ROOTS DRESSER

RGS·HVB

HIGH VACUUM BOOSTER PUMPS

6 inch gear diameter

CONTENTS

NOTE: NUMBERS IN ( ) FOLLOWING ENGLISH UNITS ARE METRIC EQUIVALENTS.

DO THESE THINGS To Get The Most From Your Roots Booster

1 Check shipment for damage in transit and for shortages. File any necessary claim with carrier, and notify your supplier or the nearest Roots Sales Office. See listing on last page.

2 Store in a dry and clean location, if possible, until installation is made. Protect against weather and corrosion if outdoor storage is necessary. Keep covers on all openings. Use handling methods discussed under INSTALLATION.

3 Plan the installation carefully, after reading the LIMITATIONS and INSTALLATION sections of this manual. When required, assistance by a Service Engineer may be obtained through the nearest Dresser Parts and Service Center. Request service at least a week in advance, and confirm by purchase order to cover standard changes.

4 In the event of trouble during installation or operation of a new unit, do not attempt repairs. Notify your supplier or nearest Roots Sales Office, giving complete description of the unit and the trouble.

5 Units out of warranty may be adjusted and repaired at owner's risk. See MAINTENANCE section. Good inspection and servicing practices should minimize the need for repairs.

SUMMARY — MAJOR ATTENTION ITEMS

1 Make sure proper oil levels are maintained in the sight gauges at both ends of the vacuum booster. In the drive end shaft seal reservoir, do not allow oil level to fall below lower mark on the dip stick.

2 Check oil levels after each 40 hours of operation. Loss of oil below the required minimum level indicates a possibility of seal leakage.

3 Change oil in main sumps at the two ends every 2000 operating hours, or more often if the oil becomes dirty. Oil in the drive shaft seal reservoir does not need to be changed. Maintain the required level by adding oil as necessary.

CAUTION: Never add or drain oil at either of the main sumps without closing inlet valve, stopping pumps and breaking vacuum on the pumps. Failure to observe this precaution can result in back flow of oil to the vacuum system and damage to the booster. Before handling or shipping, always drain sumps to prevent oil leakage into pumping compartment.

Bulletin IRB-140-379

OPERATING CHARACTERISTICS

The Roots RGS high vacuum booster pumps covered in this manual are intended especially for use in the first stage of a vacuum pumping system, in combination with a suitable fore-pump or roughing pump, to produce vacuum conditions in the micron range. It is *not* suitable for duty as a normal pressure blower.

Principle design features of the basic Roots rotary lobe blower are used in the pump. Two double-lobe impellers are mounted on parallel shafts, and rotate in opposite directions within a cylinder closed at the ends by headplates. The impellers are positioned one above the other, while the cylinder has inlet and discharge piping connections located on opposite vertical sides.

As shown in Figure 1, **Position 1**, rotation of the impellers draws air into one side of the cylinder, then traps a definite quantity between one impeller and the cylinder as represented in **Position 2**. Further rotation to **Position 3** pushes this trapped volume around the cylinder and out the discharge opening against the pressure existing there. During one complete drive shaft rotation, two such volumes are trapped by each impeller and discharged in an almost continuous flow. A Roots booster is therefore a positive displacement type unit, whose pumping capacity is determined by physical dimensions, operating speed and pressure conditions.

Accurate machining of the cylinder, impellers and gears allows normal operation at necessary speeds without internal contacts. Operating clearances are only a few thousandths of an inch (hundredths of mm), in order to provide effective sealing of the blower inlet area from the discharge so that back-leakage is held to a minimum. Absence of moving contacts also eliminates the need for internal lubrication, thus minimizing the possibility of oil back-streaming.

OPERATING LIMITATIONS

To permit continued satisfactory performance, a Roots RGS vacuum booster pump must be operated within certain approved limiting conditions. The Manufacturer's warranty is, of course, also contingent on such operation.

Since the pump may be driven either by direct coupling to a standard motor or by a V-belt arrangement, it is essential to consider the *maximum speed* limit shown in Table 1 when planning the drive. Specified limits for *pressure rise and temperature rise* must also be observed during operation. This will require the installation of good thermometers and gauges, located at or near the inlet and discharge connections of the pump.

Table 1 — Maximum Allowable Operating Conditions

Model	Speed RPM	Pressure Rise Torr	Temperature Rise Fahr. Degrees (°C)
615	2300	180	200 (93.3)
67	2400	380	200 (93.3)

NOTE: Maximum temperature rise and maximum pressure rise do not necessarily occur together. Whichever limit is reached first is to be considered the controlling factor.

INSTALLATION

It is assumed that the booster was checked for shipping damage when originally received, and that all covers, tapes and protective coatings were left in place at that time. During installation these protections should be allowed to remain in place as long as possible, in order to reduce the chances for dirt or other foreign materials to enter the booster, and to help prevent rusting of machined surfaces. Before shipment, the interior is protected against normal atmospheric corrosion by small bags of an inhibiting material fastened to the connection covers. The period of protection is considered to be a maximum of one year if closing seals are not broken. *Protection against chemical or salt water atmosphere is not provided.*

Handling of the unit should at all times be accomplished with care, using methods that conform with safe-practice standards. In many cases the use of a fork lift truck may best satisfy these requirements. In other cases, rope slings may be used in lifting or positioning the booster.

