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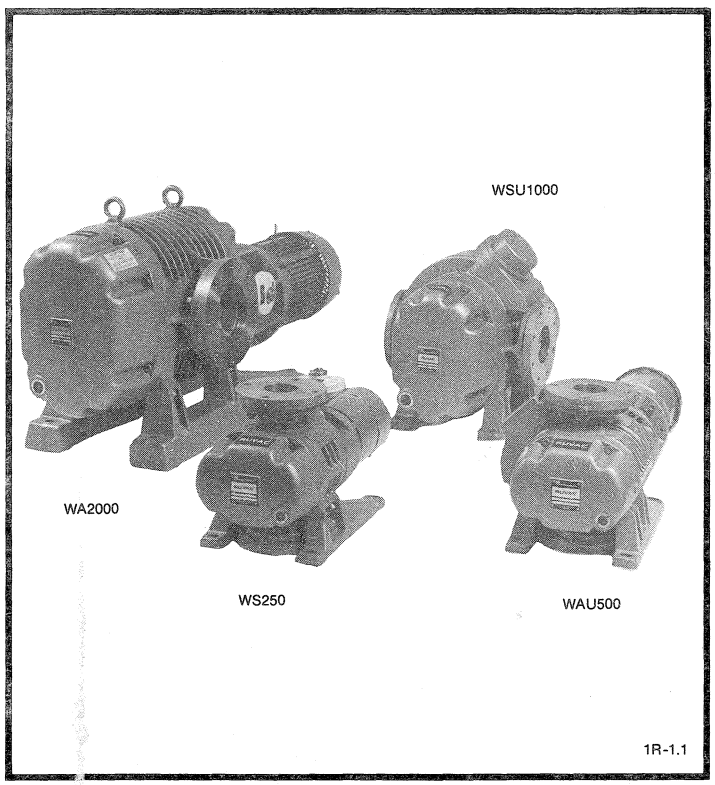
LEYBOLD

LEYBOLD
VACUUM PRODUCTS INC.

Part Number 99-800-001 ■ Edition M

RUVAC "00"
WA/WAU/WS/WSU
Single Stage Roots Pump
MANUAL



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SECTION 1

INTRODUCTION

This manual contains important information regarding the safe* operation, maintenance, and repair of the RUVAC WA/WAU- and WS/WSU-Series roots pumps. We urge you to read Sections 1, 2, and 3 before using your pump. Section 6, the troubleshooting chart, should be used in conjunction with the rest of the manual should the need arise.

1-1 MANUAL KEY

"WARNING" statements are used in this manual to prevent injury to personnel; "CAUTION" statements are used to prevent damage to equipment; "NOTES" contain helpful information; "REQUIRED ACTION" is used where necessary to distinguish the action of the step from the WARNINGS, CAUTIONS, and NOTES.

All numbers in parentheses refer to position numbers of parts in the spare parts list (see Section 7). These numbers are also used to identify parts on the figures.

1-2 MODEL AND CATALOG NUMBERS

This manual covers the following pump models.

WA 150, 250, 500, 1000, 2000
WAU 150, 250, 500, 1000, 2000
WS 150, 250, 500, 1000, 2000
WSU 150, 250, 500, 1000

This manual can't be used for pump models that end with "01" such as WA151, WS251, WAU501, etc.

To understand many of the instructions in this manual, you need to know the model number of your pump. The plate attached to the end or to the foot of the pump contains the model, catalog, and serial numbers of your pump (see Figure 1-1).

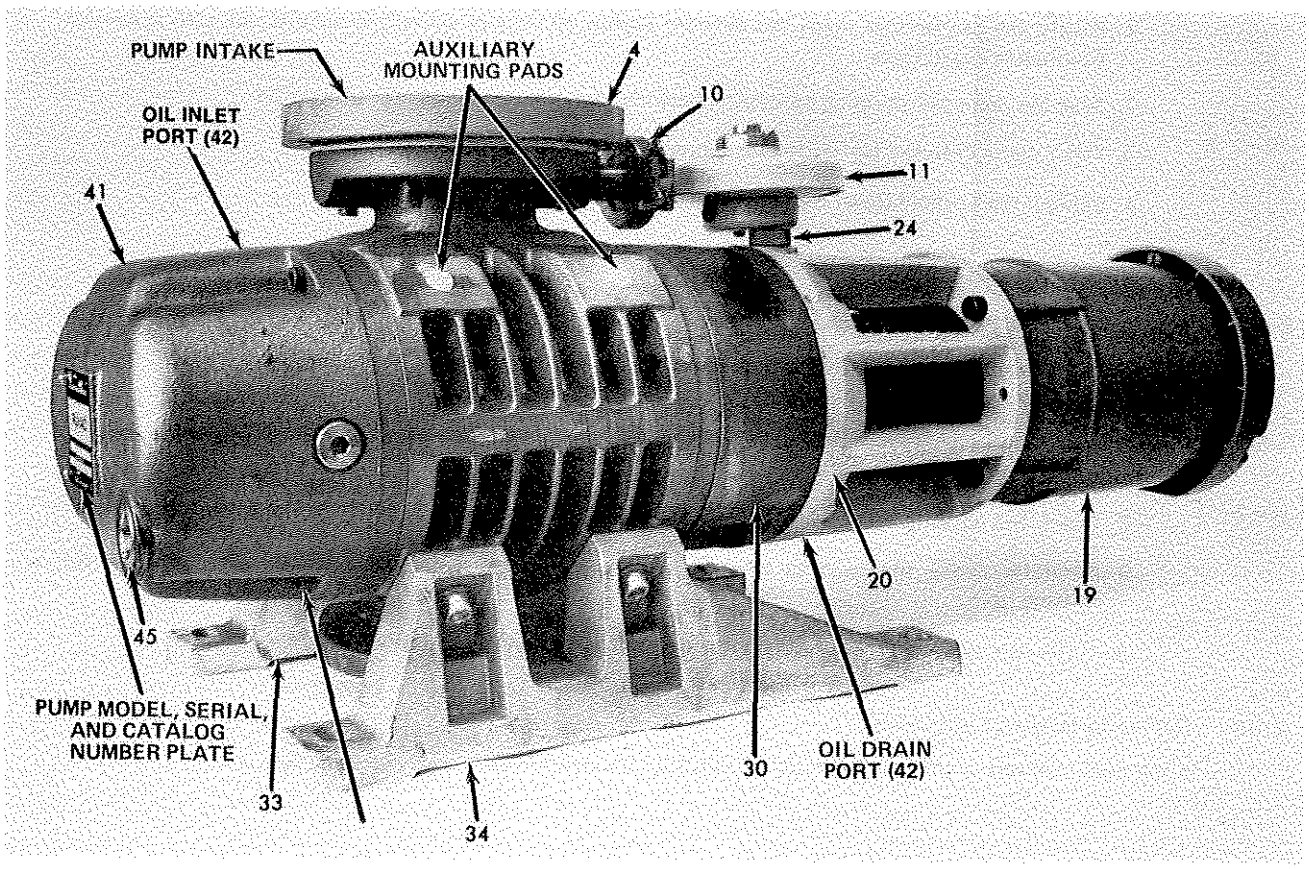

Figure 1-1. Assembled Pump Mounted for Vertical Flow (WA-250 pump model shown). 1R-2.5

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Section 1-2 Cont.

The model number, such as "WA-250," is listed on the plate after "Typ."

The pump catalog number (Kat Nr) is the six digit number, such as "89511-1." An "EX" following the catalog number indicates that the pump has an explosion proof motor. An "H" following the catalog number indicates that the pump is mounted for horizontal flow (see Figure 2-1).

The 10 digit number in the "Fabr. Nr" block is the serial number of your pump. You will need to know the serial number if your pump requires warranty repair.

SECTION 2

PREPARING, INSTALLING, AND OPERATING THE PUMP

2-1 RECEIVING

NOTE: The Leybold packing list is attached to the outside of one of the shipping containers.

2-1-1 Reporting Shipping Damage

Leybold makes every effort to ensure that your goods are not damaged in transit due to improper packing. However, rough or careless handling in transit may result in shipping damage.

When the goods are delivered, inspect the condition of the outside of the shipping container and of the goods. If you find any damage, you **must** do the following:

1. **Notify the carrier that made the delivery within 15 days of delivery in accordance with Interstate Commerce regulations.**
2. Save the damaged shipping container, packing material, and goods for inspection.
3. File a claim with the carrier for the damage.
4. Contact the Leybold Order Services Department to replace the damaged part.

2-1-2 Reporting Shipping Shortage

If you did not receive all the goods that you ordered, do the following:

1. Check the number of pieces listed in the upper right section of the packing list. If the number of pieces listed is greater than the number of shipping containers received, contact the carrier concerning the missing piece.
2. Check the packing list to see if the missing item is back ordered.
3. Carefully check the packing material and container to ensure that you did not overlook the missing item.
4. If you cannot locate the missing item, contact the Leybold Order Services Department.

2-1-3 Reporting Incorrect Shipment

If the item received is not the item ordered, contact the Leybold Order Services Department.

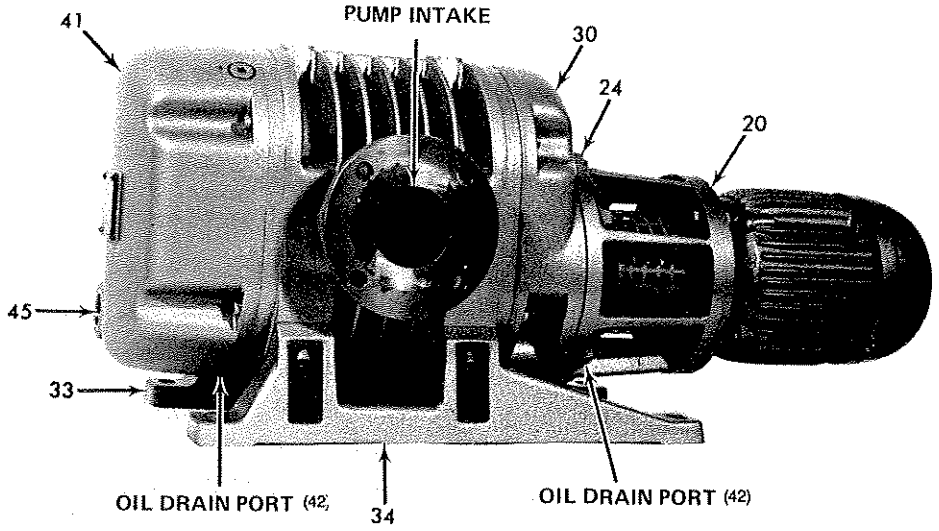


Figure 2-1. WA-Series Pump Mounted for Horizontal Flow.

2-2 MOUNTING ORIENTATION

CAUTION: FAILURE TO MOUNT THE ROOTS PUMP LEVEL COULD RESULT IN PUMP FLUID RUNNING INTO THE PUMPING CHAMBER.

Unless you specify otherwise, all Leybold roots pumps are assembled for pumping in the vertical flow position (see Figure 1-1).

2-2-1 Converting WA- and WAU-Series Pumps from Vertical to Horizontal Flow

NOTE: The motor mount (20) on WA-and WAU-Series pumps is filled with vacuum pump fluid before these pumps are shipped. WS- and WSU-Series pumps do not have a motor mount (20).

NOTE: Figure 1-1 shows a pump mounted for vertical flow; Figure 2-1 shows a pump mounted for horizontal flow.

WARNING: IF THE PUMP HAS BEEN USED ON CORROSIVE, TOXIC, VOLATILE, OR HAZARDOUS MATERIALS, OBSERVE PROPER SAFETY PRECAUTIONS TO PROTECT PERSONNEL BEFORE REMOVING ANY OF THE PLUG SCREWS.

Proceed as follows to convert a **WA- or WAU-Series pump** from vertical to horizontal flow.

1. If the front cover (41) and the intermediate flange (30) are filled with pump fluid, remove the pug screw (42) from the bottom of the front cover (41) to drain the fluid before proceeding with Steps 2 through 9 below (see Figure 1-1).
2. Do Steps 1 through 10 of Section 4-2-2-1 to disassemble the motor end of the pump.
3. Do Steps 1 through 4 of Section 4-2-3 to disassemble the intermediate flange (30).
4. Do Steps 6, 7, 8, 9, and 11 of Section 4-4-3 to install the oil slinger (63), new O-ring (3), new compression ring (64), and intermediate flange (30).
5. Do Steps 1, 2, 3, 4, 5, 6a and 6b of Section 4-4-4-1 to install the retainer rings (25/51), shaft bushing sleeve (28), bearing (27), radial shaft seal (26), O-ring (13), dip stick (24), and plug screw (42).
6. Looking from the motor end, turn the motor mount 90° in the clockwise direction from the alignment used in Step 6c of Section 4-4-4-1.
7. Do Steps 6d through 11 of Section 4-4-4-1 to assemble the motor mount (30), seal (26), coupling (15), coupling insert (16), coupling shield (17), shield retainer (21), and motor (19).
8. **CAUTION:** FAILURE TO KEEP THE PUMP LEVEL WILL RESULT IN PUMP FLUID RUNNING INTO THE PUMPING CHAMBER.

   Remove the feet (33/34) and reinstall them on the auxiliary mounting pads on the pump body. Turn the pump so that it rests on its feet in the horizontal flow position as shown in Figure 2-1.
9. Do Steps 9 and 11 of Section 4-4-5 to fill the pump with the correct vacuum pump fluid.

2-2-2 Converting WS- and WSU-Pumps from Vertical to Horizontal Flow

NOTE: Figure 5-1 shows a pump mounted for vertical flow; Figure 2-2 shows a pump mounted for horizontal flow.

Proceed as follows to convert a **WS- or WSU-Series pump** from vertical to horizontal flow.

1. Remove the feet (33/34).
2. **CAUTION:** FAILURE TO KEEP THE PUMP LEVEL DURING STEPS 3 THROUGH 6 WILL RESULT IN PUMP FLUID RUNNING INTO THE PUMPING CHAMBER.
   Turn the pump 90° counterclockwise looking from the motor end.

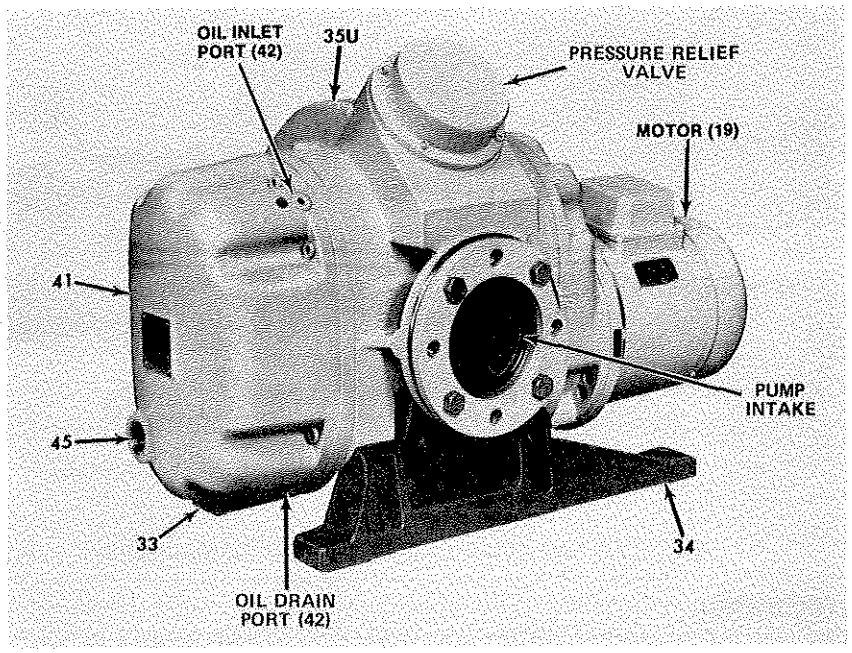


Figure 2-2. WSU-1000 Mounted for Horizontal Flow. 1R-1.2

3. Remove the plug screw (42) from the oil drain port on the bottom of the front cover (41) and allow the pump fluid to drain into a suitable container until the pump fluid level is visible in the upper third of the sight glass (45).
4. **CAUTION:** FAILURE TO PROPERLY SEAT THE PLUG SCREW COULD RESULT IN POOR VACUUM, LOSS OF PUMP FLUID, AND PUMP DAMAGE.

   Tighten the plug screw (42) with flat gasket (43) firmly into the oil drain port in the bottom of the front cover (41).
5. If not already done, remove the plastic plugs from the thread holes in the auxiliary mounting pads that are used for mounting the feet for horizontal flow.
6. Use the screws and washers to attach the feet to the pump housing (35) for horizontal flow.

2-3 LOCATION OF THE PUMP AND PUMPING SYSTEM

Mount the pump so as to provide adequate ventilation for the motor and pumping system. Placing the pumping system in a high temperature environment will accelerate wear of the moving parts and necessitate changing the vacuum pump fluid more frequently.

2-4 MAKING THE ELECTRICAL CONNECTION

Wire the pumping system so that the RUVAC can't operate unless the backing pump is running. If the RUVAC is operated without a backing pump, the RUVAC will overheat and fail. For WA- and WS- Series models, we recommend using a pressure switch and contact amplifier to ensure that the roots pump doesn't operate above its normal starting pressure (see Tables 2-2 and 2-3 and Section 2-5).

When making the electrical connection, use grounded outlets and connectors. Ensure that the AC power source for the motor matches the requirements listed on the motor nameplate. Install overloads and a circuit breaker to protect the motor.

2-4-1 WA- and WAU-SERIES PUMPS

For WA- and WAU-Series pumps with 60 Hz motors, use the schematic diagram on the motor name plate or in the motor junction box to make the electrical connection.

For WA- and WSU-Series pumps with 50 Hz motors, refer to Figure 2-3A to make the electrical connections.

2-4-2 WS- and WSU-SERIES PUMPS

For all WS/WSU pump models, refer to Figure 2-3B to make the electrical connections. Be sure to wire the thermal snap switch (terminals A and D) in series with the contactor coil (see Figure 2-4) to protect the motor from overheating.

For WS/WSU -2000 pump models only, also refer to Figure 4-42 to wire the fan motor.

CAUTION: IF YOU ARE WIRING A WS/WSU -2000 FOR 460V, BE SURE TO USE THE VARIABLE AUTOTRANSFORMER (P/N 723-34-005) FOR THE FAN MOTOR. (See Figure 4-42B).

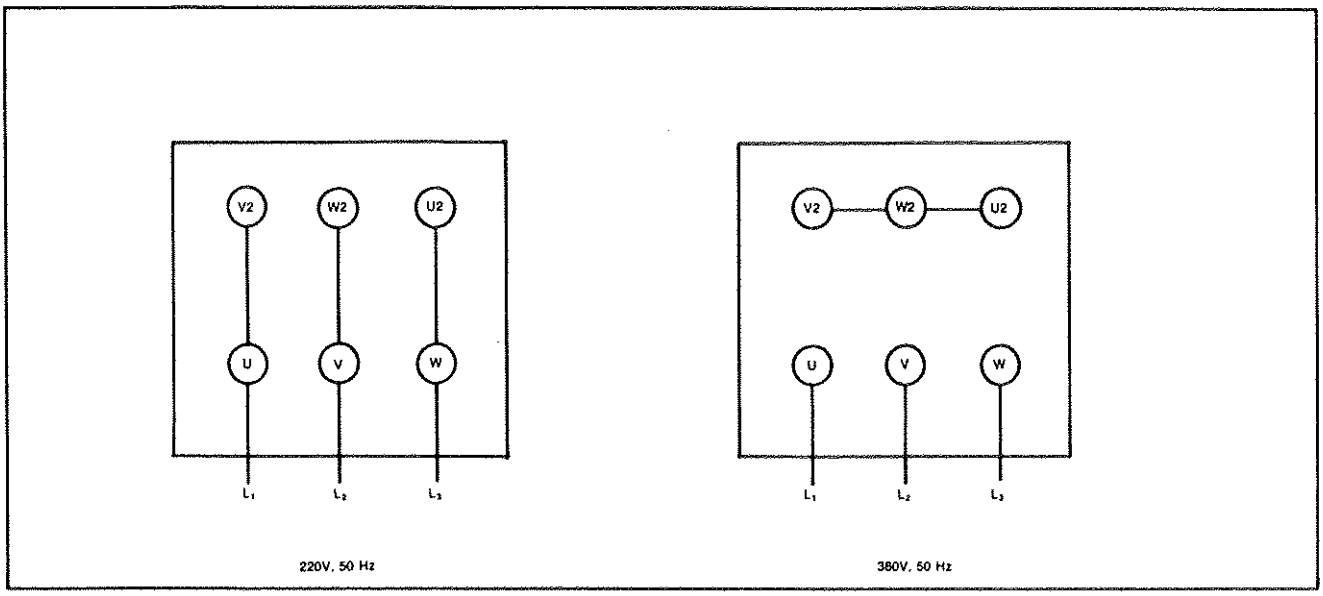
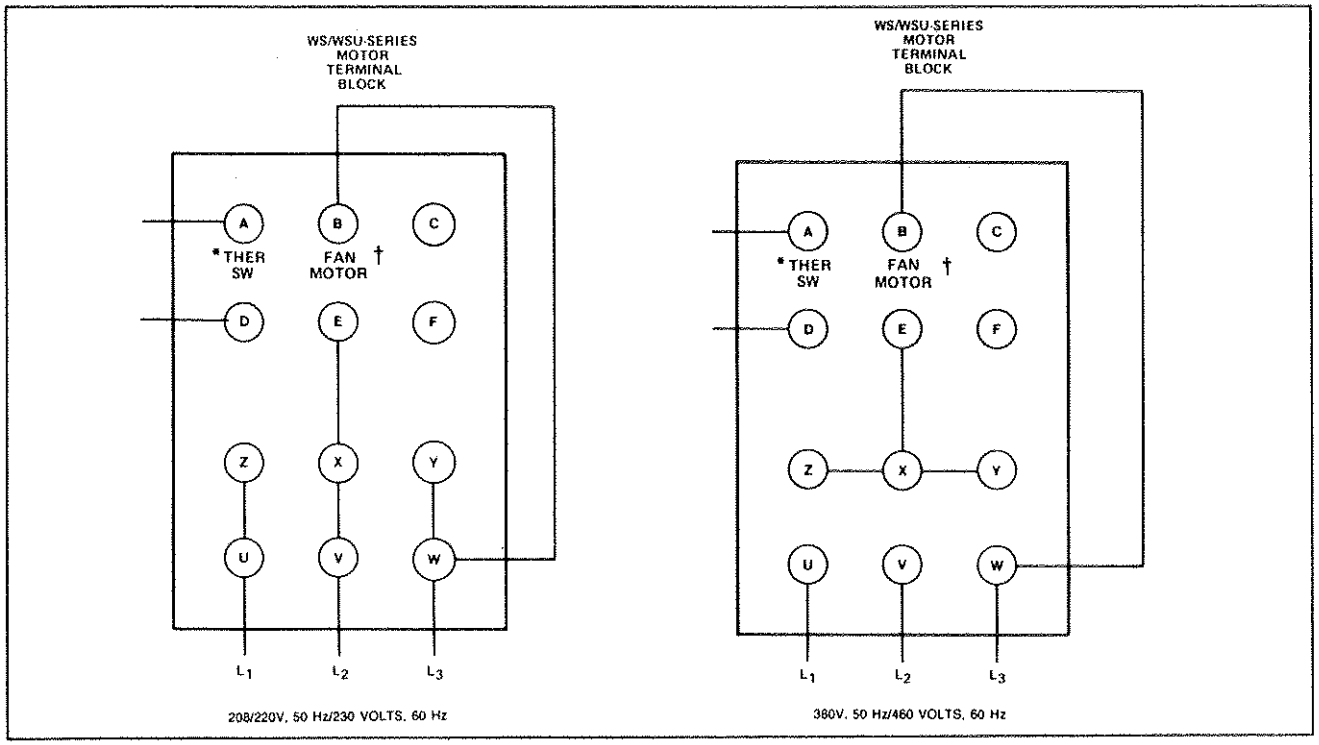


Figure 2-3A Motor Connections for WA/WAU Series Pumps with 50 Hz Motors.



* Wire the thermal snap switch (THER SW), in series with the contactor coil (See Figure 2-4) to protect the motor from overheating.

† Refer to Figure 4-42 to wire the motor fan for WS/WSU -2000 Pump Models.

Figure 2-3B Motor Connections for WS/WSU -150, -250, -500, and -1000 Pump Models. (Refer to Figure 4-42 for WS/WSU -2000 Pump Models),

2-5 WIRING THE WA- AND WS-SERIES PUMPS FOR AUTOMATIC CONTROL

WARNING: FOR AREAS WITH AN EXPLOSION HAZARD, USE THE EXPLOSION PROOF DIAPHRAGM PRESSURE SWITCH (11) (Catalog No. 98-131-3010). A CONTACT AMPLIFIER IS NOT REQUIRED WHEN USING THE EXPLOSION PROOF PRESSURE SWITCH.

WARNING: DO NOT CONNECT THE DIAPHRAGM PRESSURE SWITCH DIRECTLY TO LINE VOLTAGE.

NOTE: See Section 5-4 for an explanation of the purpose and operation of the diaphragm pressure switch, the contact amplifier, and the Power Control Unit.

The diaphragm pressure switch (see Section 5-4-1) comes standard with all WA- and WS-Series pumps. It is attached just below the intake flange of the pump. The diaphragm pressure switch has the following characteristics:

Response sensitivity	1% of preset switching pressure
Max. switching current	4.5 mA
Max. switching voltage	24V
Max. contact resistance	1 Kohm
Max. ambient temperature	50°C (122°F)

The diaphragm pressure switch is preset at the factory for the correct starting pressure. It requires the use of a contact amplifier containing a relay to be controlled by the diaphragm contact.

The optional SV-110 contact amplifier (Catalog No. 16078-1) provides open or closed contacts in response to a signal from the diaphragm pressure switch (11). You need an SV-110, a standard motor starter, a transformer, and overloads (see Table 2-1) to complete the control circuit shown in Figure 2-4. See Appendix A for specifications, connecting instructions, and a schematic of the SV-110. See Table B-2 in Appendix B for the part numbers of the motor starter (A1), the transformer (T1), the circuit breaker (E1), the contactor (C1), and the SV-110 contact amplifier (U1).

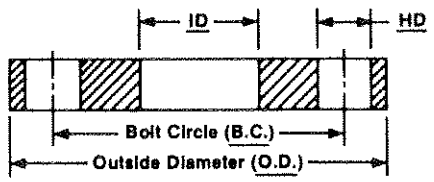
WA- and WS- Series pumps (except the WS-2000) can also be controlled with the optional Power Control Unit. You must specify the pump model, voltage, frequency, and amperage of overloads when ordering (see Table 2-1). See Appendix B for the specifications and connecting instructions for the Power Control Unit.

RUVAC FLANGE DIMENSIONS

The standard flanges on RUVAC pumps are DIN flanges. Pumps shipped from the USA have ASA adapter flanges over the standard DIN flanges.

The dimensions of the ASA adapter flanges and the standard DIN flanges are listed below.

The sealing discs required to connect the flanges to the system are included with the pump.



Pump Model	Flange	Bolt Circle BC	Outside Diameter OD	Inside Diameter ID	Diameter of Bolt Hole HD	Number of Bolt Holes
150, 250 and 500	DIN65*	130mm	160mm	65mm	14mm	4
	3" ASA+	6.00 inches	7.5 inches	2.75 inches	5/8-11 1/2" DP	4
1000	DIN100*	170mm	210mm	100mm	18mm	4
	4" ASA*	7.5 inches	9 inches	4 inches	5/8-11 1/2" DP	8
2000	DIN150*	225mm	265	150mm	18mm	8
	6" ASA+	9.5 inches	11 inches	6 inches	3/4-10 1/2" DP	8

* The bolt holes are straddling the centerline.

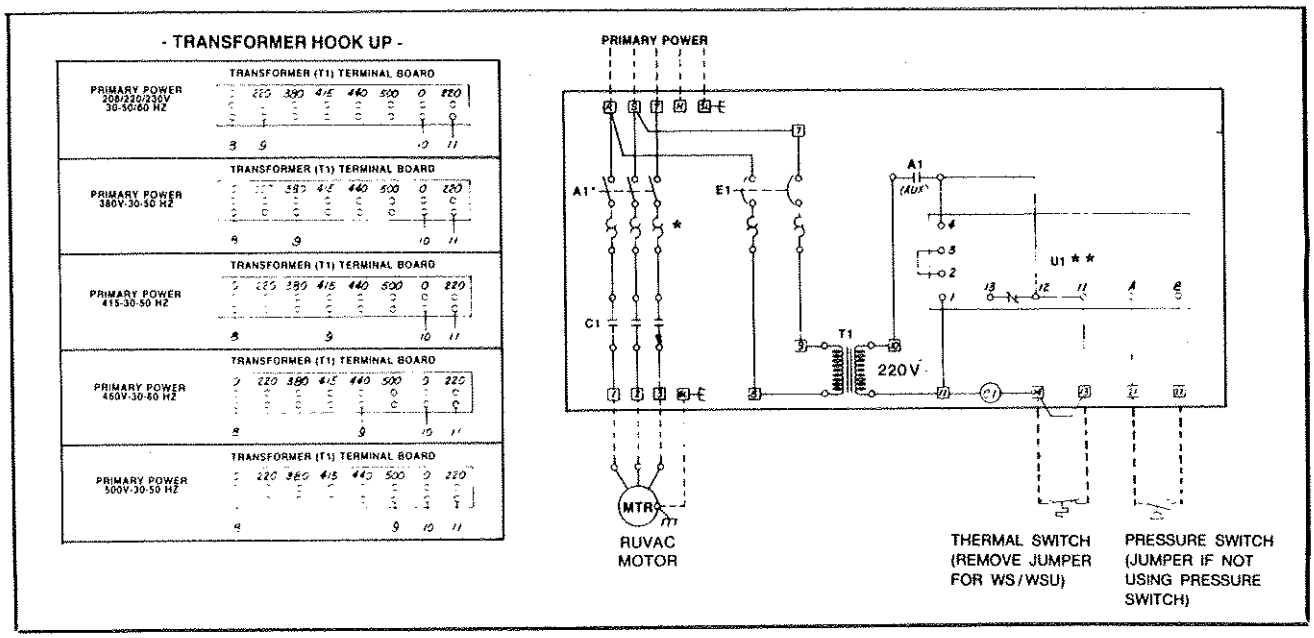
\+ 150-lb flange; the bolt holes are on centerline.

TABLE 2-1 -- AMPERAGE FOR OVERLOADS*

Pump Model	220V-3ph 50Hz	208V-3ph 60Hz	230V-3ph 60Hz	380V-3ph 50Hz	460V-3ph 60Hz
WA/WAU 150/250	4.7	4.7	4.6†	2.7	2.3†
WS/WSU 150/250	2.0	2.25	2.25	1.2	1.3
WA/WAU 500	8.5	9.4	8.6†	4.9	4.3†
WS/WSU 500	3.6	4.0	4.0	2.1	2.3
WA/WAU 1000	14.6	14.0	12.8†	8.4	6.4†
WS/WSU 1000	7.2	7.2	7.2	4.15	4.7
WA/WAU 2000	N/A	26.8	24.4†	15.6	12.2†
WS/WSU 2000	15.0	14.0	14.0	9.0	8.0

*See Table B-2 in Appendix B for the part numbers of the motor starter (A1), the transformer (T1), the circuit breaker (E1),the contactor (C1), and the SV 110 contact amplifier (U1).

†Denotes 1.15 service factor motor.



*See Table 2-1 for the correct amperage for overloads.

**See Appendix A for instructions for connecting the SV 110 contact amplifier.

Figure 2-4. Wiring Schematic for WA/WAU/WS/WSU Series Pumps Using the SV 110 Contact Amplifier and a Conventional Motor Starter.

2-6 CHECKING THE DIRECTION OF ROTATION

Before operating the roots pump, make sure that the impellers are rotating in the proper direction. This can be done by one of the two methods described below.

NOTE: The cooling fan (68) on the WS- and WSU-Series pumps is driven by a separate monophase motor and, therefore, cannot be used for checking the direction of pump rotation (see Figure 5-1).

2-6-1 Method 1 – Visual Inspection

1. On new pumps, remove the protective tape that covers the ASA flange (4) (see Figure 1-1) on the intake and on the outlet of the pump and remove the moisture adsorbent packs from the inlet of the pump.
2. **CAUTION:** TO PREVENT DAMAGE TO THE DRIVE MOTOR OR THE GEARS, DO NOT JOG MOTORS FOR MORE THAN 30 SECONDS.

   NOTE: When using the Power Control Unit (see Appendix B), use the pushbuttons on the unit to **briefly** switch on and then immediately turn off the motor to check the direction of rotation.

   REQUIRED ACTION: Jog the pump momentarily and look through the intake or outlet port to observe the rotation of the impeller; the rotation must be as shown in Figure 5-2. If the impellers are not visible, proper rotation is indicated by a noticeable air stream from the outlet port when the motor is jogged.
3. If the direction of rotation is incorrect, reverse it by interchanging two of the input leads at the drive motor.

2-6-2 Method 2 – Pressure Measurement

If the pump is connected to your system (see Section 2-7) and the front cover (41) is filled with vacuum pump fluid (see Section 2-8), you can check the direction of rotation as follows:

1. Use the backing pump to pump down the system to an acceptable pressure for starting the roots pump (see Tables 2-2 and 2-3).
2. Measure the pressure on the intake side of the roots pump.
3. Turn the roots pump on.
4. Again, measure the pressure on the intake side of the roots pump. If the second pressure reading is less than the first, the direction of rotation is correct.
5. If the direction of rotation is incorrect, reverse it by interchanging two of the input leads at the drive motor.

2-7 CONNECTING THE PUMP TO YOUR SYSTEM

Figure 2-5 illustrates a typical installation arrangement for a vacuum system containing a roots pump.

CAUTION: EXCEEDING AN OVERPRESSURE OF 7 PSIG (1.5 BAR) WITH THE PUMP OFF COULD RESULT IN DAMAGE TO THE PUMP.

2-7-1 Fittings

Leybold-Heraeus roots pumps are fitted with ASA adapters (4) for the intake and outlet of the pump (see Figure 1-1). A vacuum sealing disc (37/6) with O-ring (38/7) is supplied for the intake and outlet of the pump. The sealing disc for the intake contains a wire mesh dirt trap (39) (see Figure 4-1). The additional two sealing discs for connecting the ASA adapters (4) to your system do not come standard with the pump.

Leybold also has a complete line of components, fittings, and adapters to connect your pump to any system. See the Leybold Catalog for a list of these components. See Page 10 for the intake and outlet flange dimensions of your pump model.

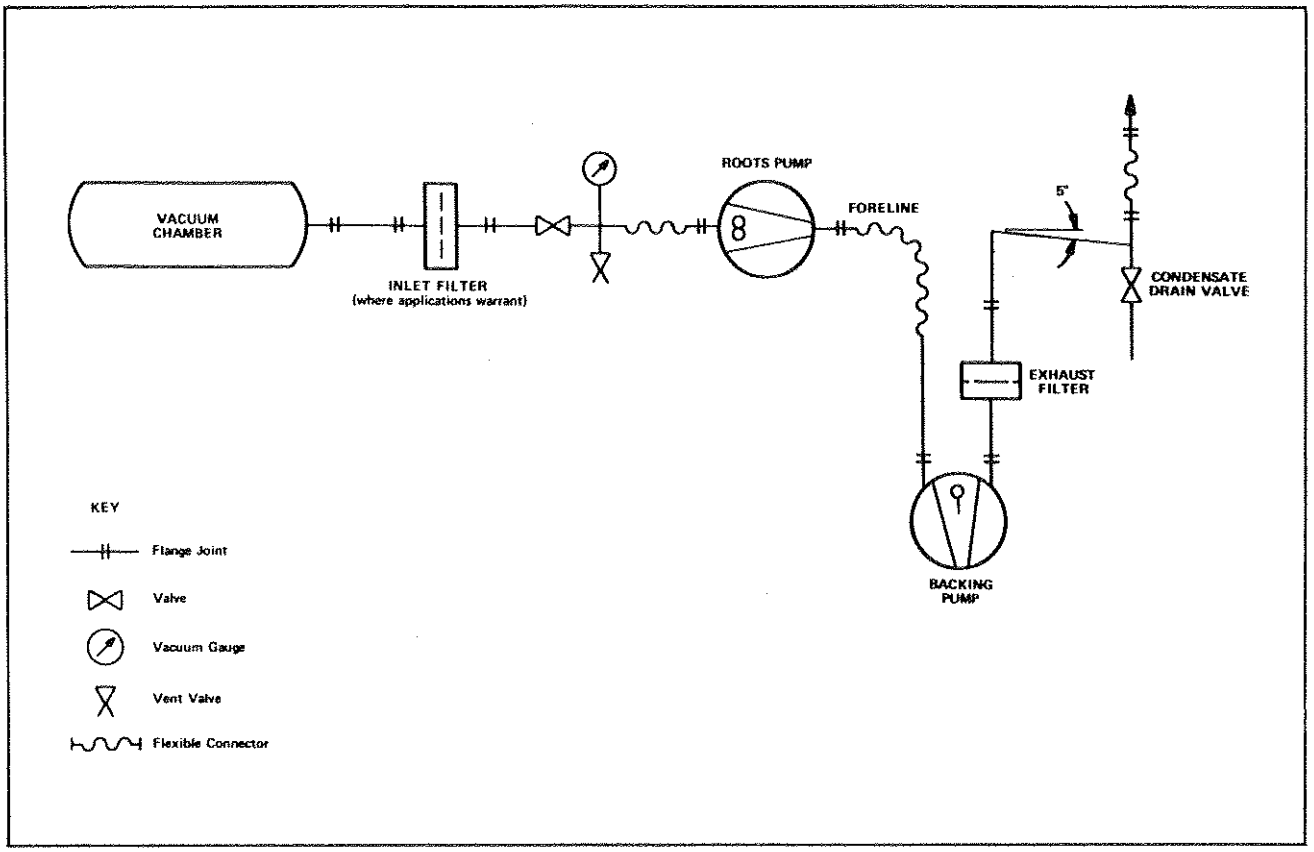


Figure 2-5. Typical Installation Arrangement for a Vacuum System Containing a Roots Pump. 1R-5 3

2-7-2 Foreline (see Figure 2-5)

Roots pumps are always installed in the foreline of the vauum system between the vacuum chamber and the backing pump. Ensure that the packs of moisture adsorbent are removed from the pump's inlet before connecting the vacuum lines.

The foreline should have a minimum of flow resistance and should have an ID no smaller than the backing pump intake. In applications where the foreline is long enough to reduce the gas conductance below the rated pumping speed of your pump, use a foreline with an ID larger than the backing intake ID. In all cases, roots pumps should be located as close as practicable to the vacuum chamber to obtain the maximum benefit.

2-7-3 Placement of the Pump (see Section 2-3)

CAUTION: FAILURE TO MOUNT THE PUMP PROPERLY COULD RESULT IN DISTORTION OF THE PUMP CASING. ANY DISTORTION WILL ADVERSELY AFFECT THE CLOSE TOLERANCES BETWEEN THE IMPELLERS AND THE CHAMBER.

NOTE: We recommend installing flexible connectors (bellows) on the intake or outlet of the roots pump to minimize stress from the vacuum lines (see Figure 2-5).

1. Use a machinist level to ensure that the pump is level. If the pump isn't reasonably level from the motor to the gear end, oil could enter the pumping chamber.

2. Bolt the mounting feet (33/34) to the pumping system frame, making certain that there is no stress or twist in the pump casing. **If the roots pump is to be stacked on the backing pump,** remove the mounting feet and use Steps 3 through 8 to bolt the roots pump outlet flange to the backing pump intake flange.

3. If not already done, remove the protective covers from the ASA adapters (4) on the intake and outlet of the pump (see Figure 1-1).

4. **WARNING:** DO NOT USE A HYDROCARBON SOLVENT ON PUMPS USING PERFLUOROPOLYETHER VACUUM OIL.

   Clean the intake and outlet ASA adapters (4) with a suitable solvent.

5. Inspect the inlet lines for dirt or other particles which could pass through the dirt trap (39) on the intake of the pump; clean as necessary. If heavy concentrations of dirt are generated in the system application, we recommend installing an inlet filter to protect the pump. Contact the factory for assistance in selecting the correct inlet filter for your pump and its application.

6. Lightly coat the O-rings on the vacuum sealing discs with the correct vacuum pump fluid (see Section 2-8).

7. Place the vacuum sealing disc onto the ASA adapter (4) on the intake and outlet of the pump.

8. **CAUTION:** IF NEWLY FABRICATED PIPING IS USED, ENSURE THAT THE WELD JOINTS ARE CLEAN AND FREE OF LOOSE SLAG. PIPE MUST ALSO BE FREE OF SCALE AND RUST.

   Use screws to attach the intake and outlet ASA adapters (4) of the pump to the mating system flanges.

2-8 INITIAL FILLING WITH PUMP FLUID

NOTE: The motor mount (20) on WA- and WAU-Series pumps is filled with vacuum pump fluid before these pumps are shipped. WS- and WSU-Series pumps do not have a motor mount (20).

NOTE: All pumps are shipped **without** pump fluid in the **front cover (41) and intermediate flange (30).** The correct vacuum pump fluid is shipped in a separate container.

1. Using an allen wrench, remove the plug screw (42) from the oil inlet port in the top of the front cover (41) (see Figure 1-1).

2. **NOTE:** See Table 2-2 or 2-3 for the pump fluid capacity for your pump model.

   NOTE: During pump operation, the pump fluid level should be between 1/4 to 1/2 of the sight glass. The pump fluid level should be at the center of the sight glass (45) when the pump is not running.

   NOTE: The oil level equalization tubes (2/36) connect the front cover (41) to the intermediate flange (30) (see Figure 5-1). The equalization tubes (2/36) allow both oil casings (41/30) to be filled through the oil inlet port in the front cover.

   REQUIRED ACTION: Pour the required amount of the correct vacuum pump fluid into the oil inlet port in the front cover (41).

3. **CAUTION:** FAILURE TO PROPERLY SEAT THE PLUG SCREW IN THE FRONT COVER CAN RESULT IN PUMP FLUID LOSS AND PUMP DAMAGE AND VOID THE WARRANTY.

   Replace the plug screw (42) with flat gasket (43) into the oil inlet port in the top of the front cover (41). Be sure that the plug screw is properly seated.

2-9 START-UP

See Sections 2-3 through 2-8 before starting the system.

2-9-1 WA- and WS-Series Pumps (see Section 5-4-1)

If the optional Contact Amplifier or Power Control Unit is properly installed on your pump, the WA- or WS-Series roots pump will be started automatically at the preset pressure. See Appendices A and B for additional information on the SV-110 Contact Amplifier and the Power Control Unit.

CAUTION: STARTING A WA- OR WS-SERIES ROOTS PUMP AT A PRESSURE ABOVE THE NORMAL STARTING PRESSURE LISTED IN TABLE 2-2 OR 2-3 COULD RESULT IN DAMAGE TO THE PUMP.

If the WA- or WS-Series roots pump is operated without a Contact Amplifier or Power Control Unit, wait until the backing pump reduces the intake pressure below the normal starting pressure (see Table 2-2 or 2-3) before starting the roots pump.

2-9-2 WAU- and WSU-Series Pumps (see Section 5-4-2)

You can switch on the WAU- and WSU-Series roots pump together with the backing pump at atmospheric pressure because WAU- and WSU-Series pumps have a built-in pressure relief line (see Figure 5-3).

2-10 OPERATION

NOTE: See Section 6 (Troubleshooting) to resolve corrective maintenance problems and Section 3 for preventative maintenance instructions.

Tables 2-2 and 2-3 list operating and other technical data for each of the WA-, WS-, WAU-, and WSU-Series pump models.

Don't allow the RUVAC pump to operate while the backing pump isn't running. Operating a RUVAC pump without a backing pump causes the RUVAC to overheat and fail.

WARNING: Death or serious injury can result from the improper use or application of this pump. If the pump will be exposed to toxic, explosive, pyrophoric, highly corrosive or other hazardous process gases including greater than atmospheric concentrations of oxygen, contact Leybold for specific recommendations.

CAUTION: Exceeding an overpressure of 7 psig (1.5 Bar) with the pump off could damage the pump.

If you will be pumping oxidizers or highly corrosive gases, your pump must be adapted for extreme corrosive service to prevent damage to the pump and to ensure safe operation. The pump must be disassembled, cleaned and degreased; new gaskets, O-rings, and seals must be installed; after assembly inert vacuum pump fluid must be used. See Section 4-3-2 for special cleaning instructions.

2-11 SHUTTING DOWN THE PUMP

Ensure that the RUVAC pump is switched off before the backing pump. If the RUVAC pump continues to operate after the backing pump shuts down, the RUVAC may overheat and fail.

For all roots pump models, vent the roots pump after shutdown. See Section 3-6 for preparation for long term storage (2 weeks or longer).

See Table 3-1 for the maintenance schedule and Sections 3-1 through 3-6 for detailed instructions and important safety precautions for the required maintenance.

See Section 6 (Troubleshooting) to resolve corrective maintenance problems.

TABLE 2-2. TECHNICAL DATA FOR WA- AND WAU-SERIES PUMPS

Roots Pumps	Unit	WA 150/ WAU 150	WA 250/ WAU 250	WA 500/ WAU 500	WA 1000/ WAU 1000	WA 2000/ WAU 2000
Displacement	CFM	104	169	341	685	1385
Maximum Pressure Difference + During Continuous Operation	Torr	100	60	60	60	35
During Intermittent Operation, <3 min	Torr	150	90	90	90	70
Fluid* Capacity for Pump (Front Cover and Intermediate Flange) Vertical Flow, approx.	Qts.	0.75	0.75	1	2	4.25
Horizontal Flow, approx.	Qts.	0.5	0.5	0.75	1	2
Fluid* Capacity for Shaft Seal Housing	Qts.	0.3	0.3	0.5	1.0	2.0
Rotational Speed (loaded)	RPM	3450	3450	3450	3450	3450
Motor Power	HP	1.5	1.5	3	5	10
Drive Motor Operating Voltage	230/460 Volt, 3 Phase, 60 Cycle is standard					
Intake and Outlet Flange Size ASA	Inch	3	3	3	4	6
Weight with Motor approx. WA	Lbs.	176	187	282	484	880
(WAU)	Lbs.	(185)	(196)	(293)	(495)	(893)
Recommended Backing Pump	Type	S30A	E75, S100C	E150, S160C	E250, S250C	2xE250, TR400, 2xS250C
(Capacity)	CFM	(27)	(49), (70)	(94), (114)	(162), (177)	(2x162), (320), (2x177)
Normal Starting Pressure ++ with WA	Torr	50	50	40	30	20
Recommended Backing Pump (WAU)	Torr	(760)	(760)	(760)	(760)	(760)
Ultimate Partial Pressure with Recommended Backing Pump**	Torr	$<10^{-3}$	$<10^{-3}$	$<10^{-3}$	$<10^{-3}$	$<10^{-3}$

*We recommend HE-200 vacuum pump fluid for use in roots pumps. If the roots pump is being used for pumping greater than atmospheric levels of oxygen, an inert vacuum pump fluid **must** be used. Contact the Leybold main office for the recommended vacuum pump fluid for use on oxygen service or other nonstandard applications.

+The values apply to air at 68°F (20°C).

++The smaller numbers apply to WA-Series pumps; the 760 Torr applies to WAU-Series pumps.

