



UNIVERSAL RAI® & RAM™ SERIES

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DO THESE THINGS TO GET THE MOST FROM YOUR ROOTS™ BLOWER

- Check shipment for damage. If found, file claim with carrier and notify ROOTS.
- Unpack shipment carefully, and check contents against Packing List. Notify ROOTS 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 OPERATING LIMITATIONS and INSTALLATION sections in this manual and plan the complete 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 check points 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 ROOTS, giving all nameplate information plus an outline of operating conditions and a description of the trouble. Unauthorized attempts at equipment repair may void ROOTS 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 in this manual, using ROOTS™ parts. Good inspection and maintenance practices should reduce the need for repairs.

NOTE: Information in this manual is correct as of the date of publication. ROOTS reserves the right to make design or material changes without notice, and without obligation to make similar changes on equipment of prior manufacture.

For your nearest ROOTS Office, dial our Customer Service Hot Line toll free; 1 877 363 ROOT(S) (7668) or direct 281-966-4700.



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).

SAFETY PRECAUTIONS

It is important that all personnel observe safety precautions to minimize the chances of injury. Among many considerations, the following should be particularly 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. Protect external moving parts with adequate guards.
- Disconnect power before doing any work, and avoid bypassing 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.
CAUTION: Never cover the blower inlet with your hand or other part of body.

- 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.
- Use proper care and good procedures in handling, lifting, installing, operating and maintaining the equipment.
- Casing pressure must not exceed 25 PSI (1725 mbar) gauge. Do not pressurize vented cavities from an external source, nor restrict the vents without first consulting ROOTS.
- 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 trained to exercise adequate general safety precautions.

OPERATING LIMITATIONS

A ROOTS™ blower or exhauster must be operated within certain approved limiting conditions to enable continued satisfactory performance. Warranty is contingent on such operation.

Maximum limits for pressure, temperature and speed are specified in TABLE 1 for various models & sizes of blowers & exhausters. These limits apply to all units of normal construction, when operated under standard atmospheric conditions. Be sure to arrange connections or taps for thermometers and pressure or vacuum gauges at or near the inlet and discharge connections of the unit. These, along with a good tachometer, will enable periodic checks of operating conditions.

PRESSURE – The pressure rise, between inlet and discharge, must not exceed the figure listed for the specific unit frame size concerned. Also, in any system where the unit inlet is at a positive pressure above atmosphere a maximum case rating of 25 PSI gauge (1725 mbar) should not be exceeded without first consulting the ROOTS. Never should the maximum allowable differential pressure be exceeded.

On vacuum service, with the discharge to atmospheric pressure, the inlet suction or vacuum must not be greater than values listed for the specific frame size.

TEMPERATURE – Blower & exhauster frame sizes are approved only for installations where the following temperature limitations can be maintained in service:

- Measured temperature rise must not exceed listed values when the inlet is at ambient temperature. Ambient is considered as the general temperature of the space around the unit. This is not outdoor temperature unless the unit is installed outdoors.
- If inlet temperature is higher than ambient, the listed allowable temperature rise values must be **reduced** by 2/3 of the difference between the actual measured inlet temperature and the ambient temperature.
- The average of the inlet and discharge temperature must not exceed 250°F. (121°C).

SPEED – These blowers & exhausters may be operated at speeds up to the maximum listed for the various frame sizes. They may be direct coupled to suitable constant speed drivers if pressure/temperature conditions are also within limits. At low speeds, excessive temperature rise may be a limiting factor.

Special Note: The listed maximum allowable temperature rise for any particular blower & exhauster may occur well before its maximum pressure or vacuum rating is reached. This may occur at high altitude, low vacuum or at very low speed. The units' operating limit is always determined by the maximum rating reached first. It can be any one of the three: Pressure, Temperature or Speed.

INSTALLATION

ROOTS™ blowers & exhausters are treated after factory assembly to protect against normal atmospheric corrosion. The maximum period of internal protection is considered to be one year under average conditions, if shipping plugs & seals are not removed. Protection against chemical or salt water atmosphere is not provided. Avoid opening the unit until ready to start installation, as corrosion protection will be quickly lost due to evaporation.

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

- Coat internals of cylinder, gearbox and drive end bearing reservoir with Nox-Rust VCI-10 or equivalent. Repeat once a year or as conditions may require. Nox-Rust VCI-10 is petroleum soluble and does not have to be removed before lubricating. It may be obtained from Daubert Chemical Co., 2000 Spring Rd., Oak Brook, Ill. 60521.
- Paint shaft extension, inlet and discharge flanges, and all other exposed surfaces with Nox-Rust X-110 or equivalent.
- 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 Nox-Rust VCI-10 vapor will escape and lose its effectiveness.
- Protect units from excessive vibration during storage.
- Rotate shaft three or four revolutions every two weeks.
- Prior to start up, remove flange covers on both inlet and discharge and inspect internals to insure absence of rust. Check all internal clearances. Also, at this time, remove gearbox and drive end bearing cover and inspect gear teeth and bearings for rust.

Because of the completely enclosed unit design, location of the installation is generally not a critical matter. A clean, dry and protected indoor location is preferred. However, an outdoor location will normally give satisfactory service. Important requirements are that the correct grade of lubricating oil be provided for expected operating temperatures, and that the unit be located so that routine checking and servicing can be performed conveniently. Proper care in locating driver and accessory equipment must also be considered.

Supervision of the installation by a ROOTS Service Engineer is not usually required for these units. Workmen with experience in installing light to medium weight machinery should be able to produce satisfactory results. Handling of the equipment needs to be accomplished with care, and in compliance with safe practices. Unit mounting must be solid, without strain or twist, and air piping must be clean, accurately aligned and properly connected.

Bare-shaft Units: Two methods are used to handle a unit without base. One is to use lifting lugs bolted to the top of the unit headplates. Test them first for tightness and fractures by tapping with a hammer. In lifting, keep the direction of cable pull on these bolts as nearly vertical as possible. If lifting lugs are not available, lifting slings may be passed under the cylinder adjacent to the headplates. Either method prevents strain on the extended drive shaft.

Packaged Units: When the unit is furnished mounted on a baseplate, with or without a driver, use of lifting slings passing under the base flanges is required. Arrange these slings so that no strains are placed on the unit casing or mounting feet, or on any mounted accessory equipment. **DO NOT** use the lifting lugs in the top of the unit headplates.

Before starting the installation, remove plugs, covers or seals from unit inlet and discharge connections and inspect the interior completely for foreign material. If cleaning is required, finish by washing the cylinder, headplates and impeller thoroughly with a petroleum solvent. Turn the drive shaft by hand to make sure that the impellers turn freely at all points. Anti-rust compound on the connection flanges and drive shaft extension may also be removed at this time with the same solvent. Cover the flanges until ready to connect piping.

Mounting

Care will pay dividends when arranging the unit mounting. This is especially true when the unit is a "bare-shaft" unit furnished without a baseplate. The convenient procedure may be to mount such a unit directly on a floor or small concrete pad, but this generally produces the least satisfactory results. It definitely causes the most problems in leveling and alignment and may result in a "Soft Foot" condition. Correct soft foot before operation to avoid unnecessary loading on the casing and bearings. Direct use of building structural framing members is not recommended.

For blowers without a base, it is recommended that a well anchored and carefully leveled steel or cast iron mounting plate be provided. The plate should be at

least 1 inch (25 mm) thick, with its top surface machined flat, and large enough to provide leveling areas at one side and one end after the unit is mounted. It should have properly sized studs or tapped holes located to match the unit foot drilling. Proper use of a high quality machinist's level is necessary for adequate installation.

With the mounting plate in place and leveled, set the unit on it without bolting and check for rocking. If it is not solid, determine the total thickness of shims required under one foot to stop rocking. Place half of this under each of the diagonally-opposite short feet, and tighten the mounting studs or screws. Rotate the drive shaft to make sure the impellers turn freely. If the unit is to be direct coupled to a driving motor, consider the height of the motor shaft and the necessity for it to be aligned very accurately with the unit shaft. Best unit arrangement is directly bolted to the mounting plate while the driver is on shims of at least 1/8 inch (3mm) thickness. This allows adjustment of motor position in final shaft alignment by varying the shim thickness.

Aligning

When unit and driver are factory mounted on a common baseplate, the assembly will have been properly aligned and is to be treated as a unit for leveling purposes. Satisfactory installation can be obtained by setting the baseplate on a concrete slab that is rigid and free of vibration, and leveling the top of the base carefully in two directions so that it is free of twist. The slab must be provided with suitable anchor bolts. The use of grouting under and partly inside the leveled and shimmed base is recommended.

It is possible for a base-mounted assembly to become twisted during shipment, thus disturbing the original alignment. For this reason, make the following checks after the base has been leveled and bolted down. Disconnect the drive and rotate the unit shaft by hand. It should turn freely at all points. Loosen the unit foot hold-down screws and determine whether all feet are evenly in contact with the base. If not, insert shims as required and again check for free impeller rotation. Finally, if unit is direct coupled to the driver, check shaft and coupling alignment carefully and make any necessary corrections.

In planning the installation, and before setting the unit, consider how piping arrangements are dictated by the unit design and assembly. Drive shaft rotation must be established accordingly and is indicated by an arrow near the shaft.

Typical arrangement on vertical units has the drive shaft at the top with counterclockwise rotation and discharge to the left. Horizontal units are typically arranged with the drive shaft at the left with counterclockwise rotation and discharge down. See Figure 3 and 4 for other various unit arrangements and possible conversions.

When a unit is DIRECT COUPLED to its driver, the driver RPM must be selected or governed so as not to exceed the maximum speed rating of the unit. Refer to

Table 1 for allowable speeds of various unit sizes. A flexible type coupling should always be used to connect the driver and unit shafts.

Coupling halves must be accurately aligned, and a sufficient gap between shaft ends provided so that side strains and end thrust on either shaft are avoided or minimized. This will require considerable care in the mounting of the driver. The two shafts must be in as near perfect alignment in all directions as possible, and the gap must be established with the motor armature on its electrical center if end-play exists.

The following requirements of a good installation are recommended. Coupling halves must be fitted to the two shafts with a line to line thru .001" interference fit. Coupling halves must be warmed up, so that only light tapping is required to install them. Maximum deviation in offset alignment of the shafts should not exceed .005" (.13 mm) total indicator reading, taken on the two coupling hubs. Maximum deviation from parallel of the inside coupling faces should not exceed .001" (.03 mm) when checked at six points around the coupling.

When a unit is BELT DRIVEN, the proper selection of sheave diameters will result in the required unit speed. This flexibility can lead to operating temperature problems caused by unit speed being too low. Make sure the drive speed selected is within the allowable range for the specific unit size, as specified under Table 1.

Belt drive arrangements usually employ two or more V-belts running in grooved sheaves. Installation of the driver is less critical than for direct coupling, but its shaft must be level and parallel with the unit shaft. **The driver should be mounted on the inlet side of a vertical unit (horizontal piping) and on the side nearest to the shaft on a horizontal unit.** The driver must also be mounted on an adjustable base to permit installing, adjusting and removing the V-belts. To position the driver correctly, both sheaves need to be mounted on their shafts and the nominal shaft center distance known for the belt lengths to be used.

Install the unit sheave so that its inner hub face is not more than 1/8 inch (3mm) from the drive end cover. See page 18 for minimum sheave diameter and maximum sheave width. The shaft fit should be such that the sheave can be worked into place by hand or by very light tapping. A tight or driving fit can damage a bearing, and may cause internal unit damage by forcing the impeller out of its normal operating position. A loose fit or wobbly sheave will cause vibration, and may result in shaft breakage.

CAUTION: Couplings as well as sheave bushings must have a slight slide fit with the unit shaft such that they can be installed in place by hand. Any force used to install them could change unit end clearance resulting in unit damage. If interference fit is desired for the coupling, the coupling hub should be heated and shrunk on the shaft. For engine drives, use "locktite" between the coupling hubs and the shafts and on the threads of the coupling set screws.

The driver sheave should also be mounted as close to its bearing as possible, and again should fit the shaft correctly. Position the driver on its adjustable base so that 2/3 of the total movement is available in the direction away from the unit, and mount the assembly so that the face of the sheave is accurately in line with the unit sheave. This position minimizes belt wear, and allows sufficient adjustment for both installing and tightening the belts. After belts are installed, adjust their tension in accordance with the manufacturer's instructions. However, only enough tension should be applied to prevent slippage when the unit is operating under load. Excessive tightening can lead to early bearing failures or shaft breakage.

Before operating the drive under power to check initial belt tension, first remove covers from the unit connections. Make sure the interior is still clean, then rotate the shaft by hand. Place a coarse screen over the inlet connection to prevent anything being drawn into the unit while it is operating, and avoid standing in line with the discharge opening. Put oil in the sumps per instructions under **LUBRICATION**.

Piping

Before connecting piping, remove any remaining anti-rust compound from Unit connections. Clean pipe should be no smaller than unit connections. In addition, make sure it is free of scale, cuttings, weld beads, or foreign material of any kind. To further guard against damage to the unit, especially when an inlet filter is not used, install a substantial screen of 16 mesh backed with hardware cloth at or near the inlet connections. Make provisions to clean this screen of collected debris after a few hours of operation. It should be removed when its usefulness has ended, as the wire will eventually deteriorate and small pieces going into the unit may cause serious damage.

Pipe flanges or male threads must meet the unit connections accurately and squarely. **DO NOT** attempt to correct misalignment by springing or cramping the pipe. In most cases this will distort the unit casing and cause impeller rubbing. In severe cases it can prevent operation or result in a broken drive shaft. For similar reasons, piping should be supported near the unit to eliminate dead weight strains. Also, if pipe expansion is likely to occur from temperature change, installation of flexible connectors or expansion joints is advisable.

Figure 2 represents an installation with all accessory items that might be required under various operating conditions. Inlet piping should be completely free of valves or other restrictions. When a shut-off valve can not be avoided, make sure a full size vacuum relief is installed nearest the unit inlet. This will protect against unit overload caused by accidental closing of the shut-off valve.

Need for an inlet silencer will depend on unit speed and pressure, as well as sound-level requirements in the general surroundings. An inlet filter is recommended, especially in dusty or sandy locations. A discharge silencer is also normally suggested, even though Whispair units operate at generally lower noise levels than conventional rotary blowers. Specific recommendations on silencing can be obtained from ROOTS.

Discharge piping requires a pressure relief valve, and should include a manual unloading valve to permit starting the unit under no-load conditions. Reliable pressure/vacuum gauges and good thermometers at both inlet and discharge are recommended to allow making the important checks on unit operating conditions. The back-pressure regulator shown in Figure 2 is useful mainly when volume demands vary while the unit operates at constant output. If demand is constant, but somewhat lower than the unit output, excess may be blown off through the manual unloading valve.

In multiple unit installations where two or more units operate with a common header, use of check valves is mandatory. These should be of a direct acting or free swinging type, with one valve located in each line between the unit and header. Properly installed, they will protect against damage from reverse rotation caused by air and material back-flow through an idle unit.

After piping is completed, and before applying power, rotate the drive shaft by hand again. If it does not move with uniform freedom, look for uneven mounting, piping strain, excessive belt tension or coupling misalignment.

DO NOT operate the unit at this time unless it has been lubricated per instructions.

LUBRICATION

LUBRICATION: For Units with a Grease Lubricated Drive End

A simple but very effective lubrication system is employed on the drive shaft end bearings. Hydraulic pressure relief fittings are provided to vent any excess grease, preventing pressure build-up on the seals. A restriction plug and metering orifice prevent loss of lubricant from initial surges in lubricant pressure but permit venting excess lubricant under steadily rising pressures.

When servicing drive end bearings, use a NLGI #2 premium grade grease with 300°F (149°C) service temperature and moisture resistance and good mechanical stability. Using a pressure gun, slowly force new lubricant into each drive end bearing housing until traces of clean grease comes out of the relief fitting.

After a long shutdown, it is recommended that the grease fittings be removed, the old grease flushed out with kerosene or #10 lubricating oil, drained thoroughly, and bearings refilled with new grease. Be sure grease relief fittings are reinstalled. Grease should be added using a hand operated grease gun to the drive end bearings at varying time intervals depending on duty cycle and RPM. Table 4 has been prepared as a general greasing schedule guide based on average operating conditions. More frequent intervals may be necessary depending on the grease operating temperature and unusual circumstances. ROOTS™ synthetic grease (ROOTS P/N T20019-) is highly recommended.

LUBRICATION: For Units with Splash Lubrication on Both Ends

Bearings and oil seals are lubricated by the action of the timing gears or oil slingers which dip into the main oil sumps causing oil to splash directly on gears and into bearings and seals. A drain port is provided below each bearing to prevent an excessive amount of oil in the bearings. Seals located inboard of the bearings in each headplate effectively retain oil within the sumps. Any small leakage that may occur should the seals wear passes into a cavity in each vented headplate and is drained downward.