The best procedure on the 615 is to place the slings around the cylinder just behind the feet. If placed outside the feet, bearing on the gearbox and drive end cover, great care must be exercised to prevent the slings from slipping off. Best procedure on the 67 is to pass a rope or sling

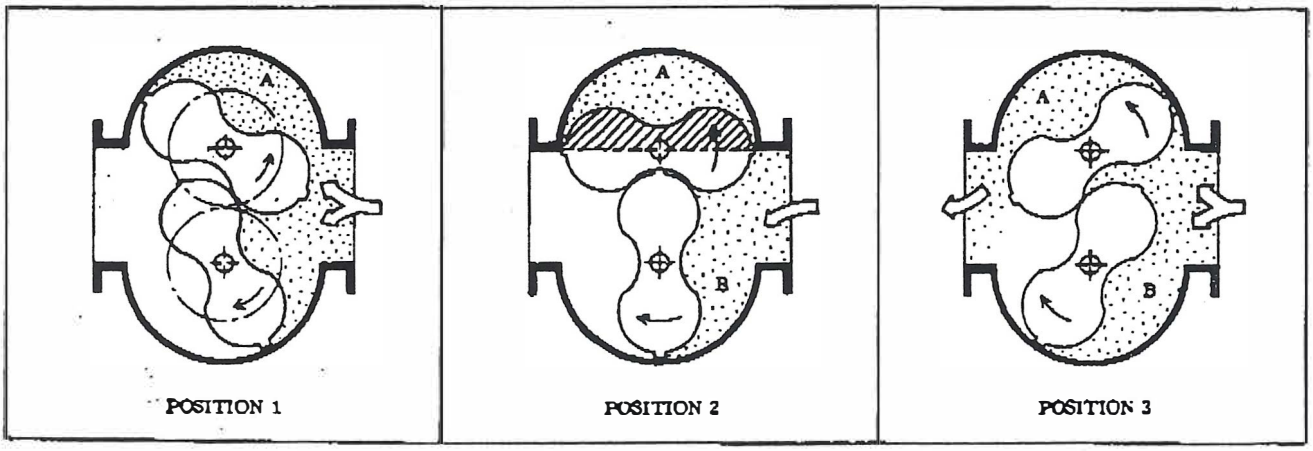

Figure 1 — Flow Through a Roots Vacuum Booster

through eyebolts attached in the upper flange.

It is important that the booster be mounted *level and without twist*, so that impellers turn freely with no contacts between themselves or with the casing. A common installation arrangement for the 615 involves mounting the unit on a welded steel baseplate, along with other related equipment. The area where the booster feet are to rest should consist of a rigid flat plate larger than the total length and width dimensions of the feet, or two smaller raised pads positioned to carry the feet at each end. Top surfaces should be machined or ground flat, and should not vary from level more than .001" per horizontal foot (.083 mm per Horz. meter) in either length or width directions. These same general requirements will also apply to any other type of installation.

Prepare the mounting surface by filing lightly to remove burrs, then set the 615 booster in place and determine whether all feet are in firm contact. If there is some rocking, use feeler blades to find the total clearance under one foot when the other three are in contact with the surface. Obtain laminated shim stock of suitable size and equal in thickness to the clearance found. Divide this into two approximately equal parts and place them under the diagonal short feet. Do not tighten booster hold-down bolts until the direct coupled or belted drive requirements are satisfied.

The 67 booster is to be mounted with top and bottom connection and rotation may be either clockwise or counter-clockwise. Top inlet and counter-clockwise rotation are standard.

DIRECT COUPLED DRIVE: Check shaft heights of the driving motor and booster accurately, and find the differences. If the motor shaft is higher, obtain four solid shims equal to this difference plus about .025" (.635 mm), and place them under the 615 booster feet. Final accurate alignment of the two shafts for flexible coupling installation may then be made by careful shimming under the motor feet. If the booster shaft is higher, proceed directly to final alignment by use of appropriate shim thickness under the motor. Make sure also that coupling halves fit both shafts so that only light tapping is required to install them.

Consideration must also be given to limitations imposed by the need for the booster to operate freely and without stresses transmitted from the drive. Misalignment can be in either shaft offset or angularity, but is usually a combination of both. Maximum deviation in offset should not exceed .002" (.0508 mm) total indicator reading taken on the coupling hubs, while deviation from parallel of the inside coupling faces should not exceed .001" (.0254 mm) when checked at four points around the coupling.

BELTED DRIVE: Variation in heights of booster and drive shafts is of no consequence, but the two shafts should be parallel in both vertical and horizontal planes. Belt sheaves should be properly fit to their respective shafts, so that they may be worked into place by hand or by very light tapping, but the fit must not be loose enough to allow wobbling. Mount each sheave close to its shaft bearing, allowing a minimum of ¼" (6.35 mm) clearance between the inner hub face and the bearing cover. Finally, position the driver so that sheave edges are in alignment to allow belts to run freely without excessive wear in the sheave grooves. The driver position must be adjustable to allow installing, tightening or removing the belts.