**All pressures are measured with a McLeod gauge.

TABLE 2-3. TECHNICAL DATA FOR WS- AND WSU-SERIES PUMPS

Roots Pumps	Unit	WS 150/ WSU 150	WS 250/ WSU 250	WS 500/ WSU 500	WS 1000/ WSU 1000	WS 2000
Displacement	CFM	100	164	330	660	1342
Maximum Pressure Difference+						
During Continuous Operation	Torr	60	40	40	40	30
During Intermittent Operation, <3 min	Torr	90	50	50	50	50
Fluid* Capacity for Pump (Front Cover and Intermediate Flange)						
Vertical Delivery, approx.	Qts.	0.75	0.75	1	2	4.25
Horizontal Delivery, approx.	Qts.	0.5	0.5	0.75	1	2
Rotational Speed (loaded)	RPM	3350	3350	3350	3350	3350
Motor Power	HP	0.8	0.8	1.7	3.5	7
Drive Motor Operating Voltage	208/230/460 Volt, 3 Phase, 60 Cycle					
Intake and Outlet Flange Dimension, ASA	Inch	3	3	3	4	6
Pump Weight with Motor, approx. WS	Lbs.	165	176	255	418	858
(WSU)	Lbs.	(174)	(185)	(266)	(429)	(871)
Recommended Backing Pump	Type	D30A	DK50	DK100	DK200	2xDK200
(Capacity)	CFM	(27)	(32)	(65)	(130)	(2x130)
Normal Starting Pressure ++ with Recommended Backing Pump WS	Torr	10	10	10	10	10
(WSU)	Torr	(760)	(760)	(760)	(760)	(760)
Ultimate Partial Pressure with Recommended Backing Pump**	Torr	$<10^{-5}$	$<10^{-5}$	$<10^{-5}$	$<10^{-5}$	$<10^{-5}$

*We recommend HE-200 vacuum pump fluid for use in roots pumps. If the roots pump is being used for pumping greater than atmospheric levels of oxygen, an inert vacuum pump fluid **must** be used. Contact the Leybold main office for the recommended vacuum pump fluid for use on oxygen service or other nonstandard applications.

+The indicated values apply to air at 68°F (20°C).

++The 10-Torr figure applies to WS-Series pumps; the 760-Torr figure applies to WSU-Series pumps.

**All pressures are measured with a McLeod gauge.

SECTION 3

PREVENTATIVE MAINTENANCE

TABLE 3-1. MAINTENANCE SCHEDULE

Action	Frequency*	Reference Section
Check pump fluid level		
Front cover	Daily	3-1-1
Motor mount (WA/WAU only)	Weekly	3-1-2
Check pump fluid for contamination	Weekly	3-3
Change pump fluid +		
First change*	500 hours of operation	3-2
Subsequent changes*	3000 hours of operation	3-2
Long term storage*	Before and after	3-6
Check dirt trap	Monthly	3-5
Clean chamber and impellers	Annually	3-4

*More frequent maintenance is required under adverse operating conditions.

+If your pump uses perfluoropolyether (PFPE) vacuum oil, it doesn't normally need to be changed; however, if the PFPE oil becomes contaminated, it should be reconditioned.

3-1 CHECKING THE PUMP FLUID LEVEL

3-1-1 Front Cover and Intermediate Flange Pump Fluid Level

CAUTION: DO NOT REMOVE ANY OF THE PLUG SCREWS (42) FROM THE FRONT COVER (41) WHILE THE PUMP IS RUNNING.

Check the pump fluid level once a day while the system is running.

The minimum pump fluid level is reached when the fluid surface is one-fourth the way up the sight glass (45) (see Figure 1-1). If the pump fluid level is low, use Section 3-2-1 Steps 1 and 6 through 10 to add the appropriate amount of the correct fluid. Insufficient pump fluid will cause improper operation and may result in damage to the pump.

The maximum pump fluid level is reached when the fluid surface is one half of the way up the sight glass (45). A fluid level which is too high can result in a temperature increase in the front cover (41) and excessive power consumption. If the pump fluid level is too high, use Section 3-2-1, Steps 1 through 4 to drain **some** fluid. Recheck the sight glass (45) while the pump is running to ensure that the fluid level is correct.

3-1-2 Motor Mount Pump Fluid Level (WA- and WAU-Series Pumps Only)

CAUTION: USE ONLY FACTORY-APPROVED VACUUM PUMP FLUID IN YOUR PUMP (SEE SECTION 4-1-1). THE USE OF NONAPPROVED FLUIDS VOIDS YOUR WARRANTY.

NOTE: The fluid level in the motor mount (20) should be checked once a week.

NOTE: Pump fluid expands as the pump warms to its operating temperature; therefore, the fluid level should be below the scribe line of the dip stick (24) on a cold pump. As long as the pump fluid shows on the dip stick, the level is adequate.

NOTE: WS- and WSU-Series pumps do not have a motor mount.

Section 3-1-2 Cont.

For WA- and WAU-Series pumps, check the pump fluid level in the motor mount (20) while the system is running; the pump fluid should be between the scribe line and the bottom of the motor mount dip stick (24) (see Figure 1-1). If the fluid level does not show on the dip stick, add the correct pump fluid until the fluid level is just below the scribe line while the pump is running.

If the pump fluid is above the scribe line on the dip stick, use Section 3-2-2, Steps 1 through 4 to drain **some** pump fluid from the motor mount. Recheck the motor mount fluid level while the pump is running.

3-2 CHANGING THE PUMP FLUID

We recommend changing the pump fluid in the front cover (41) and intermediate flange (30) and in the motor mount (20) after the first 500 hours of operation. Later on, change the pump fluid every 3000 hours of operation. If pumps are exposed to heavily contaminated gases or dirt, change the pump fluid more frequently (see Section 3-3). The fluid should also be changed before and after the pump is stored for 2 weeks or more (see Section 3-6).

NOTE: The pump fluid can be changed concurrently for the front cover (see Section 3-2-1) and the motor mount (see Section 3-2-2).

WARNING: IF THE PUMP HAS BEEN USED ON CORROSIVE, TOXIC, HAZARDOUS, OR VOLATILE CHEMICALS, OBSERVE PROPER SAFETY PRECAUTIONS TO PROTECT PERSONNEL BEFORE REMOVING ANY OF THE PLUG SCREW (42) OR THE DIP STICK (24).

3-2-1 Changing the Pump Fluid in the Front Cover and Intermediate Flange

Change the fluid as follows:

1. Turn the pump off and vent it to atmosphere.
2. Place a container under the lower plug screw (42) for catching the used pump fluid.
3. **WARNING:** DO NOT REMOVE THE OIL-FILL OR OIL-DRAIN PLUG SCREWS WHILE THE PUMP IS RUNNING.

   SEE THE SECTION 3-2 WARNING – Using an allen wrench, unscrew and remove the lower plug screw (42) from the oil drain port in the bottom of the front cover (41), and allow the fluid to drain from the pump (see Figure 1-1).
4. **CAUTION:** FAILURE TO PROPERLY SEAT THE PLUG SCREW COULD RESULT IN POOR VACUUM, LOSS OF PUMP FLUID, AND PUMP DAMAGE.

   Ensure that the sealing surfaces are clean and free from defect; then install and tighten the plug screw (42) with flat gasket (43) firmly into the oil drain port in the bottom of the front cover (41).
5. If the used pump fluid is discolored, contains particles, has a foul odor, or is very dirty, flush out the pump as follows:

   a. Using an allen wrench, remove the plug screw (42) from the top of the front cover (41).

   b. **CAUTION:** WHEN FLUSHING OUT THE PUMP, FILL THE FRONT COVER TO CAPACITY WITH CLEAN VACUUM PUMP FLUID. SEE TABLE 2-2 OR 2-3 FOR THE FLUID CAPACITY FOR YOUR PUMP MODEL.

      Pour the required amount of vacuum pump fluid into the oil inlet port in the top of the front cover (41). See Section 4-1-1 for the approved vacuum oils.

   c. **CAUTION:** FAILURE TO PROPERLY SEAT THE PLUG SCREW COULD RESULT IN POOR VACUUM AND PENETRATION OF PUMP FLUID INTO THE PUMPING CHAMBER.

      Ensure that the sealing surfaces are clean and free from defect; then install and tighten the plug screw (42) with flat gasket (43) firmly into the oil inlet port in the top of the front cover (41).

d. Turn the pumping system on (see Section 2-9), allow the roots pump to run for 10 minutes, and then turn it off.

e. Repeat Steps 1, 2, 3, and 4 to drain the fluid from the front cover (41).

f. If the pump fluid used for flushing is dirty, repeat Steps 5a through 5f.

6. **SEE THE SECTION 3-2 WARNING** — Unscrew and remove the plug screw (42) from the oil inlet port in the **top** of the front cover (41).

7. **NOTE**: The fluid capacity for each WA-, WS-, WAU-, and WSU-Series pump is listed in Tables 2-2 and 2-3.

   Pour the vacuum pump fluid into the oil inlet port in the top of the front cover (41) until the fluid level is at the top of the sight glass (45). See Section 4-1-1 for the approved vacuum oils.

8. Repeat Step 5c.

9. Turn the pumping system on.

10. **NOTE**: The fluid level should be between 1/4 to 1/2 of the sight glass (45) with the pump running.

    After the roots pump has run for 5 minutes, recheck the fluid level while the system is running. If necessary, use Section 3-1-1 to adjust the pump fluid level.

3-2-2 Changing the Pump Fluid in the Motor Mount (WA- and WAU-Series Pumps Only)

NOTE: WS- and WSU-Series pumps do not have a motor mount.

Change the fluid in the motor mount as follows:

1. Turn the pump off and vent it to atmosphere.

2. Place an appropriate container for catching the used pump fluid under the plug screw located in the bottom of the motor mount (20).

3. **SEE THE SECTION 3-2 WARNING** — Using an allen wrench, unscrew and remove the plug screw (42) from the oil drain port in the bottom of the motor mount (20) and allow the fluid to drain from the mount (see Figure 1-1).

4. Install and tighten the plug screw (42) with flat gasket (43) into the oil drain port in the bottom of the motor mount (20).

5. If the used pump fluid is discolored, contains particles, has a foul odor, or is very dirty, flush out the motor mount as follows:

   a. Unscrew the dip stick (24) from the top of the motor mount (see Figure 1-1).

   b. **CAUTION:** WHEN FLUSHING OUT THE MOTOR MOUNT, FILL IT TO CAPACITY WITH CLEAN VACUUM PUMP FLUID. SEE TABLE 2-2 FOR THE FLUID CAPACITY OF THE MOTOR MOUNT FOR YOUR PUMP MODEL.

      CAUTION: USE ONLY VACUUM PUMP FLUID APPROVED BY THE FACTORY FOR YOUR PUMP (see Section 4-1-1). THE USE OF NONAPPROVED FLUIDS VOIDS YOUR WARRANTY.

      Pour the correct vacuum pump fluid into the oil inlet port in the top of the motor mount (20) until the fluid level is halfway between the bottom of the dip stick (24) and the scribe line.

   c. Install and tighten the dip stick (24) with flat gasket (23) into the oil inlet port in the top of the motor mount (20).

   d. Turn the system on, allow the roots pump to run for 10 minutes, and then turn it off.

Section 3-2-2, Step 5 Cont.

e. Repeat Steps 1, 2, 3, and 4 to drain the fluid from the motor mount (20).

f. If the pump fluid used for flushing is dirty, repeat Steps 5a through 5f.

6. **SEE THE SECTION 3-2 WARNING** – Unscrew and remove the dip stick (24) from the oil inlet port in the top of the motor mount (20).

7. **NOTE:** The fluid capacity for the motor mount for each WA- and WAU-Series pump model is listed in Table 2-2.

   CAUTION: USE ONLY VACUUM PUMP FLUID APPROVED BY THE FACTORY FOR YOUR PUMP (see Section 4-1-1). THE USE OF NONAPPROVED FLUIDS VOIDS YOUR WARRANTY.

   Pour the correct vacuum pump fluid into the oil inlet port in the top of the motor mount (20).

8. Install and tighten the dip stick (24) with flat gasket (23) into the oil inlet port in the top of the motor mount (20).

9. Turn the system on.

10. **NOTE:** The motor mount fluid level should be just below the scribe line on the dip stick (24) with the pump running.

    After the roots pump has run for 5 minutes, remove the dip stick to check the fluid level while the system is running. Adjust the fluid level, if necessary (see Section 3-1-2).

3-3 CHECKING THE PUMP FLUID FOR CONTAMINATION

Occasionally check the pump fluid for contamination by looking through the sight glass (45). If the fluid has an unusual color, is very dark, contains particles, or appears dirty or turbid, use Section 3-2 to change the fluid. If heavy concentrations of dirt are generated in the system application, we recommend installing an inlet filter to protect the roots pump. Contact the Leybold-Heraeus main office for the correct inlet filter for your system.

3-4 CLEANING THE PUMPING CHAMBER AND IMPELLERS

Certain processes, degassing in particular, produce huge quantities of dust. These contaminants deposit on the internal surfaces of the pumping chamber and on the impellers and must be removed before an accumulation hinders pump performance. For the WAU- and WSU-Series pumps, dirt also accumulates in the bypass line and on the pressure relief valve (see Figures 5-3 and 2-2).

In most cases, you can use the instructions below to clean the pump; however, if the contamination is severe, you may have to use Section 4 to disassemble, clean, and assemble the pump.

Turn the pump off (see Section 2-11) and proceed as follows:

1. Remove the inlet and outlet connecting lines from the pump (see Section 4-2-1, Steps 1a, 1b, and 1c).

2. **WARNING:** DO NOT TURN THE PUMP ON WHILE THE SYSTEM IS AT ATMOSPHERIC PRESSURE. ALWAYS TURN THE IMPELLERS BY HAND WHEN CLEANING THE PUMP.

   Wash the impellers and the inside of the pumping chamber with acetone, triethane III, or another suitable solvent (see Figure 4-27). **For the WAU- and WSU-Series pumps,** also wash the bypass line and the pressure relief valve (see Figures 5-3 and 2-2).

3. **CAUTION:** WHEN SCRAPING, MAKE CERTAIN THAT SURFACES ARE NOT NICKED OR DAMAGED.

   Use a wire brush, scouring pad, sandpaper, or a scraper to remove contaminates which cannot be washed out.

4. **CAUTION:** DO NOT ALLOW DISSOLVED DEPOSITS TO REMAIN IN THE PUMP.

   Use compressed air to remove loosened dirt from the pumping chamber and to ensure that the pumping chamber is dry.

5. **WARNING:** FOR PUMPS THAT USE PERFLUOROPOLYETHER VACUUM OIL, ALL HYDROCARBON SUBSTANCES MUST BE REMOVED FROM THE PUMP AND THE PUMP MUST BE RINSED WITH FREON OR ANOTHER NONHYDROCARBON SOLVENT (see Section 4-3-2).

   For standard pump applications, rinse the pumping chamber with acetone or another standard laboratory solvent.

6. Check the working condition of the pump by slowly turning the impellers by hand; there should not be any noticeable resistance. If there is resistance, locate and eliminate the obstructions.

7. Use Section 3-2 to change the vacuum pump fluid.

8. **CAUTION:** DO NOT ALLOW THE ROOTS PUMP INTERIOR TO BE EXPOSED TO ATMOSPHERE FOR EXTENDED PERIODS WHEN WET.

   If solvent or water remains in the pumping chamber, install the pump to the system immediately after cleaning. Operate the system until the system pressure approaches the ultimate pressure of the backing pump, indicating that all solvent vapors have been removed from the roots pump.

3-5 CHECKING THE DIRT TRAP

Occasionally check the wire mesh dirt trap (39) that rests on the pump intake (see Figure 4-1). Coarse contamination on the dirt trap reduces the pumping speed.

3-6 LONG TERM STORAGE (2 weeks or longer)

CAUTION: DO NOT TRANSPORT THE ROOTS PUMP WITH PUMP FLUID IN THE FRONT COVER (41); THE FLUID FROM THE FRONT COVER WILL SPILL INTO THE PUMPING CHAMBER IF THE PUMP IS TILTED OR JOLTED.

Use the Section 3-2 instructions to flush out the pump and change the vacuum fluid **before** and **after** the pump is stored for 2 weeks or longer. After changing the fluid, run the system for about 10 minutes to ensure that all the internal parts of the pump are coated with clean pump fluid. Cover the intake and outlet of the pump to prevent dirt and dust from accumulating in the pumping chamber during storage.

SECTION 4

DISASSEMBLY, CLEANING, AND ASSEMBLY INSTRUCTIONS

4-1 REQUIRED MATERIALS AND TOOLS

4-1-1 Required Materials

CAUTION: DO NOT DISASSEMBLE THE PUMP UNLESS YOU HAVE A NEW GASKET SET, BEARINGS, PISTON RINGS, THE CORRECT VACUUM PUMP FLUID, AND A SET OF SHIMS. FOR OLDER PUMPS WITH LABYRINTH RINGS, YOU NEED A COMPLETE PISTON RING KIT.

NOTE: The catalog numbers for the sets, kits, and required new parts for your pump model are listed in Section 7-1 of the spare parts list.

Vacuum oil - Based on extensive operational testing, we selected HE-200 hydrocarbon oil for standard RUVAC pumps and HE-2700 perfluoropolyether oil for extreme corrosive service pumps. HE-2700 can't be used in standard pumps; a pump must be totally degreased at our factory before using HE-2700.

If you use a nonapproved oil, we can't guarantee that our pumps will meet their operating specifications (ultimate pressure, pumping speed, operating temperature, etc.). However, the warranty is voided only if the nonapproved oil adversely affects the operation or reliability of the pump.

Bearings
Piston rings
Set of shims
Container for catching pump fluid
Bar made of soft metal (see the first NOTE in Section 4-2)
Screw that has the same metric threads as the internal threads of the dowel pins (see Section 4-2-3, Step 6a)
Brass bolt (see Section 4-2-3, Step 7)
Cleaning solvent -- Triethane III, acetone, or another suitable solvent
Degreasing solvent for pumps using perfluoropolyether vacuum oil - Freon TF
Rinse solvent for pumps using perfluoropolyether vacuum oil - Freon or another nonhydrocarbon solvent
Loctite 271
Two wooden blocks (see Figure 4-34)
For WA-2000 and WAU-2000 pump models only - 5 minute epoxy
Spare parts as required (see Section 7-2)

4-1-2 Required Tools

NOTE: All required tools and all nuts, bolts, screws, and threaded holes are metric, except for the motors on WA- and WAU-Series pumps, which contain U.S. standard bolts and screws. The screws attaching a U.S. motor to a WA- and WAU-Series pump are also U.S. standard.

Metric box or ratchet wrench set
For WA- and WAU-Series pumps -- 5/16- or 3/8 inch allen wrench
Metric allen wrench set
Oil injector equipment (see Section 4-2-1, Step 6b)
Large snap ring pliers
Flat blade screwdrivers
For WS- and WSU-Series pumps -- phillips screwdriver
Rubber hammer
Regular hammer
Ohmmeter (optional) (see Section 4-2-2)
Adjustable wrench (Section 4-2-3, Step 6a)
Puller (see Section 4-2-3, Step 3)
Jackscrews with the same metric threads as the jackscrew holes in the end plates (see Section 4-2-3, Step 6c)
Four 1/16- or 1/8-inch thick metal plates (see Section 4-2-3, Step 6c)

Adjustable spanner; or large pair of snap ring pliers; or two drill bits, drift pins, or other sturdy pins (see Section 4-2-4, Step 2)
Wire brush
Grade 220 and 80 sandpaper
Air compressor (optional) (see Section 4-3-1, Step 5)
For pumps being converted from labyrinth rings to piston rings and for pumps with new end plates – drill and plug (see Section 4-4-1, Step 3b); puller (see Section 4-2-4, Step 1)
File (see Section 4-4-1, Step 7a)
Press, or a pipe with the correct dimensions to be used as a driver (see Figure 4-23)
Punch (see Section 4-4-2, Step 1d)
Spacer sleeve (see Section 4-4-2, Step 7)
Set of long feeler gauges (see Figure 4-28)
Straightedge
Dial indicator gauge (see Figures 4-30 and 4-32)
Pipe and bar (see Figure 4-32)
For WA- and WAU-Series pumps only - shaft seal driver or pipe with the correct characteristics (see Section 4-4-4-1, Step 3).
For WA- and WAU-Series pumps only – vice-grip pliers and levers (see Figure 4-37)
Long nose pliers
For WA- and WAU-Series pumps only – 3/4-inch open end wrench (see Section 4-4-5, Step 5a)

4-2 DISASSEMBLING THE PUMP

WARNING: DO NOT BEGIN DISASSEMBLING THE PUMP UNTIL THE SYSTEM IS TURNED OFF AND THE POWER IS DISCONNECTED.

WARNING: IF THE PUMP HAS BEEN USED ON HAZARDOUS, CORROSIVE, OR VOLATILE CHEMICALS, OBSERVE PROPER SAFETY PRECAUTIONS BEFORE OPENING THE PUMP.

NOTE: Any time you loosen or tighen a nut or screw on an impeller shaft or turn the oil injector, insert a bar made of aluminum or other soft metal into the pump **intake** to prevent the impeller shaft from turning. Do not insert the bar through to the pump outlet because it could bend the oil equalization tube (2).

4-2-1 Disassembling the Front End of the Pump

1. Remove the pump from your system as follows:

   a. Remove the screws attaching the inlet and the outlet line of the system to the ASA adapters (4) on the intake and outlet of the pump; remove the sealing discs from the adapters (4).

   b. Remove the nuts from the adapter flange studs; remove the adapter flange (4) from the intake and outlet of the pump (see Figures 1-1 and 4-1).

   c. Remove the sealing disk (37) with dirt trap (39) from the pump intake and the sealing disk (6) from the pump outlet (see Figure 4-1).

   d. Remove the bolts attaching the mounting feet (34/33) of the pump to the frame of the system.

2. **CAUTION:** FAILURE TO DRAIN THE PUMP FLUID FROM THE FRONT COVER (41) BEFORE TRANSPORTING THE PUMP COULD RESULT IN FLUID SPILLING INTO THE PUMPING CHAMBER.

   Remove the plug screws (42) from the oil inlet port and the oil drain port in the front cover (41) and allow the pump fluid to drain into a suitable container (see Figure 4-1).

3. **WARNING:** VACUUM PUMP FLUIDS ARE EXCELLENT LUBRICANTS AND AS SUCH ARE VERY SLIPPERY. BE CAREFUL WHEN HANDLING THE FRONT COVER (41) SINCE IT CONTAINS PUMP FLUID WHICH COULD SPILL CAUSING A HAZARD.

   Remove the front cover (41) as follows:

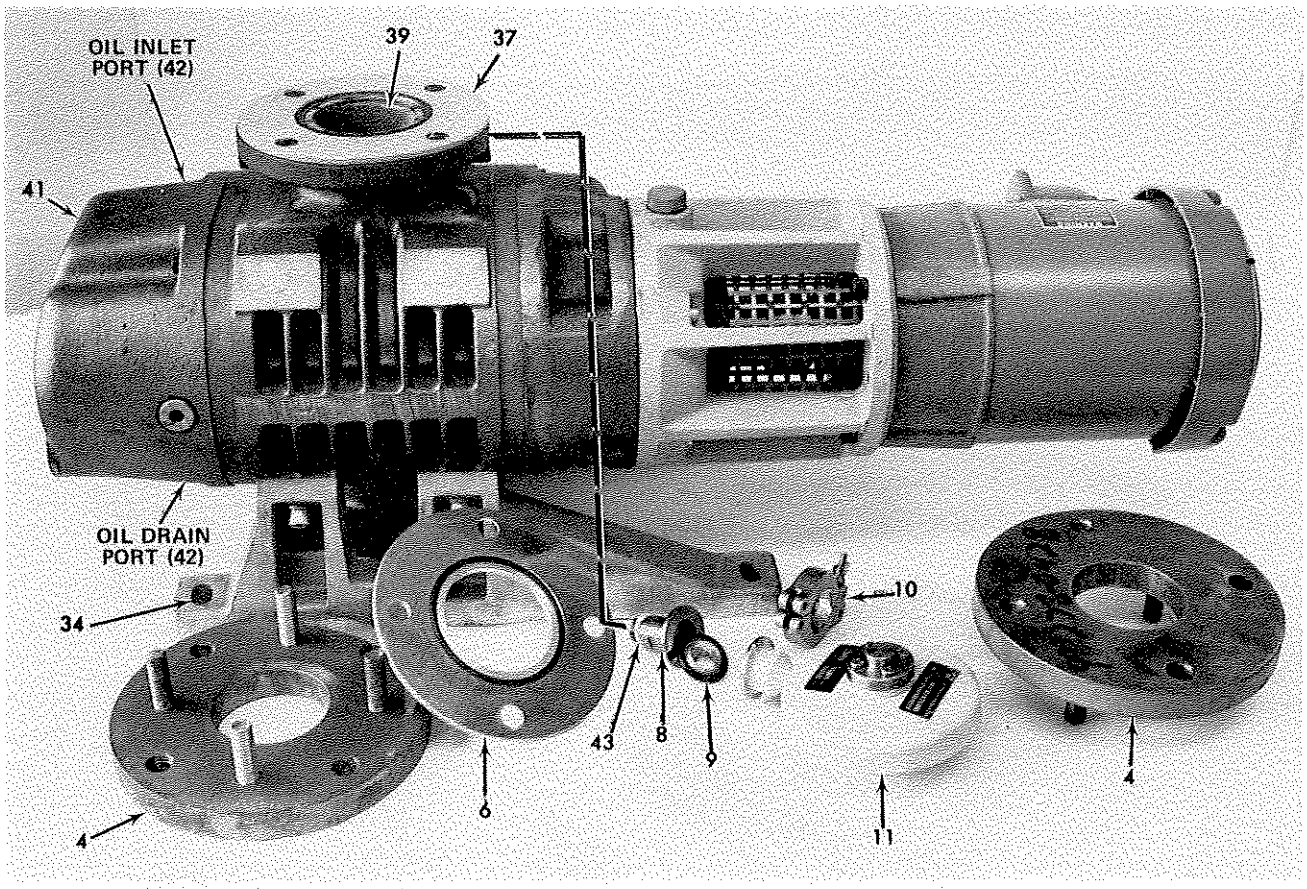


Figure 4-1. ASA Adapters, Sealing Discs, and Diaphragm Pressure Switch Removed from the Pump (WA-250 pump model shown). 1R-2.15

Section 4-2-1, Step 3 Cont.

a. Unscrew and remove the lower screws that attach the front cover (41) to the pump (see Figure 4-2).

b. **WARNING:** ESPECIALLY FOR THE HEAVIER PUMPS, BE SURE TO SUPPORT THE FRONT COVER WHILE REMOVING THE SCREWS; OTHERWISE, THE COVER MAY FALL, RESULTING IN DAMAGE OR INJURY.

While supporting the front cover, unscrew and remove the upper screws.

c. Pull the front cover (41) from the pump and the O-ring (3) from its groove in the front end plate (40) (see Figure 4-2).

4. Remove the nuts (48) from the impeller shafts (60) (see Figure 4-2 and the NOTE at the beginning of Section 4-2).

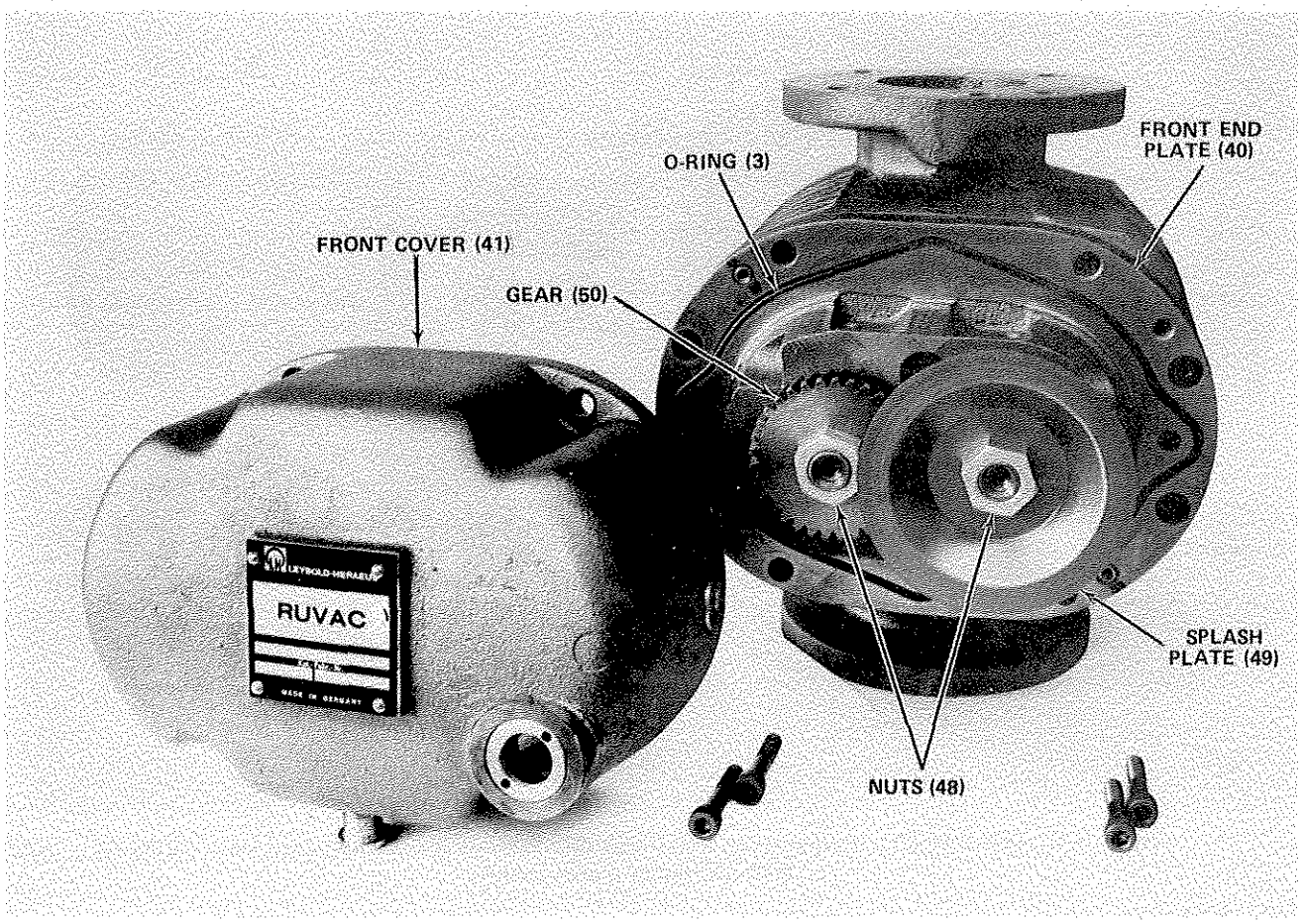
For WA/WAU/WS-2000 pump models only, also remove the washers (Part No. 627-05-445) from the impeller shafts.

5. Remove the splash plate (49) from the drive (right) shaft (see Figure 4-2).

6. Remove the two gears (50) from the shaft as follows:

a. **WARNING:** FAILURE TO HAVE THE NUT (48) SCREWED ON THE SHAFT WHILE USING THE OIL INJECTOR TO REMOVE THE GEAR COULD RESULT IN THE GEAR (50) FLYING OFF OF THE SHAFT AND CAUSING INJURY.

Install the nut onto the impeller shaft with a 1/8-inch gap between the nut (48) and the gear (50).



1R-4.22A

Figure 4-2. Front Cover Removed from the Pump (WA-250 pump model shown).

TABLE 4-1. OIL INJECTOR EQUIPMENT PART NUMBERS

Part Name	Dimensions (inches)	Part No.
Oil Injector	R3/8	590-60-109-1
Valve Nipple	R3/8/R3/8	431-79-104
Reducing Nipple†	R3/8 to R1/8	431-79-103
Reducing Nipple*	R3/8 to R1/4	701-20-332

*This reducing nipple is required only for the WA/WAU/WS/WSU-500 and -1000 pump models.

† This reducing nipple is required for the WA/WAU/WS/WSU-150, -250 pump -2000 pump models.

Section 4-2-1, Step 6 Cont.

b. **WARNING:** Never use the oil injector if it hasn't been modified with the safety hole and rupture-disc assembly. See the oil injector instructions (P/N 722-78-034) for important safety instructions.

NOTE: Oil injector equipment can be odered from Leybold. Table 4-1 lists the part numbers for the equipment.

Install the oil injector onto the end of the shaft as follows (see Figure 4-28).

(1) Unscrew the threaded cylinder from the oil injector sleeve until three-fourths of the threads on the cylinder are exposed. Apply vacuum grease to the threads on the cylinder.

(2) Push the plunger, which is in the center of the threaded cylinder, back until it bottoms out in the sleeve.

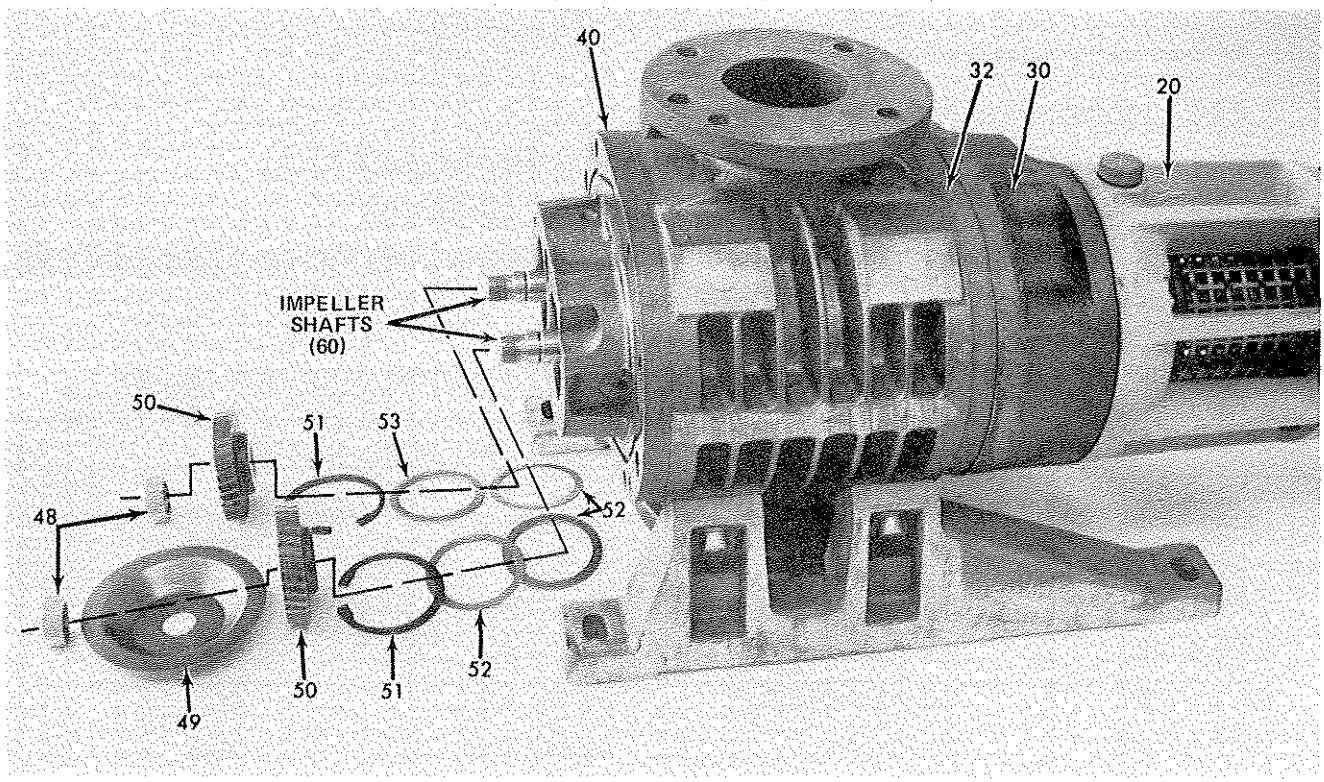
(3) Tilt the threaded cylinder/sleeve assembly back and fill the hole in the center of the cylinder with the correct vacuum pump fluid (see Section 4-1-1).

(4) **NOTE:** The threaded cylinder, valve nipple, and reducing nipple must be screwed together tightly to ensure an oil-tight seal.

Attach the valve nipple to the oil injector and the reducing nipple to the valve nipple.

(5) **NOTE: For WA/WAU/WS-2000 pump models only,** screw the oil injector into the threaded hole on the gear rather than into the end of the shaft.

Screw the oil injector assembly firmly into the threaded hole in the end of the shaft (see Figure 4-28).



1R-2.24

Figure 4-3. Splash Plate, Gears, and Rings Removed from the Front End of the Pump (WA-250 pump model shown).

c. **WARNING:** DO NOT STAND BEHIND THE OIL INJECTOR WHEN IT IS INSTALLED ON THE SHAFT. THE HIGH OIL PRESSURE INSIDE OF THE INJECTOR AND SHAFT CAN CAUSE THE INJECTOR TO FLY OFF THE SHAFT CAUSING DAMAGE OR INJURY. BE SURE TO WEAR SAFETY GLASSES.

NOTE: When using the oil injector, be prepared to catch the excess pump fluid.

NOTE: It may be necessary to tap the face of the gear with a hammer to loosen it or to pry it off with a screwdriver.

While supporting the reducing nipple with an open end wrench, turn the handle of the oil injector clockwise so that pump fluid is forced between the shaft and the ID of the gear, until the gear (50) becomes separated from the tapered shaft and knocks against the nut (48).

d. Remove the oil injector equipment and the nut (48).

e. Pull the gear (50) from the shaft (see Figure 4-3).

f. Repeat Steps 6a through 6e to remove the gear (50) from the other impeller shaft.

7. Using snap ring pliers, remove the retainer rings (51) and then the spacers (53) and shims (52) from the two bearing wells in the front end plate (40) (see Figure 4-3). Wire or tape the retainer rings, spacers, and shims together so that you don't misplace them.

8. **NOTE:** The pressure switch adapter (8) is screwed into a tapped hole just below the intake of the pump.

For WA- and WS-Series pumps only, remove the KF® clamp ring (10) and centering ring (9) that secure the diaphragm pressure switch (11) to the pressure switch adapter (8). Remove the diaphragm pressure switch (11) from the pump (see Figures 1-1 and 4-1).

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4-2-2 Disassembling the Motor End of the Pump

If you suspect a motor malfunction, use an ohmmeter to check the motor as follows:

a. Check each of the windings to ground for short circuits.

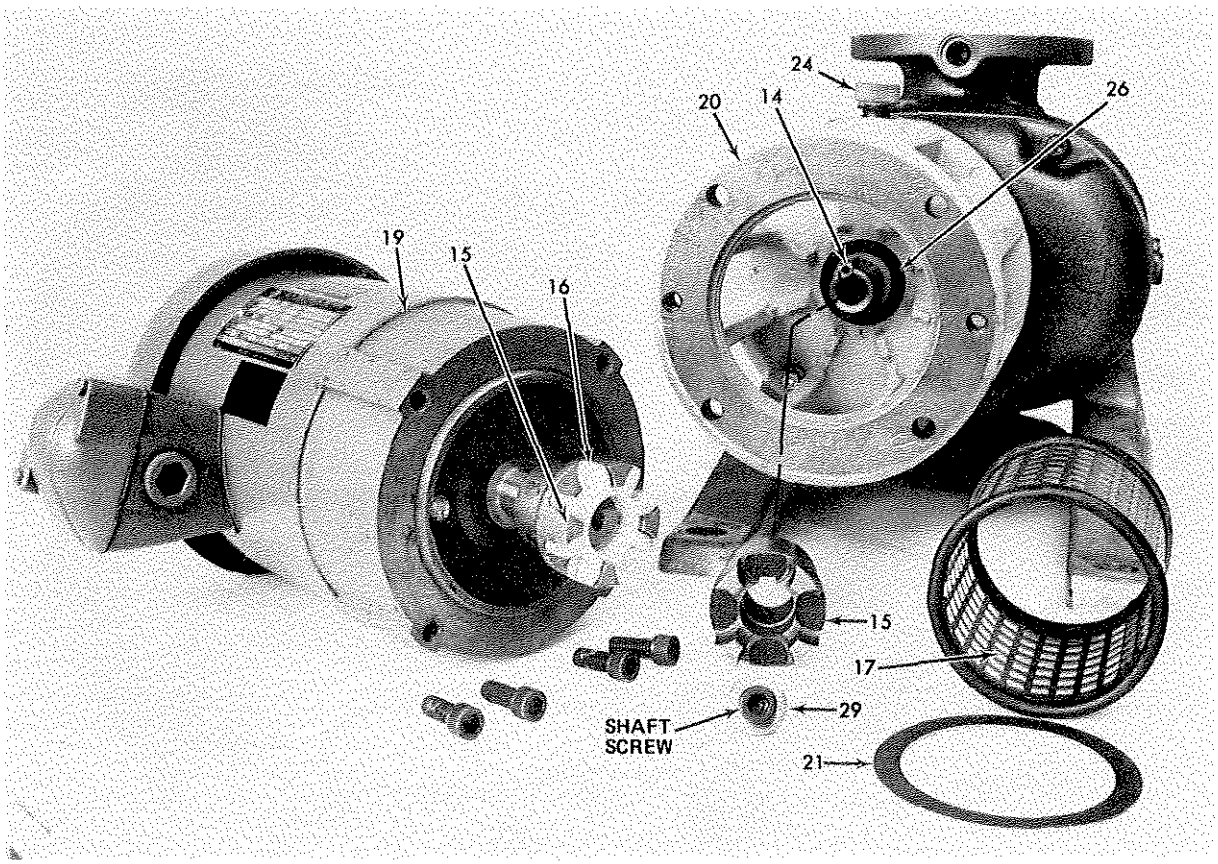
b. Check the resistances between windings (phases); Table 4-2 lists the approximate resistance for each pump model.

TABLE 4-2. APPROXIMATE RESISTANCE BETWEEN MOTOR WINDINGS (phases)

WA- and WAU-Series Pumps	
Pump Model	**Approximate Resistance* (Ohms)**
WA/WAU-150	See Appendix C.
WA/WAU-250	See Appendix C.
WA/WAU-500	See Appendix C.
WA/WAU-1000	See Appendix C.
WA/WAU-2000	See Appendix C.

WS- and WSU-Series Pumps	
Pump Model	**Approximate Resistance* (Ohms)**
WS/WSU-150	12.7
WS/WSU-250	12.7
WS/WSU-500	14.0
WS/WSU-1000	9.0
WS-2000	2.2

*Resistances are measured over star point.



NOTE: This figure applies only to WA- and WAU-Series pumps. 1R-2.27

Figure 4-4. Motor, Coupling, and Coupling Shield Removed from the Pump (WA-250 pump model shown).

4-2-2-1 WA- and WAU-Series Pumps — Motor End Disassembly

NOTE: Section 4-2-2-1 is for WA- and WAU-Series pumps only.

1. **WARNING:** FAILURE TO SUPPORT THE MOTOR WHEN REMOVING THE SCREWS COULD RESULT IN THE MOTOR FALLING AND CAUSING DAMAGE OR INJURY.

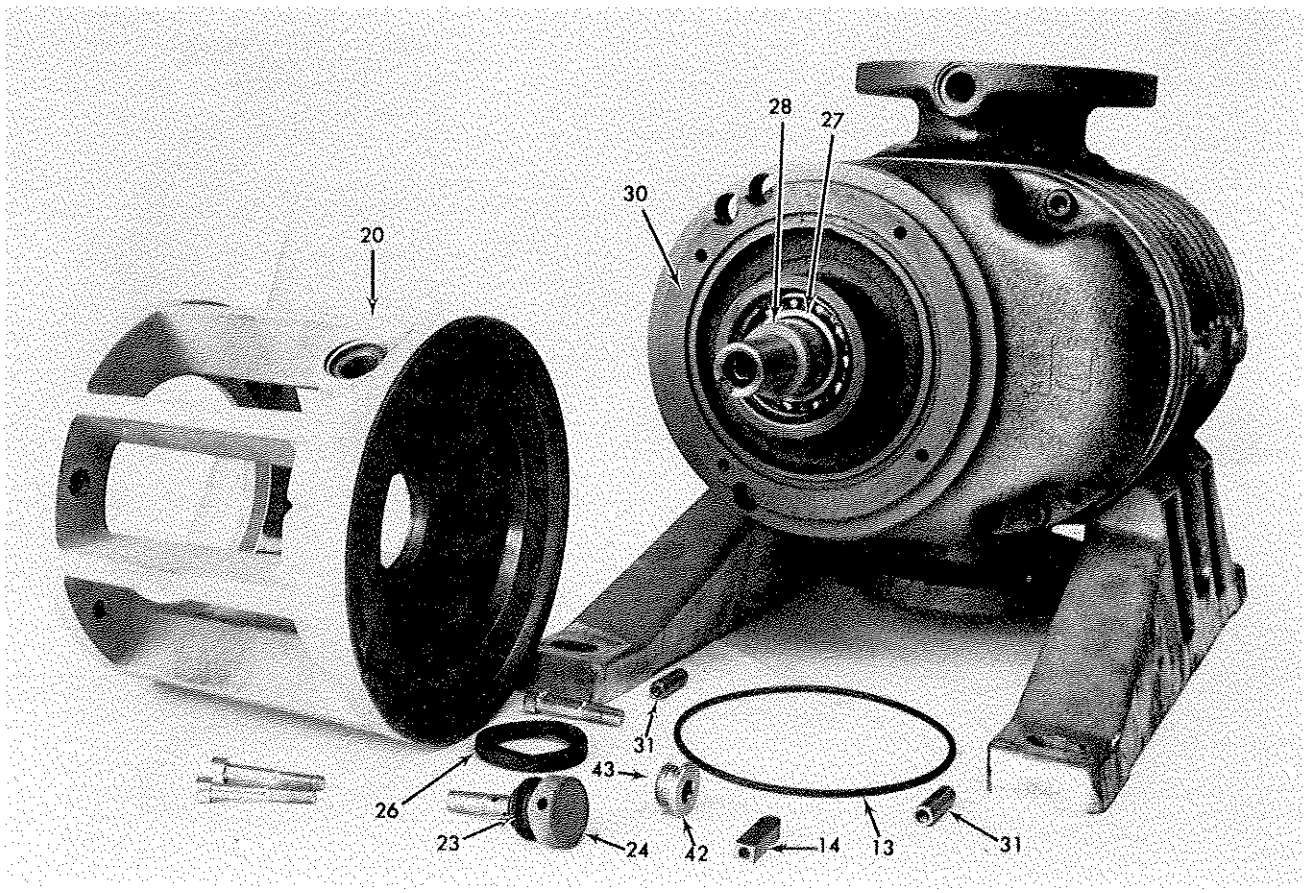
   NOTE: Sometimes it is necessary to use metric jackscrews to pry the motor from the pump.

   Remove the U.S. standard screws that attach the motor (19) to the motor mount (20) and pull the motor from the pump (see Figure 4-4).

2. **For WA/WAU-150, -250, -500, and -1000 pump models,** remove the shield retainer (21) from the end of the motor mount (20) (see Figure 4-4).

   For WA/WAU-2000 pump models, if necessary for repair, remove the motor adapter flange (22) from the motor.

3. Remove the coupling insert (16) from the motor-side coupling (15) (see Figure 4-4).
4. Pull the coupling shield (17) from the inside of the motor mount (20) (see Figure 4-4).
5. Unscrew and remove the dip stick (24) from the top and the plug screw (42) from the bottom of the motor mount (20), and allow the fluid to drain into a suitable container (see Figures 4-4 and 4-5).
6. Remove the shaft screw and washer (29) from the end of the pump shaft (see Figure 4-4).
7. Pull the coupling (15) from the pump shaft (see Figure 4-4).
8. Lift the key (14) from the pump shaft (see Figures 4-4 and 4-5).



1R-2.30

NOTE: This figure applies only to WA- and WAU-Series pumps.

Figure 4-5. Motor Mount Removed from the Pump (WA-250 pump model shown).

Section 4-2-2-1 Cont.

9. **WARNING:** BE CAREFUL WHEN HANDLING THE MOTOR MOUNT SINCE IT CONTAINS PUMP FLUID WHICH COULD SPILL CAUSING A HAZARD.

   Remove the screws attaching the motor mount (20) to the pump; pull or pry the mount (20) off of the pump and pull the O-ring (13) from its groove in the intermediate flange (30) (see Figure 4-5).

