Haebel etc

WELCH
TURBO-MOLECULAR
VACUUM PUMP
No. 3101
and NO. 3101A

Instructions for Maintenance and Repair

SINCE 1880

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FOREWORD

This manual covers the Model 3101A Turbo-Molecular Pump illustrated in Figure 1, hereafter referred to as "Turbo Pump" or "pump."

The normal life of the pump bearings, seals, belts and lubricants is such that no major maintenance whatsoever should be required for at least 10,000 hours of continuous operation. Items which require only short down-time for inspection and repair are covered in the Maintenance section. Items which require further or complete disassembly of the machine for inspection or replacement are discussed in the Repair section. Exploded views and Parts Lists are included to aid the customer in the procurement of specific parts for replacement. The three exploded views of the pump components are referenced throughout the manual by item number as an aid in locating the parts or part under discussion. A section on troubleshooting is included to aid diagnosis of possible pump problems.

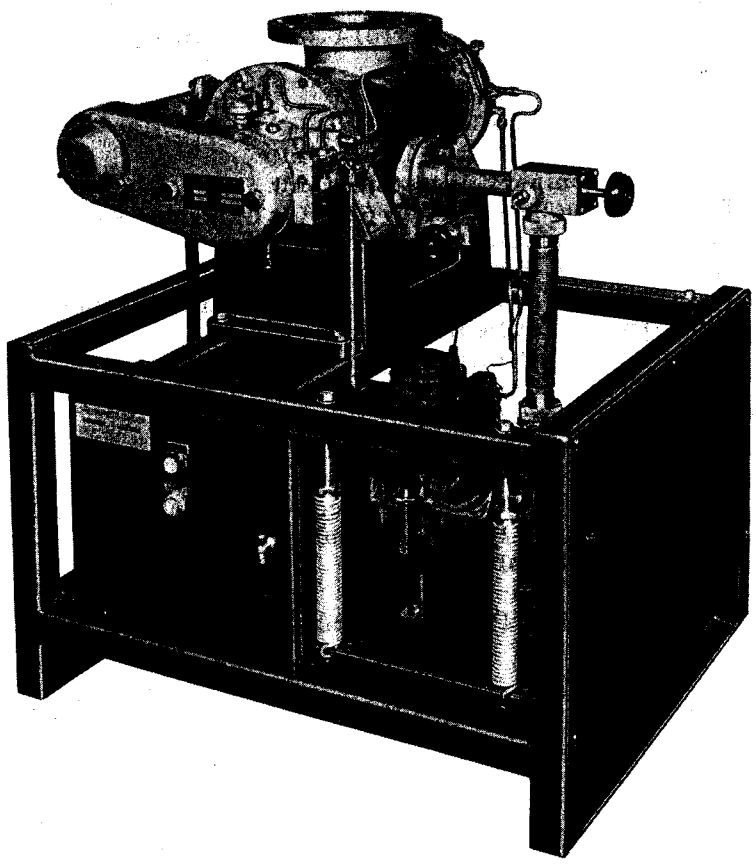


FIG. 1.

1.0 MOTOR -- The electric drive motor is a three-phase induction type with grease lubricated ball bearings. The motor should not require disassembly and repacking of the bearings for several years.

2.0 CLUTCH -- The clutch assembly contains one roller bearing which functions only during pump acceleration at startup. During this time the roller bearing spreads the lubricating grease as in any bearing. During long periods of continuous operation the grease tends to be whirled out of the bearing. Therefore, it is recommended that the clutch roller bearing be checked for malfunctions listed below after 1,000 hours of continuous operation or after 200 starts, unless there is an earlier malfunction, namely too slow or too rapid startup or a noisy clutch bearing. It is not necessary to interrupt operation of the pump in order to lubricate the clutch bearing. The lubrication may be delayed until the next shutdown. To lubricate the bearing, see steps 9.1.1 through 9.1.4 in REPAIR section. Lubricate the bearing with grease (provided) and clean the clutch linings (18) (Fig. 16) with solvent and place a clean, fine, flat file on the linings to remove imbedded particles. Clean pressure plates (10) and (26) in a like manner. Reassemble in reverse order.

3.0 FLAT BELT -- The flat belt (10) (Fig. 18) and its pulleys should be kept free of any oil film or contaminants which might cause slipping or undue wear. The belt and pulleys may be cleaned with alcohol. The belt should track on the pulleys so that no part of the belt hangs over the edge of the pulleys, otherwise refer to PULLEY ALIGNMENT (8.0). The belt tension should be as described in 7.7 in the REPAIR section. NOTE: If the pump is operating without the belt guard in place, extreme care should be used to keep fingers and clothing, especially neckties, away from flat belt and pulleys.

4.0 TRANSPARENT OILER -- The transparent oiler (43) (Fig. 17) located on top of the transmission housing lubricates the outer drive shaft bearing (9) and the seals of the transmission assembly. This oiler should be refilled with Turbo-Molecular Pump Oil (Cat. No. 1377K) when 3/4 empty.

5.0 CIRCULATING OIL SYSTEM -- The high-speed rotor bearings (95) (Fig. 18) and the inner drive shaft bearing (23) (Fig. 17) are lubricated by an oil pump in the transmission housing. Turbo-Molecular Pump Oil (Cat. No. 1377K) must be used for this purpose. The Welch Scientific Company will not otherwise guarantee the pump. The prime consideration when handling Turbo oil should be cleanliness. A small amount of dirt or minute chips can shorten bearing life from thousands of hours to a few hours. To change oil, use the following procedure:

5.1 Drain Oil

5.1.1 Vent the Turbo-Pump to atmospheric pressure using dry N2 through the evacuated system vent. Do not open drain or filling plugs until pressure is equalized as this will blow oil into the high vacuum areas of the pump.

5.1.2 Thoroughly clean plugs (41) (Fig. 17) and adjacent areas and front tube elbow (38) (Fig. 18) and nut (35) (Fig. 18) directly under front cover plate (73) (Fig. 18).

5.1.3 Place a drain pan under the transmission housing and front cover plate. Remove plugs (41) (Fig. 18). Drain oil into drain pan. NOTE: Tube elbow (38) (Fig. 18) must be removed completely, as there is a ball check valve in it which will prevent proper drainage.

5.2 Refill Oil

5.2.1 Grease "O" rings on plugs with stopcock grease, and check for damaged "O" rings.

5.2.2 Replace the bottom plug, elbow and tube nut.

5.2.3 Using only thoroughly clean vessels, pour 680 cc of Turbo Oil into the transmission. Avoid spilling oil on drive pulley (2) (Fig. 17). Use only new oil, as the probability of contamination is too high with reclaimed oil.

5.2.4 Replace the top plug.

5.2.5 Wipe away all spilled oil, using alcohol on the drive pulley if there is any trace of oil film on it.

5.2.6 New oil should be subjected to a vacuum of at least 100 millitorr before operating the Turbo Pump as explained in the Turbo Molecular Pump Set Manual. After the pump has been started, the oil flow indicator tubes (32) (Fig. 17) should be observed. The steel ball in each tube should rise, indicating oil flow, by the time the pump rotor has reached full speed. If they do not, and light tapping on adjacent metal does not prove that they were merely stuck, then TURN THE TURBO-PUMP OFF. This indicates insufficient oil, plugged oil filters, or an inoperative oil pump The lip seal (11) (Fig. 17) should be checked occasionally for oil leakage. This can be done by removing the belt guard and directing a light behind the drive pulley. There is normally a slight outward seepage at this point which causes the oil level in the transparent oiler to drop. When this oiler needs refilling within a week, the seal needs replacement. Any other leaks in the oil system will not be detectable with the pump in operation, since the oil is under vacuum. A helium leak detector will, however, give a delayed indication of oil system air leaks, as the helium bubbles will be carried into the pump by the oil.

REPAIR

The Repair section covers only the progressive disassembly, inspection, repair, and reassembly of components. Diagnoses of malfunctions are covered in the Troubleshooting section.

6.0 BELT GUARD --

6.1 Remove two knurled thumb nuts (1) (Fig. 18).

6.2 Remove belt guard assembly (9) (Fig. 18).

6.3 Rubber cushion on edge of belt guard should be cemented to belt guard. If loose, apply flexible oil-resistant cement, such as Goodyear Pliobond.

7.0 FLAT BELT --

7.1 Remove belt guard as in 6.0.

7.2 Remove flat belt (10) (Fig. 18) by gently turning drive pulley (2) (Fig. 17) and sliding belt off pulley.

7.3 Inspect belt and replace if obviously deteriorated as compared to when new. Clean belt and pulley with alcohol if oily or dirty.

7.4 If the same belt is to be used, reassemble. If a new belt is to be used, first install the new belt on the pulleys to determine if the tension is correct (see 7.7). Since the flat belt is made to exact length, it is probable that no tension adjustments will be necessary. However, when the drive motor and clutch assembly has been moved to gain access to other parts of the Turbo-Pump, it becomes necessary to reset the belt tension. If the tension is too loose or too tight, it will cause slipping or mistracking of the belt. Mistracking may also be caused by other factors (see 8.0). If access to other parts of the pump or readjustment of the tension is necessary, proceed as follows.

7.5 Loosen hex nuts (16) (Fig. 18) on eye bolt (19). Motor and clutch assembly may now be swung aside for further disassembly of the Turbo-Pump, or tension may be adjusted.

7.6 Install flat belt on clutch assembly (14) (Fig. 18) and drive pulley (2) (Fig. 17).

7.7 Tighten hex nut adjustment until belt does not slip when correctly adjusted clutch (see 9.5 and 9.6) is turned in the drive direction by quick motions of the hand so that clutch slips. Keep opposing nuts tight enough to flatten both lock washers as this point is approached. Finally, increase belt tension by 1/6 turn of nuts.

8.0 PULLEY ALIGNMENT -- Mistracking of the flat belt occurs when the clutch pulley and the transmission drive pulley are not in the same plane, assuming that the belt tension is correct. The pulleys are aligned at the factory and it is extremely improbable that they will become misaligned unless a new motor is installed. The four screws (11) (Fig. 18) SHOULD NOT BE LOOSENED except to install a new motor. Minor adjustments are made by loosening nut (21) (Fig. 18) and rotating the motor pivot rod (25) at the flatted end with a wrench. This should not be necessary unless the transmission drive pulley (2) (Fig. 17) has been moved on its shaft causing the two pulleys under discussion to be in different but parallel planes. Should the motor be replaced, or the alignment inadvertantly altered, the following procedure should be used for realignment.

8.1 Remove belt guard and flat belt as in 6.0 and 7.0.

8.2 With four screws (11) (Fig. 18) slightly loose, lift the motor until the four slots in the motor base are stopped by the four screws.

8.3 Tighten the screws and install the flat belt.

8.4 Grasp the clutch pressure plate assembly (6) (Fig. 16) and rotate in the normal drive direction. If the flat belt tracks properly, alignment is completed,but if not, proceed as below.

8.5 Disassemble as in (9.1.2) and (9.1.3).

8.6 Rest the edge of a straightedge across the outer face of the transmission drive pulley (2) (Fig. 17) on the upper half of the pulley, and extend the straightedge to the clutch pulley outer face immediately above the clutch lining (18) (Fig. 16). Care should be exercised to avoid chipping the carbon clutch lining. To adjust the lateral position of the clutch pulley, loosen nut (21) (Fig. 18) and rotate the motor pivot rod (25) at the flatted end with a wrench. By holding the straightedge firmly against the drive pulley, it may be observed whether or not the clutch pulley is in a line with the drive pulley. By making the same observation with the straightedge on the lower portions of the pulleys, it may be determined whether or not the entire motor and clutch assembly requires tipping or shimming. To tip the motor loosen four screws (11) (Fig. 18). To shim the motor, loosen the screws and insert shim stock where needed. It is essential that both pulleys are in the same plane (see Fig. 2).

