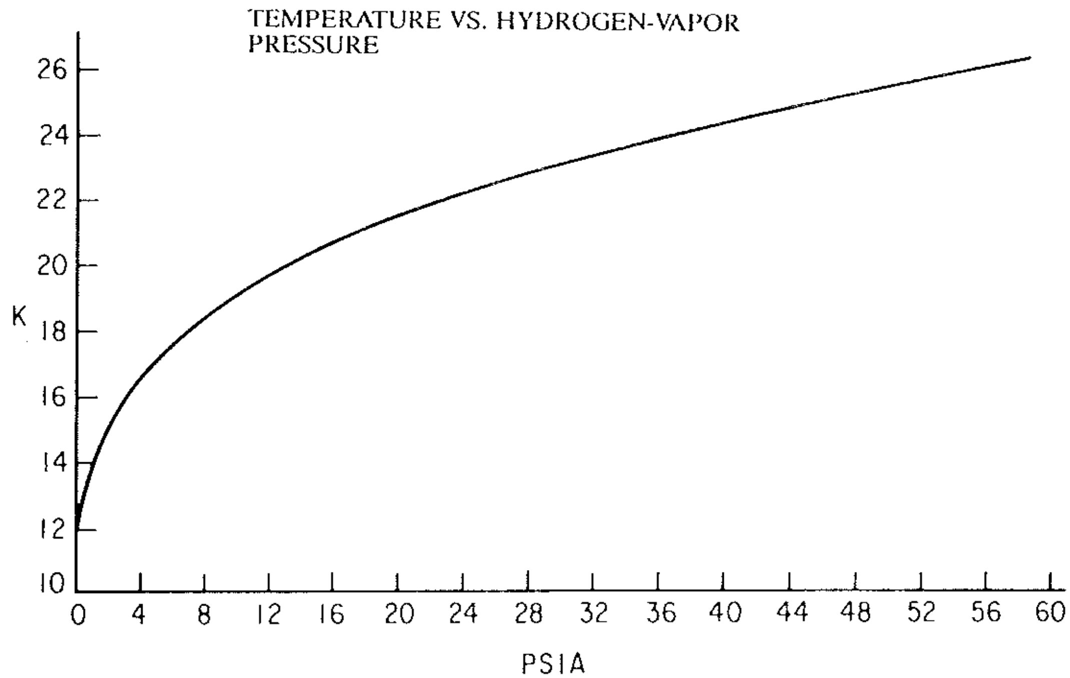
Figure B.4 Exploded view of Cryo-Torr 8F Cryopump

Appendix C
Accessories List for Cryo-Torr High-Vacuum Pumps

PART NUMBER	DESCRIPTION
8042001G003	Remote Temperature Indicator (115V, 60 Hz) with Dual Set Points
8042001G004	Remote Temperature Indicator (208V, 50 Hz) with Dual Set Points
8044001G001	Automatic Regeneration Controller (115V, 60 Hz)
8044001G002	Automatic Regeneration Controller (208/230V, 60 Hz)
8080250K003	Maintenance Manifold
8080250K020	Purge Gas Heater (110V, 50/60 Hz)
8080250K022	Roughing Valve (110V, 50/60 Hz)
8080250K023	Purge Valve (110V, 50/60 Hz)
8080250K036	Purge Gas Heater (230V, 50/60 Hz)
8080250K037	Roughing Valve (230V, 50/60 Hz)
8080250K017	Purge Valve (230V, 50/60 Hz)

Appendix D
Conversion of Hydrogen-Vapor-Pressure Gauge Readings to Temperature

Use the data given below to convert a reading of the optional hydrogen-vapor-pressure gauge (in psia) to the temperature of the second-stage cold station (in degrees Kelvin). The hydrogen-vapor-pressure gauge should not be used to measure temperatures higher than 26K.



PSIA	K	PSIA	K
0	Less than 12	15	20.5
1	13.9	18	21.1
2	15.2	21	21.7
3	16.0	24	22.2
4	16.7	27	22.6
5	17.2	30	23.1
6	17.7	35	23.7
7	18.1	40	24.3
8	18.5	45	24.8
10	19.2	50	25.3
12	19.7	55	25.8