10. **CAUTION:** DO NOT SCRATCH THE INSIDE OF THE MOTOR MOUNT WHEN DRIVING THE RADIAL SHAFT SEAL; SCRATCHES TO THESE SURFACES COULD RESULT IN A PUMP FLUID AND GAS LEAK.

    Drive the radial shaft seal (26) toward the motor side of the motor mount (20) until the seal (26) falls out of the motor mount (20) (see Figures 4-4 and 4-5).

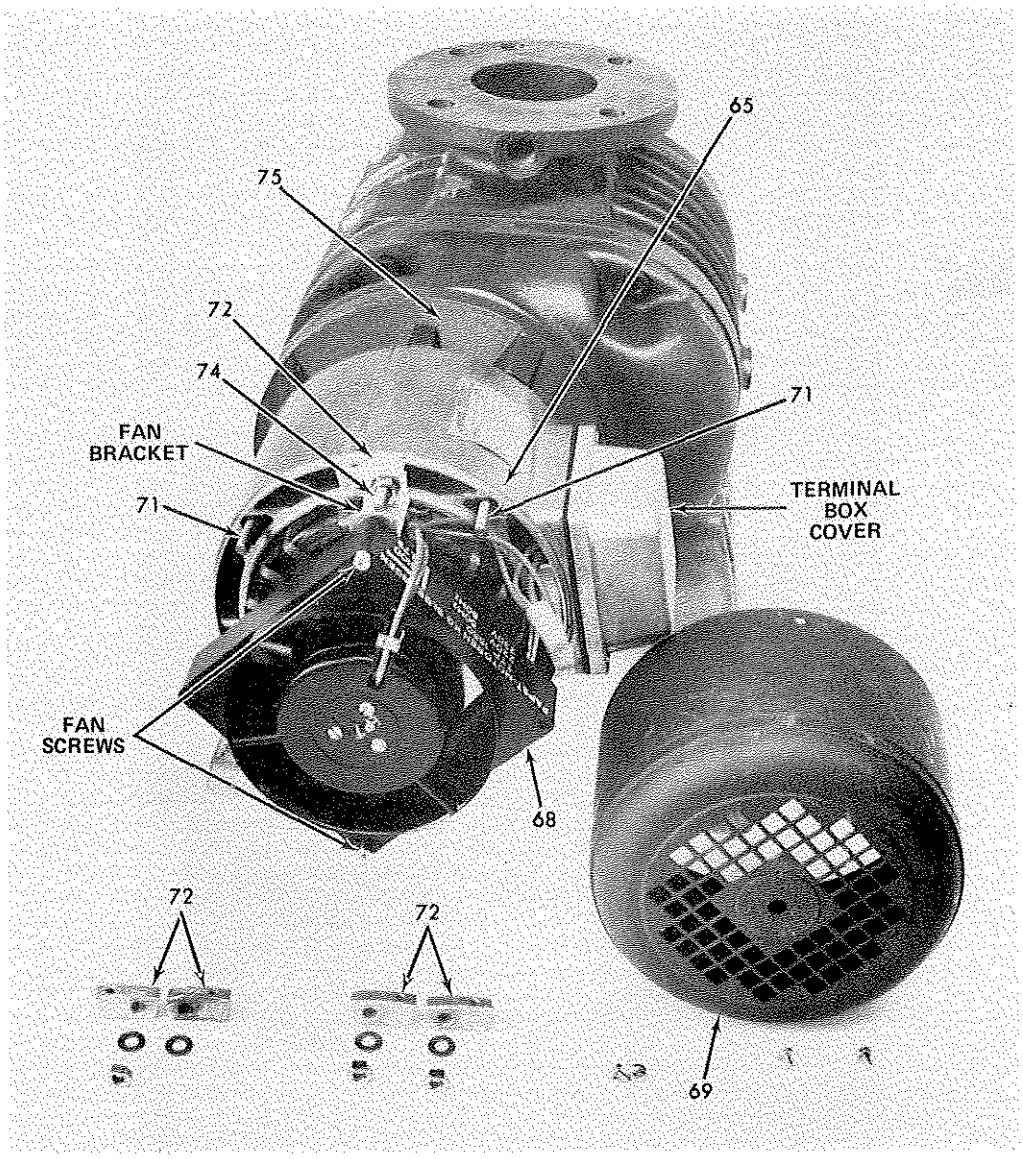
4-2-2-2 WS- and WSU-Series Pumps — Motor End Disassembly

NOTE: Section 4-2-2-2 is for WS- and WSU-Series pump models only.

1. Remove the phillips screws that attach the motor end cover (69) to the motor and remove the cover (see Figure 4-6).

2. Remove the nuts, washers, and the spacer lugs (72) from the four studs (71) that do not have fan brackets attached to them (see Figure 4-6).

3. If necessary for repair, remove the screws that attach the cover to the terminal box of the motor; remove the cover from the terminal box.



NOTE: This figure applies only to WS- and WSU-Series pumps. 1R-6.22A

Figure 4-6. Motor End Cover Removed from the Pump (WS-250 pump-model shown).

Section 4-2-2-2 Cont.

4. If necessary for repair, disconnect the wires that attach the fan to the terminal board of the motor (see Figure 4-41).

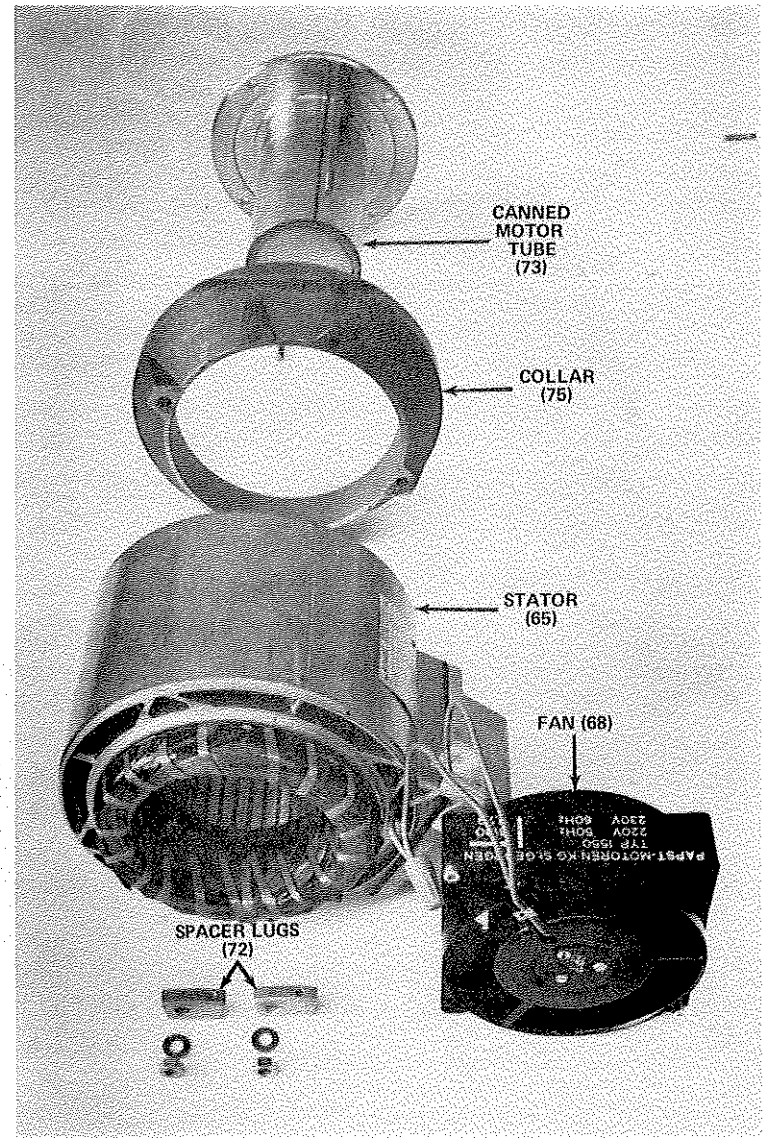
5. Use a screwdriver and a rubber hammer to pry and tap the collar (75) loose from the pump; pull the collar/canned motor tube/stator assembly (75/73/65) from the pump (see Figure 4-6); remove the O-ring (13) from its groove in the outside of the intermediate flange (30).

6. If necessary for repair, disassemble the collar/tube/stator assembly (75/73/65) as follows:

   a. Remove the nuts and washers from the two studs (74) that have fan brackets attached to them (see Figure 4-6).

   b. **NOTE:** The fan on the WS-2000 has a large capacitor attached to it.

      Remove the fan (68) and the two remaining spacer lugs (72) from the motor (see Figures 4-6 and 4-7).



1R-6.30A

NOTE: This figure applies only to WS- and WSU-Series pumps.

Figure 4-7. Disassembled Canned Motor (WS-250 pump model shown).

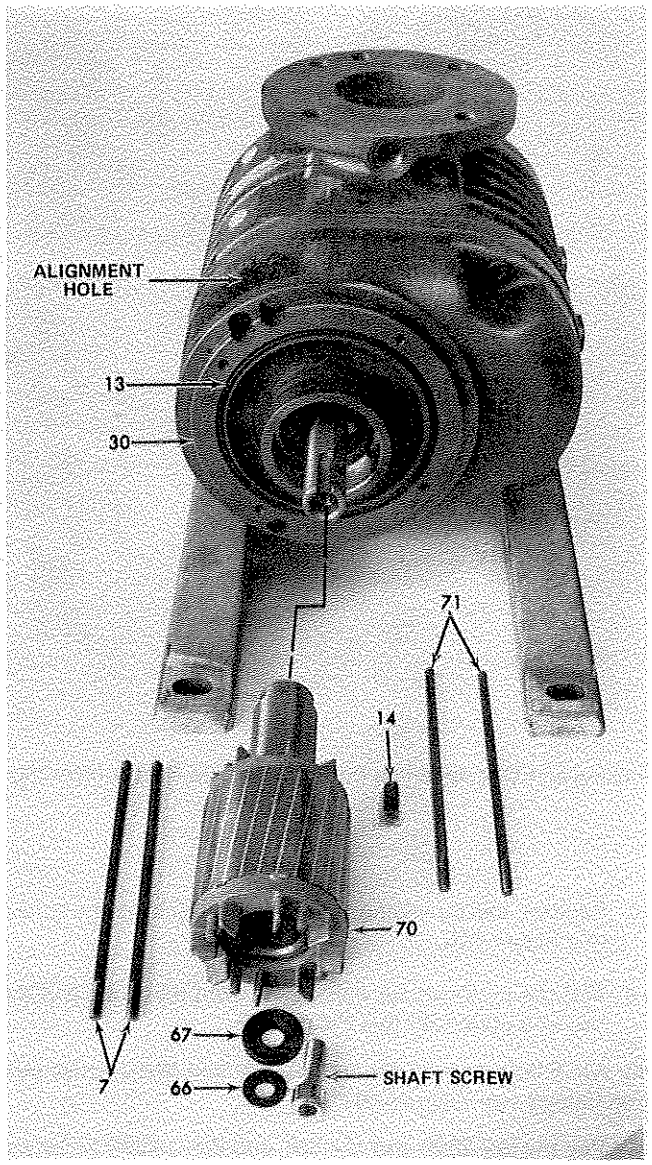
Section 4-2-2-2, Step 6 Cont.

c. Use two screwdrivers to pry the stator (65) off of the canned motor tube (73) (see Figures 4-6 and 4-7).

d. **CAUTION:** DO NOT DENT THE CANNED MOTOR TUBE.

Remove the collar (75) from the canned motor tube (73) (see Figure 4-7).

7. Remove the shaft screw, ball washer (66), and seat washer (67) from the end of the shaft (see Figure 4-8).
8. Remove the four studs (71) and the O-ring (13) from the intermediate flange (30) (see Figure 4-8).
9. Pry the armature (70) and attached sleeve off of the shaft (see Figure 4-8).
10. Remove the key (14) from the pump shaft (see Figure 4-8).



NOTE: This figure applies only to WS- and WSU-Series pumps.

Figure 4-8. Armature Removed from the Pump (WS-250 pump model shown).

4-2-3 Disassembling the Intermediate Flange and End Plates

1. **WARNING:** BE CAREFUL WHEN HANDLING THE INTERMEDIATE FLANGE (30) SINCE IT CONTAINS PUMP FLUID WHICH COULD SPILL CAUSING A HAZARD.

   Remove the intermediate flange as follows:

   a. Remove two of the screws attaching the intermediate flange (30) to the pump (see Figure 4-8).

   b. **CAUTION:** FAILURE TO SCREW THE METRIC SCREW ALL THE WAY INTO THE THREADED HOLE IN THE DOWEL PINS (31) COULD RESULT IN DAMAGE TO THE THREADS.

      Using a hammer, an adjustable wrench, and a screw that has the same metric threads as the internal threads of the dowel pins (31), pull the two dowel pins (31) from the intermediate flange (30) (see Figures 4-5 and 4-8). Figure 4-10 shows the above-mentioned tool being used to remove a dowel pin from the rear end plate.

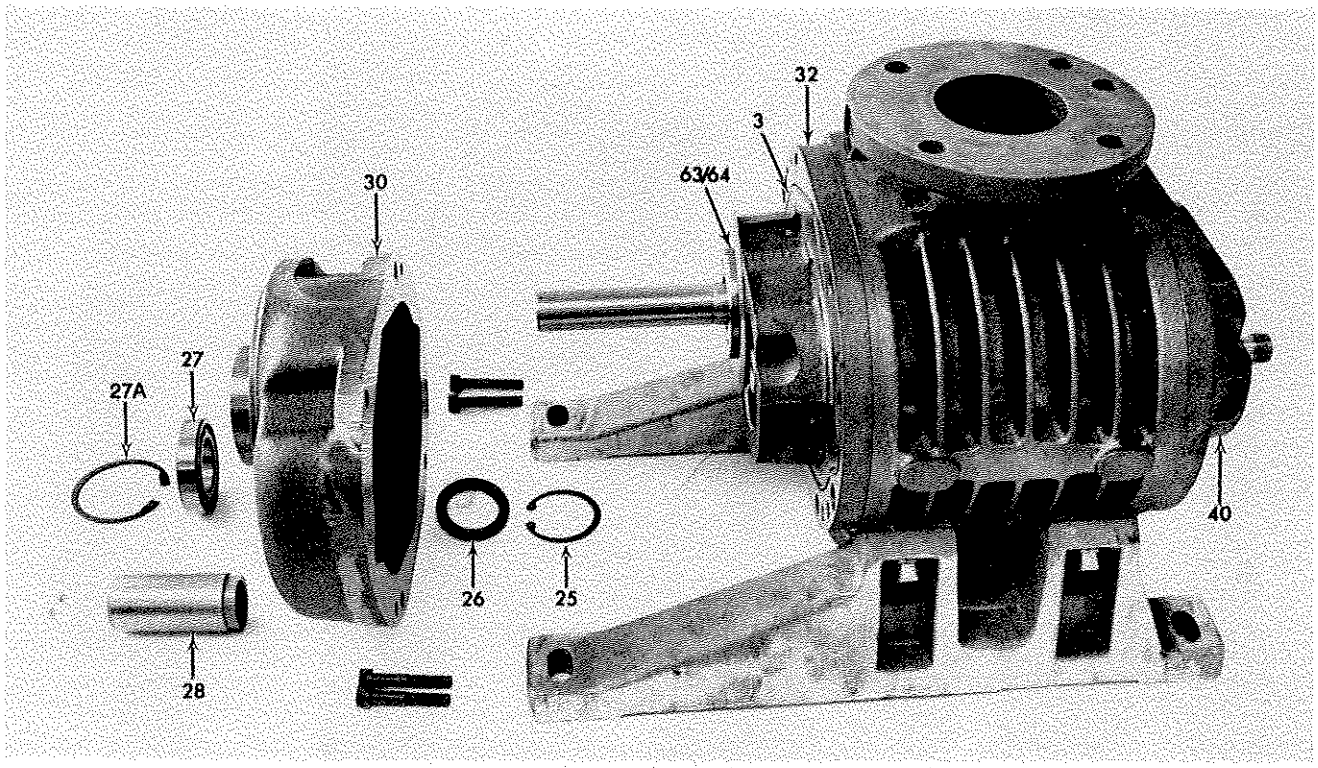


Figure 4-9. Removing and Disassembling the Intermediate Flange (WA-250 pump model shown). 1R-7.36

Section 4-2-3, Step 1 Cont.

c. Remove the remaining two screws attaching the intermediate flange (30) to the pump (see Figure 4-8).

d. Pull the intermediate flange (30) from the pump and the O-ring (3) from its groove in the rear end plate (32) (see Figure 4-9).

2. **For the WS-2000 pump model and all WA- and WAU-Series pumps,** disassemble the intermediate flange as follows (see Figure 4-9).

   a. **For the WS-2000 and the WA- and WAU-2000 Series pumps only,** remove the two screws and washers that hold the bearing (27) in place.

      For all other WA- and WAU-Series pumps, use snap ring pliers to remove the retainer rings (25/27A) from each end of the bearing well in the intermediate flange (30).

   b. **NOTE:** New bearings should be used when reassembling the pump.

      Pull the bearing (27) from the bearing well.

   c. **CAUTION:** DO NOT SCRATCH THE INSIDE OF THE BEARING WELL; SCRATCHES COULD RESULT IN A GAS OR PUMP FLUID LEAK.

      Drive the radial shaft seals (26) from the intermediate flange bearing well.

3. **NOTE:** If necessary, use the puller (P/N 701-00-254), or use two long metric screws and a flat bar to make a puller for removing the oil slinger.

   Using a puller with the same threads as the metric holes in the oil slinger, remove the oil slinger/compression ring assembly (63/64) and the shaft bushing sleeve (28) from the drive shaft (see Figure 4-9).

4. Remove the compression ring (64) from the oil slinger (63) (see Figure 4-9).

5. Use snap ring pliers to remove the retainer ring (51) from its groove in each bearing well in the rear end plate (32); pull the spring washers (62) from each bearing well (see Figure 4-12).

6. **NOTE:** Note the location of the four or six large threaded holes in the end plate. These holes will be used with jackscrews in Step 6c.

   Remove the rear end plate (32) from the pump as follows:

   a. **CAUTION:** FAILURE TO SCREW THE METRIC SCREW ALL THE WAY INTO THE THREADED HOLE IN THE DOWEL PINS (31) COULD RESULT IN DAMAGE TO THE THREADS.

      Using a hammer, an adjustable wrench, and a screw with the same metric threads as the internal threads in the dowel pins, pull the two dowel pins (31) from the rear end plate (32) as shown in Figure 4-10.

   b. Remove the screws attaching the rear end plate (32) to the pump housing (35).

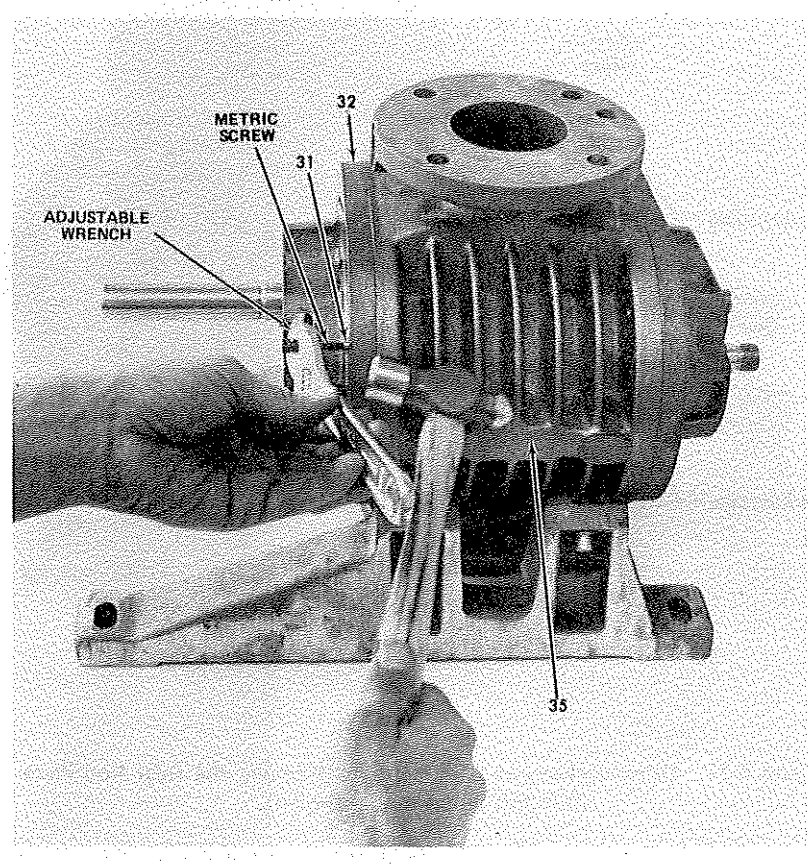


Figure 4-10. Removing the Dowel Pins from the Rear End Plate (WA-250 pump model shown).

   c. **CAUTION:** DO NOT SCRATCH THE SEALING SURFACES OF THE END PLATE OR PUMP HOUSING.

      Pull the end plate (32) from the pump as follows (see Figure 4-11).

      (1) Screw a jackscrew with the correct metric threads and diameter into each of the four or six large threaded jackscrew holes, until the end plate is 1/16- to 1/8-inch from the pump housing.

      (2) Unscrew the jackscrews.

(3) Slide a 1/16- or 1/8-inch-thick metal plate between the end plate and the pump housing at each of the jackscrew holes.

NOTE: The thin plate is to prevent the smaller threaded holes in the pump housing from being damaged by the jackscrews.

(4) **WARNING:** FAILURE TO SUPPORT THE END PLATE WHILE REMOVING IT FROM THE PUMP COULD RESULT IN THE END PLATE FALLING AND CAUSING DAMAGE OR INJURY.

Screw a jackscrew into each of the jackscrew holes, until the end plate is free from the pump housing. Remove the end plate (32) from the pump.

(5) Remove the jackscrews from the end plate.

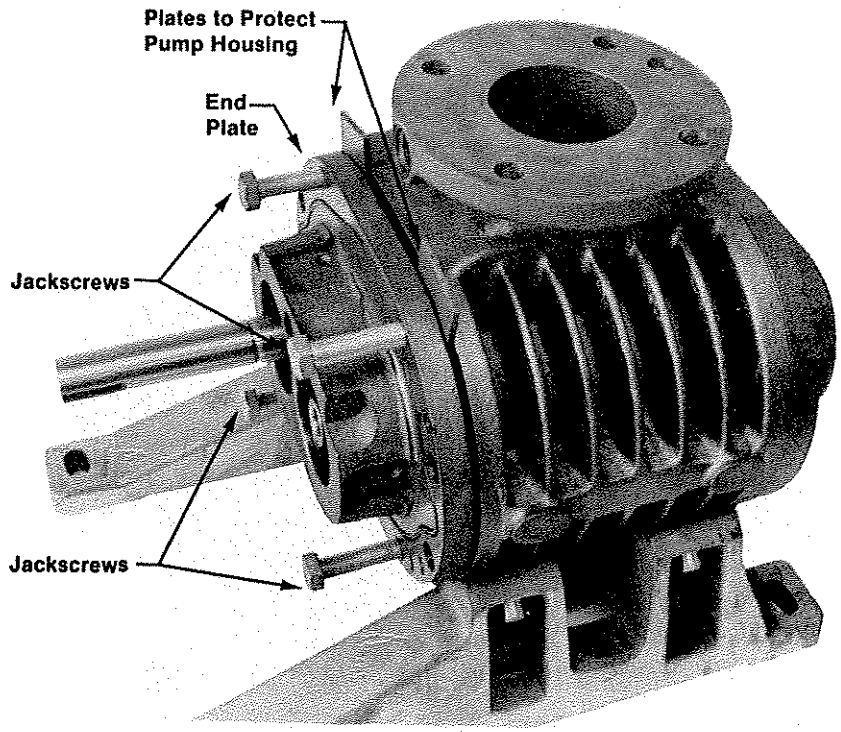


Figure 4-11. Using Jackscrews and Plates to Remove the Rear End Plate (WA-250 pump model shown).

d. Pull the O-ring (3) from its groove in the inside of the rear end plate (32) (see Figure 4-12).

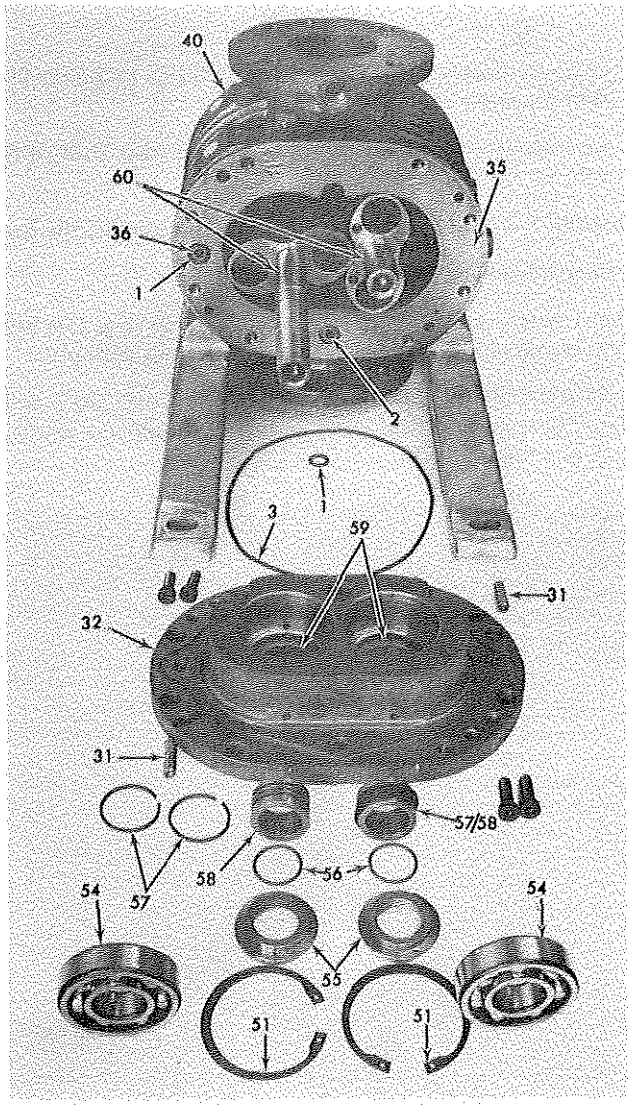
e. Pull the O-ring (1) from its groove around the end of each of the oil level equalization tubes (2/36) in the pump housing (see Figure 4-12).

7. **NOTE:** New bearings should be used when reassembling the pump.

NOTE: It is sometimes necessary to tap the bearings from the inside with a brass bolt to remove them from the end plate.

Pull the bearing (54) from each of the two bearing wells in the end plate (see Figure 4-12).

8. Remove the splash ring (55) and O-ring (56) from each bearing well in the end plate (see Figure 4-12).



NOTE: The spring washers (62) are not shown in this photograph.
Figure 4-12. Disassembled Rear End Plate (WA-250 pump model shown).

Section 4-2-3 Cont.

9. **NOTE:** Older model pumps have the labyrinth rings; more recent units have piston rings; skip Step 9 if your pump has labyrinth rings (see Figure 4-13).

   For pumps with piston rings, proceed as follows (see Figure 4-12).

   a. Push the piston ring holder (58) from each bearing well.

   b. **NOTE:** New piston rings should be used when reassembling the pump.

      Remove the piston rings (57) from the piston ring holders (58).

   c. **NOTE: It is necessary to remove the piston ring housing (59) from the end plate only if the piston ring housing (59) is damaged.**

      If necessary for repair, use a press and a pipe with the same ID and OD as the piston ring housing (59) to drive the piston ring housing (59) toward the outside of the end plate until it is out of each bearing well in the end plate (see Figure 4-12).

10. **NOTE:** It may be necessary to tap the front end of each impeller shaft with a rubber hammer to loosen it from the **front** end plate (40).

    Pull the two impellers (60) through the open end (rear end) of the pump housing (35) to remove them from the pump (see Figure 4-12).

11. Repeat Steps 6, 7, 8, and 9, except remove and disassemble the front end plate (40).

4-2-4 Disassembling the Remaining Parts

1. **NOTE:** Most older model pumps have the labyrinth rings (see Figure 5-1), more recent units have piston rings. We recommend replacing labyrinth rings with piston rings.

   REQUIRED ACTION: For pumps with labyrinth rings, use a puller to remove the labyrinth rings and the inner bearing race from each end of both impeller shafts. Discard the labyrinth rings and bearing race (see Figure 4-13).

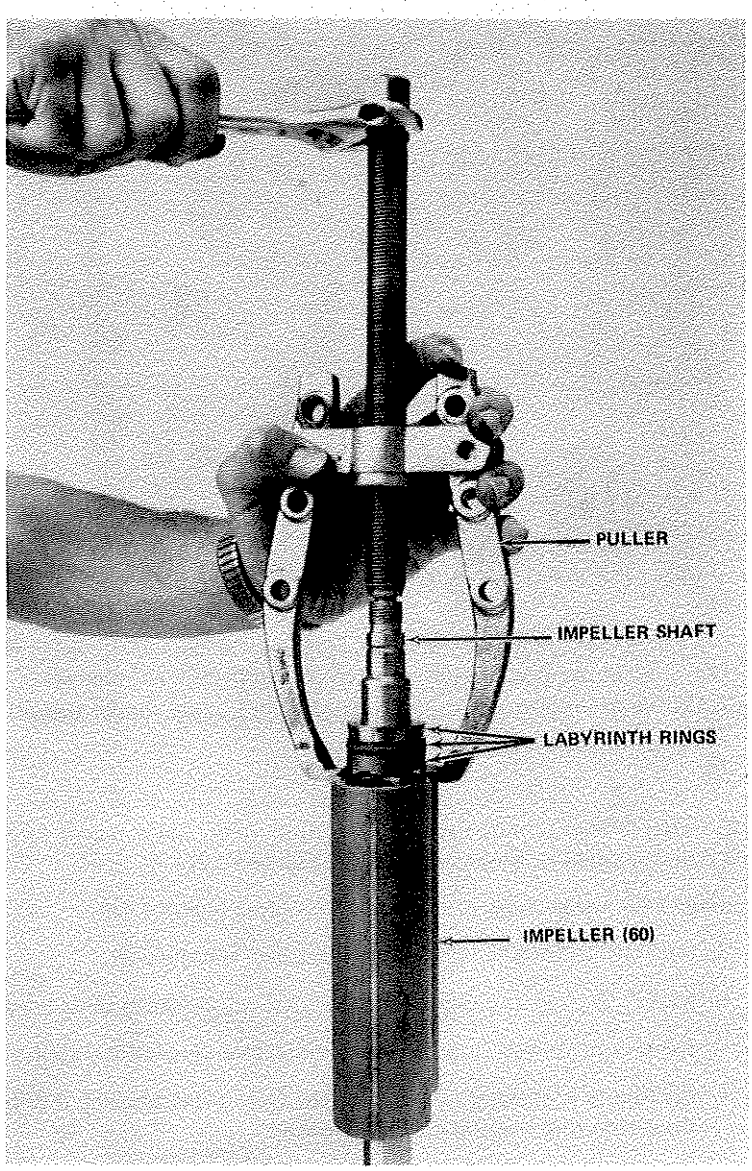


Figure 4-13. Using a Puller to Remove Labyrinth Rings from the Impeller Shaft of an Older Model Pump (WA-250 pump model shown).

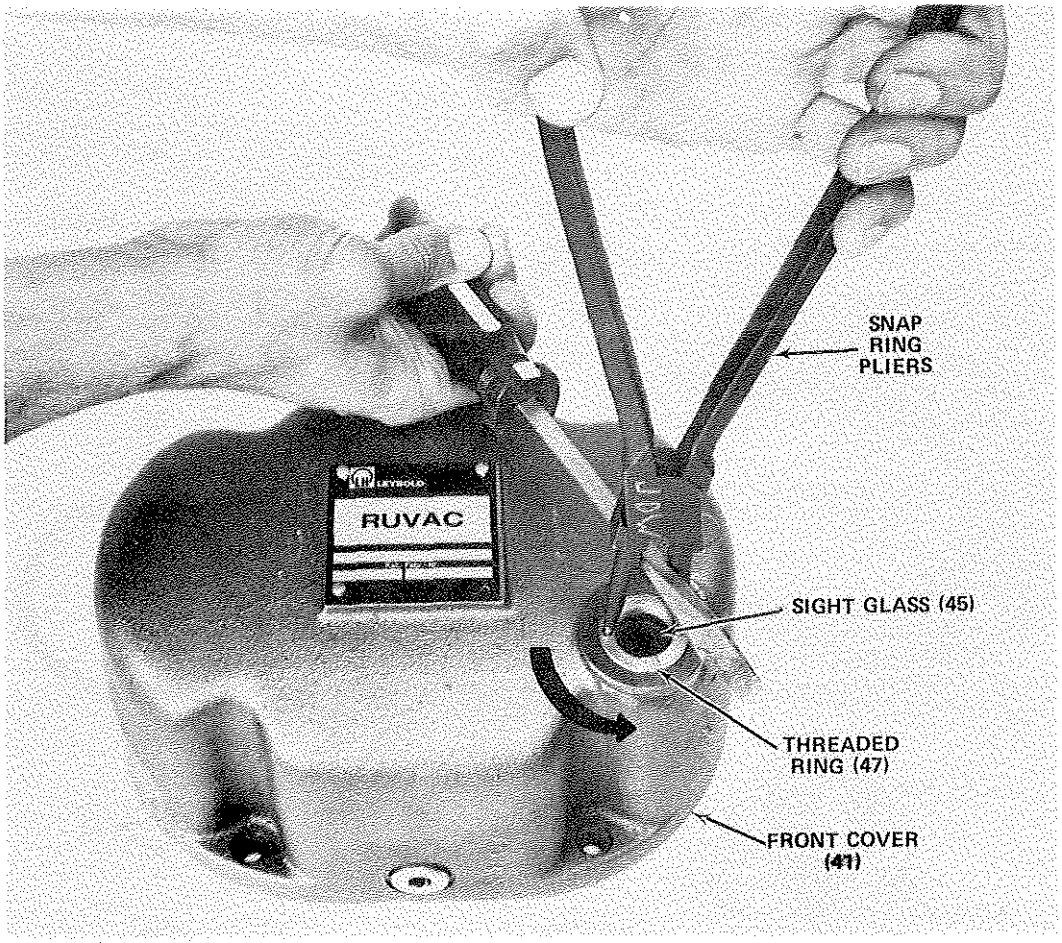


Figure 4-14. Using Snap Ring Pliers to Remove the Oil-Level-Sight-Glass Assembly from the Front Cover (WA-250 pump model shown).

Section 4-2-4 Cont.

2. **NOTE:** It is not necessary to remove the sight glass assembly unless it is damaged or leaking.
   If necessary, remove and disassemble the oil level sight glass as follows:
   a. Use one of the following three methods to remove the sight glass assembly from the front cover (41).
      Method (1) – Unscrew the assembly using a spanner which has the correct pin locations to match the two holes in the threaded ring (47).
      or
      Method (2) – (See Figure 4-14.) Place the nose ends of a large pair of snap ring pliers into the two holes in the threaded ring (47); insert a screwdriver or small bar between the nose ends of the snap ring pliers; use the screwdriver or bar to force the pliers and the threaded ring (47) to turn counterclockwise; unscrew the ring (47) from the front cover (41).
      or
      Method (3) – Place a sturdy pin, drift pin, or drill bit into each of the two holes in the threaded ring (47); cross the pins to form an "X"; insert a screwdriver or small bar through the sight-glass side of the "X"; use the screwdriver or bar to force the pins and ring (47) to turn counterclockwise; unscrew the ring (47) from the front cover (41).
   b. Remove the thrust washer (46), sight glass (45), and gasket (44) from the front cover (41) (see Figure 4-15).

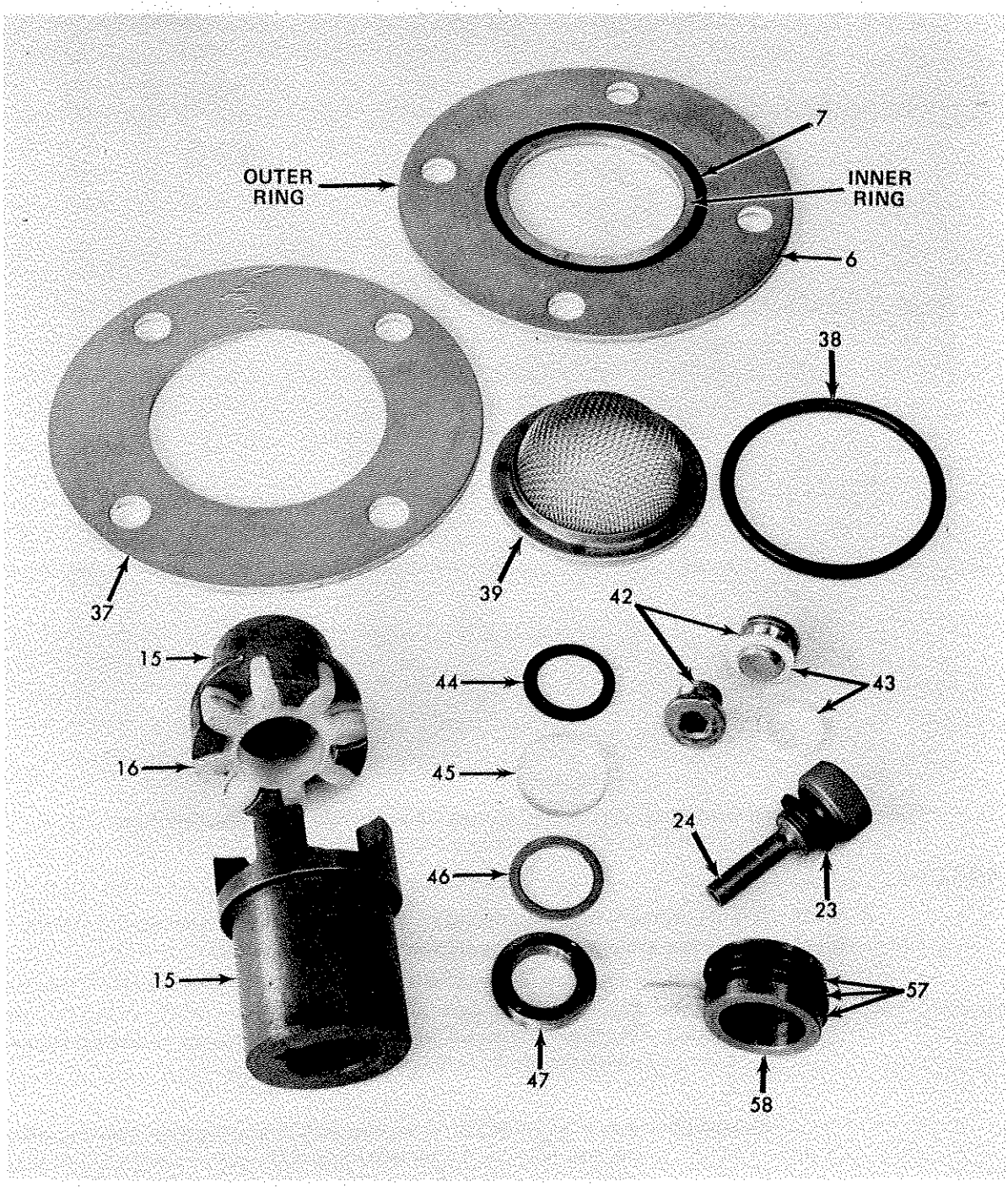
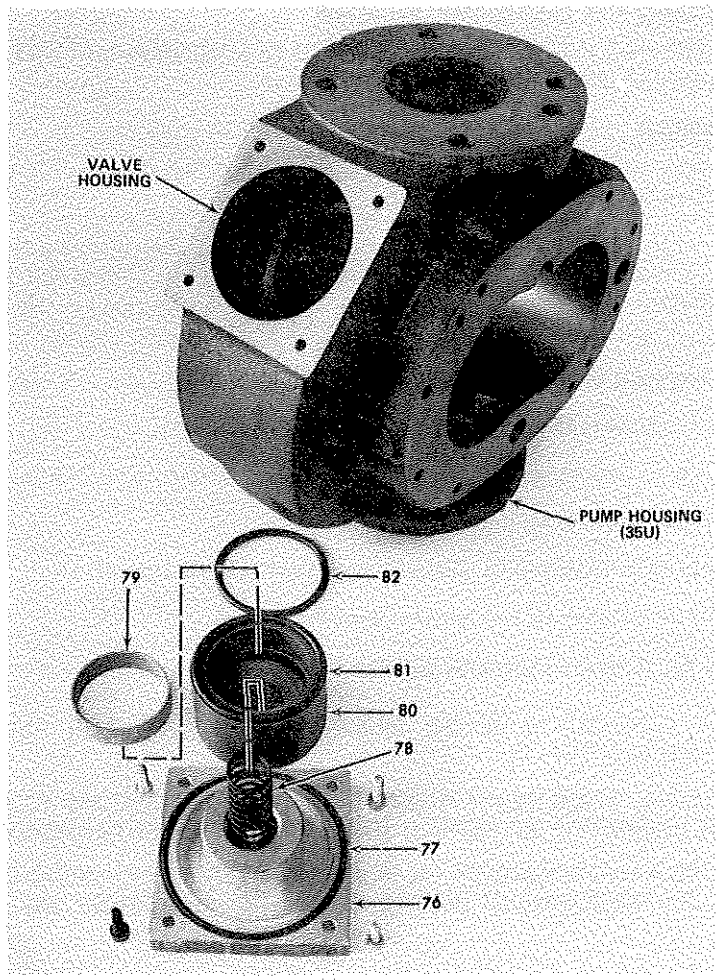


Figure 4-15. Miscellaneous Disassembled Parts (WA-250 pump model shown). 1R-7 11A

Section 4-2-4 Cont.

3. Remove the dirt trap (39) and the O-ring (38) from the intake sealing disc (37) (see Figure 4-15).
4. Remove the O-ring (7) and inner ring from the outlet sealing disc (6) (see Figure 4-15).
5. Remove the flat gasket (43) from each plug screw (42) (see Figure 4-15).
6. **For WA- and WAU-Series pumps only,** remove the flat gasket (23) from the dip stick (24) (see Figure 4-15).



NOTE: This figure applies only to WAU- and WSU-Series pumps.

NOTE: The design of the parts of the pressure relief valve differs from pump model-to-pump model; however, the parts are functionally similar. The WSU-Series pumps do not have the spring (78).

Figure 4-16. Disassembled Differential Pressure Relief Valve (WAU-250 pump model shown).

Section 4-2-4 Cont.

7. **For WAU- and WSU-Series pumps only,** remove and disassemble the differential pressure relief valve as follows (see Figures 4-16 and 4-44).

   a. Remove the socket head cap screws attaching the valve cover (76) to the pump housing (35U). Remove the valve cover.

   b. **For WAU-pump models only,** remove the spring (78) from the valve plate (80).

   c. Remove the valve plate (80) from the pump housing (35U).

   d. Remove the O-ring (77) from the valve cover (76) and the two O-rings (81/82) from the valve plate (80).

   e. **NOTE:** The WAU/WSU-150 and -2000 Series pumps have two bushings (79); all other pump models have one bushing (79).

      For WAU- and WSU-150 pump models, remove the two bushings (79) from the valve cover (76) **only if the bushings are worn.**

      For all other pump models, remove the bushing (79) from the valve plate (80) **only if the bushing (79) is worn.**

4-3 CLEANING AND INSPECTING THE DISASSEMBLED PUMP

CAUTION: THE SECTION 4-3 INSTRUCTIONS ARE FOR CLEANING PUMP PARTS. DO NOT USE THESE INSTRUCTIONS FOR CLEANING THE MOTOR.

4-3-1 General Cleaning Instructions

NOTE: It is best to clean each part just before it is assembled so that dust does not accumulate on the part between cleaning and assembly.

It is not necessary to clean parts that will not be reused. If you are disassembling the pump, we recommend installing new bearings, a new compression ring, new piston rings, and new O-rings and gaskets. If your pump has labyrinth rings, we recommend replacing the labyrinth rings with a piston ring kit (see Section 7-1 of the Spare Parts List).

Use the following cleaning steps to clean all pump parts.

1. Wash the part in triethane III, acetone, or another suitable solvent.
2. Use a wire brush to remove loose dirt and burrs. Be sure to remove burrs from the edges of parts.
3. Use Grade 220 sandpaper to sand the surface smooth.
4. Rinse the part in clean triethane III, acetone, or another suitable solvent.
5. Use compressed air to blow off any remaining solvent or dirt.

4-3-2 Special Requirements for Extreme-Corrosive Service Pumps

WARNING: STEPS 1 THROUGH 6 BELOW MUST BE FOLLOWED FOR ALL PUMPS THAT USE PERFLUOROPOLYETHER VACUUM OIL.

WARNING: DO NOT SMOKE WHEN USING FREON. FREON CAN DECOMPOSE TO A HAZARDOUS VAPOR IN THE HOT TIP OF A CIGARETTE. BE CERTAIN TO HAVE PROPER VENTILATION WHEN USING FREON.

WARNING: DO NOT USE A HYDROCARBON OIL IN PUMPS USED FOR PUMPING OXIDIZERS OR HIGHLY CORROSIVE GASES. WE RECOMMEND HE-2700 PERFLUOROPOLYETHER VACUUM OIL FOR THESE APPLICATIONS.

1. Clean all parts using the instructions in Sections 4-3-1 and 4-3-3.
2. Degrease all tools that will be used for handling degreased oxygen-service pump parts. Ensure that the working surface is free of all hydrocarbon substances.
3. Degrease all metal pump parts in Freon TF vapors.
4. Rinse all parts in Freon or another nonhydrocarbon solvent.
5. Wet all seals and all parts that go inside of the front cover or inside of the shaft seal housing with HE-2500 perfluoropolyether vacuum oil.
6. Refer to Section 4-4 to reasssemble the pump using new o-rings and gaskets, and HE-2500 vacuum oil.

4-3-3 Instructions for Cleaning and Inspecting all Pump Models

NOTE: See Section 4-3-1 for recommended cleaning solvents and methods for standard series pumps. See Section 4-3-2 for special cleaning instructions for oxygen service pumps.

Give particular attention to cleaning the following areas.

1. Inspect the O-ring grooves for burrs and dirt. Sand smooth and clean as necessary.
2. Check the tapered dowel pins (31) and impeller shafts (60) to ensure that they are perfectly straight. If a pin or shaft is bent, replace the bent part with a new part (see Figure 4-12).
3. Inspect the coupling key (14) and the shaft for burrs and scratches. Use Grade 220 sandpaper to lightly sand the shaft and remove any burrs and scratches. Clean the shaft (see Figure 4-8).

4. Sand the key (14) until it will slide easily into its slot in the drive impeller shaft (see Figure 4-8).

5. Check the impellers for marks, scoring, or flattened edges. Replace, if necessary. Use Grade 220 sandpaper to sand the edges of the impellers (60); clean the outside and inside surfaces of the impeller (see Figure 4-12).

6. Ensure that all dirt is cleaned from the inside of the oil level equalization tubes (2/36) (see Figure 4-12).

7. Check the inside of the pump housing (35) for marks. Thoroughly clean the inside of the pump housing (35). Sand the edges to remove any burrs. Make sure that the surfaces that will fit against the O-rings are clean and free of scratches (see Figure 4-16).

8. Check the surface of the end plates for burrs, impeller marks, cracks, and scratches in the bearing well. Replace, if necessary. Sand smooth with Grade 220 sandpaper and clean all the sealing surfaces on the end plates (32/40), intermediate flange (30), and the front cover (41). Ensure that the oil flow holes in the bearing wells of the end plates (32/40) and of the intermediate flange (30) are clean (see Figure 4-19). **For WA- and WAU-Series pumps only,** also sand smooth the sealing surfaces of the motor mount (20) (see Figure 4-5).

9. Test the fit of the bearings (54) in the two bearing wells in each end plate (32/40) as follows (see Figure 4-12).

    a. Slide a bearing into each bearing well.

    b. If there is resistance, remove the bearing and sand the bearing well until the bearing slides easily into the bearing well.

    c. Clean the bearing well and the bearing with a suitable solvent.