8.7 Reassemble the clutch and install the flat belt.

8.8 Check tracking by rotating the clutch in the normal drive direction.

8.9 Replace the belt guard.

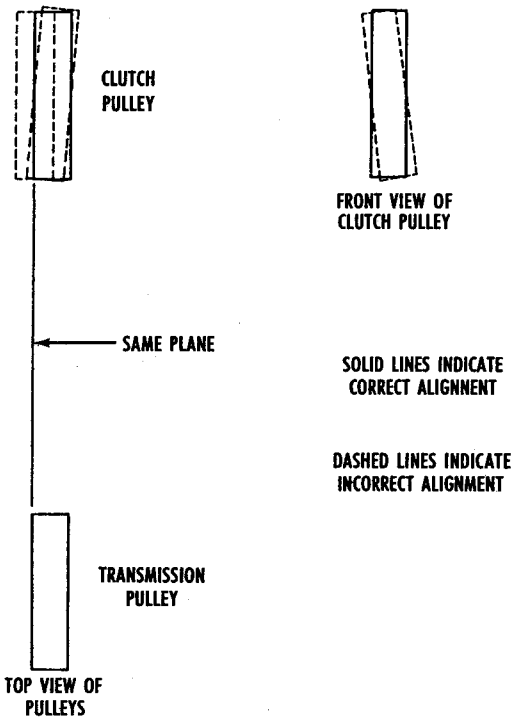


FIG. 2 SKETCH OF PULLEY ALIGNMENT

9.0 CLUTCH -- Clutch parts subject to deterioration are the bearing (14) (Fig. 16) when operated without lubrication, the clutch lining (18) (Fig. 16) which may become contaminated (see 2.0) or cracked, and the contact area between the bearing inner race (21) (Fig. 16) and the clutch sleeve (24). The clutch lining wears very slowly, and there have been no cases reported of one wearing out. Care should be exercised to prevent wear between the inner race and sleeve. When the bearing grease dries out, there is a tendency for the bearing inner race (21) to rotate on the clutch sleeve (24). This rotation wears the sleeve, increases the sleeve-inner race clearance, and starts a rolling, sliding action of the inner race on the sleeve which becomes progressively worse. This condition persists during steady running of the pump. The clutch linings are part of this system and acquire a continuous rolling, sliding motion and carbon dust starts to be evident on adjacent surfaces. If the pump is stopped and started, there may be abnormal rattling noises as a dry clutch bearing warning before any harm is done. However, if the pump is on a long duration run, there may be no warning other than a marked increase of carbon dust, indicating wear, until the worn clearance has increased to perhaps 1/32 inch. Then the clutch may rattle unmistakably. If the wear has not progressed too far, only the bearing inner race and clutch sleeve need be replaced. The basic cause of the trouble is a combination of excessive sleeve inner race clearance and insufficient lubrication. To avoid this problem, observe step 9.4.1 carefully. Although the complete disassembly procedure is given, it is recommended that only the steps required for a particular repair be made, as some of the steps may prove difficult.

9.1 Clutch Disassembly --

9.1.1 Remove the belt guard and flat belt as in 7.0.

9.1.2 Remove the spring adjuster lock screw (1) (Fig. 16), spring adjusting screw (2), anti-friction washer (3), thrust washer (4), and clutch spring (5).

9.1.3 Slide the pressure plate with hub-fan disc assembly (6) off the clutch sleeve (24).

9.1.4 Remove setscrew (22), remove the clutch sleeve key (11) and slide the clutch pulley assembly (12) off the clutch sleeve (24).

9.1.5 Remove the truarc retaining ring (20) and slide the roller bearing inner race (21) off the clutch sleeve (24).

9.1.6 Pry either snap ring (13) out of the clutch pulley assembly (12) by picking out notched end of ring and spiralling out, and press out bearing (14) with bearing sleeve (15).

9.1.7 Press the bearing outer race out of the bearing sleeve with an arbor press.

9.1.8 Remove the "O" ring (16) from inside the pulley. A disassembled clutch is shown in Figure 3.

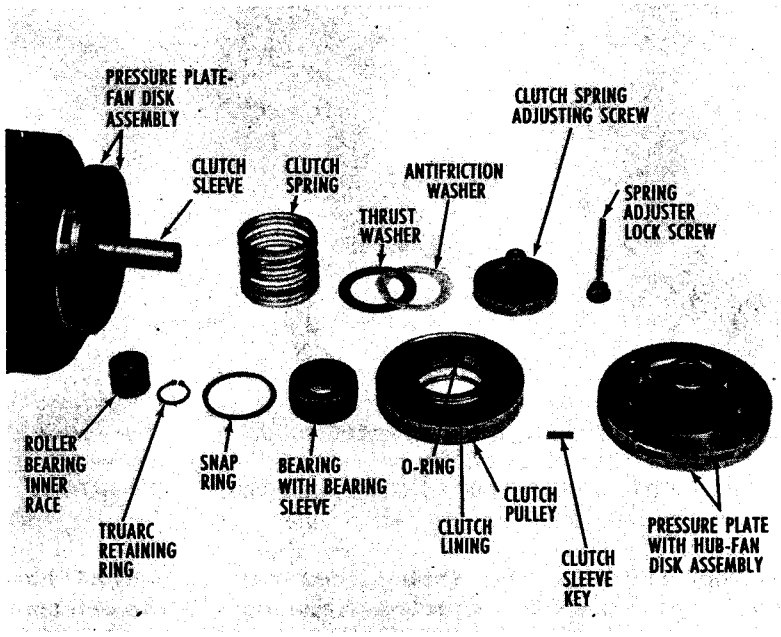


FIG. 3 CLUTCH PARTS DISASSEMBLED

9.2 Clutch Lining Replacement -- The clutch lining (18) (Fig. 16) needs replacement when the remaining lining is only 1/32 inch thick, or is cracked.

9.2.1 Follow steps 9.1.1 through 9.1.4.

9.2.2 Remove the clutch linings from the clutch pulley (19) (Fig. 16) by cracking the linings and pulling them off piece by piece.

9.2.3 Remove all traces of old cement from the pulley by peeling and scraping. Trichloroethylene is of some help. BE SURE NO BUMPS REMAIN.

9.2.4 Fit each new lining on the pulley. NOTE: The clutch linings are carbon and very fragile. If the inside diameters of the linings fit the shoulders of the pulley exactly, remove material from the inside diameter of the lining very evenly with sandpaper until the fit is somewhat loose, approximately a few thousands of an inch clearance all around.

9.2.5 Thoroughly clean the nozzle on the tube (or similar applicator) of silicone rubber (General Electric No. RTV 102) so that no lumps of dried adhesive remain. No particles of any kind must be allowed under the lining.

9.2.6 Apply adhesive to one side of each new lining and mount the lining on the clutch pulley as shown in Figure 4. Distributing pressure evenly over the lining, press the lining into place while rotating it back and forth to spread the adhesive evenly.

9.2.7 Remove excess adhesive by scraping and wiping with trichloroethylene. No adhesive must be allowed on the outer faces of the linings, or the clutch will lock under use.

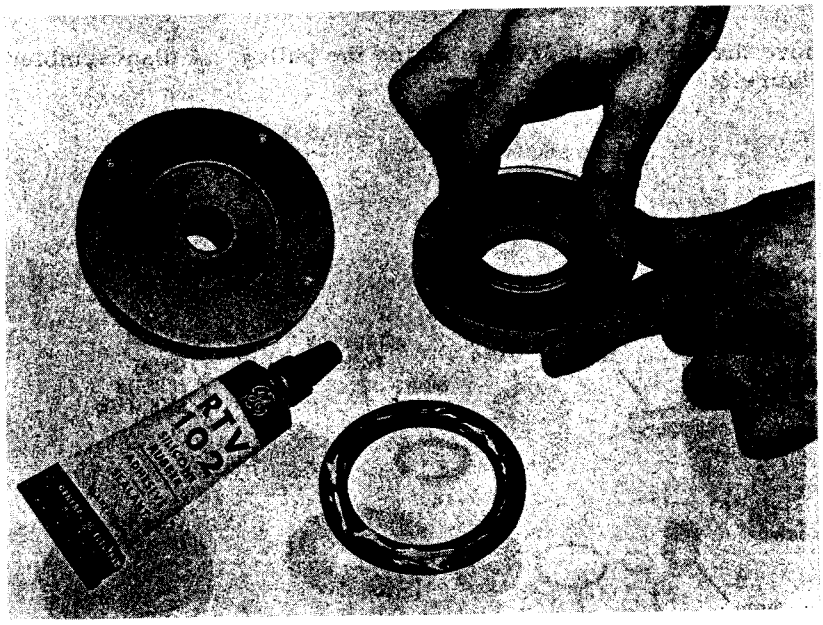


FIG. 4 CLUTCH LINING INSTALLATION

9.3 Clutch Bearing Replacement -- The bearing inner race (21) (Fig. 16) and the bearing (14) with bearing sleeve (15) should be inspected after step 9.1.4 to determine if replacement is actually necessary. If the parts are merely dry or dirty, and not scored or galled, cleaning and lubrication will suffice. The "O" ring (16) may be damaged during disassembly, and if so, must be replaced.

9.4 Clutch Reassembly -- Reassembly is essentially the reverse of disassembly except for the following preliminary steps:

9.4.1 Check the fit between the bearing inner race (21) and the clutch sleeve (24). Manufacturing tolerances give fits ranging from a light push fit to a slight shake. If the shake seems so loose that "Loctite" will not seal the parts together, replace the sleeve and inner race. Use "Loctite" in the clearance to fix the inner race to the sleeve, unless the fit is already so tight that the parts cannot be turned by hand. "Loctite" can be caused to harden in minutes if heated to about 140°F. (This temperature is just above the pain threshold.) "Loctite" is a fluid which wets into fine cracks and hardens due to the absence of air, which normally stabilizes the liquid state.

9.4.2 Apply bearing grease to the new "O" ring before insertion into the clutch pulley.

9.4.3 Pack the roller bearing with grease (small can furnished) before assembly into clutch pulley. Also coat the outer surface of the bearing sleeve lightly with grease.

9.4.4 To install the snap ring (13) which retains the bearing (14) with bearing sleeve (15), spread the ring apart as shown in Fig. 5. Insert the free end of the snap ring into the groove in the pulley and press in the ring a little at a time until it snaps into position.

9.4.5 Be certain that the pressure plate assembly (6) (Fig. 16) and the clutch pulley assembly (12) slide freely in a lateral direction on the clutch sleeve (24).

9.4.6 Complete the remaining assembly.

FIG. 5 SNAP RING INSERTION INTO CLUTCH PULLEY

9.5 Clutch Preliminary Adjustment -- A preliminary adjustment should be made before reinstalling the flat belt. The adjustment may be made using 1/2 inch wide masking tape and a spring scale (furnished) as shown in Fig. 6. Wrap the tape approximately one and one half times counterclockwise around the clutch pulley without contacting the pressure plates on either side. Double back the free end of the tape and pierce it with the hook on the 72 oz. spring scale. Grasp the pressure plate, fan disc assembly (25) and rotate it quickly clockwise while holding the spring scale so that the tape is taut. The scale should indicate a load of 60 oz. due to frictional force as the clutch slips. To adjust the clutch tension, loosen the spring adjuster lock screw (1) and rotate the spring adjusting screw (2) clockwise to increase tension and counterclockwise to decrease tension.

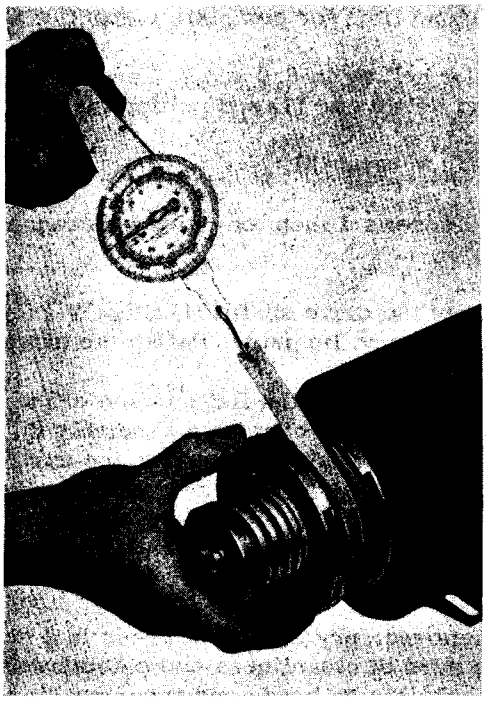


FIG. 6 CLUTCH PRELIMINARY ADJUSTMENT WITH SPRING SCALE

9.6 Clutch Final Adjustment -- The criterion for proper adjustment is to ascertain that the pump rotor reaches full speed in 4 to 6 minutes.

