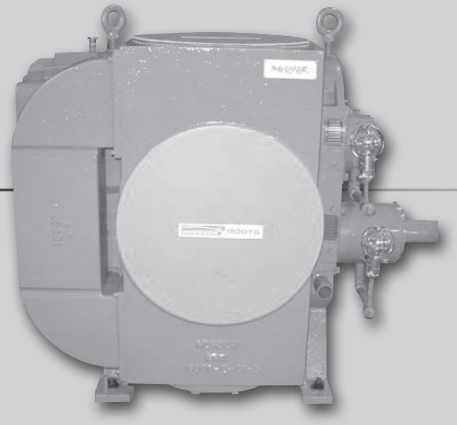
DRESSER Roots

The original ROOTS blower still leads the way™.

DVJ WHISPAIR™ Dry Exhauster

Installation, Operation & Maintenance



Contents

Do These Things To Get The Most From Your ROOTS™ Blower

- ❑ Check shipment for damage. If found, file claim with carrier and notify nearest Sales Office. See List on last page.
- ❑ Unpack shipment carefully and check contents against packing List. Notify Sales Office if a shortage appears.
- ❑ Store in a clean, dry location until ready for installation. Lift by methods discussed under installation to avoid straining or distorting the equipment. Keep covers on all openings. Protect against weather and corrosion if outdoor storage is necessary.
- ❑ Read LIMITATIONS and INSTALLATION sections in this manual and complete the installation.
- ❑ Provide for adequate safeguards against accidents to persons working on or near the equipment during both installation and operation. SEE SAFETY PRECAUTIONS.
- ❑ Install all equipment correctly. Foundation design must be adequate and piping carefully done. Use recommended accessories for operating protection.
- ❑ Make sure both driving and driven equipment is correctly lubricated before start-up. See LUBRICATION.
- ❑ Read starting checkpoints under OPERATION. Run equipment briefly to check for installation errors and make corrections. Follow with a trial run under normal operating conditions.
- ❑ In event of trouble during installation or operation, do not attempt repairs of Roots furnished equipment. Notify nearest Sales Office giving all nameplate information plus an outline of operating conditions and a description of the trouble.
- ❑ Unauthorized attempts at equipment repair may void Manufacturer's warranty. Units out of warranty may be repaired or adjusted by the owner. It is recommended that such work be limited to the operations described this manual, using Factory Parts. Good inspection and maintenance practices should reduce the need for repairs.

ILRB-3006 0810

Roots products are sold subject to the current General Terms of Sale, GTS-5001 and Warranty Policy WP-5020. Copies are available upon request.
Contact your local Roots Office or Roots Customer Service Hot Line 1-877-363-ROOT(S) (7668) or direct 281-966-4700.

Operating Characteristics

DVJ WHISPAIR™ dry vacuum exhausters are covered in this manual. In size they range from 10 inches through 20 inches gear diameter. All are equipped with an effective splash oil lubrication system. From a principle usage standpoint they are designated as air blowers.

The DVJ rotary lobe blower is a positive displacement type unit, whose pumping capacity is determined by size, operating speed and inlet conditions. It employs two double-lobe impellers mounted on parallel shafts and rotating in opposite directions within a cylinder closed at the ends by headplates. As the impellers rotate, air is drawn into one side of the cylinder and forced out the opposite side against the existing pressure. **The differential pressure developed, therefore, depends on the resistance of the connected systems.**

Effective sealing of the blower inlet area from the discharge area is accomplished by use of very small operating clearances. (This feature also eliminates rubbing contact between rotating and stationary parts, hence, internal lubrication is not required.) Clearances between the impellers during rotation are maintained by a pair of accurately machined timing gears, mounted on the two shafts extending outside the air chamber.

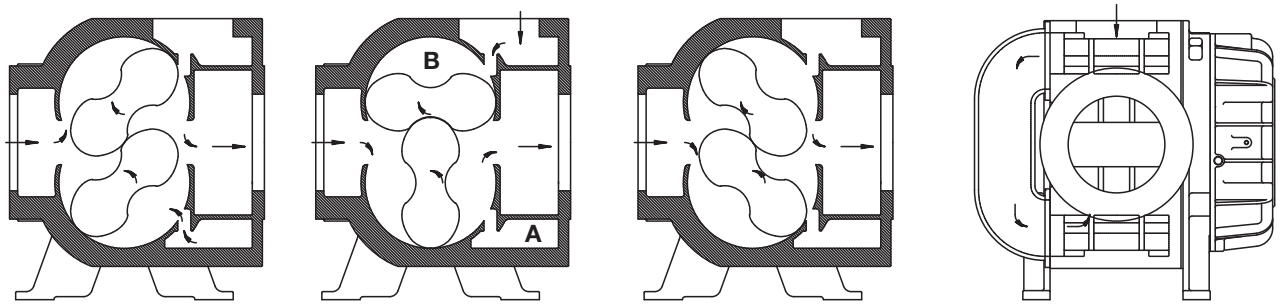
The DVJ blower is used in vacuum service and uses the same principle as the RAS WHISPAIR™ design except the discharge and slots feeding air back into the cylinder closed pocket areas all have individual plenums. In vacuum operation, the discharge pressure differs from atmospheric only by the backpressure in the discharge system. Atmospheric pressure air flows into one cylinder slot plenum supplying air to the closed Pocket B as shown in Position 2 of figure 1 and through the cross-over pipe (DVJ jet air flow diagram-above figures) to Pocket A. The atmospheric air, flowing to the closed pockets, is at a much lower temperature than the discharge air returned to the pockets in RAS WHISPAIR design. The cooling effect allows blower operation at higher vacuum levels without exceeding the blower's maximum temperature rise. For closed loop DVJ applications, as shown in Fig. 4, a portion of discharge gas is recycled back through a cooler to the cylinder slot plenum to give similar cooling effects.

No attempt should ever be made to control capacity by means of a throttle valve in the intake or discharge piping. This increases the power load on the driver, and may seriously damage the blower. Likewise, if a possibility exists that flow to the blower inlet may be cut off during normal operation of a process, then an adequate vacuum relief valve should be installed in the inlet line near the blower. A pressure type relief valve in the discharge line near the blower is also strongly recommended for protection against cut-off or blocking in this line.

When a belt drive is employed, blower speed can usually be adjusted to obtain desire capacity by changing the diameter of one or both sheaves. In a direct coupled arrangement, a variable speed motor or transmission is required, or air may be vented through a manually controlled unloading valve and silencer. If discharge air is returned to the blower inlet, it must go through a cooling by-pass arrangement.

Before making any change in blower capacity or operating conditions, contact the nearest Sales Office for specific information applying to your particular blower. In all cases, operating conditions must be maintained within the approved range or pressures, temperatures and speeds as stated under LIMITATIONS. Also, the blower **must not be used to handle air containing liquids or solids**. Serious damage to the rotating parts will result.

Figure 1 - DVJ WHISPAIR™ Operating Principle



Position 1 **Position 2** **Position 3**

Operating Limitations

To establish and maintain continued satisfactory performance, and Roots blower must be operated within certain approved limiting conditions. The Manufacturer's warranty is, of course, contingent on such operation.

Any unnecessary restrictions of discharge flow or atmospheric air inlet to the cylinder slots reduces the cooling air flow and limits blower operation as the maximum temperature rise will occur below the normal limits of vacuum level. For an open loop system, the discharge pressure must not exceed 0.2" H_2O per 100 FPM gear speed. Example - 10" GD unit running at 1500 rpm, maximum discharge pressure = 0.262*10*1500*0.2/100=7.9" H_2O. This also applies to close loop system, this is the pressure difference between the blower discharge and the casing bleed back port. The pressure drop through the jet filter/silencer must not exceed 10" H_2O. The the listed maximum allowable temperature rise (increase in air temperature between inlet and discharge) for any particular blower may occur well before maximum speed or maximum pressure rating is reached. **Temperature rise then is the limiting condition.** In other words, the operating limit is always to be determined by the maximum rating reached first. It can be any one of the three: pressure/vacuum, temperature or speed.

Be sure to arrange connections or taps for thermometers and pressure or vacuum gauges at or near the inlet and discharge connections of the blower. These, along with a good tachometer, will enable periodic checks of operating conditions.

Note - Some special purpose blowers may be assembled with nonstandard clearances other than shown in Table 8 or 9. These units may be operated at vacuum and or temperature rises higher than those listed in applicable Table 1. Before doing so however, request specific approval from the nearest Sales Office. Normally, when a blower is operated at the design condition stamped on its nameplate, the specified limits apply.

VACUUM - With the discharge going to atmospheric pressure, the inlet suction or vacuum in inches of mercury (kPa) must not be greater than the values listed for the specific frame size. The pressure rise in pounds per square inch (kPa) between blower inlet and discharge, must not exceed the figure listed for the specific blower and frame size concerned. The blower case is rated for a maximum pressure of **25 PSI (172 kPa)** gauge regardless of blower size.

TEMPERATURE - Various blower frame sizes are approved only for installations where the following temperature limitations can be maintained in service.

A. Maximum temperature rise (T.R.) in Fahrenheit degrees (°C) must not exceed listed values when the inlet is at ambient temperature. Ambient is considered as the general temperature of the space around the blower. This is not outdoor temperature unless the blower is installed outdoors.

B. If inlet temperature is higher than ambient, the listed allowable temperature rise values must be calculated using blower selection program (Contact Sales Office if you do not have access to the program).

SPEED RANGE - Blowers may be operated at speeds up to the maximums listed for the various frame sizes. They may be direct coupled to suitable constant speed drivers if vacuum/temperature conditions are also within limits. Splash lubricated blowers should not be operated below 1000 FPM gear speed for proper lubrication.

Table 1 - Maximum Allowable Operating Conditions - DVJ

Frame Size	Inlet Vacuum		Temperature Rise		Speed
	Inches HG	mm HG.	°F	°C	RPM Maximum
1016	27.0	684	275	153	1800
1021	27.0	684	300	167	1800
1220	27.0	684	275	153	1500
1222	24.0	610	275	153	1500
1428	22.5	571	300	167	1300
1431*	22.0	558	300	167	1300
1639	18.5	470	300	167	1130
1643	16.5	420	300	167	1130
1833	24.0	610	300	167	1000
1838	21.5	546	300	167	1000

*Requires GE drive arrangement above 20" Hg.

Table 2 - DVJ Clearances

Blower Size	Impeller Ends				Impeller Strips To Cylinder			Impeller Lobes		Max. Temp Rise -°F
	Thrust Ends	Gear End Min.			Inlet	Center	Disch.	Fronts	Backs	
1016	.010/.012	.023/.027	----	----	.014/.016	.010/.012	.014/.016	.020/.024	.010/.014	275°
1021	.010/.012	.032/.036	----	----	.016/.018	.010/.012	.016/.018	.022/.026	.010/.014	300°
1220	.010/.012	.034/0.38	----	----	.015/.017	.011/.013	.015/.017	.021/.025	.011/.015	275°
1222	.011/.015	.037/.041	----	----	.015/ .017	.011/ .013	.015/ .017	.021/ .025	.011/ .015	275°
1428	.013/.015	.032/.036	----	----	.019/.021	.012/.014	.019/.021	.022/.026	.012/.016	300°
1431	.014/.016	.035/039	----	----	.019/.021	.012/.014	.019/.021	.022/.026	.012/.016	300°
1639	.016/.018	.048/.052	----	----	.025/.027	.015/.017	.025/.027	.024/.028	.014/.018	300°
1643	.018/.020	.050/.054	----	----	.026/.028	.016/.018	.026/.028	.024/.028	.014/.018	300°
1833	.015/.017	.042/.046	----	----	.024/.026	.015/.017	.024/.026	.025/.029	.015/.019	300°
1838	.017/.019	.048/.052	----	----	.024/.026	.015/.017	.024/.026	.025/.029	.015/.019	300°

INSTALLATION

The DVJ blower should have a full-sized silencer installed on the discharge and a minimum length of full size piping, if necessary, for the installation. Back pressure created by silencer restriction and pipe losses reduces the jet inlet flow and increases blower temperature rise. No valves should be used in the discharge piping.

The 1016 and 1220 blower has a temporary cover installed on one cylinder slot inlet port at the factory and a permanent metal cover on the other. A full size acoustic absorption type silencer should be installed in place of the temporary cover, however, the cover and silencer may be reversed on the cylinder slot plenum ports if the installation requires it. Some type of protection such as a filter screen is necessary to stop foreign particle entry through the cylinder slots. Outside installations may also require some weather protection to prevent the entry of rain or snow. Jet inlet restriction will cause an increase in blower temperature rise and should be checked as a possible cause if temperature rise limits operation to a vacuum level less than maximum allowable.

Technical assistance at installation by a factory Service Engineer is usually not required for the smaller units, frame series 1000 through 1400. Workmen with general experience in installing heavy machinery should be able to complete a satisfactory installation. Information in this manual is supplemented by the more detailed discussions of foundations and piping in API recommended practice 686 and the Compressed Air and Gas Handbook, published by the Compressed Air and Gas Institute, New York City and the American Petroleum Institute, Washington, D.C. However, a Service Engineer may be employed for assistance or for final checking of an installation.

Handling of the equipment should be accomplished by methods conforming to safe practice for the weight involved. Weight of a bare unit, without base plate, driver or accessories will range from about 1 ton (910 kg) for the smallest to approximately 7 tons (6350 kg). On such units, an eyebolt is provided near each end for lifting. A unit mounted on a base plate should be lifted only by the four lifting lugs provided. Weight in this case will be greater than the following figures.