    NOTE: For the WS-2000 and all WA- and WAU-Series pumps, also use Steps 9a, 9b, and 9c to test the fit of the bearing (27) in the bearing well in the intermediate flange (30) (see Figure 4-5).

10. Use Grade 220 sandpaper to sand all new metal parts as necessary to remove burrs and then clean the parts with a suitable solvent. Lubricate the new bearings with the same type of vacuum pump fluid as will be used in the pump.

11. **NOTE:** Replace gears that have blue marks; blue spots on the gears indicate that they have been hot.

    Inspect the gears (50), shaft bushing sleeve (28), and all other parts for grooves, wear, seizing marks, scoring, etc.; replace as necessary (see Section 7-2 of the Spare Parts List).

12. Carefully sand all edges of the gear teeth to remove burrs and sharp edges and then clean the gears (50) (see Figure 4-3).

13. **This step is for WA- and WAU-Series pumps only;** inspect the prongs on the motor-side and pump-side couplings (15) for grooves. Replace the coupling with a new coupling if necessary (see Figure 4-4).

14. Ensure that the vent holes in the dip stick (24) are clear. Blow through the holes with an air gun (see Figure 4-15).

15. Order replacement parts by catalog number shown in the Spare Parts List (see Section 7-2).

4-4 ASSEMBLING THE PUMP

See the foldouts in the back of this manual for the Exploded Isometric drawings of the WAU-250 and WSU-250 pump models.

After you determine that all parts are suitable for reassembly, proceed as follows to assemble the pump.

NOTE: Anytime you tighten or loosen a nut or screw on the impeller shafts or turn the oil injector, insert a bar made of aluminum or other soft metal into the pump intake to prevent the impeller shafts from turning. Do not insert the bar through to the outlet because it could bend the oil equalization tube (2).

4-4-1 Preparing the Pump Housing and End Plates for Assembly

1. **NOTE:** Cover the outlet flange with cardboard so that it is not scratched during pump assembly. Set the pump housing (35) onto its outlet flange as shown in Figure 4-17.

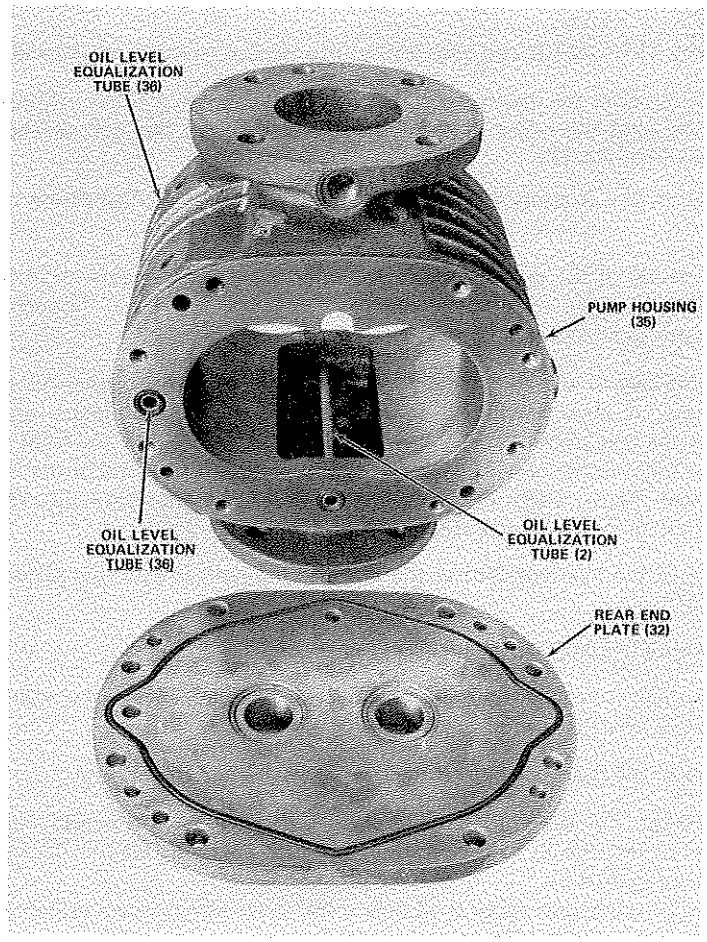


Figure 4-17. Pump Housing and Rear End Plate (WA-250 pump model shown).

Section 4-4-1 Cont.

2. If not already done, install the two short (36) and one long (2) oil level equalization tubes as follows:

   a. Insert the long tube through the lower oil equalization holes in the pump housing (see Figure 4-17).

   b. **NOTE:** One of the short oil equalization tubes (36) fits into the rear of the pump housing (35). The other short tube (36) fits into the front of the housing (35).

      Insert a short tube (36) into each of the two ends of the oil equalization hole in the side of the pump housing (see Figure 4-17).

   c. Use a structural adhesive to ensure a proper seal between the ends of the oil equalization tubes (2/36) and the pump housing. Be sure to clean off any excess adhesive.

3. **If you are installing new end plates (32/40) or are replacing labyrinth rings with piston rings on old end plates,** modify the end plates as follows:

   a. **NOTE:** All end plates on pumps using piston rings and all end plates on new pumps have the 45° hole predrilled at the factory.

      For reused end plates on pumps being converted from labyrinth rings to piston rings, proceed as follows:

      (1) Lay the end plate flat so that the side oil-equalization hole is facing you as shown in Figure 4-18.

      (2) **NOTE:** The piston ring kit (see Section 7-1) includes a plug for the evacuation hole.

      Insert the plug into the vacuum side of the evacuation hole in each end plate (see Figure 4-18), and seal it with epoxy.

(3) Drill a hole with the following characteristics into the shoulder of the lower bearing well (see Figure 4-18).

- The hole should have a 4mm diameter for theWA/WAU/WS/WSU-150,-250, and -500 pump models; the hole diameter should be 5mm for the -1000 pump models and 6mm for the -2000 pump models.
- The hole should be drilled on the outside edge of the shoulder in the lower bearing well just above the flow hole that connects the two bearing wells (see Figure 4-19).
- The hole should be at a 45° angle slanting down toward the upper bearing well (see Figure 4-19).
- The 45° hole should be drilled to a depth that allows it to intersect with the oil flow hole that connects the two bearing wells (see Figure 4-19).

TABLE 4-3. PLUG ROD PART NUMBERS

Pump Model	Part Name	Quantity Required	Catalog No.	Dimensions (mm)
WA/WAU WS/WSU				
150, 250, 500	Plug rod	2	241-03-155	4x14
1000	Plug rod	2	241-03-164	5x6x10
2000	Plug rod	2	241-03-176	6x14

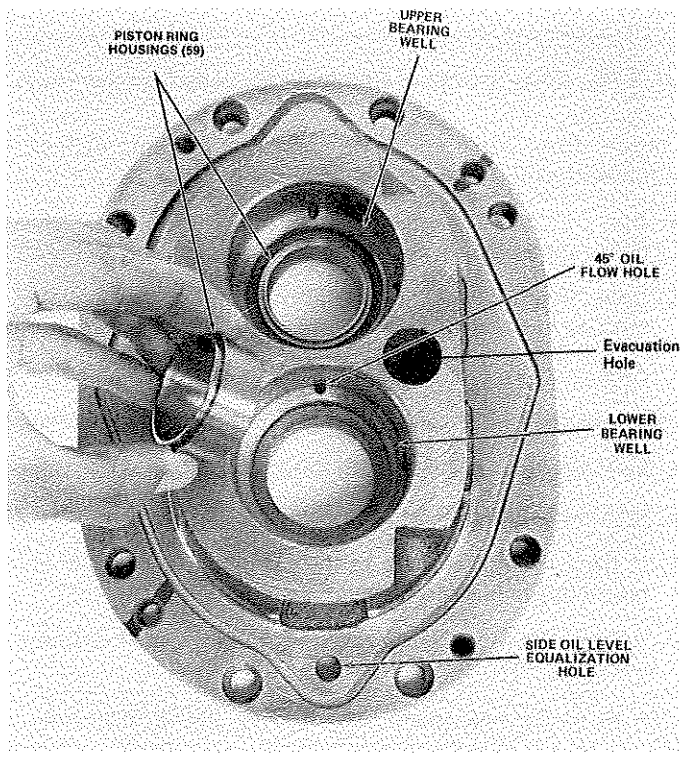


Figure 4-18. Installing the Piston Ring Housings into the End Plates (WA-250 pump model shown).

b. **For new end plates and for reused end plates on pumps being converted from labyrinth rings to piston rings,** plug a portion of the oil flow hole connecting the two bearing wells in each end plate as follows:

(1) **NOTE:** The plug rod must be the correct diameter to tightly plug the oil flow hole and must be cut to the proper length so that it does not block the 45° hole (see Figure 4-19). Table 4-3 lists the catalog number for the plug rod for each pump model.

Tap a metal plug rod into the lower-bearing-well end of the oil flow hole connecting the two bearing wells (see Figure 4-19).

(2) Sand smooth the end of the rod so that it is flush with the bearing well.

(3) Clean the bearing wells and end plate.

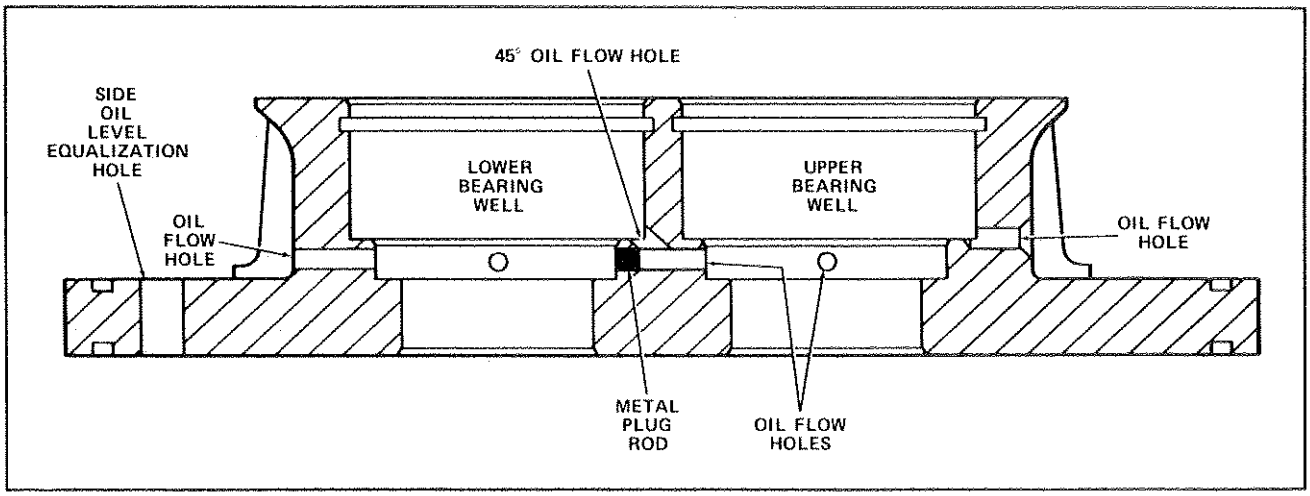


Figure 4-19. Cross Section of End Plate Showing Oil Flow Holes. 1R-5 4

4. If not already done, install a piston ring housing (59) into each of the end-plate (32/40) bearing wells as follows (see Figure 4-18).

a. Apply Loctite 271 around the ID of the bottom of each bearing well and on the mating OD of the piston ring housing (59).

b. Drive the piston ring housing (59) down into each end-plate bearing well until it bottoms out (see Figure 4-18 for the correct orientation of the piston ring housing).

c. Clean any excess Loctite from the bearing well and from all end plate surfaces.

5. Check the fit of the four piston ring holders (58) as follows (see Figure 4-20).

a. Slide a piston ring holder (58) onto the shaft on either side of each impeller (60).

b. Spin the holder (58) on each shaft.

c. If there is any resistance to the spinning, use grade 80 sandpaper to sand the ID of the piston ring holder until it spins freely on the shaft.

d. Remove the piston ring holder (58) from the shaft and rinse it with a suitable solvent (see Section 4-1-1).

6. Check the fit of the four splash rings (55) by sliding them onto the impeller shaft (see Figure 4-12). If you cannot slide the rings (55) easily, use grade 80 sandpaper to sand the ID of the splash rings (55), until they slide easily. Rinse the splash rings (55) with a suitable solvent (see Section 4-1-1).

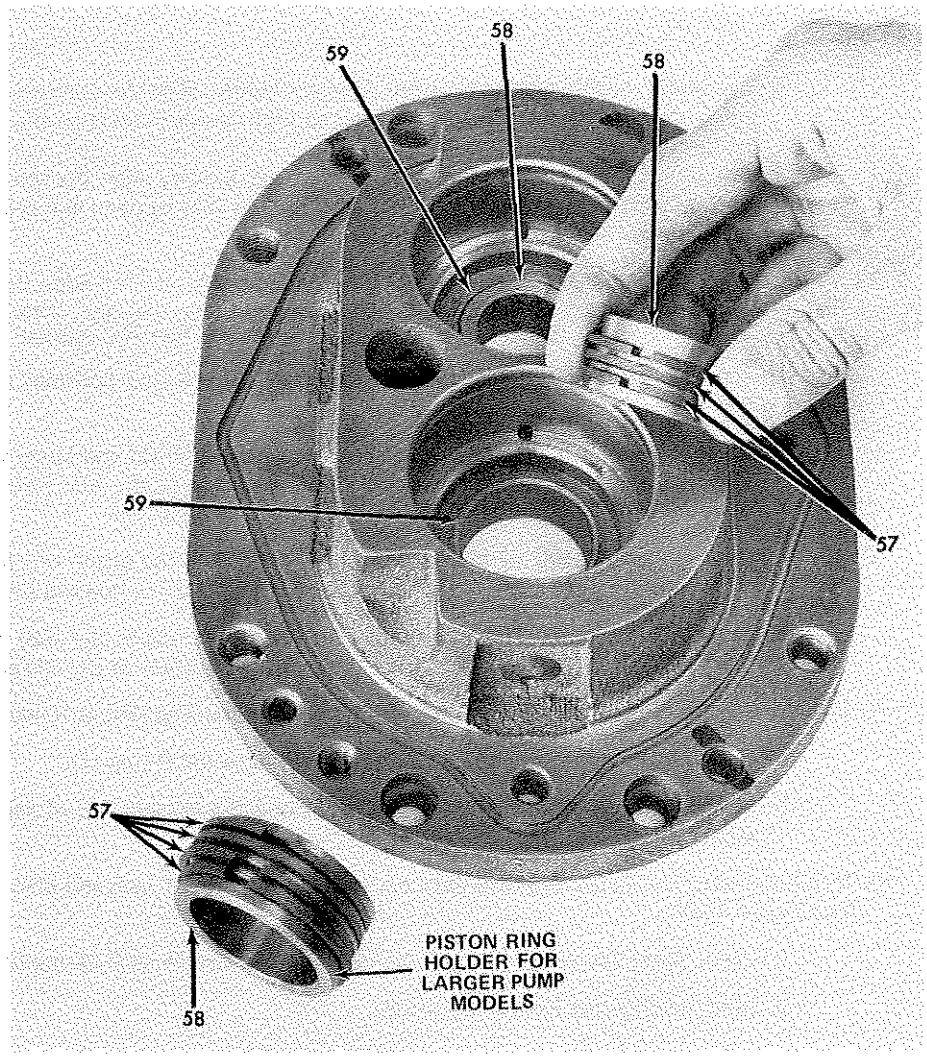


Figure 4-20. Installing the Piston Ring Holders into the End Plates (WA-250 pump model shown).

Section 4-4-1 Cont.

7. **NOTE:** The larger pumps have four piston rings per holder; the smaller pumps have three (see Figure 4-20).

   Install the piston rings (57) as follows (see Figure 4-20).

   a. Check if each piston ring (57) is the correct size by sliding each one into a piston ring housing (59) in an end plate (32/40). If the piston ring is too large to slide easily into the housing, file the open ends of the piston ring until it slides easily into the piston ring housing.

   b. **NOTE:** It is easier to insert the slotted end of the piston ring into the groove first and then push the remainder of the ring into the groove.

      First insert a piston ring (57) into the middle groove(s) and then insert one into each outer groove in the piston ring holders (58).

   c. After the piston rings are installed, check to see if the rings (57) are bent by pushing them tight against the piston ring holder (58) on one side of the holder, and then releasing them. If a ring does not fall back into its groove when released, it is bent or twisted; straighten any twisted rings.

d. **For pump models with four piston rings per holder,** align the open ends of the four piston rings; then rotate the third piston ring so that its open end is on the opposite side of the holder (58) (see Figure 4-20).
For pump models with three piston rings per holder, align the open ends of the three piston rings; then rotate the middle ring (57) so that its open end is on the opposite side of the holder (58) (see Figure 4-20).

8. NOTE: The end of the piston ring holder (58) that has the beveled edge on the ID is the end that faces the machined surface of the end plate. Ensure that the outer end of the piston ring holder is smooth so that it doesn't damage the O-ring that fits against it.

   Insert the four piston ring holders (58) into the four piston ring housings (59) as follows (see Figure 4-20).

   a. Reach through the bearing well of each end plate (32/40) and insert a piston ring holder (58) into the piston ring housing (59) until one side of the first piston ring is inside the housing (59) and the other side of the first piston ring is free.

   b. Depress the free side of the piston ring (57) and push the piston ring holder (58) into the housing (59) until all of the first piston ring is inside of the housing (59).

   c. Repeat Steps 7a and 7b for the other piston rings on the holder (58) until the end of the holder (58) is indented slightly from the machined surface of the end plate (32/40).

9. Install the four O-rings (1) into their grooves in the pump housing (35) as follows:

   a. Clean and apply the correct vacuum pump fluid to the O-ring (1).

   b. Insert an O-ring into the O-ring groove around the outside end of each oil level equalization tube (2/36) (see Figure 4-22).

10. Install the large O-ring (3) into its groove on the inside surface of each end plate (32/40) as follows (see Figure 4-22).

    a. Clean, apply the correct vacuum pump fluid, and stretch each O-ring (3).

    b. Insert each O-ring (3) into its groove.

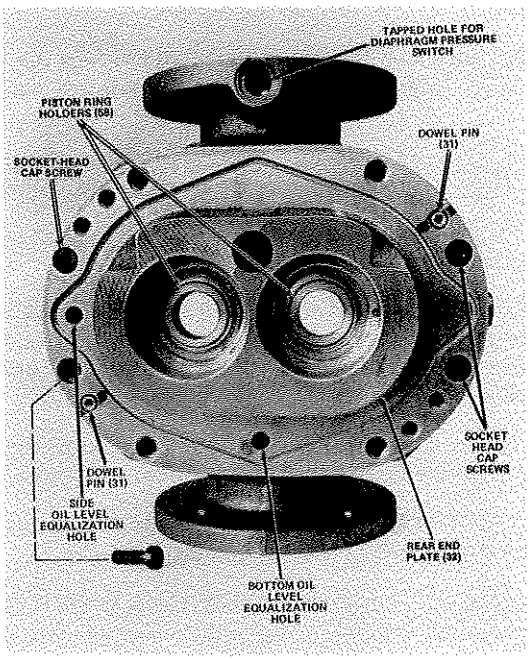


Figure 4-21. Rear End Plate Installed on the Pump Housing (WA-250 pump model shown).

4-4-2 Installing the End Plates and Impellers and Checking the Axial Gap

NOTE: For WA- and WS-Series pumps, the side of the intake flange with a tapped hole for the diaphragm pressure switch (11) is the rear end (the motor end) of the pump (see Figure 4-21).

For WAU- and WSU-Series pumps, there is a plug screw in the tapped hole just below the pump intake on the rear end (motor end) of the pump.

1. **CAUTION:** FAILURE TO INSTALL EACH END PLATE ON THE CORRECT SIDE OF THE PUMP HOUSING WILL RESULT IN DAMAGE TO THE PUMP.

   NOTE: The only difference between the two end plates is the location of the mating holes for the side oil level equalization tubes. The side hole is on the right on one end plate and on the left on the other end plate. **Make sure that both the side and bottom holes in the end plate align with the side and bottom oil level equalization tubes in the pump housing.** If both holes cannot be aligned with both tubes, it means that the end plate is on the wrong side of the pump housing.

   NOTE: The machined surface is the inside surface of the end plate.

   NOTE: If you are installing a new end plate (32/40) or a new pump housing (35), the dowel pin holes have not been reamed out, therefore, skip Steps 1a, 1b, and 1d for now.

   CAUTION: FAILURE TO ENSURE THAT THE O-RINGS ON THE END PLATE AND AT THE END OF THE OIL LEVEL EQUALIZATION TUBES REMAIN IN THEIR GROOVES COULD RESULT IN DAMAGE TO THE O-RINGS AND POOR PUMP PERFORMANCE.

   REQUIRED ACTION: Install the rear end plate (32) onto the pump housing (35) as follows (see Figure 4-21).

   a. Insert the narrow end (the end without the internal threads) of the tapered dowel pins (31) into the two alignment holes in the rear end plate (32).

   b. **NOTE:** The top of the end plate has two oil slots, each with an oil flow hole.

      Align the tapered dowel pins extending out of the end plate (32) with the alignment holes in the pump housing (35) and attach the plate to the housing (35) (see Figures 4-21 and 4-22).

   c. **NOTE:** Hold the end plate tight against the pump housing so that the O-rings (1/3) cannot slip out of their grooves while attaching the end plate.

      Screw the four socket head cap screws finger-tight to secure the end plate to the pump housing.

   d. **NOTE:** Do not drive the dowel pins in hard or they will be difficult to remove.

      Use a punch to **tap** the dowel pins (31) until they are seated in their alignment holes.

   e. Tighten the four screws installed in Step 1c.

2. **NOTE:** Both impellers should be installed into the pump housing so that the lobes are vertical for now (see Figure 4-22).

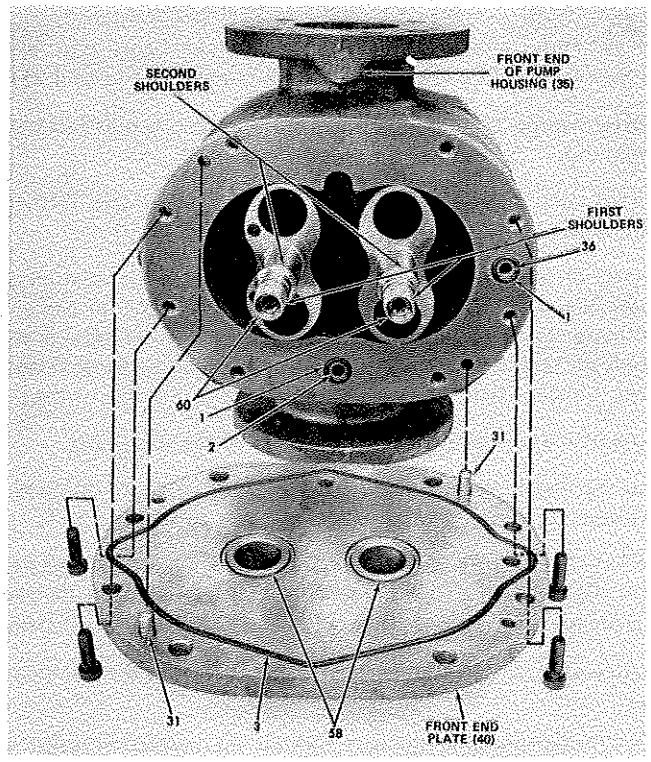
   NOTE: Make sure that the piston ring holders (58) are not pushed out when inserting the impellers. If a piston ring holder is pushed out, insert it back into position after the impellers are installed (see Figure 4-21).

   REQUIRED ACTION: Install the impellers (60) as follows (see Figure 4-22).

   a. Looking from the open end of the pump housing, insert the nonthreaded end of the impeller (60) that has the shorter shaft through the left piston ring holder in the rear end plate (32).

   b. Insert the longer end of the drive impeller (60) (the impeller that has the longer shaft) through the other piston ring holder (58) in the rear end plate (32).

3. Repeat Step 1, except install the front end plate (40) onto the front end of the pump housing (see Figure 4-22).



NOTE: The impellers (60) shown in this figure are not the solid type.

Figure 4-22. Installing the Impellers and Front End Plate.

Section 4-4-2 Cont.

4. Slide an O-ring (56) over both ends of the two impeller shafts (60) until each O-ring (56) is tight against the piston ring holder (58) (see Figure 4-12).

5. **NOTE:** When installed correctly, the narrower end (the neck) of the splash ring (55) faces the outside of the pump.

   Slide a splash ring (55) over each of the two impeller shafts (60) extending out of the **front** end plate (40) until each splash ring (55) is tight against the O-ring (56) (see Figure 4-12).

6. Install a new ball bearing (54) into the two bearing wells in the front end plate (40) as follows:

   a. Apply the correct vacuum pump fluid to the bearings, the ID of the bearings, and to the shafts.

   b. Slide a ball bearing (54) over each of the two impeller shafts (60) extending out of the front end plate (40).

   c. **NOTE:** The thickness of the feeler gauge used in this step should be within the tolerance shown for the corresponding axial gap for your pump model in Table 4-4.

      Place the feeler gauge through the pump intake so that it is between the end of the impeller and the end plate; the feeler gauge must be placed on the opposite end of the impeller from where you are installing the bearing (see Figure 4-23). For example, before pressing a bearing into the front end plate (40) on the drive impeller shaft of a WA-250 pump model, insert a 0.2-mm or 0.008-inch feeler gauge between the end of the drive impeller and the rear end plate (32).

   d. Press fit a bearing into each bearing well. If a press is not available, use a hammer and a pipe that has the same ID and OD as the **inner** bearing race to drive the bearing until it is tight against the splash ring (55) (see Figure 4-23).

   e. Remove the feeler gauge that you inserted in Step 6c.

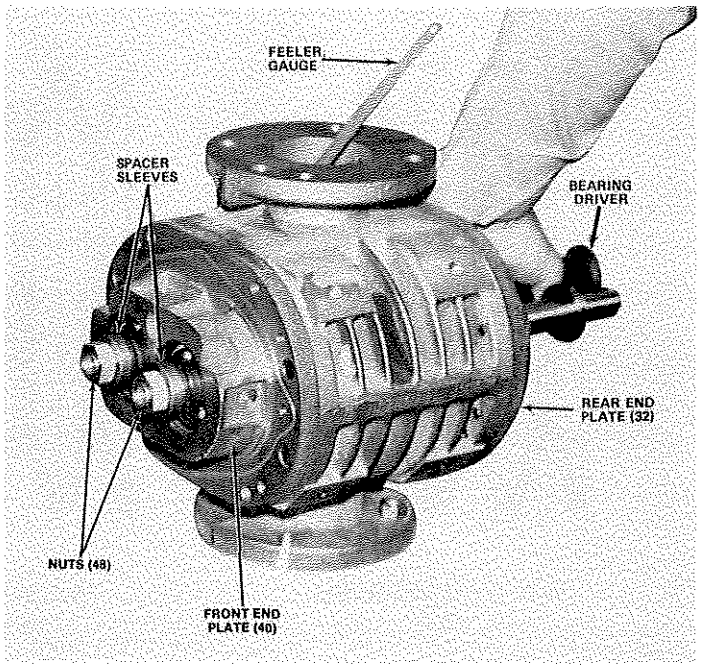


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Figure 4-23. Installing a Bearing in the Rear End Plate (WA-250 pump model shown).

TABLE 4-3A - DIMENSIONS FOR SPACER SLEEVE TOOLS FOR INSTALLING BEARINGS

WA/WAU/WS/WSU Pump Models	Spacer Tubing Diameter (inches)	Spacer Length (inches)	#126 Metric Washer
RUVAC 150/250	1 1/4 Dia. x 1/8 wall	1 1/8	M18
RUVAC 500	1 1/2 Dia. x 1/8 wall	1 1/2	M24
RUVAC 1000	1 3/4 Dia. x 5/32 wall	1 7/8	M27
RUVAC 2000	2 Dia. x 3/16 wall	2 1/2	M30

7. Install a spacer sleeve, a #126 metric washer (see Table 4-3A), and the nut onto each of the two impeller shafts which extend out of the front-end-plate (40) (see Figure 4-23); the nut, washer, and spacer sleeve hold the front-end-plate bearings in place while you drive the bearings into the rear-end-plate in Step 8.
8. Repeat Steps 5 and 6, except install a splash ring (55) and ball bearing (54) onto each of the two impeller shafts which extend out of the rear end plate (32) (see Figure 4-23).
9. Remove the nut and spacer sleeve from the two shafts which extend out of the front end plate (40) (see Figure 4-23).
10. **For WA/WAU- and WS/WSU-1000 and -2000 pump models only,** install the distance ring (61) over the drive shaft and into the bearing well in the rear end plate (32), until it is against the bearing (54).
11. Install spring washers into **each of the two bearing wells** in the rear end plate (32) as follows:
    a. Test the spring washers (62) to ensure they have sufficient spring.
    b. Proceed as follows to insert the spring washers (62).
        (1) Place each set of two spring washers (62) together so that the ID's are tight against each other and so that there is a gap between the OD's (see Figure 4-24).
        (2) Slide the spring washers onto the shaft until they fit against the bearing in the rear end plate (32). The quantity of spring washers needed in each rear-end-plate bearing well is four for the WA/WAU/WS/WSU -150 and -250 pump models, six for the WA/WAU/WS/WSU -500 models, and eight for the WA/WAU/WS/WSU -1000 and -2000 models.

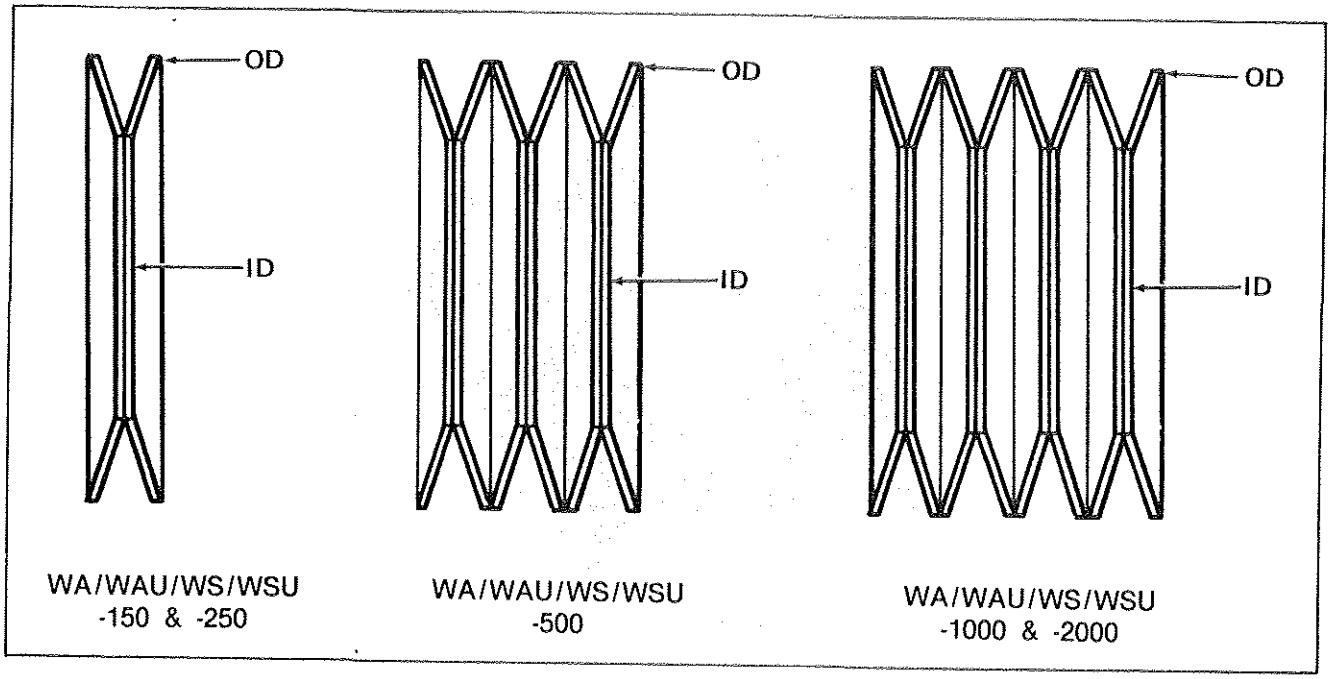

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Figure 4-24. Spring Washer Arrangement, Side View.

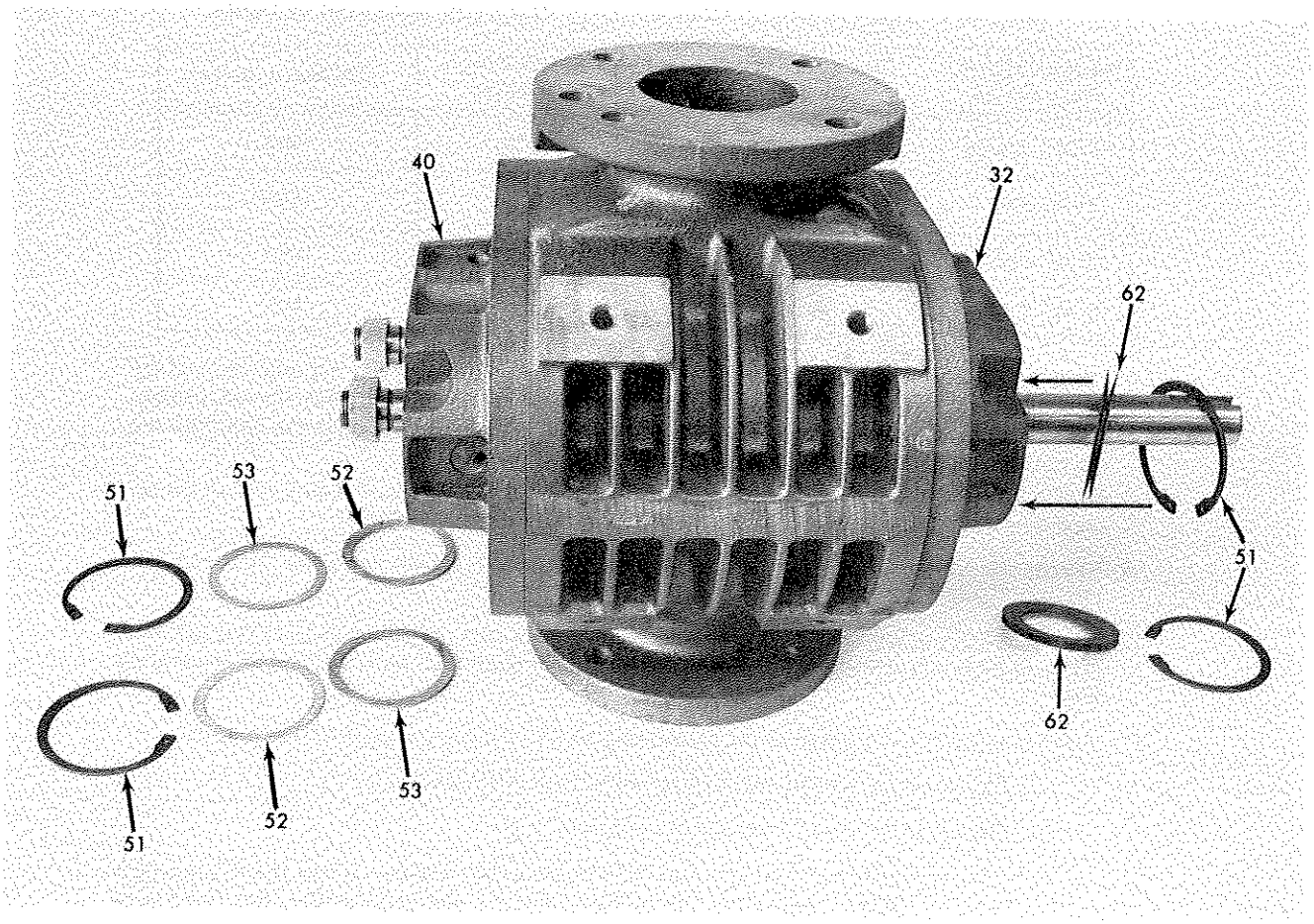


Figure 4-25. Installing Spring Washers, Retainer Rings, Shims, and Spacers in the Bearing Wells of the End Plates (WA-250 pump model shown).

1R-4.7A

12. Use a large pair of snap ring pliers to install a retainer ring (51) into the retainer ring slot in **each of the two bearing wells** in the **rear** end plate (32) (see Figure 4-25).

13. **NOTE:** A shim set is necessary to do Step 13. The catalog numbers for shim sets are listed in Section 7-1 of the Spare Parts List.

    Install a shim (52) and a spacer (53) into each of the two bearing wells in the **front** end plate (40) as follows (see Figure 4-25).

    a. Slide a shim (52) and then a spacer (53) onto the shaft until they fit against the bearing in the front end plate.

    b. Use a large pair of snap ring pliers to install a retainer ring (51) into the retainer ring slot in **each of the two bearing wells** in the front end plate (40) (see Figure 4-25).

    c. **NOTE:** The clearance between the ends of the impellers (60) and the front (40) and rear (32) end plates is referred to as the axial gap.

    NOTE: Before measuring the axial gap on the front end of the pump, it may be necessary to push the front end of the shaft (see Figure 4-26), insert the feeler gauge between the end of the impeller and the front end plate (40), and then pull the front end of the shaft to ensure that it is not binding.

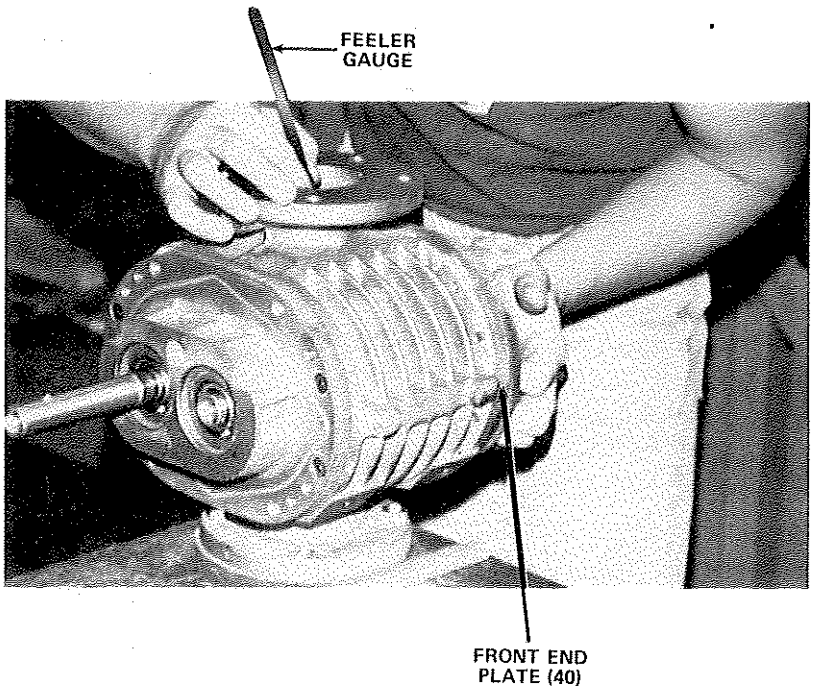
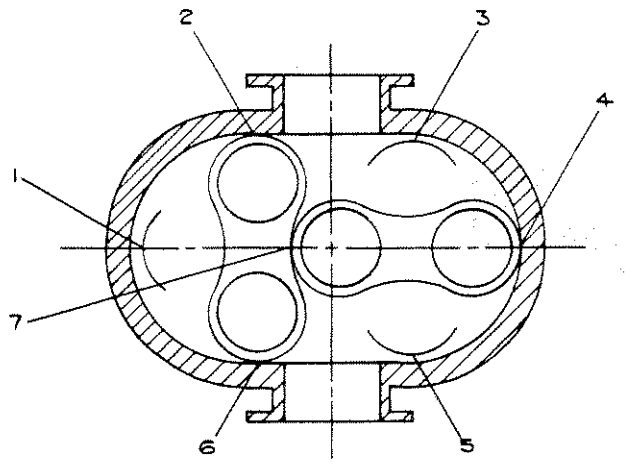


Figure 4-26. Measuring the Axial Gap Between the End of the Impeller and the Front End Plate (WA-250 pump model shown).

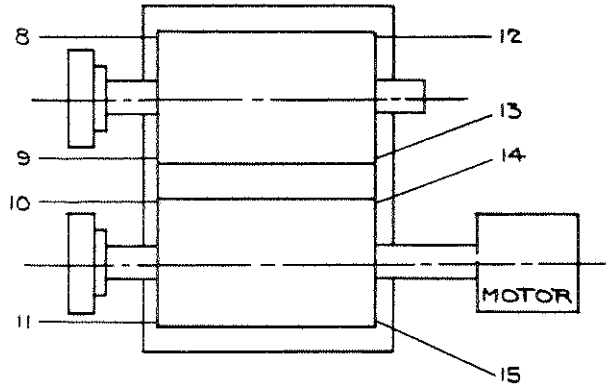
REQUIRED ACTION: Reach through the intake of the pump housing with a feeler gauge and measure the axial gap on both ends of each impeller while the impellers (60) are resting freely.

d. If the axial gap is not within the tolerance listed for your pump model in Table 4-4, remove the retainer rings (51) and spacers (53) from the bearing wells in the front end plate (40), replace the shim in each bearing well (52) with a thicker or thinner shim as necessary, reinstall the retainer ring and spacer, and recheck the axial gap. Continue changing the shims and rechecking the axial gap until the gap is within the tolerance.

TABLE 4-4. CRITICAL IMPELLER TOLERANCES



MEASURING POINTS



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Pump Model	Circumferential Gap Measuring Points 1-6*	Top Clearance 7*	AXIAL GAP GEAR (FRONT) END 8-11*		AXIAL GAP MOTOR (REAR) END 12-15*	
			WA/WAU	WS/WSU	WA/WAU	WS/WSU
WA/WAU-150 WS/WSU-150 mm (in.)	0.09 to 0.12 (0.0035 to 0.0047)	0.15 to 0.22 (0.0059 to 0.0087)	0.05 to 0.07 (0.0020 to 0.0028)	0.05 to 0.07 (0.0019 to 0.0028)	0.16 to 0.21 (0.0063 to 0.0083)	0.16 to 0.21 (0.0063 to 0.0083)
WA/WAU-250 WS/WSU-250 mm (in.)	0.09 to 0.12 (0.0035 to 0.0047)	0.15 to 0.22 (0.0059 to 0.0087)	0.08 to 0.10 (0.0032 to 0.0039)	0.08 to 0.10 (0.0032 to 0.0039)	0.20 to 0.25 (0.0079 to 0.0098)	0.20 to 0.25 (0.0079 to 0.0098)
WA/WAU-500 WS/WSU-500 mm (in.)	0.14 to 0.17 (0.0055 to 0.0067)	0.18 to 0.26 (0.0071 to 0.0102)	0.10 to 0.12 (0.0039 to 0.0047)	0.10 to 0.12 (0.0039 to 0.0047)	0.30 to 0.35 (0.0118 to 0.0138)	0.30 to 0.35 (0.0118 to 0.0138)
WA/WAU-1000 WS/WSU-1000 mm (in.)	0.18 to 0.23 (0.0071 to 0.0091)	0.25 to 0.32 (0.0098 to 0.0126)	0.15 to 0.20 (0.0059 to 0.0079)	0.15 to 0.20 (0.0059 to 0.0079)	0.40 to 0.45 (0.0158 to 0.0177)	0.40 to 0.45 (0.0158 to 0.0177)
WA/WAU-2000 WS/WSU-2000 mm (in.)	0.23 to 0.30 (0.0091 to 0.0118)	0.22 to 0.30 (0.0087 to 0.0118)	0.15 to 0.20 (0.0059 to 0.0079)	0.15 to 0.20 (0.0059 to 0.0079)	0.63 to 0.68 (0.0248 to 0.0268)	0.63 to 0.68 (0.0248 to 0.0268)

*See sketch for measuring points

4-4-3 Installing the Gears and Intermediate Flange and Adjusting the Impeller Tolerances

1. **NOTE:** Failure to remove all burrs or sharp edges from the gears could result in noisy operation of the pump and could change the impeller clearances.

   Install the gears (50) onto the two shafts which extend out of the front end plate (40) as follows:

   a. Align the impellers (60) as follows (see Figure 4-27).

      (1) Turn the impellers until the number written toward the center of the one impeller is as close as practicable to the matching number on the other impeller.

      NOTE: On some older impellers, the number written toward the center of each impeller may not be visible; in this case, turn the impellers so that the lobe of one impeller is against the waist of the other impeller.

      (2) **NOTE:** The thickness of the feeler gauge used in this step should be the minimum figure for your pump model in the top clearance column of Table 4-4.

      Insert a feeler gauge between the two impellers as shown in Figure 4-27. Position a bar made of soft metal into the pump intake to prevent the impellers from turning and to keep the two impellers tight against the feeler gauge until the gears and nuts are installed.

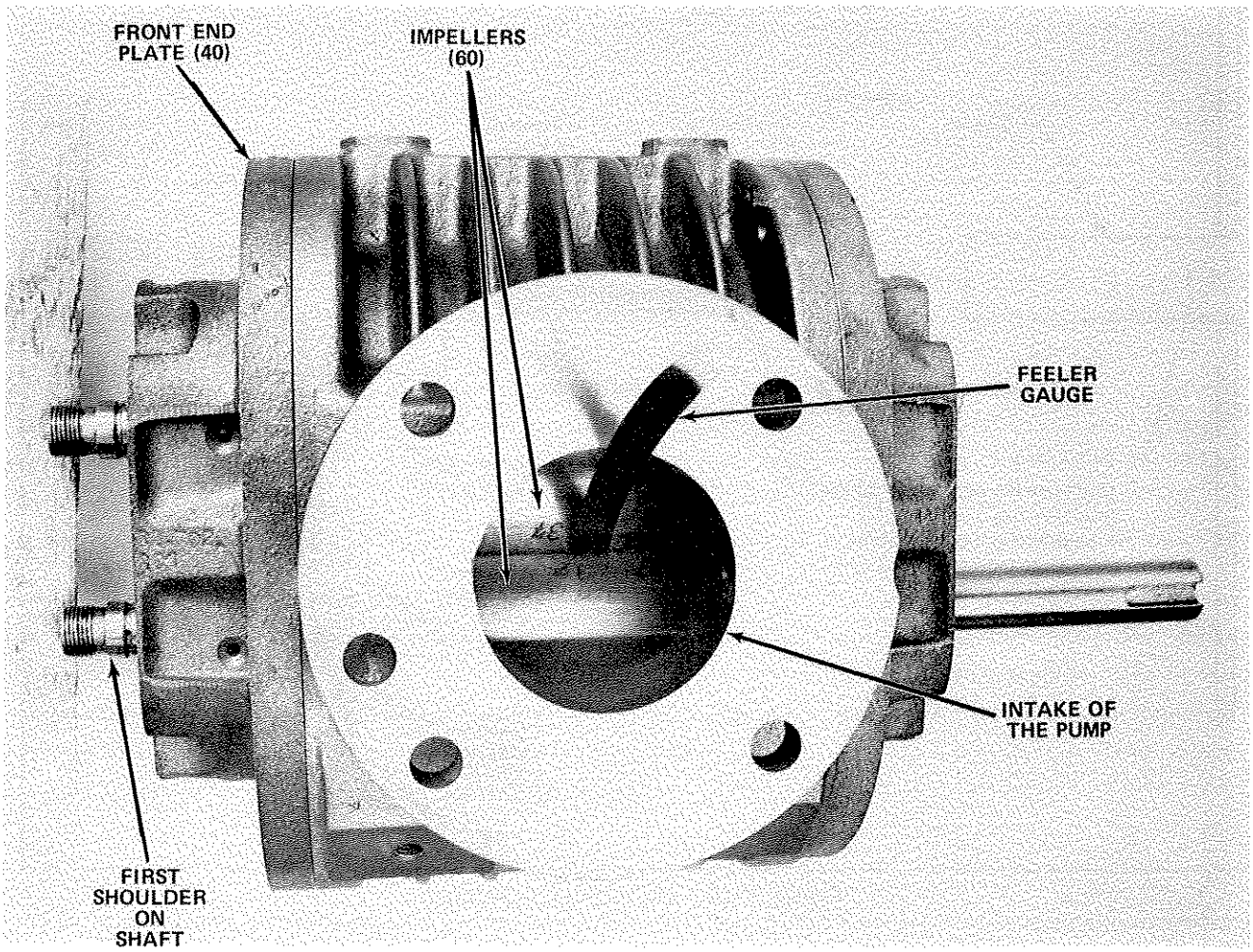

Figure 4-27. Aligning the Impellers (WA-250 pump model shown). 1R-10.17A

b. Wet the ID of the gears and the tapered part of both shafts with the correct vacuum pump fluid (see Section 4-1-1).

c. **NOTE:** The side of the gear with the scribe line and number is the surface that faces the **outside** of the pump.