For driving the booster at its maximum permissible performance rating, the use of "Dyna-V" or equal high rating sheaves and belts is recommended. Limiting specifications for the booster sheave are: maximum rim face width 2-3/8" (6.033 cm) for three size 5-V belts; minimum sheave pitch diameter 7.1" (18.034 cm) for size 5-V belts. Other conventional V-belt drive selections may be used as long as these same limits are observed for the booster sheave. Such drives may be adequate for many booster pumping applications, but may not be capable of driving the booster to its maximum performance rating.

For either direct coupled or belted drive, follow the alignment procedures by tightening securely all booster and driver mounting bolts. Recheck the alignment carefully, particularly for coupling drive, and make any necessary corrections. Also rotate the booster drive shaft by hand several times. If any binding, scraping or impeller contacts are found, these must be eliminated now. Foreign materials inside the casing can cause trouble, but mounting twist is a more common cause of loss of internal clearances. On the 615, this trouble can usually be eliminated by loosening all booster mounting bolts and re-shimming under feet until all are solid. Drive realignment may then be necessary.

At this point the flexible coupling assembly and lubrication should be completed, or the V-belt installed and tightened until snug. Final tensioning of a belt drive should be in accordance with the drive manufacturer's instructions, but over-tightening should be avoided since it can lead to premature bearing failure. However, a new drive can originally be tensioned about ⅓ greater than normal to allow for stretch and wear-in.

It may be desirable to operate the booster briefly under power to make sure the driver rotation is correct, as shown by the arrow near the booster shaft. A check for noise and vibration can also be made. **Before operating**, put the required amount of oil into the three booster reservoirs per instructions under LUBRICATION. Also remove protective covers from the booster piping connections and make sure all of the internal surfaces and pockets are free of any kind of dirt. If cleaning is required, finish by washing the cylinder, headplates and impellers thoroughly with a petroleum solvent such as Triethane. Place an 8-mesh screen over the inlet connections to prevent anything being sucked into the booster while operating, and avoid standing in line with the discharge opening.

Note — Vacuum Boosters intended for oxygen service receive special preparation for shipment. In addition to required cleaning, they are purged with nitrogen and sealed under 5 to 10 PSIG (.352 to .703 Kg/cm^2) nitrogen pressure to prevent in-leakage of contaminating atmosphere. Before uncovering the pipe connections, bleed off the internal pressure by slowly loosening a pipe plug at each end of the booster plus one flange cover.

After the check run, piping may be fitted to the booster connections. It is of the utmost importance to be **absolutely certain** that all pipe and fittings used are free of dirt, scale, loose corrosion deposits, thread cuttings, or other foreign material. Failure to exercise sufficient care in this matter can result in jamming and internal damage to the booster. It is equally important that the piping be both accurately in line and square with the connections. In addition, if pipe runs of any appreciable length are involved, adequate supports must be provided near the booster to minimize strains on the connections. Small

distortions of the booster cylinder from pipe strains can easily result in loss of internal clearances.

LUBRICATION

Timing gears, shaft bearings and drive shaft seals are all lubricated by the same grade of oil, carried in three separate reservoirs.

At the gear end, gear teeth dip into oil carried in a tray which forms a secondary oil sump within the gearbox. Part of the splash oil from the gears lubricates both bearings at this end of the booster, while the surplus is thrown out into the primary sump formed by the gearbox. From there it is returned to the secondary sump at a controlled rate through an orifice hole in the tray wall. The gearbox is provided with an oil level sight gauge (18 in Figure 5) for the primary supply sump.

At the drive end, bearings are also splash lubricated. Here a single oil reservoir is formed between the end cover (13) and the head plate, and oil level gauge (18) is provided at the side. The splash effect is produced by rotation of special slinger disc (16) mounted on the drive shaft. At this end of the booster, and also at the gear end, oil passing through the bearings is thrown off and returned to the sumps by action of rotating shaft slingers (8) and stationary seal sleeves (7) in the headplates.

Sealing of the drive shaft against in-leakage of both atmospheric air and lubricating oil is accomplished by an assembly of two high pressure type stationary seals (17). These are mounted in end cover (13), and provide sealing both at their circumference and by contact with the rotating shaft surface. A vital element in the sealing performance is the reservoir of oil between and above the two shaft seals. It not only lubricates the areas of friction on the shaft, but also helps to eliminate leakage of air into the booster. Since the reservoir is vented to atmosphere, there is no appreciable pressure difference across the outer seal to cause oil leakage at that point.

Use rust, oxidation and foam inhibited non-detergent oil with low vapor pressure characteristics (0.1 micron of mercury or less at 180°F and 1.8 micron of mercury or less at 250°F). Viscosity range should be 490-1050 SUS at 100°F.

For high vacuum service conditions, a suitable low vapor pressure commercial oil is SUNVIS 999. Equivalent products of other suppliers are assumed to be equally satisfactory. Quantities of oil required to fill the three reservoirs are indicated in Table 2, the same type and grade of oil being used in all places. Except at the seal reservoir, filling should be done only with the booster not operating and not under vacuum.