10.0 TRANSMISSION SEALS -- Two seals are located in the transmission assembly: a lip seal and a face seal. Both are contained in a seal cartridge. It is necessary to consider possible leaks in the seal cartridge region more thoroughly than is practical in the troubleshooting section. Referring to Fig. 7, consider the path taken by oil as it flows downward from the transparent oiler (22) and fills the area between the lip seal (15) and the face seal (16 and 17). The pressure on the oil is one atmosphere plus the head of oil up to the level in the transparent oiler. Beginning at the point where the vertical hole leading from the oiler meets the hole in the seal cartridge (20) the oil can creep outwards (to the left) until stopped by the outer "O" ring (30). This ring (30) only seals against a three-inch "head" of oil as does the stationary lip seal (15) which seals against the seal cartridge (20) and the rotating drive shaft (3). Starting again at the junction of the oil holes, the oil can also creep inward (to the right) until stopped by the inner "O" ring (30) which seals against vacuum. As does the outer "O" ring, the inner "O" ring must also form a seal between the seal cartridge and the housing (1). The next seal to consider is at "O" ring (18). The spring (9) and cone (10) force "O" ring (18) against the seal cartridge (20) and the carbon half of the face seal (17) which is stationary, forming a seal at both lines of contact against vacuum. The stationary carbon half of the face seal, when lubricated with oil, forms a vacuum seal with the steel half of the face seal (16) which is rotating with the drive shaft (3). The steel face seal is sealed to the drive shaft with a rubber ring insert (5).

A leak which develops in the cartridge seal area can be caused by a slight scratch or piece of foreign material at the seal line on any of the above mentioned parts. Only by close inspection can any accurate diagnosis of the cause of leakage be made. If oil leaks outward and drips from the transmission, and the level in the transparent oiler goes down, there are four possible leakage paths. The path may be on either the housing side or the seal cartridge side of the outer "O" ring (30), or on the shaft side or the seal cartridge side of the lip seal (15). If the oil level in the transparent oiler drops and there is no external evidence of leakage, there are seven possible leakage paths. The path may be on either side of the inner "O" ring (30), on either side of "O" ring (18), between the carbon and steel faces of the face seal (17) (16), or on either side of the rubber insert (5). Carelessly backfilling the Turbo Pump with pressurized gas in excess of atmospheric pressure can cause "O" ring (18) to be "blown" outward where it can catch on the oil passages adjacent to it, thereby "cocking" the cone (10), which in turn will prevent the return of "O" ring (18) to a normal sealing position. The leak caused by this can drain the transparent oiler into the pump in seconds on the next pumpdown. This cause is seldom apparent, because the cone is jarred back into position when the cartridge is removed for diagnosing the leak. To determine the exact cause of leakage, it is necessary to disassemble the transmission seals for careful inspection. Slow oil leaks inward or outward are no cause for alarm. It may be convenient to continue adding oil to the transparent oiler until an opportune time for complete inspection occurs.

10.1 Remove belt guard and flat belt as in 6.0 and 7.2 and remove the drive pulley (2) (Fig. 17) by loosening the socket-head setscrews (1) and pulling the pulley off the drive shaft.

10.2 Remove four fillister-head screws (3).

10.3 Install two #10-32 "jack" screws 1 inch long in the threaded holes in the seal cartridge (13) (Fig. 17).

10.4 Check the visible portion of the drive shaft (24) (Fig. 17) for sharp burrs or scratches which might damage an otherwise sound lip seal. Polish the drive shaft if necessary.

10.5 The two "jack" screws press against the flat surface of the transmission housing (44) and when advanced evenly, will force the seal cartridge assembly (5) out of the housing until it can be grasped by hand. Care should be taken to remove the cartridge in a straight line. The carbon face of the face seal is very fragile and can be easily cracked or chipped if the cartridge is "cocked" against the drive shaft. The metal face of the face seal will remain on the drive shaft when the cartridge is removed. Fig. 10 shows the removed seal cartridge assembly and the metal face of the face seal partially removed.

10.6 If the lip seal is to be removed, pry it out and press in a new one, observing both lip seal and cartridge surfaces to be sure of cleanliness and smoothness. The lip seal is best installed by starting it as evenly as possible by hand, and then pressing the external face of the seal

cartridge against a clean, flat surface. Reassmebly is essentially the reverse of disassembly. When reassembling, inspect the "O" rings (12) (Fig. 17) for damage and replace if necessary. Grease these "O" rings liberally before reassembly and feel carefully for burrs or sharp edges in the housing which might scratch or pinch the "O" rings. If the face seal is to be replaced, continue as below instead of reassembling.

10.7 To disassemble the seal cartridge assembly (5), the internal face seal spring must be compressed. Needed for this operation are a 5/16" x 2" temporary bolt and nut, a washer to rest against the exterior (lip seal) end of the seal cartridge, and a fibre or nylon washer to depress the carbon face seal. When reference is made in this section to Fig. 7, visualize the seal cartridge assembly (5) (Fig. 17) as standing alone. By using both Fig. 17 and Fig. 7, it will be easier to disassemble the components. Fig. 8 shows the disassembled seal cartridge components.

10.7.1 Put the temporary nylon washer on the temporary bolt and insert the bolt through the seal cartridge from the face seal (17) (Fig. 7) end, being very careful not to touch the polished carbon face with the bolt. Install the washer and nut on the bolt at the lip seal (15) (Fig. 7) end of the cartridge and tighten the nut until the carbon face seal is depressed enough to allow removal of the internal retaining ring (32) (Fig. 7), (6) (Fig. 17).

10.7.2 Remove the internal retaining ring (32) (Fig. 7), which is a spiral spring, by lifting one end with a small screwdriver and spiralling the ring out (see Fig. 9).

10.7.3 Remove the temporary bolt from the cartridge.

10.7.4 Remove the carbon face seal (17) (Fig. 7), "O" ring (18), cone (10), and spring (9). See Fig. 8.

10.7.5 Cover the drive shaft (3) (Fig. 7) with a thin plastic or rubber tube to protect it from scratches during the next operation.

10.7.6 Use a pair of long-nosed pliers to grasp the outside of the steel face seal (16) (Fig. 7) which remained on the drive shaft. Pull the face seal off the shaft, exercising caution to avoid scratching the drive shaft or the transmission housing. Be sure the rubber insert (5) (Fig. 7) is also removed.

10.7.7 Inspect all parts, keeping in mind the sealing function of each as described in 10.0, and replace parts where needed.

10.7.8 Reassembly is similar to disassembly, except that the metal face seal with rubber insert is to be greased and pushed onto the drive shaft with a stiff rubber hose.

10.8 When reassembling the drive pulley (2) (Fig. 17) place two 1/8" shims between the pulley and the transmission housing while tightening the set screws.

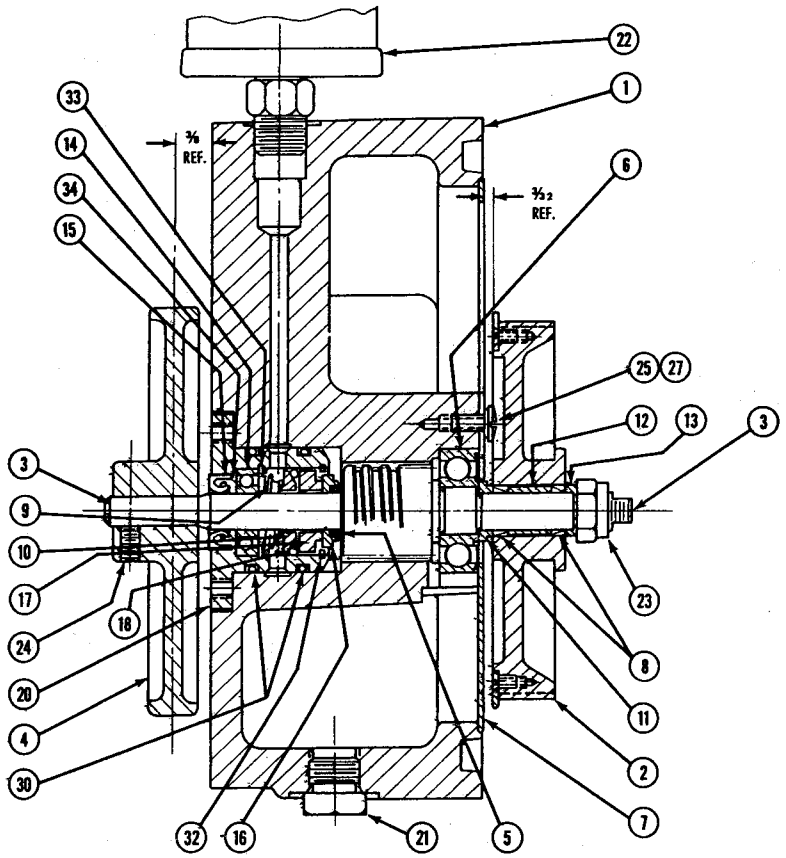


FIG. 7 TRANSMISSION SECTION SHOWING CARTRIDGE SEAL

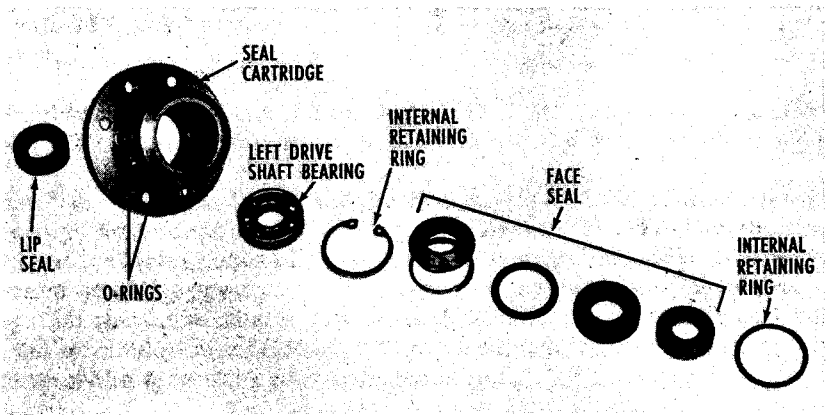


FIG. 8 SEAL CARTRIDGE DISASSEMBLED

FIG. 9 SEAL CARTRIDGE RETAINING RING INSTALLATION

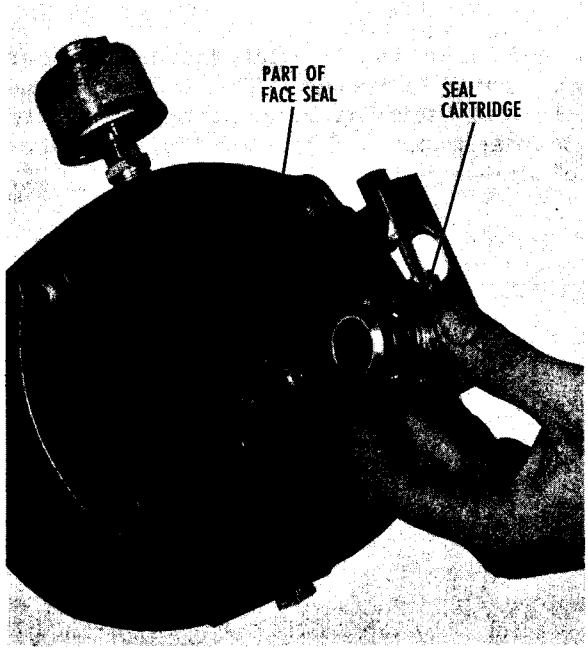


FIG. 10 SEAL CARTRIDGE AND METAL FACE
SEAL PARTIALLY REMOVED

11.0 TIMING BELT -- When a new timing belt is installed, there might be a temporary increase in the rate at which fibrous matter collects in the oil line filters (37) (Fig. 18). If there is a timing belt failure for any reason, the oil line filters might have a considerable amount of foreign material in them. In either case, the oil line filters should be inspected and cleaned if necessary as in 17.5.

11.1 Remove the belt guard assembly as in 6.0.

11.2 Remove the flat belt as in 7.0.

11.3 Drain the transmission oil as in 5.1.

11.4 Remove oil lines (28) and (32) (Fig. 18). Plug or cap the oil line openings to prevent contamination from foreign matter.

11.5 While supporting the transmission assembly (68) by hand, remove the four screws (66) and (67) which secure the transmission assembly to the pump, and remove the transmission assembly. Do not let the weight of the transmission drop onto the toothed belt as the bolts are removed.

11.6 Remove the timing belt (69).

11.7 Inspect, and if necessary replace, the timing belt.

11.8 Place the new (or old) timing belt on the driven pulley (92) on the rotor shaft.

11.9 Support the transmission assembly with one hand under the transmission and one hand holding the drive pulley (2) (Fig. 17). (Note that this is the exterior pulley.) Bring the transmission close to the pump so that the teeth on the right side of the timing belt driver pulley (15) (Fig. 17) barely engage the timing belt. Slowly and gently turn the pulleys on the transmission in a clockwise direction, simultaneously moving the transmission toward the pump. After one complete turn of the pulleys, the belt should be engaged. The inertia of the rotor will then continue turning the pulleys. Continue supporting the transmission by hand until the four screws (66) and (67) are installed; otherwise the weight of the transmission might stretch or break the timing belt.