Looking toward the front end plate (40), slide the thinner gear onto the left shaft so that the scribe line is positioned as shown in Figure 4-29.

d. **NOTE: For WA/WAU/WS-2000 pump models only,** install the washer (Cat. No. 627-05-445) onto the pump shaft just before the nut.

Clean the threads of the shaft and nut, apply Loctite 271 to the threads on the left shaft, and install and tighten the nut (48) onto this shaft until it is tight.

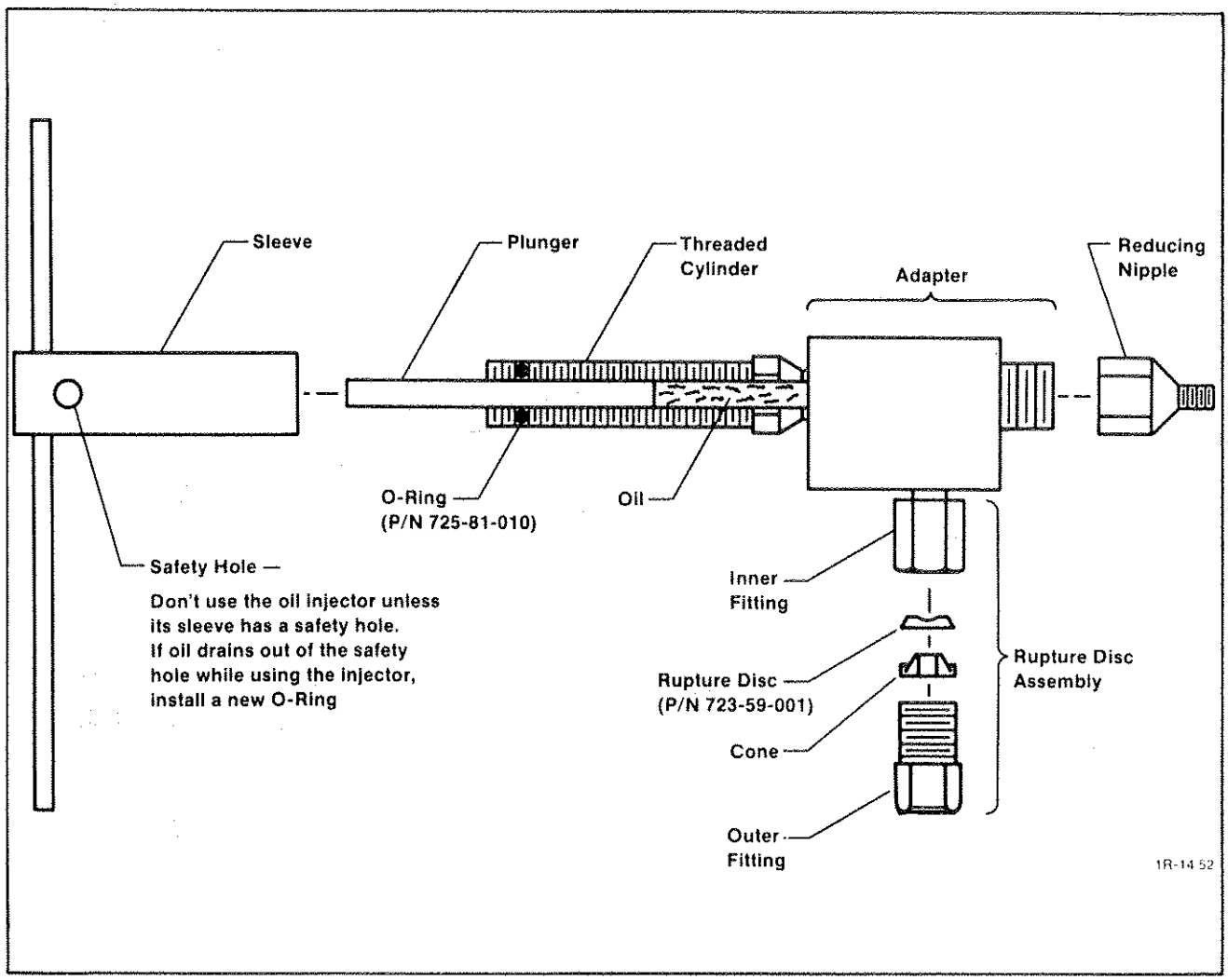

Figure 4-28. Oil Injector Assembly

e. **WARNING:** Never use the oil injector if it hasn't been modified with the safety hole and rupture-disc assembly. See the oil injector instructions (P/N 722-78-034) for important safety instructions.

NOTE: Use the same type of vacuum pump fluid for the oil injector as you will be using in the pump.

Install the oil injector onto the end of the left shaft as follows (see Figure 4-28).

(1) Unscrew the threaded cylinder from the oil injector sleeve until 3/4 of the threads on the cylinder are exposed. Apply vacuum grease to the threads on the cylinder.

(2) Push the plunger, which is in the center of the cylinder, back until it bottoms out in the sleeve.

(3) Tilt the threaded cylinder/sleeve assembly back and fill the hole in the center of the cylinder with the correct vacuum pump fluid.

(4) **NOTE:** The threaded cylinder, valve nipple, and reducing nipple must be screwed together tightly to ensure an oil tight seal.

Attach the valve nipple to the oil injector and the reducing nipple to the valve nipple

(5) **NOTE: For WA/WAU/WS-2000 pump models only,** screw the oil injector into the threaded hole on the gear rather than into the end of the shaft.

Screw the oil injector assembly into the threaded hole in the end of the shaft (see Figure 4-28).

(6) If you need to refill the oil injector, proceed as follows:

(a) Unscrew the sleeve from the threaded cylinder and leave the threaded cylinder and nipple(s) attached to the shaft.

(b) Remove the plunger from the threaded cylinder.

(c) **NOTE:** Be prepared to catch the excess fluid which will drip out of the oil injector during Step (c).

Fill the threaded cylinder with the correct vacuum pump fluid, insert the plunger into the end of the threaded cylinder, and screw the sleeve onto the threaded cylinder.

f. Determine if the gear is positioned correctly as follows:

(1) Place a straightedge so that its one side abuts against the first shoulder (see Figure 4-27) of the right (drive) shaft and its other end rests against the outside surface of the gear on the left shaft.

(2) Using a feeler gauge, read the widest gap between the straightedge and the gear. The gap between the straightedge and the gear on the left shaft will be widest near the gear teeth that are closest to the right (drive) shaft. If the gear on the left shaft is positioned correctly, the widest gap will be between 0.1 and 0.2mm (0.004 and 0.008 inch).

g. **If the gear is not positioned correctly as determined in Step f,** proceed as follows:

(1) WARNING: DO NOT STAND BEHIND THE OIL INJECTOR WHEN IT IS INSTALLED ON THE SHAFT. THE HIGH OIL PRESSURE INSIDE OF THE INJECTOR AND SHAFT CAN CAUSE THE INJECTOR TO FLY OFF OF THE SHAFT CAUSING DAMAGE OR INJURY. BE SURE TO WEAR SAFETY GLASSES.

NOTE: The oil injector forces pump fluid through the center of the shaft and into the groove in the OD of the shaft underneath the gear.

NOTE: When using the oil injector, be prepared to catch the excess pump fluid.

While supporting the reducing nipple with an open end wrench, turn the oil injector handle clockwise until the fluid pressure has built enough to float the gear on the tapered shaft.

(2) Tighten the nut (48) to force the gear (50) farther onto the shaft as necessary.

(3) Repeat Step f to check if the gear is positioned correctly on the shaft. If not, repeat Step g.

h. Remove the oil injector, including nipple(s), from the left shaft.

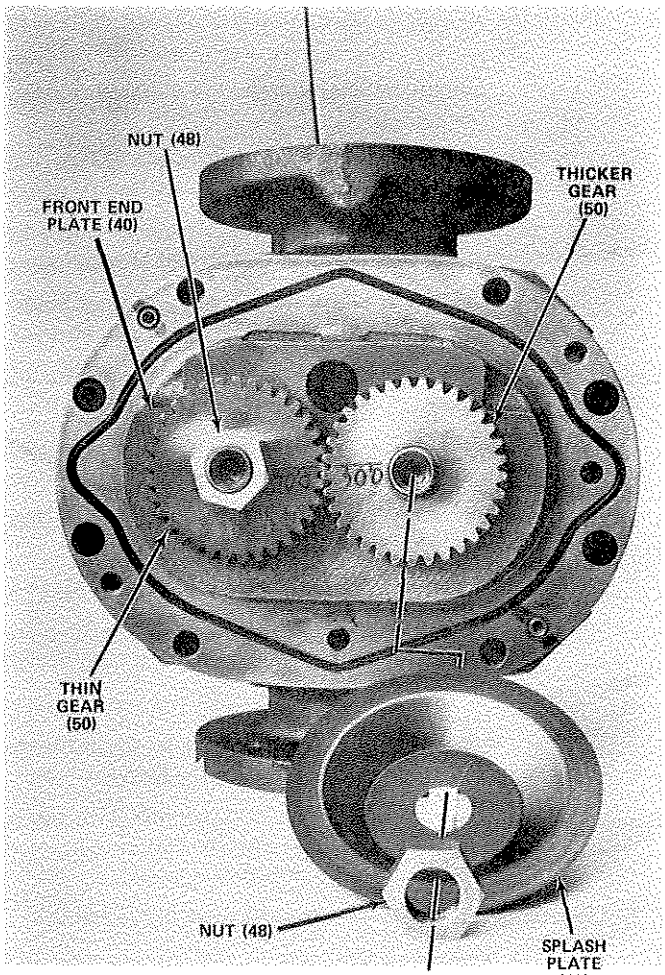

Figure 4-29. Gears Installed on the Pump with the Scribe Lines Aligned (WA-250 pump model shown).

i. Install the gear onto the right (drive) shaft extending out of the front end plate (40) as follows:

(1) **NOTE:** The scribe marks are on the outside surface of the gear.

Slide the thicker gear onto the right (drive) shaft so that the scribe lines on the outside of the two gears are aligned with each other as shown in Figure 4-29.

(2) Install and tighten the nut (48) onto the drive shaft.

(3) Using a straightedge, ensure that the outside surfaces of the two gears are exactly flush with each other. If they are not flush, repeat Step e to install the oil injector onto the right (drive) shaft, turn the oil injector handle clockwise, tighten or loosen the nut (48) as necessary to position the gear correctly, and remove the oil injector.

j. Remove the feeler gauge and bar from between the impellers (see Figure 4-28).

2. **NOTE: This step is necessary only if you are installing a new end plate (32/40) or the pump housing (35) is new.**

   Using a feeler gauge, check the circumferential gap at locations 1 through 6 shown on the sketch in Table 4-4; check the circumferential gap near the front end (gear end) and also near the rear end (motor end) of the impellers. **If all the gaps are within the tolerances shown in Table 4-4,** skip Steps 2a through 2d and proceed with Steps 2e through 2g. **If a gap is not within the tolerance shown in Table 4-4,** proceed as follows:

   a. Tap the edge of the front end plate (40) as necessary to adjust the circumferential gap.

   b. Use a feeler gauge to recheck the circumferential gaps near the front end (gear end) of the impellers.

   c. If a gap is not within the tolerances, repeat Steps 2a and 2b until the gaps are correct.

   d. Repeat Steps 2a through 2c for the rear end plate (32) and the circumferential gap near the rear end of the impellers.

   e. Lock the end plates in place on the pump housing (35).

   f. Ream out the alignment holes to the correct diameter and clean the end plate (32/40).

   g. **NOTE:** Do not drive the dowel pins in too hard or they will be difficult to remove.

      Insert and tap the dowel pins (31) into the alignment holes.

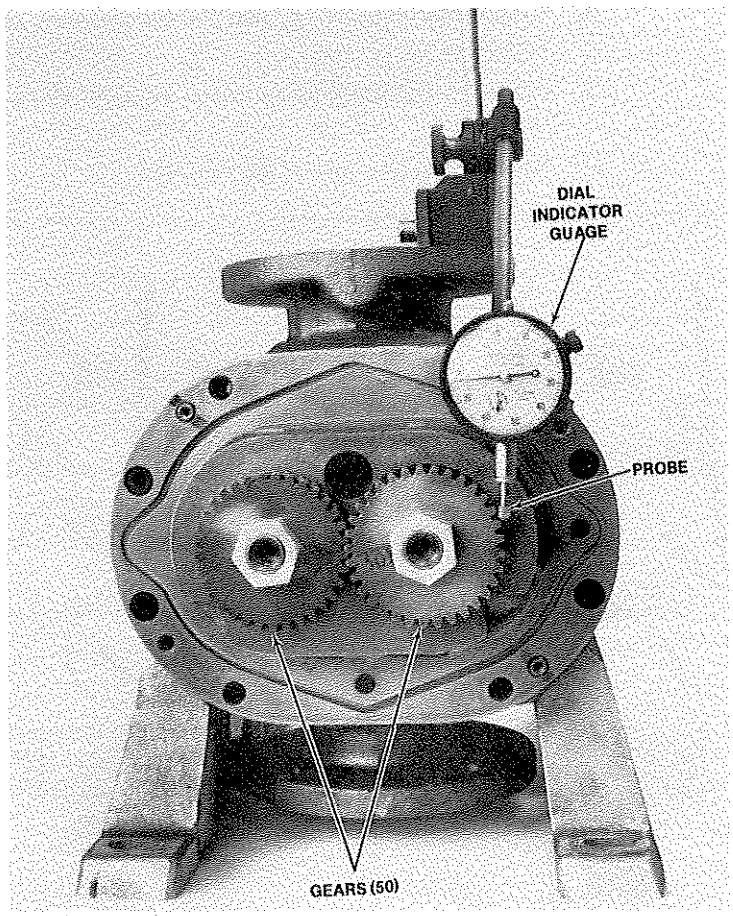

Figure 4-30. Using a Dial Indicator to Read the Gear Play for Reused Gears (WA-250 pump model shown).

3. **NOTE:** Read and follow the instructions in Step 3 carefully to ensure that the tolerance is set correctly.

   NOTE: There is usually one location (a tight spot) between the impellers where the clearance is the smallest. Use this tight spot as the measuring point when determining the clearances.

   Check and adjust the clearance between the impellers as follows:

   a. **NOTE:** The gear play number etched on the outside of the gears is in millimeters.

      NOTE: If the gears are new, the number etched on the outside of the gears is the gear play; therefore, it is not necessary to do Steps a(1) and a(2) (see Figure 4-29).

      If you are reusing the old gears, proceed as follows to determine the gear play (see Figure 4-30).

      (1) Position a dial indicator gauge so that its probe is contacting one of the gear teeth.

      (2) While holding the impellers stationary, move the gears (50) and read the gear play from the dial indicator gauge.

   b. **NOTE:** The clearance between the top of the drive impeller and the bottom of the other impeller **(see Figure 4-31A)** is referred to as the top clearance.

      Use feeler gauges to determine the top clearance as follows (see Figure 4-31A):

      (1) Position the impellers so that the top clearance can be measured (see Figure 4-31A).

      (2) Check the top clearance at several locations along the impellers to locate the tight spot.

      (3) Read the top clearance at the tight spot.

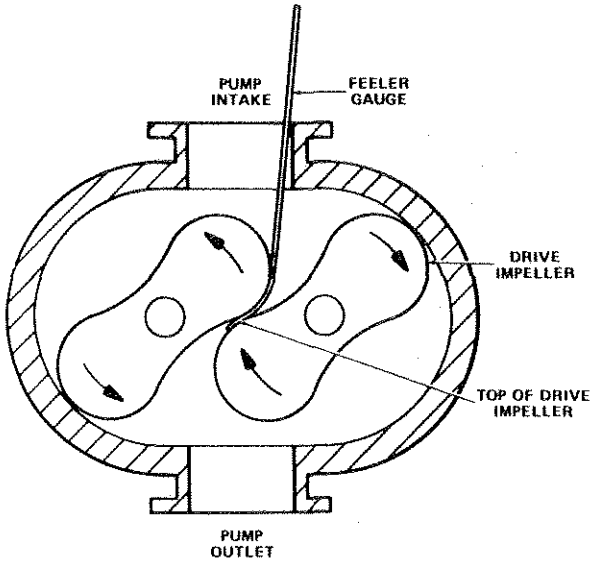

Figure 4-31A. Top Clearance.

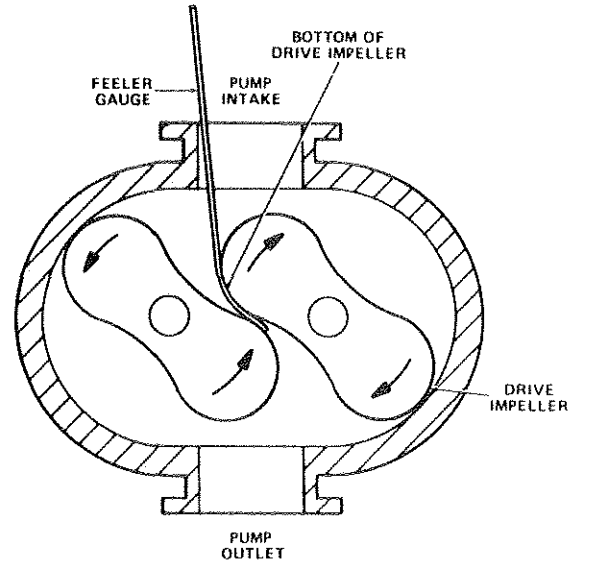

Figure 4-31B. Bottom Clearance.

Figure 4-31. Measuring the Top and Bottom Clearances Between the Impellers.

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c. **NOTE:** The clearance between the bottom of the drive impeller and the top of the other impeller is referred to as the bottom clearance (see Figures 4-31B and 4-27).

Use a feeler gauge to determine the bottom clearance as follows (see Figures 4-31B and 4-27).

(1) Position the impellers so that the bottom clearance can be measured.

(2) Check the bottom clearance at several locations along the impellers to locate the tight spot.

(3) Read the bottom clearance at the tight spot.

d. Subtract the top clearance from the bottom clearance.

e. **If the bottom clearance is larger than the top clearance and the difference obtained in Step d is equal to the gear play (see Step 3a),** the clearance is correct and there is no need to adjust the clearance any further; go to Step 4.

f. **If the difference obtained in Step d is not equal to the gear play or the top clearance is larger than the bottom clearance,** proceed as follows to adjust the clearance between the impellers (see Figure 4-31).

(1) Use a feeler gauge that is 0.08 to 0.10mm (0.0032 to 0.0039 inch) larger than the clearance you measured in Step b(3).

(2) **If the difference calculated in Step d is greater than the gear play,** place the large feeler gauge (see Step f(1)) into the tight spot of the top clearance. **If the difference calculated in Step d is a negative number, or is smaller than the gear play (see Step 3a),** then place the large feeler gauge in the tight spot of the bottom clearance.

(3) Use Step 1e to install the oil injector on the right (drive) shaft.

(4) Turn the oil injector handle clockwise to float the gear on the drive shaft.

(5) Grab the gear on the left shaft to turn the impellers about 1/8 of a turn back-and-forth several times.

NOTE: Turning the impellers in this manner results in the feeler gauge forcing the impeller apart and enlarging the clearance at the correct location.

(6) Remove the large feeler gauge.

(7) Repeat Steps 3b through 3f until the difference obtained in Step 3d equals the gear play (see Step 3a) and the top clearance is within the tolerance shown for your pump model in Table 4-4.

4. Install the splash plate (49) onto the right (drive) shaft, which extends out of the front end (gear-end) plate as follows (see Figure 4-29).

a. Remove the nut (48) from the drive shaft.

b. Slide the splash plate (49) onto the shaft so that it centers itself and locks in place on the shaft.

c. **NOTE:** Overtightening the nut could change the impeller clearance.

NOTE: For WA/WAU/WS/WSU-2000 pump models only, install the washer (Cat. No. 627-05-445) onto the pump shaft just before the nut.

Clean and apply Loctite 271 to the threads on the right (drive) shaft, and install and tighten the nut (48) onto this shaft until snug.

d. Repeat Steps 3b through 3f to recheck the clearance.

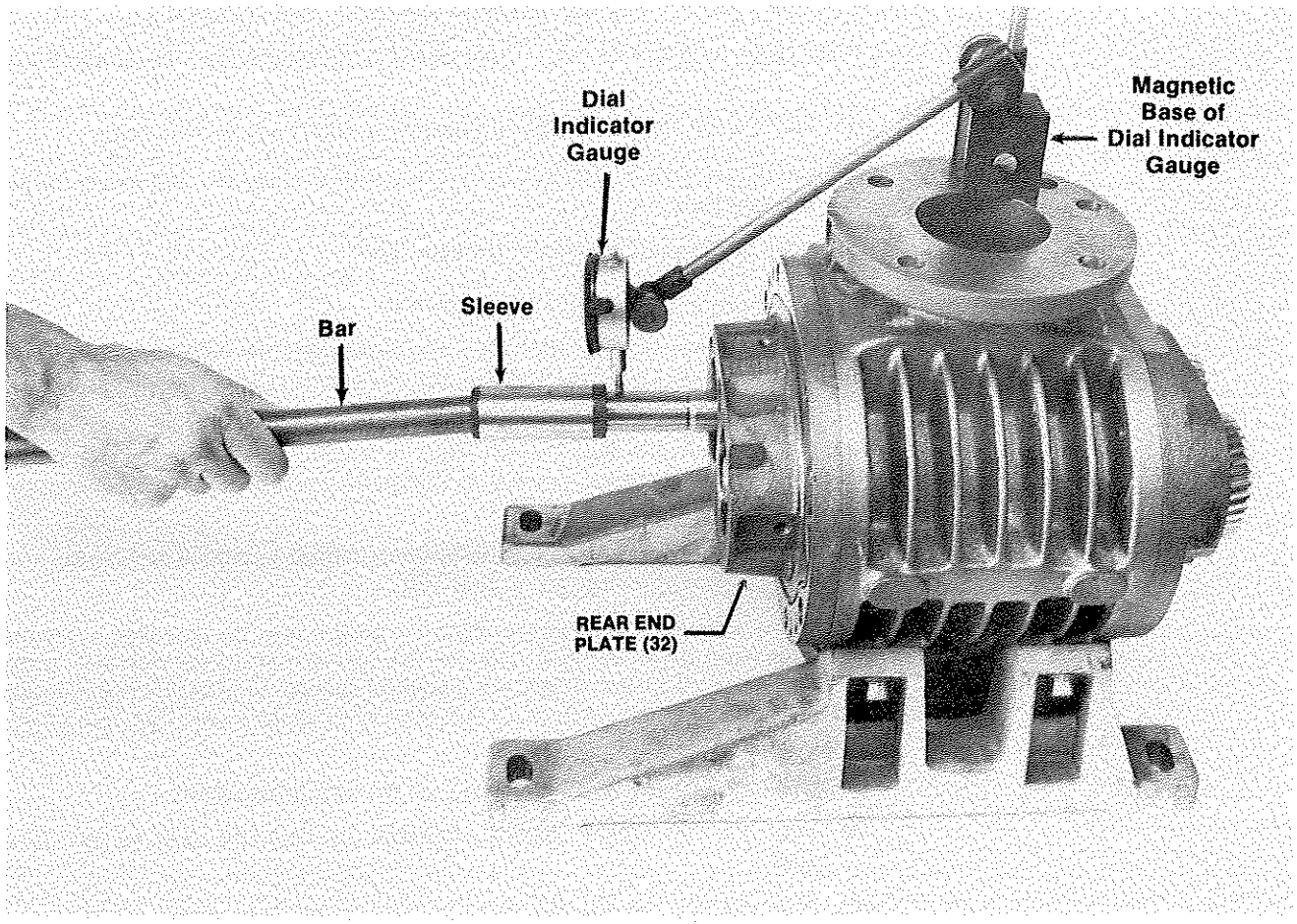

Figure 4-32. Adjusting the Eccentricity of the Drive Shaft (WA-250 pump model shown).

Section 4-4-3 Cont.

5. Check the eccentricity of the longer shaft which extends out of the rear end plate (32) as follows (see Figure 4-32).

    a. Position a dial indicator gauge on the pump so that it can read the eccentricity of the longer shaft.

    b. Turn the shaft by hand while checking the dial indicator gauge.

    c. If the eccentricity is greater than 0.01 of a millimeter (0.0004 inch), proceed as follows to adjust the eccentricity.

        (1) Slide a pipe or sleeve over the shaft.

        (2) Insert a bar into the pipe or sleeve.

        (3) Use the bar to thrust the shaft in the proper direction.

        (4) Repeat Steps b and c until the eccentricity is within 0.01 of a millimeter (0.0004 inch).

    d. Remove the dial indicator gauge from the pump.

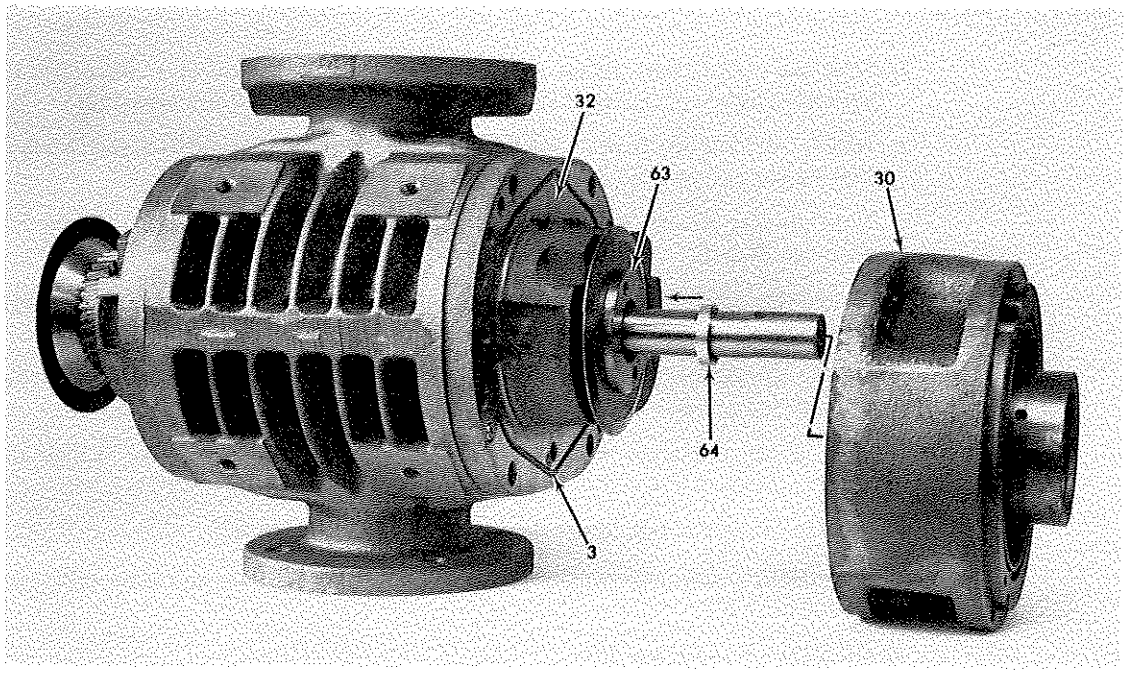

Figure 4-33. Installing the Oil Slinger and the Intermediate Flange (WA-250 pump model shown). 1R-4.24A

Section 4-4-3 Cont.

6. **For WA- and WAU-Series pumps only,** if practicable, set the pump vertical with the rear end up and the front end (the end with the gears) supported by wooden blocks (see Figure 4-34).

7. **NOTE:** The side of the oil slinger with the collar extending out of it faces the center of the pump.

   NOTE: For WA/WAU/WS/WSU-1000 and -2000 pump models only, slide the distance ring onto the shaft before installing the oil slinger. The side of the oil slinger with the collar extending out of it faces the center of the pump.

8. **NOTE:** Use a new compression ring (64) when reassembling the pump.

   Slide the aluminum compression ring (64) over the longer shaft extending out of the rear end plate (32) until the ring (64) fits into the slot in the ID of the oil slinger (63) (see Figure 4-33). You can use the shaft bushing sleeve (28) as a tool to tap the compression ring (64) into its slot.

9. **NOTE:** It is usually necessary to stretch the O-ring so that it will remain in its groove in the end plate.

   Apply the correct vacuum pump fluid to the O-ring (3) and then fit the new O-ring (3) into its groove in the rear end plate (see Figure 4-33).

10. **CAUTION:** THIS STEP APPLIES ONLY IF YOU ARE INSTALLING A NEW INTERMEDIATE FLANGE (30) ON A WS- OR WSU-SERIES PUMP.

    For WS- and WSU-Series pumps only, if not already done, drill two 1/2-inch diameter oil drain holes on the intermediate flange, at the locations shown in Figure 4-34.

11. **NOTE: If you reinstalled the used rear end plate and are reinstalling the used intermediate flange,** do Step 11.

    If you are installing a new intermediate flange or a new rear end plate, skip Step 11 and do Step 12.

    Reinstall the used intermediate flange (30) onto the used rear end plate as follows (see Figures 4-33 and 4-34).

    a. Insert the narrow end (the end without the internal threads) of the two tapered dowel pins (31) through the alignment holes in the intermediate flange (30).

b. Slide the intermediate flange (30) over the longer shaft and align the dowel pins (31) extending out of the flange (30) with the mating holes in the end plate (32).

c. **NOTE:** Holding the flange (30) tight against the plate (32) prevents the O-ring (3) from moving out of its groove in the plate (32).

Hold the intermediate flange (30) tight against the rear end plate (32) until the screws are snug (see Step d).

d. Install the screws that secure the intermediate flange (30) to the rear end plate (32) hand-tight.

e. **NOTE:** Do not continue to drive the dowel pins (31) after they are seated or they will be difficult to remove.

Use a punch to tap the tapered dowel pins (31) until they are seated in their alignment holes.

f. Tighten the screws that secure the flange (30) to the plate (32).

12. **If you are installing a new intermediate flange or installed a new rear end plate (32),** proceed as follows (see Figure 4-34).

a. Do Steps 11c, 11d, and 11f.

b. Use a dial indicator gauge to determine if the shaft is **exactly** centered in the bearing well of the intermediate flange (30) as follows:

(1) Mount the base of the dial indicator gauge onto the end of the drive shaft so that the bottom surface of the base is perpendicular to the shaft.

(2) Adjust the position of the dial indicator gauge so that its probe contacts the inside wall of the bearing well of the intermediate flange (30).

(3) Slowly rotate the shaft while watching the dial to determine if the shaft is exactly centered in the bearing well.

c. If the shaft is **not** centered, proceed as follows:

(1) Use a rubber hammer to tap the edge of the flange (30) as necessary to center the shaft in the bearing well.

(2) Repeat Steps b and c as necessary.

d. Proceed as follows to install the dowel pins:

(1) If not already done, lock the intermediate flange in place and ream out the alignment holes to the correct diameter for the tapered dowel pins (31).

(2) **NOTE:** Do not continue to drive the dowel pins (31) after they are seated or they will be difficult to remove.

Insert the narrow end (the end without the internal threads) of the tapered dowel pins (31) through their holes in the intermediate flange and into the alignment holes in the end plate. Tap the pins until they are seated (see Figure 4-34).

4-4-4 Assembling the Motor End of the Pump

4-4-4-1 WA-and WAU-Series Pumps — Motor End Assembly

NOTE: Section 4-4-4-1 is for WA- and WAU-Series pumps only.

1. Using snap ring pliers, install the smaller retainer ring (25) into its slot in the bottom of the bearing well in the intermediate flange (30) (see Figure 4-34).

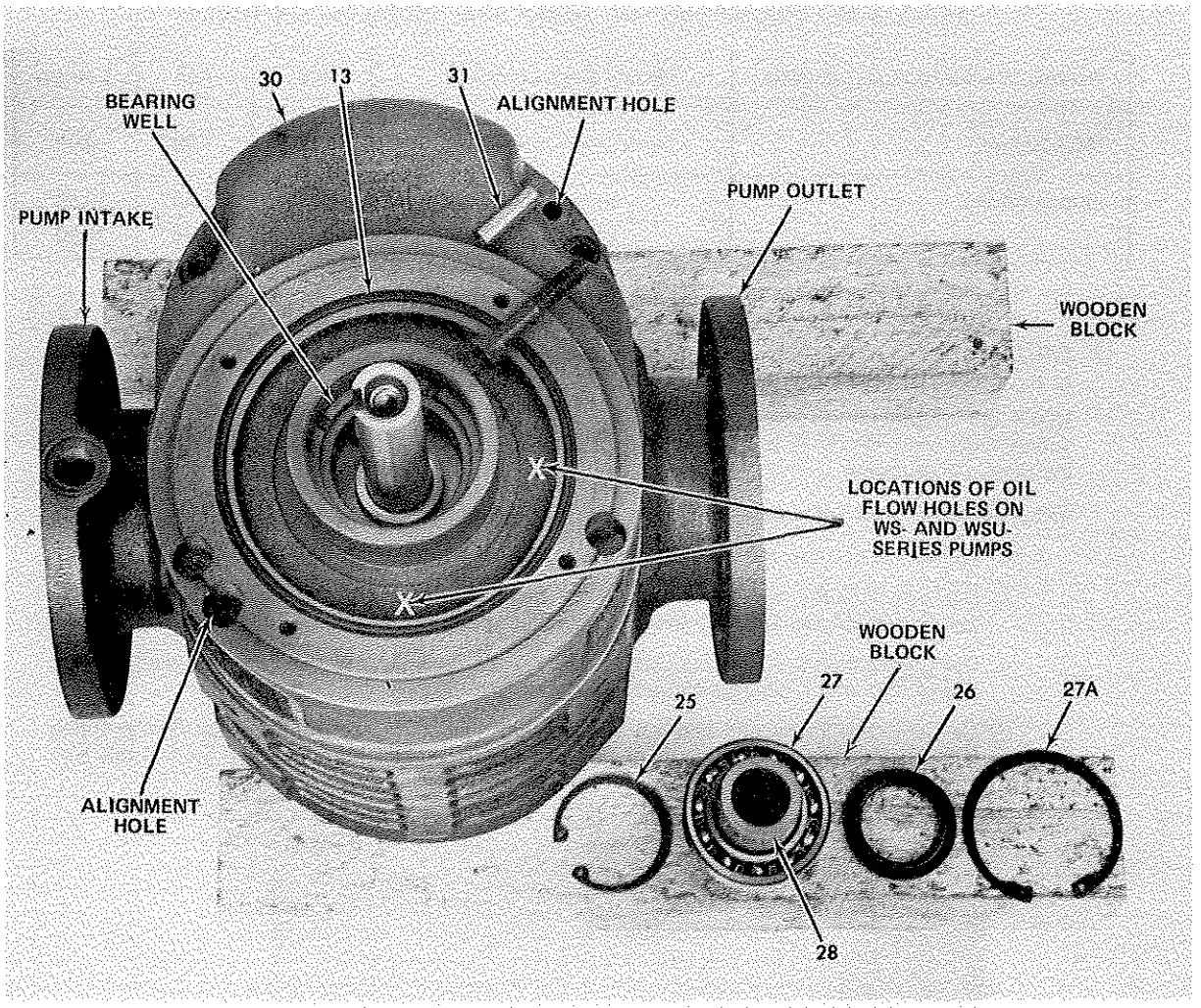

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Figure 4-34. Securing the Intermediate Flange and Loading its Bearing Well (WA-250 pump model shown).

Section 4-4-4-1 Cont.

2. **NOTE: For WA/WAU -150, -250, or -500 pump models using the HE-2700 perfluoropolyether oil,** see Appendix D for instructions for installing special shaft seals.

Install the shaft bushing sleeve (28) as follows (see Figure 4-34).

a. **CAUTION:** IF SANDING IS NECESSARY, SAND ONLY THE BULGE OF THE SLEEVE (28). DO NOT SAND THE REMAINDER OF THE SLEEVE, SINCE IT HAS A FINE GROUND SURFACE WHICH COULD BE DAMAGED.

   Test to see if you can push the bearing (27) over bulge in in the middle of the shaft bushing sleeve (28) (see Figure 4-34). If you cannot fit the bearing over the bulge, use grade 80 sandpaper to sand the bulge until you can push the bearing over it. Remove the bearing from the sleeve and clean the sleeve (28) as necessary.

b. Apply the correct vacuum pump fluid to the portion of the shaft extending through the intermediate flange bearing well.

c. **NOTE:** The end of the shaft bushing sleeve (28) with the small teeth faces the outside of the pump.

   Slide the shaft bushing sleeve (28) over the shaft extending out of the intermediate flange until the sleeve (28) is against the aluminum compression ring (64).

TABLE 4-4A - DIMENSIONS FOR SHAFT SEAL INSTALLATION TOOLS*

RUVAC WA/WAU Pump Models	Shaft Seal Location	O.D.	I.D.	Length
150/250/500	Inner and Outer Seals	1.80"	1.60"	9.00"
1000/2000	Inner Seals	2.78"	2.25"	10.50"
	Outer Seals	2.50"	2.25"	10.50"

*The end of the seal driver must be blunt to prevent damage to the seal.

3. **CAUTION:** The lip of the shaft seals are easily cut; use care when sliding the shaft seals over the end of the shaft and bushing to avoid damaging the shaft seal's lip.

   NOTE: On WA/WAU -150, -250, and -500 pump models that use perfluoropolyether vacuum oil, a single special shaft seal (P/N 720-27-011) is used instead of the two inner shaft seals. See Appendix D for special installation instructions.

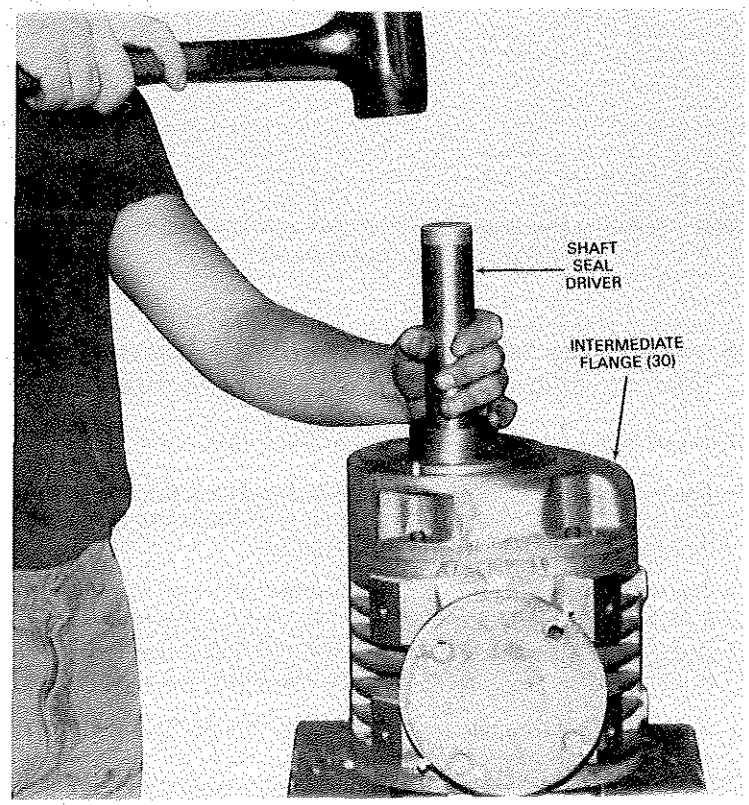
   Install the radial shaft seals over the shaft bushing sleeve as follows (see Figure 4-34):

   a. Wet two of the new radial shaft seals (26) and the bushing (28) with the correct vacuum oil.

   b. Carefully slide the seal (26) over the shaft which extends out of the intermediate flange (30); the side of the seal that has the small circular springs faces the inside of the pump.

   c. Using a hammer and a seal driver (see Table 4-4A), drvie the first seal down the shaft bushing sleeve (28) until it bottoms out against the retainer ring (25) (see Figure 4-35).

   d. Carefully slide the second seal (26) over the shaft so that the side with the small circular spring faces the outside of the pump; then, drive this seal until it bottoms out against the first seal (see Figure 4-35).



NOTE: This figure applies only to WA- and WAU-Series pumps.

Figure 4-35. Using a Seal Driver to Install the Radial Shaft Seal (WA-250 pump model shown).

4. **NOTE:** Ensure that the bearing is clean and lubricated with the correct vacuum pump fluid before installing.

   Slide the bearing (27) over the shaft bushing sleeve (28) until it bottoms out in the bearing well in the intermediate flange (30) (see Figure 4-34).

5. **For WA/WAU-2000 pump models only,** attach the two screws and washers that hold the bearing in the bearing well.

   For all other pump models, use snap ring pliers to install the larger retainer ring (27A) into the slot in the intermediate flange bearing well (see Figure 4-34).

6. Install the motor mount (20) onto the intermediate flange (30) as follows:

   a. Apply the correct vacuum pump fluid to the new O-ring (13) and install it into the O-ring groove on the outside of the intermediate flange (see Figure 4-34).

   b. Screw the dip stick (24) with the flat gasket (23), and the plug screw (42) with the flat gasket (43) into the ports in the motor mount (20) (see Figures 4-5, 4-37, and 4-38).

   c. Align the motor mount (20) so that its dip stick (24) and the intake flange of the pump are facing the same direction (see Figure 4-38).

   d. Tap the motor mount (20) until it is tight against the flange (30).

   e. Use the screws to secure the mount (20) to the flange (30).

   f. **For all WA/WAU pump models,** use a dial indicator gauge to determine if the shaft is centered in the radial-shaft-seal groove in the motor mount (20) as follows:

      (1) Mount the base of the dial indicator gauge onto the end of the shaft so that the bottom surface of the base is perpendicular to the end of the shaft.

      (2) Adjust the position of the dial indicator gauge so that its probe contacts the wall of the shaft-seal groove in the motor mount (20).

      (3) Slowly rotate the shaft while watching the dial to determine if the shaft is concentric within the shaft-seal bore. The Total Indicator Runout (TIR) must NOT exceed 0.08 mm (0.003 inch).

   g. **For all WA/WAU pump models,** if the TIR exceeds 0.08 mm loosen the motor mount (20) screws, use a rubber hammer to center the seal bore, retighten the screws, and repeat Step (f3). If necessary, you can switch the dip stick (24) and the drain plug (42), rotate the motor mount 180°, and repeat Step (f3).

      For the WA-2000 and WAU-2000 pump models, the following procedure may be necessary to reduce the TIR to less than 0.08 mm (see Figure 4-37).

      (1) Loosen the screws attaching the motor mount (20) to the intermediate flange (30).

      (2) Insert a long feeler gauge between the edge of the motor mount (20) and the intermediate flange (30) so that one of the long sides of the feeler gauge intersects the edge of the mount (20) and flange (30) in the two places.

      (3) Repeat Step 6f to check if the shaft is exactly centered.

      (4) **If the shaft is not exactly centered,** repeat Steps (2) and (3) with a thicker or thinner feeler gauge as necessary to center the shaft. **If the shaft cannot be centered by using a feeler gauge at the first location,** repeat Steps (2) through (4) except insert a feeler gauge between the edge of the intermediate flange (30) and the motor mount (20) at a different location.

      (5) When the shaft is exactly centered in the shaft seal groove, mark a line on the outside edge of the motor mount (20) and intermediate flange (30) at the two locations where the feeler gauge intersects the mount (20) and flange (30).

      (6) Remove the motor mount (20) from the pump.

      (7) NOTE: The seating surface of the motor mount (20) is the flange on the pump side of the mount (20) that has screw holes in it.

Place a few drops of 5-minute epoxy on the seating surface of the motor mount (20) near both locations marked in Step g(5).

(8) Use the marks you made in Step g(5) on the intermediate flange (30) to place the feeler gauge in the same location on the edge of the flange (30).

(9) Before the epoxy dries, use the marks you made in Step g(5) to align the motor mount (20) and intermediate flange (30); tap the mount (20) until it is tight against the flange (30).

(10) Use the screws to secure the mount (20) to the flange (30).

(11) After the epoxy dries, remove the feeler gauge from between the mount (20) and flange (30).

(12) Use Step 6f to check if the shaft is exactly centered; if it is not exactly centered, repeat Step 6g.

7. **NOTE:** WA/WAU -150, -250,, and -500 pump models that use perfluoropolyether vacuum oil require a special shaft seal (P/N 720-27-012); see Appendix D for installation instructions.
Install the remaining radial shaft seal (26) as follows (see Figure 4-36).

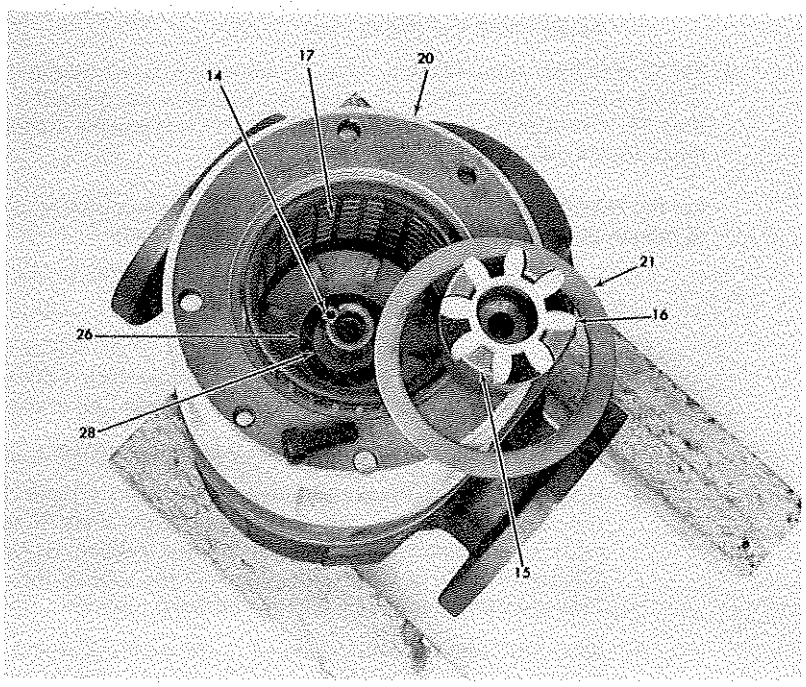
a. Wet the seal (26) and shaft bushing sleeve (28) with the correct vacuum pump fluid.

b. **NOTE:** The side of the radial shaft seal (26) with the circular spring faces the center of the pump.
Use your fingers to work the seal (26) over the shaft bushing sleeve (28).

c. **CAUTION:** DO NOT DAMAGE THE SHAFT SEAL (26) WHEN TAPPING IT INTO THE MOTOR MOUNT (20).

NOTE: Be sure to hold the seal driver perfectly straight so that the seal (26) is seated evenly in its slot.

Using a seal driver (see Table 4-4A), tap the seal (26) until it bottoms out in its slot in the motor mount (20).



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NOTE: This figure applies only to WA- and WAU-Series pumps.
Figure 4-36. Installing the Coupling (WA-250 pump model shown).

8. Install the coupling as follows:

   a. **NOTE:** If the key does not slide easily into its slot, sand it with grade 80 sandpaper.