Table 2 —

Approximate Oil Capacities in Pints (Liters)

Model	Gear End	Drive End	Seal Reservoir
615	2½ (1.18)	1 (.473)	½ (.237)
67	5 (2.37)	1¾ (.828)	½ (.237)

To fill the gear end, remove plug (24) at the top of the gearbox. Pour in oil until it reaches the center of sight gauge (18). Wait five minutes for oil to accumulate in the primary sump and flow through the orifice into the oil tray or secondary sump. Recheck the gauge, and add oil if required to bring the final level to the center of the bullseye. Replace the filler plug (24), making sure the threads are sealed so there will be no leak during operation under vacuum.

At the drive end, remove top filler plug (24) and proceed as outlined above for the gear end. In this case the oil level gauge is at the side of the end cover. Since there is no secondary sump, the waiting period before final check is only for oil to run down and collect in the bottom. Seal and replace the filler plug.

Note — The static oil level on each end should be held within 1/16" (1.588 mm) of the center of the bullseye gauge. During operation the levels may change slightly, particularly at the gear end where a small rise may be expected.

The seal reservoir is filled by removing vented plug (26), which has a bayonet or dip stick attached. Pour in oil until it reaches the top mark on the dip stick when the plug is screwed in finger tight. This level is not critical if exceeded, since the excess will flow out the filler plug vent hole as the oil heats up during operation in the booster. No trouble is indicated by such leakage, which will stop when the excess oil has been expelled. Add oil when the level falls to the lower line on the dip stick.

For draining oil, at replacement periods or to lower the levels, plugs (24) are provided in the bottoms of the gearbox and drive end cover. A similar plug (25) drains the seal reservoir, but it is not necessary to change this oil except at disassembly. Proper resealing of all these plugs after removal is required.

Note — Oil must be drained before handling or shipment, to prevent possible leakage past slinger seals into the pumping compartment.

OPERATION

A preliminary or run-in period of operation of the booster pump, under no-load conditions, is recommended. This will serve to verify that direction of rotation is correct, that bearings, gears and oiling system are functioning properly, and to indicate whether hot spots or noises caused by internal contact are present. A first operating period of about five minutes should reveal any immediate problems.

After making corrections, if required, a run of about one hour should be made. During this period check frequently for loud noises, increase in vibration, and development of hot spots in the cylinder, drive end cover and gearbox oil sumps, or in the drive shaft seal area.

After clearance on these points the pump should be operated under normal pressure conditions for about fifteen minutes. Let the forepump bring the system down to the desired vacuum level, then start the Roots Booster. During this run watch the behavior of lubricating oil levels in addition to checking for noises and heating. If correction of oil levels is required, stop the booster and break the

vacuum. This should always be done by closing inlet valve and opening a bleed valve located in the piping near the booster inlet.

During the first week of regular service, oil levels should be checked daily to determine whether any losses occur. In the gearbox and drive end cover the levels should not be permitted to drop more than 1/16" (1.588 mm) below gauge center when the booster is not operating. In the seal oil reservoir the level must be maintained at or above the lower mark on the dip stick. This level may be checked, and oil added if necessary, while the booster is operating. The reservoir is not under vacuum.

After the first week it should not be necessary to check oil levels oftener than once a week. Frequency of oil changes will be determined mostly by operating conditions. *Periods of 2000 operating hours before change of oil in the front and rear sumps may be considered normal.* Oil in the drive shaft seal sump does not require changing. It is necessary only to maintain the proper level by adding oil as necessary.

Other regular service procedures should include coupling lubrication, or checking and adjustment of drive belt tension, and periodic inspection of the booster for unusual noises, increase in vibration, and development of heating. See MAINTENANCE section.

SAFETY PRECAUTIONS

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

- **Pump casing and associated piping or accessories may become hot enough to cause major skin burns on contact.**
- **Internal and external rotating parts of the pump and driving equipment can produce serious physical injuries. Do not reach into any opening in the pump while it is operating, or while subject to accidental starting. Cover external moving parts with adequate guards.**
- **Disconnect power before doing any work, and avoid by-passing or rendering inoperative any safety or protective devices.**
- **If pump is operated with piping disconnected, place a strong coarse screen over the inlet.**
- **Stay clear of open inlet piping [suction area] and the open discharge blast.**
- **Stay clear of the blast from pressure relief valves and the suction area of vacuum relief valves.**
- **Avoid extended exposure in close proximity to machinery which exceeds safe noise levels.**
- **Use proper care and good procedures in handling, lifting, installing, operating and maintaining the equipment.**
- **Casing pressure must not exceed 25 PSI (172 kPa) gauge. Do not pressurize vented cavities from an external source, nor restrict the vents.**
- **Do not use air blowers on explosive or hazardous gases.**
- **Other potential hazards to safety may also be associated with operating of this equipment. All personnel working in or passing through the area should be warned by signs and trained to exercise adequate general safety precautions.**

MAINTENANCE & REPLACEMENTS

A consistent program of inspection and maintenance servicing is the most effective method of minimizing booster repairs or operating problems. A simple record of services and dates is recommended to help keep this work on a regular schedule.

As discussed under OPERATION, correct lubrication is probably the most important requirement, other than operating the booster within its specified rating limits. In a new and properly installed unit there are no moving contacts between the two impellers, or between the impellers and cylinder or headplates. Wear is then confined to the timing gears, the bearings which support and locate the shafts, and the drive shaft seals. All are lubricated, and wear should be nominal if clean oil of the proper grade is always supplied.