Before lifting with eyebolts, test one for tightness and fractures by tapping with a hammer. Direction of pull on the bolts during lift should be nearly vertical. Since a considerable cable angle will usually be unavoidable, place a stiff spreader between the eyebolts to take the side strain, and adjust cable lengths so that the unit is approximately level during the lift.

A harness featuring four lifting hooks is required to lift base-mounted units. After inserting the hooks in the lifting lugs, block the chains out on the sides to avoid placing the unit under strain. At the same time, adjust lengths to produce a level lift.

LOCATION of the installation is generally not a critical matter. A clean, dry and protected indoor location is to be preferred. However, an outdoor location will give satisfactory service if correct lubrication for expected temperatures is provided. Effect of such a location on driver and other equipment must also be considered.

PROTECTION of internal machined surfaces against normal atmospheric corrosion is normally provided at the factory, using a vaporizing inhibitor. Markings on the flange covers will indicate this protection. Maximum period of protection is one year under average conditions, if flange covers and closing seals are not removed. **Protection against chemical or salt water atmosphere is not provided.** Leave covers and tape seals over all openings as long as possible during installation to avoid loss of protection.

If there is to be an extended period between installation and start up, the following steps should be taken to insure corrosion protection:

1. Coat internal of gearbox and drive end bearing covers with a vapor phase rust inhibiting liquid such as Nox-Rust VCI-10. Use Zerust vapor capsules in the inlet port of cylinder. Repeat once a year or as conditions may require. VCI-10 is oil soluble and does not have to be

removed before lubricating. If desired, VCI-10 may be removed from within the cylinder shortly before start up by spraying fine mist of petroleum solvent through the blower while it is running at a slow speed with open inlet and discharge, or it can remain in the blower if it is not harmful to the operation of the connected system. VCI-10 is a product of Daubert Chemical Co., Oak Brook, IL.

2. Paint shaft extension, inlet and discharge flanges, and all other exposed surfaces with Nox-Rust X-110 or equivalent.
3. Seal inlet, discharge, and vent openings. It is not recommended that the unit be set in place, piped to the system, and allowed to remain idle for extended periods. If any part is left open to the atmosphere, the VCI-10 vapor will escape and lose its effectiveness.
4. Units are not to be subjected to excessive vibration during storage.
5. Rotate drive shaft three or four revolutions every two weeks.
6. Prior to start up, remove flange covers on both inlet and discharge and inspect internal to insure absence of rust. Check all internal clearances. Also, at this time, remove gearbox and bearing covers and inspect gear teeth and bearings for rust.

When ready to connect piping, remove main flange covers and inspect blower interior for presence of foreign particles or dirt adhering to machined surfaces. Clean out such material by washing carefully with a petroleum solvent then rotate impellers manually to make sure they turn freely. Also use the same solvent to remove the anti-rust coating from flange faces and any other surfaces. **Note:** interior cleaning is not required if no dirt is found.

FOUNDATION design depends on local soil conditions and several other factors and can only be discussed generally here. Additional information will be found in the publication referred to at the beginning of this section. For satisfactory operation of supported equipment, a concrete foundation must be rigid, must have minimum defections, and must be free from resonant frequencies in the operating speed range of the equipment.

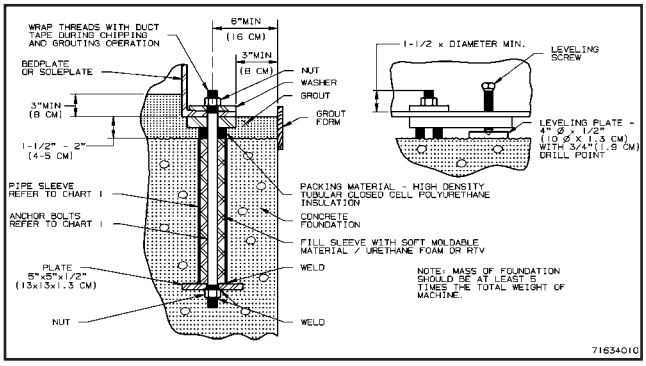
Length and width dimensions of the foundation should provide at least 6 inches (150 mm) from any edge to the nearest machine anchor bolt, as located from the certified manufacturer's general arrangement drawing. Depth dimension should be determined by design, but a minimum practical depth is considered to be twice the distance between shaft centers (or gear diameter) of the unit, or sufficient depth to attain a concrete mass a minimum of 1-1/2 times the weight of the blower and motor. The concrete block should be permitted to cure for a minimum of 28 days before the blower is grouted in place. Any block distortions during curing then will have little or no affect on equipment and alignment. To simplify machine leveling and provide good grouting bond, the top of the foundation should be struck-off as level as possible but left with a rough surface.

Spring-type vibration isolating mounting are **not recommended** for use directly between the operating equipment and the foundation. Where such mountings are required, they should be designed to carry a reinforced concrete slab on which the equipment is mounted. This slab must have good rigidity against bending and twisting, and the suspension system will require careful adjustment to produce a reasonably level condition during operation. All piping will require flexible sections and supports to reduce connection strains on the unit to a minimum.

Direct use of structural framing members for mounting **is not recommended**. If unavoidable, it should be restricted to units of the smaller frame sizes, and spring-type mountings should not be used. Structural members must be rigid, and will probably require reinforcement if part of a building. Noise transmission can be reduced by use of a cork isolating pad. This can be 1 to 2 inch (25-50 mm) thickness, bedding on a full steel plate attached to the structure and carrying rigid concrete slab on which the equipment is mounted.

ANCHOR BOLTS are to be placed within the foundation forms before concrete is poured. Foundation bolts installed as shown in Figure 2, with diameter and length as in Table 2

Figure 2 - Typical Anchor Bolt Detail



are recommended. The bolts must be located as accurately as possible from dimensions on certified installation drawing. To obtain a bolt location tolerance of 1/8" (3mm), use of drilled templates firmly secured to the foundation forms is recommended.

The bolt sleeves shown, if kept centered around the bolts and free of concrete, will allow bolts to be sprung enough to correct for small variations in bolt setting and machine drilling. The sleeves are filled in the final grouting operation. Bolt positions should be adjusted vertically so that the top ends will extend at least 1-1/2 diameters above the soleplate or taper washer, or as shown on the installation drawing.

Jack screws are provided to make leveling the height adjustments easier. Steel plates, approximately 4" x 4" x 1/2 " (100 x 100 x 13 mm) should be placed on the foundation under each jack screw location. Plates and anchor bolts are not furnished as standard accessories.

LEVELING is very important and should be performed with care, using a good machinists level having a ground glass bubble vial. A setting as level as possible in all directions is the result to be worked toward. Blowers should be leveled from drive shaft and pipe flanges. Machined baseplates have pads running in both length and width directions. On

soleplates, the machined top surfaces are used for leveling. Scrape pads or surfaces clean, and remove burrs on high points with a flat file.

When blower and driver have been factory mounted on a common baseplate, the assembly is to be treated as a

Table 2A - Standard Anchor Bolts in Inches

Unit Frame Size	For Soleplates				For Baseplates			
	Bolts		Sleeves		Bolts		Sleeves	
	Dia.	Lgth.	I.D.	Lgth.	Dia.	Lgth.	I.D.	Lgth.
1000	1	25	3	18	3/4	18	2-1/2	12
1200	1	25	3	18	3/4	18	2-1/2	12
1400	1-1/8	25	3	18	3/4	18	2-1/2	12
1600	1-1/8	25	3	25	1	25	3	18
1800	1-1/4	25	3	25	1	25	3	18
2000	1-1/4	25	3	25	1	25	3	18

Table 2B - Standard Anchor Bolts in Centimeters

Unit Frame Size	For Soleplates				For Baseplates			
	Bolts		Sleeves		Bolts		Sleeves	
	Dia.	Lgth.	I.D.	Lgth.	Dia.	Lgth.	I.D.	Lgth.
1000	2.4	64	7.5	46	2.0	46	6.5	30
1200	2.4	64	7.5	46	2.0	46	6.5	30
1400	3.0	64	7.5	46	2.0	46	6.5	30
1600	3.0	64	7.5	46	2.4	64	8.0	46
1800	3.0	64	7.5	46	2.4	64	8.0	46
2000	3.0	64	7.5	46	2.4	64	8.0	46

unit for leveling purposes. Use the jack screws to establish grouting space under the base flanges, and to level the base. Adjust these screws until the indicated variation from level does not exceed .001" per foot (.08 mm per m) in either length or width. Any variations should all be in the same direction, to minimize twist. The maximum allowable twist is considered to be .001" per horizontal foot (.08 mm per horizontal m) measured between any two sections of the base.

Units mounted on soleplates are to be leveled in a similar manner. The plates should be large enough to provide extensions for leveling in both length and width on the finished upper surfaces. Fasten the plates solidly to the blower feet, which are machined flat and parallel to each other, then install and level the blower carefully, using jack screws, shims or wedges for adjusting.

When a satisfactory condition of level is obtained, turn the anchor bolt nuts down snug but not tight. Elimination of twist here is **very important**, and minor adjustments can be made with shims directly under the blower feet.

ALIGNMENT of the drive shafts when the blower unit and its driver are direct coupled requires careful attention. This precaution will not only help insure satisfactory coupling operation, but will minimize chances for damage to either driving or driven unit from vibration or thrust forces.

In package units with driver and blower mounted on a common baseplate, the two shafts will have been put in approximate alignment at the factory. However, baseplate deflections can occur during shipping and installation. A close coupling alignment should be obtained during leveling, so that only small final adjustments will need to be made after grouting. In a soleplate type installation, the separately mounted driver must be positioned, leveled and aligned as part of the installation procedure. Whether it is on soleplates or on its own base, shims of 1/16" to 1/8" (2-3 mm) thickness placed directly under the driver feet before setting will permit more accurate final alignment. Spacing between the two shaft ends as required by the coupling must also be established. If a motor is being used that has end-play in the shaft, be sure its rotor is located on magnetic center before setting this spacing.

When blower is driven through V-belts, the driver must be mounted on an adjustable base to permit tightening or removing the belts. In this case the driver shaft height is of no concern, but it must be parallel to the blower shaft and level. To position the driver properly, both sheaves need to be mounted on their shafts, and the shaft center distance must be known.

The blower sheave, usually the larger one in diameter, must be of the narrow hub type. Install it so that its inner hub face is not more than 1/4" (6 mm) away from the bearing housing end cover. The driver sheave should also be mounted as close to its bearing as possible. Now position the driver so that faces of the two sheaves are accurately in line, with the adjustable base so located as to make 2/3 of its total movement available in the direction away from the blower. This positioning provides minimum belt wear and slip, and allows sufficient adjustment for installation and tightening of belts. Do not install belts until grouting has set and anchor bolts are tightened.

Blowers intended for driving by V-belts may be provided with an extended drive shaft and an additional outer bearing to handle the side pull of the drive. They may be recognized by the extended housing for the outer bearing. If necessary, these units may also be used for direct coupling to the driver. Blowers intended specifically for direct coupling have no outer bearing, and may be seriously damaged if used for belt drive. Consult your Sales Office for approval before belting these units.

GROUTING follows completion of leveling and preliminary alignment. Assuming the foundation has been properly cured, its top surface should first be roughened by chipping to remove glazed areas and oil or grease removed with a strong hot detergent or caustic solution.

Grouting serves not only to compensate for surface irregularities in the foundation and machine base but also to provide restraint against shifting. Anchor bolts are used

for hold-down only. Therefore, the grout must be adequate thickness under the soleplate or base flange, must flow into anchor bolt sleeves and all interior cavities, and must have minimum shrinkage during the setting period. By virtue of the open frame design, it is recommended that the bed¬plate be filled with concrete to a level equal to the top of the main channels. Special grouting materials designed to counteract shrinkage are commercially available, and are often preferred

to cement. The manufacturer's instructions should be followed in using these materials. Care must be exercised when employing non-shrink additives with cement, as too much can be worse than none. Any gas forming or air-entraining additives should be avoided completely, since they tend to reduce grout strength.

Wait at least 24 hours before tightening anchor bolts or connecting any piping. When jack screws have been used for leveling, make sure the bottom of the leveling screw is treated according to grout manufacturer's instructions so that leveling screw can be backed off. Such points of concentrated loading are likely to wear during machine operation, resulting in loose anchor bolts. Final bolt tightening should be only enough to hold the machine firmly against the foundation and prevent vibration.

After all anchor bolts are secured, recheck the blower for twist and level. Working from the finished pad on top of the cylinder, make corrections to meet the requirements specified under LEVELING by shimming under the blower feet. Then rotate the drive shaft by hand to make sure both impellers turn freely at all positions.

When the blower is direct coupled to its driver, final alignment of the two shafts should be accomplished next by adjusting the shims under the driver feet. This needs to be done with the greatest possible care. Even though a flexible coupling can accept some degree of misalignment, it should not be forced to compensate for careless workmanship. The flexing or sliding member in a coupling will transmit undesirable forces between the two shafts in proportion to the degree of misalignment, thus promoting vibration and unnecessary wear problems.

MISALIGNMENT can be of two basic types, offset and angular, but usually it will be a combination of both. For satisfactory coupling operation it is recommended that the following limits be used: maximum deviation in offset alignment not greater than .005" (.13 mm) total indicator reading on the coupling hubs; maximum deviation from parallel of the inside coupling faces not greater than .001" (.03 mm) when checked at six points. Where driver is a steam turbine, the final alignment should be made with the turbine at operating temperature in order to allow for shaft movement resulting from expansion.