Oil sumps on each end of the blower are filled by removing top vent plugs, Item (21), and filling until oil reaches the middle of the oil level sight gauge, Item (37), or the overflow plug.

Initial filling of the sumps should be accomplished with the blower not operating, in order to obtain the correct oil level. Approximate oil quantities required for blowers of the various models and configurations are listed in Table 3. Use a good grade of industrial type non-detergent, rust inhibiting, anti-foaming oil and of correct viscosity per Table 2. ROOTS™ synthetic oil (ROOTS P/N 813-106-) is highly recommended.

The oil level should not fall below the middle of the site gauge when the blower is idle. It may rise on the gauge during operation, to an extent depending somewhat on oil temperature and blower speed.

Proper lubrication is usually the most important single consideration in obtaining maximum service life and satisfactory operation from the unit. Unless operating conditions are quite severe, a weekly check of oil level and necessary addition of lubricant should be sufficient. During the first week of operation, check the oil levels in the oil sumps about once a day, and watch for leaks. Replenish as necessary. Thereafter, an occasional check should be sufficient. It is recommended that the oil be changed after initial 100 hours of operation. Frequent oil changing is not necessary unless the blower is operated in a very dusty location. Normal life expectancy of petroleum based oils is about 2000 hours with an oil temperature of about 200°F (93°C). As the oil temperature increases by increments of 15-18°F (8°C - 10°C), the life is reduced by half. Example: Oil temperatures of 230-236°F (110°C - 113°C) will produce life expectancy of 1/4 or 500 hours. Therefore, it is considered normal to have oil change periods of 500 hours with petroleum based oils.

OPERATION

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

- Be certain that no bolts, tools, rags, or debris have been left in the blower air chamber or piping.
- If an outdoor intake without filter is used, be sure the opening is located so it cannot pick up dirt and is protected by a strong screen or grille. Use of the temporary protective screen as described under **INSTALLATION** is strongly recommended.
- Recheck blower leveling, drive alignment and tightness of all mounting bolts if installation is not recent. If belt drive is used, adjust belt tension correctly.
- Turn drive shaft by hand to make sure impellers still rotate without bumping or rubbing at any point.
- Make sure oil levels in the main oil sumps are correct.
- Check lubrication of driver. If it is an electric motor, be sure that power is available and that electrical overload devices are installed and workable.
- Open the manual unloading valve in the discharge air line. If a valve is in the inlet piping, be sure it is open.
- Bump blower a few revolutions with driver to check that direction of rotation agrees with arrow near blower shaft, and that both coast freely to a stop.

After the preceding points are cleared, blower is ready for trial operation under “no-load” conditions. The following procedure is suggested to cover this initial operation test period.

- a. Start blower, let it accelerate to full speed, then shut off. Listen for knocking sounds, both with power on and as speed slows down.
- b. Repeat above, but let blower run 2 or 3 minutes. Check for noises, such as knocking sounds.
- c. Operate blower for about 10 minutes unloaded. Check oil levels. Observe cylinder and headplate surfaces for development of hot spots such as burned paint, indicating impeller rubs. Be aware of any noticeable increase in vibration.

Assuming that all trials have been satisfactory, or that necessary corrections have been made, the blower should now have a final check run of at least one hour under normal operating conditions. After blower is restarted, gradually close the discharge unloading valve to apply working pressure. At this point it is recommended that a good pressure gauge or manometer be connected into the discharge line if not already provided, and that thermometers be in both inlet and discharge lines. Readings from these

instruments will show whether pressure or temperature ratings of the blower are being exceeded.

During the final run, check operating conditions frequently and observe the oil levels at reasonable intervals. If excessive noise or local heating develops, shut down immediately and determine the cause. If either pressure rise or temperature rise across the blower exceeds the limit specified in this manual, shut down and investigate conditions in the piping system. Refer to the **TROUBLESHOOTING CHECKLIST** for suggestions on various problems that may appear.

The blower should now be ready for continuous duty operation at full load. During the first few days make periodic checks to determine whether all conditions remain steady, or at least acceptable. This may be particularly important if the blower is supplying air to a process system where conditions can vary. At the first opportunity, stop the blower and clean the temporary inlet protective screen. If no appreciable amount of debris has collected, the screen may be removed. See comments under **INSTALLATION**. At this same time, verify leveling, coupling alignment or belt tension, and mounting bolt tightness.

Should operating experience prove that blower capacity is a little too high for the actual air requirements, a small excess may be blown off continuously through the manual unloading or vent valve. Never rely on the pressure relief valve as an automatic vent. Such use may cause the discharge pressure to become excessive, and can also result in failure of the valve itself. If blower capacity appears to be too low, refer to the **TROUBLESHOOTING CHECKLIST**.

Vibration Assessment Criteria

With measurements taken at the bearing locations on the housings, see chart below for an appropriate assessment guide for rotary lobe blowers rigidly mounted on stiff foundations.

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.

As shown on the chart below, the level of all pass vibration will determine the need to measure discrete frequency vibration levels and the action required.

All Pass Vibration (in/sec)	Discrete Frequency Vibration (in/sec)	Action
0.45 or less	N/R	Approved
Greater than 0.45 but 1.0 or less	0.45 or less @ any frequency	Approved
	Greater than 0.45 @ any frequency	ROOTS™ Approval Required
Greater than 1.0	Less than 1.0	ROOTS™ Approval Required
	Greater than 1.0	ROOTS™ Approval Required

OPERATING CHARACTERISTICS

ROOTS™ rotary blowers and exhausters, as covered in this manual, are available in basic frame sizes ranging from 2 inch to 7 inch gear diameter. Various models, within this gear diameter range, are available with different case lengths to produce reasonable steps in flow capacity. The shorter case lengths have lower volumetric capacities, but are capable of operating against higher pressures. All models are available for air service and there are specifically designed models for gas service.

The basic ROOTS™ rotary lobe blower is a positive displacement type unit. Flow capacity is determined by frame size, operating speed and pressure conditions. It employs two impellers mounted on parallel shafts rotating in opposite directions within a cylinder closed at the ends by head-plates. As the impellers rotate, gas is drawn into one side of the cylinder and forced out the opposite side. The pressure or vacuum developed depends on the resistance of the piping and process system.

The unit is a precision engineered product with very fine clearances between the rotating impellers and stationary case. Since there is no actual contact between these surfaces, internal lubrication is not required. Clearances are maintained by a pair of accurately machined timing gears, mounted on the two shafts extended outside the blower casing.

Operation of the familiar basic rotary lobe blower is illustrated in FIGURE 1, where air flow is left to right with the top impeller rotating clockwise. In Position 1 it is delivering a known volume (B) to the discharge, while space (A) between the lower impeller and cylinder wall is being filled. Counterclockwise rotation of this impeller then traps equal volume (A) in Position 2, and further rotation delivers it to the discharge in Position 3.

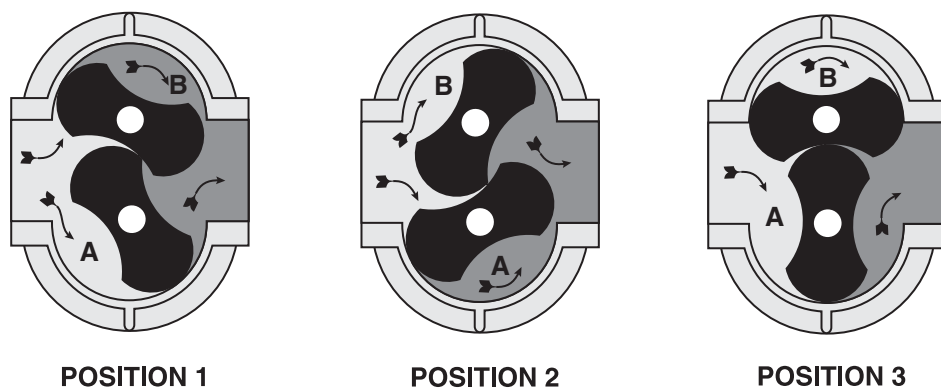
One complete revolution of the driving shaft alternately traps four fixed and equal volumes of air (two by each impeller) and pushes them through to the discharge. The volume capacity of a lobe blower operating at a constant speed therefore remains relatively independent of reasonable inlet or discharge pressure variations. To change capacity, it is necessary either to change speed of rotation or blow off some of the discharge air.

No attempt should ever be made to control capacity by means of a throttle valve in the intake or discharge piping. This will not only increase the power load on the driver, but can also overload and seriously damage the blower. If a possibility does exist that flow to the blower inlet may be cut off during normal operation of a process, then an adequate vacuum relief valve must be installed near the blower. A pressure type relief valve in the discharge line near the blower is required for protection against cut-off or blocking in this line. Refer to FIGURE 3 for a complete piping schematic.

When a belt drive is installed, blower speed can usually be adjusted to obtain desired capacity by changing the diameter of one or both sheaves. In a direct coupled arrangement a variable speed motor or transmission is required, or excess air may be blown off through a manually controlled unloading valve and silencer. If returned to the blower inlet, the air must be cooled to 100°F (38°C) through a by-pass arrangement to maintain acceptable blower temperatures.

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

FIGURE 1 – FLOW THROUGH A BASIC ROTARY LOBE BLOWER



TROUBLESHOOTING

Trouble	Item	Possible Cause	Remedy
No flow	1	Speed too low	Check by tachometer and compare with published performance
	2	Wrong rotation	Compare actual rotation with Figure 1 or 2 Change driver if wrong
	3	Obstruction in piping	Check piping, 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 with Published performance
	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 published performance
	9	Excessive pressure rise	See Item 5
	10	Impeller rubbing	Inspect outside of cylinder for high temperature areas, then check for impeller contact at these points. Correct blower mounting, drive alignment
	11	Scale, sludge, rust or product build up	Clean blower appropriately
Overheating of bearing or gears	12	Inadequate lubrication	Check oil sump levels in gear and drive end headplates
	13	Excessive lubrication	Check oil levels. If correct, drain and refill with clean oil of recommended grade
	14	Excessive pressure rise	See Item 5
	15	Coupling misalignment	Check carefully. Realign if questionable
	16	Excessive belt tension	Readjust for correct tension
Vibration	17	Misalignment	See Item 15
	18	Impellers rubbing	See Item 10
	19	Worn bearings/gears	Check gear backlash and condition of bearings, and replace as indicated
	20	Unbalanced or rubbing impeller	Scale or process material may build up on casing and impellers, or inside impellers. Remove build-up to restore original clearances and impeller balance
	21	Driver or blower loose	Tighten mounting bolts securely
	22	Piping resonances	Determine whether standing wave pressure pulsations are present in the piping
	23	Scale/sludge build-ups	Clean out interior of impeller lobes to restore dynamic balance
	24	Casing strain	re-work piping alignment to remove excess strain
Driver stops, or will not start	25	Impeller stuck	Check for excessive hot spot on headplate or cylinder. See item 10. Look for defective shaft bearing and/or gear teeth
	26	Scale, sludge, rust or product build-up	Clean blower appropriately
Excessive breather	27	Broken seal	Replace seals
Blow-by or excessive oil leakage to vent area	28	Defective O-ring	Replace seals and O-ring

MAINTENANCE & REPLACEMENTS: UNIVERSAL RAI® SERIES BLOWERS

A good program of consistent inspection and maintenance is the most reliable method of minimizing repairs to a blower. A simple record of services and dates will help keep this work on a regular schedule. Basic service needs are:

- Lubrication
- Checking for hot spots
- Checking for increases or changes in vibration and noise
- Recording of operating pressures and temperatures

Above all, a blower must be operated within its specified rating limits, to obtain satisfactory service life.

A newly installed blower should be checked often during the first month of full-time operation. Attention thereafter may be less frequent assuming satisfactory performance. Lubrication is normally the most important consideration and weekly checks of lubricant levels in the gearbox and bearing reservoirs should be customary. Complete oil change schedules are discussed under **LUBRICATION**.

Driver lubrication practices should be in accordance with the manufacturer's instructions. If direct connected to the blower through a lubricated type coupling, the coupling should be checked and greased each time blower oil is changed. This will help reduce wear and prevent unnecessary vibration. In a belted drive system, check belt tension periodically and inspect for frayed or cracked belts.

In a new, and properly installed, unit there is no contact between the two impellers, or between the impellers and cylinder or headplates. Wear is confined to the bearings (which support and locate the shafts) the oil seals, and the timing gears. All are lubricated and wear should be minimal if clean oil of the correct grade is always used. Seals are subject to deterioration as well as wear, and may require replacement at varying periods.

Shaft bearings are designed for optimum life under average conditions with proper lubrication and are critical to the service life of the blower. Gradual bearing wear may allow a shaft position to change slightly, until rubbing develops between impeller and casing. This will cause spot heating, which can be detected by observing these surfaces. Sudden bearing failure is usually more serious. Since the shaft and impeller are no longer supported and properly located, extensive general damage to the blower casing and gears is likely to occur.

Oil seals should be considered expendable items, to be replaced whenever drainage from the headplate

vent cavity becomes excessive or when the blower is disassembled for any reason. Sealing effectiveness can vary considerably from seal to seal and is also affected to surprising degree by shaft finish under the seal lip. Because of these normal variables, minor seal leakage should not be considered as indicating seal replacement.

Timing gear wear, when correct lubrication is maintained, should be negligible over a period of years. Gear teeth are cut to provide the correct amount of backlash, and gears correctly mounted on the shafts will accommodate a normal amount of tooth wear without permitting contact between lobes of the two impellers. However, too high an oil level will cause churning and excessive heating. This is indicated by unusually high temperature at the bottom of the gear housing. Consequent heating of the gears will result in loss of tooth-clearance, backlash and rapid wear of the gear teeth usually will develop. Continuation of this tooth wear will eventually produce impeller contacts (knocking), and from this point serious damage will be unavoidable if blower operation is continued. A similar situation can be produced suddenly by gear tooth fracture, which is usually brought on by sustained overloading or momentary shock loads.

Problems may also develop from causes other than internal parts failure. Operating clearances within a blower are only a few thousandths of an inch. This makes it possible for impeller interference or casing rubs to result from shifts in the blower mounting, or from changes in piping support. If this type of trouble is experienced, and the blower is found to be clean, try removing mounting strains. Loosen blower mounting bolts and reset the leveling and drive alignment. Then tighten mounting again, and make sure that all piping meets blower connections accurately and squarely. Foreign materials in the blower will also cause trouble, which can only be cured by disconnecting the piping and thoroughly cleaning the blower interior.

A wide range of causes & solutions for operating troubles are covered in the **TROUBLE SHOOTING CHECKLIST**. The remedies suggested should be performed by qualified mechanics with a good background, using procedures detailed in this manual. Major repairs generally are to be considered beyond the scope of maintenance, and should be referred to ROOTS.

Warranty failures should not be repaired at all, unless specific approval has been obtained through ROOTS before starting work. Unauthorized disassembly within the warranty period will void the warranty.

It is recommended that major repairs be performed at an authorized ROOTS facility. However, it is recognized that this may not always be practical. If a blower is out of warranty, mechanical adjustments and parts replacement may be undertaken locally at the owner's option and risk. It is recommended that ROOTS™ parts be used to insure fit and suitability. The maintenance of a small stock of on-hand spare parts can eliminate possible delays. When ordering parts give item numbers and their word descriptions from the appropriate sectional drawings. Also specify quantities required and the blower model and serial number from the nameplate.

Repairs or adjustments are best performed by personnel with good mechanical experience and the ability to follow the instructions in this manual. Some operations involve extra care, patience, and a degree of precision work. This is especially true in timing impellers and in handling bearings. Experience indicates that high percentages of bearing failures are caused by dirt contamination before or during assembly. Therefore, the work area should be cleaned before starting disassembly, and new or re-usable parts protected during progress of the work.

In the following repair procedures, numbers shown in brackets () correspond to the item numbers used in sectional drawings. It is recommended that the procedures be studied carefully and completely, with frequent reference to the drawings, before starting work. This will produce better efficiency through an understanding of what work is to be done, and the order of doing it. Before disassembly, mark all parts so that they may be returned to original locations or relative positions.

Requirements for special tools will depend on the work to be done. If impeller clearances and float are to be checked or re-set, a dial indicator and a set of long feeler gauges will be needed. Work involving removal of the timing gears cannot be accomplished without a suitable puller.

Design of ROOTS™ blower is simple, and most repair operations are straightforward. For this reason, the following procedures are intended mainly to indicate a preferred work order and to call out points to be observed. Where special operations are required, detailed coverage is given.

A – Replacing Timing Gears

1. Drain all oil from the gearhouse by removing drain plug (21) in the bottom. Remove gearhouse by taking out all cap screws (23) in its flange. It may be necessary to bump the sides with a wood block or mallet to break the flange joint.
2. Reach through one of the blower pipe connections and place a chalk mark on the strip of one impeller and the mating waist of the other, so that they may easily be returned to their original relative positions.