Timing gear wear should be negligible over a period of years of normal service. Gear teeth are provided with the correct amount of backlash, and a reasonable degree of tooth wear normally can be accommodated without permitting contact between lobes of the two impellers. However, a high oil level in the gearbox will cause churning and excessive oil heating, indicated by unusually high temperature at the bottom of the sump.

If operation is continued under this condition, gears will heat and tooth clearance will be lost. Rapid wear of teeth then will probably develop, which will eventually produce impeller contacts or knocking. From this point serious damage will be unavoidable if operation is continued. Tooth fracture, brought on by sustained overloading and momentary shock loads, will produce a similar result suddenly.

Shaft bearings are critical in the service life of a booster pump. Gradual wear may allow a shaft position to change slightly until rubbing develops between impeller and cylinder or headplate. This will cause spot heating, detected by feeling these surfaces. Sudden bearing failure is usually more serious. Since the impeller-shaft assembly is no longer supported and properly located, extensive general damage to casing and gears is likely to occur immediately after the bearing fails.

The drive shaft seal assembly, consisting of two individual high pressure type seals (17) submerged in oil and located in the drive end cover, should be considered as expendable. It should be replaced as an assembly whenever oil leakage through the inboard member becomes excessive as indicated by a rise in oil level appearing at sight gauge (18). Leakage through the outboard member is not likely to be excessive unless that seal or its shaft bearing surface is damaged. Shaft smoothness and freedom from scratches have a considerable effect on the performance of this type seal. Detailed instructions for replacement of the seal assembly are covered later in this section.

Operating problems may also result from causes other than parts failure. Since clearances within a booster are

only a few thousandths of an inch (hundredths of mm), interferences and rubs can be caused by shifts in the mounting or changes in piping support. Foreign materials entering the casing will also cause trouble. If this type of problem is experienced, and the casing is found to be clean internally, try removing strains. Disconnect piping and loosen mounting bolts, and reset the leveling and drive alignment. After tightening the mounting, make sure all piping meets booster connections accurately and squarely before reconnecting.

When a booster is to be taken out of service for some period of time, it may require internal protection against rusting or corrosion. The actual need for such protection is a matter of judgment. If down-time will not be longer than a month and internal atmosphere conditions will be favorable, protection can probably be ignored. Under atmospheric conditions producing rapid corrosion, or when shut-down period may be lengthy, protective treatment should be provided in the form of a vaporizing inhibitor. Shell VPI 250 powder, or any equivalent product, is recommended.

After disconnecting booster inlet and discharge piping, seal both openings with covers made of wood, metal or vapor barrier paper. To the inside of each cover attach a small bag containing about one ounce (29.6 milliliters) of the inhibitor powder. Booster may be returned to service at any time without internal cleaning if inspection reveals no dirt in the pumping chamber.

In general, major repairs are to be considered beyond the scope of maintenance work and should be performed at the Factory, after arrangement through the nearest Sales Office. *Warranty failures* should not be repaired at all, unless specific written authorization has been obtained through a Sales Office before starting work. *Unauthorized disassembly during the warranty period may void the warranty.*

It is recognized that it may not always be practical to return a booster to the Factory, particularly when a spare unit is not available. If the warranty period has expired, mechanical adjustment and parts replacement may be undertaken locally at the owner's option and risk. It is recommended that Factory Parts be used in all repairs to insure fit and suitability.

The maintenance of a small stock of on-hand repair parts can eliminate possible delays. When ordering parts give Item Numbers and their word descriptions from Figures 5 & 6 and Table 4. Also specify quantities wanted and the booster serial number from the nameplate. Suggested items for spare parts stock are indicated by asterisk (*) in Table 4.

Design of the booster is basically simple, and many repair operations are straightforward, but the work should be done by personnel with good mechanical experience. Some operations involve extra care and patience, and a degree of precision work. Measurement of internal clearances for comparison with the data in Table 3 should only be undertaken by **well qualified** personnel, as misleading results can easily be obtained. No attempt is made in this manual to outline procedures for replacing bearings and gears, or for timing the impellers. If this work is attempted, it will be necessary to rely on logic and assembly drawing Figures 5 & 6 for the methods to be used. Best results will be obtained by having such repairs done at the Factory.

Replacement of the drive shaft seal may be required at intervals, after booster is out of warranty, and this can be a field operation since only limited disassembly and no mechanical adjustments are involved. It is highly recommended that *both* seals be replaced at the same time, even though only one appears to be defective. The following procedures should be used.