11.10 With the four screws (66) and (67) still slightly loose, lift the transmission as far as possible against the screws and tighten the screws. This will insure that the timing belt is not supporting any weight. To verify this condition, gently but quickly "rock" the drive pulley in a clockwise-counterclockwise motion. Play should be felt in the teeth of the engaged parts, resembling the feel of a loose pulley.

11.11 Reassemble the remaining components in reverse order.

12.0 DRIVE SHAFT BEARING, LEFT --

12.1 Disassemble as in 6.0, 7.2, and 10.0 to 10.7.4.

12.2 Remove the internal retaining ring (8) (Fig. 17) and the left drive shaft bearing (9) (Fig. 17), being careful not to scratch the inside of seal cartridge (13) where it forms a seal with the "O" ring (18) (Fig. 7).

12.3 Reassemble in reverse order.

13.0 DRIVE SHAFT BEARING, RIGHT --

13.1 Disassemble as in 11.0 to 11.7.

13.2 Remove the drive pulley (2) (Fig. 17) and the seal cartridge assembly (5) as in 10.1 to 10.5.

13.3 Remove the elastic stop nut (14) (Fig. 17) and timing belt pulley (15). The shaft may be carefully tapped to release the pulley from the gripsprings.

13.4 Remove the gripsprings (17) (Fig. 17) and gripspring spacers (16), (18) and (19). Note the order of assembly.

13.5 Remove three screws (20) and transmission housing cover (22).

13.6 Remove the drive shaft (24) by pressing or lightly tapping with a soft instrument on the unthreaded external end.

13.7 Remove the right drive shaft bearing with a bearing puller as shown in Fig. 11.

13.8 Place the new bearing in position on the drive shaft. Obtain a steel sleeve about 2 inches long with an inside diameter large enough to fit loosely over the end of the drive shaft which supports the timing belt pulley and an outer diameter no larger than the outer diameter of the bearing inner race. Place a loose-fitting washer on the unthreaded end of the drive shaft. Position the parts in an arbor press as shown in Fig. 12 and press the bearing onto the shaft.

13.9 Reassembly is essentially the reverse of disassembly, except that the following procedure should be observed when installing the timing belt pulley.

13.9.1 Place two 1/8" shims under the timing belt pulley as shown in Fig. 13.

13.9.2 Tighten the elastic stop nut and remove the shims. Hold both flat belt pulley and timing belt pulley and, by opposed twist, make sure the toothed pulley doesn't slip on the shaft.

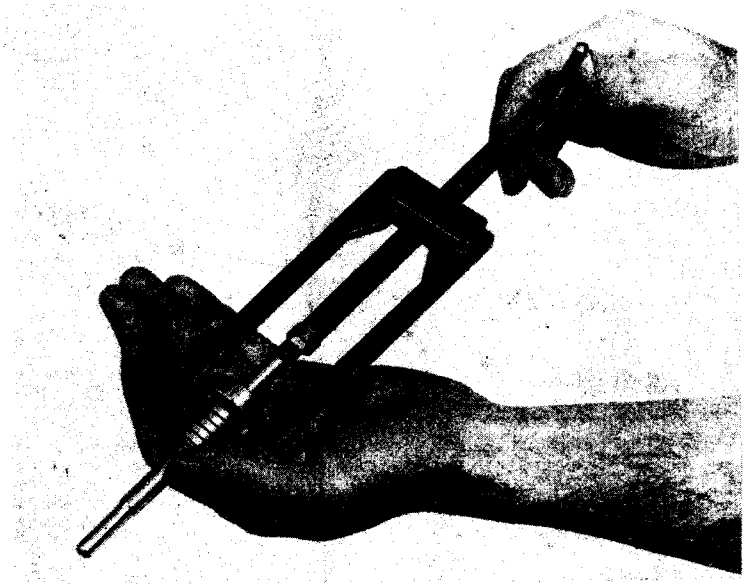


FIG. 11 RIGHT DRIVE SHAFT BEARING REMOVAL

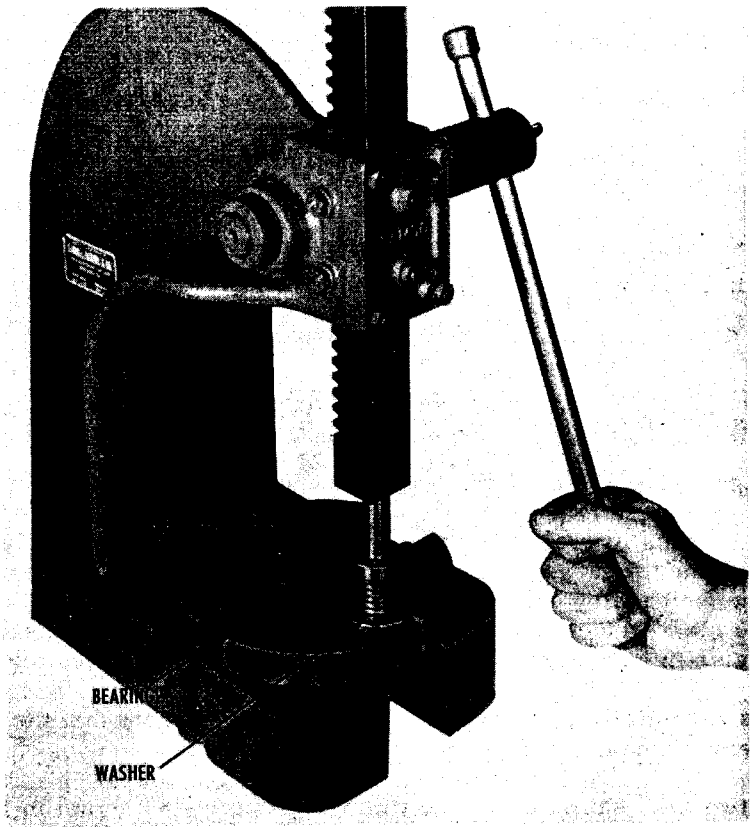


FIG. 12 RIGHT DRIVE SHAFT BEARING INSTALLATION

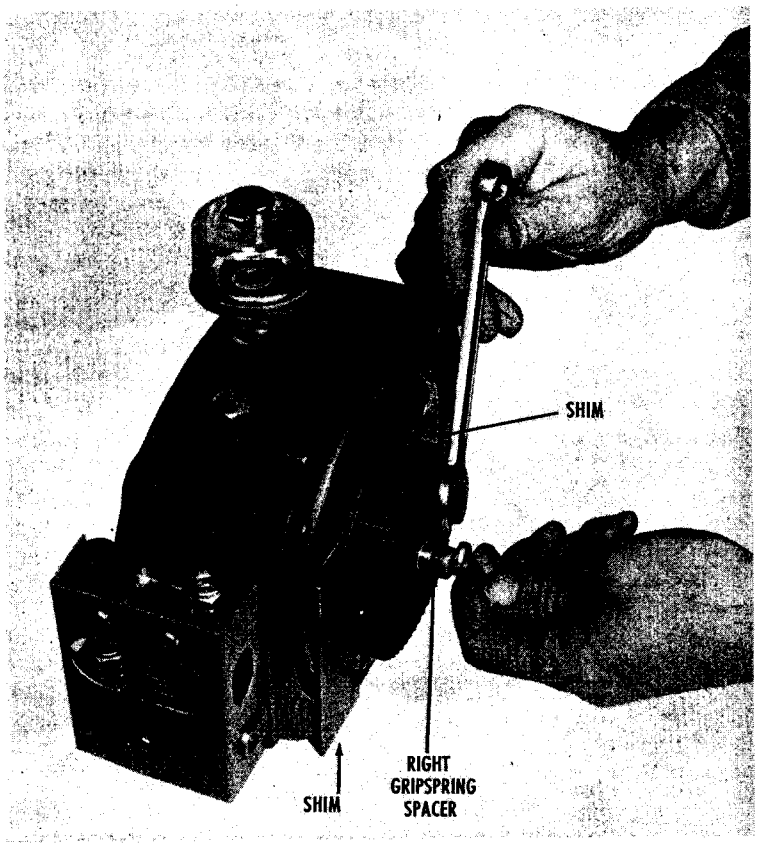


FIG. 13 TIMING BELT PULLEY INSTALLATION

14.0 FRONT ROTOR BEARING --

14.1 Disassemble as in 11.1 to 11.7.

14.2 Remove the oil return line (34) (Fig. 18). Plug or cap to prevent contamination.

14.3 Relieve coolant pressure by loosening the nuts on the coolant tubing elbows (42).

14.4 Remove coolant lines from elbows (42).

14.5 Cut and remove the safety wire between two screws (83) and two screws (84).

14.6 Back out the pressure plate adjusting screws (84) until the front retainer plate spring (85) no longer exerts pressure. Do not completely remove the screws.

14.7 While supporting the front cover plate (73) by hand, remove two screws (71) and four screws (72), and remove the cover plate. The thrust springs (75) might fall away as the cover plate is removed.

14.8 Examine the front rotor bearing (95). The outer race can normally be rocked slightly by hand. If the bearing is damaged, the ball retainer may be distorted, the balls may be flattened or nicked, or the outer race may be locked. Personnel experienced with high-speed precision ball bearings should be consulted if possible to determine if replacement is necessary.

14.9 Unscrew the elastic stop nut (91).

14.10 Pull off the driven timing belt pulley (92).

14.11 Loosen the setscrews (93) in the bearing lock nut (94). The setscrews are sealed by a drop of lacquer which can be softened with acetone or shocked loose by inserting a screwdriver of the right size in the slot, striking the screwdriver with a light hammer, and applying a steady unscrewing torque. A steady torque will not strip the slot in the setscrew as readily as a sharp twist. Should a setscrew strip, use a No. 30 drill to remove the setscrew, then clean the threads with a No. 8-32 tap, and replace the setscrew.

14.12 Use a spanner wrench to remove the bearing lock nut (94). Hold the rotor steady by grasping the oil slingers with one hand and strike the spanner wrench a sharp blow with a light hammer. Once loosened, the lock nut will unscrew easily. See Fig. 14.

14.13 Remove the ball bearing (95) with a bearing puller.

14.14 Inspect the bearing seat of the shaft for damage such as flat spots, gouges, etc. This type of damage is unlikely, but should it occur, in such a degree as to cause improper seating of the bearing, the Turbo-Pump must be returned to the factory. The bearing seat is ground to a 50 micro-inch diametral tolerance. Inspect the oil catchers (82) and oil slingers (see Fig. 14) to determine if eccentric rotation of the rotor due to a badly damaged bearing might have caused contact of catchers and slingers at high speed. These parts should be clean and smooth, and any burrs or raised metal deposits must be removed. NOTE: When scraping or sanding these parts, precautions must be taken to prevent debris from falling into any of the pump parts. If the oil catchers become unavoidably contaminated, refer to the cleaning instructions in 17.0.

14.15 Verify that the new ball bearing and the bearing seat are clean. Apply a film of oil to the ball bearing. Start the bearing on the seat by hand as squarely as possible. Screw the front bearing lock nut (94) onto the rotor shaft backwards (slotted side away from the bearing) until the bearing is pressed halfway on. Remove and reverse the bearing lock nut and screw all the way on. A light tap on the spanner wrench with a small hammer will verify proper seating of the bearing.

14.16 Tighten the setscrews (93) and seal with a drop of lacquer.

14.17 Any burrs or humps raised on the bearing lock nut by the spanner wrench must be carefully filed down. The running clearance around the nut is very small. Again, use proper precautions to prevent particles from falling into the pump.

14.18 Reassemble the driven pulley (92) and nut (91).

14.19 Check to be certain all thrust springs (75) are in place in the cover plate (73). A small amount of vacuum grease will hold them when the cover plate is vertical for assembly.

14.20 Inspect the bearing resilient mount (87) (Fig. 18) from the back of the front cover-plate assembly as seen in Fig. 14. In the case of a locked bearing or an overheated bearing due to loss of oil, the resilient mount will definitely be damaged. In any case, examine the resilient mount for signs of abrasion or cuts. Also examine the entire cover-plate assembly for particles of rubber or metal. To change the resilient mount, grasp the old one with a pair of long-nosed pliers and remove. Clean the area and press a new mount into position by hand.

14.21 Check the split stator disc segments (99) at the open end of the pump to be certain they have not fallen over one another and overlapped before the front cover plate is reinstalled. Otherwise serious damage could result because the stator stack spacing is CRITICAL.