3. **GEAR REMOVAL:** CAUTION: Do not remove gear nuts (17) completely before the gears are unseated from the taper fits or damage/injury may result. For this operation, the impellers should be wedged, as shown in Table 5. Back off gear clamping nuts (17) about 1/4". Use a suitable puller or wedge. As the puller set screw is torqued, the puller will have a tendency to turn and contact teeth of the other gear. To prevent this contact, hold the puller corner nut with a wrench while torquing the set screw. Once the gear is unseated, remove the puller. Remove gear nuts (17) and the gear.
4. **GEAR INSTALLATION:** Place impellers in correct position as previously marked. Be sure shafts and gear bores are clean, oil free and free of scratches. Clean the shaft tapered fits. Place hardwood wedges as shown in Table 5. Install drive gear (4) and gear nut (17). Tighten the drive gear nut to the torque given below. Blower assembly must be fastened down for torquing operation.
5. Installing driven gear (4) – Insert a long, metal feeler gauge between the impellers' lobes at the fronts or backs as shown below. Feeler gauge thickness to be a middle value from Table 5 for fronts and backs. Install nut (17). Tighten lightly with a small wrench, then check front and back clearances against Table 5 for each 45° position. Both fronts and backs should be about the same and within the specified range in Table 5. Adjust gear position, if necessary, then insert the corrected feeler gauge and wedges and use a torque wrench to tighten the gear nut to the torque specified in below. Remove wedges and rotate the drive shaft by hand to make sure there are no gear tight spots or impeller contacts. **CAUTION!** *Keep fingers away from impellers and gears.*

UNIVERSAL RAI® SERIES BLOWER GEAR NUT TORQUE

Frame Size	Torque	
	lb.-ft.	(kg-m)
22, 24,	60	(8.3)
32, 33, 36	110	(15.2)
42, 45, 47	190	(26.3)
53, 56, 59	250	(34.6)
65, 68, 615	400	(55.3)
76, 711, 718	550	(76.1)

6. Check the end clearances between impellers and headplates. Adjust clearances per B-15 below.
7. When clearances are correct, clean and re-install the gearhouse. Check condition of flange gasket (7) and replace if questionable. Fill gearhouse to correct level with proper grade oil.

B – Replacing Shaft Bearings and Impellers

Remove coupling or sheave from the drive shaft. Drain and remove gearhouse, and pull the timing gears. If gears are to be re-used, mark them so they may be returned to the same shafts.

1. Break corners and deburr the keyway. Remove bearing end cover at the drive end. Remove bearing clamp plates (34).
2. Make single and double identifying punch marks on the mating edges of headplate and cylinder flanges at the two ends of the blower.
3. At the drive end, drive out the two dowel pins and remove all capscrews holding headplate to cylinder. By inserting jacking screws into the two threaded flange holed, and turning them in evenly, the headplate will be separated from the cylinder. As the headplate comes off the shafts it will bring bearings with it. 2-1/2" and 3-1/2" gear diameter units do not have tapped holes for jack screws in the drive end headplates. Remove dowel pins and all capscrews holding headplate to cylinder and foot on the drive end. Support unit under gear end cylinder flange with the shafts vertical. Using soft metal block against gear end shafts, push them out of gear end headplate.
4. For 2-1/2" and 3-1/2" gear diameter units, support the drive end headplate on the underside, and using soft metal block against drive end shafts, push them out of drive end headplate.

For 4", 6" & 7" gear diameter units, from the gear end, using a wood or soft metal block against the ends of the shafts, drive them out of the head plate. If they are to be reused, protect them from damage in this operation.
5. If blower interior surfaces need cleaning, it may be advisable to separate the gear end headplate from the cylinder. Use the same general procedure as employed at the drive end.
6. Working from the back (flat) face of each head plate, push or tap out the bearings and seals. Use a round bar or tube that will pass through the shaft clearance holes in the headplates. All lip seals will be damaged during removal and must be replaced.
7. Clean bearing and seal pockets in headplates and remove burrs or rough edges. (Apply a thin coating of sealant on seal O.D.) Press new seals (27) into gear end headplate using a round tube or

bar with recessed end that will bear on the outer metal edge of seal enclosure. Seal lip should point toward the driving tool. Seals to be flush without board bore face. Apply a light coat of oil or grease to the seal lips. In a similar fashion, install lip seals into the drive end headplate.

8. Place cylinder on a flat surface. Assemble gear end headplate to cylinder after checking flange punch marks. Drive in the two locating dowel pins before tightening flange screws. Also install gear end foot using the same longer cap screws (32) and washers (41). (On 6" & 7" UNIVERSAL RAI® blower install both gear end feet.)
9. Place the assembly horizontally on steel blocks with gear end headplate on bottom. The height of the blocks should be sufficient to clear gear end shaft extensions. Assemble impellers into the cylinder with the drive shaft (longer shaft) in same location as in original assembly. Before starting the shafts through the headplate holes, make sure shaft ends have no sharp or rough edges to damage seal lips. Position impellers at 90° to each other in the cylinder, using lobe-and-waist match marks if original impellers are being re-installed. Install drive end headplate and feet in same manner as gear end.
10. It is recommended that new bearings be used for rebuild. Apply thin film of machine oil on the shaft bearing fit, bearing I.D., and headplate bearing bore. Install drive end bearings into headplate. Use a tube with flanged end that will contact both bearing faces simultaneously. Refer to Assembly Drawing for proper bearing depths.
NOTE: *Cylindrical drive bearing should be installed with inner race large shoulder facing outboard.*
11. Place blower on its feet on a flat surface. Loosen feet capscrews (32) and square up unit. Re-tighten capscrews (32). Clamp unit down to a solid base for further assembly.
12. Oil the gear end bearing fits as described previously. Install 2-1/2" thru 5" blower gear end bearings flush with the headplate bearing shoulders using proper drivers. On 6" & 7" gear diameter units, install thrust washer (29) in bearing bores then install gear end bearings so they protrude 1/16" (1.6mm) above headplate surface.
13. Install bearing clamp plates (34). On 6" & 7" gear diameter units, blower impeller end clearances are also to be set during this step. Install clamp plates (34) with capscrews (31) making sure that the gap between the clamp plates and the headplate is even all around. At the same time, set end clearances per Table 5.
14. Install gears and time impellers as in (A).

15. For setting end clearances on 2-1/2" thru 5" gear diameter units, special tools, thrust adjuster fork and thrust adjuster saddle are required. Refer to Table 5 for installation of tools. The flat side of the saddle rests against the bearing inner race and the flat side of the fork rests against the back side of the gear. Install a shim, with thickness equal to gear end clearance (Table 5), between the impeller and the gear end headplates. Tap on top of the fork until the shim becomes snug. Remove the shim and check end clearances. To increase gear end clearance, tap on the end of the gear end shaft with a soft metal mallet. Set end clearances for 6" & 7" by turning capscrews (31) evenly in or out.
16. Install drive end cover (5) after packing bearing cavities with suitable grease. Replace drive shaft seal. Lip must point toward (33) the bearing. Exercise care not to damage the lip as it passes over shaft keyway.
17. Install gasket item (7). Install the gear house after cleaning out the inside. Tighten gear box cap screws (23) evenly. Fill with correct grade of oil until oil flows out through oil level hole. Grease drive and bearings. (See Lubrication.)
18. Reinstall coupling or belt sheave making sure that they have a slight slide fit with the shaft and could be installed by hand.

TECHNICAL SUPPLEMENT

for 32, 33, 36, 42, 45, 47, 53, 56, 59, 65, 68, 615

UNIVERSAL RAI®-G BLOWERS

ROOTS™ Universal RAI™-G rotary positive gas blowers are a design extension of the basic Universal RAI™ blower model. URAI™-G blower uses (4) mechanical seals in place of the standard in board lip seals to minimize gas leakage into the atmosphere. The seal vent chambers are plugged. These units are intended for gases which are compatible with cast iron case material, steel shafts, 300/400 series stainless steel and carbon seal components, viton o-rings and the oil/grease lubricants. If there are any questions regarding application or operation of this gas blower, please contact factory.

Precaution: URAI™-G blowers: Care must be used when opening the head plate seal vent chamber plugs (43) as some gas will escape—if it is a pressure system, or the atmospheric air will leak in-if the system is under vacuum. There is a possibility of some gas leakage through the mechanical seals. This leakage on the gear end will escape through the gear box vent, and on the drive end, through the grease release fittings. If the gas leakage is undesirable, each seal chamber must be purged with an inert gas through one purge gas hole (43) per seal. There are two plugged purge gas holes(1/8 NPT) provided per seal. The purge gas pressure must be maintained one psi above the

discharge gas pressure. Also, there exists a possibility of gear end oil and drive end grease leakage into the gas stream.

The lubricants selected must be compatible with the gas. Mechanical Seal Replacement: Disassemble the blower. During disassembly, damage to mechanical seals is very likely. During rebuild, always use new mechanical seals. Prior to any assembly, make sure that all parts are completely clean and free from nicks and scratches.

- (1) Place head plate on an assembly table with seal bores pointing up. Coat the OD of the stationary seal element and install it with carbon facing up in the seal bore with a seal driver that is guided by the bearing bore. Drive the seal flush with front face of the seal bore. Repeat this procedure for all four seals. Apply a light coating of lubricating oil on the sealing surface. Protect sealing faces during assembly from any damage.
- (2) Apply teflon based sealant on the cylinder flanges before installing head plates. Continue the assembly procedure as outlined up to bearing installation. Before installation of the bearings, the seal mating rings need to be installed. Apply light film of lubricating oil on mating ring o-rings and sealing faces. Slide mating rings on the shaft and up to carbon faces making sure that no damage to the o-rings occur during installation (break sharp shaft corners to avoid damage to the o-rings during initial preparation). Install bearings all the way against the back bearing bore shoulders.
- (3) Complete the rest of the assembly. Make sure all plugged holes are sealed with teflon thread liquid sealant.

Note: On 6" gear diameter units, shims (44) are used between the bearing clamp plates and the head plate on the gear end.

Also, on size 32 and 42, washers with embedded o-rings are used on the center head plate to cylinder bolts.

After the assembly is completed, plug the blower inlet and discharge connections and run static soap bubble. Leak test to assure leak free assembly.

For satisfactory operation of mechanical seals, synthetic lubricants are recommended (Check suitability to gases before using.)

Oils:

- (1) ROOTS™ GT Synthetic Lubricant ROOTS P/N 13-106-001 (1) one quart ISO-220
- (2) Mobil SHC 600 Series Lubricating Oils

Grease:

- ROOTS™ Synthetic Grease – NLGI # 2
 ROOTS P/N T20-019-001 (1) one 14 oz tube

MAINTENANCE & REPLACEMENTS: RAM™ SERIES BLOWERS

A good program of consistent inspection and maintenance is the most reliable method of minimizing repairs to a blower. A simple record of services and dates will help keep this work on a regular schedule. Basic service needs are:

- Lubrication
- Checking for hot spots
- Checking for increases or changes in vibration and noise
- Recording of operating pressures and temperatures

Above all, a blower must be operated within its specified rating limits, to obtain satisfactory service life.

A newly installed blower should be checked often during the first month of full-time operation. Attention thereafter may be less frequent assuming satisfactory performance. Lubrication is normally the most important consideration and weekly checks of lubricant levels in the gearbox and bearing reservoirs should be customary. Complete oil change schedules are discussed under **LUBRICATION**.

Driver lubrication practices should be in accordance with the manufacturer's instructions. If direct connected to the blower through a lubricated type coupling, the coupling should be checked and greased each time blower oil is changed. This will help reduce wear and prevent unnecessary vibration. In a belted drive system, check belt tension periodically and inspect for frayed or cracked belts.

In a new, and properly installed, unit there is no contact between the two impellers, or between the impellers and cylinder or headplates. Wear is confined to the bearings (which support and locate the shafts) the oil seals, and the timing gears. All are lubricated and wear should be minimal if clean oil of the correct grade is always used. Seals are subject to deterioration and wear, and may require replacement at varying periods.

Piston ring seals (28) are designed to operate without rubbing contact, once temperature and thermal growth have stabilized. The stationary rings will rub the rotating sleeve (38) briefly as a result of temperature cycles that occur during the startup and shutdown of the unit. The sleeves are hardened and the rings are coated with dry lubricant that provides for temporary break in wear. Replace piston ring seals if they become excessively worn or inspection shows more than .010" (.25mm) axial clearance between ring and groove.

Shaft bearings are designed for optimum life under average conditions with proper lubrication and are critical to the service life of the blower. Gradual bearing wear may allow a shaft position to change slightly, until rubbing develops between impeller and casing. This will cause spot heating, which can be detected by observing these surfaces. Sudden bearing failure is usually more serious. Since the shaft and impeller are no longer supported and properly located, extensive

general damage to the blower casing and gears is likely to occur.

Oil seals should be considered expendable items, to be replaced whenever drainage from the headplate vent cavity becomes excessive or when the blower is disassembled for any reason. Sealing effectiveness can vary considerably from seal to seal and is also affected to surprising degree by shaft finish under the seal lip. Because of these normal variables, minor seal leakage should not be considered as indicating seal replacement.

Timing gear wear, when correct lubrication is maintained, should be negligible over a period of years. Gear teeth are cut to provide the correct amount of backlash, and gears correctly mounted on the shafts will accommodate a normal amount of tooth wear without permitting contact between lobes of the two impellers. However, too high an oil level will cause churning and excessive heating. This is indicated by unusually high temperature at the bottom of the gear housing. Consequent heating of the gears will result in loss of tooth-clearance, backlash and rapid wear of the gear teeth usually will develop. Continuation of this tooth wear will eventually produce impeller contacts (knocking), and from this point serious damage will be unavoidable if blower operation is continued. A similar situation can be produced suddenly by gear tooth fracture, which is usually brought on by sustained overloading or momentary shock loads.

Problems may also develop from causes other than internal parts failure. Operating clearances within a blower are only a few thousandths of an inch. This makes it possible for impeller interferences or casing rubs to result from shifts in the blower mounting, or from changes in piping support. If this type of trouble is experienced, and the blower is found to be clean, try removing mounting strains. Loosen blower mounting bolts and reset the leveling and drive alignment. Then tighten mounting again, and make sure that all piping meets blower connections accurately and squarely. Foreign materials sucked into the blower will also cause trouble, which can only be cured by disconnecting the piping and thoroughly cleaning the blower interior.

A wide range of causes & solutions for operating troubles are covered in the **TROUBLE SHOOTING CHECKLIST**. The remedies suggested should be performed by qualified mechanics with a good background, using procedures detailed in this manual. Major repairs generally are to be considered beyond the scope of maintenance, and should be referred to ROOTS.

Warranty failures should not be repaired at all, unless specific approval has been obtained through a Sales Office or the factory before starting work. Unauthorized disassembly within the warranty period will void the warranty.

It is recommended that major repairs be performed at an authorized ROOTS facility. However, it is recognized that this may not always be practical. If a blower is out of warranty, mechanical adjustments and parts replacement may be undertaken locally at the owner's option and risk. It is recommended that ROOTS™ parts be used to insure fit and suitability. The maintenance of a small stock of on-hand spare parts can eliminate possible delays. When ordering parts give Item numbers and their word descriptions from sectional drawings and parts lists. Also specify quantities wanted and the blower size and serial number from the nameplate.

Repairs or adjustments are best performed by personnel with good mechanical experience and the ability to follow the instructions in this manual. Some operations involve extra care, patience, and a degree of precision work. This is especially true in timing impellers and in handling bearings. Experience indicates that high percentages of bearing failures are caused by dirt contamination before or during assembly. Therefore, the work area should be cleaned before starting disassembly, and new or re-usable parts protected during progress of the work.

In the following repair procedures, numbers shown in brackets () correspond to the Item numbers used in assembly drawings, and parts lists. It is recommended that the procedures be studied carefully and completely, with frequent reference to the drawings, before starting work. This will produce better efficiency through an understanding of what work is to be done, and the order of doing it. Before disassembly, mark all parts so that they may be returned to original locations or relative positions.

Requirements for special tools will depend on the work to be done. If impeller clearances and float are to be checked or re-set, a dial indicator and a set of long feeler gauges will be needed. Work involving removal of the timing gears cannot be accomplished without a puller suitable. Heat must be used during bearing and sleeve installation.

Design of ROOTS™ blower is simple, and most repair operations are straightforward. For this reason, the following procedures are intended mainly to indicate a preferred work order and to call out points to be observed. Where special operations are required, detailed coverage is given.