A — REMOVING SEALS

Figure 2 — Removing Inboard and Outboard Seals

1. Drain oil from drive end cover sump by removing plug (24) at the bottom. Drain seal oil reservoir in end cover by removing plug (25) under the shaft seal housing.
2. Remove the four long cap screws (22) in the drive end cover (13), located at the 45° positions top and bottom. Replace these temporarily with four 3/8" - 16" commercial screws about 1" (2.54 cm) long, to hold the headplate flange tight against the cylinder and prevent breaking the joint seal at this point.
3. Remove all the remaining long cap screws (22) holding the drive end cover (13) in place. Bump the cover flange carefully to break its joint with the headplate, then work the cover off the two locating pins (20) and pull it off the drive shaft. Remove oil reservoir cover plate (14) and gasket (28).
4. Remove and discard the two shaft seals (17) by pressing both out together from one side of the end cover as illustrated in Figure 2. Pressing may be done from either side, as convenient, but the arbor used must not contact or scratch the seal housing bore.
5. Carefully clean the seal housing bore, and inspect the oil reservoir for dirt.
6. Slip end cover (13) back over the drive shaft and align with locating pins (20). Insert four long cap screws (22) evenly spaced, and pull the cover firmly against the headplate. Check concentricity of seal bore with the drive shaft using a dial indicator. If concentricity varies more than .005" (.127 mm) TIR, remove the end cover and install new seals per Steps 2 and 5 under Operation B. Also modify Step 4 to permit rechecking bore concentricity at the outer seal after inner seal is installed. If still not within the limit specified, remove both locating pins and reposition the end cover to produce best concentricity. After clamping securely and rechecking, drill for and install the next larger size locating pins.

B — INSTALLING NEW SEALS

1. Lightly file off sharp or rough edges on the drive shaft shoulders and keyway, and cover these areas with masking tape. This will help prevent damage to seal lips as they slide along the shaft.
2. Install the new *inboard* seal first (after preparing it as discussed below) using an arbor press. Place the machined front face of the end cover directly on the press table as shown in Figure 3, and use a steel disc or plug between the press ram and the seal. The disc should be 1-7/8" (4.763 cm) diameter, and must not be allowed to touch the housing bore. Press the seal into the bore lip side first, until its metal back face is approximately flush with the back surface of the end cover. The seal back face should also be true with the machined front face of the end cover within .005" (.127 mm) total indicator reading.

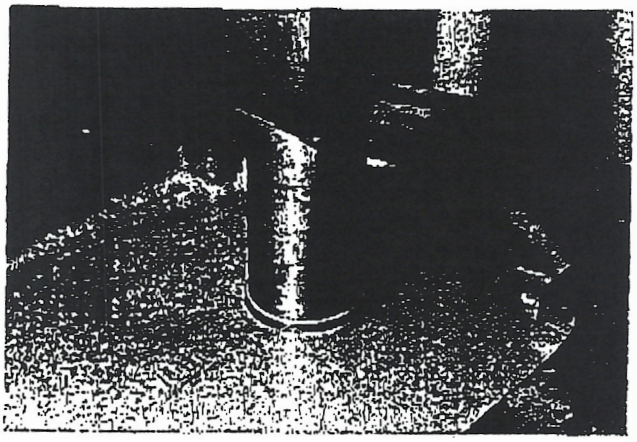

Figure 3 — Installing New Inboard Shaft Seal

To prepare a seal for installation, first inspect it very carefully for notches or cuts in the sealing lips and for burrs on the outer metal rim. Metal burrs may be removed, but if lips are defective the seal must be discarded. Make sure there is no foreign material any where on the seal, then coat the outer edge of the metal lightly with a suitable high vacuum sealing compound. The inner lip, which contacts the shaft, should be coated with vacuum grease.

3. Install the new *outboard* seal from the outside or front face of the end cover, after preparation as above. Installation may be made either before or after the end cover is reinstalled on the headplate. If before, follow the procedure outlined in Step 2 for arbor press work except with the end cover front face up. See Figure 4.

   The lip side of the seal must enter the housing first, and the same final check for squareness must be obtained. If seal is not installed while end cover is free, go to Steps 4 and 5.
4. Reinstall the drive end cover. First coat the back of the main flange with a suitable high vacuum sealing compound, then carefully guide the cover over the drive shaft so that seal lips are not damaged. As the flange approaches the headplate, position it so that the two small holes at the top and bottom are over the locating pins (20) in the headplate. Insert long flange screws in all holes except the four occupied by the temporary

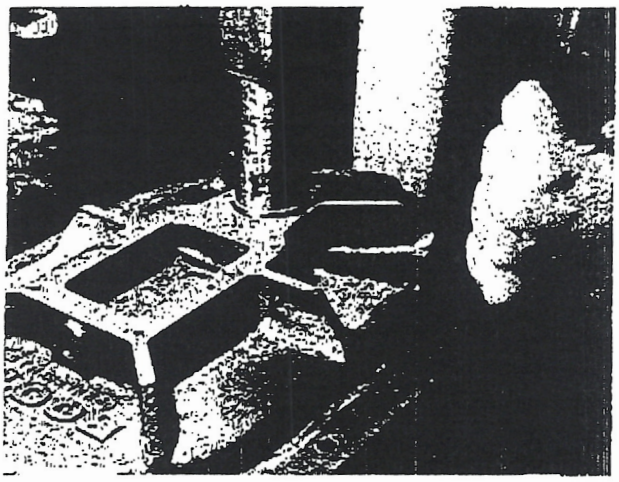

Figure 4 — Installing New Outboard Seal Before Mounting End Cover on Booster

short screws, and tighten the long ones evenly. Then replace the temporary screws with long ones and tighten them. Read Step 6 in Operation A.