14.22 The remaining reassembly is the reverse of disassembly. When the screws (84) are retightened, they should not be screwed in so far that the safety wire cannot be rewired. If the rear rotor bearing is also to be removed, halt reassembly of the front cover plate before the screws (71) (72) are tightened.

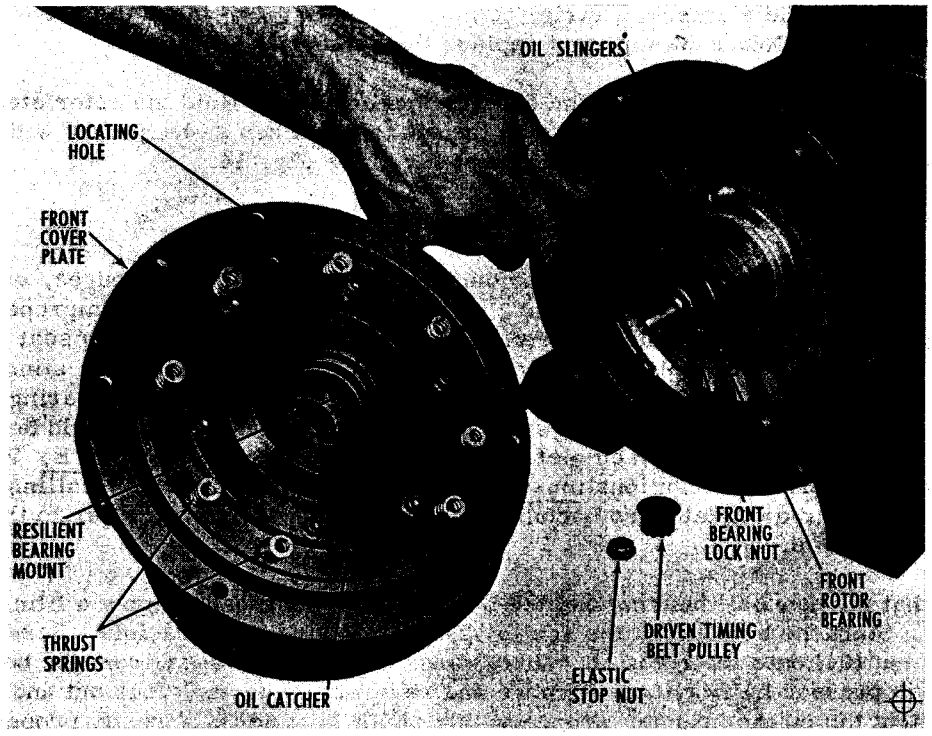


FIG. 14 BEARING LOCK NUT REMOVAL

15.0 BACK ROTOR BEARING -- Before disassembling the back cover plate (117) (Fig. 18) it is necessary to loosen the front cover plate so as to relieve the tension of the thrust rings (75). Otherwise, the thrust rings will push the stator discs out of position toward the back of the pump when the back cover is removed.

15.1 Disassemble as in 11.1 to 11.7 and 14.2 to 14.6.

15.2 Loosen the screws (71) (72) (Fig. 18) holding the front cover plate until the thrust rings (75) no longer exert pressure.

15.3 Remove three screws (72) and the cover (108) from the back cover plate (117).

15.4 Loosen the four elastic stop nuts (114) until the clamp bolts (115) can be rotated with a screwdriver 180° so that the punch mark on the end of the clamp bolt faces away from the rotor shaft. This punch mark indicates the position of the hook on the end of the clamp bolt which clamps onto the outer race of the back ball bearing.

15.5 Remove the safety wire from screws (84) and loosen the screws.

15.6 Remove the screws (71) (72) which secure the back cover plate (117).

15.7 Verify that the punch marks on the slotted ends of the clamp bolts (115) face away from center, and remove the back cover plate (117). It is usually necessary to use a bearing puller to pull the cover plate from the outer race of the ball bearing because the resilient mount adheres to the bearing outer race and the cover plate. The cover plate must not be forcibly pulled away from the pump housing without using a bearing puller to insure that the rotor remains stationary, otherwise it will pull the rotor, which will in turn drag the stator discs out of the pump. The center screw of the bearing puller should rest against the rotor shaft while the arms hook onto the perimeter of the cover plate. The resultant lateral movement of the rotor during cover plate removal should be zero.

15.8 Examine the back rotor ball bearing (95). The outer race can normally be rocked slightly by hand. If the bearing is damaged, the ball retainer may be distorted, the balls may be flattened or have bumps, or the outer race may be locked. Personnel experienced with precision ball bearings should be consulted before judgment is passed on the bearing.

15.9 Loosen the setscrews (93) in the bearing lock nut (103). The setscrews are sealed by a drop of lacquer which can be softened with acetone or shocked loose by inserting a screwdriver of the right size in the slot, striking the screwdriver with a light hammer, and applying a steady unscrewing torque. A steady torque will not strip the slot in the setscrew as readily as a sharp twist. Should a setscrew strip, use a No. 30 drill to remove the setscrew, then clean the threads with a No. 8-32 tap, and replace the setscrew.

15.10 Use a spanner wrench to remove the bearing lock nut (103). Hold the rotor steady by grasping the oil slingers with one hand and strike the spanner wrench a sharp blow with a light hammer. Once loosened, the lock nut will unscrew easily. See Fig. 14 for front end example.

15.11 Remove the ball bearing (95) with a bearing puller.

15.12 Inspect the bearing seat of the shaft for damage such as flat spots, gouges, etc. This type of damage is unlikely, but should it occur in such a degree as to cause improper seating of the bearing, the turbo-pump must be returned to the factory. The bearing seat is ground to a 50 micro-inch diametral tolerance. Inspect the oil catchers (82) and oil slingers (see Fig. 14) to determine if eccentric rotation of the rotor due to a badly damaged bearing might have caused contact of catchers and slingers at high speed. These parts should be clean and smooth, and any burrs or raised metal deposits must be removed. NOTE: When scraping or sanding these parts, precaution must be taken to prevent debris from falling into any of the pump parts. If the oil catchers become unavoidably contaminated, refer to the cleaning instructions in 17.2.

15.13 Verify that the new ball bearing and the bearing seat are clean. Apply a film of oil to the ball bearing. Start the bearing on the seat by hand as squarely as possible. Screw the back bearing lock nut (103) onto the rotor shaft with the slotted side toward the bearing, pressing the bearing into position. A light tap on the spanner wrench with a small hammer will verify proper seating of the bearing.

15.14 Tighten the setscrews (93) and seal with a drop of lacquer.

15.15 Any burrs or humps raised on the bearing lock nut by the spanner wrench must be carefully filed down. The running clearance around the nut is very small. Again use proper precautions to prevent particles from falling into the pump.

15.16 Inspect the bearing resilient mount (87) (Fig. 18) from the inside of the back cover plate assembly as seen for the front cover plate in Fig. 14. In the case of a locked bearing or an overheated bearing due to loss of oil, the resilient mount will definitely be damaged. In any case, examine the resilient mount for signs of abrasion or cuts. Also examine the entire cover plate assembly for particles of rubber or metal. To change the resilient mount, grasp the old one with a pair of long-nosed pliers and remove. Clean the area and press a new mount into position by hand.

15.17 Check the split stator disc segments (101) at the open end of the pump to be certain they have not fallen over one another and overlapped before the back cover plate is reinstalled. Otherwise, serious damage could result. Also check the clamp bolts (115) to be certain the hooks (indicated by the punch marks) face away from center.

15.18 Lift the back cover plate into position and secure with screws (71) (72).

15.19 Turn the clamp bolts (115) so that the punch marks face center and barely tighten the elastic stop nuts (114) enough to prevent the clamp bolts from rattling. To insure that the rotor ball bearing (95) is seated against the back bearing adjusting nut (112), alternately tighten each elastic stop nut (114) until the clamp bolts (115) are difficult to turn slightly with a small screwdriver. Back off the elastic stop nuts until the clamp bolts can be turned slightly with a small screwdriver, but there is no axial play in the clamp bolts.

15.20 Tighten the screws (84) which hold the pressure plate (116) until barely finger tight with a small screwdriver. Safety wire the screws so they cannot work loose.

15.21 The remaining reassembly is the reverse of disassembly.

16.0 ROTOR AXIAL ALIGNMENT -- The rotor has been axially aligned with respect to the stators at the factory, and this operation is not recommended unless the locking plate (111) has been removed and the adjusting nut (112) turned (even slightly). The only other factor which would necessitate axial alignment is the changing of a major dimension of the pump which might cause axial displacement of the rotor.

16.1 Disassemble as in 11.1 through 11.6 and 15.3 through 15.5.

16.2 Remove the safety wires on the screws (84) (Fig. 18) on the front cover plate and loosen the screws.

16.3 Strike the pump housing (96) sharply with a rubber mallet several times. This will help position any stator segments (99) (101) which might be stuck (especially after cover plates have been removed, as during a bearing change).

16.4 Remove the locking plate screw (109) and the locking plate (111). These items are shown in Fig. 15.

16.5 Unscrew the elastic stop nuts (114) several turns until they are at the ends of the clamp bolts (115).

16.6 Spin the rotor (102) by turning the driven timing belt pulley (92) by hand.

16.7 Move the rotor toward the front of the pump by turning the bearing adjusting nut (112) clock-wise. The rotor should still be spinning. Continue screwing the adjusting nut in slowly until a definite scraping or ticking is heard, then stop. NOTE: During this operation, the front rotor ball bearing is supposed to slide through the front resilient mount. In some cases, the mount may stick to the outer race of the bearing. This will be evidenced by an increased resistance to the screwing of the adjusting nut, followed by a sudden release. If this condition persists to the point where the rotor lurches or jumps as it approaches the stator discs, an accurate adjustment will be impossible. Instead of gradually striking the stators, the rotor will jam against them and lock. If this sticking occurs, return the adjusting nut (112) to approximately its original position and hook the clamp bolts (115) onto the rotor bearing by turning the punch marks toward center. Tighten the elastic stop nuts (114) until the rotor spins freely again. Then remove the front cover plate as in 14.1 through 14.7, liberally oil the front rotor bearing outer race and the inside of the bearing resilient mount (87), and re-assemble. Start again at 16.3.

16.8 Assuming that the rotor has been pushed slowly by turning the adjusting nut, and the scraping or ticking noise is heard, place an obvious pencil mark on both the adjusting nut and the back cover plate to mark this point of adjustment.

16.9 Back out the adjusting nut (112) exactly one full turn.

16.10 Hook the clamp bolts (115) onto the rotor bearing outer race by facing the punch marks toward center and gently tightening the elastic stop nuts (114). When all the clamp bolts are in place, begin tightening the stop nuts alternately to draw the rotor toward the back of the pump. Spin the rotor again and listen for the scraping or ticking noise. In some cases, the rotor might not scrape before the rotor bearing is stopped by the adjusting nut. In that case, back out the adjusting nut an additional exactly recorded amount, perhaps a half turn, and continue.

16.11 When the rotor is heard to scrape the stators, screw in (clock-wise) the adjusting nut (112) until the scraping noise diminishes or just barely disappears, meanwhile observing the relative position of the adjusting nut with respect to its original setting. At this point the notches on the adjusting nut serve as ideal units of measurement. The adjusting nut will probably be from eight to eleven notches from its original setting. Count these notches. This is the amount of clearance from a forward scraping to a backward scraping of the rotor. For a correct adjust-ment, screw in the adjusting nut half the total number of notches, thereby moving the rotor midway between the stators.