DISASSEMBLY OF DRIVE END

1. Remove the sheave or coupling and key from the drive shaft. File off any burrs or sharp edges along the keyway.
2. Drain oil by removing drain plug (22).
3. Remove the flange screws (75). Tap the drive end cover to loosen it, then slide it along the shaft carefully to avoid damaging the lip seal (33) on the drive shaft keyway. Remove the gasket (7). Remove oil slinger (40) and cap screw (60).

4. Remove bearing clamp plates (34) by unscrewing capscrews (32) and removing lock washers (35). Keep shim halves (10) together exactly as removed by tagging them with each clamping plate.
5. Remove the headplate – remove all capscrews (23) holding headplate to the cylinder. Insert jacking screws into the four threaded flange holes and turn them in evenly. The headplate will separate from the cylinder. The lip seals (27), and bearing outer race and rollers, are removed with the headplate and can be pressed out later.
6. Remove the bearing inner race and sleeve (38) from the shaft with aid of a bearing puller by inserting the puller jaws in the groove in the sleeve and applying the jacking screw against the end of the shaft. Protect the threaded hole and the end of the shaft with a small, flat spacer between the shaft and the puller.

DISASSEMBLY OF GEAR END

1. Drain oil completely from the gearbox sump by removing plugs (22) in bottom of the headplate (1).
2. Loosen all flange screws (75) in the gearbox and remove all but two upper screws. Bump the gear box to break the joint if it cannot be pulled free by hand, then remove the last two screws and lift off the gearbox. Remove gasket (7).
3. Removing gears: CAUTION: Do not remove gear nuts (31) completely before the gears are unseated from the taper fits or damage/injury may result. Be sure that each gear is marked for return to the same shaft in the same angular position and that the gears have match marks for the teeth. For this operation, the impellers should be wedged as shown in Figure 8. Back off nuts (31) and slinger (46). The timing gears (4) have two 1/2" – 13 holes for pulling purposes. Use a suitable puller.
4. Remove bearing clamp plates (54) by unscrewing capscrews (32) and removing lock washers. Group the shims (10), the wavy spring washers (29) with each clamp plate and tag for ease of reassembly.
5. Remove the headplate – remove all capscrews (23) holding the headplate to the cylinder. Insert jacking screws into the four (4) threaded flange holes and turn them in evenly. They headplate will separate from the cylinder. The lip seals (27), and bearing outer race and rollers, are removed with the headplate and can be pressed out later.

For RAM™-J WHISPAIR™ gas pump units:

The gear end headplate which is removed next requires a different approach from the drive end. On this end, the shafts are forced from the bearing bore by using a bar across the end of the shaft with threaded rods to the headplate. Once the headplates are removed from the assembly, the seal housings can be pressed or driven from

the headplate bores. Generally, new seals will be required prior to reassembly.

- Remove the bearing inner race and sleeve (38) from the shaft with the aid of a bearing puller by inserting the puller jaws in the groove in the sleeve and applying the jacking screw against the end of the shaft. Protect the threaded hole and the end of the shaft with a small, flat spacer between the shaft and the puller.

ASSEMBLY

Prior to any assembly operation, it is essential that all parts are completely clean and free from nicks and scratches.

Prior to assembly, lightly coat the groove in the sleeve with slip plate. ROOTS P/N813-314-000.

- Assembly of Piston ring seals (28) – To avoid scratching the lip seal surface, install the Piston ring seals (28) in the sleeves (38) from the end nearest the groove before assembling the sleeve on the shaft.

Unhook the gap joint and expand the ring while sliding it to the groove, then compress it so one end of the hook joint slides over the other. Move the ring in the groove to be sure it is free.

NOTE: Care must be taken not to scratch or dent the sleeve surface since it is the sealing surface for the lip seal.

- Installation of sleeves (38) – heat the sleeve to 300° F. (149°C) then quickly slide it on the shaft tightly against the impeller. If the sleeve hangs up during assembly, it can be pressed into place using a tubular pressing tool with square, clean ends.
- Assembly of seals (27) in headplate (1) – Place headplate flat with seal bores up. Be sure the pressing tool face is clean and square and there is a smooth, clean entering bevel in the headplate. Lubricate the seal lips. Place seal over the bore with lip facing up, then press the seal evenly until it is flush with bore face.

For Gas Sealed Units: Assemble mechanical seals (27) in headplate – (**CAUTION:** Care must be used to avoid damaging the carbon face. Before proceeding with this step, you should have a piloted seal driver which is designed to clear the carbon face.) with headplate positioned horizontally with seal bores up. Be sure the pressing tool face is clean and square and there is a smooth, clean entering bevel in the headplate. Place the seal over the bore with carbon facing up. Then press the seal evenly on its steel shell using the piloted seal driver until the driver seats against the stop.

- Assembly of impellers (12 and 13) to headplate (1) – Place gear end headplate flat on 3 in. (76 mm) blocks with the smallest bores facing up.

Inspect entering bevels to be sure they are smooth and clean. Locate the drive impeller correctly (top for vertical units and toward the driver for horizontal units). Place the seal ring gaps toward the inlet for pressure applications and towards discharge for vacuum applications. Insert the impeller shafts in the headplate so the impellers rest on the headplate. Use care to avoid damaging the lip seals.

- Assembly of cylinder (11) to gear end headplate (1) – Install dowel pins (16) and secure cylinder to headplate with capscrews (23). Torque to 35 ft.-lbs (4.5 Kg-m). Then, install drive end headplate (1) and dowel pins (16) and secure with capscrews (23). Install feet (76) & 77) to both headplates and secure with capscrews (66). Torque to 35 ft.-lbs. (4.5 kg-m).

For Gas Sealed Units: Use a Teflon sealant between headplate and cylinder joint. Assemble rotating seal – apply a light coating of oil to the O-ring and seal face. Then with flute side out install the rotating seat tight to the shaft sleeve. Check and record seal compression – With the seal body in place and the impeller against the opposite headplate, check that seal compression is adequate. This can be checked using a depth gauge or dial indicator from the face of the head plate to the face of the mating ring. First, measure this distance while the carbon is out at its full length. Then, push the mating ring back against its stop and measure it again. The difference between these measurements is the compression. This can be done easily with finger pressure as the spring force is only 10 lbs. The correct travel is given below (record actual compression on clearance sheets).

SEAL COMPRESSION

Frame	Minimum	Maximum
400	.047"	.097"
600	.108"	.151"

* Prior to assembly, lightly coat the groove in the sleeve(38) with slip plate. ROOTS™ P/N 813-314-000

- Installation of bearings (14) – Heat bearing inner race to 300°F (149°C) in an oven or hot oil; then slide it onto the shaft so the bearing shoulder is snugly against the sleeve. Note: Be sure to install the shaft shim (70) behind the shaft sleeve before installing the drive end drive bearing inner race. This is required to compensate for the oil leader for shimming. Insert the bearing outer race and rollers in each bore and tap lightly in place. Spray bearings with lubricant.
- Measure and record the end clearances between the impellers and drive headplate using long feeler gauges. Then, subtract the allowed average drive end clearance. See Table 6. The result is the space required between clamping plates (34) and bearing outer race. Place shims (10) as required to get this clearance. Then, fasten the clamping

plates to the headplate with capscrews (32) and lock washers (35).

8. Installation of gear end bearings (14) – Turn the blower so that the gear end headplates is up. Heat bearing inner race to 300°F (149°C) in an oven or hot oil; then slide it onto the shaft so that the bearing shoulder is snugly against the sleeve. Insert the bearing outer race and rollers in each bore and tap lightly into place.
9. Measure and record the end clearance between the impellers and gear end headplate, then subtract the allowed average gear end clearance. See Table 6. The result is the space required between clamping plate (54) and bearing outer race. Place shims (10) as required to get this clearance. Then fasten the clamping plates (54) to the headplate using capscrews (32) and lock washers (35). Do not install wavy-spring washers (29) at this time, as a final check of clearances is required first.
10. Final check of end clearances and float – Using long feeler gauges, check the clearance between the impellers and drive end headplate. See Table 6. Place the blower assembly on its feet and correct shimming as required. Then, force the impellers as close to the gear end headplate as possible, and check the clearance between impellers and gear end headplate for agreement with Table 6. Adjust shimming on the gear end as required. With unit securely fastened down, use a dial indicator to measure the impeller float. Again push the impeller to one end of the cylinder. With indicator firmly mounted, place contact point on the end of the shaft just pushed and set dial on zero. Force the impeller to the opposite end (toward indicator). Indicator reading will be a measurement of the impeller float. Repeat process on second impeller and compare float to Table 6. Adjust shimming at bearing clamp plates to obtain both float and end clearances specified in Table 6.

Finally, after clearances and float have been corrected and checked, remove the gear end clamping plates (54) and install wavy-spring washers (29) and reinstall shims (10) and clamping plates (54). Be sure oil feed grooves are up and toward bearings.

11. Installing drive gear (4) – Be sure shafts and gear bores are clean and free of scratches. Oil gear nut threads lightly. Place hardwood wedges as shown in Figure 8. Install gear (4) and nut (31) so match mark at the tooth is at the line of engagement. Tighten the drive gear to the torque given below. Blower assembly must be fastened down for torquing operation.
12. **Left side discharge machine**
Installing driven gear (14) – Insert a long metal feeler gauge between the impellers' lobes at the fronts as shown in Table 6. Feeler gauge thickness to be a middle value from Table 6 for fronts.

13. Right side discharge machine

Installing driven gear (4) – Insert a long metal feeler gauge between the impellers' lobes at the backs. Feeler gauge thickness to be minimum value from Table 6 for backs.

RAM™ SERIES BLOWER GEAR NUT TORQUE

Frame Size	Torque	
	lb.-ft.	(kg-m)
404, 406, 409, 412, 418	400	(56)
616, 624	630	(88)

RAM™ SERIES BLOWER OIL SLINGER SCREW TORQUE

Frame Size	Torque	
	lb.-ft.	(kg-m)
404, 406, 409, 412, 418	75	(10)
616, 624	140	(19)

Align the gear so the tooth match marks agree with the drive gear, then install slinger (46) and nuts (31). Tighten lightly with a small wrench, then check front and back clearances against Table 6 for each 45° position. Both fronts should be about the same and backs should about equal and be within the specified range in Table 6. Adjust gear position if necessary, then insert the corrected feeler gauge and wedges and use a torque wrench to tighten the gear nut to the torque specified above. Remove wedges and rotate the drive shaft by hand to make sure there are no gear tight spots or impeller contacts. **CAUTION: Keep fingers away from impeller end gears.**

Install gearbox (3) with gasket (7) and tighten the capscrews (75) evenly to 10 ft.-lbs. (1.3 kg-m).

Install drive end oil slinger (40) and capscrew (60), apply Loctite to threads and torque to value specified above.

Install drive end cover (5) and gasket (7) with drive lock pins (17) in place, being careful not to dent or scratch drive shaft lip seal surface. Tighten capscrews (75) evenly. Check seal bore for concentricity with shaft using an indicator; reposition drive lock pins, if necessary. Install seal (33) with lip facing inward, using care to avoid tearing or scratching seal on shaft keyway. Use a pressing tool with clean, square ends to insure correct positioning of the seal. For hydrodynamic style seals, the shaft rotation is critical for correct installation and proper sealing. Match the directional arrow shown on the seal faces with the required shaft rotation. An installation protective sleeve is required to protect seal lip during installation.

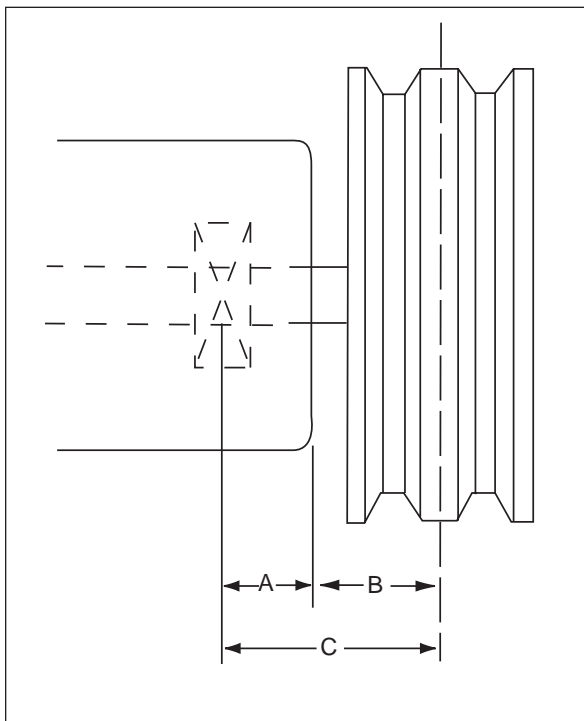
Install vent plug (21) in each headplate.

Replace oil drain plugs (22) and refill drive end and gear sumps with proper grade of oil as discussed under **LUBRICATION**.

Install drive sheave or coupling half and install blower, refer to **INSTALLATION instructions**.

FIGURE 2

ALLOWABLE OVERHUNG LOADS FOR V-BELT DRIVES UNIVERSAL RAI®/URAI™-J UNITS



$$\text{Belt Pull lbs} = \frac{252100 \cdot \text{Motor HP}}{\text{Blower RPM} \cdot \text{Sheave Diameter}}$$

C = Distance between drive bearing center line and sheave center line (A+B)

$$B = \left(\frac{1}{8} + \frac{\text{Sheave Width}}{2} \right)$$

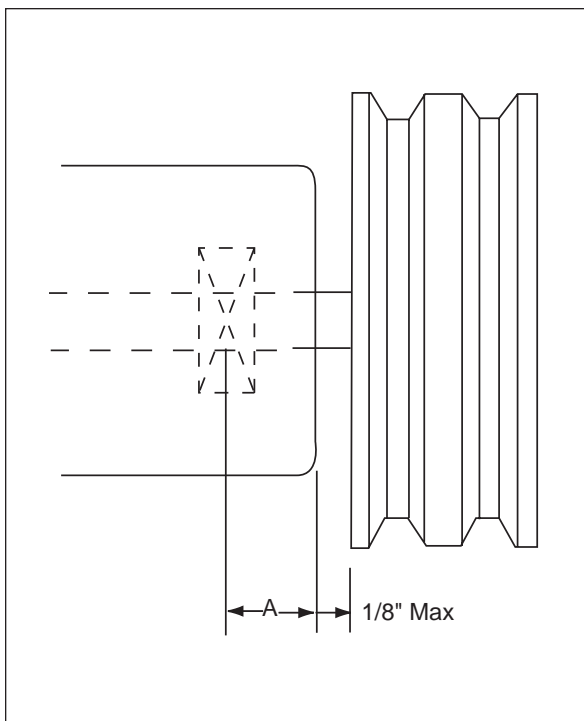
$$\text{Shaft Load (lb.in)} = \text{Belt Pull} \cdot C$$

Frame Size	Dimension "A"	Max Allowable Shaft Load (lb-in.)
22, 24	0.61	80
32, 33, 36	0.80	300
42, 45, 47	1.02	640
53, 56, 59	1.13	1,110
65, 68, 615	1.36	1,550
76, 711, 718	1.16	2,300

NOTE: Arc of sheave belt contact on the smaller sheave not to be less than 170°

Driver to be installed on the inlet side for vertical units, and on the drive shaft side for horizontal units.