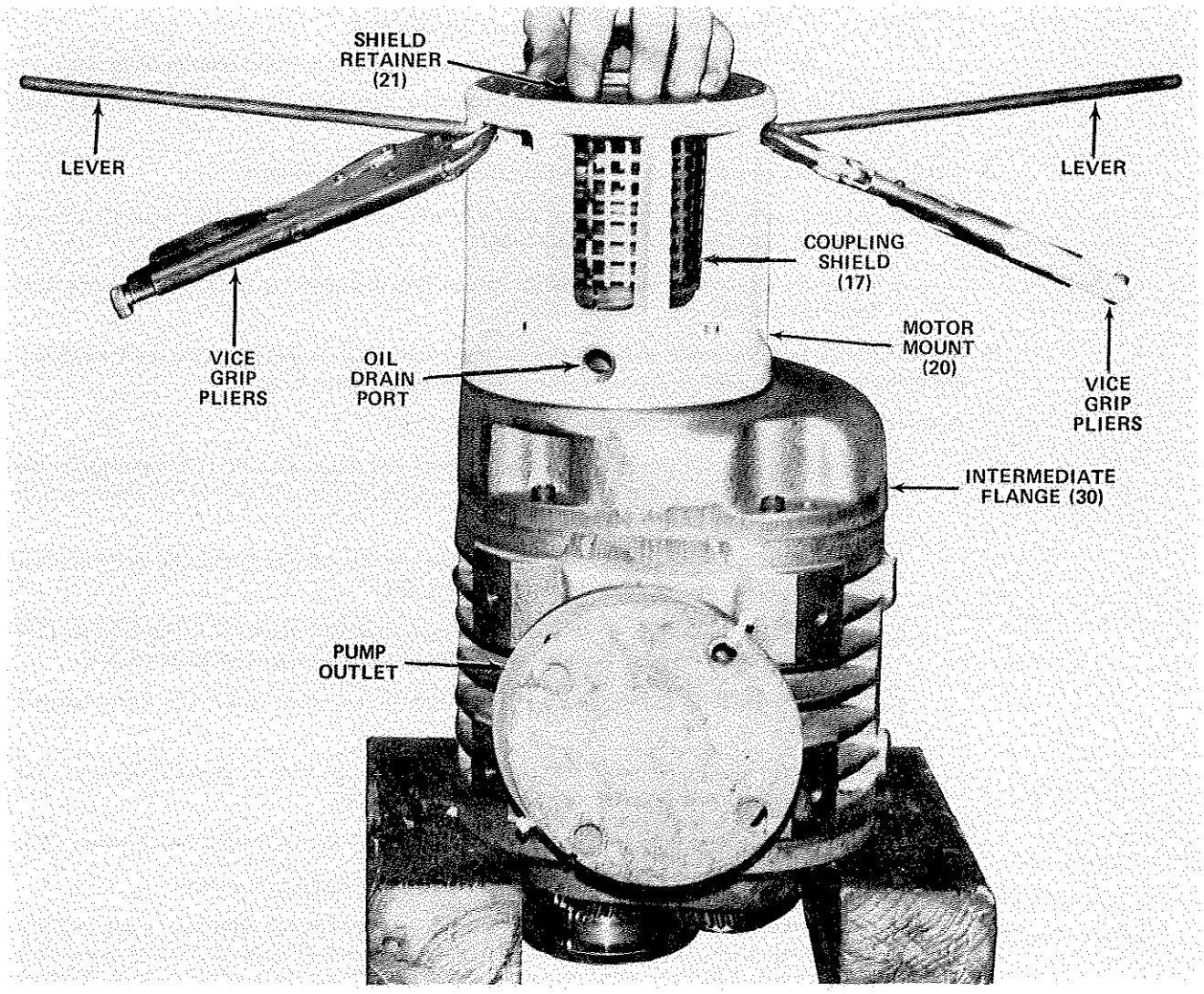
      Slide the coupling key (14) into its slot in the shaft that extends out of the motor mount (20) (see Figure 4-36).

   b. **NOTE:** The coupling that does not have a setscrew in it is the pump-side coupling.

      For WA-1000, WA-2000, WAU-1000 and WAU-2000 pump models only, apply epoxy onto the ID of the plastic fan (12) and slide the fan onto the pump-side coupling (15).

   c. **NOTE:** If the coupling does not slide easily onto the shaft, sand the ID of the coupling and the OD of the shaft with grade 80 sandpaper.

      Slide the pump-side coupling (15) onto the shaft that extends out of the motor mount (20) until the coupling is against the shaft bushing sleeve (28) (see Figures 4-36 and 4-38).



1R-11-31

NOTE: This figure applies only to WA- and WAU-Series pumps.

Figure 4-37. Installing the Coupling Shield and the Shield Retainer (WA-250 pump model shown).

d. Install the motor-side coupling as follows (see Figure 4-38).

(1) Slide the motor key into its slot in the motor shaft.

(2) Slide the motor-side coupling (15) onto the motor shaft.

(3) Tighten the setscrew to secure the motor-side coupling to the motor shaft.

e. Apply Loctite 271 to the internal threads on the end of the pump shaft, place the washer (29) onto the shaft screw, and then screw the shaft screw into the end of the pump shaft (see Figure 4-4).

f. Tighten the shaft screw as follows:

(1) Insert a bar or large screwdriver through the motor mount (20) and pump-side coupling prongs to prevent the shaft from turning.

(2) **CAUTION:** Failure to tighten the shaft screw enough to crush the compression ring (64) will result in a vacuum leak around the shaft.

Firmly tighten the shaft screw into the shaft.

(3) Remove the bar from the motor mount (20) and pump-side coupling (15).

g. Fit the coupling insert (16) into the coupling (15) mounted on the pump shaft (see Figures 4-36 and 4-38).

9. Install the coupling shield (17) over the pump-side coupling (15) as follows:

a. If not already done, install rubber trim (18) around the top and bottom circumference of the coupling shield (17) (see Figure 4-38).

b. Insert the shield (17) into the motor mount (20) and over the pump-side coupling (15) (see Figure 4-36).

10. **NOTE:** Looking from the motor end of the pump, the junction box should be on the right; however, the motor can be mounted in any convenient position (see Figure 4-38).

Attach the motor (19) to the motor mount (20) as follows:

a. Use a lever on both sides of the pump to force the coupling shield (17) tight against the motor mount (20), and then lock the levers and coupling shield (17) in this position with vice-grip pliers (see Figure 4-37).

NOTE: The coupling shield must be held down in this manner so that the shield retainer (21) can fit into its groove in the motor mount (20).

b. **For WA/WAU-150, -250, -500, and -1000 pump models,** place the shield retainer (21) into its groove on the outside end of the motor mount (see Figures 4-36 and 4-37).

c. **For WA/WAU-2000 pump models only,** if not already done, attach the motor adapter flange (22).

d. Align the prongs in the motor-side coupling (15) with the slots in the coupling insert (16) located on the pump-side coupling (15) (see Figure 4-38).

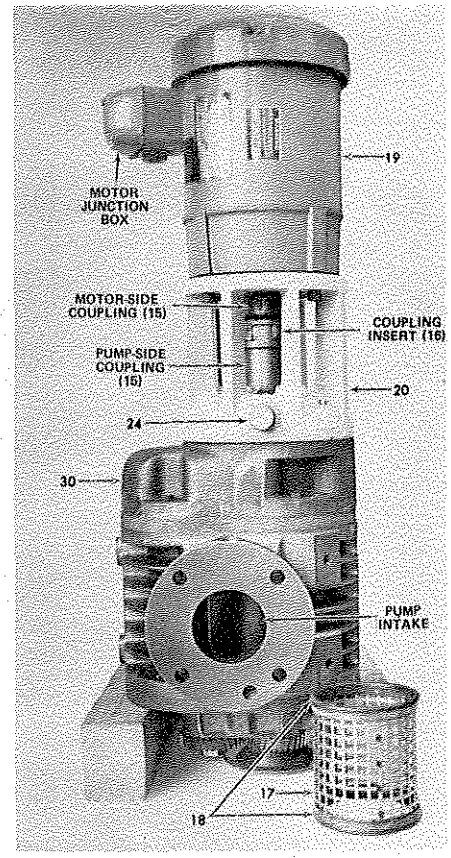
e. Align the bolt holes in the motor flange with the mating holes in the motor mount (20).

f. Apply Loctite 271 to the U.S. standard bolts used for attaching the motor.

g. **CAUTION: FOR WA/WAU-150, -250, -500, AND -1000 PUMP MODELS,** FAILURE TO KEEP THE SHIELD RETAINER (21) IN ITS GROOVE IN THE MOTOR MOUNT (20) WHILE TIGHTENING THE BOLTS WILL RESULT IN DAMAGE TO THE MOTOR FLANGE.

Install and tighten the U.S. standard bolts that attach the motor to the pump.

h. Remove the levers and vice-grip pliers installed in Step 10a.



NOTE: This figure applies only to WA- and WAU-Series pumps.

NOTE: The coupling shield (17) is not installed in this photograph so that you can see the fit of the coupling (15) and coupling insert (16) more clearly.

Figure 4-38. Coupling Halves Fit Together and Motor Attached to Pump (WA-250 pump model shown).

Section 4-4-4-1 Cont.

11. **CAUTION:** IF THE PUMP-SIDE COUPLING AND THE MOTOR-SIDE COUPLING ARE TOO TIGHT AGAINST EACH OTHER, IT WILL PUT PRESSURE ON THE SHAFT WHICH COULD CAUSE DAMAGE TO THE PUMP OR MOTOR.

    NOTE: There should be approximately 1/8-inch of space between each coupling (15) and the coupling insert (16).

    REQUIRED ACTION: Check if the spacing between the pump-side and motor-side coupling is correct. If not, loosen the setscrew on the motor-side coupling and adjust it on the motor shaft until the spacing is correct; then retighten the coupling setscrew (see Figure 4-38).

4-4-4-2 WS- and WSU-Series Pumps — Motor End Assembly

NOTE: Section 4-4-4-2 is for WS- and WSU-Series pumps only.

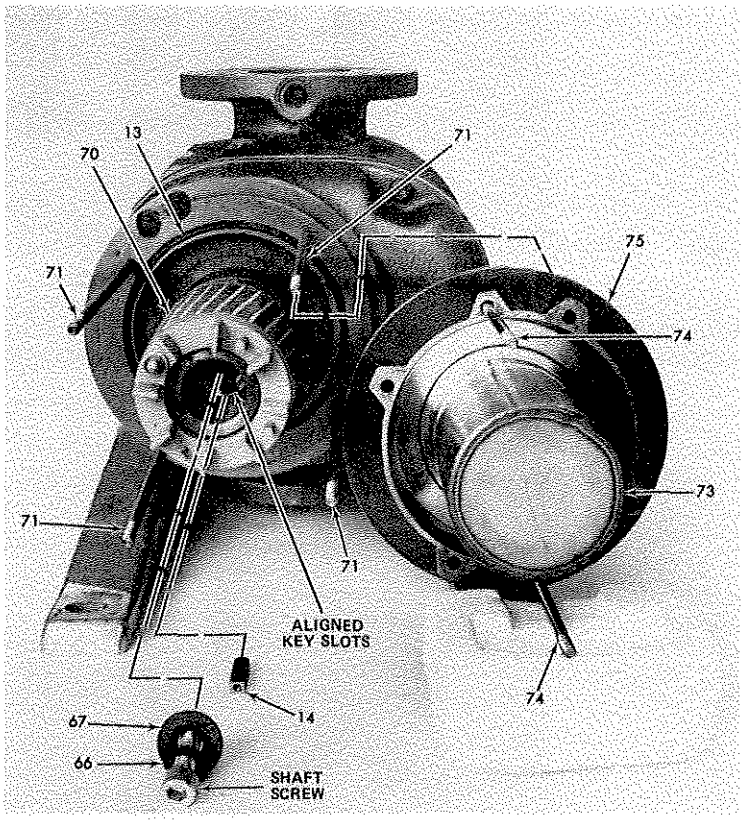
1. **NOTE: Step 1 is for WS-2000 pump models only.**

    NOTE: Ensure that the bearing is clean and lubricated with the correct vacuum pump fluid before installing.

    For the WS-2000 pump model only, install the bearing into the intermediate flange as follows:

    a. Slide the bearing (27) over the shaft until it bottoms out in the bearing well of the intermediate flange (30).

    b. Attach the two screws and washers that hold the bearing in the bearing well.



NOTE: This figure applies only to WS- and WSU-Series pumps.

Figure 4-39. Installing the Armature and Canned Motor Tube (WS-250 pump model shown).

Section 4-4-4-2 Cont.

2. Attach the armature (70) to the shaft extending out of the intermediate flange (30) as follows (see Figure 4-39).

   a. **NOTE:** The sleeve of the armature should slide freely over the shaft. If it does not, sand and then rinse the ID of the sleeve with a suitable solvent (see Section 4-1-1).

      Slide the sleeve of the armature (70) over the shaft until the sleeve is tight against the compression ring (64).

   b. Align the key slot in the armature ID with the key slot in the shaft.

   c. Using long nose pliers, reach through the end of the armature (70) to insert the key (14) into the key slot until the rectangular end of the key is flush with the end of the shaft.

   d. Screw the shaft screw with washers into the end of the shaft as follows:

      (1) Place the ball washer (66) and then the seat washer (67) onto the shaft screw.

      (2) Apply Loctite 271 to the threads of the shaft screw.

      (3) Tighten the shaft screw firmly into the shaft to secure the armature (70) to the shaft.

   e. Check the eccentricity of the armature (70) as follows:

      (1) Position a dial indicator gauge on the pump so that it can read the eccentricity of the armature.

      (2) Turn the drive impeller (60) and attached armature (70) by hand while checking the dial indicator gauge.

(3) If the eccentricity is greater than 0.01mm (0.0004 inch), insert a bar through the armature ID to pry the armature in the proper direction. Recheck the gauge and use the bar to adjust the armature until the eccentricity is within 0.01mm (0.0004 inch).

3. **NOTE:** The stud end with the shorter threaded section screws into the intermediate flange (30).

   NOTE: All six studs (71/74) in the WS-150 and -250 are the same length.

   Screw the four longer studs (71) into the intermediate flange (30) until they are tight (see Figure 4-39).

4. **NOTE:** The stud end with the shorter threaded section screws into the canned motor tube (73).

   NOTE: All six studs (71/74) in the WS-150 and WS-250 pump models are the same length.

   If not already done, screw the two shorter studs (74) into the outside of the canned motor tube flange until they are tight (see Figure 4-39).

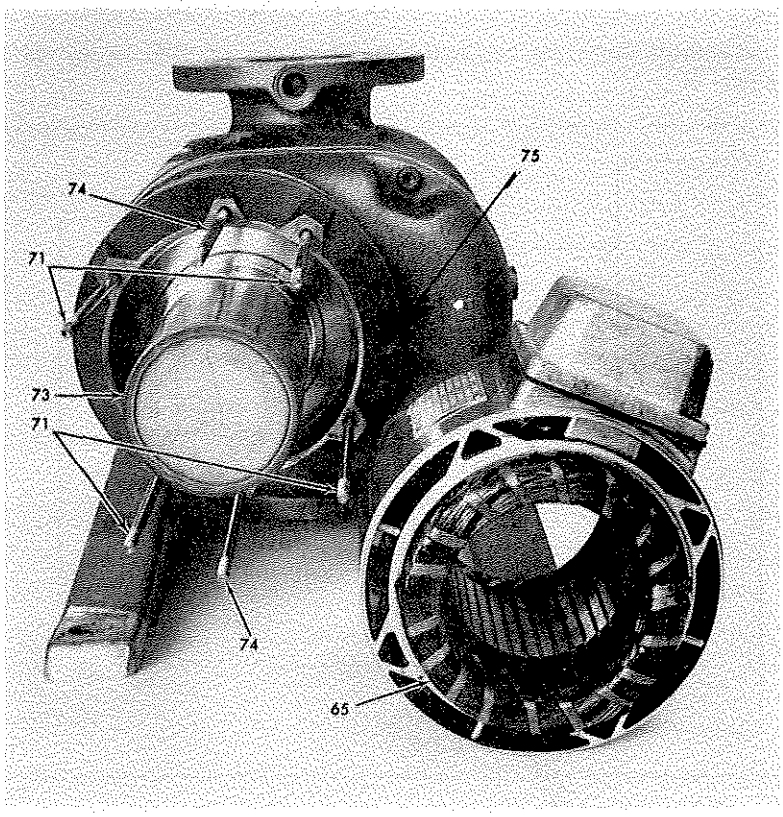
5. Attach the collar (75) to the canned motor tube (73) as follows (see Figure 4-39).

   a. Align the stud holes in the collar (75) with the two studs (74) extending out of the canned motor tube (73) as shown in Figure 4-39.

   b. Slide the collar over the studs until the collar (75) is against the flange of the tube (73).

   c. **CAUTION:** DO NOT DENT THE CANNED MOTOR TUBE (73).

      Use a rubber hammer to tap the flange of the tube (73) until it bottoms out on the shoulder of the collar (75).



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NOTE: This figure applies only to WS- and WSU-Series pumps.
Figure 4-40. Installing the Stator (WS-250 pump model shown).

6. Install the collar/tube assembly (75/73) onto the pump as follows (see Figures 4-39 and 4-40).

   a. Apply the correct pump fluid to the new O-ring (13) and fit it into its groove in the intermediate flange (see Figure 4-39).

   b. **NOTE:** When installing the collar/tube assembly (75/73), one of the studs (74) which extends out of the canned motor tube faces the intake of the pump; the other stud (74) faces the outlet of the pump.

      Slide the collar/tube assembly (73/75) over the armature (70) and studs (71) and tap the collar (75) until it locks in place against the intermediate flange (30).

   c. Turn the gears (50) while listening to hear if the armature (70) is contacting the motor tube (73). If it is, reposition the tube (73) until the armature (70) does not contact the tube.

7. **NOTE:** Looking from the motor end of the pump, the terminal box on the stator (65) should be on the right (see Figure 4-43).

   Slide the stator (65) over the studs (71/74) until it is tight against the collar (75) (see Figure 4-40).

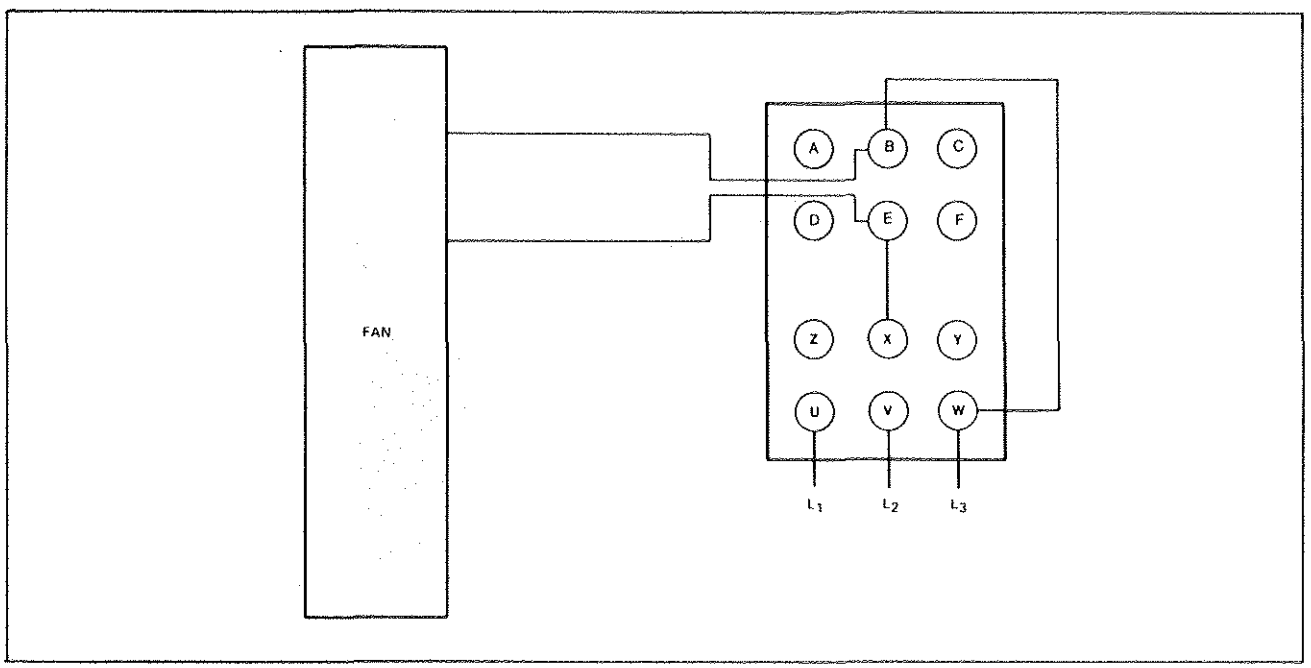
8. **NOTE:** The screw hole in the edge of the spacer lugs (72) faces out (see Figure 4-6).

   Install a spacer lug (72), metal fan bracket, washer, and nut onto the two studs (74) which extend out of the canned motor tube. One of the studs faces the intake of the pump; the other faces the outlet of the pump.

9. **NOTE:** The screw hole in the edge of the spacer lugs (72) faces out (see Figure 4-6).

   Install four spacer lugs (72) onto the four studs (71) that extend out of the intermediate flange (30) and then tighten the nuts and washers that hold the lugs in place.

10. If not already done, use two screws to attach the fan (68) to the two metal fan brackets (see Figure 4-6).



NOTE: This figure applies only to WS- and WSU- Series pumps.

NOTE: See Section 2-4 for instructions for wiring the remaining terminals and the thermal switch.

Figure 4-41. Wiring the Motor Fan to the Motor on WS/WSU-150, -250, -500, and -1000 Pump Models.

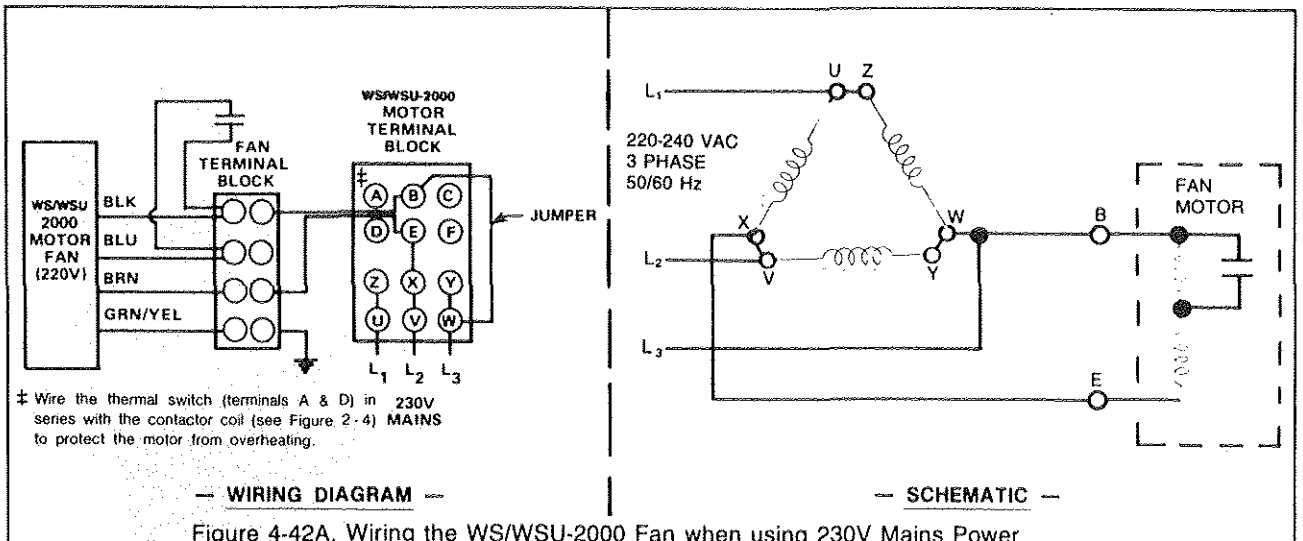


Figure 4-42A. Wiring the WS/WSU-2000 Fan when using 230V Mains Power

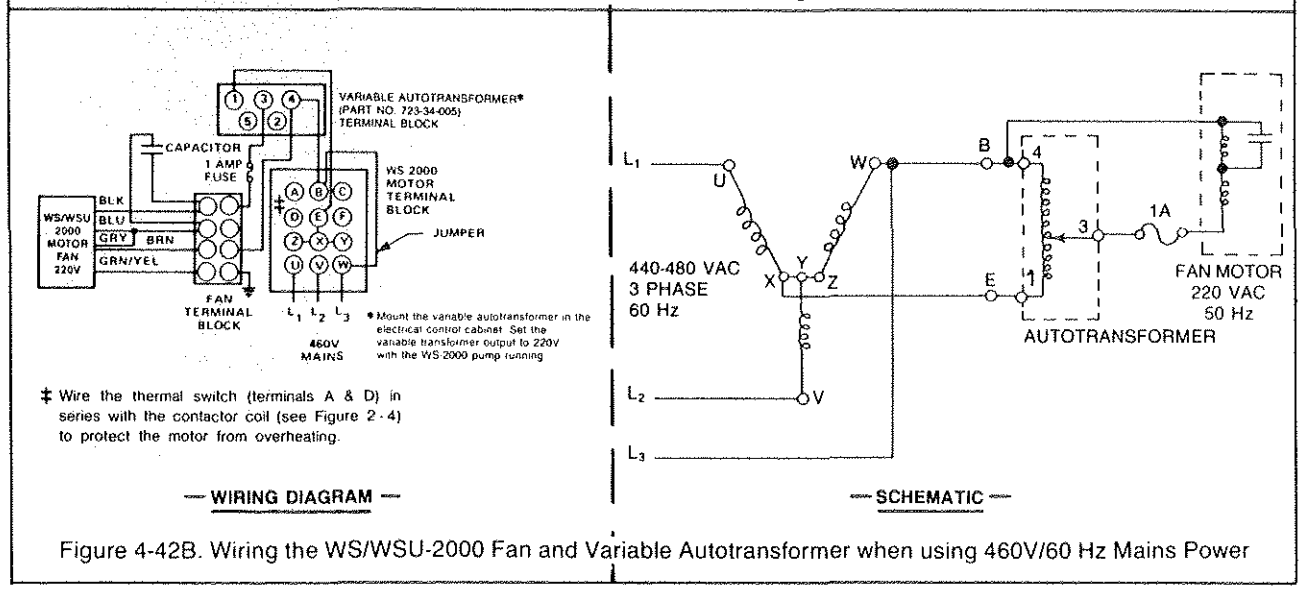


Figure 4-42B. Wiring the WS/WSU-2000 Fan and Variable Autotransformer when using 460V/60 Hz Mains Power

NOTE: This figure applies to the WS/WSU-2000 pump model only.

1R-5 9

Figure 4-42. Wiring the Fan to the Motor on the WS/WSU-2000 Pump Models.

Section 4-4-4-2 Cont.

11. **NOTE:** The wires running from the terminal block to the fan must go through the small hole in the upper left corner of the terminal block.

    If not already done, remove the terminal cover from the stator (65) and wire the fan (68) to the terminal block using the wiring diagram in Figure 4.41. **For the WS/WSU-2000 pump model only,** use the wiring diagram in Figure 4-42.

12. **NOTE:** The screws that attach the motor end cover to the motor, screw into the holes in the outside edge of the six spacer lugs (72).

    NOTE: If you are installing a new motor end cover (69), drill holes through the cover (69) for the screws that attach the cover (69) to the spacer lugs (72).

    REQUIRED ACTION: Use the phillips head screws to attach the motor end cover (69) to the end of the motor (see Figures 4-6 and 4-43).

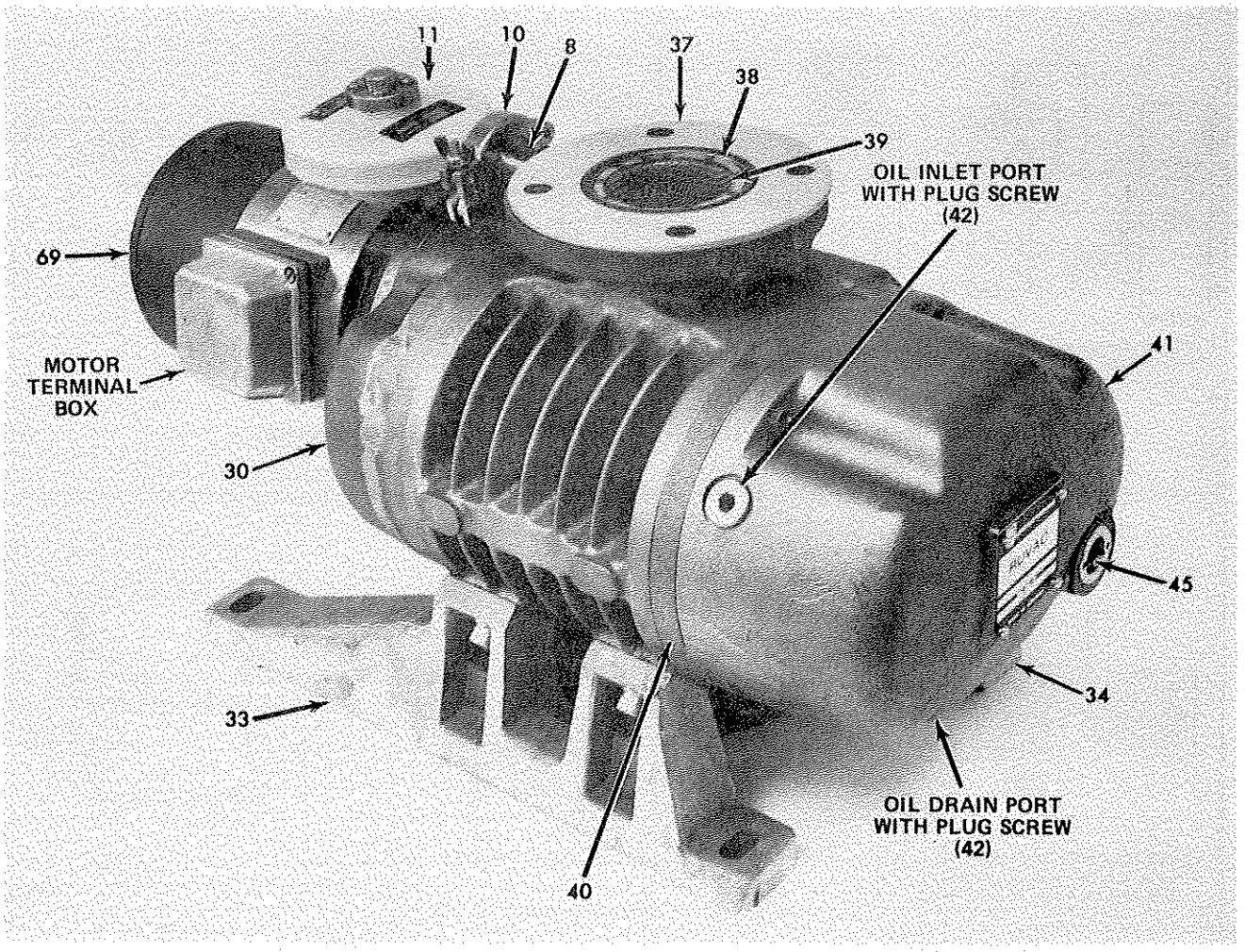


Figure 4-43. Assembled WS-Series Pump (WS-250 pump model shown).

4-4-5 Completing the Assembly of the Pump

1. If not already done, install the oil level sight glass assembly as follows:

   a. Insert the gasket (44), sight glass (45), and thrust washer (46) into the sight-glass hole in the front cover (41) (see Figures 4-15 and 4-14).

   b. Screw the threaded ring (47) into the sight-glass hole.

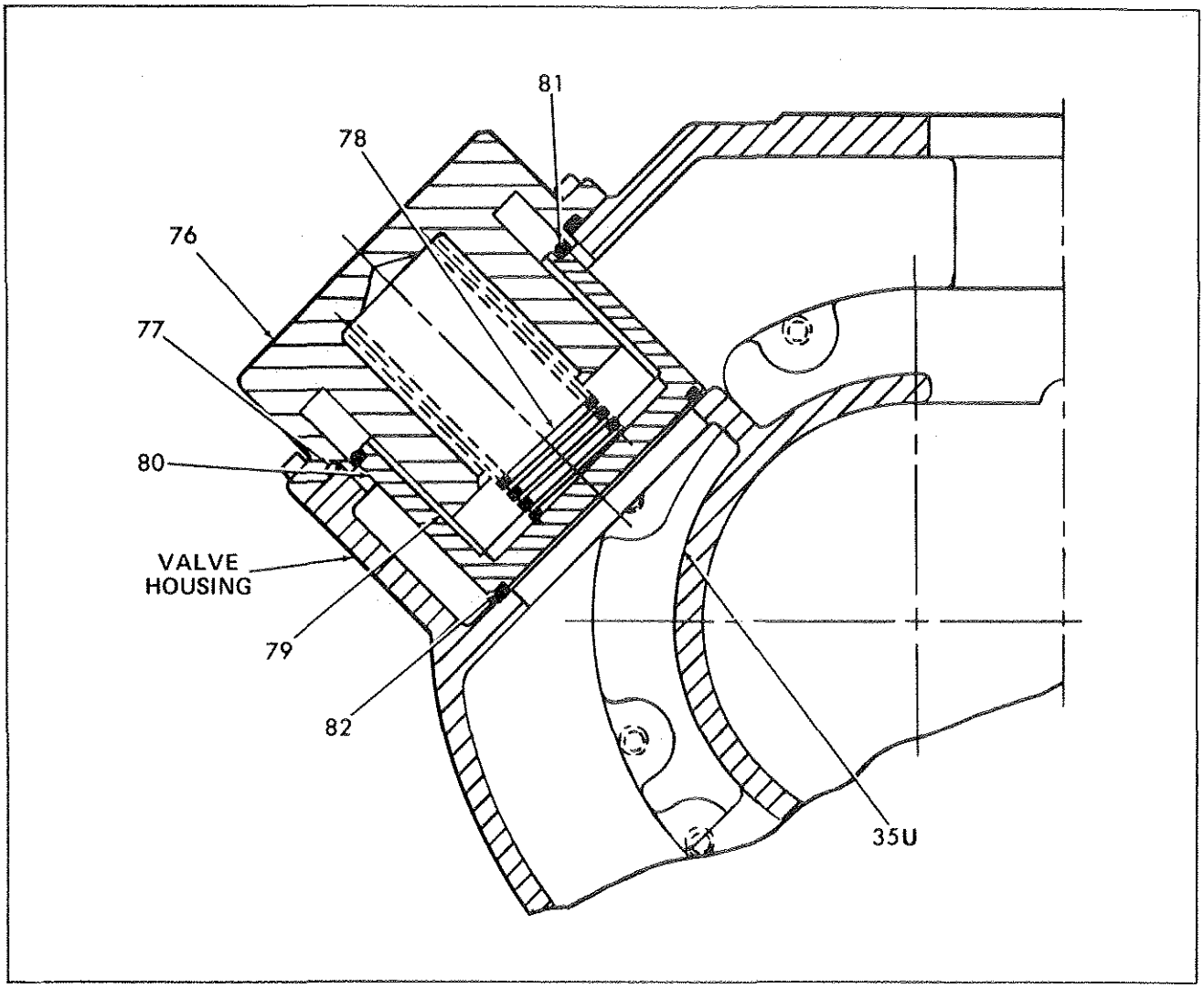
   c. Using a spanner or a large pair of snap ring pliers and a screwdriver or bar, tighten the threaded ring (47) into the front cover (41) (see Figure 4-14).

2. **NOTE:** It is usually necessary to stretch the O-ring (3) so that it will remain in its groove.

   Apply the correct vacuum pump fluid to the O-ring (3) and then fit the O-ring into its groove on the front end plate (40) (see Figure 4-2).

3. **CAUTION:** FAILURE TO ENSURE THAT THE O-RING (3) REMAINS IN ITS GROOVE WHILE INSTALLING THE FRONT COVER COULD RESULT IN DAMAGE TO THE O-RING.

   Tighten the two top socket head cap screws and then the two bottom screws to install the front cover (41) onto the front end plate (40) (see Figure 4-43).



1R-5 10

NOTE: This figure applies only to WAU- and WSU-Series pumps. The WSU-Series pumps do not have the spring (78).

NOTE: The design of the parts of the pressure relief valve differs from pump model-to-pump model; however, the parts are functionally similar.

Figure 4-44. Cross Section of Assembled Differential Pressure Relief Valve.

Section 4-4-5 Cont.

4. **NOTE:** Step 4 is for WAU- and WSU-Series pump only.

   If not already done, install the differential pressure relief valve as follows (see Figures 4-16 and 4-44).

   a. **For the WAU/WSU-150 pump model only,** press the large steel bushing (79) into the valve cover (76); then press the small teflon-coated bushing (79) into the large bushing until it bottoms out on the shoulder in the ID of the larger bushing.

      For all other pump models –

      NOTE: The WAU-2000 pump model has two identical bushings (79) that fit on top of each other in the valve plate (80).

      Use a press to insert the bushing (79) into the inside of the valve plate (80) until the bushing bottoms out on the shoulder in the ID of the valve plate (80).

b. Install the new top O-ring (81) and the new bottom O-ring (82) into their grooves on the valve plate (80).

c. Insert the valve plate/O-ring assembly (80/81/82) into the valve housing located in the pump housing (35U) so that the open end of the valve plate (80) is facing the outside of the pump.

d. **For WAU-Series pumps only,** insert the spring (78) into the cylinder extending out of the center of the valve cover (76).

e. Insert the new O-ring (77) into its groove in the valve cover (76).

f. Using the socket head cap screws, attach the valve cover/O-ring/spring assembly (76/77/78) to the pump housing (35U) as shown in Figure 4-44.

5. **NOTE:** Step 5 is for WA- and WS-Series pumps only.

   Install the diaphragm pressure switch as follows (see Figures 4-1 and 4-43).

   a. If not already done, use a 3/4-inch open end wrench to screw the pressure switch adapter (8) and gasket (43) into the threaded hole just below the intake of the pump.

   b. Use the centering ring with O-ring (9) and the KF clamp ring (10) to attach the diaphragm pressure switch (11) to the adapter (8).

6. **NOTE:** Step 6 is for WA- and WS-Series pumps only.

   See Section 2-5 and Appendices A and B of this manual for instructions for installing the optional SM-43 Contact Amplifier or the optional Power Control Unit onto the pumping system.

7. Use Section 2-4 to make the electrical connections and Section 2-6 to check the direction of rotation.

8. **NOTE:** The intake and outlet flanges of the pump and the sealing discs (6/37) must be clean and faultless to ensure a vacuum tight fit.

   Assemble and install the sealing discs as follows:

   a. If not already done, place the O-ring (38) onto the dirt trap (39), and then fit the O-ring/dirt trap assembly (38/39) into the sealing-disc outer ring for the pump intake (see Figure 4-43).

   b. If not already done, place the O-ring (7) onto the inner ring and then fit the O-ring/inner ring assembly into the sealing-disc outer ring for the pump outlet (see Figure 4-15).

   c. Place the sealing disc assembly (37) which has the dirt trap (39) onto the pump intake; remove any protective cover from the outlet, and place the outlet sealing disc assembly (6) onto the pump outlet.

   d. Place an ASA adapter flange (4) onto the intake and outlet of the pump so that the studs on the adapter (4) fit through the stud holes in the sealing discs and in the intake and outlet flanges of the pump (see Figure 1-1).

   e. Tighten the nuts and washers onto the studs of the ASA adapters (4) to secure the adapters (4) to the intake and outlet of the pump.

9. **NOTE: Step 9 is for WA- and WAU-Series pumps only.**

   Fill the **motor mount** with vacuum pump fluid as follows (see Figure 1-1).

   a. Install and tighten the plug screw (42) with flat gasket (43) into the oil drain port in the bottom of the motor mount (20).

b. **NOTE:** The fluid capacity of the motor mount for each WA- and WAU-Series pump model is listed in Table 2-2.

CAUTION: USE ONLY VACUUM PUMP FLUID APPROVED BY THE FACTORY FOR YOUR PUMP (see Section 4-1-1). THE USE OF OTHER FLUIDS VOIDS THE WARRANTY.

Pour the correct vacuum pump fluid into the oil inlet port in the top of the motor mount (20) until the fluid level is half way between the bottom of the dip stick (24) and the scribe line.

c. Install and tighten the dip stick (24) with flat gasket (23) into the oil inlet port in the top of the motor mount (20).

10. **CAUTION:** DO NOT TRANSPORT THE ROOTS PUMP WHILE IT HAS PUMP FLUID IN THE **FRONT COVER (41)**; THE FLUID FROM THE **FRONT COVER** WILL SPILL INTO THE PUMPING CHAMBER IF THE PUMP IS TILTED OR JOLTED.

NOTE: See Sections 2-2 through 2-7 for additional details on connecting the pump to the system.

Attach the pump to your system as follows (see Figure 1-1).

a. **CAUTION:** FAILURE TO INSTALL THE ROOTS PUMP PERFECTLY LEVEL COULD PREVENT PROPER CIRCULATION OF THE VACUUM PUMP FLUID AND CAUSE DAMAGE TO THE PUMP.

Use a machinest level to ensure that the pump is level.

b. Bolt the mounting feet (33/34) of the pump to the frame of the system.

c. **NOTE:** The O-rings on the sealing discs must be clean to avoid leaks.

Place a clean sealing disc on each of the two ASA adapters (4). The adapters (4) are attached to the intake and outlet of the pump.

d. Attach the screws securing the intake and outlet line of the system to the ASA adapters (4).

11. **CAUTION:** FAILURE TO PROPERLY SEAT THE PLUG SCREW COULD RESULT IN POOR VACUUM AND PENETRATION OF PUMP FLUID INTO THE PUMPING CHAMBER.

Fill the **front cover (41)** with vacuum pump fluid as follows (see Figure 4-43).

a. Using an allen wrench, screw the plug screw (42) with flat gasket (43) into the oil drain port in the bottom of the front cover (41).

b. **CAUTION:** USE ONLY VACUUM PUMP FLUID APPROVED BY THE FACTORY FOR YOUR PUMP (see Section 4-1-1). THE USE OF OTHER FLUIDS VOIDS THE WARRANTY.

Pour the required amount (see Tables 2-2 and 2-3) of the correct vacuum pump fluid into the oil inlet port in the top of the front cover.

c. Using an allen wrench, screw the plug screw (42) with flat gasket (43) into the oil inlet port in the top of the front cover (41).

12. Use Sections 3-1-1 and 3-1-2 to check the pump fluid level.

4-4-6 Frequently Encountered Problems Resulting from Incorrect Assembly

Table 4-5 contains problems that commonly result from incorrect assembly of the pump. The rows on the left side of the Table list the symptoms you might observe if the pump is incorrectly assembled. The upper columns, "probable cause," list the parts that might be assembled incorrectly. The "X's" indicate which causes are associated with each symptom. The first row, "Reference Section in Manual" indicates the section(s) in this manual which describe how to correctly assemble the part in question.

If you cannot solve your problem using Table 4-5, use Section 6, "Troubleshooting," to locate and correct the problem.

TABLE 4-5. PROBLEMS RESULTING FROM INCORRECT ASSEMBLY

		PROBABLE CAUSE													
		Impeller clearances exceed tolerances	*Motor-side shaft seal (26) damaged	*Inner shaft seal (26) damaged	O-rings are dirty, damaged, or out of their grooves	Plug screws (42)/ gaskets (43) are damaged or improperly seated	Bearings are worn due to insufficient lubrication resulting from drive impeller or end plates being installed on wrong side	Spring washers (62) installed improperly	Motor is wired incorrectly resulting in the pump rotating in the wrong direction	Drive shaft eccentricity is too large	Fluid level is too high	Pump was tilted or is not level	*Couplings (15) are too tight against insert (16)	Motor flange is damaged
	Reference Section in Manual	4-4-2/ 4-4-3	4-4-4-1	4-4-4-1	4-4	4-4-5	4-4-2	4-4-2	2-6	4-4-3 and 4-4-4-1 or 4-4-4-2	3-1-1	4-4-5 Step 10	4-4-4-1 Step 11	4-4-4-1 Step 10g
SYMPTOMS	High temperature (greater than 115°C or 239°F)	X	X	X			X	X		X	X	X	X	X
	Excessive noise	X					X	X		X		X	X	X
	Poor pumping speed	X		X	X	X	X	X	X	X		X	X	X
	Poor ultimate pressure	X		X	X	X		X	X	X				
	Pump will not start	X					X	X		X			X	X
	Pump fluid leaking from motor mount (20)*		X		X	X				X	X			
	Pump fluid leaking from intermediate flange (30)				X									
	Pump fluid leaking from front cover (41)				X	X								
	Pump fluid found in pumping chamber			X	X	X				X	X	X		
	Pump fluid level increasing in front cover (41)			X						X				
	Pump fluid level decreasing in motor mount (20)*		X	X		X				X				

*Applies to WA/WAU-Series pumps only

SECTION 5

PRINCIPLES OF OPERATION

Vacuum pumps are used to reduce the pressure in an enclosed vessel or system. Roots pumps are used in combination with other types of vacuum pumps for applications requiring high pumping speeds. Normally, the backing pump selected should have approximately one-fifth of the displacement of the roots pump; the roots pump will compress large volumes of gas into the foreline for exhausting by the backing pump. Recommended backing pumps are listed in Tables 2-2 and 2-3.

Our roots pumps with external motor (RUVAC WA- and WAU-Series) and with canned motor (RUVAC WS- and WSU-Series) are identical as far as the actual pump parts are concerned, but differ in the form and drive of the motor.

5-1 MOTOR AND DIRECT DRIVE MECHANISM

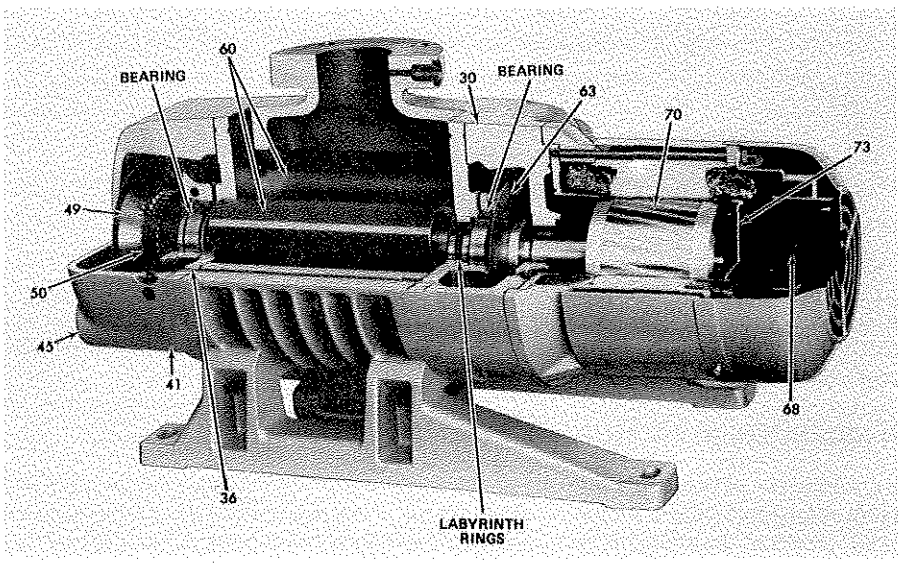
5-1-1 WA- and WAU-Series Pumps

WA- and WAU-Series pumps are standard equipped with 230/460 volt, 3 phase, 60 cycle, totally enclosed fan cooled motors (see Appendix C). When the motor is switched on, the motor shaft turns the pump shaft. The motor shaft and pump shaft are connected directly through a coupling (15) and a coupling insert (16) (see Figure 4-38). The coupling insert (16) absorbs shock and vibration and results in quiet operation of the pump. For WA/WAU-1000 and -2000 pump models, a fan (12) is attached to the coupling (15) to cool the shaft seal (26).