16.12 Replace the locking plate (111) in one of the two holes provided.

16.13 Reassembly is the reverse of disassembly.

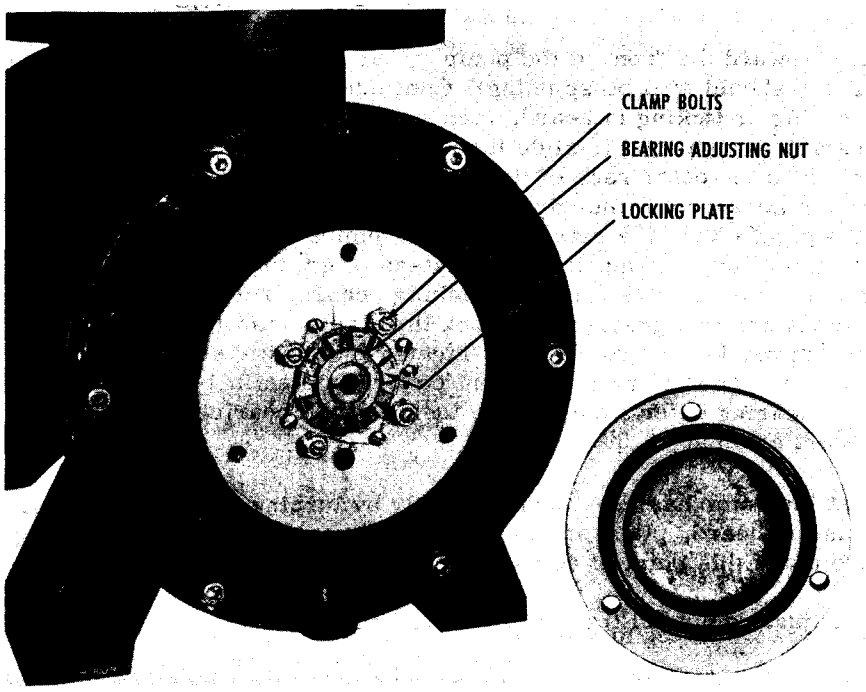


FIG. 15 ROTOR ALIGNMENT PARTS

17.0 CIRCULATING OIL SYSTEM -- Whenever the oil in the Turbo-Molecular Pump has been contaminated, it is necessary to flush the system by running the pump for five or ten minutes with clean oil, draining the oil, and refilling. However, when non-soluble particles or gummy substances are found in any region of the oil system, it is necessary to disassemble and thoroughly clean the entire oil system.

17.1 Remove each cover plate (73) and (117) (Fig. 18) as in 14.1 to 14.7 and 15.1 to 15.7, respectively.

17.2 Remove the screws and oil catchers (82) and (113). It may be necessary to tap the oil catchers with a plastic mallet to loosen them. CAUTION: Do not interchange front and back oil catchers; also note that there is an oil drain hole in each which must be at the bottom when reassembled.

17.3 Remove screws (84) and pressure plates (86) and (116).

17.4 Remove resilient mounts (87).

17.5 Thoroughly clean all disassembled parts with Welch Turbo Flush or other good solvent. Use careful visual inspection to detect all chips or particles. Flush the transmission assembly. To clean the oil lines (28) (32) disassemble the lines at the oil filter bodies and remove the filters (37). Pick debris from filters. Replace clogged filters.

17.6 Reassemble, replacing any damaged "O" rings.

18.0 ROTOR AND STATOR DECONTAMINATION -- The interior of the Turbo-Molecular Pump might become contaminated accidentally during operation or installation of vacuum equipment. To obtain ultra-high vacuum performance, the pump must then be decontaminated.

18.1 Vent the Turbo Pump to atmospheric pressure and drain the oil as in 5.1.

18.2 Expose the inlet of the pump by removing the shipping cover, blank-off plate, or other vacuum system components.

18.3 Remove the inlet screen (64) (Fig. 18) and the flat belt (10).

18.4 Wipe the inlet, the interior of the housing, and the rotor shaft center section with a clean cloth saturated with Welch Turbo Flush or other pure solvent.

18.5 Remove the outlet nipple plug (56) and place a drain pan under the pump.

18.6 Spin the rotor in the normal drive direction by turning the drive pulley (2) (Fig. 17) in a clockwise direction by hand. CAUTION: Do not over-torque the pulley, or the timing belt may be stretched or broken. Pour only one quart of Turbo Flush into the inlet and continue spinning the rotor until the solvent no longer flows into the drain pan.

18.7 Repeat 18.6 three or four times, using clean solvent each time.

18.8 Flush the inlet screen (64) (Fig. 18) thoroughly with Turbo Flush.

18.9 Replace the outlet nipple plug (56), the inlet screen and those components which were removed previously from the inlet.

18.10 To pump the solvent vapors out of the Turbo Pump, it is convenient to use an auxiliary Welch pump equipped with a vented exhaust. This will eliminate the necessity of changing the forepump oil two or three times, because the contaminated auxiliary pump can be set aside and run blanked off with the vented exhaust open to purge the solvent vapors.

18.11 Start the forepump (or auxiliary pump connected to the 3/4" foreline fitting). If possible, allow a small amount of dry N2 (or air) to bleed into the Turbo Pump upstream of the inlet.

18.12 When a pressure below 50 microns (with the bleed valve closed) is reached, stop the forepump (or auxiliary pump) and vent the Turbo Pump to atmospheric pressure.

18.13 If an auxiliary pump has been used, remove it from the system. If an auxiliary pump has not been used, change the forepump oil at this time.

18.14 Refill the Turbo Pump with oil as described in 5.2, and replace the flat belt (10) (Fig. 18) and belt guard (9).

18.15 Start the forepump with the foreline valve closed. Open the by-pass valve slowly as per the operating instructions, and start the Turbo Pump. Open the foreline valve.

18.16 After 10 minutes, check the forepressure with an untrapped Pirani or Thermocouple gauge. If the forepressure is greater than 20 microns, change the forepump oil again. (This may be done without stopping the forepump if care is observed not to catch fingers or clothing in the pulleys.)

18.17 An alternative to changing forepump oil is to leave the vented exhaust open while the Turbo Pump and forepump run all night.

18.18 The pump may be baked-out in accordance with the operating instructions.

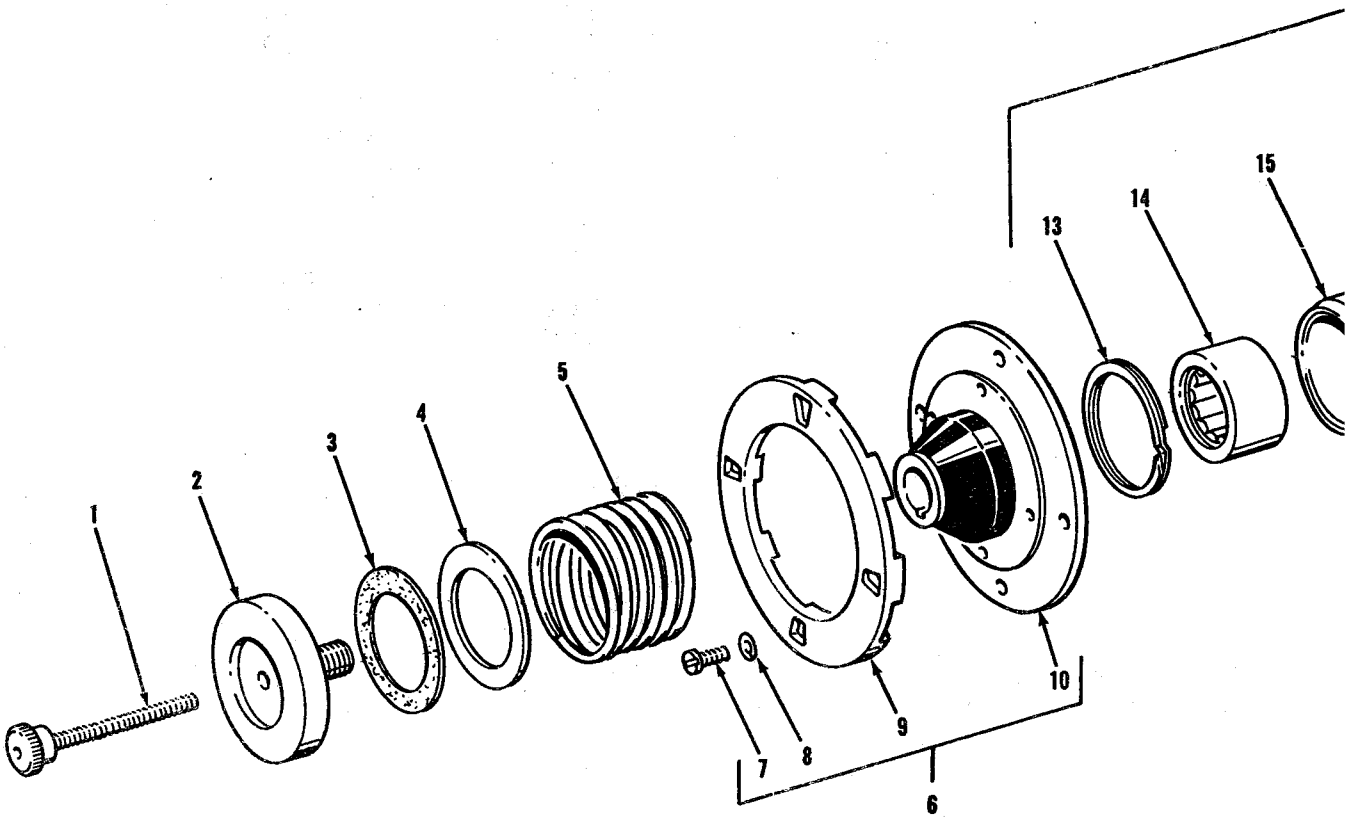
19.0 TROUBLE SHOOTING --

SYMPTOM	CAUSE	CURE
Motor will not go	Open switches, blown fuses, wrong motor connections, tripped starter overloads	Replace fuses with adequate slow blow capacity, make motor connections per diagram on motor label or motor junction box
Motor growls or goes wrong way slowly	One power lead open, one fuse open, motor winding open	Repair wiring, replace fuse, replace motor
Motor gets too hot to touch (other than at startup)	Abnormally high motor current, faulty overload protection	Install correct rating of heaters in motor starter
Excessive motor current	Wrong connections, low voltage, high voltage, clutch too tight	Make connections per diagram on motor label or motor junction box. Correct voltage condition to ±15% of motor name plate voltage. See 2.0.
Flat belt slips off	Oily pulleys, incorrect belt tension, incorrect pulley alignment, tight clutch	Clean pulley and belt surfaces with oil solvent, see 8.0.
Turbine pulley does not turn freely and smoothly by hand, scraping noises	Timing belt too tight, rotor not centered, bearing damaged, rotor or stator disks damaged	See 11.0, 16.0, 14.0, 15.0.
Turbine pulley turns without rotor inertia	Pulley setscrews loose, large toothed pulley inside loose, timing belt inside broken	Tighten setscrews, see 11.0, tighten clamp nut on large toothed pulley end of drive shaft (inside transmission) Replace belt.
Rotor takes more than five minutes to reach full operating speed	Clutch too loose	See 2.0
Oil runs rapidly out of oil cup into pump	Inward leakage through or around inner shaft seal	See 10.0
Oil drips onto control box	Spill during filling, leakage of outer shaft seal	Some leakage is normal; if cup empties in less than 3 days see 10.0
Flat belt does not track in middle of pulleys	Shafts not perfectly parallel, pulley crowns not in same plane, belt tension incorrect	Perfect tracking unnecessary; if belt overhangs edges, see 8.0
Clutch makes rattling noises	Loose setscrew in hub next to motor, insufficient lubrication on clutch bearing, worn rusty bearing from lubrication neglect	Push clutch against shaft shoulder and tighten setscrew. See 9.0.
Clutch "grabs"	Oil and grease on clutch face, Clutch too tight	Remove clutch pulley and remove deposits on carbon rings with solvent and light sanding. See 2.0.
Oil level drops in transmission window, oil collects in outlet trap	Oil getting past oil catchers, foaming during deaeration of oil, too fast roughing	Take at least 1 minute to "rough-pump" to -70 cm mercury (based on uniform pressure decrease rate) before using unrestricted forepump capacity.
Pump will not meet guaranteed blank-off pressure	Forepressure (McLeod) too high, leaks in Turbo-Molecular pump inlet section, contamination of rotor and stator with oil or water absorbed on pump surfaces	Check for leaks. See 18.0.