ALLOWABLE OVERHUNG LOADS FOR V-BELT DRIVES 400 - 600 RAM™ UNITS



$$\text{Belt Pull lbs} = \frac{27500 \cdot \text{Motor HP}}{\text{Blower RPM} \cdot \text{Sheave Diameter}}$$

$$\text{Shaft Load (lb.in)} = \text{Belt Pull} \cdot \left(A + \frac{1}{8} + \frac{\text{Sheve Width}}{2} \right)$$

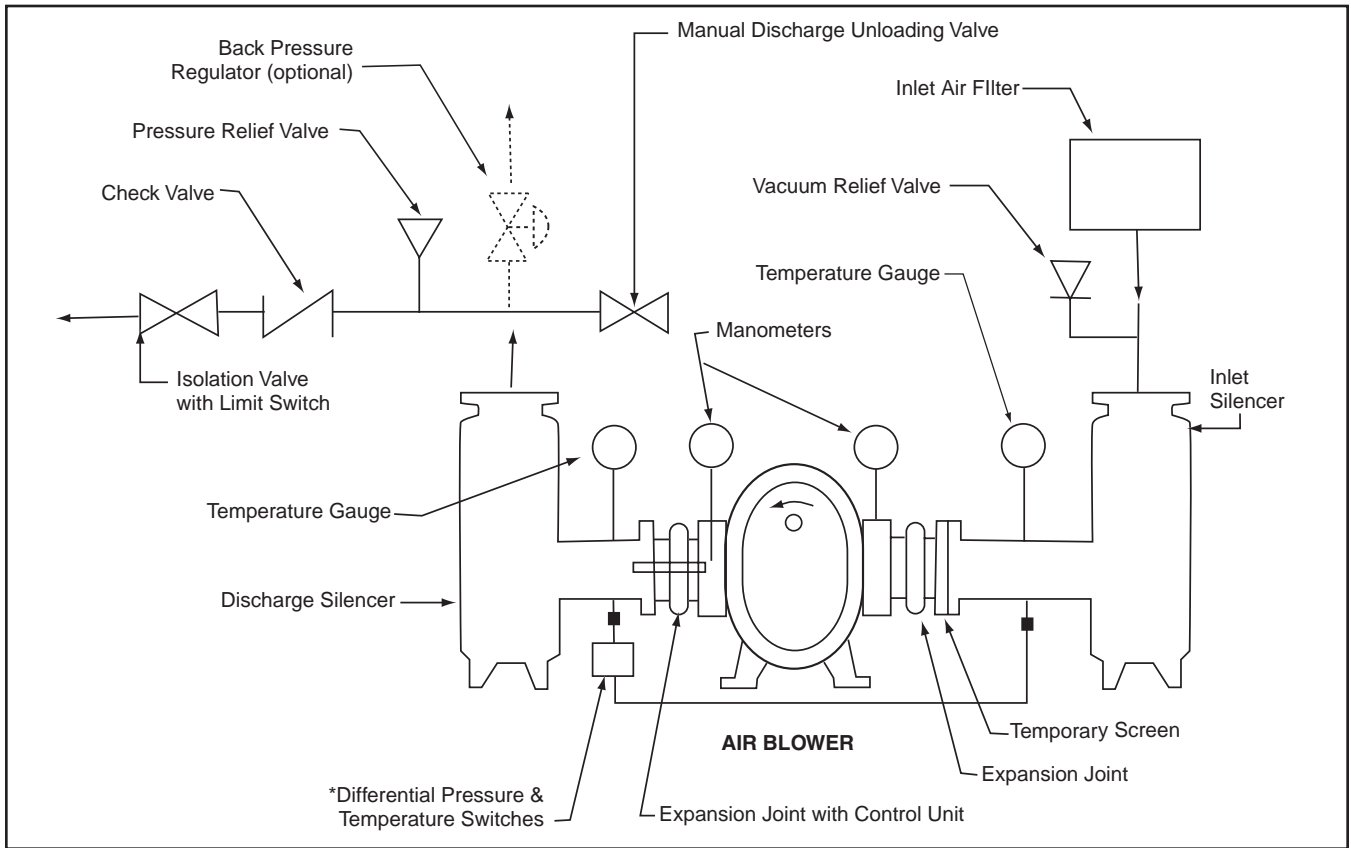
Frame Size	Dimension "A"		Max Allowable Shaft Load (lb-in.)
	Standard Unit	Bottom Drive or Double Shaft Seal	
404, 406	1.90	2.11	3,200
409, 412, 418	1.90	2.11	3,200
616, 624	2.11	2.67	7,975

NOTE: Arc of sheave belt contact on the smaller sheave not to be less than 170°

Driver to be installed on the inlet side for vertical units, and on the drive shaft side for horizontal units.

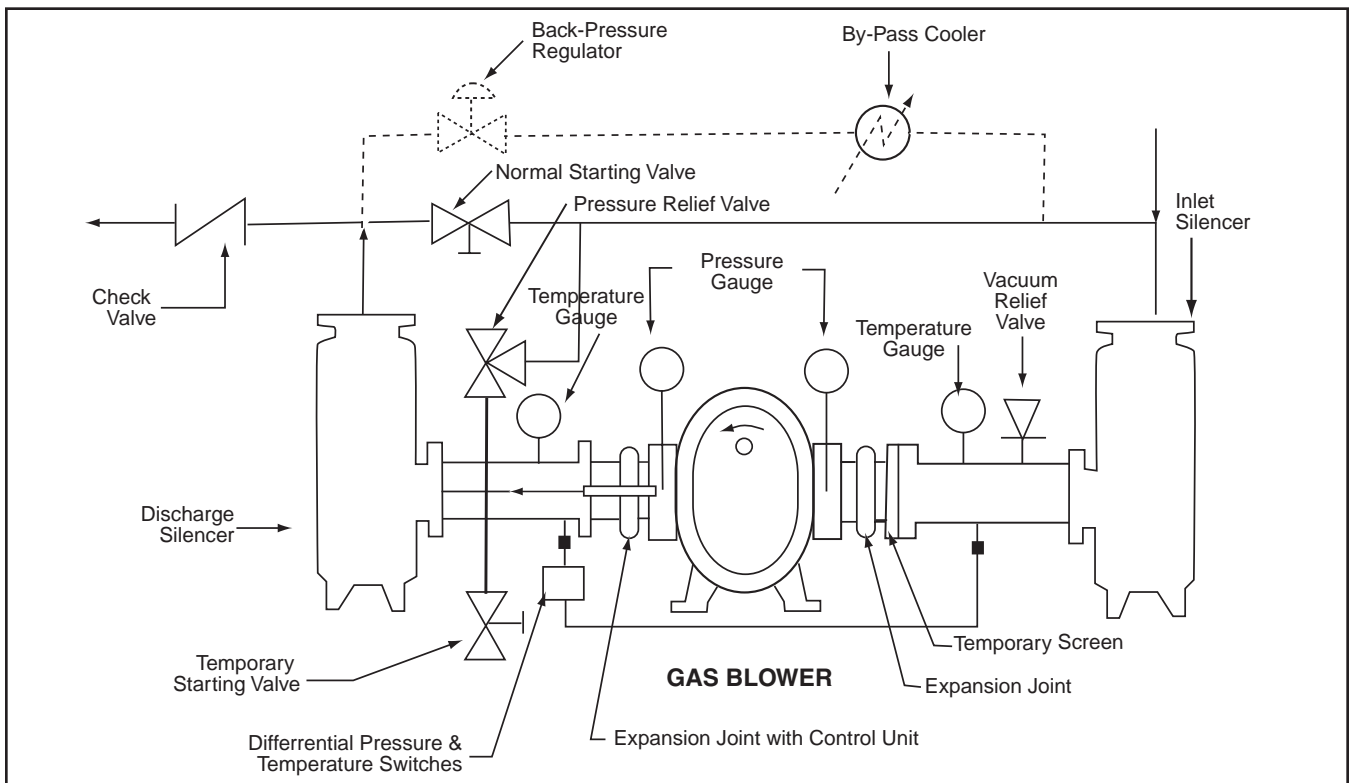
FIGURE 3

AIR BLOWER INSTALLATION WITH ACCESSORIES



Above are suggested locations for available accessories.

GAS BLOWER INSTALLATION WITH ACCESSORIES



Above are suggested locations for available accessories.

FIGURE 4

BLOWER ORIENTATION CONVERSION

Model	Reversible Rotation	Whispair Design
Universal RAI	yes	no
URAI-J	no	yes
URAI-G	yes	no
RAM	yes	no
RAM-J	no	yes
RAM-GJ	no	yes

Special Note: WHISPAIR™ models are designed to operate with only one shaft rotation direction to take full advantage of the Whispair feature. Therefore, a WHISPAIR™ blower should be operated in the following combinations only.

- **CCW Rotation:** Bottom Shaft; Right side discharge or a Left Shaft; Bottom discharge
- **CCW Rotation:** Top Shaft; Left side discharge or a Right Shaft; Top discharge
- **CW Rotation:** Bottom Shaft; Left side discharge or a Right Shaft Bottom discharge
- **CW Rotation:** Top Shaft; Right side discharge or a Left Shaft Top discharge

BLOWER ORIENTATION AND LUBRICATION POINTS: UNIVERSAL RAI® & URAI™-G GAS BLOWERS

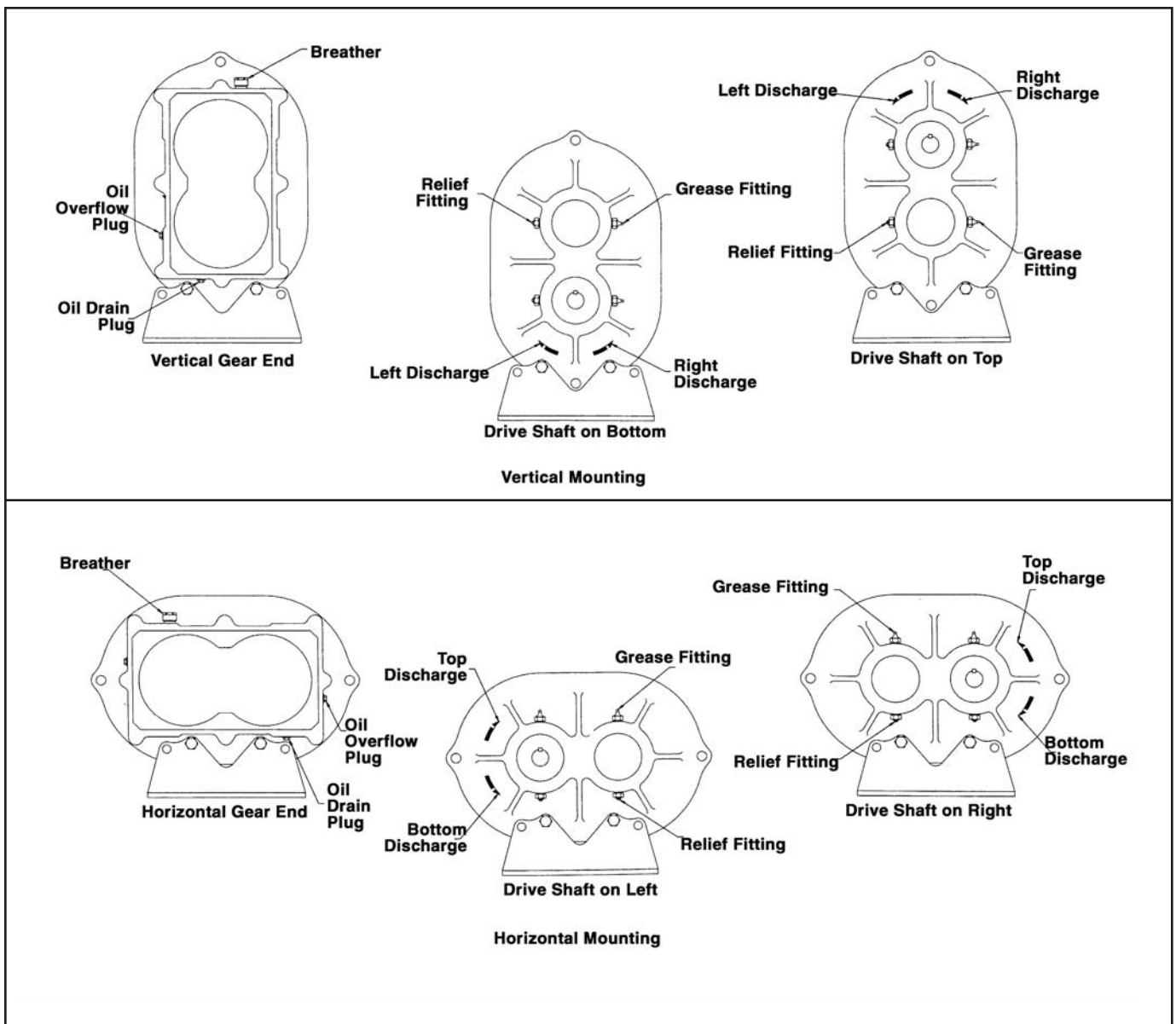
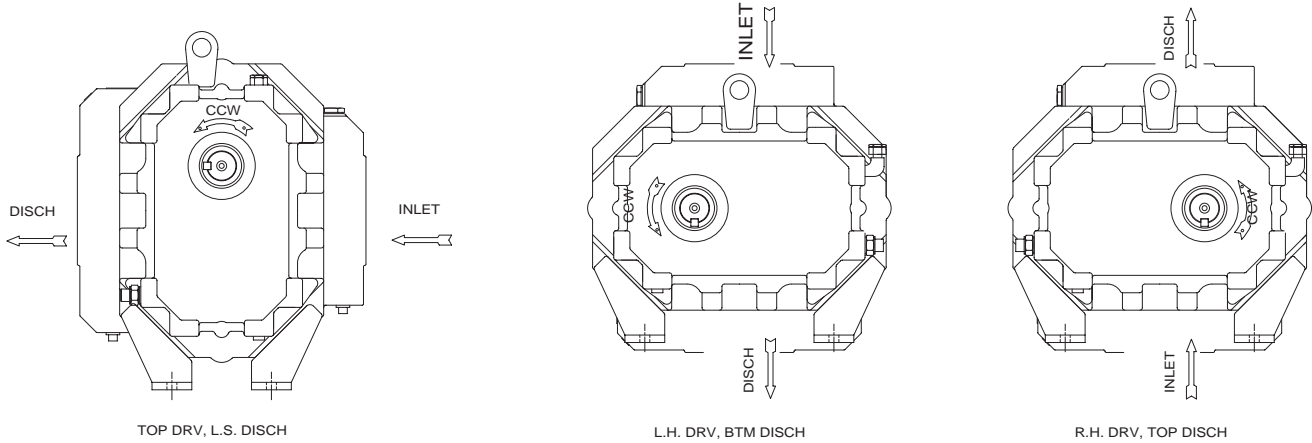


FIGURE 5

BLOWER ORIENTATION CONVERSION - WHISPAIR™ UNITS

1. STANDARD ARRANGEMENT (3-WAY UNIVERSAL)

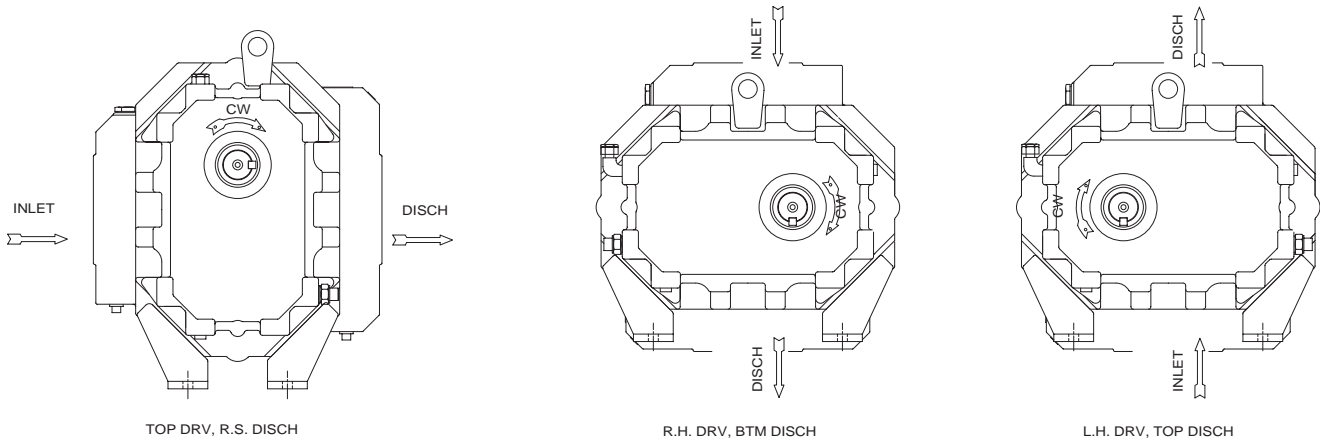
EXTERNAL SIGHT GLASSES (37) & BREATHERS (21) MUST BE RELOCATED AS SHOWN.
FEET (76&77) & LIFTING LUGS (63) MUST BE RELOCATED AS SHOWN.



2. NON-STANDARD ARRANGEMENT (3-WAY UNIVERSAL)

CYLINDER (11) MUST BE UNBOLTED FROM HEADPLATES (1) AND DISCHARGE RELOCATED AS SHOWN. **MUST HAVE AUTHORIZATION FOR CONVERSION SO NOT TO VOID WARRANTY.**

EXTERNAL SIGHT GLASSES (37) & BREATHERS (21) MUST BE RELOCATED ALSO.
FEET (76&77) & LIFTING LUGS (63) MUST BE RELOCATED AS SHOWN



3. BOTTOM DRIVE SHAFT ARRANGEMENT "SPECIAL ORDER" (3-WAY UNIVERSAL)

SPECIAL OGE OIL SLINGER REQUIRED FOR ASSEMBLY.

MAY BE CONVERTED TO HORIZONTAL CONFIGURATION AS PREVIOUSLY SHOWN.