A coupling that has been Factory installed as part of a pre-assembled package should receive the same final alignment check as outlined above. It will need to be disassembled by removing cover bolts, removing or drawing back the two cover halves, and removing the internal member. In some cases the latter item may have been packed separately for shipment. After necessary adjustments for alignment are completed, lubricate the coupling with grease as specified by its manufacturer and assemble.

A belt-driven installation should require no realignment if all items were correctly positioned and leveled before grouting. Belts may be installed now by adjusting driver position toward the blower sufficiently to permit belts to be laid in their sheave grooves easily. Do not pry or roll them into place. Before doing this, inspect all grooves for burrs, rough spots or oil that might shorten belt life. If equipment is not to be operated immediately, leave the belts slack.

Proper tensioning of the drive for operation should be done in accordance with manufacturer's recommendations, keeping in mind that excessive tension can seriously overload shaft bearings and also lead to premature drive failure. Under-tensioning can produce slippage, with consequent loss of blower capacity in addition to belt damage.

Make sure at this point that driver rotation is correct to produce the blower shaft rotation indicated by an arrow near the shaft. Blowers are not reversible, hence drive shaft rotation and discharge flange location are predetermined in manufacturing assembly. Figure 4 illustrates the assembly options available by specification on original order, to meet piping and drive requirements.

PIPING must be clean, and should be sized so that air velocity in the line will not exceed 100 feet per second (30 m per second). When a blower is being operated at or near its maximum volume rating, the pipe size should not be smaller than the blower connections. Where possible, use long radius elbows to insure smooth flow. Design the piping layout so that no strains are placed on the blower, either from weight or expansion forces. This means providing adequate supports, anchors, and expansion joints or loops.

Installation of a spool-type rubber expansion joint near the blower inlet connection is recommended. A similar unit with control elements added to minimize piping vibrations may be required near the discharge. Use of SNUBBERS or SILENCERS in the inlet or discharge piping will be dependent on such factors as blower speed, operating pressure, length and kind of piping, and consideration of sound level requirements in the general surrounding area. For specific silencer recommendations refer to the nearest Sales Office.

Inlet piping should be completely free of valves or restrictions, but when a shut-off valve cannot be avoided, make sure a full size vacuum relief valve is installed near the blower inlet connection. See Figure 5. This will protect against an overload caused by accidental valve closing. Further protection can be provided by installation of a dependable pressure sensitive device with alarm or shutdown action.

Approximate Screen Pressure Drop, Inches H_2O (16 Mesh, .020" Wire Dia.)

Flow	Pipe Diameter (Inches)					
	12"	16"	20"	24"	30"	36"
2,500	3.0	1.1	0.3	0.3		
5,000	12.7	3.9	1.7	0.8		
10,000		15.5	6.4	3.0	1.3	
15,000			14.4	7.2	2.8	1.4
20,000				12.7	5.1	2.4
30,000					11.4	5.5
40,000						12.3

Figure 3 – Installation with Suggested Locations for Available Accessories (DVJ)

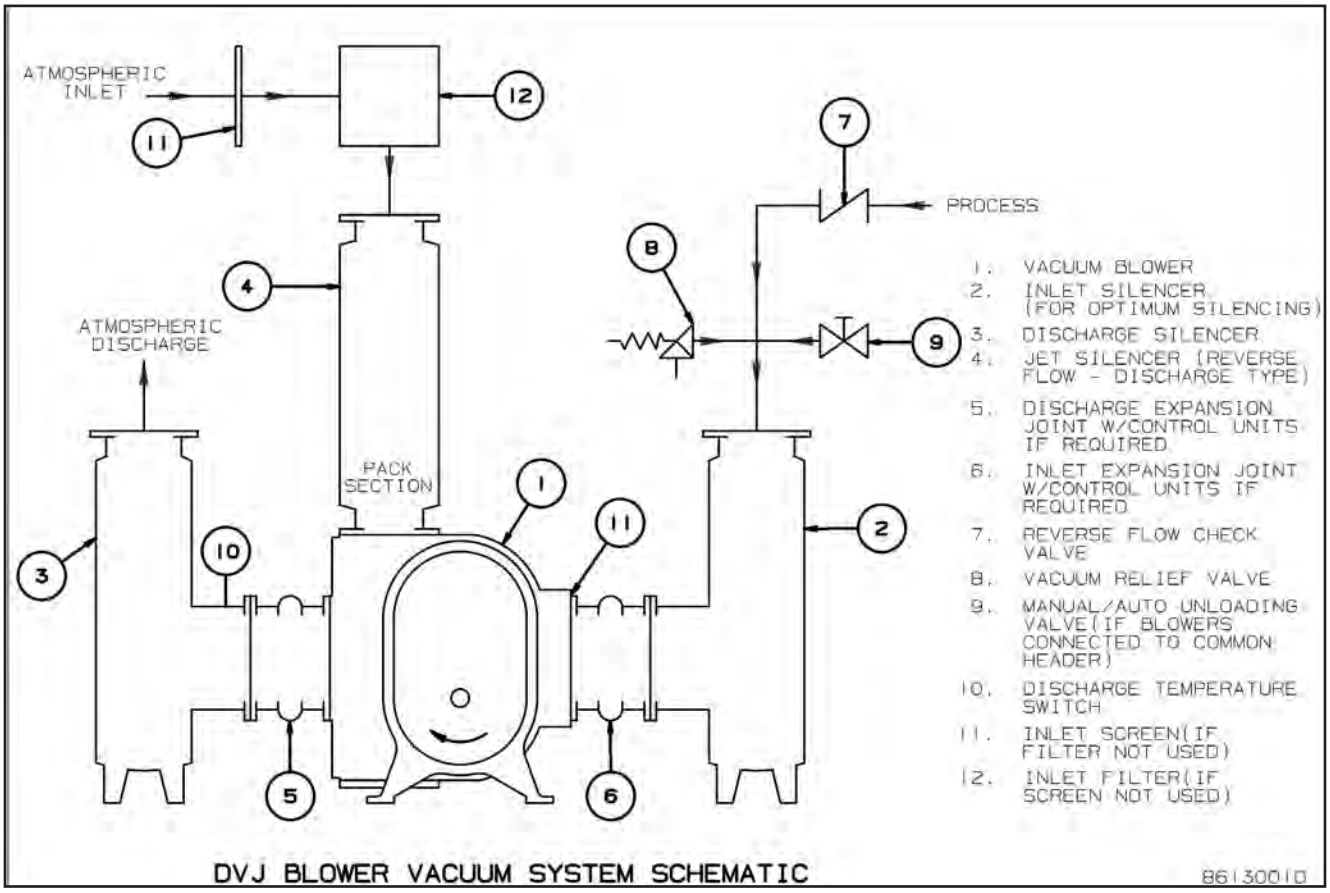
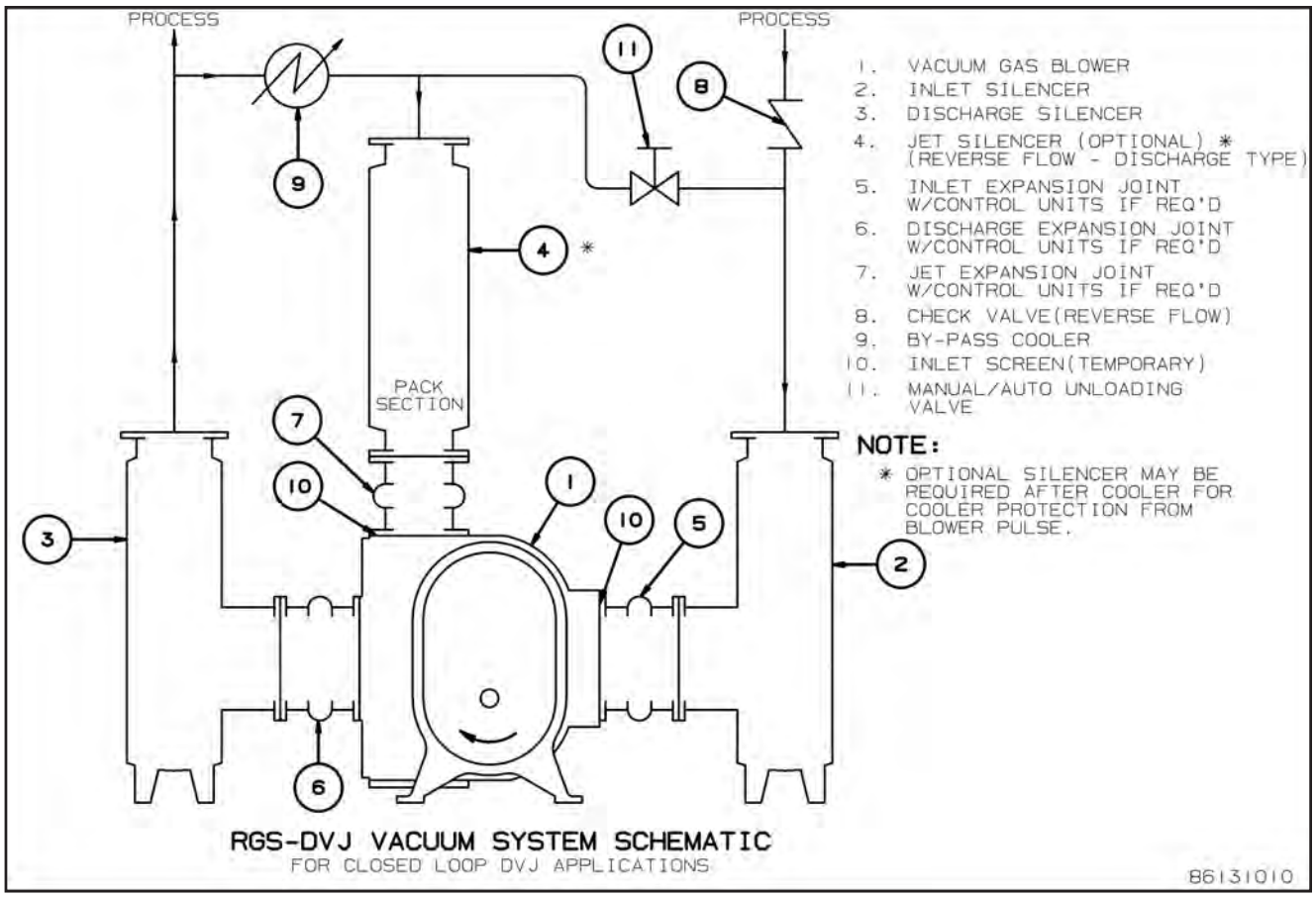


Figure 4 – Installation with Suggested Locations for Available Accessories (RGS-DVJ)



During initial operation, install a temporary corrosion resistant screen at the compressor inlet connection. Screen should be made of 16 mesh (.020" diameter) wire backed with 2 mesh wire cloth. Backing cloth-wire diameter shall be a minimum of 0.063" diameter for 12" pipe, 0.080" diameter for 16" pipe, 0.105" diameter for 20" pipe, and 0.120" diameter for 24" pipe. For 30" and 36" pipe use 1 mesh backing cloth with a minimum of .180" wire diameter for 36" pipe. The table below gives approximate screen pressure drop. A manometer connected to read pressure drop across the screen will indicate when it needs cleaning. Do not allow pressure drop to exceed 55 inches H2O. Clean and replace the screen until debris no longer appears. Do not leave it installed permanently, as the wire will eventually deteriorate and pieces may go into the blower causing serious damage. (Typically, screens are installed 1-2 days of operation.)

Discharge piping requires a pressure relief valve, and should also include a suitable pressure gauge and a manually operated unloading valve. The latter permits starting under no-load conditions. The optional back pressure regulator shown in figure 5 will be required if volume demands vary while blower operates at constant speed. It may be vented if only air is being handled. A vent silencer may be required, depending on permissible sound levels in the general surroundings.

In some installations, particularly where two or more blowers discharge into a common header, it is recommended that a direct acting or free swinging check valve be provided in each discharge line. These valves, properly installed protect against damage resulting from reverse rotation caused by back flow through an idle blower.

In making pipe connections to the blower, use special care in lining up the mating flanges. They must contact squarely and accurately, without imposing strain on the blower casing. Any attempt to draw flanges together by force will probably distort the blower and cause internal contacts. Also, the blower should not carry more than the weight of one pipe fitting at each connection. After bolting up the flanges, rotate the drive shaft by hand to check for rubbing contacts caused by strains or dirt.

Lubrication

A - SEPARATE OPPOSITE GEAR END RESERVOIRS

A simple and reliable splash lubrication system is employed in ROOTS® blowers. All friction parts - gears, bearings and shaft seals - are lubricated either by dipping directly into oil reservoirs or by receiving splash oil from other rotating parts. All reservoirs require the same grade of oil as specified in Table 3 for various ambient temperature ranges at the installation site. Reference to the appropriate assembly drawing, Figure 15, will assist in understanding of the following discussion.

Table 3 - Recommended Lubrication Oils

Ambient Temperature	Viscosity Range, SSu at 100% °F (83 °C)
Above 90 °F (32°C)	1000-1200
32° to 90°F (0°-32°C)	700-1000
0° to 32°F (-18°- 0°C)	500-700
Below 0°F (-18°C)	300-500

At the opposite gear end of the blower, the upper (or driven) shaft bearing is lubricated from its own oil reservoir, formed by the bearing carrier (6) and the deep blind end cover (5A). At a normal oil level, bearing rollers dip into the oil as they roll through the bottom of their raceway. The oil picked up is carried over the top by bearing rotation, and some of it transfers to the shaft behind the bearing to lubricate the dynamic lip-type inboard seal (27). A slight amount of oil may work through this seal, but it will be thrown off by the shaft slinger, and further prevented from reaching the air chamber by a labyrinth type seal where the shaft passes through the headpiece. The chamber between the two sealing points is vented to atmosphere and serves not only to drain any seal leakage but also to keep the lubrication system at atmospheric pressure.

