thermionics laboratory, inc.

RNN Series

Differentially Pumped Rotary Seals
Operating Manual

DC-IM-1002

Revision 2.2.2

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RNN Series Differentially Pumped Rotary Seals
Operating Manual

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1.0 INTRODUCTION

1.1 PRODUCT DESCRIPTION

The RNN SERIES of differentially pumped rotating seals are ultra high vacuum compatible devices. When properly installed and pumped, systems have achieved base pressures of less than 2 x10 $^{-11}$ Torr. They may be used in any vacuum system where rotational motion is desired.

1.2 CONSTRUCTION

The metal components exposed to vacuum are type 304 stainless steel. There are two pumping chambers, isolated by three spring loaded Teflon-graphite seals. The chambers are pumped through the 1.33" OD mini-ports located at the perimeter of the seal. The internal sealing surfaces are specially prepared by a proprietary manufacturing process.

Linear and lateral alignments are maintained by a set of preloaded special bearing assemblies. The bearings are made of hardened carbon steel.

WARNING

These bearings will corrode. Do not allow moisture to condense on or in the seal.

Do not allow LN2 to chill the unit. If the internal probe is a cryogenic system consider mounting a fan or heating units to keep the seal dry. Whenever the unit is exposed to moisture, it must be disassembled, cleaned and re-lubricated.

1.3 LEAKS/PRESSURE BURSTS

This device is a controlled leak. When properly installed and with suitable differential pumping, RNN seals will show an effective leak rate of between 1 x 10^{-9} and 2 x 10^{-10} std. cc He/sec., depending on seal size. Pressure bursts will be observed as it is rotated. This is normal. When correctly pumping on both pumping ports, the typical observed pressure burst will be 0.5 to 1.0 decade, with a system base pressure of 2 x 10^{-10} Torr. Typical system base pressure recovery times range from 15 to 50 seconds, depending up system pump speed. The recovery time may vary depending upon system condition and pumps used.

CAUTION

Please read and follow the instructions to insure the seal will provide years of service.

1.4 RECEIVING, INSPECTION AND UNPACKING

Most RNN platforms are shipped with custom foam-in-place packing. We have found this to be the best system to provide protection for shipment. The foam is separated approximately half way inside the carton with thin plastic. The unit is also double bagged in polyethylene. This is necessary to assure no packing material or foreign matter is able to contaminate the unit in transit.

Upon arrival of the shipment, inspect the outside of the box(s) for damage such as crushed corners and tears which would indicate the parcel was mishandled in shipping. If damage is noted, immediately notify the shipping company of the damage and that there may be hidden damage.

Unpack the equipment and check the contents to be sure everything shown on the packing list is identified and located. Optional equipment may be attached to the main assembly. If something later on is found missing it is difficult to establish responsibility.

Give particular attention to small parts such as cables and/or spare gaskets as they can be overlooked in the unpacking process and are then difficult to locate during the installation process.

It is always good to save the packing material until the equipment is fully installed. Should anything be missing the original packing can be checked.

2.0 INSTALLATION

The RNN is shipped clean and ready to install. Remove the protective polyethylene bags. Removal of the protective UHV clean foil covering the flange areas should be done in a clean environment. Foil covering the pre lubricated gears on /FA and /MD models is recommended after installation to minimize migration of the grease.

Prior to shipment, the RNN is leak checked. A certificate indicating the leak rate is included with the RNN.

Be certain no foreign residue or particles adhere to the device or the sealing flange knife edges. As a precaution, it is recommended the flanges be wiped with a lint free cloth prior to installation.

WARNING

Shipping vibration can loosen screws. The user must check to verify that the external screw fasteners have not backed off on the unit.

This is important !!!

WARNING

NEVER ALLOW THE TWO PUMPING PORTS LOCATED ON THE PERIMETER TO REMAIN UNCOVERED. This device is sensitive to foreign matter entering the sealing system. The seal effectiveness and useful life are affected by the cleanliness of its environment.

Particles can migrate through the pumping ports, contaminate the chambers, and this can cause seal failure. **At all times, do one of the following:**

1. Connect the ports to suitable pumps
2. Cover the ports with the plastic caps provided (always remove during bakeout and replace with materials which will not melt)
3. Cover with clean foil or other suitable material.

2.1 ORIENTATION and LOAD

The RNN will accommodate up to a 50 lb. load in a vertical orientation. **Consult the factory for loads greater than 50 lbs., inverted position, and/or horizontal cantilever operation**.