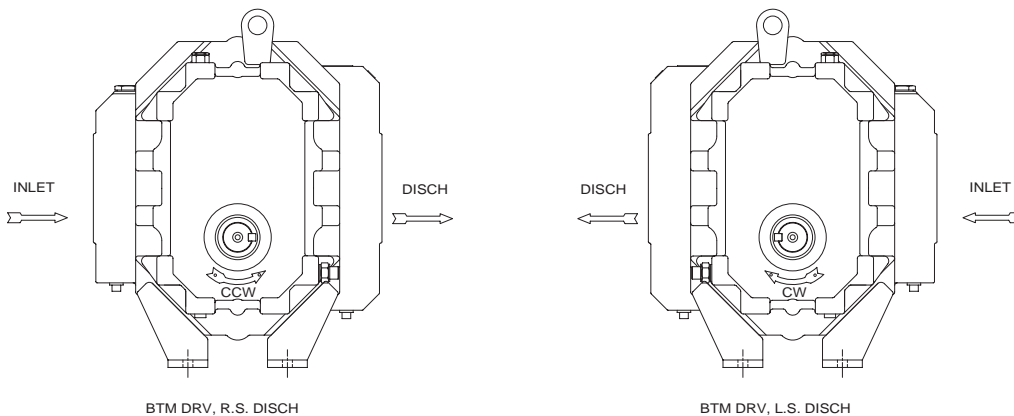


TABLE 1 -

URAI™-J WHISPAIR™ & URAI™-G GAS BLOWER, MAXIMUM ALLOWABLE OPERATING CONDITIONS

Frame Size	Gear Diameter (Inch)	Speed RPM	Temp. Rise F° (C°)	Delta Pressure PSI (mbar)	Inlet Vacuum INHG (mbar)
22	2.5	5275	225 (125)	12 (227)	15 (500)
24	2.5	5275	210 (117)	7 (483)	15 (500)
32	3.5	3600	240 (133)	15 (1034)	16 (539)
33	3.5	3600	225 (125)	12 (827)	15 (500)
36	3.5	3600	225 (125)	7 (483)	15 (500)
42	4.0	3600	240 (133)	15 (1034)	16 (539)
45	4.0	3600	225 (125)	10 (690)	16 (539)
47	4.0	3600	225 (125)	7 (483)	15 (500)
53	5.0	2850	225 (125)	15 (1034)	16 (539)
56	5.0	2850	225 (125)	13 (896)	16 (539)
59	5.0	2850	225 (125)	7 (483)	15 (500)
65	6.0	2350	250 (130)	15 (1034)	16 (539)
68	6.0	2350	240 (133)	14 (965)	16 (539)
615	6.0	2350	130 (72)	7 (483)	12 (405)
76	7.0	2050	250 (139)	15 (1034)	16 (539)
711	7.0	2050	225 (125)	10 (690)	16 (539)
718	7.0	2050	130 (72)	6 (414)	12 (405)

**RAM™, RAM™-J WHISPAIR™ BLOWER, RAM™-GJ GAS BLOWER
MAXIMUM ALLOWABLE OPERATING CONDITIONS**

Frame Size	Gear Diameter (Inch)	Speed RPM	Temp. Rise F° (C°)	Delta Pressure PSI (mbar)	Inlet Vacuum INHG (mbar)
404	4.5	4000	240 (133)	18 (1241)	16 (539)
406	4.5	4000	240 (133)	18 (1241)	16 (539)
409	4.5	4000	240 (133)	18 (1241)	16 (539)
412	4.5	4000	240 (133)	15 (1034)	16 (539)
418	4.5	4000	240 (133)	10 (690)	16 (539)
616	6.0	3000	230 (128)	15 (1034)	16 (539)
624	6.0	3000	230 (128)	10 (690)	16 (539)

TABLE 3**RECOMMENDED OIL GRADES**

Ambient Temperature °F (°C)	Viscosity Range SSU at 100°F	ISO No.	Approximate SAE No.
Above 90° (32°)	1000-1200	320	60
32° to 90° (0° to 32°)	700-1000	220	50
0° to 32° (-18° to 0°)	500-700	150	40
Below 0° (-18°)	300-500	100	30

UNIVERSAL RAI®, URAI™-J, URAI™-G OIL SUMP CAPACITIES

Frame Size	Capacity Fl. Oz. (Liters)	
	Vertical	Horizontal
22	3.4 (.1)	6.1 (.18)
24	3.4 (.1)	6.1 (.18)
32	8.5 (.25)	16.0 (.47)
33	8.5 (.25)	16.0 (.47)
36	8.5 (.25)	16.0 (.47)
42	12.7 (.37)	22.8 (.67)
45	12.7 (.37)	22.8 (.67)
47	12.7 (.37)	22.8 (.67)
53	16.0 (.47)	27.6 (.82)
56	16.0 (.47)	27.6 (.82)
59	16.0 (.47)	27.6 (.82)
65	28.3 (.84)	52.1 (1.54)
68	28.3 (.84)	52.1 (1.54)
615	28.3 (.84)	52.1 (1.54)
76	32.3 (.96)	59.5 (1.76)
711	32.3 (.96)	59.5 (1.76)
718	32.3 (.96)	59.5 (1.76)

RAM™, RAM™-J & RAM™-GJ OIL SUMP CAPACITIES

Orientation	Gearbox		Drive End	
	Fl. Oz.	(Liters)	Fl. Oz.	(Liters)
400 (Horizontal)	36	1.06	19	.56
400 (Vertical)	18	.52	9	.27
600 (Horizontal)	95	2.81	50	1.48
600 (Vertical)	55	1.63	28	0.83

TABLE 4**SUGGESTED BEARING GREASING INTERVALS**

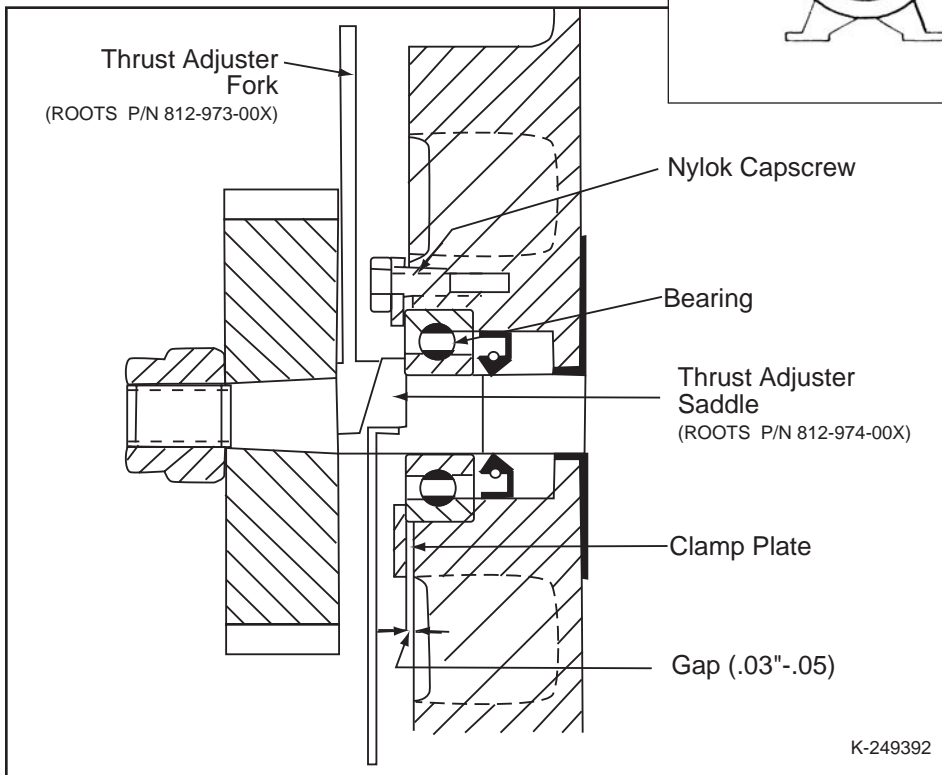
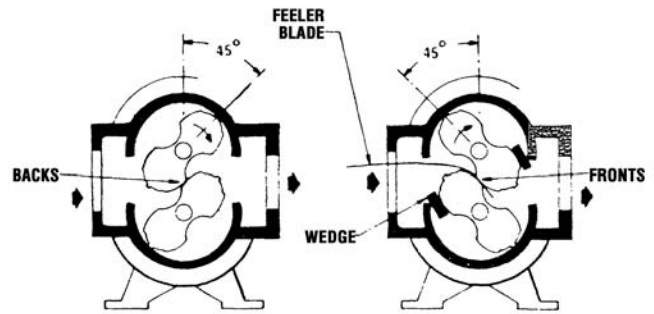
Speed In RPM	Operating Hours Per Day		
	8	16	24
	Greasing Intervals in Weeks		
750-1000	7	4	2
1000-1500	5	2	1
1500-2000	4	2	1
2000-2500	3	1	1
2500-3000	2	1	1
3000 and up	1	1	1

TABLE 5

NORMAL CLEARANCES FOR UNIVERSAL RAI® AND URAI™-J, URAI™-G BLOWERS - INCHES (MM)

Frame Size	Impeller Ends			Cylinder		Impeller
	Total	Drive End Minimum	Gear End Minimum	Inlet & Discharge	Center Center	* Fronts/Backs
22	.006/.010 (.15-.25)	.003 (.08)	.003 (.08)	.004/.005 (.10-.13)	.002/.003 (.05-.08)	.007/.01 (.18-.25)
24	.006/.010 (.15-.25)	.003 (.08)	.003 (.08)	.004/.006 (.10-.15)	.002/.003 (.05-.08)	.007/.01 (.18-.25)
32	.006/.011 (.15-.28)	.003 (.08)	.003 (.08)	.004/.006 (.10-.15)	.002/.003 (.05-.08)	.01/.012 (.25-.30)
33	.006/.011 (.15-.28)	.003 (.08)	.003 (.08)	.004/.006 (.10-.15)	.002/.003 (.05-.08)	.01/.012 (.25-.30)
36	.006/.011 (.15-.28)	.003 (.08)	.003 (.08)	.004/.006 (.10-.15)	.002/.003 (.05-.08)	.01/.012 (.25-.30)
42	.008/.011 (.20-.28)	.004 (.10)	.004 (.10)	.005/.007 (.13-.18)	.003/.004 (.08-.10)	.009/.012 (.23-.30)
45	.008/.013 (.20-.33)	.004 (.10)	.004 (.10)	.005/.007 (.13-.18)	.003/.004 (.08-.10)	.012/.015 (.30-.38)
47	.008/.013 (.20-.33)	.004 (.10)	.004 (.10)	.005/.007 (.13-.18)	.003/.004 (.08-.10)	.012/.015 (.30-.38)
53	.008/.011 (.20-.28)	.004 (.10)	.004 (.10)	.005/.008 (.13-.20)	.003/.004 (.08-.10)	.011/.013 (.28-.33)
56	.008/.013 (.20-.33)	.004 (.10)	.004 (.10)	.005/.008 (.13-.20)	.003/.004 (.08-.10)	.015/.017 (.38-.43)
59	.008/.013 (.20-.33)	.004 (.10)	.004 (.10)	.005/.008 (.13-.20)	.003/.004 (.08-.10)	.015/.017 (.38-.43)
65	.012/.016 (.30-.40)	.008 (.20)	.004 (.10)	.006/.008 (.15-.20)	.006/.008 (.15-.20)	.010/.014 (.25-.36)
68	.014/.018 (.36-.46)	.010 (.25)	.004 (.10)	.006/.008 (.15-.20)	.006/.008 (.15-.20)	.010/.014 (.25-.36)
615	.014/.018 (.36-.46)	.010 (.25)	.004 (.10)	.006/.008 (.15-.20)	.006/.008 (.15-.20)	.010/.014 (.25-.36)
76	.012/.016 (.30-.40)	.008 (.13)	.004 (.10)	.006/.008 (.15-.20)	.006/.008 (.15-.20)	.013/.015 (.33-.38)
711	.014/.018 (.36-.46)	.010 (.25)	.004 (.10)	.006/.008 (.15-.20)	.006/.008 (.15-.20)	.013/.015 (.33-.38)
718	.014/.018 (.36-.46)	.010 (.25)	.004 (.10)	.006/.008 (.15-.20)	.006/.008 (.15-.20)	.013/.015 (.33-.38)

*** IMPELLER TIMING FOR STANDARD ROTATION VIEWED FROM GEAR END**



**THRUST SETTING,
2-1/2" THRU 5"
UNIVERSAL RAI® BLOWERS**

K-249392

TABLE 6

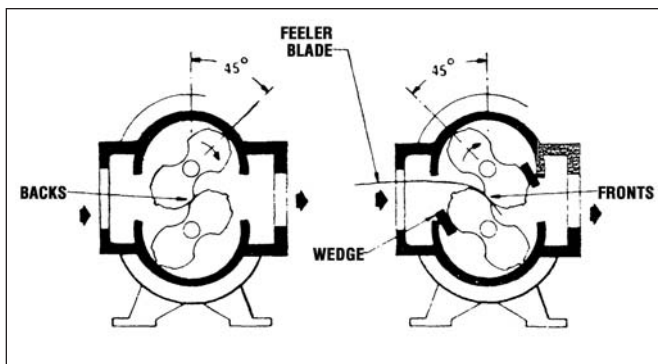
NORMAL CLEARANCES FOR RAM™-J & RAM™-GJ WHISPAIR™ BLOWERS - INCHES (MM)

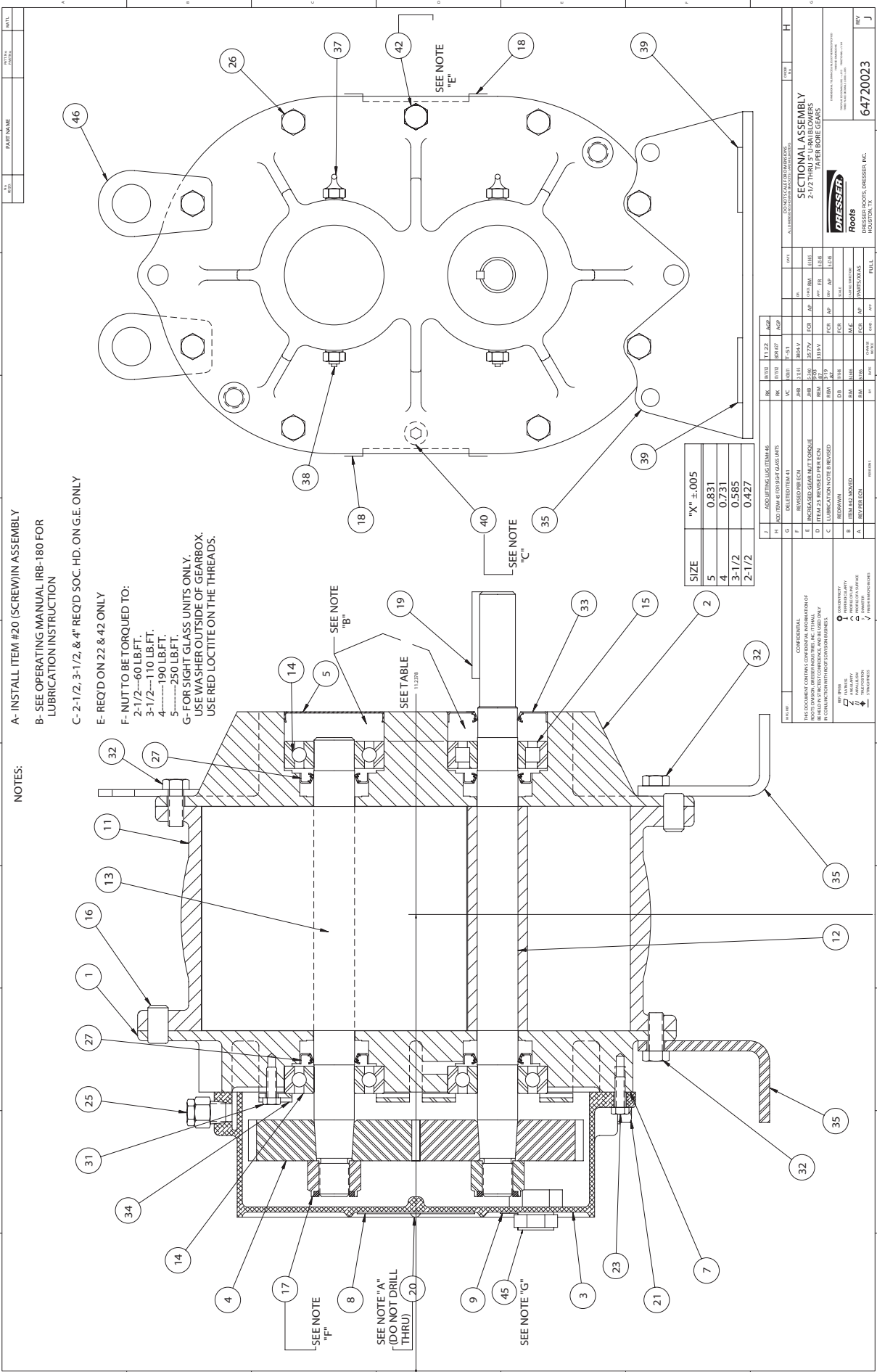
Blower Frame Size	* Impeller Lobes at 45°		End Clearance			Impeller Tips to Cylinders		
			Each End Without Wavy Spring	Gear End Without Spring Installed	Required End Float	Inlet	Center	Discharge
	Fronts	Backs	Min-Max	Min-Max	Minimum	Min-Max	Min-Max	Min-Max
404	.012-.014 (.31-.36)	.006-.009 (.15-.23)	.003-.005 (.08-.13)	.003-.008 (.10-.15)	.003 (.08-.20)	.004-.006 (.08)	.002-.004 (.05-.10)	.002-.004 (.05-.10)
406	.012-.014 (.31-.36)	.006-.009 (.15-.23)	.003-.005 (.08-.13)	.007-.012 (.15-.30)	.006 (.13)	.005-.007 (.13-.18)	.003-.005 (.08-.13)	.002-.004 (.05-.10)
409	.013-.015 (.33-.38)	.006-.009 (.15-.23)	.003-.005 (.08-.13)	.013-.018 (.31-.43)	.008 (.17)	.005-.007 (.13-.18)	.003-.005 (.08-.13)	.002-.004 (.05-.10)
412	.013-.015 (.33-.38)	.006-.009 (.15-.23)	.003-.005 (.08-.13)	.016-.021 (.36-.48)	.011 (.28)	.006-.008 (.15-.20)	.004-.006 (.10-.15)	.004-.006 (.10-.15)
418	.013-.015 (.33-.38)	.006-.009 (.15-.23)	.003-.005 (.08-.13)	.022-.027 (.51-.64)	.017 (.38)	.008-.010 (.20-.25)	.004-.006 (.10-.15)	.004-.006 (.10-.15)
616	.012-.014 (.31-.36)	.006-.008 (.15-.20)	.004-.006 (.10-.15)	.017-.022 (.38-.51)	.011 (.28)	.009-.011 (.23-.28)	.004-.006 (.10-.15)	.002-.005 (.05-.13)
624	.012-.015 (.31-.36)	.006-.009 (.15-.23)	.004-.006 (.10-.15)	.024-.029 (.61-.74)	.018 (.46)	.013-.015 (.33-.38)	.005-.007 (.13-.18)	.002-.005 (.05-.13)