At the lower (driving) shaft the arrangement is the same as described above when a short shaft for direct coupling is provided. Here an outboard shaft seal (23) is provided in the end cover (5). On V-belt driven blowers the drive shaft and bearing carrier (63) are extended and provided with and additional inboard bearing (60). This creates a larger reservoir requiring about three times as much oil to fill. Lubrication is the same as for the shorter shaft, except that two protruding screws (96) are provided to insure adequate splash oil for bearing (60).

At the gear end of the blower the bearings, seals and timing gears are enclosed by a gearbox containing a double (primary and secondary) oil sump arrangement. In a vertical style blower the secondary sump is formed of sheet steel and contoured around the bottom half of the lower gear. It is fed with oil at a controlled rate from the surrounding primary sump in the gearbox itself, through a metering orifice in the secondary wall. The lower gear teeth pick up oil and carry it to the meshing point with the upper gear, from where it is splashed onto oil control shields with leaders that direct the oil to the two bearings. A dam at each bearing maintains the desired oil level there, with excess overflowing into the gearbox primary sump. Inboard sealing of the shafts is the same as at the drive end. In a horizontal style blower the gear end lubrication arrangement is identical, except that a secondary sump is formed around each gear and the total oil capacity is more than doubled.

Note - A good grade of industrial type non-detergent, anti-foaming oil should be used when the average of blower inlet and discharge temperature is 125°F (52°C) or lower. Oil should be changed after the first 100 hours of operation. After initial oil change, normal oil change periods under these conditions may be considered as 2000 operating hours.

Table 4 - Oil Sump Capacities

Blower Frame Size	Gearbox - gallons (liters)		Opposite Gear End Bearings - fluid oz. (liters)		
	Vertical	Horizontal	Driven Shaft	Drive Shaft Coupled	Drive Shaft Belted
1000	¾ (2.8)	2 (7.6)	4 (.12)	4 (.12)	12 (.36)
1200	1½ (5.7)	3½ (13)	5 (.15)	5 (.15)	16 (.47)
1400	1¾ (6.6)	4 (15)	8 (.24)	8 (.24)	28 (.83)
1600	2½ (9.5)	5¾ (22)	9 (.27)	9 (.27)	
1800	3 (11)	7½ (28)	16 (.47)	16 (.47)	
2000	4 (15)	9¾ (37)	19 (.56)	19 (.56)	

At higher temperatures these oils may turn black and leave carbon deposits. For average temperatures above 125°F (52°C) it is recommended that oil with an efficient oxidation inhibitor be used, and that change interval be reduced. Shell **TELLUS** is a suitable oil type with the required characteristics, and equivalent oils from other suppliers are assumed to be comparable in performance. Suggested oil change periods for the higher operating temperatures are as follows:

Average Temp. °F (C°)	Operating Hrs.
Below 150 (65)	1000
151-160 (66-71)	500

Above average temperature of 180°F, use of synthetic oil like ROOTS Synfilm ST Synthetic Oil is specified.

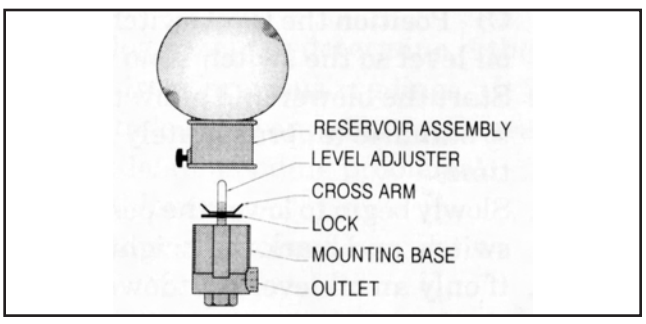
On the gearbox and the two opposite gear end bearings sumps, oil levels are indicated in sight windows. All three sight windows are completely unobstructed circular discs, and the oil level should always be in view.

Approximate capacities in gallons or fluid ounces for the three sump locations are given in Table 4 as a guide. Actual filling requirements may vary slightly from the listed figures. Select a good industrial grade of oil per Table 3 for the existing ambient temperature conditions.

Filling of the oil sump **must** be performed with the blower not operating, so that correct levels may be established. At the gearbox, remove vent plug (37) in the top and pour in slightly less oil than indicated in Table 4 for the blower size concerned, or until the oil rises to the center of the sight glass. Wait several minutes for the levels to equalize between the primary and secondary sumps, then add more oil if needed, or drain excess at plug (67).

The opposite gear end sumps use constant level oilers. To fill the sumps, remove the top glass reservoir. Fill it with oil and place it on its holder and let the bottle empty to fill the sump.

Figure 5



To obtain proper oil level in the sump, that is to the center of the sight glass (90), pull out level adjuster “A” (see fig. 5) and raise or lower cross-arm “B” as needed, secure “B” with lock “C” and drop assembly back into lower reservoir and replace bottle. Note - Raising “B” raises oil level and lowering “B” lowers oil level.

During operation the sump levels can be expected to fluctuate. At the gearbox sight window the level will rise as a result of oil being thrown out of the secondary sump (oil pan) into the primary sump. A satisfactory oil level is assured as long as it is visible in the window. A blower should not be operated when the oil is either above or below the circle on the sight window.

Oil levels at the opposite gear end will fall slightly during operation because of the apparent “loss” carried in the bearings and on the shafts. To be satisfactory, the level must be visible in the sight glass.

During the first week of blower operation, check the oil level daily and watch for leaks. Replenish oil as necessary. Thereafter, an occasional check should be sufficient. Drain plugs (67 and 88) are provided at the bottom of gearbox and bearing sumps.

B - COMMON OPPOSITE GEAR END RESERVOIRS

Some blowers are equipped with a common reservoir on the opposite gear end. The small reservoirs are replaced with a large cover similar to that covering the gear end. The oil is transmitted to the bearings by use of a slinger plate which dips into the oil. The oil is then captured and directed to the bearings by oil control shields. Reference to the sectional drawings at the back of this manual will help in understanding this system.

Table 5 – Common O.G.E. Sump Capacity

Blower Frame Size	Gearbox Gallon/liters		O.G.E. Gallon/liters	
	Vertical	Horizontal	Vertical	Horizontal
1000	3/4 (3.3)	2 (7.6)	3/4 (2.8)	2 (7.6)
1200	1-1/2 (5.7)	3-1/2 (13)	1-1/2 (5.7)	3-1/2 (13)
1400	1-3/4 (6.6)	4 (15)	1-3/4 (6.6)	4 (15)
1600	2-1/2 (9.5)	5-3/4 (22)	2-1/2 (9.5)	5-3/4 (22)
1800	3 (11)	7-1/2 (28)	3 (11)	7-1/2 (28)
2000	4 (15)	9-3/4 (37)	4 (15)	9-3/4 (37)

Operation

Before operating a blower under power for the first time, recheck the unit and the installation thoroughly to reduce the likelihood of troubles. Use the following procedure check list as a guide, but consider any other special conditions in the installation.

1. **Be certain** that no bolts, tools, rags or dirt have been left in the blower air chamber.
2. **Be certain** that inlet piping is free of any debris. Use of the temporary protective screen at the blower inlet as described under INSTALLATION is strongly recommended during early operation. If an outdoor intake without filter in used, be sure the opening is clean and protected by a strong screen.
3. **Check** blower leveling, drive alignment, belt tension and tightness of all mounting bolts if installation is not recent.
4. Turn drive shaft over by hand to make sure impellers will rotate without bumping or rubbing at any point.
5. **Check** the blower lubrication system. Oil level should be at the center of the sight glasses.
6. **Make sure** driver (and gear unit if supplied) are properly lubricated. Check that power is available and that all electrical overload and safety controls installed, connected and in operating condition.
7. Open the manual unloading valve in the inlet air line, and make sure that any blocking valve in the discharge piping is open.
8. Bump blower a few revolutions with driver to check direction of rotation and to see that both units coast freely to a stop.
9. Start blower, let it accelerate to full speed, then shut off. Listen for any knocking sounds, both with power on and also as it slows down.
10. If no problems have appeared, restart unit and operate for 5 to 10 minutes under no-load conditions as paragraph 7. Check the cylinder surfaces all over by feeling to locate any hot spots indicating impeller rubs. Continue to listen for noises and watch for changes in vibration. If all conditions are acceptable, proceed as follows:
11. Continue operating, but gradually close the inlet unloading valve to establish normal operating conditions as closely as possible. It is recommended that pressure and vacuum gages and good thermometers be used in both inlet and discharge locations to permit determination of pressure rise and temperature rise across the blower. Observe the vacuum increase as the unloading valve is closed, and do not allow it to exceed the rating of the specific blower as listed under LIMITATIONS.
12. All conditions being satisfactory to this point, continue the run for about one hour. Observe the vacuum and temperature rise periodically to make sure neither exceeds specified limits. Continue to check for noises and hot spots, and observe oil level behavior at the three sumps. If trouble appears, refer to the TROUBLESHOOTING CHECKLIST for suggested remedies.

The unit should now be ready for continuous duty under full load. During the first several days, make periodic checks to be sure that all conditions remain reasonably steady and within limits. These checks may be especially important if the unit is part of a process system where conditions may vary. At the first opportunity, stop the blower and clean or remove the protective inlet screen. At the same time, verify leveling, coupling alignment or belt tension, and anchor bolt tightness.

Should operation of an air blower prove that its capacity is a little too high for actual requirements, a **small** excess may be blown off through the manual unloading or vent valve. **Never rely on the pressure relief valve as an automatic vent.** Such use may cause the inlet vacuum to become excessive, and can also result in failure of the valve itself. If blower capacity is low, refer to TROUBLESHOOTING CHECKLIST before contacting the nearest Sales Office for recommendations. Be prepared to give all operating conditions and requirements.

Safety Precautions

For equipment covered specifically or indirectly in this instruction book, it is important that all personnel observe safety precautions to minimize the chances of injury. Among many considerations, the following should particularly be noted:

- **Blower casing and associated piping or accessories may become hot enough to cause major skin burns on contact.**
- **Internal and external rotating parts of the blower and driving equipment can produce serious physical injuries. Do not reach into any opening in the blower while it is operating, or while subject to accidental starting. Cover external moving parts with adequate guards.**
- **Disconnect power before doing any work, and avoid by-passing or rendering inoperative any safety or protective devices.**
- **If blower is operated with piping disconnected, place a strong coarse screen over the inlet and avoid standing in the discharge air stream.**
- **Stay clear of open inlet piping (suction area) of pressure blowers, and the open discharge blast from vacuum blowers.**
- **Stay clear of the blast from pressure relief valves and the suction area of vacuum relief valves.**
- **Avoid extended exposure in close proximity to machinery which exceeds safe noise levels.**

- **Use proper care and good procedures in handling, lifting, installing, operating and maintaining the equipment.**
- **Casing pressure must not exceed 25 PSI (172 kPa) gauge. Do not pressurize vented cavities from an external source, nor restrict the vents.**
- **Do not use air blowers on explosive or hazardous gases.**
- **Other potential hazards to safety may also be associated with operation of this equipment. All personnel working in or passing through the area should be warned by signs and trained to exercise adequate general safety precautions.**

Preventive Maintenance

1. **Daily**

   A. Record the following:

      1) Lube oil pressure (if applicable).

      2) Lube oil temperature (if applicable).

      3) Blower inlet temperature.

      4) Blower inlet pressure.

      5) Blower discharge temperature.

      6) Blower discharge pressure or differential pressure.

      7) Motor amperage.

      8) Motor voltage, if available.

      9) Motor stator temperature, if available.

      10) Motor bearing temperature, if available.

   B. Observe any abnormalities, i.e. burned paint, unusual noises, vibration, strange odors, oil leaks, etc.

   C. Review log sheets to determine if there are any changes from previous readings. (It is very important to look for any changes or trends which might indicate pending problems).

   D. Check oil levels.

   E. Record hour meter readings.

2. **Monthly**

   A. Record bearing housing vibration levels at each bearing in the horizontal, vertical, and axial planes. Use velocity (in./sec.) measurements and note any changes from previous readings. Take a complete vibration signature (amplitude versus frequency) if any trends are noted. (It may be helpful to keep a chart on monthly readings.)

3. **Quarterly**

   A. Sample lube oil or change.

   B. Change oil if the following values are exceeded:

      1) Water 100 PPM maximum.

      2) Metals 200 PPM maximum.

      3) Acid 5.0 to 7.5 Mg/KOH/g maximum.

   C. Increase frequency of sampling if any of the above values show about 20 to 25% increase over the last sample.

   D. Flush all oil reservoirs before filling with clean oil.

4. **Annually**

   A. Remove an inlet expansion joint, inspect impellers, measure impeller clearances and note wear patterns.

   B. Check coupling alignment, inspect coupling for wear, and repack with fresh grease.

   C. Inspect oil cooler tubes, as applicable.

   D. Check all protective switches for proper setpoints and operation.

   E. Check V-belt drive condition and tension.

5. A Preventative Maintenance Schedule should be established for driver(s) and all accessories in accordance with the applicable manufacturer's recommendation.