2.2 FASTENING/GASKETS

Install the RNN on your chamber/manipulator/instrument as you would any other ConFlat type flange. Use standard, 0.080" thick, flat copper gaskets. Recommended bolt sizes are in the table below. These recommended bolt lengths are for standard thickness ConFlat type flanges.

WARNING

The holes in the RNN are blind tapped holes. **Using incorrect lengths for installation will damage the RNN assembly.** The bolts may be supplied by you, or you may use an RNN bolt set available from Thermionics.

Helicoil brand thread inserts are used to improve thread life/performance. They also allow for replacement if thread damage occurs.

Double check that your equipment has standard thickness flanges.

2.3 BOLT SIZES/LUBRICATION

You may use hex head, socket head or 12 point bolts. The lengths in the following tables are meant to be used *without* washers and should be stainless steel. Use an anti-seize lubricant to minimize the chance of galling the threads.

Standard SAE threads:

RNN Model	Bolt Quantity	Bolt Size
RNN-150	12 ea	1/4-28 x .75
RNN-250	16 ea	5/16-24 x 1
RNN-400	32 ea	5/16-24 x 1.25
RNN-600	40 ea	5/16-24 x 1.25
RNN-800	48 ea	5/16-24 x 1.5
RNN-1000	60 ea	3/8-24 x 1.5

METRIC threads:

RNN Model	Bolt Quantity	Bolt Size
RNN-150/TM	12 ea	M6 x 20mm
RNN-250/TM	16 ea	M8 x 25mm
RNN-400/TM	32 ea	M8 x 25mm
RNN-600/TM	40 ea	M8 x 30mm
RNN-800/TM	48 ea	M8 x 35mm

The instrument/manipulator/chamber to be installed on the RNN may now be installed in the same manner as detailed above.

2.4 PUMP REQUIREMENTS AND ORIENTATION

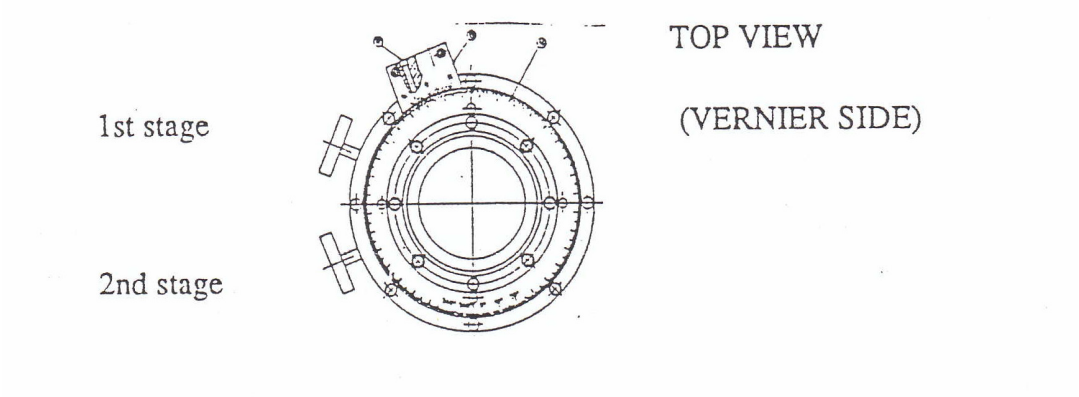
Pumping Ports/Stages:
There are two ports for pumping the RNN. They are located about the circumference and are terminated with 1.33" mini-port flanges.

These ports are etched or stamped with the labels "1st stage" and "2nd stage". The markings are found on the mini-flange perimeters. Remove the protective caps to read these markings.

CAUTION

Never allow the two pumping ports located on the perimeter to remain uncovered as particulate contamination may occur causing seal failure.

The following top view diagram is for reference orientation. The 1st stage port is for the roughing pump, the 2nd stage port is for the high vacuum system, of the RNN.



2.5 PUMP CONNECTIONS

First Stage

Connect a roughing pump to the first port flange. The roughing system must have a pumping speed of 1.6 CFM or greater AT THE PORT FLANGE, and be capable of achieving a vacuum base pressure of less than 10 microns, MEASURED AT THE RUNN PUMPING PORT FLANGE. The platform should be protected from back streaming oil or other contaminates with suitable traps.