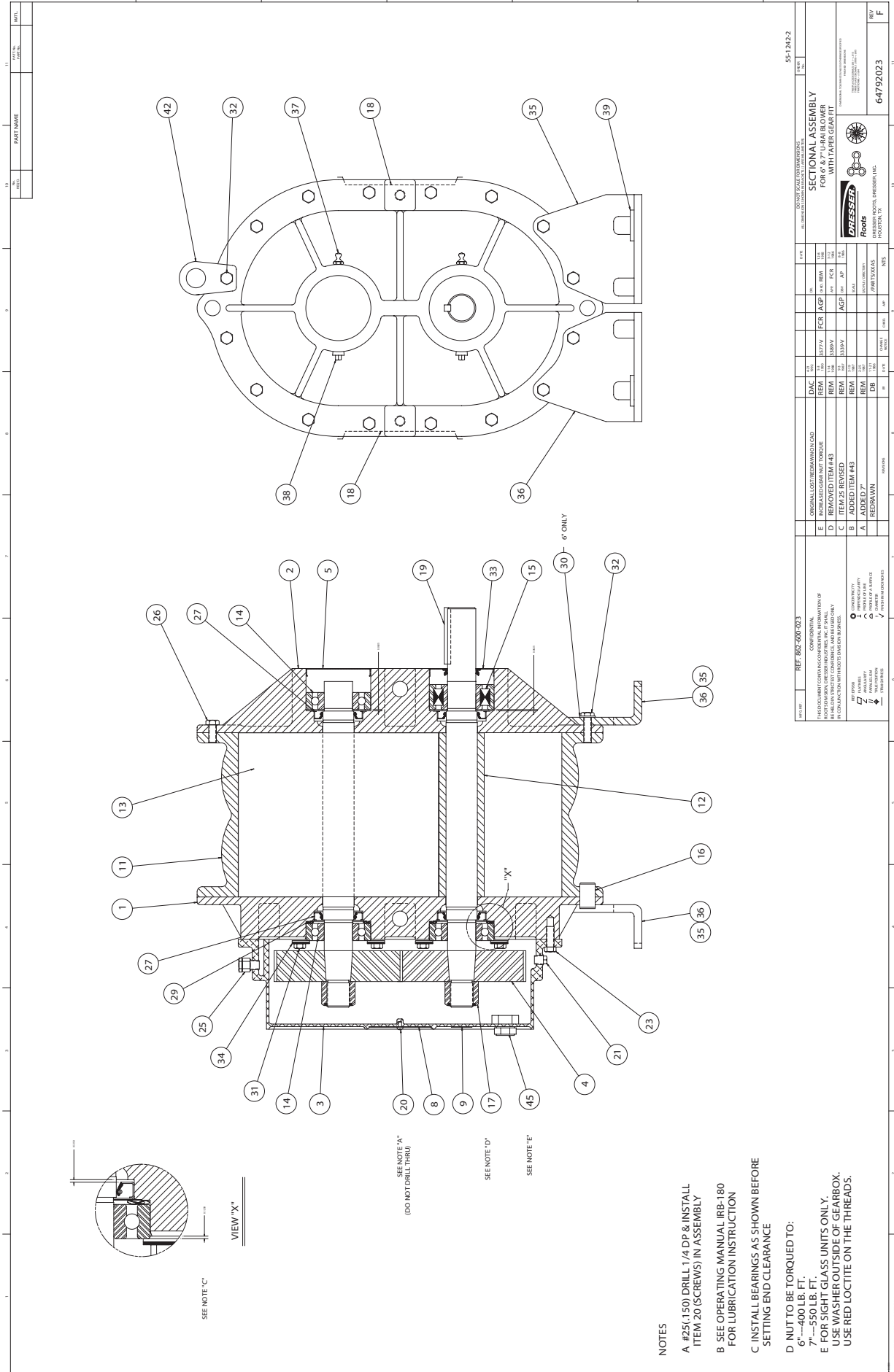
NORMAL CLEARANCES FOR RAM™ BLOWERS - INCHES (MM)

Blower Frame Size	* Impeller Lobes at 45°		End Clearance			Impeller Tips to Cylinders		
			Each End Without Wavy Spring	Gear End Without Spring Installed	Required End Float	Inlet	Center	Discharge
	Fronts	Backs	Min-Max	Min-Max	Minimum	Min-Max	Min-Max	Min-Max
404	.009-.013 (.23-.33)	.009-.013 (.23-.33)	.003-.005 (.08-.13)	.003-.008 (.08-.20)	.003 (.08)	.004-.006 (.10-.15)	.002-.004 (.05-.10)	.004-.006 (.10-.15)
406	.009-.013 (.23-.33)	.000-.013 (.23-.33)	.003-.005 (.08-.13)	.007-.012 (.15-.30)	.006 (.13)	.005-.007 (.13-.18)	.003-.005 (.08-.13)	.005-.007 (.13-.18)
409	.010-.014 (.25-.36)	.010-.014 (.25-.36)	.003-.005 (.08-.13)	.013-.018 (.31-.43)	.008 (.17)	.005-.007 (.13-.18)	.003-.005 (.08-.13)	.005-.007 (.13-.18)
412	.010-.014 (.25-.36)	.010-.014 (.25-.36)	.003-.005 (.08-.13)	.016-.021 (.36-.48)	.011 (.28)	.006-.008 (.15-.20)	.004-.006 (.10-.15)	.006-.008 (.15-.20)
418	.010-.014 (.25-.36)	.010-.014 (.25-.36)	.003-.005 (.08-.13)	.022-.027 (.51-.64)	.017 (.38)	.008-.010 (.20-.25)	.004-.006 (.10-.15)	.008-.010 (.20-.25)
616	.011-.013 (.28-.33)	.011-.013 (.28-.33)	.004-.006 (.10-.15)	.017-.022 (.38-.51)	.011 (.28)	.009-.011 (.23-.28)	.004-.006 (.10-.15)	.009-.011 (.23-.28)
624	.011-.013 (.28-.33)	.011-.013 (.28-.33)	.004-.006 (.10-.15)	.024-.029 (.61-.74)	.018 (.46)	.013-.015 (.33-.38)	.005-.007 (.13-.18)	.013-.015 (.33-.38)

*** IMPELLER TIMING FOR STANDARD ROTATION VIEWED FROM GEAR END**

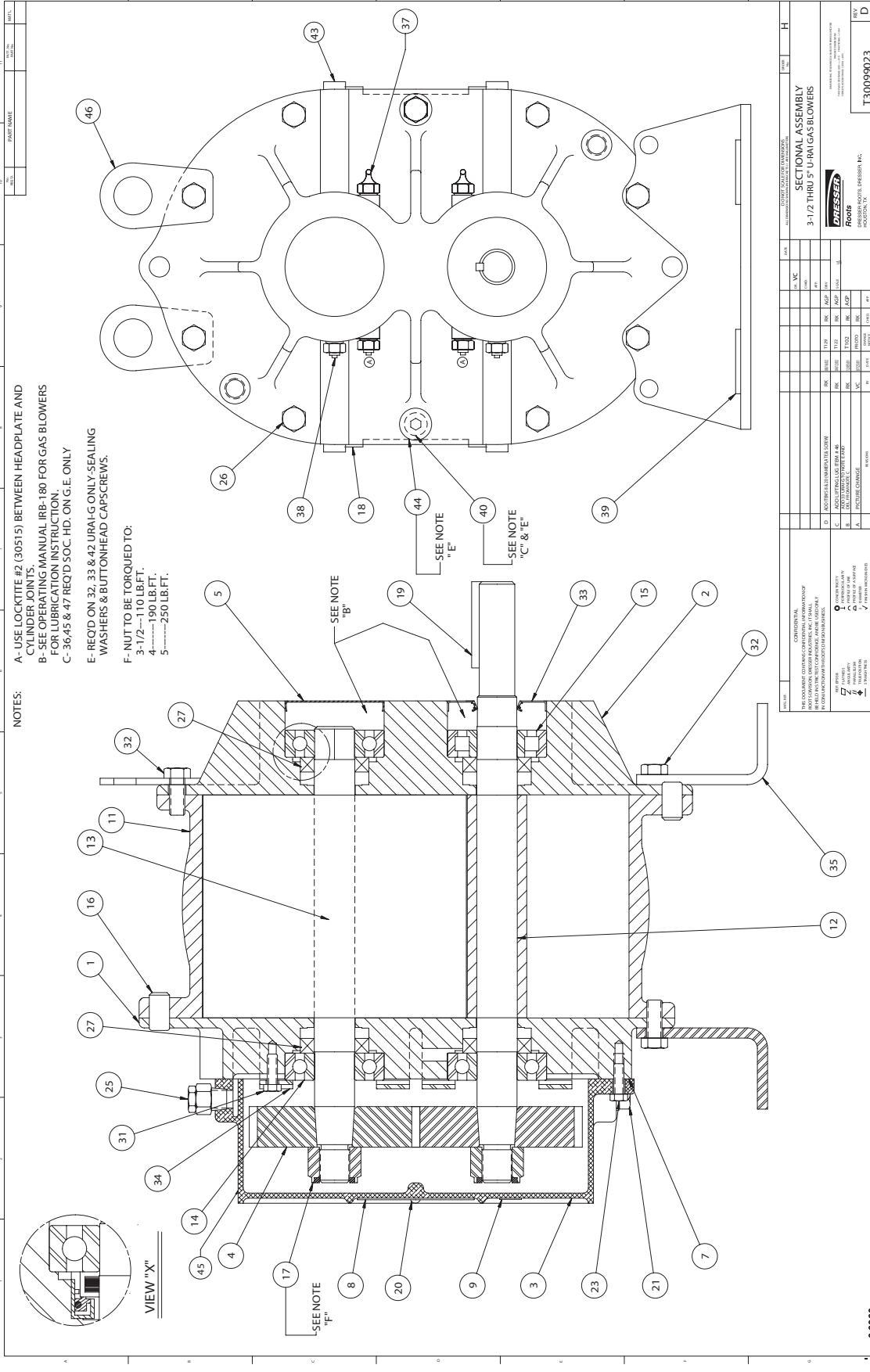






ASSEMBLY OF UNIVERSAL RAI® BLOWERS, 6" AND 7" DIAMETER

- NOTES**
- A #25 (.150) DRILL 1/4 DP & INSTALL ITEM 20 (SCREWS) IN ASSEMBLY
 - B SEE OPERATING MANUAL IRB-180 FOR LUBRICATION INSTRUCTION
 - C INSTALL BEARINGS AS SHOWN BEFORE SETTING END CLEARANCE
 - D NUT TO BE TORQUED TO:
 6"
 7"
 400 LB. FT.
 550 LB. FT.
 - E FOR SIGHT GLASS UNITS ONLY. USE WASHER OUTSIDE OF GEARBOX. USE RED LOCTITE ON THE THREADS.



- NOTES:
- A- USE LOCKWITE #2 (30515) BETWEEN HEADPLATE AND CYLINDER JOINTS.
 - B- SEE OPERATING MANUAL IRB-180 FOR GAS BLOWERS FOR OIL LUBRICATION INSTRUCTION.
 - C- 36,45 & 47 REQ'D SOC. HD. ON G.E. ONLY
 - E- RECD ON 32, 33 & 42 URAI-G ONLY- SEALING WASHERS & BUTTONHEAD CAPSCREWS.
 - F- NUT TO BE TORQUED TO:
 3-1/2"---110 LB.FT.
 4"-----190 LB.FT.
 5"-----250 LB.FT.

REV	DATE	BY	CHKD	DESCRIPTION
1				ISSUED FOR PRODUCTION
2				REVISED TO REFLECT CHANGES TO THE DRAWING
3				REVISED TO REFLECT CHANGES TO THE DRAWING
4				REVISED TO REFLECT CHANGES TO THE DRAWING
5				REVISED TO REFLECT CHANGES TO THE DRAWING
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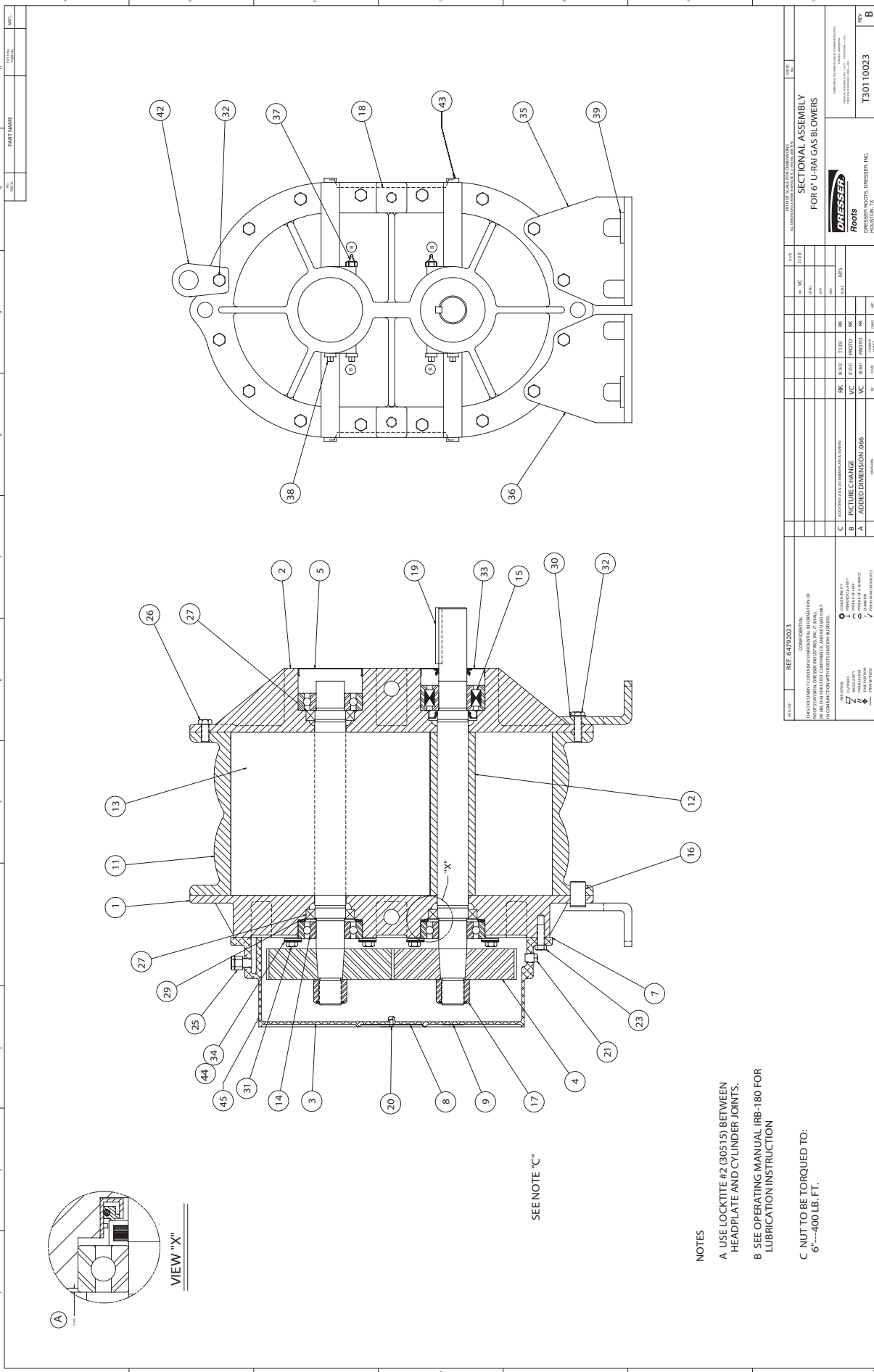
SECTIONAL ASSEMBLY
 3-1/2" THRU 5" URAI-GAS BLOWERS