The leadthrough of the shaft is sealed against atmosphere by two radial shaft seals (26) immersed in an oil reservoir in the motor mount (20). This oil reservoir is completely isolated from the rest of the pump. Vacuum pump fluid is added to the motor mount through a venting screw with dip stick. There is an oil drain port with plug screw on the bottom of the mount (20) for draining the pump fluid.

5-1-2 WS- and WSU-Series Pumps

The WS- and WSU-Series pumps are equipped with canned motors. The armature (70) of the motor and the stator (65) are separated from each other by a vacuum tight can (73) of nonmagnetic steel in such a way that the armature is within the evacuated space of the pump (see Figure 5-1). The stator (65) is open to atmosphere. The armature is mounted on a sleeve which is attached directly to the pump shaft. This design eliminates the need for conventional shaft seals, allows the pump to achieve lower ultimate pressure and permits operating WS- and WSU-Series pumps at 208/220, or 440 volts, 60 cycle. A fan with its own drive motor cools the canned motor.



1R-1.3

NOTE: This photograph is of an older pump model which has labyrinth rings.

Figure 5-1. Cutaway View of a WS-Series Pump Mounted for Vertical Flow.

5-2 BEARINGS, SYNCHRONIZED GEARS, AND THEIR LUBRICATING SYSTEM

Attached to the outside of the pumping chamber on the motor side is the intermediate flange (30). It contains an oil slinger (63) which provides the motor-side bearings (54) with lubricating fluid (see Figure 5-1).

Attached to the other side of the pumping chamber is the front cover (41). It contains a splash plate (49) which provides the gears (50) and front bearings (54) with lubricating fluid (see Figure 5-1).

Vacuum pump fluid for both the front cover (41) and the intermediate flange (30) is added and drained through ports in the front cover. Oil level equalization tubes (2/36) connect the two housings (41/30). The sight glass (45) located in the front cover is used to determine the pump fluid level for both housings (41/30) (see Figures 4-43 and 5-1).

The gears (50) in the front cover synchronize the rotation of the impellers (60) (see Section 5-3 and Figure 5-1).

For WA- and WAU-Series pumps, the pump fluid in the motor mount (20) lubricates the bearing (27) in the intermediate flange (30) in addition to sealing the shaft against atmosphere (see Section 5-1-1 and Figure 1-1).

5-3 PUMPING MECHANISM

The pumping mechanism of a roots pump consists of two counter-rotating impellers of "figure 8" design (see Figure 5-2). The impellers sweep all internal surfaces of the pumping chamber for positive displacement of gases. The gas drawn in by the pump is compressed by the rotating impellers and transported to the forevacuum side.

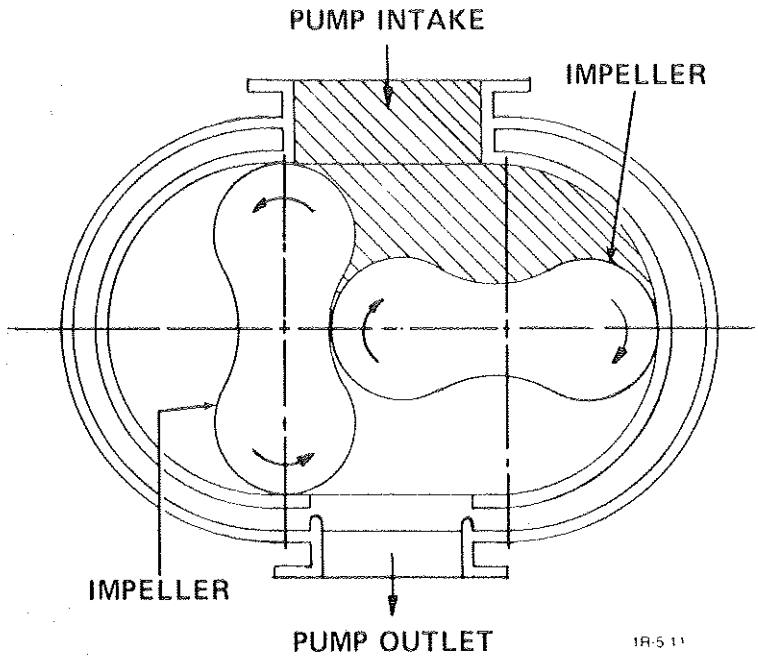


Figure 5-2. Cross Section of WA/WS Pumping Chamber.

Pump fluid is not required in the pumping chamber because there is no metal-to-metal contact between the impellers and the chamber walls. Extremely close operating tolerances (see Table 4-4) hold backstreaming to a minimum without the use of a sealing fluid.

5-4 PROTECTION AGAINST HIGH PRESSURE DIFFERENCE

The pressure difference between the intake and the outlet of the roots pump should not exceed the values listed for your pump model in Tables 2-2 and 2-3. Running the pump above the maximum pressure difference increases the work of compression resulting in high power consumption and warming of the roots pump. If the pump is run continuously above the maximum pressure difference, the impellers may become hotter than the pump housing and thus expand more than the housing causing pump seizure. In general, the maximum pressure difference can be exceeded for short periods (3 minutes) if small chambers are being evacuated.

The WA- and WS-Series and the WAU- and WSU-Series pumps contain different solutions to this problem.

5-4-1 WA- and WS-Series Pumps

The WA- and WS-Series pumps come with the diaphragm pressure switch (11). The pressure switch, when connected to the optional SV 110 contact amplifier (see Appendix A) or the optional Power Control Unit (see Appendix B), automatically protects your roots pump from operating above the maximum pressure difference. This system works as follows:

When the backing pump has evacuated the system to a preset pressure, the diaphragm in the diaphragm pressure switch bulges and closes a microcontact. This operates the SV 110 contact amplifier which amplifies the signal enough to actuate the motor starter of the roots pump.

The SV 110 and the Power Control Unit contain a built-in time delay to prevent the roots pump from being shut down as a result of short pressure burst or fluttering of the pressure switch. A more permanent increase in pressure will result in the SV 110 or the Power Control Unit shutting off the roots pump. See Appendices A and B for additional information on the SV 110 and Power Control Unit.

5-4-2 WAU- and WSU-Series Pumps

The WAU- and WSU-Series pumps come with a built-in bypass line containing a differential pressure relief valve to ensure that the maximum pressure difference between the intake and the outlet port is not exceeded (see Figure 5-3). A weight-and-spring-loaded compensation valve opens if the pressure difference is too high. The portion of the gas that is greater than the capacity of the backing pump is returned from the roots pump outlet, through the bypass line and pressure relief valve, and into the intake of the roots pump. Therefore, no additional protective control units for ON and OFF switching of the pump are required.

The WAU- and WSU-Series roots pumps can be switched ON at atmospheric pressure along with the backing pump. Because the roots pump starts at atmosphere, it takes less time to evacuate the vessel. Even at varying gas loads (e.g., inrush of air), the pump and the motor are always safely protected against overloading.

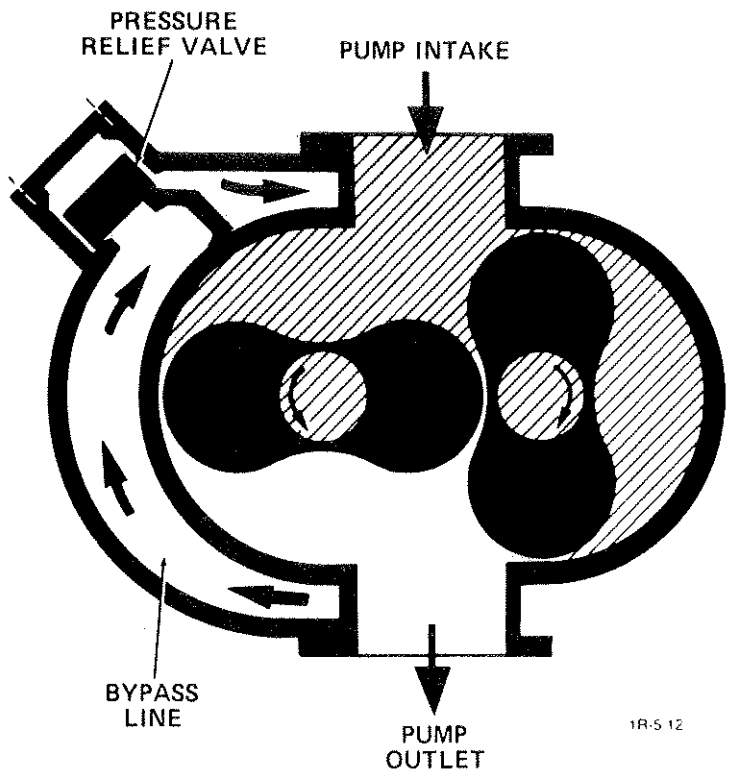


Figure 5-3. Cross Section of WAU/WSU Pumping Chamber.

SECTION 6

TROUBLESHOOTING

WARNING: BEFORE BEGINNING WORK ON THE PUMP, BE SURE TO READ ALL WARNINGS AND CAUTIONS IN SECTION 4-1-1 AND AT THE BEGINNING OF SECTION 4-2.

Most corrective maintenance problems can be resolved by using the Troubleshooting Chart (Table 6-1). Table 4-5 is also useful for troubleshooting problems. For repairs beyond the scope of this manual, contact your nearest Leybold Sales Office for the location of your nearest service center.

Table 6-1 contains the instructions for troubleshooting your pump if a malfunction occurs. To use the table, first observe the symptom, then locate the trouble area, and perform the recommended corrective action. If disassembly of a component is necessary to perform the corrective action, refer to the steps listed in the "Repair Steps" column of Table 6-1. If the Table recommends cleaning, use the general cleaning instructions in Section 4-3-1 or 4-3-2, in addition to any specific "Repair Steps" recommended.

CONTENTS

TABLE 6-1. TROUBLESHOOTING CHART

Symptom	Trouble Area	Probable Cause	Recommended Corrective Action	Repair Steps*
1. Pump becomes too hot (max. operating temperature is 100° to 115°C; 212° to 239°F)	a. Pump location	Insufficient space around motor fan for air circulation.	Place pump so motor end is in open area.	Sec. 2-3
	b. Pump fluid	Contamination of fluid.	Change pump fluid.	Sec. 3-2
		Pump fluid level is too high.	Drain some fluid from the front cover (41).	Sec. 3-1
			For WA- and WAU-Series pumps only, see Symptom 11.	See Symptom 11
		Pump fluid level is too low.	Add some fluid.	Sec. 3-1
			For WA- and WAU Series pumps only, check outer shaft seal (26) on motor mount (20) for leaks.	Fig. 4-36; See Symptom 5a(2)
		Wrong vacuum pump fluid is being used.	Replace with correct vacuum pump fluid.	Sec. 4-1-1 & Sec. 3-2
	c. Backing pump	Wrong backing pump is being used.	Replace with correct backing pump.	Tables 2-2 & 2-3
		Backing pump pressure is poor.	Repair backing pump.	See backing pump manual.
	d. Clearances between impellers (60) and pump housing (35) or end plates (32/40)	Dirt or oil varnish on impellers or in pump housing (35).	+Clean the impellers (60) and pump housing (35).	Sec. 3-4
		Distortion of the pump housing resulting from stress from the vacuum line connection or improper mounting.	Use flexible connectors (bellows) on the intake and outlet and mount the pump correctly.	Sec. 2-7-3 CAUTION & NOTE
		Hot spot on impellers resulting in high point which contacts pump housing.	Sand high point (hot spot); hot spot is silver with blue ring around it.	Sec. 3-4
			Check inside of pump housing (35) for wear; sand and clean+ or replace as necessary.	Sec. 3-4

*The sections and steps listed in the "Repair Steps" column help you to find the information needed to do the "Recommended Corrective Action." This column is not intended to be a complete list of every step necessary to do the corrective action.

+Use the general cleaning instructions in Sections 4-3-1 or 4-3-2.

TABLE 6-1. TROUBLESHOOTING CHART (Continued)

Symptom	Trouble Area	Probable Cause	Recommended Corrective Action	Repair Steps*
1. Pump becomes too hot (max. operating temperature is 100° to 115°C; 212° to 239°F) (cont'd)	d. Clearances between impellers (60) and pump housing (35) or end plates (32/40) (cont'd)	Dowel pins are bent.	Replace dowel pins (31).	Sec. 4-2-1 Steps 2 & 3. Sec. 4-2-2; Sec. 4-2-3 Steps 1 thru 4 and 6a
		Impeller shaft is bent.	Replace impeller and shaft.	Sec. 4
		End of impellers (60) is contacting end plate (32/40).	Replace spring washers (62) or shims (52). Check for damage to housing or impellers.	Sec. 4-2-2; Sec. 4-2-3 Steps 1 thru 5; or Sec. 4
		Heat or mechanical stress has caused clearances to change.	Adjust clearances to within tolerances.	See Symptom 10g
	e. Bearings (54/27)	Bearings are worn.	Install new bearings (54/27). +Clean oil flow holes in bearing wells of the end plates (32/40) and intermediate flange (30). +Clean oil equalization tubes (2/36), if blocked.	Sec. 4. Figure 4-19
	f. Excessive heat of compression due to exceeding maximum pressure difference	**For WAU- and WSU-Series pumps only**, differential pressure relief valve malfunction.	+Clean or replace worn parts of pressure relief valve.	Sec. 4-2-4 Step 7 Sec. 4-4-5 Step 4
		For WA- and WS-Series pumps only, diaphragm pressure switch malfunction.	Replace the pressure switch (11) or send it to the factory for repair.	Sec. 4-2-1 Step 8
		For WA- and WS-Series pumps only, see Symptom 10f.	See Symptom 10f.	
		For WA- and WS-Series pumps only, pressure switch is set too high.	Return the pressure switch to factory to have it adjusted.	Sec. 4-2-1 Step 8
	g. Connecting line between backing pump and roots pump	Line diameter is too small.	Replace line with larger diameter line.	Sec. 2-7-2

*The sections and steps listed in the "Repair Steps" column help you to find the information needed to do the "Recommended Corrective Action." This column is not intended to be a complete list of every step necessary to do the corrective action.

+Use the general cleaning instructions in Sections 4-3-1 or 4-3-2.

TABLE 6-1. TROUBLESHOOTING CHART (Continued)

Symptom	Trouble Area	Probable Cause	Recommended Corrective Action	Repair Steps*
2. Excessive power consumption or circuit breaker or motor overloads are tripping	a. Motor	Voltage of power supply is different from the voltage of the motor.	Change wiring of motor (see motor nameplate) or replace motor with motor that is wired for the correct voltage.	Sec. 2-4
		For WA- and WAU-Series pumps only, motor bearing malfunction.	Replace motor bearing.	
		Motor windings or one of the phases is malfunctioning.	Contact your electrician to repair the motor.	Sec. 4-2-2, Table 4-2
		For WA- and WAU-Series pumps only, motor coupling and pump coupling are too tight against each other.	Loosen setscrew in motor coupling (15) and slide the coupling 1/16" toward the motor; then retighten the coupling setscrew.	Sec. 4-4-4-1 Step 11
		Motor is defective.	Contact motor manufacturer's service center.	Sec. 4-2-2, Table 4-2
	b. Pump fluid	Pump fluid is too viscous.	Replace fluid with correct vacuum pump fluid.	Sec. 3-2
			If ambient temperature is too low, move pump to a warmer location.	
	c. See Symptoms 1b thru 1g	See Symptoms 1b thru 1g.	See Symptoms 1b thru 1g.	

*The sections and steps listed in the "Repair Steps" column help you to find the information needed to do the "Recommended Corrective Action." This column is not intended to be a complete list of every step necessary to do the corrective action.

TABLE 6-1. TROUBLESHOOTING CHART (Continued)

Symptom	Trouble Area	Probable Cause	Recommended Corrective Action	Repair Steps*
3. The pumping chamber is contaminated with pump fluid	a. Fluid vapors are backstreaming from the backing pump	Backing pump does not have a safety valve or an antisuck back valve.	Install safety valve.	
		Backing pump has a malfunctioning safety valve or antisuck back valve.	Repair malfunctioning valve.	See manual that came with backing pump.
	b. Oil level equalization tubes (2/36)	Leak between tube (2/36) and pump housing (35).	Seal leak.	Sec. 4
		O-ring (1) is dirty or damaged.	Replace O-ring (1).	Sec. 4
	c. Piston rings (57)	Cyclic operation of pump.	Use bellows with an adsorption trap (P/N 898580) to connect the front cover to the RUVAC inlet; this reduces the ΔP across the piston rings by evacuating the front cover.	Contact LHVP, Export
		Rings are worn or damaged.	Replace rings (57).	Sec. 4
	d. Oil drain or oil inlet plug screws	Plug screws are not seated properly in ports or do not have gaskets.	Seat plug screws in their ports or install new plug screws (42) or gaskets (43) as necessary.	Sec. 4-2-1 Step 2; Sec. 4-4-5 Step 11
	e. Pump fluid	Fluid level is too high.	Drain some fluid. **For WA- and WAU-Series pumps**, check the fluid level in the motor mount (20). If it is low, the inner radial shaft seal (26) may be leaking.	Sec. 3-1 See Symptom 11
		Fluid has reacted with gas being pumped forming new substance.	Change fluid.	Sec. 3-2
	f. **WA- and WAU-Series pumps only**, dip stick (24) in motor mount (20)	Vent holes in dip stick are clogged resulting in pressure on radial shaft seals (26).	Clean vent holes; replace shaft seals (26) if necessary.	Sec. 4-3-3 Step 14; use Steps from Symptom 11 if necessary

*The sections and steps listed in the "Repair Steps" column help you to find the information needed to do the "Recommended Corrective Action." This column is not intended to be a complete list of every step necessary to do the corrective action.

TABLE 6-1. TROUBLESHOOTING CHART (Continued)

Symptom	Trouble Area	Probable Cause	Recommended Corrective Action	Repair Steps*
4. Abnormal running noise	a. Clearances between impellers (60) and pump housing (35)	See Symptom 1d.	See Symptom 1d.	
	b. Bearings	Bearings are worn.	Replace bearings (54/27)	Sec. 4
	c. Gears (50)	(1) Fluid level in front cover is low or dirty.	Add the proper vacuum pump fluid to the front cover (41) or change the fluid.	Sec. 3-1-1 or 3-2
		(2) Gears are worn.	Replace gears (50).	Sec. 4-2-1 Steps 1 thru 6; Sec. 4-4-3 Steps 1, 3, & 4; Sec. 4-4-5 Steps 2 & 3
		(3) Gears have burrs or sharp edges.	Sand burrs or edges of gears (50) until smooth.	Sec. 4-2-1 Steps 2 & 3; Sec. 4-3-3 Step 12
	d. **For WS and WSU-Series pumps only**, armature (70)	(1) Armature is contacting the canned motor tube (73).	Check if canned motor tube (73) is bent or dented.	Sec. 4-2-2-2 Steps 1, 2, 5, & 6
			Adjust eccentricity of armature (70) and check if screw on end of shaft is tight.	Sec. 4-2-2-2 Steps 1, 2, & 5. Sec. 4-4-4-2 Steps 2e, 6, 9, & 12
		(2) Pump is too hot resulting in the armature spinning on its sleeve.	See Symptom 1. Install new armature (70).	Sec. 4-2-2-2 Steps 1, 2, 5, 7, 8, 9, & 10; Sec. 4-2-3 Steps 1 thru 4. Sec. 4-4-3 Steps 7, 8, 9, & 11; Sec. 4-4-4-2 Steps 1, 2, 3, 4, 6, 9, & 12

*The sections and steps listed in the "Repair Steps" column help you to find the information needed to do the "Recommended Corrective Action." This column is not intended to be a complete list of every step necessary to do the corrective action.

TABLE 6-1. TROUBLESHOOTING CHART (Continued)

Symptom	Trouble Area	Probable Cause	Recommended Corrective Action	Repair Steps*
4. Abnormal running noise (cont'd)	e. **For WA- and WAU-Series pumps only,** shaft bushing sleeve (28)	Screw in end of shaft is loose.	Check shaft bushing sleeve (28) and bearing (27) for wear. Clean, apply Loctite 271, and tighten screw.	Sec. 4-2-2-1; Sec. 4-2-3 Steps 1 thru 4. Sec. 4-4-3 Steps 5, 6, 7, 8, 9, & 11; Sec. 4-4-4-1
	f. Splash plate (49) or gears (50)	Nut (48) on gear end of shaft is loose.	Check gears (50) for wear. Apply Loctite 271 to threads of nut and tighten nut (48).	Use Steps from Symptom 4c(2) if gears are worn
	g. **For WA- or WAU-Series pumps only,** coupling insert (16) or coupling (15)	Insert is worn or coupling is damaged.	Replace worn insert (16) and/or coupling (15).	See Symptom 8g
5. Pump fluid is leaking from pump	a. **For WA- and WAU-Series pumps only,** motor mount (20)	(1) Pump fluid level is too high.	Drain some fluid.	Sec. 3-1-2
		(2) Radial shaft seal (26) on motor-side is worn.	Install new shaft seals (26).	Use Steps from Symptom 11
			Check if vent holes on dip stick (24) are clogged, clean as necessary.	Sec. 4-3-3 Step 14.
		(3) O-ring between motor mount (20) and intermediate flange (30) is dirty or damaged.	Install new O-ring (13).	Use Steps from Symptom 11
		(4) Dip stick or plug screw is not seated properly or doesn't have gasket.	Seat it properly or replace dip stick (24) and gasket (23) or plug screw (42) and gasket (43).	Sec. 3-2-2
	b. Front cover (41)	(1) Leak at plug screw in oil drain port.	Seat plug screw (42) properly in port. If necessary, replace gasket (43) or plug screw (42).	Sec. 3-2-1

*The sections and steps listed in the "Repair Steps" column help you to find the information needed to do the "Recommended Corrective Action." This column is not intended to be a complete list of every step necessary to do the corrective action.

TABLE 6-1. TROUBLESHOOTING CHART (Continued)

Symptom	Trouble Area	Probable Cause	Recommended Corrective Action	Repair Steps*
5. Pump fluid is leaking from pump (cont'd)	b. Front cover (41) (cont'd)	(2) Leak at oil sight glass (45).	Install new gasket (44).	Sec. 3-2-1 Steps 1 thru 5; Sec. 4-2-4 Step 2; Sec. 4-4-5 Step 1; Sec. 3-2-1 Steps 6 thru 10
	c. End plates (32/40)	O-rings on outside of end plates are damaged or dirty.	Install new O-rings (3).	Sec. 4-2-1 steps 1 thru 3; Sec. 4-2-2-1 or 4-2-2-2; Sec. 4-2-3 Steps 1 thru 4; Sec. 4-4
	d. Pump housing (35)	See Symptom 3.		
6. Pump fluid has an unusual color or odor or is very dark, dirty, or turbid	a. Contamination of pump fluid	Process is dirty.	Change pump fluid.	Sec. 3-2
			Add inlet filter and/or oil purification system to pump.	
	b. Pump fluid breaks down	Wrong fluid is being used.	Use correct vacuum pump fluid.	Sec. 4-1-1, Sec. 3-2
		Pump is too hot.	See Symptom 1.	See Symptom 1
7. Excessive pump fluid is consumed	a. Pump fluid	Wrong fluid is being used.	Use correct vacuum pump fluid.	Sec. 4-1-1, Sec. 3-2
	b. Oil migrating into connecting lines	Frequent pressure fluxuations in system.	Reduce pressure fluxuations in system.	
	c. See Symtom 5	See Symptom 5.	See Symptom 5.	
	d. **For WA- WAU-Series pumps only**, inner radial shaft seal (26)	Shaft seal is worn resulting in fluid leaking from the motor mount (20) into the front cover.	Install new shaft seals (26). Readjust pump fluid level in front cover (41).	See Symptom 11

*The sections and steps listed in the "Repair Steps" column help you to find the information needed to do the "Recommended Corrective Action." This column is not intended to be a complete list of every step necessary to do the corrective action.

TABLE 6-1. TROUBLESHOOTING CHART (Continued)

Symptom	Trouble Area	Probable Cause	Recommended Corrective Action	Repair Steps*
8. The pump will not start	a. Motor	See Symptom 2a.	See Symptom 2a.	
	b. Diaphragm pressure switch (11)	Backing pump has not pumped down system to preset roots pump start-up pressure.	Allow backing pump additional time to pump down system.	
			Repair backing pump.	See manual that came with backing pump
		Switch (11) is malfunctioning.	Replace switch or send it to factory for repair.	See 4-2-1 Step 8
	c. SM-43 contact amplifier	SM-43 is malfunctioning.	Replace SM-43.	Appendix A
	d. Power Control Unit	Unit is malfunctioning.	Repair or replace unit.	Appendix B
	e. Clearances between impellers (60) and pump housing (35)	See Symptom 1d.	See Symptom 1d.	See Symptom 1d
	f. Gears (50)	There is dirt or an obstruction in the gears.	+Clean the dirt or remove the obstruction from the gears (50).	Sec. 4-2-1 Steps 2 & 3. See Symptom 4c
	g. **For WA- and WAU-Series pumps only**, coupling (15) or coupling insert (16)	Coupling and/or coupling insert is worn or improperly installed.	Properly install new coupling insert (16) and/or coupling (15).	Sec. 4-2-2-1 Steps 1, 2, & 3. If replacing pump-side coupling, do the steps in Symptom 11
	h. Bearings (54/27)	Bearings are worn.	Replace bearings (54/27)	Sec. 4
	i. **For WS- and WSU-Series pumps only**, armature (70)	Pump was too hot resulting in armature spinning on its sleeve.	See Symptom 1. Install new armature (70).	See Symptom 1 See Symptom 4d(2)
	j Viscosity of pump fluid	Pump is too cold.	Apply heat to the bottom of the front cover (41).	

*The sections and steps listed in the "Repair Steps" column help you to find the information needed to do the "Recommended Corrective Action." This column is not intended to be a complete list of every step necessary to do the corrective action.

+Use the general cleaning instructions in Sections 4-3-1 or 4-3-2.

TABLE 6-1. TROUBLESHOOTING CHART (Continued)

Symptom	Trouble Area	Probable Cause	Recommended Corrective Action	Repair Steps*
9. The pump will not achieve its rated pumping speed	a. Motor	Motor is rotating in wrong direction.	Interchange two of the input leads.	Sec. 2-6
		See Symptom 2a.	See Symptom 2a.	
	b. Vacuum line valve	Vacuum line valve is partially closed.	Open vacuum line valve.	
	c. Dirt trap (39) on intake	Trap (39) or connecting line is obstructed with dirt.	+Clean dirt trap or connecting line.	Sec. 3-5, Sec. 2-7-3 Steps 4 & 7
	d. Inlet filter	Inlet filter accessory is dirty.	Install new filtering element.	
		Wrong inlet filter is being used.	Contact main office for correct filter.	
	e. Connecting lines	Connecting line diameter is too small.	Install larger diameter connection line.	Sec. 2-7-2
		Connecting line is too long.	Use connecting line with an ID larger than the intake ID, or shorten the connecting line.	Sec. 2-7-2
	f. **For WA- and WAU-Series pumps only**, coupling (15) and/or coupling insert (16)	Coupling (15) is loose or coupling insert (16) is worn or improperly installed.	Properly install new coupling insert (16) or coupling (15).	See Symptom 8g
	g. Pump or system	Leak.	Locate and repair leak.	See Symptom 10f
	h. Impellers (60) and pump housing (35)	Dirt is preventing free rotation and free flow of gases.	+Clean impellers and inside of pump housing.	Sec. 3-4
		Clearances are larger than tolerances.	Adjust clearances.	Use steps from Symptom 10g
		See Symptom 1d.	See Symptom 1d.	See Symptom 1d

*The sections and steps listed in the "Repair Steps" column help you to find the information needed to do the "Recommended Corrective Action." This column is not intended to be a complete list of every step necessary to do the corrective action.

+Use the general cleaning instructions in Sections 4-3-1 or 4-3-2.

TABLE 6-1. TROUBLESHOOTING CHART (Continued)

Symptom	Trouble Area	Probable Cause	Recommended Corrective Action	Repair Steps*
9. The pump will not achieve its rated pumping speed (cont'd)	i. Gears	Friction between gears.	Check pump fluid for contamination.	Sec. 3-3
			Check pump fluid level in front cover (41).	Sec. 3-1-1
			Check gears (50) for damage.	Sec. 4-2-1 Steps 2 & 3. See Symptom 4c(2)
	j. Bearings (54/27)	Bearings are dirty or worn.	Replace bearings (54/27).	Sec. 4
		Oil level equalization tubes are clogged.	Clean oil equalization tube (4/36).	Sec. 4
		Oil flow holes in bearing wells of end plates (32/40) or intermediate flange (30) are clogged.	Clean oil flow holes.	Sec. 4
	k. See Symptom 4.	See Symptom 4.	See Symptom 4.	
10. The pump will not achieve its ultimate pressure	a. Motor	Motor is rotating in wrong direction.	Reverse two of the input leads at the drive motor terminal block.	Sec. 2-6
	b. Outlet connection line	Impedance in connection line.	Check valves and check connecting line for an obstruction. If necessary, install a larger diameter connection line.	Sec. 2-7-2
	c. Dirt trap (39) on intake, or inlet filter	Dirt trap or inlet filter is dirty.	+Clean dirt trap and/or install new filtering element.	Sec. 3-5; Sec. 2-7-3 Steps 4 & 7
	d. Backing pump	Backing pump is not pumping down to its ultimate pressure.	See manual that came with backing pump to repair backing pump.	
		Incorrect backing pump is being used.	Replace backing pump with recommended backing pump.	Table 2-2 or 2-3
	e. Pump fluid	Vapor pressure of fluid is too high.	Use correct vacuum pump fluid.	Sec. 4-1-1
		Fluid is contaminated.	Change vacuum pump fluid.	Sec. 3-2

*The sections and steps listed in the "Repair Steps" column help you to find the information needed to do the "Recommended Corrective Action." This column is not intended to be a complete list of every step necessary to do the corrective action.

+Use the general cleaning instructions in Sections 4-3-1 or 4-3-2.

TABLE 6-1. TROUBLESHOOTING CHART (Continued)

Symptom	Trouble Area	Probable Cause	Recommended Corrective Action	Repair Steps*
10. The pump will not achieve its ultimate pressure (cont'd)	f. Air is leaking into the pump or the system	Sealing disc (37/6) on pump intake or outlet.	Install new O-ring (38/7) and clean+ sealing surface.	Sec. 4-2-1 Steps 1a, 1b, & 1c
		Plug screw on oil inlet or drain port of front cover (41).	+Clean plug screw (42), gasket (43), and port, and seat plug screw properly in port. If necessary, install new plug screw (42) and gasket (43).	Sec. 3-2-1
		Worn gasket allowed pump fluid to leak out and then air to leak in oil sight glass (45).	Replace gasket (44) and add the correct vacuum pump fluid.	See Symptom 5b(2)
		Vacuum line or evacuated vessel.	Repair leak.	
		Diaphragm pressure switch (11).	Repair leak or replace switch (11).	Sec. 4-2-1 Step 8
		For WA- and WAU-Series pumps only, a worn radial shaft seal allowed pump fluid and then air to leak from the motor mount (20) into the pump.	Install new radial shaft seals (26); check if vent holes on dip stick (24) are clogged.	See Symptom 11; Sec. 4-3-3 Step 14
		For WA- and WAU-Series pumps only, clogged vent holes in dip stick (24) is resulting in pressure increase in motor mount (20).	Clean vent holes in dip stick (24).	Sec. 4-4-3 Step 14
		O-rings on the outside surface of the end plates (32/40) are damaged or the sealing surface is dirty.	+Clean the sealing surface and install new O-rings (3).	See Symptom 5c
		For WS- and WSU-Series pumps only, the O-ring between the canned motor tube(73) and the intermediate flange (30) is damaged or the sealing surface is dirty.	+Clean the sealing surface and install a new O-ring (13).	Sec. 4-2-2-2 Steps 1, 2, & 5. Sec. 4-4-4-2 Steps 6, 9, & 12

*The sections and steps listed in the "Repair Steps" column help you to find the information needed to do the "Recommended Corrective Action." This column is not intended to be a complete list of every step necessary to do the corrective action.

+Use the general cleaning instructions in Sections 4-3-1 or 4-3-2.

TABLE 6-1. TROUBLESHOOTING CHART (Continued)

Symptom	Trouble Area	Probable Cause	Recommended Corrective Action	Repair Steps*
10. The pump will not achieve its ultimate pressure (cont'd)	f. Air is leaking into the pump or the system (cont'd)	**For WA- and WAU-Series pumps only,** the compression ring is worn resulting in leakage of air through the shaft bushing sleeve (28).	Replace compression ring (64).	Use steps from Symptom 11
	g. Backstreaming into the evacuated vessel	Impeller (60) clearances are too large.	Adjust clearances.	Sec. 4-4-2 Step 13c; Table 4-4. If axial gap is off, do Sec. 4-2-1 Steps 1 thru 6, Sec. 4-4-2 Step 13d, and Sec. 4-4-3 Step 1. Sec. 4-2-1 Steps 1 thru 3, Sec. 4-4-3 Steps 3a thru 3e; if gap is off, do Sec. 4-2-1 Steps 4 and 5, reinstall the nuts, then do Sec. 4-4-3 Step 3f and 4. Sec. 4-4-5 Steps 2, 3, 8, 10, 11, & 12
	h. **WS- and WSU-Series pumps only,** Armature	Pump is too hot resulting in the armature spinning on its sleeve.	See Symptom 1. Install new armature (70).	See Symptom 4d(2)
11. **For WA- and WAU-Series pumps only,** the pump fluid level in the front cover (41) is increasing	Inner radial shaft seal (26)	Shaft seal is worn resulting in pump fluid leaking from the motor mount (20) into the front cover.	Install new shaft seals (26). Readjust pump fluid level in front cover (41).	Sec. 4-2-1 Step 2; Sec. 4-2-2-1; Sec. 4-2-3 Steps 1 thru 4. Sec. 4-4-3 Steps 5, 6, 7, 8, 9, & 11; Sec. 4-4-4-1; Sec. 4-4-5 Steps 9 & 11

*The sections and steps listed in the "Repair Steps" column help you to find the information needed to do the "Recommended Corrective Action." This column is not intended to be a complete list of every step necessary to do the corrective action.

+Use the general cleaning instructions in Sections 4-3-1 or 4-3-2.

SECTION 7

SPARE PARTS LIST

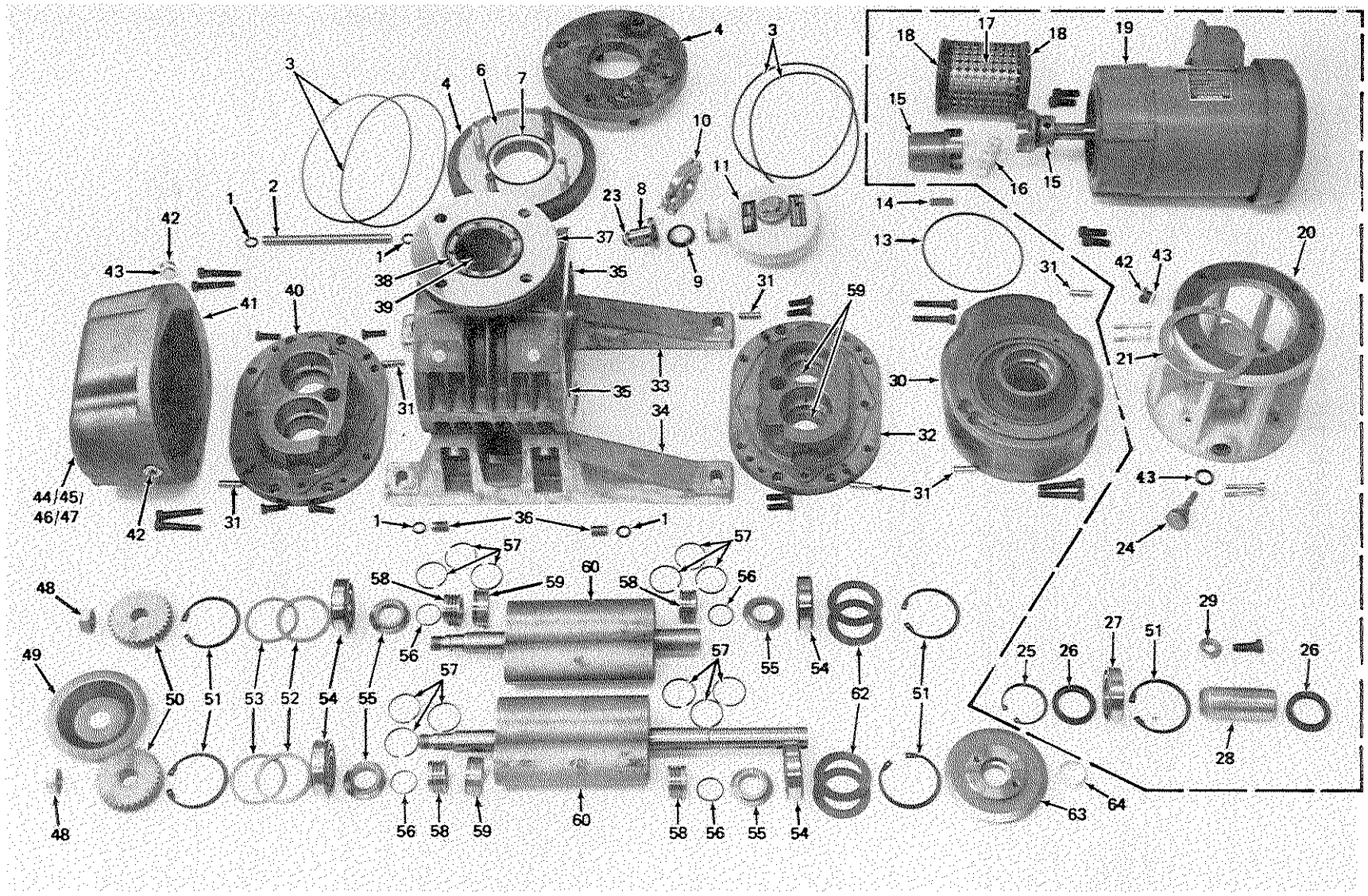
Section 7-1 lists the pump fluid, the gasket sets, and the new parts that are required to rebuild the pumps. Section 7-2 is a complete list of the spare parts for the RUVAC pumps. See Table B-2 of Appendix B for replacement parts for the power control unit.

Use Figures 7-1 and 7-2 and the exploded isometric drawings in the back of this manual to help identify the part you need. The numbers called out on the figures and drawings correspond to the position numbers listed for each part in the first column of the spare parts list. For example, the first column on page 102 lists "54" for the bearing (end plate). On Figure 7-1, the number "54" is pointing to a photograph of that bearing.

The second series of five columns indicates which pump model uses the part and how many each pump requires. For example, on page 102, the "4" under the "150" column for Position No. 54 indicates that four bearings (Catalog No. 261-01-171) are required for WA-, WAU-, WS-, and WSU-150 pump models; the "4" in the "500" column indicates that four bearings (Catalog No. 261-01-173) are required for WA-, WAU-, WS-, and WSU-500 pump models.

CONTENTS

LIST OF FIGURES



NOTE: The parts enclosed in the dashed lines are for WA- and WAU-Series pumps only. All other parts in Figure 7-1 are used in WA-, WAU-, WS- and WSU-Series pumps. See Figure 7-2 for additional parts for WS- and WSU-Series pumps.

NOTE: The numbers called out on the figure correspond to the Position No. listed for each part in the spare parts list.

Figure 7-1. Disassembled Pump (WA-250 pump model shown).

SECTION 7-1

NEW PARTS REQUIRED TO REBUILD PUMP

Position No. on Figs.	Part Name	Pump Model	Catalog No.	Dimensions (mm)	Material	Remarks
N/A †	Gasket set	WA150 and WA250	19366A		Viton	The gasket set is made up of each part listed in Sec. 7-2 with an "*" beside its catalog number.
	Gasket set	WS150 and WS250	19366S			
	Gasket set	WAU150 and WAU250	19366AU			
	Gasket set	WSU150 and WSU250	19366SU			
	Gasket set	WA500	19371A			
	Gasket set	WS500	19371S			
	Gasket set	WAU500	19371AU			
	Gasket set	WSU500	19371SU			The gasket sets are for standard pump models. If your WA/WAU pump model uses perfluoropolyether (PFPE) vacuum oil, you must order the special PFPE-service shaft seals (Item 26) in addition to the gasket set and Items 27 & 28.
	Gasket set	WA1000	19376A			
	Gasket set	WS1000	19376S			
	Gasket set	WAU1000	19376AU			
	Gasket set	WSU1000	19376SU			
	Gasket set	WA2000	19381A			
	Gasket set	WS2000	19381S			
	Gasket set	WAU2000	19381AU			
52	Shim set	WA/WS/WAU/WSU-150 and -250	98-264-001	62x50	Steel	Each shim set contains 12 or 14 shims with 6 or 7 different thicknesses. See Figure 7-1.
52	Shim set	WA/WS/WAU/WSU-500	98-264-002	72x56		
52	Shim set	WA/WS/WAU/WSU-1000	98-264-003	80x63		
52	Shim set	WA/WS/WAU/WSU-2000	98-264-004	90x70		
N/A	HE-200 vacuum pump fluid	WA/WAU/WS/WSU-Series pumps used for standard applications	98-198-006	1 qt.		Contact the factory for the approved vacuum pump fluid for nonstandard pump applications.
			98-198-049	12 qt. case		
			98-198-007	1 gal.		
			98-198-008	5 gal.		
			98-198-010	55 gal.		
N/A	HE-2700 perfluoropolyether pump fluid	WA/WAU/WS/WSU-Series pumps for extreme-corrosive service applications	898565	1 pound		Four pounds of HE-2700 = 1 quart

Viton – heat resistant synthetic rubber

† A gasket set in addition to Item No. 27 and 28 are needed to replace the shaft seals on WA/WAU series pumps.

SECTION 7-1

NEW PARTS REQUIRED TO REBUILD PUMP (Continued)

NOTE: See Figure 7-1 for a photograph of most of the parts listed below.

Position No. on Figs.	No. Required per Unit WA/WAU/WS/WSU 150	250	500	1000	2000	Part Name	Catalog No.	Dimensions (mm)	Material	Remarks
54	4	4				Bearing (end plate)	261-01-171			
54			4			Bearing (end plate)	261-01-173			
54				4		Bearing (end plate)	261-01-175			
54					4	Bearing (end plate)	261-01-176			
27	1	1	1			Bearing (intermediate flange)	261-01-301			This grooved ball bearing is used only on WA- and WAU-Series pumps and on the WS-2000 pump model.
27				1	1	Bearing (intermediate flange)	261-01-112			
57	12	12				Piston ring	231-79-256			
57			12			Piston ring	231-79-259	40x36.3x2		
57				16		Piston ring	231-53-217			
57					16	Piston ring	231-53-216			
28	1	1				Shaft bushing sleeve	627-32-509	35x78	Steel	Used only on WA and WAU Series pumps.
28			1			Shaft bushing sleeve	627-33-509	35x76	Steel	
28				1		Shaft bushing sleeve	627-34-509	50x85	Steel	
28					1	Shaft bushing sleeve	627-35-509	50x100	Steel	
N/A	1	1				Piston ring kit	19365			The kit is only necessary if you are replacing labyrinth rings in older model pumps with piston rings. The kit includes each part listed in Sec. 7-2 with a "+" beside its catalog number.
			1			Piston ring kit	19370			
				1		Piston ring kit	19375			
					1	Piston ring kit	19380			

SECTION 7-2

COMPLETE LIST OF SPARE PARTS
WA/WAU/WS/WSU Pump Parts

NOTE: See Figure 7-1 for a photograph of most of the parts listed below.

Position No. on Figs.	No. Required per Unit WA/WAU/WS/WSU 150	250	500	1000	2000	Part Name	Catalog No.	Dimensions (mm)	Material	Remarks
1	4	4	4			O-ring	239-70-111*	11.5x3	Viton	
1				4	4	O-ring	239-70-154*	17x3	Viton	
2	1					Oil level equalization tube (long)	627-00-411	12x2x99.8	Steel	
2		1				Oil level equalization tube (long)	627-02-411	12x2x162.8	Steel	
2			1			Oil level equalization tube (long)	627-03-411	12x2x209.8	Steel	
2				1		Oil level equalization tube (long)	627-04-411	18x1.5x270	Steel	
2					1	Oil level equalization tube (long)	627-05-411	18x1.5x340	Steel	
3	4	4				O-ring	239-70-424*	180x3	Viton	
3			4			O-ring	239-70-432*	235x3	Viton	
3				4		O-ring	239-70-433*	274x3	Viton	
3					4	O-ring	239-70-124*	355x4	Viton	
4	2	2	2			ASA adapter flange	98-278-0428	NW65 to ASA 3"		
4				2		ASA adapter flange	98-278-0429	NW100 to ASA 4"		
4					2†	ASA adapter flange	98-278-0432 †	NW150 to ASA 6"		†
5	1	1	1	1		Eyebolt	99-289-006	5/8-11x3/4" lg		Not shown in figures.
5					2	Eyebolt	201-13-104	M16		
6	1	1	1			Sealing disc assembly	88256	NW65	Al	This sealing disc is for the outlet of the pump. It includes the outer ring (6A), O-ring (7), and the inner ring (7A)
6				1		Sealing disc assembly	88257	NW100	and	
6					1	Sealing disc assembly	88258	NW150	Viton	
6A	1	1	1			Outer ring	233-93-341			
6A				1		Outer ring	233-93-342			
6A					1	Outer ring	233-93-343			
7	1	1	1			O-ring	239-70-136		Viton	This O-ring is part of the sealing disc listed in Position 6.
7				1		O-ring	239-70-164		Viton	
7					1	O-ring	239-70-146		Viton	
7A	1	1	1			Inner ring	233-93-329			
7A				1		Inner ring	233-93-330			
7A					1	Inner ring	233-93-331			

*Included in gasket set (see Section 7-1)

† The catalog number for the ASA adapter flange for the WAU-2000 pump model is 98-278-0470.

Viton – heat resistant synthetic rubber
Al – aluminum

COMPLETE LIST OF SPARE PARTS (Continued)
WA/WAU/WS/WSU Pump Parts (Continued)

NOTE: See Figure 7-1 for a photograph of most of the parts listed below.

Position No. on Figs.	No. Required per Unit WA/WAU/WS/WSU 150	250	500	1000	2000	Part Name	Catalog No.	Dimensions (mm)	Material	Remarks
8	1	1	1	1	1	Pressure switch adapter	16839	KF20		These parts are for WA- and WS-Series pumps; they are not necessary for WAU- and WSU-Series pumps.
9	1	1	1	1	1	Centering ring	18322	KF20		
10	1	1	1	1	1	KF clamp ring	18342	KF20		
11	1	1	1			SM-42 Diaphragm pressure switch †	16407 (WA)	30 & 300 Torr		Use Catalog No. 16406 for the switch (11) for all WS-Series pumps. For all areas with an explosion hazard, use the explosion proof diaphragm pressure switch, Catalog No. 98-131-3010.
						SM-42 Diaphragm pressure switch †	16406 (WS)	4 & 40 Torr		
11				1	1	SM-42 Diaphragm pressure switch †	16406	4 & 40 Torr		
12				1		Fan	99-137-001		Plastic	Not shown in figures. This fan is on WA- and WAU-Series pumps only.
12					1	Fan	99-137-002			
13	1	1				O-ring	239-70-411*	122x3	Viton	
13			1			O-ring	239-70-418*	150x3	Viton	
13				1		O-ring	239-70-303*	170x3	Viton	
13					1	O-ring	239-70-202*	210x3	Viton	
14	1	1				Key	627-02-425	8x7x30	Steel	
14			1			Key	627-03-425	8x7x40	Steel	
14				1		Key	627-04-425	10x8x36	Steel	
14					1	Key	627-05-425	10x8x50	Steel	

* Included in gasket set (see Section 7-1)

Viton -- heat resistant synthetic rubber

† PS 110A and PS 111A pressure switches are available under part numbers 16072 and 16073 respectively. However, the PS model pressure switches can not be used with the SM-43 contact amplifier.