Second Stage

Connect a high vacuum pump to the second stage port flange. The high vacuum system must have a pumping speed of 2 1/s or greater AT THE PORT FLANGE, and be capable of achieving an operating pressure of less than 5×10^{-6} Torr, MEASURED AT THE RNN PUMPING PORT FLANGE.

Higher pumping speeds and lower operating pressures will decrease the effective leak rates and decrease the pressure bursts upon rotation. For optimum practical performance, first stage pressures of < 1 micron and second stage pressures of $< 1 \times 10^{-8}$ are best.

A Thermionics RNN roughing manifold kit model # RNN-MFD will facilitate the assembly and roughing procedure.

Care must be taken to insure that significant pump speed losses due to conductance restrictions do not occur by using long lengths of small diameter tubing to connect suitable pumps. This is the most common cause of poor performance upon initial installation.

USING ONE PUMP STAGE ONLY

If you wish to use only one pump stage, connect the pump to the 2nd stage port. This cannot be done with an Ion pump as there is no facilitation for roughing. Cap off or seal the first stage port. Using one pump or no pump on the RNN will cause the system base pressure to degrade and limit ultimate system base pressure. In addition, system recovery time from the pressure burst observed during the RNN rotation will increase.

2.6 OPTIMAL DIFFERENTIAL PUMPING

STARTING THE RNN ROTARY SEAL DIFFERENTIAL PUMPING WITH MANIFOLD ADAPTER AND 2 l/s ION PUMP

The goal is to start the small ion pump mounted on the second stage of the RNN with a minimum of heating/out gassing and establish the correct pressure differentials across the RNN seals. Depending on the roughing pump used and the conductance of its connection to the RNN manifold, this can be achieved in several ways with associated levels of ease. We suggest the following procedure be used.

2.6.1 First, mount/assemble the equipment if not received in that situation. The RNN should be mounted to the UHV chamber (use correct bolt lengths per RNN manual**! THIS IS IMPORTANT**. The rotating payload must also be mounted. Attach the pumping manifold between the two RNN pumping ports with the manifold valve closest to the second stage flange and the 2 l/sec ion pump mounted on the manifold nipple attached to the second stage flange. Attach the roughing pump to the manifold nipple attached to the first stage flange. Be certain adequate conductance vacuum plumbing is used to provide the specified vacuum performance listed in the RNN manual. The ultimate pressure of the roughing pump at the RNN manifold will significantly influence the ease of starting the 2 l/sec ion pump. Be certain all the above equipment connections are leak tight.

2.6.2 Establish UHV in the vacuum chamber. (Do not rotate the RNN until both first and second stage pumping is established).

2.6.3 Start the roughing pump and open the valve on the RNN manifold. Establish the ultimate pressure of the roughing pump at the ion pump flange. Hopefully this will be $< 10^{-4}$ Torr but the ion pump can be started at pressures as high as 10^{-3} Torr. Refer to and read the Ion pump manual. It is best to have some method of measuring the pressure of the first stage vacuum at or near the RNN manifold to verify this condition.

2.6.4 Read and follow the ion pump starting procedure written in the Ion Pump Controller manual. Turn on the ion pump controller and start closing the manifold valve while monitoring the ion pump current and ion pump temperature. DO NOT ALLOW THE ION PUMP TO OVERHEAT. Cycling the controller on and off may be required so as not to overheat the ion pump. Each time the pump is turned off to cool the manifold valve must be returned to the fully open condition. Again, the better vacuum that can be achieved in the ion pump prior to starting, the easier this starting will be.