Troubleshooting Checklist

Trouble	Item	Possible Cause	Remedy
No Flow	1	Speed too low	Check by tachometer and compare with speed on Roots Order Acknowledgment
	2	Wrong Rotation	Compare actual rotation with Figure 4 or 5. Change driver if wrong.
	3	Obstruction in piping	Check piping, screen, valves, silencer, to assure open flow path.
Low Capacity	4	Speed too low	See item 1. If belt drive, check for slippage and readjust tension.
	5	Excessive pressure rise	Check inlet vacuum and discharge pressure, and compare these figures with specified operating conditions on order.
	6	Obstruction in piping	See item 3.
	7	Excessive slip	Check inside of casing for worn or eroded surfaces causing excessive clearances
Excessive Power	8	Speed too high	Check speed and compare with Roots Order Acknowledgement.
	9	Excessive pressure rise	See item 3.
	10	Impellers rubbing	Inspect outside of cylinder for high temperature areas, then check for impeller contact at these points. Look for excessive scale build-up. Correct blower mounting, drive alignment.
Overheating of Bearings of Gears	11	Inadequate lubrication	Check oil sump levels in gearhouse and drive end covers.
	12	Excessive lubrication	Check oil levels. If incorrect, drain and refill with oil of recommended grade.
	13	Excessive pressure rise	See item 5.
	14	Coupling misalignment	Check carefully. Realign if questionable.
	15	Excessive belt tension	Readjust for correct tension.
Vibration - Refer to “Rotary Lobe Blower Vibrations”	16	Misalignment	See item 14.
	17	Impellers rubbing	See item 10.
	18	Worn bearings/gears	Check gear backlash and condition of bearings, and replace as indicated.
	19	Unbalanced or rubbing impellers	Scale or process material may build up on casing and impellers, or inside impellers. Remove build-up to restore original clearances and impeller balance.
	20	Driver or blower loose	Tighten mounting bolts securely.
	21	Piping resonances	Determine whether standing wave pressure pulsations are present in the piping. Refer to Sales Office.

Rotary Lobe Blower Vibrations

The general vibration severity charts derived from Rathbone vibration severity charts provide guidelines for machines basically having mass unbalance-turbomachinery, electric motors, etc. The German specification VDI 2056 - Criteria for Assessing Mechanical Vibrations of Machines - provides vibration guide lines for machines with rotating masses (turbomachinery) and machines having mass effects which cannot be balanced (reciprocating machines), but does not specifically address rotary lobe blowers (also known as ROOTS Blowers) with inherent fluctuating dynamic bearing loads and torques.

API Standard 619, Rotary Type Positive Displacement Compressors for General Refinery Services, limits the vibration level to 0.1 in/sec peak, which is quite ambitious.

Based on experience, practical acceptable vibration levels lie somewhere between API 619 requirement and VDI 2056 allowance for group D reciprocating machines.

Elements Generating Vibrations in Rotary Lobe Blower:

1. Blower inherent characteristic -
   a. Impacting bearing loads excite component/system natural frequencies.
   b. Pressure pulsations set up vibrations at four times the running speed.
2. Rotary lobe blowers use very close clearances between the impellers and the housing. The impeller contact will setup vibrations as follows:
   a. Impeller to impeller frontal lobe contact - if contact is between only one set of lobes, the vibration frequency will be 1XRPM, if both sets of lobes contact, the vibration frequency will be 2X RPM.
   b. Impeller to cylinder contact - the vibration frequency will depend on the number of impeller tips contacting the cylinder which could range from one to four times the RPM.
   c. Impeller to head plate contact - the vibration frequency will be erratic and unsteady.
3. Damaged gears will generate vibrations at mesh frequency, number of teeth times RPM.
4. Damaged bearings will generate vibrations at ball pass frequency, fundamental train frequency and ball spin frequency.
5. Rotor unbalance and bent shaft will generate vibrations at 1XRPM.
6. Blower/driver coupling misalignment will generate vibrations at 1XRPM and 2XRPM.
7. Acoustic resonance in the blower inlet/discharge piping will generate vibrations at 4XRPM.
8. Operation of rotary lobe blower at or near system torsionals may cause impeller lobe contact and increases vibrations.
9. External piping if not properly isolated will transmit vibrations into the blower.
10. Foundation design and method of mounting has considerable effect on blower vibrations.

Vibration Criteria:

1. Units of measurement: Rotary lobe blower vibrations are measured in inches/sec. Measurements of spike energy is not recommended for judging blower condition because the rotary lobe blower has inherent impacting bearing loads.
2. Measurement location: Vibrations should be measured at the bearing locations on the housing.

The following table provides an appropriate assessment guideline for rotary lobe blowers rigidly mounted on the stiff foundations.

Unfiltered Vibrations (in/sec peak)	Assessment
>0.62 thru 1.0	Satisfactory
>1.0	Review Required

If the blower is operating at “review required” levels then the installation must be fully evaluated to determine the source or cause of vibration and the cause shall be corrected.

In general, blower vibration levels should be monitored on a regular basis and the vibration trend observed for progressive or sudden change in level. If such a change occurs, the cause should be determined through spectral analysis.

The blower vibrations will be transmitted into the motor, speed reducer etc. and more so if they are mounted on the common blower baseplate. Allowable vibration levels into these accessories should be obtained from the vendors.

Maintenance/Replacements

A good program of inspection and maintenance servicing, if followed consistently, is the most reliable means of preventing costly repairs to a blower. A simple record of procedures and dates will help maintain this work on a regular schedule. Basic requirements are lubrication and cleaning, along with periodic checking for increased vibration and hot spots on the cylinder. Inlet and discharge pressures and temperatures should be observed frequently, to minimize the chances for trouble resulting from blower ratings being exceeded. **Above all, the unit must be operated within its specifications.**

In a blower properly installed and operated, there is no moving contact between the two impellers, or between the impellers and cylinder or headplates. Wear is then confined to the timing gears, the bearings which support and locate the shafts, and shaft seals. All are lubricated, and wear should be normal if they are always supplied with clean, high grade lubricating oil. Shaft seals, weather lip type or rotating mechanical type, are subject to deterioration as well as wear. They may require replacement at varying periods. O-rings should be replaced at each disassembly.

If trouble should occur during operation, and its cause cannot be readily determined, consult the TROUBLESHOOTING CHECKLIST. Remedies suggested there can usually be performed by qualified mechanics, using procedures detailed in this manual. Major repairs not covered here are considered beyond the scope of maintenance, and should be referred to the nearest Sales Office. See listing on the last page. **Warranty failures** should not be repaired at all, unless specific approval has been obtained through a Sales Office before starting the work. Unauthorized disassembly within the warranty period may void the warranty.

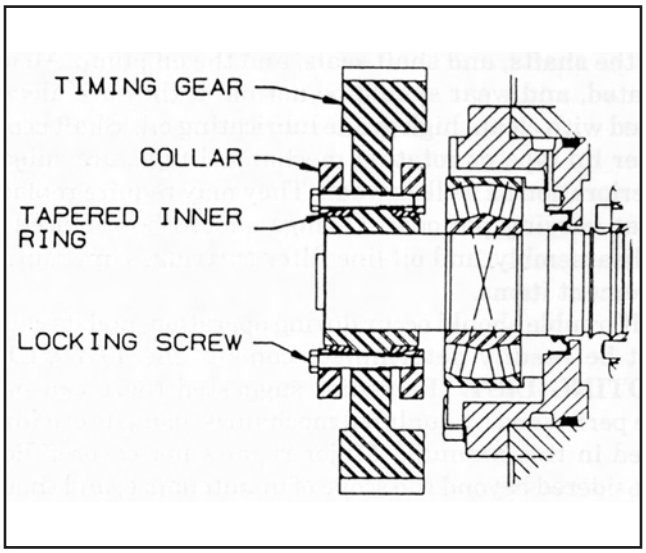
Where repairs involve parts replacement, it is recommended that Factory Parts be used to insure fit and suitability. Delay in making such repairs can be reduced by having spare parts on hand.

When ordering parts, please furnish all information from the blower nameplate.

Repairs or adjustments to blowers should be performed by personnel with a good background of general mechanical experience and the ability to follow the detailed instructions in this manual. Some operations involve extra care and a degree of precision work. This is especially true in timing impellers, and in handling bearings. Experience indicates that a high percentage of bearing failure is caused by dirt contamination before or during assembly. Therefore, clean the work area before starting disassembly, and protect new or reusable parts during progress of the work.

The following detailed work procedures cover repairs and adjustments that can normally be handled successfully at the installation site. Numbers shown in brackets ( ) correspond to Item Numbers used in the sectional assembly drawings and in Table 9. Refer to the drawing applying to the type unit being repaired while reading the instructions.

Figure 6 - Gear Locking Assembly



A - REMOVING GEARS WITH GEAR LOCKING ASSEMBLIES

1. Drain oil at plug (67) near bottom of gearbox (3).
2. Loosen cap screws (30) attaching gearbox to headplate
3. Attach lifting device to support gearbox and remove capscrews. Move gearbox out of way.
4. Match mark gears so that they can be returned to the same shafts in same position.
5. Gradually release gear locking assembly capscrews evenly all round. Initially each screw should be released about a quarter of a turn only to prevent tilting and jamming of collars. DO NOT REMOVE LOCKING SCREWS COMPLETELY OR THE COLLAR MAY SPRING OFF CAUSING INJURY. Just loosen the locking assembly, both collars should be loose on the tapered inner rings. To loosen the back collar, tapping on the locking screws may be necessary. To loosen the front collar, use of wedges between the collar and the gear web may be required
6. Using two puller holes in the gear (see Table 6 for size) pull the gears off the shafts,

Table 6 - Puller Hole Sizes

Blower Size	Gear Puller Hole Size	Carrier Puller Hole Size
1000	1/2/13	5/8/11
1200	3/4/10	5/8/11
1400, 1600	8-Jan	3/4/10
1800, 2000	1-1/4 - 7	8-Jan

B - INSTALLING GEARS WITH GEAR LOCKING ASSEMBLIES

1. Apply NEVERSEEZ paste on the gear locking device screw threads, under the screw heads, on the tapered rings, on the collar tapers, and on the gear hub outside diameters.

2. Slide each tapered ring collar and the web clearance holes and screw them loosely into the opposite collar.
3. Do not tighten screws at this time.
4. DEGREASE GEAR HUB BORE AND SHAFT. THE GEARFIT MUST BE FREE OF ANY LUBRICANT.
5. Install two 12" long threaded rods (sizes are give in Table 5) in the bearing carrier puller holes. Line up the gear puller holes with the rods and using proper nuts on the guide rods, push the gears on flush with the shaft end. Make sure that the gear match marks line up. Take any 3 or 4 locking screws equally spaced and snug them up.
6. Set impeller timing as described under Step 4 of Operation C.
7. Once satisfactory timing is achieved, locking screws are to be tightened to Table 7 values, using a calibrated torque wrench. Tighten all locking screws gradually and all the way around in either clockwise or counter-clockwise sequence, but not in diametrically opposite sequence. Tighten screws half a turn at a time. Check and make sure that no screw will turn any more by applying specified torque.

Table 7 - Torque Wrench Data

Frame Series	Gear Capscrew Size-Metric	Gear Capscrew Torque Values, LB-FT (kg-M)	Stub Shaft Screws LB-FT (kg-M)
1000	M8	(4.2) 30	45 (6)
1200	M8	(4.2) 30	75 (10)
1400	M10	(8.3) 53	75 (10)
1600	M10	(8.3) 60	105 (15)
1800	M12	(13.8) 100	105 (15)
2000	M16	(33.2) 240	250 (35)

10" TAPER BORE GEAR REMOVAL PROCEDURE

1. Remove the gear nut.
2. Install Gear Remover within 1/8th inch of the gear face. This gap is necessary to unseat gear from the shaft taper.
3. Apply Neverseez on 3/4-10X3” long, grade 8 capscrew threads and under hex heads.
4. Install capscrews through gear remover holes into the gear puller holes.
5. Tighten these capscrews quarter turn at a time in either clockwise or counter-clockwise sequence, but not diametrically opposite sequence, till the gear is unseated from the taper.
6. If the gear does not come off using above method, use hydraulic assist feature provided in the gear in addition to the above. Hydraulic pump capable of generating about 20,000 PSI pressure is required. Make sure all tubing and fittings are good for 40000 PSI. The gear connections are 1/4 NPT. Hook up pump to bottom connection. Leave top hole open. Crank the pump till some oil comes through the open hole bleed¬ing all air out. Close the top hole with 1/4 NPT solid steel plug. Crank the pump up till the gear comes off. Do not exceed 20,000 PSI oil pressure. If not sure how to use the hydraulic removal system, contact factory.