CLUTCH ASSEMBLY PARTS LIST

ITEM NO.	NO. REQUIRED	PART NO.	DESCRIPTION
1	1	41-3951	Spring Adjuster Lock Screw
2	1	41-3949	Clutch Spring Adjusting Screw
3	1	41-3955	Antifriction Washer
4	1	41-3954	Thrust Washer
5	1	41-3950	Clutch Spring
6	1		Pressure Plate with Hub-Fan Disk Assembly
7	8	32042	Fillister-Head Screw, 8-32 NC x 3/8
8	8	32548	Split Lock Washer, 8
9	2	41-3946	Fan Disk
10	1	41-3944	Clutch Pressure Plate with Hub
11	1	41-3956	Clutch Sleeve Key
12	1		Clutch Pulley Assembly
13	2	41-3958	Snap Ring
14	1	41-3952	Bearing
15	1	41-3948	Bearing Sleeve
16	1	41-2489	O-Ring, 1-3/4 ID x 2 OD x 1/8 W
17	1		Clutch Pulley with Lining
18	2	41-3947	Clutch Lining
19	1	41-4046	Clutch Pulley
20	1	41-3959	Truarc Retaining Ring
21	1	41-3953	Roller Bearing Inner Race
22	1	32443-A	Headless Setscrew, 8-32 NC x 1/4
23	3	32358-3A	Socket-Head Cap Screw, 4-40 x 1/4
24	1	41-3945	Clutch Sleeve
25	1		Pressure Plate - Fan Disk Assembly
26	1	41-3943	Clutch Pressure Plate, Left
27	1	41-3957	Motor Shaft Key

(See illustration next page)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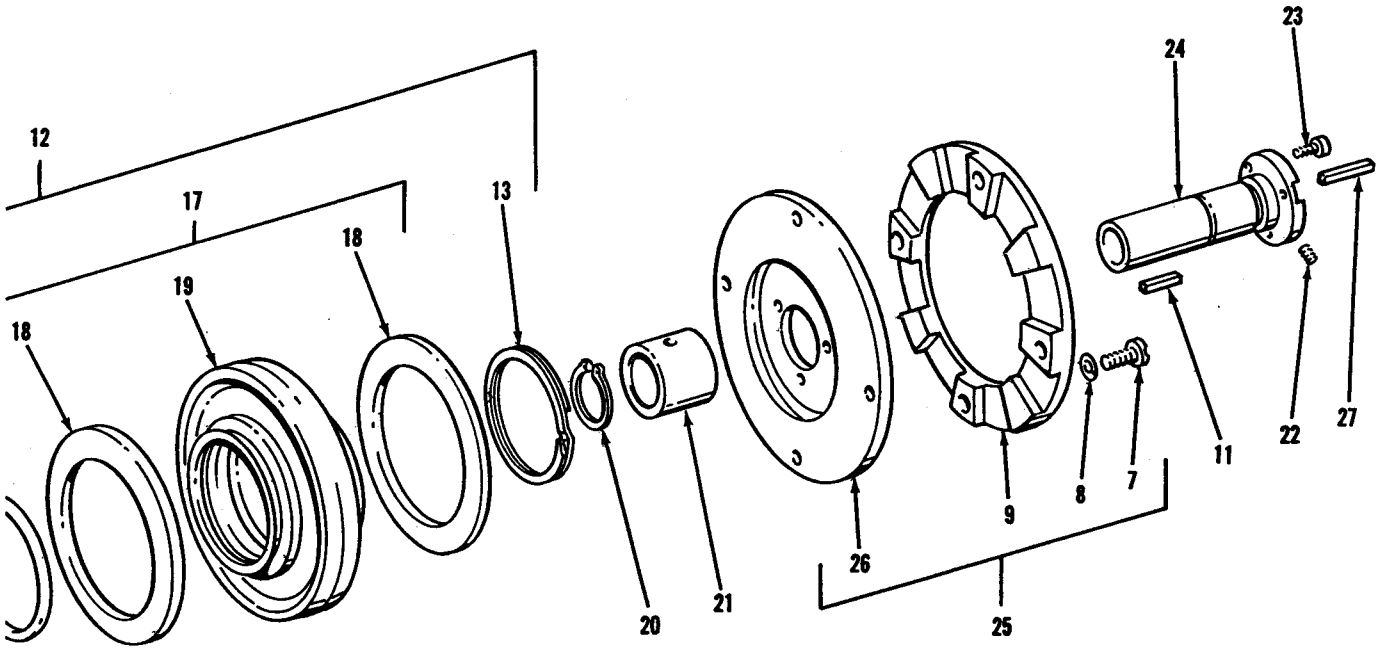
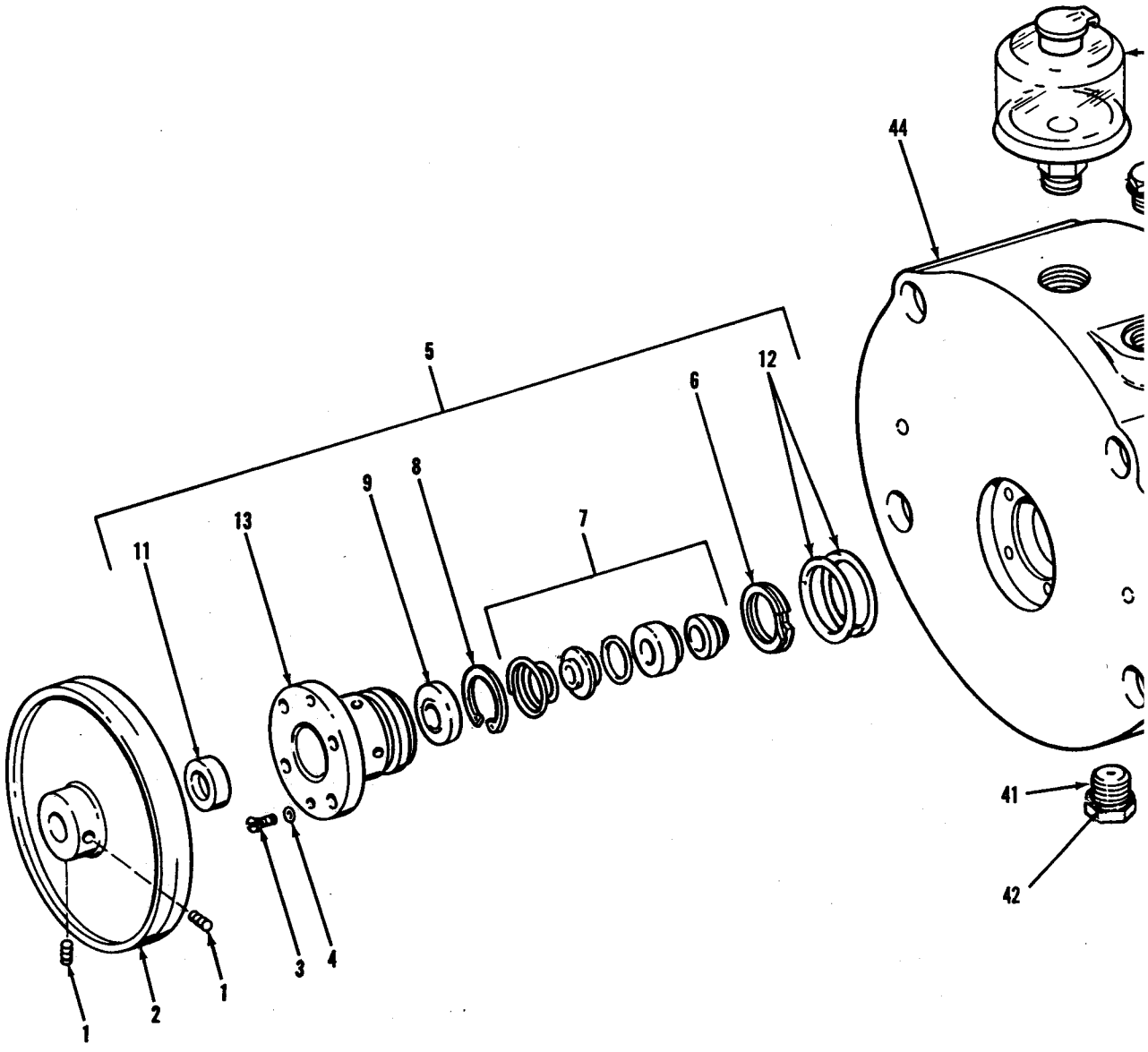


FIG. 16. CLUTCH ASSEMBLY.

TRANSMISSION ASSEMBLY PARTS LIST

ITEM NO.	NO. REQUIRED	PART NO.	DESCRIPTION
1	2	32465-5	Socket-Head Setscrew, 10-32 x 1/4
2	1	41-4047	Drive Pulley
3	4	32375-5	Fillister-Head Screw, 6-32 x 3/8
4	10	32545	Split Lock Washer, 6
5	1		Seal Cartridge Assembly
6	1	41-4004	Retaining Ring, Internal, 7/8
7	1	41-3995	Face Seal, 3/8 Shaft
8	1	41-4005	Retaining Ring, Internal, 7/8
9	1	41-3993	Drive Shaft Bearing, Left
11	1	41-3994	Lip Seal, 3/8 Shaft
12	2	41-4002	O-Ring, 1-1/16 ID x 1-1/4 OD x 3/32 W
13	1	41-3999	Seal Cartridge
14	1	32483-9	Elastic Stop Nut, Light, Thin, 3/8-24 UNF-3B
15	1	41-3941	Timing Belt Pulley, Driver
16	1	41-3990	Gripspring Spacer, Right, 3/8
17	2	41-3985	Gripspring, 3/8
18	1	41-3989	Gripspring Spacer, Center, 3/8
19	1	41-3988	Gripspring Spacer, Left, 3/8
20	3	32374-6	Binder-Head Screw, 8-32 NC x 3/8
21	3	32548	Split Lock Washer, 8
22	1	41-3984	Transmission Housing Cover
23	1	41-3983	Drive Shaft Bearing, Right
24	1	41-3980	Drive Shaft
25	3	32374-2	Binder-Head Screw
26	3	32556-1	Lock Washer
27	1	41-4017	Oil Flow Indicator Cover
28	4	32464-12	Socket-Head Setscrew
29	2	41-4023	Union
30	6	41-4131	Sleeve, 1/4 Tube Size
31	2	41-4024	Connector
32	2	41-4019	Oil Flow Indicator Tube
33	6	32358-4	Socket-Head Cap Screw, 6-32 NC x 3/4
34	1	41-4016	Oil Flow Indicator Bracket
35	1	41-4051	Plug
36	1	41-4018	Tetraseal, 11/16 ID x 7/8 OD x 3/32 W
37	1	41-3996	Oil Level Indicator Window
38	1	41-3978	O-Ring, 11/16 ID x 13/16 OD x 1/16 W
39	1	41-4132	Oil Indicator Sleeve
40	1	41-3979	O-Ring, 5/16 ID x 7/16 OD x 1/16 W
41	2	41-4000	Plug
42	2	41-4112	O-Ring
43	1	41-4001	Oiler
44	1	41-3925	Transmission Housing

(See illustration next page)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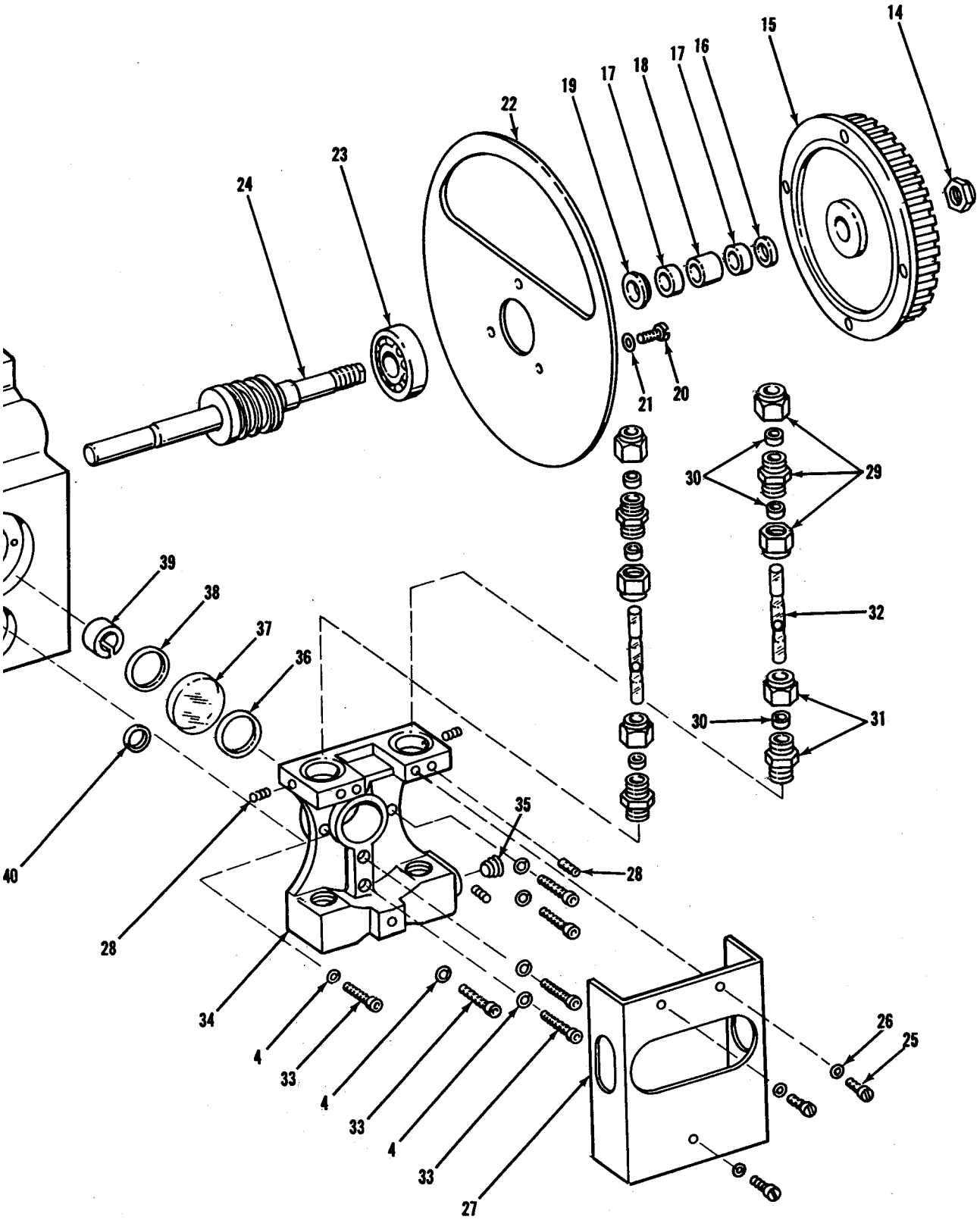


FIG. 17. TRANSMISSION ASSEMBLY.