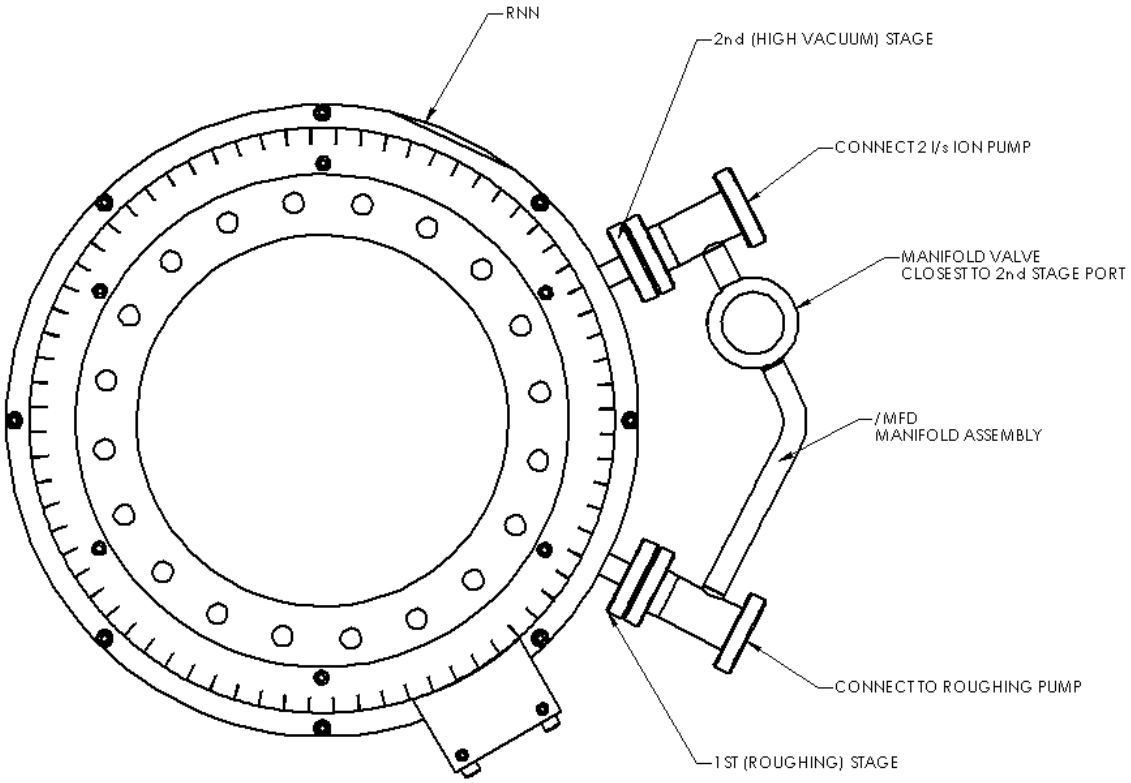
2.6.5 Once the ion pump is running without overheating and the manifold valve closed, the ion pump current should continue to reduce, indicating a final pressure of between 10^{-6} and 10^{-8} Torr after pumping for a period of time. Be certain to switch the Ion Pump Controller Protection switch to "ON" to protect the pump and controller from overload conditions. (Typically you would not have the protection ON when starting the ion pump.) Refer again to the Ion pump controller manual.

2.6.6 Continue to pump the 1st stage with the roughing pump with the manifold valve closed.

2.6.7 As you rotate the RNN and observe the pressures in UHV chamber, the 2 l/s ion pump (second stage) and first stage RNN pumping should be better than the requirements/performance listed in the RNN manual.

2.6.8 We recommend the pumping for the two stages of the RNN be continuously maintained when possible. It is acceptable to leave the differential pumping system running while the UHV chamber is up to air for short periods of time provided the second stage pressure does not exceed 1 x 10^{-5} Torr. Do not rotate the RNN stage while the chamber is up to air and the differential pumping system is in operation.

Please contact your Thermionics representative or the factory if difficulty is encountered in implementing this procedure



3.0 OPERATION

3.1 PUMPING SEQUENCE

The user has the option of roughing and then starting the high vacuum pumps for the RNN, and then roughing and starting main system high vacuum pumps, or vice versa. In our experience, we have found it easier to achieve crossover pressures in the main system if the RNN pumps are started first. Refer to previous sections 2.5 and 2.6.

3.2 ROTATION

The RNN may be rotated continuously in either direction. The direction of rotation may be reversed any time.

THIS DEVICE IS A CONTROLLED LEAK. Pressure bursts will be observed as it is rotated. This is normal. When pumping on both pumping ports, the typical pressure burst observed, with a system base pressure of 2×10^{-10} Torr, will be 0.5 to 1.0 decade. Typical system base pressure recovery time ranges from 15 to 50 seconds. The recovery time may vary depending upon system condition and pumps used.

3.3 TORQUE

Depending upon the size of the RNN, the user may find it difficult to rotate non-fine adjust models, especially while under vacuum. Listed below are approximate values of required torque for rotation.

The user may find it advantageous to make a set of handles, purchase a set of handles from Thermionics, or upgrade to a fine adjust model by purchasing and installing a fine adjust kit available from Thermionics.