Figure 7 - Taper Gear Remover

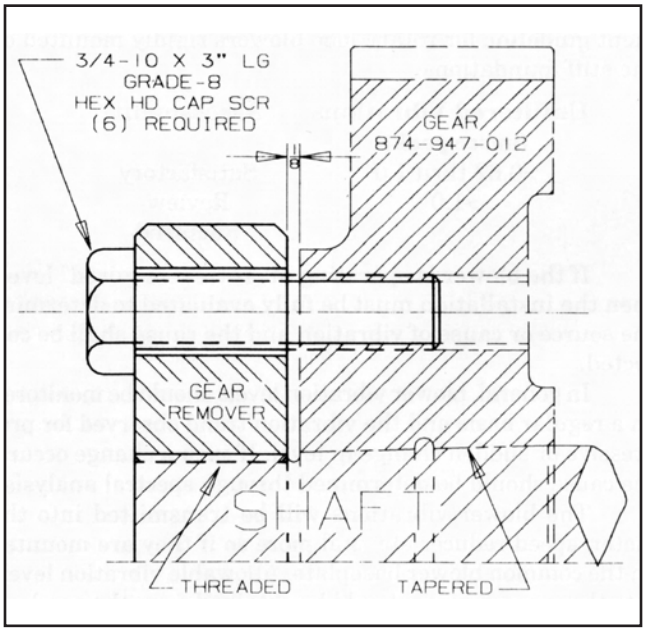
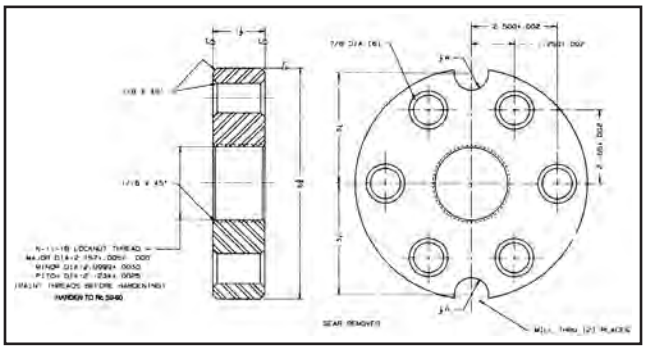


Figure 8 - Gear Remover Material - Steel, Hardness - Rc-25



10" TAPER BORE GEAR INSTALLATION PROCEDURE

1. Block the impellers inside the blower using wooden blocks/wedges.
2. Degrease gear bore and shaft taper. **THESE SURFACES MUST BE FREE OF OIL.**
3. Screw the inside ring onto the shaft, snug it up against the gear by hand.
4. Slide outside ring onto the inside ring.
5. Apply Neverseez on the threads and under the head of the installation capscrews. Install the capscrews finger tight.
6. Install indicator on the gear outside face for measuring the gear axial movement.

Figure 9 - Taper Gear Installation

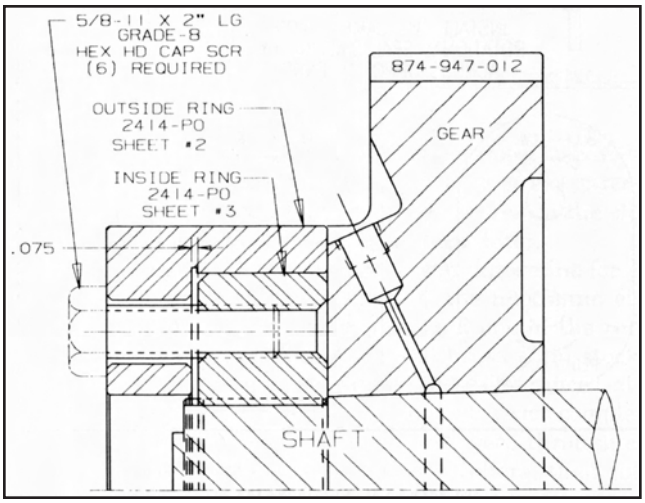


Figure 10 - Outside Ring Material, Steel, Hardness - Rc-25 min

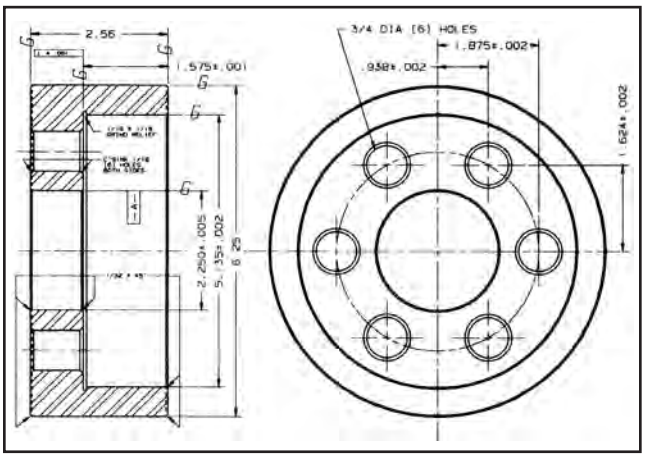
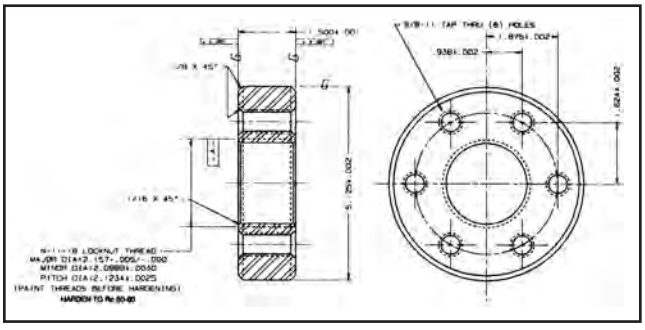


Figure 11 - Inside Ring Material, Steel, Hardness - Rc-25 min



7. Tighten each screw quarter turn at a time in either clockwise or counter-clockwise sequence, but not diametrically opposite sequence, till the outer ring is solid against the inside ring. **THE GEAR SHOULD MOVE .065 to .075".**
8. Loosen up the installation capscrews and remove the gear installation tooling.
9. Install gear locknut and tighten nut with a spanner wrench.

C - TIMING THE IMPELLERS

1. Disconnect the piping at both inlet and discharge flanges of the machine, moving the pipe flanges at least far enough away for easy insertion of an arm into the openings.
2. Use a set of feeler gauges with blades about 12" (300 mm) long for measuring clearances between the impeller lobes. These clearances are identified as "front" and "backs", and are measured with the impellers in the positions shown in Figures 12 and 13. The drive shaft rotation indicated is **counter-clockwise**. For opposite rotation, impeller positions will be reversed from that shown in Figures 12 and 13 and the front and back identifications will be interchanged. Fronts may be defined as the lobes that tend to contact during rotation because of pressure load and gear tooth wear; conversely, backs are the surfaces that tend to separate.
3. Determine and record the total lobe clearance by measuring the front and back clearances and adding them. It will normally be satisfactory to take these measurements at the mid-point of the impeller length. Place a wedge between the gear teeth to prevent the impellers from shifting during the measurement, making sure that any gear tooth clearance is always taken up in the same direction. **Note that there are two front and two back clearance positions in one complete revolution, use minimum value of clearance found along length of impeller for fronts and backs throughout 90° rotation.**
4. Loosen the screws on one gear (make sure collars are loose) to permit slight adjustments of position rela tive

Figure 12 - Impeller Timing Viewed from Standard Rotation

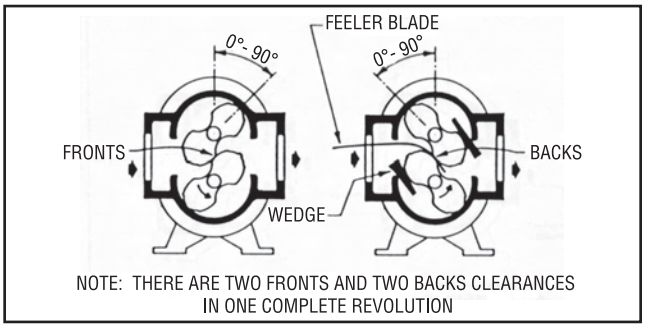
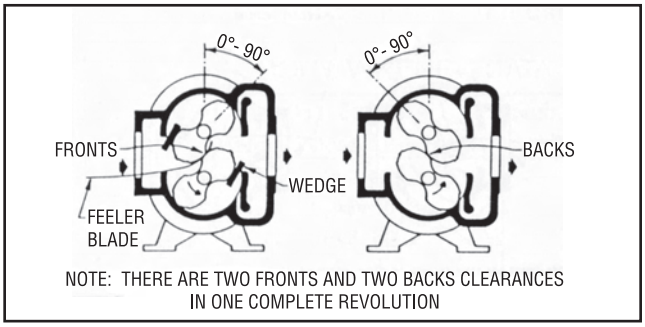


Figure 13 - Impeller Timing Viewed from Standard Rotation



to its impeller, and set the impeller "front" clearance so that it is two-thirds of the total clearance found in Step 3. Make sure that any backlash in the gears is taken up in the direction of rotation with the lower gear driving.

5. Tighten all screws as in Step 7. OPERATION B, and recheck front and back clearances.

D - REMOVING BEARINGS AND/OR SEALS

1. Dismantle as in Operation A.
2. Remove gear end bearing carriers (6). Bearings and shaft seals will come out with the carriers. Discard the O-rings (20). Impellers will now be supported by the labyrinth seals in headplate holes.
3. Dismount drive and remove drive end cover (5) and/ or (58), using care with seal (23).
4. Remove bearing locknuts (24) and lockwashers (25), using a spanner wrench.
5. Remove bearing clamp plates (8).
6. Pull drive end bearing carriers with bearings and seals as on gear end. Shims (17) under the flanges should be kept in order and identified for replacing the same positions.

E - REPLACING LIP SEALS

1. Check shafts for surface finish of 10-16 micro-inch (.3 to .4 micrometers) RMS in seal contact area, and for good condition at bearing locations. Carefully remove any burrs or sharp corners, but do no attempt refinishing.

The seals are **"Directional, Hydrodynamic"**, which means for proper sealing they are completely **dependent on the direction of the shaft rotation**. In each seal kit, there are:

(2) Clockwise (CW) "Blue coated" seals for inboard seal replacement

(2) Counter-Clockwise (CCW) "Red coated" seals for inboard seal replacement

(1) Reversible (CW/CCW) "Green coated" seal for drive shaft seal replacement

(1) Protective Sleeve Tool (Inboard seals)

(1) Protective Sleeve Tool (Drive shaft seal)

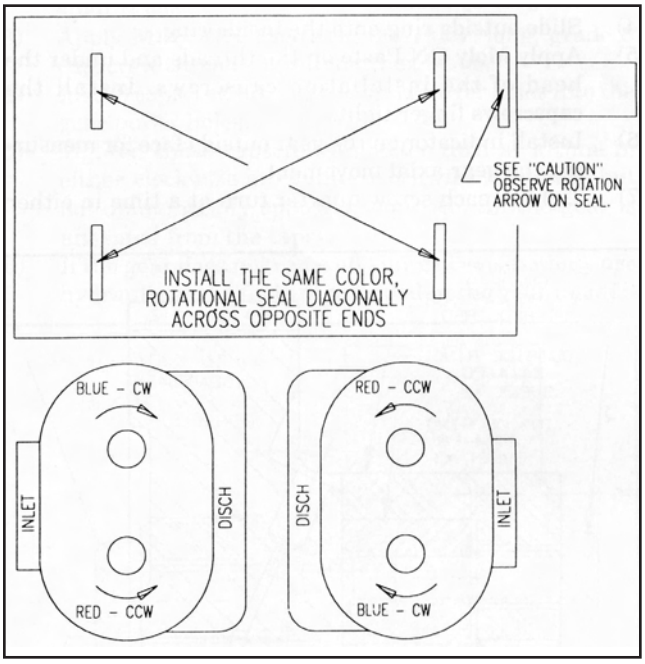
CAUTION: FOR SEALS TO PERFORM PROPERLY

- Use careful handling procedures so not to damage seals during installation. Must use the installation sleeves provided in kit as shown Under Final Assembly. Seal lips are not very flexible and will tear or become damaged if not installed properly.
- Shaft surface must be clean and free of scratches with a finish between 10 to 20 RMS.
- Seals must stay on shipping rings until time of installation, or the seal lips will deform over time.

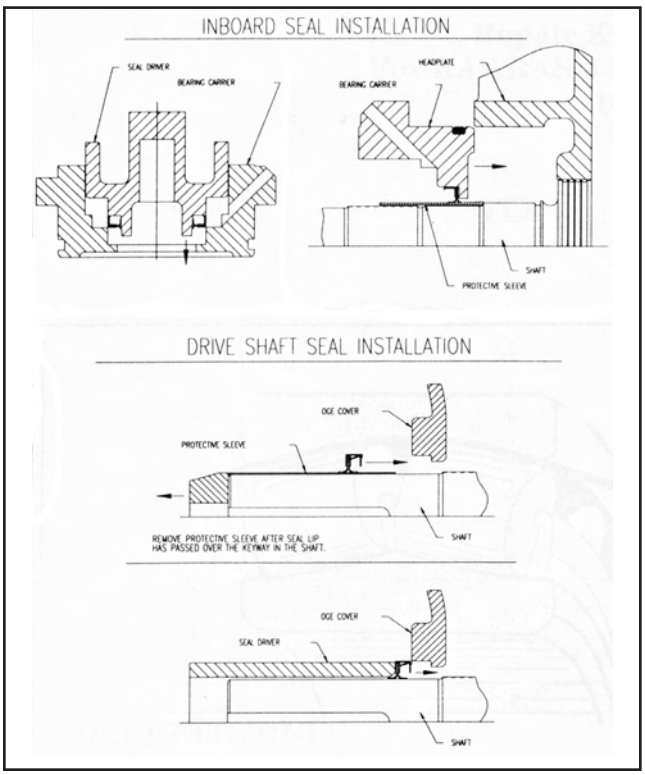
NOTE: Proper sealing for shafts that have been repaired with a "speedi-sleeve". depends on the quality of the "speedi-sleeve" and its installation.