5. Installing the outboard shaft seal after the end cover is in place will probably require the use of a conventional installation tool for metal shell type seals. This must pass over or around the extended drive shaft, and bear uniformly on the seal back face with a stiff metal ring that will keep the seal square with the shaft and housing bore. Again, the ring must not touch the housing bore or shaft surface because scratches must be avoided. Press the seal in until its metal face is flush with the end cover face, and parallel with that surface within .005" (.127 mm) TIR.
6. Refill the drive end cover oil sump and seal oil reservoir per instructions under LUBRICATION, after reinstalling reservoir cover plate (14) with a new gasket (28).

INTERNAL CLEARANCES

For a booster in good operating condition, information on the specific values of internal clearances is of no real benefit. Situations may arise, however, where it is desirable to compare existing clearances with the correct Engineering values. For this reason, Table 3 lists the *ranges* of impeller clearances used in Factory assembly of normal 67 and 615 high vacuum boosters. It should be kept in mind that clearances may change slightly in service, but they should never be *less* than the minimum values given here. In any case, only *well qualified* and experienced personnel should attempt to measure clearances for direct comparison with this data.

Table 3 — Normal Internal Clearances

A — Impeller ends to headplates: Total of both ends On 615 .018-.024 inches (.457-.610 mm) On 67 .012-.014 inches (.305-.356 mm) Note — When either impeller is pushed to a stop at either end, clearance at that end should not be less than .003 (.0762 mm) or more than .005 (.127 mm)
B — Impeller tips to cylinder .006-.008" (.152-.203mm)
C — Between impellers (lobe to lobe): Fronts or backs .014-.018" (.356-.457 mm)

Table 4 — Parts Identification List for Figures 5 & 6

Item Number	Quantity Used	Identification	Item Number	Quantity Used	Identification
1	2	Headplate - drive end or gear end	23	6	Cap Screw - Reservoir cover
2	1	Cylinder	24	4	Pipe Plug, Dryseal - fill & drain
3	1	Impeller & Shaft - driving	25	1	Pipe Plug - reservoir drain
4	1	Impeller & Shaft - driven	26	1	Gauge stick - oil reservoir
			27	1	Nipple - Oil drain
5	1	Gearbox	28*	1	Gasket - oil reservoir
6*	1 pair	Timing Gear	29*	8	Shim - bearing clamp (halves)
7	4	Sleeve - oil slinger	30*	4	Shaft Bearing
8	4	Oil Slinger	31	2	Cap Screw - oil leaders
9	4	Clamp Plate - bearing	32	1	Arrow - rotation
10	1	Oil Leader - gear end	33	1	Nameplate
11	1	Oil Leader - drive end	34	4	Drive screw - nameplate & arrow
12	6	Lockwasher - oil tray	35	1	Label - oil reservoir
13	1	End Cover - drive end	36	2	Label - lubrication
14	1	Cover Plate - oil reservoir	37	2	Set Screw - slinger disc
16	1	Oil Slinger Disc - drive end	38	2	Nylon Pellet - slinger disc
17*	2	Seal, High Pressure - drive shaft	39	3	Pipe Plug, Dryseal
18	2	Sight Gauge - oil level	40	1	Key - drive shaft
19	4	Dowel Pin - gear end & drive end	41*	2	Taper Pin - timing gears
20	2	Locating Pin - drive end	42	6	Screw, thd. cutting - oil tray
21	16	Cap Screw - brng. clamp plate	43	1	Oil Tray
22	64	Cap Screw - main assembly	44	1	Back Plate - oil tray

*Suggested items for spare parts stock. Before ordering, review the limitation on repairs during warranty period as discussed under MAINTENANCE & REPLACEMENTS. Note: this limitation does not apply to Item 28.