RNN-150	7 ft.-lbs.
RNN-250	10 ft.-lbs.
RNN-400	16 ft.-lbs.
RNN-600	22 ft.-lbs.
RNN-800	32 ft.-lbs.
RNN-1000	130 ft.-lbs.

3.4 VERNIER

The vernier is a reference for location.

4.0 BAKEOUT

All motors and limit switches/position indicators must be removed before bakeout.

MOTOR REMOVAL PROCEDURES

The motor/gearbox assembly is removed by loosening and removing two screws that attach the mount to the lower flange. Observe gear engagement when removing or installing. Some rotation of the worm may be needed during this procedure to obtain bolt and gear alignment.

Alternatively, the drive motor alone can be removed by first releasing the clamp screw on the drive shaft. This screw is accessed through a hole in the aluminum gearbox. Once this coupling is released, the four socket head screws holding the motor can be removed and then the motor.

Limit Switches:
The limit switches are mounted in removable assemblies. Simply remove the two associated mounting screws and remove the assembly (typically the vernier scale bracket).

Position indicators:
Position indicators may be removed with limit switch mounting plates or individually as required. Care should be used upon re-assembly to dress the wires as not to interfere with stage motion

Bakeout in normal fashion, but never exceed 150 degrees C stage temperature during bakeout. Higher temperatures will damage the seals. Monitor seal stage temperature near the seals during bakeout.

NEVER ROTATE THE SEAL DURING BAKEOUT OR WHEN IT IS ABOVE AMBIENT TEMPERATURE.

ALWAYS PUMP THE RNN THROUGH THE PORTS DURING BAKEOUT. NEVER ALLOW THE PORTS TO REMAIN UNCOVERED. PARTICULATE CONTAMINATION MAY OCCUR CAUSNG SEAL FAILURE. IF ION PUMP IS USED ON SECOND STAGE REFER TO ION PUMP MANUAL FOR MAGNET REMOVAL.

WARNING

The lubricant used in this unit has been tested to 230 C. We recommend limiting the temperature of the lubricant to 200s C or less.

DANGER

The manufacturer warning states "avoid inhalation of decomposition products formed above 300 C." This material may give off toxic gases at elevated temperatures.

NEVER run uncontrolled bakeouts!

5.0 MAINTENANCE

No regular maintenance involving disassembly is required for normal operation.

If the unit is fitted with fine adjust or motor drive, occasional lubricant is needed. This should include the fine adjust/motor gear, worm and bearings/bushing. Frequency is dependent on the operation environment.

The platform main bearings are hardened carbon steel, and susceptible to corrosion. Clearing and re-lubrication may be required from time to time, depending on operational environment. Service requiring disassembly is needed if:

a. reduced sealing performance is observed
b. greater torque is required for operation
c. the unit has been exposed to higher humidity or cryogenic chilling (condensing) environment

Seal wear is not normally a problem when used as designed as a positioning device. High use or continuous operation will reduce service life of the seals.

We recommend the RNN series be returned to the factory for service involving disassembly/assembly. The main reason for this policy is the sensitivity of RNN units to contamination and mechanical damage of interior components and surfaces.

These units can be successfully serviced in the field if a clean work environment is available and adequate skill and care is used. The equipment warranty does not cover units which, in the sole judgment of Thermionics, may have been damaged during attempted customer repair.

Refer to the drawing at the end of the manual for clarification.

5.1 FIELD DISASSEMBLY PROCEDURE

5.1.1 Remove the RNN from use and cap pumpout ports. Remove vernier scale. Remove worm drive gear and motor/fine adjust unit, if mounted. Take care to note the spacers used in mounting this equipment.

5.1.2 **Thoroughly clean all exposed surfaces with alcohol and 'LINT FREE" wipes.** Move unit to a clean work area. Use a clean hood or laminar flow work area if possible.

5.1.3 Remove perimeter bolts/screws from the black anodized clamp ring and ring.

5.1.4 The two flanges can now be separated. Special care needs to be taken with the bearings. The outer race is split on some models, and bearing will disassemble easily. **Protect sealing surfaces from mechanical damage at all times.** Remove and clean all interior components. It is normal to find some amount of black residue from seal wear. Use alcohol and **"LINT FREE'** wipes. Inspect

actual seal surfaces and seals for damage or wear. Replace seals that appear worn, pitted, scratched or dented. The seals are soft and delicate and must be handled with great care. Clean 1st and 2nd stage port holes with barely damp swabs or rolled up lint free wipes. If available use compressed N2 or other clean air to blow out port holes and to remove particles from plate faces.