2. Finish the assembly as outlined in "Final Assembly".

Seal Installation Guide



Inboard Seal Installation and Drive Shaft Seal Installation



F - FINAL ASSEMBLY

1. Install all bearings. Making sure they are up tight against their respective shaft shoulders. Work on gear end bearings first and press them info place by means of a suitable length of tubing in contact only with the inner races. The impellers will be driven against the opposite headplate. Then remove shims (17) from behind both drive end bearing carrier flanges and press the bearings at this end into place against their shaft shoulders.

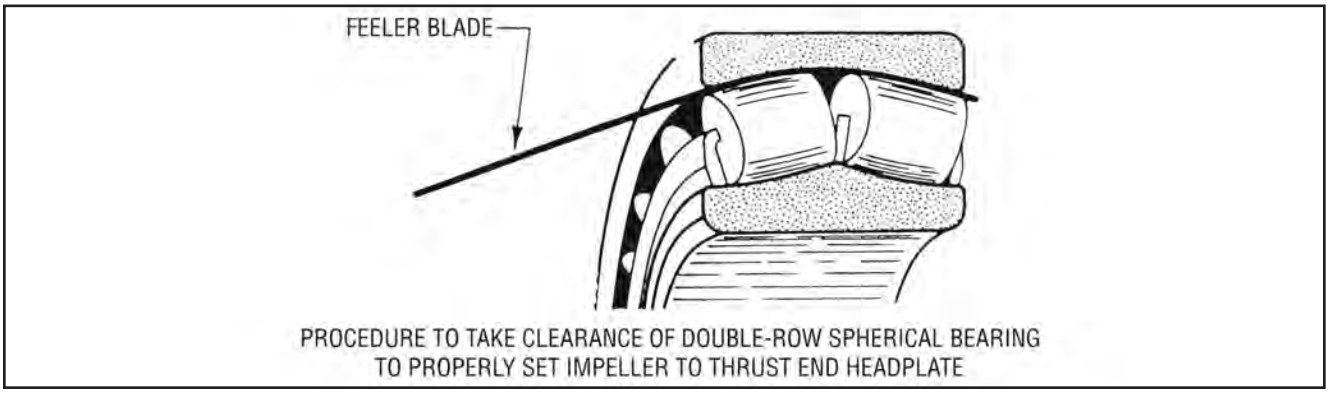
On a belt-drive unit with extended shaft, use spacer sleeve (62) to push inboard bearing (60) into its final position. There is no shaft shoulder behind this bearing, but there is a stop for the sleeve. Make sure that the inner race flange of bearing (60) is facing outboard.

2. Install bearing lockwasher (25) and locknuts (24) on each shaft, and tighten nuts with a spanner wrench. Lock the nuts by bending a tab on each washer into a slot in the nut.
3. Install new or original gears and set impellers as described in Operation B.
4. Place bearing clamp plate (8) over main bearing (31) and tighten all screws. In the case of the extended type drive shaft, end cover (58) serves as the clamp plate but cannot be installed until later.
5. Using 1/2" (13mm) feeler gauges, determine for each of the drive end bearings (31) the maximum clearance between the outer race and one of the rollers near the top. Obtain pieces of brass shim stock, of thicknesses corresponding to these clearances, about 3/4" (19mm) wide and long enough to reach completely through the bearings. Push one piece through each bearing, in the spaces between rollers, then rotate that shaft so that one roller of each row is up on the shim stock. This removes all clearances, and forces the bearing rollers and races to center as in normal running. Refer to Figure 14.
6. Set the impellers lengthwise in the case by using long pieces of shim stock, or feelers, as wedges between the two ends of each impeller and the headplates. Using the total end clearance obtained in Step 8 of Operation D, the two ends of each impeller and the headplates. Using the total end clearance obtained in Step 8 of Operation D, place wedges equal to two-thirds of the total at the gear end and one-third at the drive or thrust end. It will be necessary to bump the shafts to obtain the required impeller positions. Set the drive end clearance first, after installing and tightening drive shaft end cover (58) if used.
7. With feeler gauges, carefully measure the spaces between the drive end bearing carrier flanges and the headplate face. Insert shims (17) of correct thickness to fill these spaces. The original shims should be correct if bearings and carriers have been returned to the original location.
8. Remove wedges from ends of impellers inside the casing.
9. Tighten all bearing carrier flange screws.
10. Recheck impeller end clearances for proper values per tables, then remove brass shim stock from both bearings (31).
11. Check front and back clearances of impeller lobes as outlined in Operation C, and reset timing if not correct.
12. Reassemble the unit, starting by installing the main end cover (5) and then proceeding in reverse order through Operation A from Step 5. Be careful with lip seal (23) or new O-ring (59) in end cover (5).
13. Check the work area to make sure no parts have been left out in assembly.
14. Turn the drive shaft over several times by hand as final check for impeller contact or case rubs.
15. Reinstall coupling or belt sheave, check their alignment with driver and reconnect all external piping.
16. Start and operate unit for a reasonable period in the manner outlined for initial starting. See OPERATION.

IMPELLER CLEARANCES

Instructions on impeller clearances under Operation C and Operation D do not include data on the amount of clearance to be expected. For blowers in good condition this information is not essential in field service work. However, situations may arise where it is desirable to compare existing clearances with the correct values. Listed in Table 8 or 9 are the ranges of values used in original factory assembly. Clearances may change in service, but they should never be less than the minimum values listed. Only well **qualified personnel** should attempt to measure clearances for comparison with this data.

Figure 14



PROCEDURE TO TAKE CLEARANCE OF DOUBLE-ROW SPHERICAL BEARING TO PROPERLY SET IMPELLER TO THRUST END HEADPLATE

Repair Kit Information For DVJ WHISPAIR™ Dry Exhausters

REF.	QTY.	PART DESCRIPTION
17	1	SHIM SET
18	1	GASKET
19	2	GASKET SUMP (P/L)
20	4	O-RING B/C (PL)
23	1	SEAL-DR. SHAFT
24	2	LOCKNUT-BRG.
25	2	LOCKWASHER-BRG.
27	4	SEAL-HDPLT
31	4	BEARINGS
60	1	BEARINGS*
61	2	O-RING
81	2	GASKETS
-	1 Set	GEAR SCREWS**

*V-Belt kits only **12" kits and above

Repair Kit Part Numbers

SIZE	REPAIR KIT NOS. (CPLG DRIVE)	REPAIR KIT NO. (V-BELT DRIVE)
10"	RK10ACP00	RK10AVB00
12"	RK12ACP00	RK12AVB00
14"	RK14ACP00	RK14AVB00
16"	RK16ACP00	
18"	RK18ACP00	
20"	RK20ACP00	

WHEN ORDERING CONTACT:

Dresser Roots

900 West Mount Street

Connersville, IN 47331-1675

Phone: 765-827-9200

Rapifax: 765-827-9309

Parts Indentification List for Figures 15, 16, 17 or 18

Item Number	Quantity Used	Identification	Item Number	Quantity Used	Identification
1	1	Headplate - Gear End	62	1	Spacer Sleeve - Outboard Brng.
1A	1	Headplate - Drive End	63	1	Bearing Carrier - Extended Drive
2	1	Cylinder	64	2	Dowel Pin - End Cover
3	1	Gearbox	66	1	Air Vent - End Cover (Belted)
5	1	End Cover - Driving (Cplg.)	67	1	Plug - Gearbox Drain
5A	1	End Cover - Driven Shaft	69	4	Plug - Bearing Housing
6	4a	Bearing Carrier	70	4	Plug - Instrument Taps
7	2	Impeller	71	2	Leveling Label
9	2	Timing Gear	72	4	Set Screw - Leveling
10	2	Timing Gear Locking Assembly	73		
12	2	Stub Shaft - Gear End	74		
13	1	Stub Shaft - Driving	75		
14	1	Stub Shaft - Driven	76		
15			77	1 or 2c	Spacer Ring - Drive End Bearing
16	1	Key - Drive Sheave or Coupling	78		
17	4 halves	Shims – Brng. Carrier, Drive End	80		
18	1	Gasket - Gearbox Flange	81	2	Gasket - Brng. Carrier, Gear End
22	Varies	Capscrew - End Cover (Soc. Hd.)	82	2	Oil Dam - Gear End Bearing
23	1	Shaft Seal - Outboard	83	2	Oil Control Shield
24	2	Bearing Locknut	84	1 or 2b	Oil Pan (Secondary Sump)
25	2	Bearing Lockwasher	85	4	Capscrew - Oil Pan
26	8	Lockwasher - Brng. Carrier (See 49)	86	Varies	Self-Tap Screw - Oil Pan
27	4	Shaft Seal - Inboard	87	1	Gauge Oil Level - Gear End
28	2	Air Vent - Drive End	88	6	Plug - Drive end Fill & Drain
29	2	Eyebolt - Lifting	89	2	Locking Nut (See 96)
30	Varies	Capscrew - Gearbox & Headplate Fig.	90	2	Gauge Oil Level - Drive End
31	4	Bearing - Roller	91		
34	1	Nameplate	92	1	Lube Nameplate - Gear End
35	6	Drive Screw - Nameplate & Arrow	93	1	Lube Nameplate - Drive Enc
36	8 or 0d	Dowel Pin - Flange Locating	94	Varies	Manifold
37	1	Vent Plug - Gearbox	95		
42	Varies	Capscrew - Stub Shaft (Soc. Hd.)	96	2	Slinger Set Screw (See 89)
43	Varies	Taper Pin - Stub Shaft, Gear End	100	4 or 0d	Dowel Pin - Flange Locating
45			101	2	Locknut Gear
49	16	Capscrew - Brng. Carrier (See 26)	109	4	Piston Ring Seal
56	1	Rotation Arrow	110	1 or 0e	Oil Shroud
58	1	End Cover - Driving (Belted)	111	1 or 0e	Oil Shield
60	1	Bearing - Inboard	132	2 on IBB	Trico Oiler
61	2	O-ring - End Cover			

a. All units having extended shaft for belt drive, use three item 6 and one item 63.
b. Vertical style units, use one item 84. Horizontal units, require two item 84.
c. Used on sized 1000 through 1400 only.
d. Units of frame sizes 1000 through 1400 except 1442 use four item 100. Frames 1600 through 2000 and 1442 use eight item 36.
e. Vertical style units use one item 110 and one item 111. Not required on horizontal units.
f. Inboard bearing item 60 is a double row spherical type on current production units, and the cylindrical roller bearing on older units will be replaced with the new spherical roller bearing.