Roots
 Dresser
 ROOTS TECHNOLOGICAL SERVICES, INC.
 HOUSTON, TEXAS

T30099023

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ASSEMBLY OF UNIVERSAL RAI™-G SERIES GAS BLOWERS, 3-1/2" THRU 5" GEAR DIAMETER

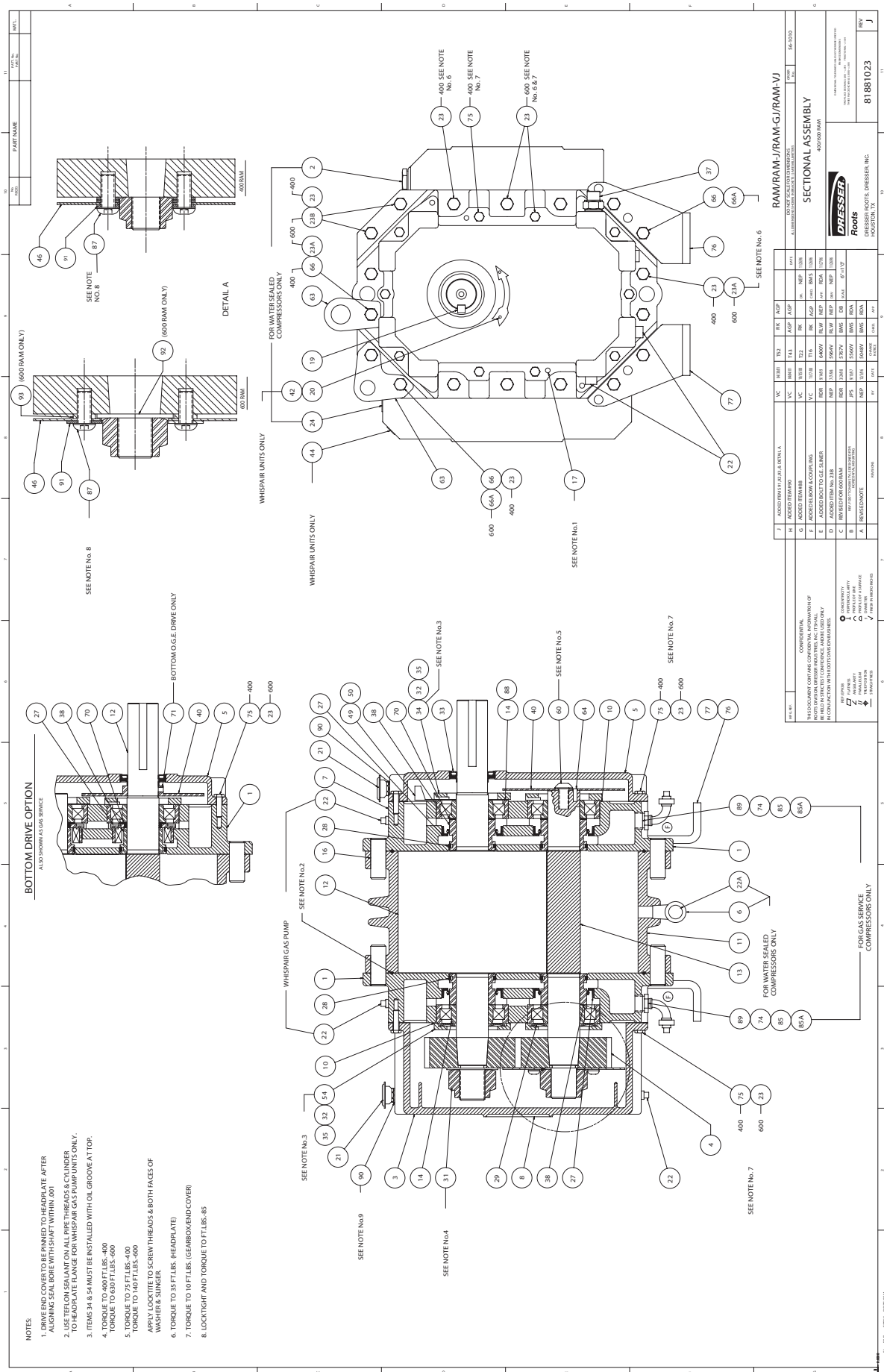


NOTES

- A USE LOCKTITE #2 (30515) BETWEEN HEADPLATE AND CYLINDER JOINTS.
- B SEE OPERATING MANUAL IRB-180 FOR LUBRICATION INSTRUCTION
- C NUT TO BE TORQUED TO:
6"³—400 LB. FT.

ASSEMBLY OF UNIVERSAL RAI® SERIES GAS BLOWERS, 6" GEAR DIAMETER

REF: 64792023	CONFIDENTIAL	DATE: 01/11/02	REV: 1
THIS DOCUMENT CONTAINS CONFIDENTIAL INFORMATION OF DRESSER. IT IS TO BE KEPT CONFIDENTIAL AND NOT REPRODUCED OR TRANSMITTED IN ANY FORM OR BY ANY MEANS, ELECTRONIC OR MECHANICAL, INCLUDING PHOTOCOPYING, RECORDING, OR BY ANY INFORMATION STORAGE AND RETRIEVAL SYSTEM.		DATE: 01/11/02	REV: 1
C: DIMENSIONS FOR ASSEMBLY OVER DIMENSIONS B: PICTURE CHANGE VC: VERTICAL DIMENSION A: ADDED DIMENSION 266	0: CONFIDENTIAL 1: INTERNAL USE ONLY 2: INTERNAL USE ONLY 3: INTERNAL USE ONLY 4: INTERNAL USE ONLY 5: INTERNAL USE ONLY 6: INTERNAL USE ONLY 7: INTERNAL USE ONLY 8: INTERNAL USE ONLY 9: INTERNAL USE ONLY 10: INTERNAL USE ONLY 11: INTERNAL USE ONLY 12: INTERNAL USE ONLY 13: INTERNAL USE ONLY 14: INTERNAL USE ONLY 15: INTERNAL USE ONLY 16: INTERNAL USE ONLY 17: INTERNAL USE ONLY 18: INTERNAL USE ONLY 19: INTERNAL USE ONLY 20: INTERNAL USE ONLY 21: INTERNAL USE ONLY 22: INTERNAL USE ONLY 23: INTERNAL USE ONLY 24: INTERNAL USE ONLY 25: INTERNAL USE ONLY 26: INTERNAL USE ONLY 27: INTERNAL USE ONLY 28: INTERNAL USE ONLY 29: INTERNAL USE ONLY 30: INTERNAL USE ONLY 31: INTERNAL USE ONLY 32: INTERNAL USE ONLY 33: INTERNAL USE ONLY 34: INTERNAL USE ONLY 35: INTERNAL USE ONLY 36: INTERNAL USE ONLY 37: INTERNAL USE ONLY 38: INTERNAL USE ONLY 39: INTERNAL USE ONLY 40: INTERNAL USE ONLY 41: INTERNAL USE ONLY 42: INTERNAL USE ONLY 43: INTERNAL USE ONLY 44: INTERNAL USE ONLY 45: INTERNAL USE ONLY	0: INTERNAL USE ONLY 1: INTERNAL USE ONLY 2: INTERNAL USE ONLY 3: INTERNAL USE ONLY 4: INTERNAL USE ONLY 5: INTERNAL USE ONLY 6: INTERNAL USE ONLY 7: INTERNAL USE ONLY 8: INTERNAL USE ONLY 9: INTERNAL USE ONLY 10: INTERNAL USE ONLY 11: INTERNAL USE ONLY 12: INTERNAL USE ONLY 13: INTERNAL USE ONLY 14: INTERNAL USE ONLY 15: INTERNAL USE ONLY 16: INTERNAL USE ONLY 17: INTERNAL USE ONLY 18: INTERNAL USE ONLY 19: INTERNAL USE ONLY 20: INTERNAL USE ONLY 21: INTERNAL USE ONLY 22: INTERNAL USE ONLY 23: INTERNAL USE ONLY 24: INTERNAL USE ONLY 25: INTERNAL USE ONLY 26: INTERNAL USE ONLY 27: INTERNAL USE ONLY 28: INTERNAL USE ONLY 29: INTERNAL USE ONLY 30: INTERNAL USE ONLY 31: INTERNAL USE ONLY 32: INTERNAL USE ONLY 33: INTERNAL USE ONLY 34: INTERNAL USE ONLY 35: INTERNAL USE ONLY 36: INTERNAL USE ONLY 37: INTERNAL USE ONLY 38: INTERNAL USE ONLY 39: INTERNAL USE ONLY 40: INTERNAL USE ONLY 41: INTERNAL USE ONLY 42: INTERNAL USE ONLY 43: INTERNAL USE ONLY 44: INTERNAL USE ONLY 45: INTERNAL USE ONLY	0: INTERNAL USE ONLY 1: INTERNAL USE ONLY 2: INTERNAL USE ONLY 3: INTERNAL USE ONLY 4: INTERNAL USE ONLY 5: INTERNAL USE ONLY 6: INTERNAL USE ONLY 7: INTERNAL USE ONLY 8: INTERNAL USE ONLY 9: INTERNAL USE ONLY 10: INTERNAL USE ONLY 11: INTERNAL USE ONLY 12: INTERNAL USE ONLY 13: INTERNAL USE ONLY 14: INTERNAL USE ONLY 15: INTERNAL USE ONLY 16: INTERNAL USE ONLY 17: INTERNAL USE ONLY 18: INTERNAL USE ONLY 19: INTERNAL USE ONLY 20: INTERNAL USE ONLY 21: INTERNAL USE ONLY 22: INTERNAL USE ONLY 23: INTERNAL USE ONLY 24: INTERNAL USE ONLY 25: INTERNAL USE ONLY 26: INTERNAL USE ONLY 27: INTERNAL USE ONLY 28: INTERNAL USE ONLY 29: INTERNAL USE ONLY 30: INTERNAL USE ONLY 31: INTERNAL USE ONLY 32: INTERNAL USE ONLY 33: INTERNAL USE ONLY 34: INTERNAL USE ONLY 35: INTERNAL USE ONLY 36: INTERNAL USE ONLY 37: INTERNAL USE ONLY 38: INTERNAL USE ONLY 39: INTERNAL USE ONLY 40: INTERNAL USE ONLY 41: INTERNAL USE ONLY 42: INTERNAL USE ONLY 43: INTERNAL USE ONLY 44: INTERNAL USE ONLY 45: INTERNAL USE ONLY
SECTIONAL ASSEMBLY FOR 6" U-RAI GAS BLOWERS DRESSER ROOTS DRESSER, INC. HOUSTON, TX		T30110023 REV B	0: INTERNAL USE ONLY 1: INTERNAL USE ONLY 2: INTERNAL USE ONLY 3: INTERNAL USE ONLY 4: INTERNAL USE ONLY 5: INTERNAL USE ONLY 6: INTERNAL USE ONLY 7: INTERNAL USE ONLY 8: INTERNAL USE ONLY 9: INTERNAL USE ONLY 10: INTERNAL USE ONLY 11: INTERNAL USE ONLY 12: INTERNAL USE ONLY 13: INTERNAL USE ONLY 14: INTERNAL USE ONLY 15: INTERNAL USE ONLY 16: INTERNAL USE ONLY 17: INTERNAL USE ONLY 18: INTERNAL USE ONLY 19: INTERNAL USE ONLY 20: INTERNAL USE ONLY 21: INTERNAL USE ONLY 22: INTERNAL USE ONLY 23: INTERNAL USE ONLY 24: INTERNAL USE ONLY 25: INTERNAL USE ONLY 26: INTERNAL USE ONLY 27: INTERNAL USE ONLY 28: INTERNAL USE ONLY 29: INTERNAL USE ONLY 30: INTERNAL USE ONLY 31: INTERNAL USE ONLY 32: INTERNAL USE ONLY 33: INTERNAL USE ONLY 34: INTERNAL USE ONLY 35: INTERNAL USE ONLY 36: INTERNAL USE ONLY 37: INTERNAL USE ONLY 38: INTERNAL USE ONLY 39: INTERNAL USE ONLY 40: INTERNAL USE ONLY 41: INTERNAL USE ONLY 42: INTERNAL USE ONLY 43: INTERNAL USE ONLY 44: INTERNAL USE ONLY 45: INTERNAL USE ONLY



ASSEMBLY OF RAM™ SERIES AIR & GAS BLOWERS

UNIVERSAL RAI® SERIES BLOWERS PARTS LIST

Item No.	Part Name	Qty.
1	Headplate Gear End	1
2	Headplate Drive End	1
3	Gearbox	1
4	Gears	1
5	Cover-Blind (Plug Opening)	1
7	Gasket	1
9	Nameplate Lube	1
14	Bearing G.E., - Driven	3
15	Bearing Drive D.E., - Drive	1
16	Pin, Dowel	4
17	Gear Nut	2
19	Key	1
20	Screw, Self Tap	1
21	Plug, Pipe	3
23	Screw Hex	6
25	Breather (Plug Vent)	1
26	Screw, Hex	14
27	Seal	4
29	Washer - wavy Spring	2
30	Washer	8
31	Screw, Hex	4
32	Screw, Hex	4
33	Seal Lip-Drive	1
34	Clamp Plate	2
35	Foot	2
36	Foot	2
37	Fitting, Grease	2
38	Fitting, Relief	2
39	Washer Flat	4
40	Screw Socket	2
40*	Screw, Button Hd.	4
42	Screw Hex	2
43	Plug	8
44*	Washer	4

*For 32 and 42 URAI-G only.

RAM™ SERIES PARTS LIST

Item No.	Part Name	Qty.
01	Headplate	2
03	Gearbox	1
04	Gear, Assembly	1
05	End Cover	1
07	Gasket – Gearbox/Cover	2
09	Installation Tag	2
10	Shims-(.010)	Lot
14	Bearing Roller	4
16	Pin, Dowel (Pull Out)	4
17	Pin, Dowel	2
19	Key Square	1
20	Screw, Drive - Rd. Hd.	4
21	Breather	2
22	Plug, Pipe	12
23	Screw, Cap Hex Hd.	24
27	Seal, (Viton)	4
28	Piston, Ring-Seal	4
29	Washer, Wavy Spring	2
31	Nut, Hex ESNA	2
32	Scr, Cap Hex Hd.	16
33	Seal, Lip	1
34	Brg. Clamp Plate - D. E.	2
35	Lock Washer - Spring	16
37	Sight Plug - Oil Level	2
38	Sleeve - GE & DE	4
38	Sleeve - Piston Ring	4
40	Slinger - D.E. (Top Drive)	1
40	Slinger - D. E. (Bottom Drive)	1
42	Rotation Arrow	1
44	Label	1
46	Slinger - G.E.	1
49	Oil Leader L/S	1
50	Oil, Leader-R/S	1
54	Brg Clamp Plate - G. E.	2
60	Screw, Cap Butt. HD.	1
63	Lifting Lug	2
64	Pin, Spring	1
66	Screw, Cap Hex HD.	12
66.1	Whispair, Spring Lock 3/8M	12
70	Shims D.E. Brg.	1
75	Screw, Cap - Hex HD.	20
76	Blower Foot - RH	2
77	Blower Foot - LH	2
85	Elb, Pipe-Black	2
85.1	Plug, Pipe	2
87	Scr, Cap BH	2
88	Ball Spherical	4
90	BSHG-RDCG	2
91	Washer, Plain Flat	2
92	Washer, Plain Flat	2
93	Washer	2

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Houston, TX 77041

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Local Fax: 713-896-4927

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IRB-180-102
Rev. 12.02

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