5.1.5 Clean and re-lubricate bearings. We highly recommend Thermionics GHT lubricant be used.

5.1.6 Reassembly

Replace components, taking special care to clean sealing surfaces. Be watchful of lint, hairs or other matter that may interfere with the seals and plates. Install clamp ring screws and gently tighten ring. **IMPORTANT …** tighten using a balanced "star" pattern to obtain even clamping. Blank off and pump on platform (<1 torr). Rotate the upper flange at least one full revolution. Re-tighten clamp ring screws to ¼ beyond 'just touching', then rotate again. As vacuum aids in pulling the two halves together, continue this sequence of rotating and screw tightening. Several sequences may be required during this break-in process. Between 6 and 15 is typical. The RNN will be properly adjusted when the upper flange comes to rest on the inner race of the bearing in the lower plate. It is important to not over tighten the clamp ring at this juncture. Measuring the distance across the flange faces prior to assembly with the seals is one way to be sure the RNN is tightened adequately. Measuring this distance to ensure parallelism of the two halves is also a good guide during the process. When done the flange faces should be parallel to each other within.005" as measured in 4 places @90 degrees +/- 10.

5.1.7 Test unit.

5.2 PLATFORM PERFORMANCE TESTING

5.2.1 Install platform per specifications with mass spectrograph leak detector on the UHV volume, and pumping on first and second stages with different pumps. Bag check for 30 seconds. No leak should be observed with a maximum sensitivity of 5×10^{-10} std. cc He/sec.

5.2.1.1 With the platform installed on leak detector and pumping on the second stage to between 1 and 5 microns, transfer 1 atm. of He into the first pumping stage. A correctly operating platform will display a leak rate of between 1×10^{-9} and 2×10^{-8} std. cc He/sec, depending on the seal size.

5.2.2 Refer to the table in section 3. 3 for the torque specification.

5.3 LUBRICATION

The bearings are lubricated with Thermionics GHT high temperature lubricant. This lubricant has a VAC3 rating. The user may need to add more lubricant from time to time, depending on the frequency and temperature of bakeouts and operating environment.

The seals have a temperature limit of 150 C. (See BAKEOUT Section 4.0). The lubricant has a temperature limit of 200 C.

WARNING

This lubricant has been test to 230 C. We recommend limiting the temperature of the lubricant to 200 C. or less.

DANGER

The manufacturer warning states "avoid inhalation of decomposition products formed above 300 C." We believe this material may give off toxic gases at elevated temperatures.

Do not run uncontrolled bakeouts!

5.4 MOTORIZED AND FINE ADJUST OPERATION

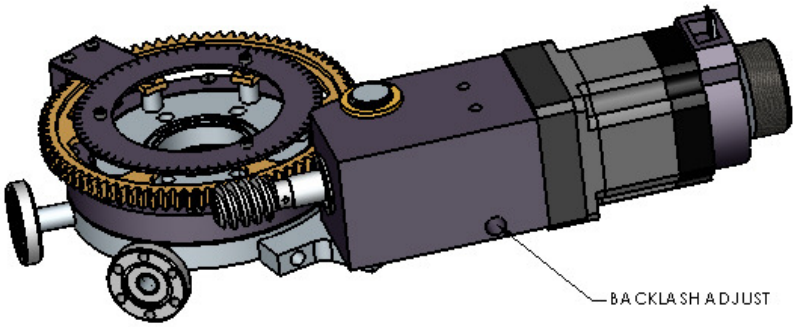
All motors and limit switches/position indicators must be removed before bakeout.

Motorized/fine adjust adjustment

RNN-150 and RNN-250 fine adjust models use a standard (non-dynamic) worm gearbox. Gear lash (and thus backlash) is adjusted by loosening the two SHCS attaching the gearbox to the gearbox base. The worm is then pushed into the worm wheel, and the two screws re-tightened. Operate to check performance.

This adjustment is limited by how accurately the worm wheel axis aligns with the rotating flange axis. This can also be adjusted by loosening ad re-tightening the worm wheel attachment bolts/screws to achieve centering of the gear to the top flange. Paper shims may be used between the ID of the gear/ dial and a mating top flange to achieve this.