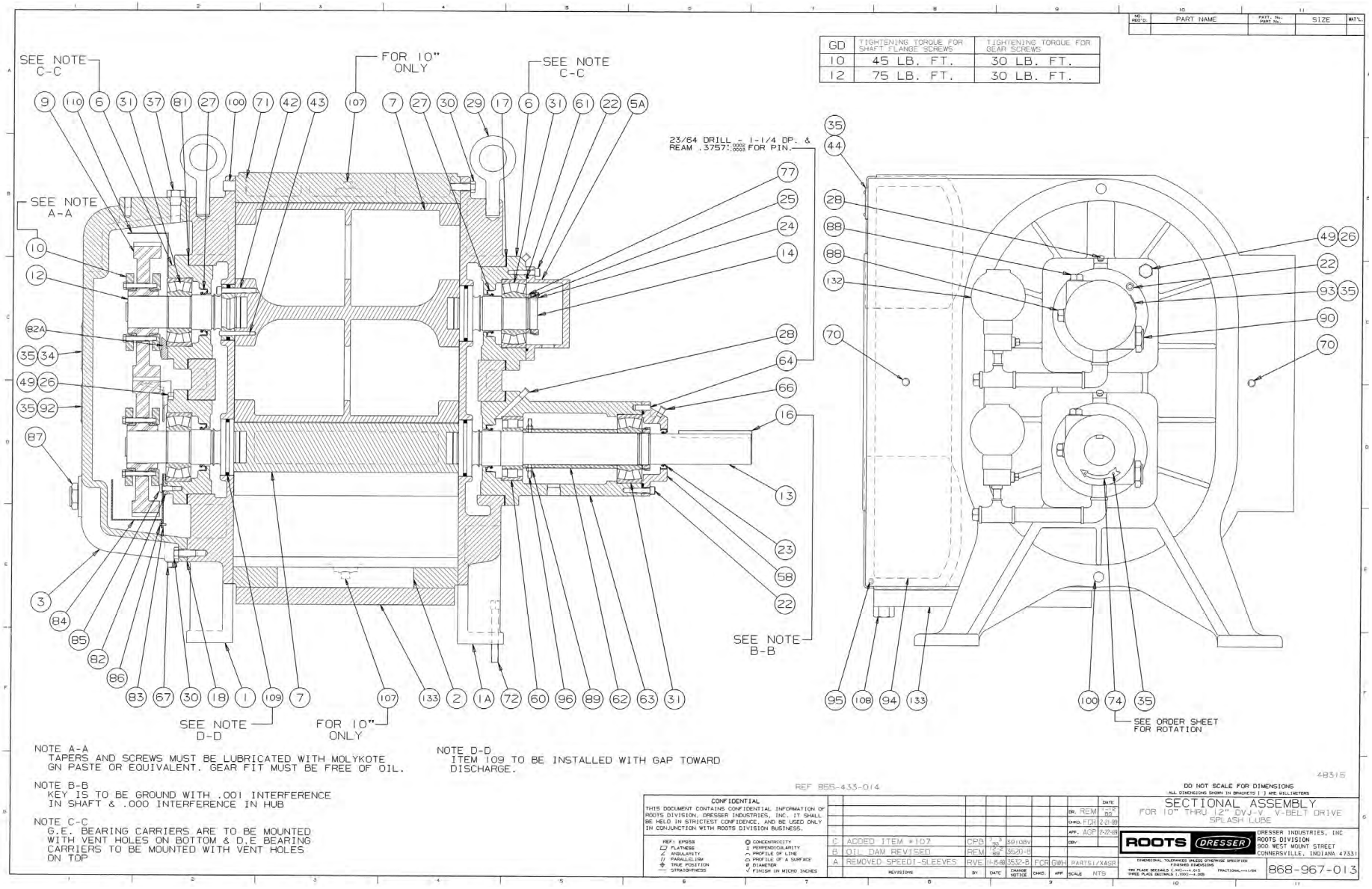


Figure 15 - Assembly of 10" thru 12" DVJ-V V-Belt Drive Splash Lube

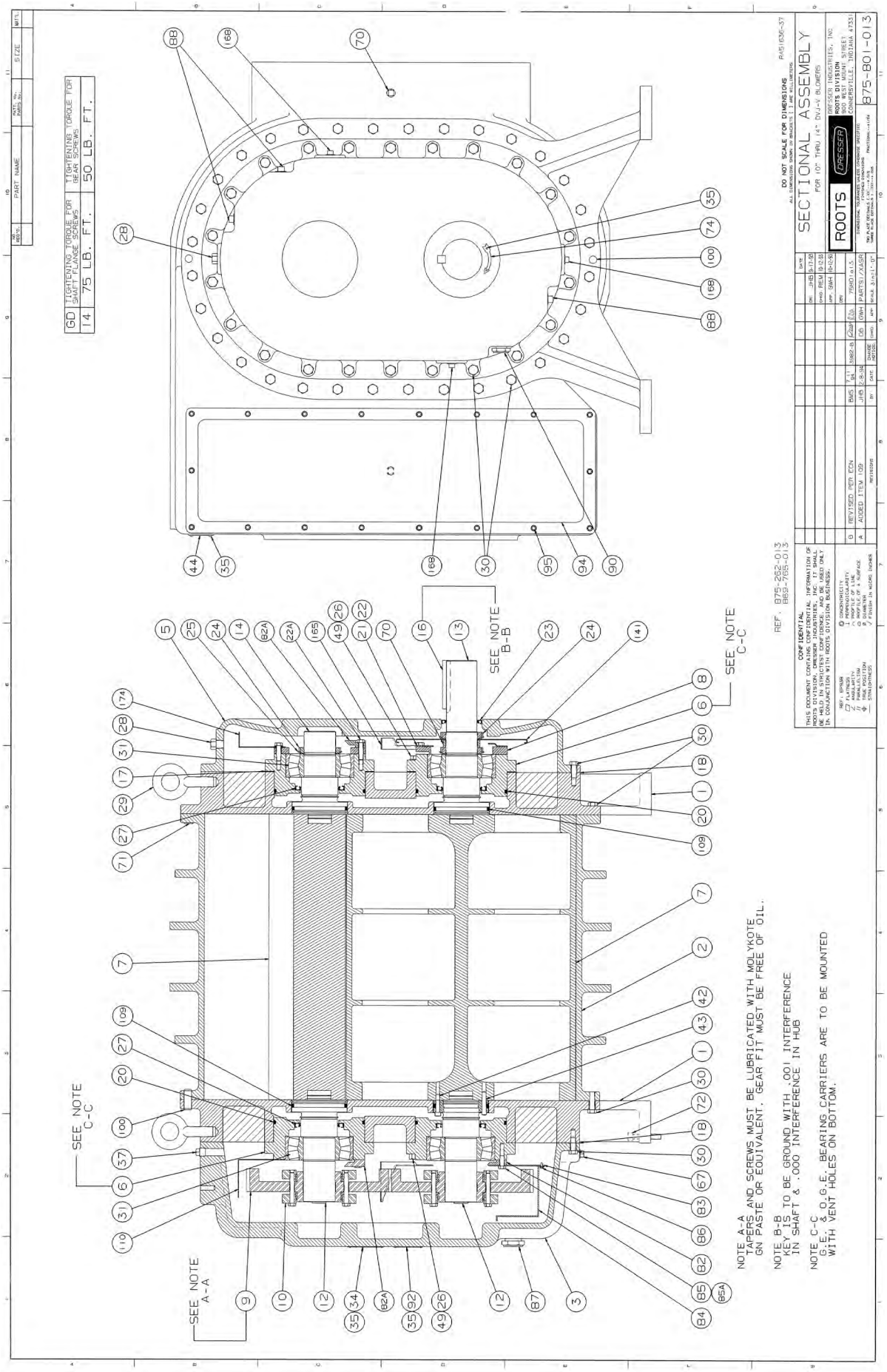


Figure 16 - Sectional Assembly of 10" thru 14" DVJ-V Blowers

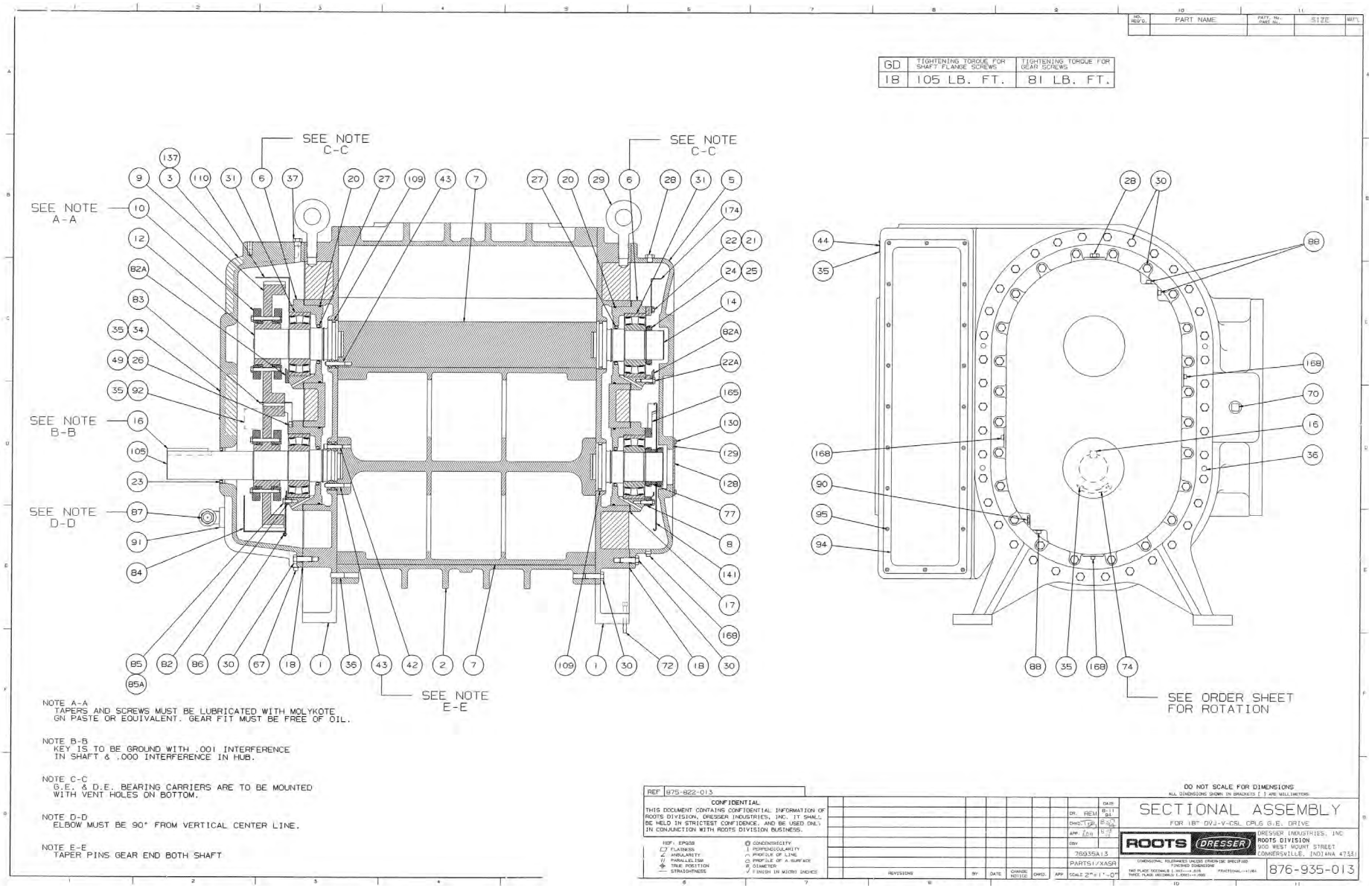


Figure 17 - Sectional Assembly of 16 - 20 DVJ Common Lube

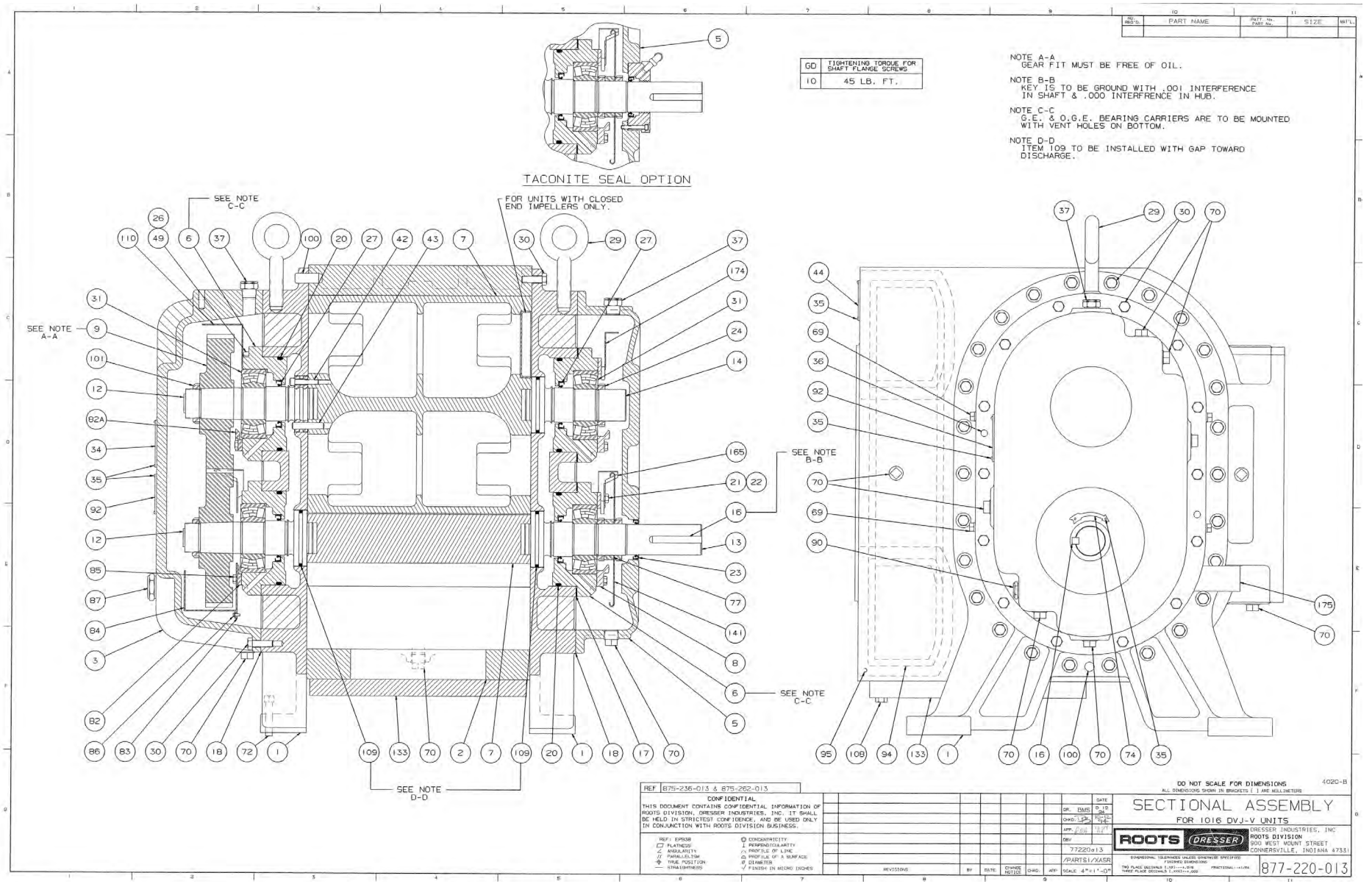


Figure 18 - Sectional Assembly of 1016 DVJ-V Units

About Dresser Roots

Dresser Roots, a major product brand of Dresser, Inc., is the manufacturer of the original ROOTS™ blower, centrifugal compressors and control systems. ROOTS® air and gas moving equipment is used in a wide variety of applications, including MVR (Mechanical Vapor ecompression), water and wastewater treatment, flue gas desulphurization, petrochemical and chemical processes, conveying, and other general industrial applications.

About Dresser, Inc.

Dresser, Inc. is a leader in providing highly engineered infrastructure products for the global energy industry. The company has leading positions in a broad portfolio of products, including valves, actuators, meters, switches, regulators, piping products, natural gas-fueled engines, retail fuel dispensers and associated retail point-of-sale systems, and air and gas handling equipment. Leading brand names within the Dresser portfolio include Dresser Wayne® retail fueling systems, Waukesha® natural gas-fired engines, Masoneilan® control valves, Consolidated® pressure relief valves, and Roots® blowers. It has manufacturing and customer service facilities located strategically worldwide and a sales presence in more than 150 countries.

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