COMPLETE LIST OF SPARE PARTS (Continued)
WA/WAU Only, Motor-End Parts

NOTE: Position Numbers 15 through 29 are for WA- and WAU-Series pumps only; they are not used in WS- and WSU-Series pumps.

NOTE: See Figure 7-1 for a photograph of most of the parts listed below.

Position No. on Figs.	No. Required per Unit WA/WAU 150	250	500	1000	2000	Part Name	Catalog No.	Dimensions (mm)	Material	Remarks
	1	1	1	1	1	Key	See Position No. 14			See Position No. 14.
				1	1	Fan	See Position No. 12			See Position No. 12.
15	1	1				Coupling	627-31-483-1	D55x100		The coupling includes both the pump-side and motor-side couplings and the coupling insert (16).
15			1			Coupling	627-33-483-1	D80x98		
15				1		Coupling	627-34-483-1 †	D160x119		
15					1	Coupling	627-35-483-1 †	D160x149		
16	1	1				Coupling insert	701-00-197*	D54x14		
16			1	1	1	Coupling insert	701-00-198*	D80x18		
17	1	1	1			Coupling shield	627-31-480			
17				1		Coupling shield	627-34-480			
17					1	Coupling shield	627-35-457			
18	2 ft	2 ft	2 ft	3 ft	3 ft	Rubber trim	189-27-112		Rubber	
19	1	1	1	1	1	Motor				See Appendix C for a list of motors for WA- and WAU-Series pumps.
20	1	1				Motor mount	627-31-321			
20			1			Motor mount	627-33-321			
20				1		Motor mount	200-13-511			Shaft seal P/N 200-13-455 must be used with these motor mounts.
20					1	Motor mount	200-13-512			
21	1	1	1			Shield retainer	627-31-481			
21				1		Shield retainer	627-34-481			
22					1	Motor adapter flange	627-35-484			Not shown in figures.
23	1	1	1	1	1	Flat gasket	239-55-165*	22x1.5	Viton	

* Included in gasket set (see Section 7-1)

D — diameter
Vitron — heat resistant synthetic rubber

† The WA/WAU -1000 and -2000 pump models have a small plastic fan that fits on the coupling. This fan is not included when you order the coupling. The part number of this fan for the WA/WAU -1000 is 99-137-001; the part number of the fan for the WA/WAU -2000 is 99-137-002.

COMPLETE LIST OF SPARE PARTS (Continued)
WA/WAU Only, Motor-End Parts (Continued)

NOTE: Position Numbers 15 through 29 are for WA- and WAU-Series pumps only; they are not used in WS- and WSU-Series pumps.

NOTE: See Figure 7-1 for a photograph of all of the parts listed below.

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Position No. on Figs.	No. Required per Unit WA/WAU 150	250	500	1000	2000	Part Name	Catalog No.	Dimensions (mm)	Material	Remarks
24	1	1				Dip stick	627-30-109	16x1.5,25x56	Steel	
24			1			Dip stick	627-33-109	16x1.5,25x66	Steel	
24				1	1	Dip stick	627-34-109	16x1.5,25x76	Steel	
25	1	1	1			Retainer ring	231-04-132	47x1.75		
25				1	1	Retainer ring	231-04-145	72x2.5		
26	3	3	3			Shaft seal (Standard)	200-13-031*	35x47x6	Viton	
26	1	1	1			Inner shaft seal (PFPE Service)	720-27-011			For use with Perfluoropolyether oil.
26	1	1	1			Outer shaft seal (PFPE Service)	720-27-012			
26				2	2	Inner shaft seal (Standard)	200-13-032*	50x72x8	Viton	
26				1	1	Outer shaft seal (Standard)	200-13-455*	50x65x8	Viton	For older pumps, use P/N 200-13-032. (50x72x8).
26				1	1	Inner shaft seal (PFPE Service)	720-27-013			For use with Perfluoropolyether oil.
26				1	1	Outer shaft seal (PFPE Service)	720-27-019			
27	1	1	1			Grooved bearing	261-01-301			
27				1	1	Grooved bearing	261-01-112			This bearing is also used on the WS-2000 pump model.
27A	1	1	1			Retainer ring	231-04-140	60 x 2		This item is only used on WA and WAU pump models
27A				1		Retainer ring	231-04-150	90 x 3		
27A					2	Slotted screw	201-80-185			
28	1	1				Shaft bushing sleeve	627-32-509	35x78	Steel	
28			1			Shaft bushing sleeve	627-33-509	35x76	Steel	
28				1		Shaft bushing sleeve	627-34-509	50x85	Steel	
28					1	Shaft bushing sleeve	627-35-509	50x100	Steel	
29	1	1				Washer	627-30-461	26x11x5	Steel	
29			1			Washer	627-03-410	32x12.5x6	Steel	
29				1		Washer	627-04-410	36x12.5x6	Steel	
29					1	Washer	627-05-410	45x12.5x7	Steel	

*Included in gasket set (see Section 7-1)

Viton heat resistant synthetic rubber

COMPLETE LIST OF SPARE PARTS (Continued)
WA/WAU/WS/WSU Pump Parts

NOTE: See Figure 7-1 for a photograph of all of the parts listed below.

Position No. on Figs.	No. Required per Unit WA/WAU/WS/WSU					Part Name	Catalog No.	Dimensions (mm)	Material	Remarks
	150	250	500	1000	2000					
30	1	1				Intermediate flange	627-00-304			
30			1			Intermediate flange	627-03-304			
30				1		Intermediate flange	627-04-304			
30					1	Intermediate flange	627-05-304			
31	6	6	6			Tapered dowel pin	241-30-107			
31				6		Tapered dowel pin	241-30-106			
31					6	Tapered dowel pin	241-30-105	12x40		
32	1	1				Rear end plate	361-46-253			
32			1			Rear end plate	361-46-254			
32				1		Rear end plate	361-46-257			
32					1	Rear end plate	361-46-258			
33	1					Left foot	627-01-309	400x52	Al	For WA/WS-150 only.
33	1					Left foot	463-50-108			For WAU/WSU-150 only.
33		1				Left foot	627-02-309	405x50	Al	
33			1			Left foot	627-03-309	486x58	Al	
33				1		Left foot	627-04-309	560x65	Al	
33					1	Left foot	627-05-309	800x110	CI	
34	1					Right foot	627-01-310	400x52	Al	For WA/WS-150 only.
34	1					Right foot	463-50-107			For WAU/WSU-150 only.
34		1				Right foot	627-02-310	400x50	Al	
34			1			Right foot	627-03-310	468x58	Al	
34				1		Right foot	627-04-310	560x65	Al	
34					1	Right foot	627-05-310	800x110	CI	

Al – aluminum
CI – cast iron

COMPLETE LIST OF SPARE PARTS (Continued)

WA/WAU/WS/WSU Pump Parts (Continued)

NOTE: See Figure 7-1 for a photograph of most of the parts listed below.

Position No. on Figs.	No. Required per Unit WA/WAU/WS/WSU 150	250	500	1000	200	Part Name	Catalog No.	Dimensions (mm)	Material	Remarks
35	1					Pump housing (WA/WS)	331-54-151			This housing is for WA- and WS-Series pumps. See Position No. 35U for WAU- and WSU-Series pump housings.
35		1				Pump housing (WA/WS)	331-54-150			
35			1			Pump housing (WA/WS)	331-54-149			
35				1		Pump housing (WA/WS)	331-54-148			
35					1	Pump housing (WA/WS)	331-54-152			
35U	1					Pump housing (WAU/WSU)	331-54-144			This housing is for WAU- and WSU-Series pumps. See Figure 4-16. See Position No. 35 for WA- and WS-Series pump housings.
35U		1				Pump housing (WAU/WSU)	331-54-143			
35U			1			Pump housing (WAU/WSU)	331-54-140			
35U				1		Pump housing (WAU/WSU)	331-54-141			
35U					1	Pump housing (WAU/WSU)	331-54-142			
36	2	2	2			Oil level equalization tube (short)	627-02-412	12x2x20	Steel	
36				2	2	Oil level equalization tube (short)	627-04-412	18x1.5x20	Steel	
37	1	1	1			Sealing disc/dirt trap assembly	410-70-112	NW65		This assembly is for the pump intake. It includes an outer ring (37A), an O-ring (38) and a dirt trap (39).
37				1		Sealing disc/dirt trap assembly	410-70-113	NW100		
37					1	Sealing disc/dirt trap assembly	410-70-114	NW150		
37A	1	1	1			Outer ring	233-93-301			
37A				1		Outer ring	233-93-302			
37A					1	Outer ring	233-93-303			
38	1	1	1			O-ring	239-70-510*	72.39x5.33	Viton	
38				1		O-ring	239-70-511*	104.14x5.33	Viton	
38					1	O-ring	239-70-512*	151.77x5.33	Viton	
39	1	1	1			Dirt trap	410-70-116	NW65		
39				1		Dirt trap	410-70-117	NW100		
39					1	Dirt trap	634-08-344	NW150		
40	1	1				Front end plate	361-46-252			
40			1			Front end plate	361-46-255			
40				1		Front end plate	361-46-256			
40					1	Front end plate	361-46-259			

*Included in gasket set (see Section 7-1)

Viton – heat resistant synthetic rubber

COMPLETE LIST OF SPARE PARTS (Continued)
WA/WAU/WS/WSU Pump Parts (Continued)

NOTE: See Figure 7-1 for a photograph of most of the parts listed below.

Position No. on Figs.	No. Required per Unit WA/WAU/WS/WSU					Part Name	Catalog No.	Dimensions (mm)	Material	Remarks
	150	250	500	1000	2000					
41	1	1				Front cover	627-02-107			The front cover includes the sight glass assembly (44/45/46/47) and plug screws (42) and flat gaskets (43).
41			1			Front cover	627-03-107			
41				1		Front cover	627-04-107			
41					1	Front cover	627-05-107			
42	5	5	5	5	5	Plug screw	201-27-105	16x1.5	Steel	WA- and WAU- Series pumps have 5 plug scews and flat gaskets; WS- and WSU- Series pumps have 4.
43	6	6	6	6	6	Flat gasket	238-80-504		Teflon	
44	1	1				Gasket	239-55-140*			See Figure 4-15.
44			1	1	1	Gasket	239-55-162*	40x33x1.5		
45	1	1				Sight glass	226-80-139	D30x4	Glass	See Figure 4-15.
45			1	1	1	Sight glass	226-80-140	D39.5x4	Glass	
46	1	1				Thrust washer	233-75-135	30x23x2	Al	See Figure 4-15.
46			1	1	1	Thrust washer	233-75-152	40x33x2	Al	
47	1	1				Threaded ring	231-54-207	32x1.5	Al	See Figure 4-15.
47			1	1	1	Threaded ring	233-31-110	42x1.5	Al	
48	2	2				Nut	627-00-445	18x1.5	Steel	
48			2			Nut	627-03-445	24x1.5	Steel	
48				2		Nut	627-04-445	27x1.5	Steel	
48					2	Nut	211-14-513	30x1.5	Steel	
49	1	1				Splash plate	627-02-409	D100x15	Steel	
49			1			Splash plate	627-03-409	D135x18	Steel	
49				1		Splash plate	627-04-409	D175x18	Steel	
49					1	Splash plate	627-05-409	D195x18	Steel	
50	1	1				Pair of gears	627-02-114	D71.5x20	Steel	
50			1			Pair of gears	627-03-114	D89x30	Steel	
50				1		Pair of gears	627-04-114	D111x36	Steel	
50					1	Pair of gears	627-05-114	D141x40	Steel	

*Included in gasket set (see Section 7-1)

D diameter
Al - aluminum

COMPLETE LIST OF SPARE PARTS (Continued)
WA/WAU/WS/WSU Pump Parts (Continued)

NOTE: See Figure 7-1 for a photograph of all of the parts listed below.

Position No. on Figs.	No. Required per Unit WA/WAU/WS/WSU					Part Name	Catalog No.	Dimensions (mm)	Material	Remarks
	150	250	500	1000	2000					
51	4	4				Retainer ring	231-04-140	62x2		
51			4			Retainer ring	231-04-145	72x2.5		
51				4		Retainer ring	231-04-149	80x2.5		
51					4	Retainer ring	231-04-150	90x3		
52	1	1				Shim set	98-264-001	62x50	Steel	
52			1			Shim set	98-264-002	72x56	Steel	
52				1		Shim set	98-264-003	80x63	Steel	
52					1	Shim set	98-264-004	90x70	Steel	
53	2	2				Spacer ring	231-92-161+			
53			2			Spacer ring	231-92-160+	71.9x62x2		
53				2		Spacer ring	627-04-408+			
53					2	Spacer ring	627-05-408+			
54	4	4				Ball bearing (end plate)	261-01-171+			
54			4			Ball bearing (end plate)	261-01-173+			
54				4		Ball bearing (end plate)	261-01-175+			
54					4	Ball bearing (end plate)	261-01-176+			
55	4	4				Splash ring	231-52-108+			
55			4			Splash ring	231-52-110+			
55				4		Splash ring	231-52-109+			
55					4	Splash ring	231-52-107+			
56	4	4				O-ring	239-70-191*+	25x2	Viton	
56			4			O-ring	239-70-415*+	30x2	Viton	
56				4		O-ring	239-70-435*+	35x2	Viton	
56					4	O-ring	239-70-416*+	40x2	Viton	

*Included in gasket set (see Section 7-1)
+Included in piston ring kit (see Section 7-1)

Viton — heat resistant synthetic rubber

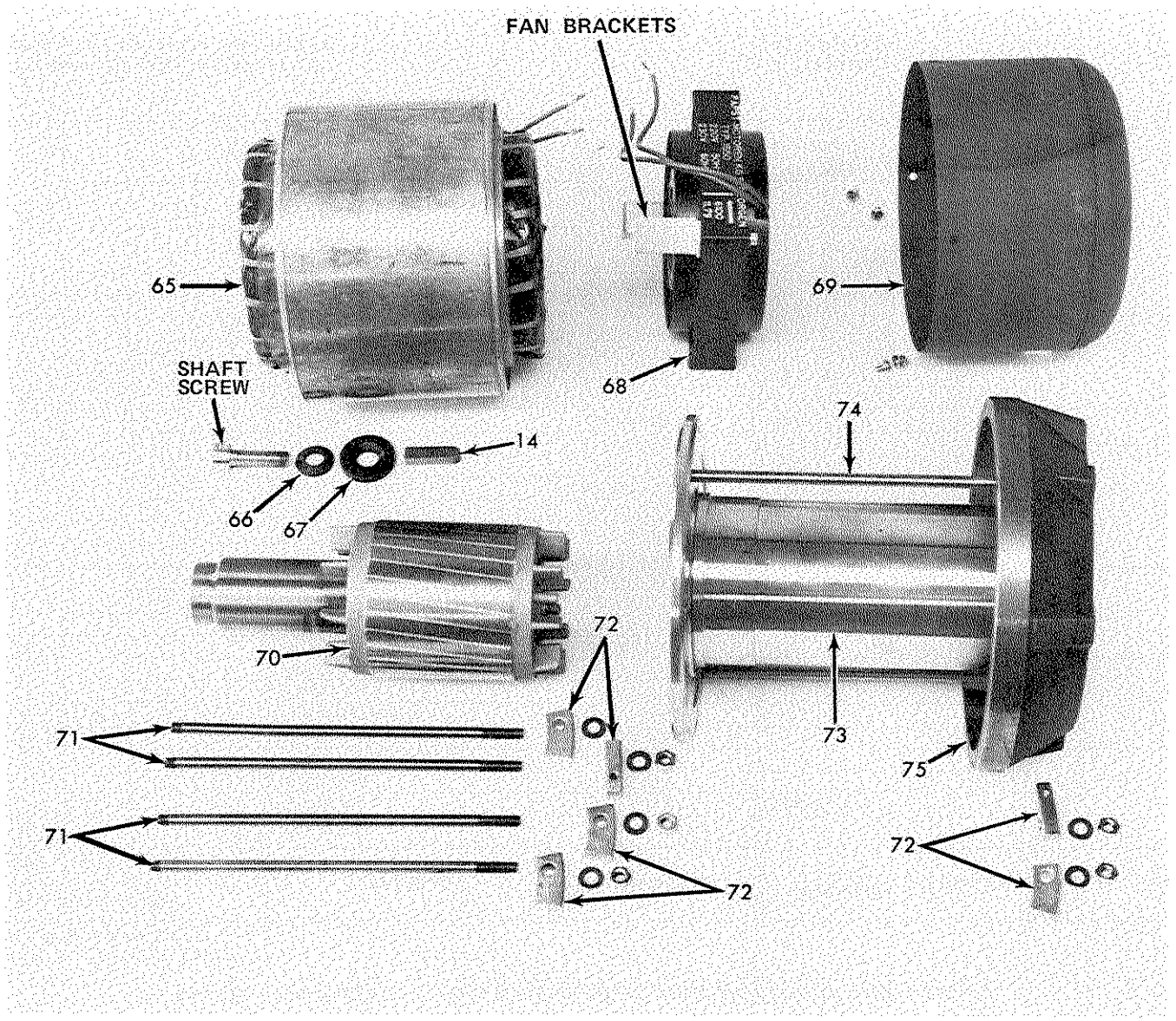
COMPLETE LIST OF SPARE PARTS (Continued)
WA/WAU/WS/WSU Pump Parts (Continued)

NOTE: See Figure 7-1 for a photograph of most of the parts listed below.

Position No. on Figs.	No. Required per Unit WA/WAU/WS/WSU					Part Name	Catalog No.	Dimensions (mm)	Material	Remarks
	150	250	500	1000	2000					
57	12	12				Piston ring	231-79-256+			
57			12			Piston ring	231-79-259+	40x36.3x2		
57				16		Piston ring	231-53-217+			
57					16	Piston ring	231-53-216+			
58	4	4				Piston ring holder	431-31-291+			
58			4			Piston ring holder	431-31-293+			
58				4		Piston ring holder	431-31-290+			
58					4	Piston ring holder	431-31-292+			
59	4	4				Piston ring housing	331-88-120+			
59			4			Piston ring housing	331-88-122+			
59				4		Piston ring housing	331-88-121+			
59					4	Piston ring housing	331-88-119+			
60	1					Pair of impellers	627-00-113	236x102	Steel	
60		1				Pair of impellers	627-02-113	417x102	Steel	
60			1			Pair of impellers	627-03-113	472x128	Steel	
60				1		Pair of impellers	627-04-113	585x160	Steel	
60					1	Pair of impellers	627-05-113	710x202	Steel	
61				1		Distance ring	627-04-499	45x35x2.5	Steel	Not shown in figures.
61					1	Distance ring	627-05-499	50x40x2.2	Steel	
62	8	8				Spring washers	221-82-212	61.5x40.5x0.7	Steel	
62			12			Spring washers	221-82-211	71.5x45.5x0.7	Steel	
62				16		Spring washers	221-82-210	79.5x50.5x0.8	Steel	
62					16	Spring washers	221-82-209	89.5x60.5x0.9	Steel	
63	1	1				Oil slinger	221-02-213	110x19	Steel	
63			1			Oil slinger	221-02-212+	135x24	Steel	
63				1		Oil slinger	627-04-103	175x28	Steel	
63					1	Oil slinger	627-05-103	195x37	Steel	
64	1	1				Compression ring	627-02-426*	D32x25x7	Al	
64			1			Compression ring	627-03-426*	D35x30x7	Al	
64				1		Compression ring	627-04-426*	D43x35x7	Al	
64					1	Compression ring	627-05-426*	D48x40x7	Al	

*Included in gasket set (see Section 7-1)
+Included in piston ring kit (see Section 7-1)

D diameter
Al aluminum



1R-12.13A

NOTE: See Figure 7-1 for a photograph of the remainder of the parts for a WS- or WSU- Series Pump.

NOTE: The numbers called out on the figure correspond to the Position No. listed for each part in the spare parts list.

Figure 7-2. Disassembled Canned Motor for a WS- or WSU-Series Pump (WS-250 pump model shown).

COMPLETE LIST OF SPARE PARTS (Continued)
WS/WSU Only, Motor-End Parts

NOTE: Position Numbers 65 through 75 are for WS- and WSU-Series pumps only; they are not used in WA- and WAU-Series pumps.

NOTE: See Figure 7-2 for a photograph of most of the parts listed below.

Position No. on Figs.	No. Required per Unit WS/WSU 150	250	500	1000	2000	Part Name	Catalog No.	Dimensions (mm)	Material	Remarks
	1	1	1	1	1	Key	See Position No. 14			See Position No. 14.
65	1	1				Stator	627-01-106	D160x55		208/230/460 volt, 3-phase, 60 Hz.
65			1			Stator	627-03-106	D196x168		
65				1		Stator	627-04-106	D216x190		
65					1	Stator	627-05-106	D290x358		
66	1	1				Ball washer	221-22-103	10.5	Steel	
66			1	1	1	Ball washer	221-22-104	13	Steel	
67	1	1				Conical seat washer	221-22-303	12	Steel	
67			1	1		Conical seat washer	221-22-304	14.2	Steel	
67					1	Conical seat washer	627-05-448	D45x7	Steel	
68	1	1	1			Fan	380-93-103	Type 1550		
68				1		Fan	380-91-123	Type 7550		
68					1	Fan †	627-05-124	Type E 225-21		The fan on the WS- and WSU-2000 has a capacitor attached to it. †
69	1	1				Motor end cover	627-01-429			
69			1			Motor end cover				The covers for these pump models do not have separate cat. no.; they come with the stator (65).
				1		Motor end cover				
					1	Motor end cover				
27					1	Grooved bearing	261-01-112	DIN 625		Not shown
70	1	1				Armature	627-02-120	D79x185		
70			1			Armature	627-03-120	D102x190		
70				1		Armature	627-04-120	D108x215		
70					1	Armature	627-05-104	D139x245		

† If you are wiring the WS-2000 for 460V, you need a variable transformer (Part No. 723-34-005) for the 220V WS-2000 motor fan (68) (See Figure 4-42).

D = diameter

COMPLETE LIST OF SPARE PARTS (Continued)
WS/WSU Only, Motor-End Parts (Continued)

NOTE: Position Numbers 65 through 75 are for WS- and WSU-Series pumps only; they are not used in WA- and WAU-Series pumps.

NOTE: See Figure 7-2 for a photograph of most of the parts listed below.

Position No. on Figs.	No. Required per Unit WS/WSU 150	250	500	1000	2000	Part Name	Catalog No.	Dimensions (mm)	Material	Remarks
71	4	4				Stud (intermediate flange)	627-03-428	6x175	Steel	
71			4			Stud (intermediate flange)	627-03-427	8x190	Steel	
71				4		Stud (intermediate flange)	627-04-427	8x215	Steel	
71					4	Stud (intermediate flange)	627-05-427	10x275	Steel	
72	6	6				Spacer lug	627-02-422			
72			6			Spacer lug	627-03-422			
72				6		Spacer lug	627-04-422			
72					6	Spacer lug	627-05-462			
73	1	1				Canned motor tube	627-02-105	D160x165	Steel	
73			1			Canned motor tube	627-03-121		Steel	
73				1		Canned motor tube	627-04-105		Steel	
73					1	Canned motor tube	627-05-105		Steel	
74	2	2	2			Stud (motor tube)	627-03-428	6x175	Steel	
74				2		Stud (motor tube)	627-04-428	6x200	Steel	
74					2	Stud (motor tube)	627-05-428	8x260	Steel	
75	1	1				Collar	627-02-305			
75			1			Collar	627-03-305			
75				1		Collar	627-04-305			
75					1	Collar	627-05-305			
75A	2	2				Fan bracket	627-02-424			
75A			2			Fan bracket	627-03-424			
75A				2		Fan bracket	627-04-424			

COMPLETE LIST OF SPARE PARTS (Continued)
WAU/WSU Only, Pressure Relief Valve Parts

NOTE: Position Numbers 76 through 82 are for WAU- and WSU-Series pumps only; they are not used in WA- and WS-Series pumps.

Position No. on Figs.	No. Required per Unit WAU/WSU 150	250	500	1000	2000	Part Name	Catalog No.	Dimensions (mm)	Material	Remarks
76	1					Valve cover	351-11-256			See Figures 4-16 and 4-44, and the foldouts in the back of this manual.
76		1				Valve cover	351-11-257			
76			1			Valve cover	351-11-252			
76				1		Valve cover	351-11-259			
76					1	Valve cover	403-03-124			
77	1					O-ring (cover)	239-70-129*	65x5	Viton	See Figures 4-16 and 4-44, and the foldouts in the back of this manual
77		1	1			O-ring (cover)	239-70-302*	90x3	Viton	
77				1		O-ring (cover)	239-70-142*	120x5	Viton	
77					1	O-ring (cover)	239-70-424*	180x3	Viton	
78	1					Spring	221-61-254	1.4x25x150	Steel	This spring is used only on WAU-Series pumps. It is not used on WSU-Series pumps. See Figures 4-16 and 4-44.
78		1				Spring	221-61-236	1.5x20x64	Steel	
78			1			Spring	221-61-235	1.5x20x115	Steel	
78				1		Spring	221-61-239	3.0x45x165	Steel	
79	1					Bushing	271-54-146			See Figures 4-16 and 4-44, and the foldouts in the back of this manual.
79	1	1				Bushing	270-27-205	52x57x15		
79			1			Bushing	270-27-125	40x44x30		
79				1		Bushing	270-27-212	90x95x60		
79					2	Bushing	270-27-211	110x150x30		

*Included in gasket set (see Section 7-1)

Viton – heat resistant synthetic rubber

COMPLETE LIST OF SPARE PARTS (Continued)
WAU/WSU Only, Pressure Relief Valve Parts (Continued)

NOTE: Position Numbers 76 through 82 are for WAU- and WSU-Series pumps only; they are not used in WA- and WS-Series pumps.

Position No. on Figs.	No. Required per Unit WAU/WSU 150	250	500	1000	2000	Part Name	Catalog No.	Dimensions (mm)	Material	Remarks
80	1					Valve plate	401-59-152			See Figures 4-16 and 4-44.
80		1				Valve plate	401-59-153			
80			1			Valve plate	401-48-108			
80				1		Valve plate	401-59-155			
80					1	Valve plate	401-59-156			
81	1					O-ring	239-70-127*	40x5	Viton	This O-ring goes onto the top of the bushing. See Figures 4-16 and 4-44.
81		1				O-ring	239-70-129*	65x5	Viton	
81			1			O-ring	239-70-504	55x5	Viton	
81				1		O-ring	239-70-139*	100x5	Viton	
81					1	O-ring	239-70-419*	125x5	Viton	
82	1					O-ring	239-70-127*	40x5	Viton	This O-ring goes onto the bottom of the bushing. See Figures 4-16 and 4-44.
82		1	1			O-ring	239-70-129*	65x5	Viton	
82				1		O-ring	239-70-139*	100x5	Viton	
82					1	O-ring	239-70-526*	150x5	Viton	
	1	1	1	1	1	Pump housing	See Position No. 35U.			See Position No. 35U.

*Included in gasket set (see Section 7-1)

Viton heat resistant synthetic rubber

APPENDIX A*

SV 110 CONTACT AMPLIFIER FOR WA- AND WS-SERIES PUMPS

NOTE: The diaphragm pressure switch and contact amplifier are not used on WAU- and WSU-Series pumps.

NOTE: The diaphragm pressure switch comes standard with all WA- and WS-Series pumps; it is preset at the factory for the correct starting pressure. The SV 110 contact amplifier can be purchased from Leybold for use with the diaphragm pressure switch.

A-1 STANDARD SPECIFICATIONS

Table A-1 contains the specifications for the SV 110 contact amplifier. Figure A-1 is the wiring diagram of the SV 110. Figure 2-4 shows the circuit required for automatic control of the pump.

The diaphragm pressure switch requires the use of a contact amplifier, containing a relay to be controlled by the diaphragm contact. The sweep stage with a delay of about 0.3 second is connected in series to the switching circuit, allowing flutter-free operation of the output relay. The output relay is energized when the pressure attains or falls below the preset value of the diaphragm pressure switch.

TABLE A-1. SPECIFICATIONS FOR SV 110 CONTACT AMPLIFIER*

Mains supply, 50/60 Hz	110 to 130 V, 220 to 240 V
Power Consumption	3 VA
RELAY OUTPUT max. switching voltage max. switching current max. switching capacity	 250V (A.C.) 5A 500 VA
SWITCHING LAG Response time Releasing time	 approx. 0.3 second approx. 0.007 second
CONTROL CIRCUIT Voltage Current	 7.3 V 2.1 mA
Maximum ambient temperature	50°C (122°F)
Weight	0.36 Kg (0.79 lb)
Catalog no.	16078-1

*The information in this appendix does not apply to the SM-43 contact amplifier. See the manual (GA-584) that came with the SM-43 or contact the main office for information on the SM-43. The SM-43 contact amplifier can not be used with the PS 110A and PS 111A pressure switches.

A-2 CONNECTING THE CONTACT AMPLIFIER*

1. **NOTE:** The pressure switch (11) shown in Figures 4-43 and 10-1 is the SM-42.

   If you are using the SM-42 pressure switch, set the slide switch on the SV 110 contact amplifier to the 16404 . . . 07 position (see Figure A-1).

   If you are using the PS 110A or PS 111A pressure switch, set the slide switch on the SV 110 to the 16072 . . . 73 position (see Figure A-1).

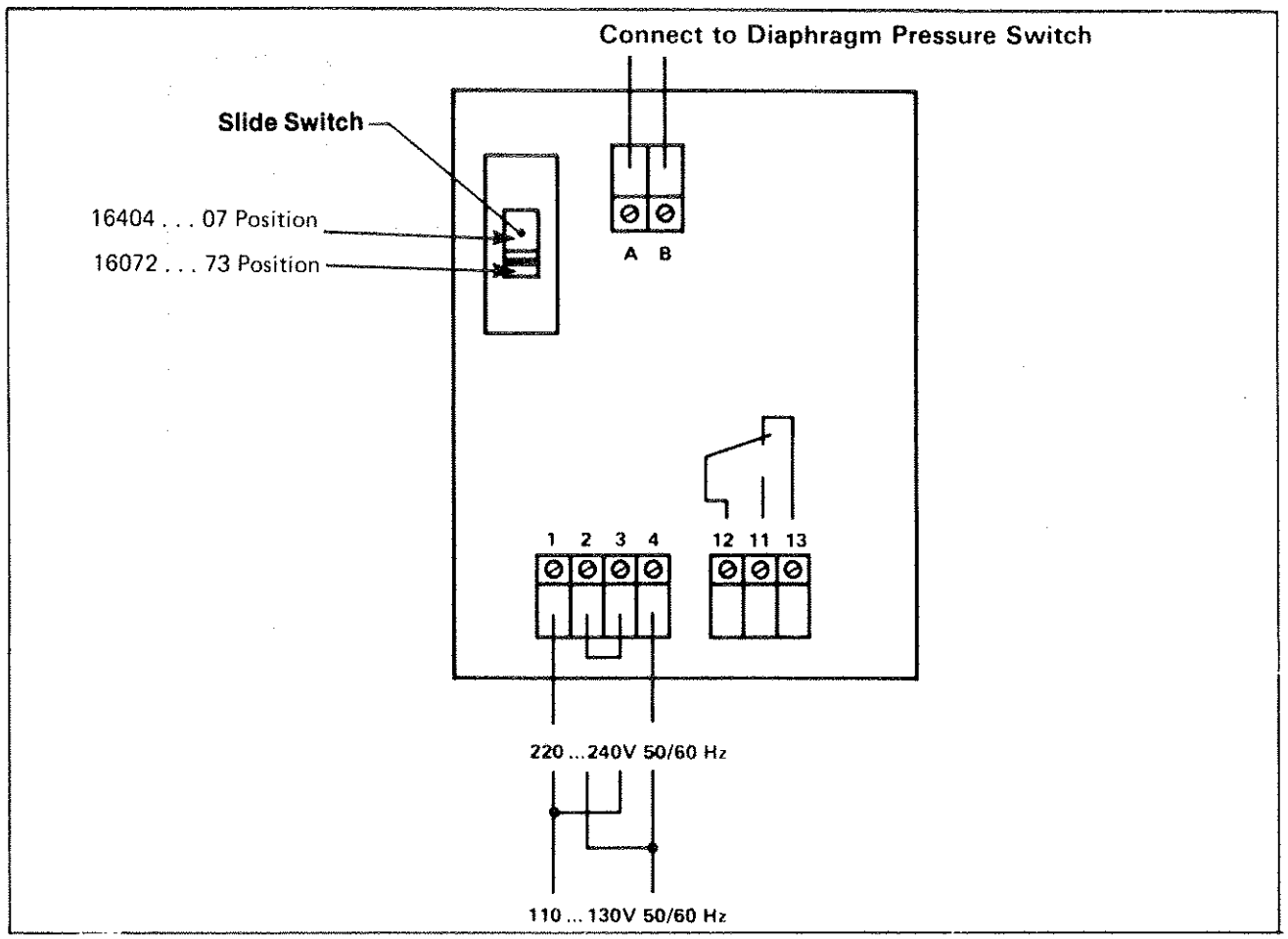
2. Use a two-core cable to connect terminals A and B of the SV 110 contact amplifier to the diaphragm pressure switch (see Figure A-1). The relay carries no potential, so that it can be freely connected to the terminals of the diaphragm pressure switch.

3. **NOTE:** The mains connection of the SV 110 is set to 110 V before delivery. For connection to different voltages, see Figure A-1 or the wiring diagram on the inside of the contact amplifier housing.

   Apply the mains connection and the relay output to the 4-pole terminal strip in the SV 110 (see Figure A-1 or the wiring diagram inside of the plastic housing of the SV 110.

   NOTE: You need a standard motor starter, a transformer, and overloads (see Table 2-1) to complete the control circuit shown in Figure 2-4.

   Use Figure 2-4 to complete the automatic control circuit.



NOTE: This schematic does not apply to the SM-43 contact amplifier.

Figure A-1. Wiring Diagram for the SV-110 Contact Amplifier

APPENDIX B

POWER CONTROL UNIT
(P/N 16446)

NOTE: You must specify the pump model, voltage, frequency, and amperage of overloads (see Table 2-1) when ordering the Power Control Unit.

B-1 STANDARD SPECIFICATIONS

Table B-1 contains the specifications for the Power Control Unit. Figure 2-4 is the wiring diagram for the unit.

The Power Control Unit includes overloads (range set according to order), a motor contactor, a fuse for relays, a SM-43 contact amplifier, and a control transformer (see Figure 2-4).

WS-Series pumps have an additional overtemperature safety switch embedded in the stator winding; when connected to the Power Control Unit, this switch protects the motor against thermal overload.

TABLE B-1. SPECIFICATIONS FOR POWER CONTROL UNIT

Mains supply*	220/380/415/440/500V, 3-ph, 50/60 Hz
Control voltage	220 Volts
Fuses for relays	6 Amps
Dimensions	210x300x155mm
Weight	6 kg (13.23 lbs)

*As specified in order.

B-2 CONNECTING THE POWER CONTROL UNIT

Connect the Power Control Unit to the pump as follows (see Figure 2-4).

1. Connect the motor of the pump to terminals 1-2-3-SL of the Power Control Unit.
2. Use the dial on the top of the Power Control Unit to set the overloads to the rated motor current indicated on the motor nameplate.
3. **NOTE:** This step is only for WS-Series pumps. Connect the overtemperature safety switch on a WS-Series pump to terminals 13 and 14 of the Power Control Unit.
4. Check if the primary voltage connection corresponds to the mains voltage; correct, if necessary.
5. Connect the diaphragm pressure switch (11) to terminals 21 and 22 of the Power Control Unit.
6. Connect the operation voltage to terminals R,S,T and SL of the Power Control Unit; observe regulations.
7. Use the switch on the top of the power control unit to connect the fuse for the relays.
8. **CAUTION:** REVIEW SECTION 2-6 BEFORE DOING STEP 8.

   Use the pushbuttons **to briefly** switch on and then **immediately** turn off the motor to check the direction of rotation. If the direction of rotation is wrong, change the polarity.

B-3 OPERATING THE POWER CONTROL UNIT

The Power Control Unit protects the motors from overload and two-phase operation. The motors can be switched on manually by the pushbuttons on the Power Control Unit. In addition, contacts for remotely controlled on-switching or interlocking can be connected in the control circuit of the motor contactor. For pressure interlocking or pressure-dependent starting, a diaphragm pressure switch must be connected. The diaphragm pressure switch comes standard with all WA- and WS-Series pumps.

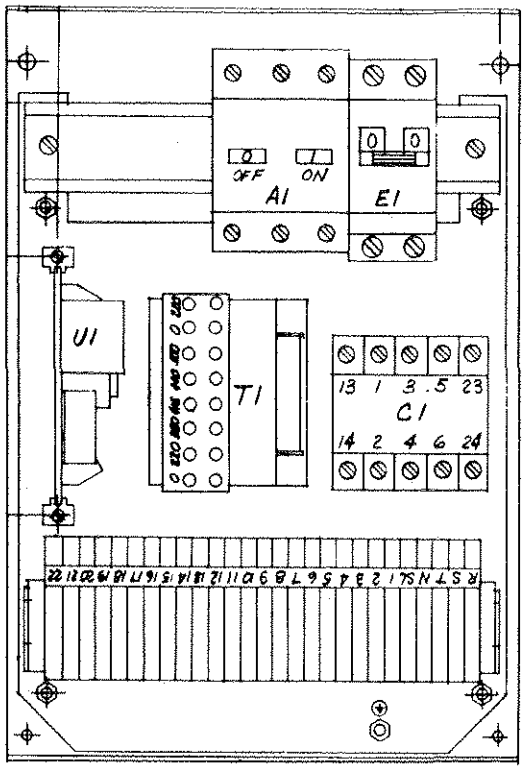


Figure B-1 - Power Control Unit

B-4 REPLACEMENT PARTS FOR THE POWER CONTROL UNIT

Table B-2 lists the critical replacement parts for the power control unit. See Figure B-1 to identify the item codes in Table B-2. See Figure 2-4 for the electrical schematic of the power control unit.

TABLE B-2 -- CRITICAL REPLACEMENT PARTS FOR THE POWER CONTROL UNIT.

ITEM	QTY	DESCRIPTION	PART NUMBER
A1	1	Manual Motor Starter, 1-1.6 Amps*	500-69-130
A1	1	Manual Motor Starter, 1.6-2.5 Amps*	500-69-131
A1	1	Manual Motor Starter, 2.5-4.0 Amps*	500-69-132
A1	1	Manual Motor Starter, 4-6.3 Amps*	500-69-133
A1	1	Manual Motor Starter, 6.3-10 Amps*	500-69-134
A1	1	Manual Motor Starter, 10-16 Amps*	500-69-135
T1	1	Transformer	510-32-483
E1	1	Circuit Breaker, Control, 6A	520-31-235
C1	1	Contactor	590-19-210
U1	1	SV 110 Contact Amplifier	16078-1

*The overloads of the motor starters are adjustable within the range indicated. Set the overload amperage based on the motor nameplate full load current (FLA); for motors operated at a service factor of 1.15, multiply the FLA by 1.15.

APPENDIX C

COMPLETE LIST OF MOTORS FOR WA- AND WAU-SERIES PUMPS

See Figure 7-2 for the canned motors on WS and WSU pump models.

If you are replacing a German motor with a U.S. motor or vice-versa, you must also replace the motor mount (20), the coupling shield (17), the coupling (15), the O-ring (13), the radial shaft seals (26), the compression ring (64), and the screws attaching the motor to the motor mount (20). A shield retainer (21) or motor adapter flange (22) is necessary for U.S. motors. Catalog numbers for U.S. motors begin with 99; catalog numbers for the German motors begin with 380.

TABLE C-1. MOTOR SPECIFICATIONS AND CATALOG NUMBERS (WA- AND WAU-SERIES PUMP MOTORS ONLY)

Pump Model	Motor Specifications	Resistances between Motor Windings (ohms) (measured over star point)	Motor Catalog No.
WA/WAU 150 and 250	1.5 hp, 3600 rpm, 3 ph, 60 Hz, 230/460V, TEFC	18 at 25°C	99-215-085*
	1.5 hp, 3600 rpm, 3 ph, 60 Hz, 575V, TEFC	28 at 25°C	99-215-143
	1.5 hp, 3600 rpm, 3 ph, 230/460V, explosion proof, TEFC	14 at 20°C	99-215-095
	220/380V, 0.75 kw, 3000 rpm, 50 Hz, 3 ph		380-66-101
	220/380V, 1.1 kw, 3000 rpm, 50 Hz, 3 ph		380-66-102
WA/WAU 500	3 hp, 3600 rpm, 3 ph, 60 Hz, 230/460V, TEFC	7 at 20°C	99-215-087‡
	3 hp, 3600 rpm, 3 ph, 60 Hz, 208V, TEFC	1 at 25°C	99-215-144‡
	3 hp, 3600 rpm, 3 ph, 60 Hz, 575V, TEFC	11 at 20°C	99-215-145
	3 hp, 3600 rpm, 3 ph, 230/460V, explosion proof, TEFC	7 at 25°C	99-215-097
	220/380V, 2.2 kw, 3 ph, 3000 rpm, 50 Hz		380-66-104
WA/WAU 1000	5 hp, 3600 rpm, 3 ph, 60 Hz, 230/460V, TEFC	5 at 25°C	99-215-089
	5 hp, 3600 rpm, 3 ph, 60 Hz, 208V, TEFC	1 at 25°C	99-215-147
	5 hp, 3600 rpm, 3 ph, 60 Hz, 575V, TEFC	6 at 25°C	99-215-148
	5 hp, 3600 rpm, 3 ph, 60 Hz, 230/460V, explosion proof, TEFC	4 at 25°C	99-215-099
	220/380V, 4 kw, 3 ph, 3000 rpm, 50 Hz		380-66-106
WA/WAU 2000	10 hp, 3600 rpm, 3 ph, 60 Hz, 230/460V, TEFC	1.5 at 25°C	99-215-091†
	10 hp, 3600 rpm, 3 ph, 60 Hz, 208V, TEFC	0.3 at 25°C	99-215-150†
	10 hp, 3600 rpm, 3 ph, 60 Hz, 575V, TEFC	1.5 at 25°C	99-215-151
	10 hp, 3600 rpm, 3 ph, explosion proof, 230/460V, TEFC		99-215-101
	380V, 7.5 kw, 3 ph, 3000 rpm, 50 Hz		380-66-111

hp – horsepower
ph – phase
Hz – hertz
V – voltage
rpm – revolutions per minute
TEFC – totally enclosed fan cooled

* Replaced by 722-60-054.
‡ Replaced by 722-60-055.
† Replaced by 722-60-063.

APPENDIX D

INSTALLING SPECIAL RADIAL SHAFT SEALS IN EXTREME-CORROSIVE SERVICE PUMPS

HE-2500 oil must be used when pumping oxidizers or highly-corrosive gases. However, HE-2500 is prone to leak around standard shaft seals. We recommend using special shaft seals in WA/WAU -150, -250, and -500 pumps models that are charged with HE-2500 (Y25/5) oil to minimize the chance of a shaft seal leak.

Required Materials:

Compression ring (64),
Bearing (27),
Shaft bushing sleeve (28),
O-rings (3/13),
Special inner shaft seal (P/N 720-27-011),
Special outer shaft seal (P/N 720-27-012),
Loktite 271,
Seal Driver (see Step 6j below).

CAUTION: Do not remove the special shaft seals from their cardboard shipping sleeves until you are installing them.

Proceed as follows to install the special shaft seals onto the WA/WAU -150, -250, or -500 pump model:

1. Ensure that the pump is shut down.

2. **WARNING: If the pump has been used to pump toxic, corrosive or hazardous gases, use proper precautions before draining the oil or disassembling the pump.**

   Drain the HE-2500 oil from the front cover and from the shaft seal housing into a clean hydrocarbon-free container and save it for reuse.

3. Refer to Section 4-2-2-1 to remove the motor, the coupling, the motor mount, and the shaft seal from the pump.

4. Refer to Steps 1 through 4 of Section 4-2-3 to remove and disassemble the intermediate flange and oil slinger.

5. Refer to Steps 6, 7, 8, 9, and 11 of Section 4-4-3 to install the oil slinger (63), O-ring (3), compression ring (64), and intermediate flange (30) onto the pump.

6. Install the bushing sleeve and red inner shaft seal onto the pump as follows:

   a. Install the retainer ring (25) into its slot in the bottom of the bearing well in the intermediate flange (30).

   b. **CAUTION:** If sanding is necessary, sand only the bulge of the sleeve; **DO NOT sand the area where the seal will ride.**

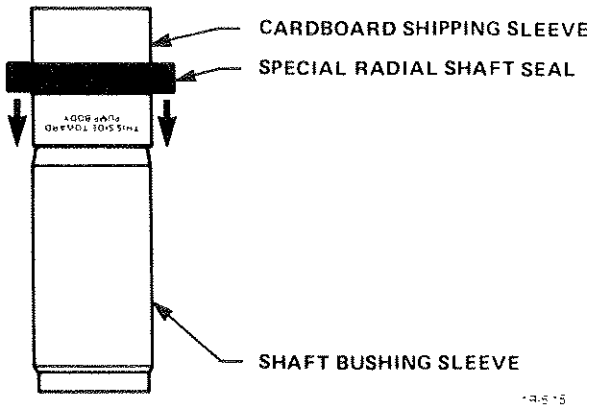
      Test to see if you can push the bearing (27) over the bulge in the middle of the shaft bushing sleeve (28) (see Figure 4-34). If you cannot fit the bearing over the bulge, use grade 80 sandpaper to sand the bulge until you can push the bearing over it. Remove the bearing from the sleeve and clean the sleeve as necessary.

   c. Ensure that the shaft seal groove in the bearing well is clean.

   d. Lightly coat the elastomer on both shaft seals with HE-2500 (Y25/5) oil while the seals are on the cardboard shipping sleeves.

   e. Set the shaft bushing sleeve (28) vertically on its end so that the end with the small teeth is facing up.

   f. Set the red seal with the cardboard shipping sleeve onto the end of the bushing sleeve so that the lip on the seal is facing up. (see sketch).



g. Carefully slide the seal down off the cardboard sleeve and onto the shaft bushing sleeve; continue to slide it down over the shaft bushing sleeve until it is ½" from the bottom end of the sleeve. Discard the cardboard shipping sleeve.

h. Place a **light** film of FOMBLIN grease on the ID of the shaft bushing sleeve. **Do not allow the grease to come into contact with the elastomer on the shaft seals.**

i. Slide the shaft bushing sleeve with red seal down over the shaft so that the end of the sleeve with the small teeth faces out.

j. **NOTE:** You **must** alternate between driving the shaft seal and tapping the shaft bushing sleeve so that the seal and sleeve are driven evenly down the shaft.

Proceed as follows to drive the shaft seal and shaft bushing sleeve:

1) Use a hammer and a seal driver (see Table 4-4A) to tap the shaft seal to drive it slightly down (see Figure 4-35).

2) Remove the seal driver and tap the end of the shaft bushing sleeve with a rubber hammer to drive the sleeve an equal distance down.

3) Continue repeating Steps 1) and 2) until the shaft seal is seated on the snap ring and the bushing sleeve is tight against the compression ring.

7. Refer to Steps 4, 5, and 6 of Section 4-4-4-1 to install the bearing, retainer ring, and motor mount onto the pump.

8. Install the blue outer shaft seal as follows:

a. Set the blue seal with cardboard sleeve onto the end of the bushing sleeve so that the lip of the seal is facing the bushing sleeve (see sketch).

b. **CAUTION: Ensure that the seal lips do not become folded as you install the seal onto the bushing sleeve. Once a seal folds, you cannot use it.**

Carefully slide the blue seal off of the cardboard shipping sleeve and onto the shaft bushing sleeve; discard the cardboard sleeve.

c. Drive the seal down the shaft bushing sleeve until it bottoms out.

9. Refer to Steps 8 through 11 of Section 4-4-4-1 to reinstall the coupling, coupling shield, and the motor onto the pump.

10. Refer to Steps 9 through 12 of Section 4-4-5 to charge your pump with HE-2500 (Y25/5) oil.

MAINTENANCE RECORD

Date	Maintenance