RNN-400 and larger fine adjust models and all motor drive units employ anti-backlash (dynamic) gearboxes. These allow the worms to move to maintain constant gear mesh. The force of this movement is adjusted by a setscrew at the base of the gearbox (see drawing). This screw should be adjusted such that the worm/worm wheel engagement is uniform in operation without causing unacceptable friction and a minimum of acceptable backlash.



When purchased without a controller the wiring comes un-terminated. Motor and or encoder wiring diagrams are provided per unit. It is the customer's responsibility to be sure the wiring is properly strain-relieved mechanically. Retrofit kits are available for field installation. Please consult the factory for further information.

WIRING COLOR CODE.....Limit switches and Position indicators

Switches:

Common	Yellow
Normally closed	Green
Normally open	Red

Zero Position Connectors

SIGNAL	SENSOR WIRE COLOR
Detector Ground	Green
Detector Output	Blue
Detector Vcc	White
Anode (3.3 V)	Red
Ground	Black

6.0 PACKING FOR RE-SHIPMENT OR STORAGE

RNN platforms are sensitive to contamination. If the need arises to re-ship the unit, or put the unit in storage, follow these guidelines.

6.1 Work on a clean surface when packing

6.2 Seal off both pumpout mini-ports with flange/gasket sets or foil and snugly fitting plastic caps.

6.3 Protect and seal the two flange surfaces. Use metal cover plates if possible.

6.4 Double bag unit in polyethylene bags. Seal each bag separately. Heat seal if possible. This is necessary to assure no packing material or foreign matter is able to contaminate the unit in transit.

6.5 Re-use original carton with form-in-place packing if available. If not, use suitable, non-migrating padding. Use adequate padding. Some shippers require 6" of padding be used for them to guarantee safe arrival of shipments. If the unit is being stored, or shipped to another user, include this manual in the package.

7.0 PARTS AND FACTORY SERVICE ORDERING INFORMATION

7.1 Replacement parts and non-warranty factory services are available on a fast turnaround basis. Please consult the factory with your specific need. The following is a list of replacement parts and current services available. Consult factory for price and availability.

SEAL SETS

Set of three

Part Number:	For:
RNNSS-150	RNN-150
RNNSS-250	RNN-250
RNNSS-400	RNN-400
RNNSS-600	RNN-600
RNNSS-800	RNN-800

FINE ADJUST KITS

Part Number:	For:
RNNFA-150	RNN-150
RNNFA-250	RNN-250
RNNFA-400	RNN-400
RNNFA-600	RNN-600
RNNFA-800	RNN-800

REPLACEMENT BEARING SETS

Part Number:	For:
RNNBS-150	RNN-150
RNNBS-250	RNN-250
RNNBS-400	RNN-400
RNNBS-600	RNN-600
RNNBS-800	RNN-800

RESURFACE SEALING PLATES

Part Number:	For:
RNNRS-150	RNN-150
RNNRS-250	RNN-250
RNNRS-400	RNN-400
RNNRS-600	RNN-600
RNNRS-800	RNN-800

GHT LUBRICANT

Part Number:	
GHT-10	(10 oz. Tube)
GHT-100	(100 oz. Tube)

7.2 **RNN FACTORY OVERHAUL**

RNN's can be returned for factory overhaul. Thermionics provides necessary labor and materials to overhaul a RNN differentially pumped seal.

The service includes:

Disassemble and inspect
Install necessary replacement parts as required.
Reassemble seal and test.

Service does not include:

Bearings
Seals
Resurfacing of plates

These components/services will be provided as needed and the cost added as necessary.

Part Number	
RNN-OV	All models without fine adjust or motor drive
RNNFA-OV	All models with fine adjust or motor drive

If you wish to return equipment for repair, contact the Thermionics division which sold you the product in question. You will be given an RMA, Return Material Authorization number, and instructions on how and by what means to ship the product to the factory. A hazards declaration is included as part of the RMA. No shipment will be accepted without prior approval and completed RMA authorization Form.