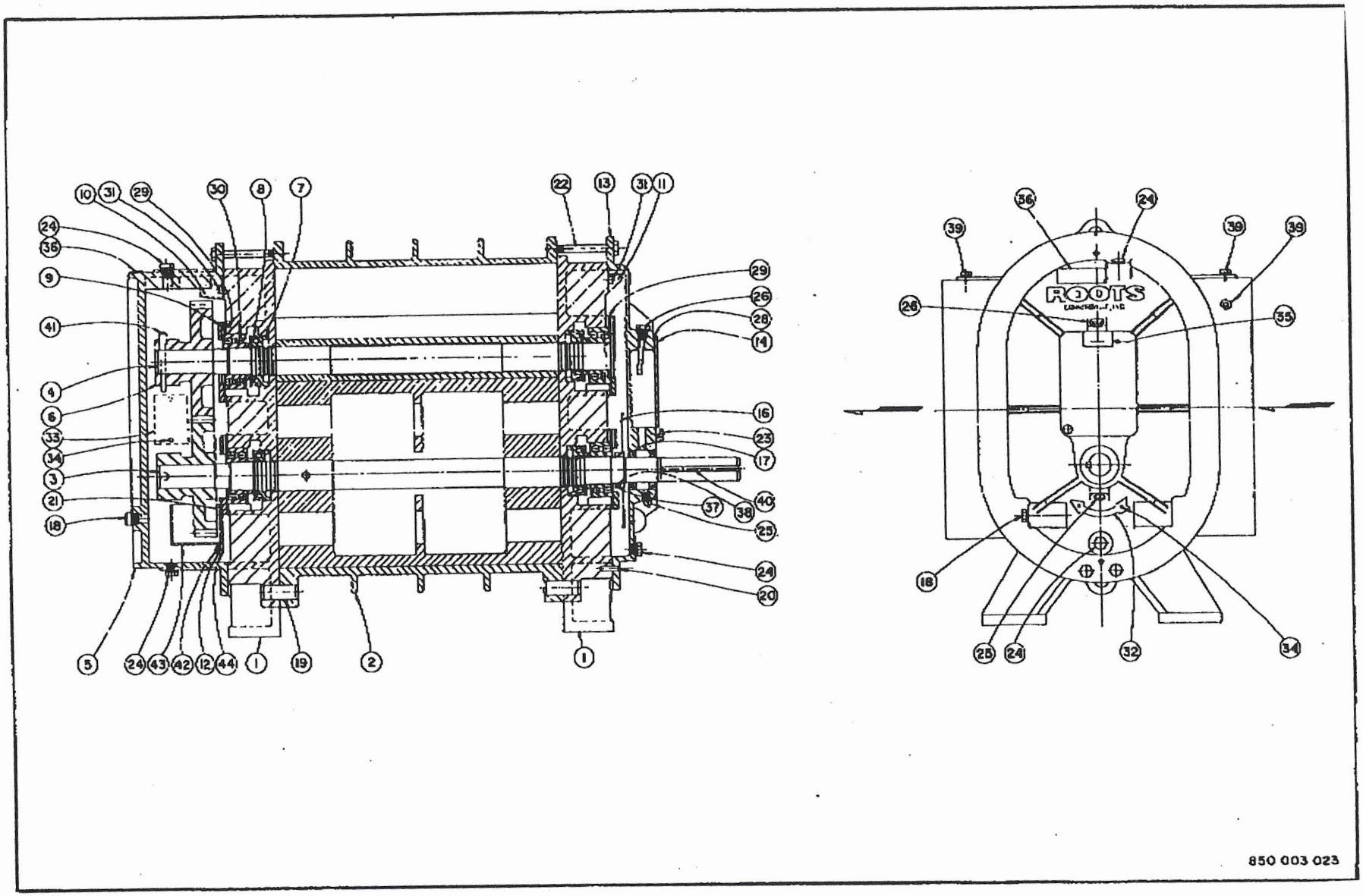

Figure 5 — Assembly of Roots 615 High Vacuum Booster

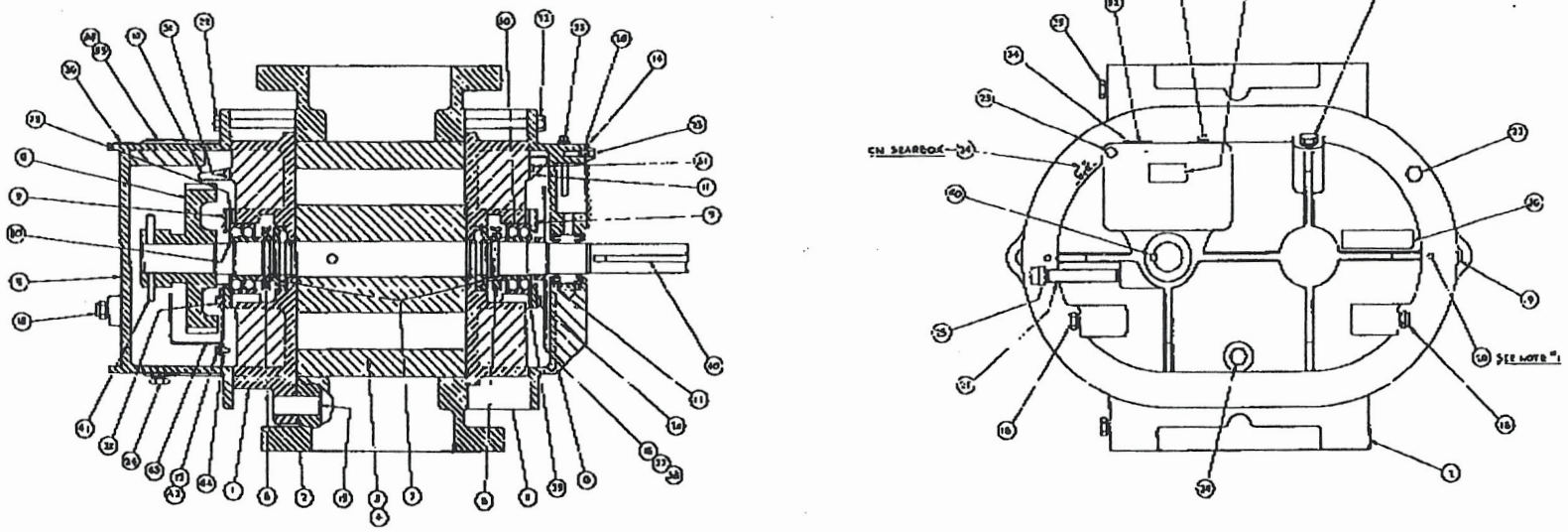

Figure 6 — Assembly of Roots 67 High Vacuum Booster

SERVICE RECORD

Date	Service	Notes