8.0 RNN ACCESSORIES

RNN-MFD Roughing Manifold Kit:

Allows first stage pump to evacuate second stage pump

Includes:
- Bakeable valve
- Custom nipples
- Flexible tube
- Installation onto customers' platform
- Thermocouples optional

TC Option, up to 2 tubes

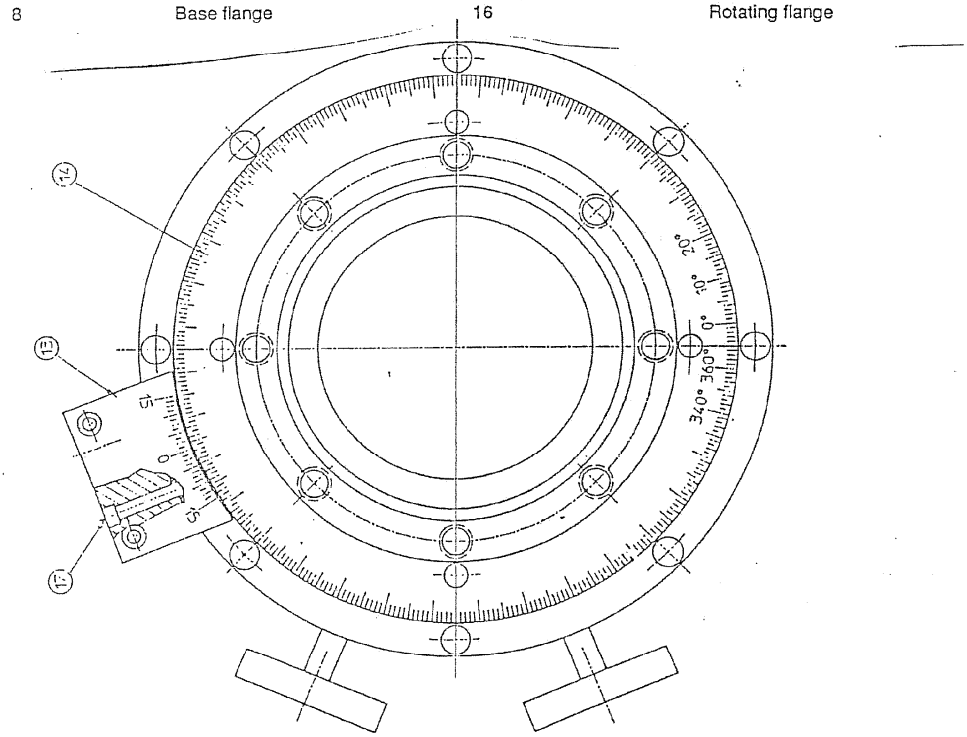
BOLTS SETS

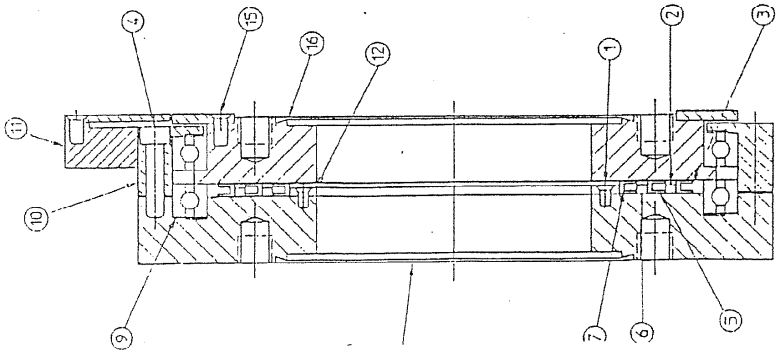
Part Number	Use with	Quantity	Size
BS-150	RNN-150	12 each	1/4-28 x .75 SHCS
DBS-150	RNN-150	12 each	12 point
BS-250	RNN-250	16 each	5/16-24 x 1 SHCS
DBS-250	RNN-250	16 each	12 point
BS-400	RNN-400	32 each	5/16-24 x 1 ¼ SHCS
DBS-400	RNN-400	32 each	12 point
BS-600	RNN-600	40 each	5/16-24 x 1 ¼ SHCS
DBS-600	RNN-600	40 each	12 point
BS-800	RNN-800	48 each	5/16-24 x 1 ½ SHCS
DBS-800	RNN-800	48 each	12 point
BS-1000	RNN-1000	60 each	3/8-24 x 1 ½ SHCS

APPENDIX A

RNN Assembly Drawing

2	1st stage space	10	Clamp ring
3	Outer seal	11	Vernier mounting block
4	Perimeter bolts	12	Inner ring
5	Middle seal	13	Vernier
6	2nd stage spacer	14	Graduated dial
7	Inner seal	15	Dial screw
8	Base flange	16	Rotating flange





APPENDIX B

DOCUMENT CONTROL and APPROVAL

RNN Series Differentially Pumped Rotary Seals
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Document Control Number

DC-IM-1002

Version 2.2.2

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