TURBO-MOLECULAR PUMP ASSEMBLY PARTS LIST

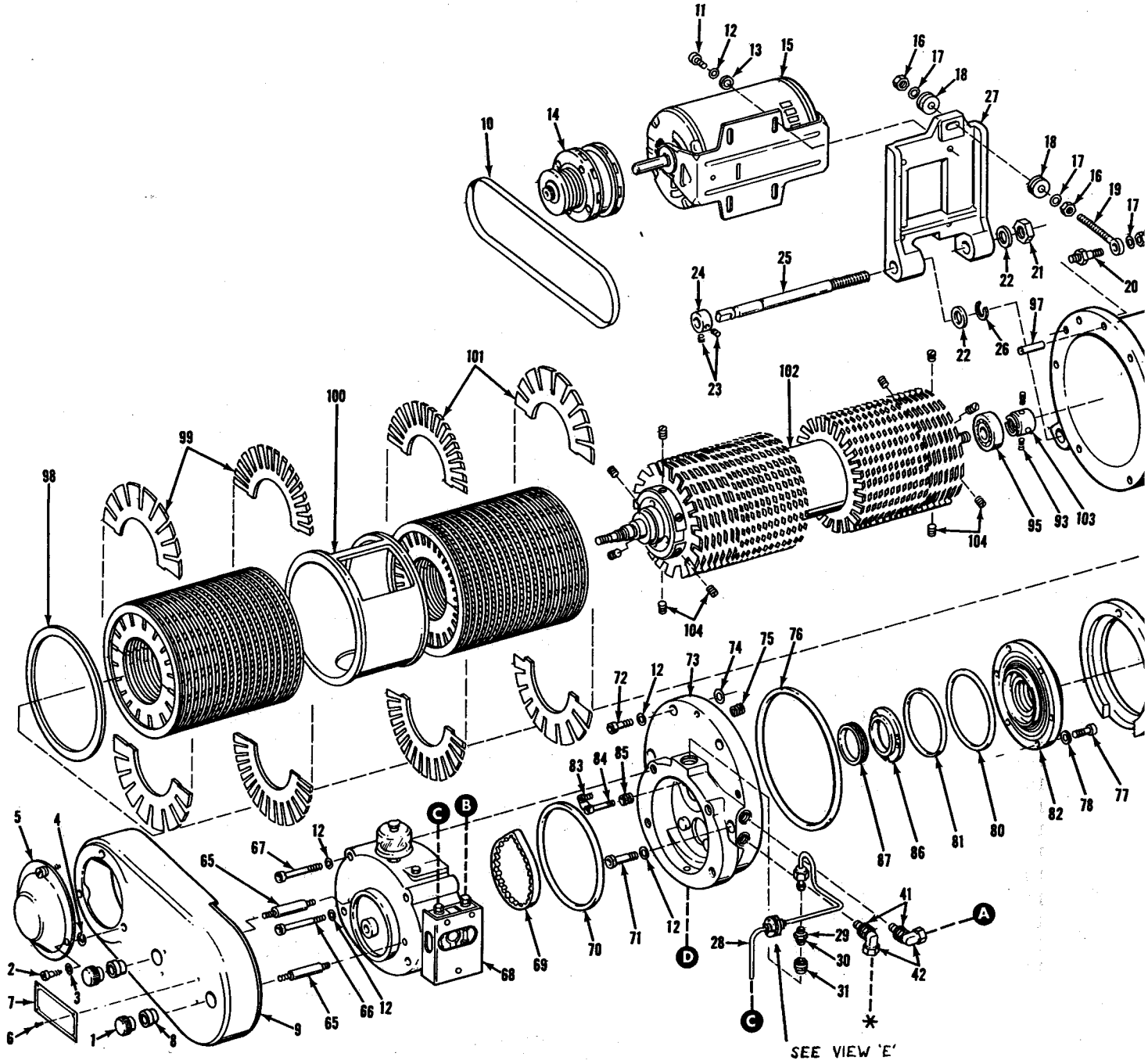
ITEM NO.	NO. REQUIRED	PART NO.	DESCRIPTION
1	2	41-4093	Knurled Thumb Nut
2	3	41-4039	Access Cover Screw
3	3	32535-5	Flat Washer, 10
4	3	41-4040	E-Ring
5	1	41-4038	Access Cover
6	4	32480-1	Self-Tapping Screw Stick, 1-72 x 1/8
7	1	41-4091	Turbo Pump Data Plate
8	2	41-4086	Insulator Bushing
9	1	41-4082	Belt Guard Assembly
10	1	41-4048	Flat Belt
11	4	32338	Hex-Head Cap Screw, 5/16-18 x 5/8
12	21	32555	Split Lock Washer, 5/16
13	4	32537	Flat Washer, 5/16
14	1	41-3939	Clutch Assembly
15	1	41-4010	Drive Motor
16	3	32484	Hex Nut, 3/8-16
17	3	32556	Split Lock Washer, 3/8
18	2	41-4015	Spherical Washer, 3/8
19	1	41-4011	Eye Bolt
20	1	41-4014	Eye Bolt Stud
21	1	32486-4	Hex Jam Nut, 3/4-16
22	2	32538-5	Flat Washer, 0.765 ID x 1-5/16 OD
23	2	32467	Hollow-Head Setscrew, 1/4-20 x 1/4
24	1	41-4009	Pivot Rod Collar
25	1	41-4008	Motor Pivot Rod
26	1	41-4079	Crescent Retaining Ring, 3/4
27	1	41-3927	Motor Pivot Bracket
28	1	41-4084	Oil Delivery Tube Assembly, Front
29	1	41-4041	Tube Connector, 1/4
30	1	41-4111	O-Ring 1/4 OD Tube
31	2	41-4090	Oil Filter Assembly
32	1	41-4083	Oil Delivery Tube Assembly, Back
33	1	41-4042	Tube Elbow, 1/4
34	1	41-4105	Oil Drain Tube Assembly
35	1	41-4098	Tube Elbow, 3/8
36	1	41-4113	O-Ring, 3/8 OD Tube
37	2	41-4182	Oil Filter Element
38	1	41-4177	Elbow, 3/8 Tube (Machining)
39	1	41-4106	Coolant Tube Assembly
40	1	41-4095	Tube Tee, 5/16
41	3	41-4112	O-Ring, 5/16 OD Tube
42	4	41-4094	Tube Elbow, 5/16
43	2	32356-1	Hex-Head Cap Screw, 1/2-13 x 2-1/2
44	4	32566	Split Lock Washer, 1/2
45	2	32354	Hex-Head Cap Screw, 1/2-13 x 1-1/2
46	1	41-4055	Outlet Connection Seal
47	1	41-4054	Outlet Connection Subassembly
48	1	41-2487	O-Ring, 3/4 ID x 1 OD x 1/8 W
49	4	32353-8	Hex-Head Cap Screw, 1/2-13 x 1-1/4
50	4	32539-1	Flat Washer, 1-1/16 OD x 17/32 ID x 3/32 W
51	1	41-4160	Outlet Cover
52	1	41-4059	Intake Nipple Nut
53	1	41-4061	Retaining Ring, 7/8 ID
54	1	41-4060	Squeeze Collar
55	1	41-4063	O-Ring, 1/2 ID x 11/16 OD x 3/32 W
56	1	41-4062	Intake Nipple Plug
58	8	32356-9B	Hex-Head Cap Screw, 5/8-11 x 3-1/4

Turbo-Molecular Pump Assembly Parts List, continued

ITEM NO.	NO. REQUIRED	PART NO.	DESCRIPTION
59	16	41-4188	Flat Washer, 5/8
60	8	41-4189	Hex Nut, 5/8-11
61	8	32568	Split Lock Washer, 5/8
62	1	41-4026	Inlet Flange Cover Plate
63	1	1377G	Inlet Flange Gasket
64	1	41-4049	Inlet Screen
65	2	41-4092	Belt Guard Stud
66	2	32365-4A	Socket-Head Cap Screw, 5/16-18 x 3-1/2
67	2	32365-4	Socket-Head Cap Screw, 5/16-18 x 3
68	1	41-3940	Transmission Assembly
69	1	41-4080	Timing Belt
70	1	41-3975	O-Ring, 5-3/4 ID x 6-1/4 OD x 1/4 W
71	2	32364	Socket-Head Cap Screw, 5/16-18 x 1-1/2
72	11	32362-5	Socket-Head Cap Screw, 5/16-18 x 1
73	1	41-3924	Front Cover Plate
74	12	41-4107	Cover Plate Shim Washer
75	8	41-3991	Thrust Spring
76	2	41-3973	O-Ring, 7-3/4 ID x 8-1/4 OD x 1/4 W
77	12	32360	Socket-Head Cap Screw, 1/4-20 x 3/4
78	12	32553	Split Lock Washer, 1/4
80	2	41-3976	O-Ring, 4-3/4 ID x 5 OD x 1/8 W
81	2	41-3977	O-Ring, 3-1/2 ID x 3-3/4 OD x 1/8 W
82	1	41-3961	Oil Catcher, Front
83	2	41-4067	Fillister-Head Screw, 8-32 x 1/4
84	6	41-4066	Fillister-Head Screw, 8-32 x 1-3/8
85	2	41-3992	Front Retainer Plate Spring
86	1	41-3970	Front Pressure Plate
87	2	41-3971	Resilient Bearing Mount
88	1	41-3966	Thrust Ring, Front
89	2	41-3974	O-Ring, 6-3/4 ID x 7-1/4 OD x 1/4 W
91	1	32483-9	Elastic Stop Nut, Light, Thin, 3/8-24
92	1	41-3933	Timing Belt Pulley, Driven
93	4	32146-6	Slotted Headless Setscrew, 8-32 x 3/16
94	1	41-3931	Front Bearing Lock Nut
95	2	41-3934	Rotor Bearing
96	1	41-3923	Housing
97	2	41-4116	Roll Pin, 1/4 x 1-1/4
98	40	41-3936	Stator Disk Spacer Ring
99	1	41-3912	Stator Disk Set, Left Screwing
100	1	41-3937	Stator Disk Spacer Tube
101	1	41-3911	Stator Disk Set, Right Screwing
102	1	41-3913	Rotor Assembly
103	1	41-3932	Back Bearing Lock Nut
104	8	41-3935	Balancing Screw
105	1	41-3965	Thrust Ring, Back
107	1	41-2481	O-Ring, 3-5/8 ID x 4 OD x 3/16 W
108	1	41-3928	Cover
109	7	32375-5	Fillister-Head Screw, 6-32 x 3/8
110	7	32545	Split Lock Washer, 6
111	1	41-3968	Locking Plate
112	1	41-3967	Back Bearing Adjusting Nut
113	1	41-3960	Oil Catcher Back
114	4	32483-8	Elastic Stop Nut, 1/4-28
115	4	41-3972	Clamp Bolt
116	1	41-3969	Back Pressure Plate
117	1	41-3926	Back Cover Plate
*	2	41-4109	Hose Connection Assembly

* This item is supplied in the event the customer desires to connect coolant to the turbo-pump from a system other than the system furnished with the turbo-pump set.

(See illustration next page)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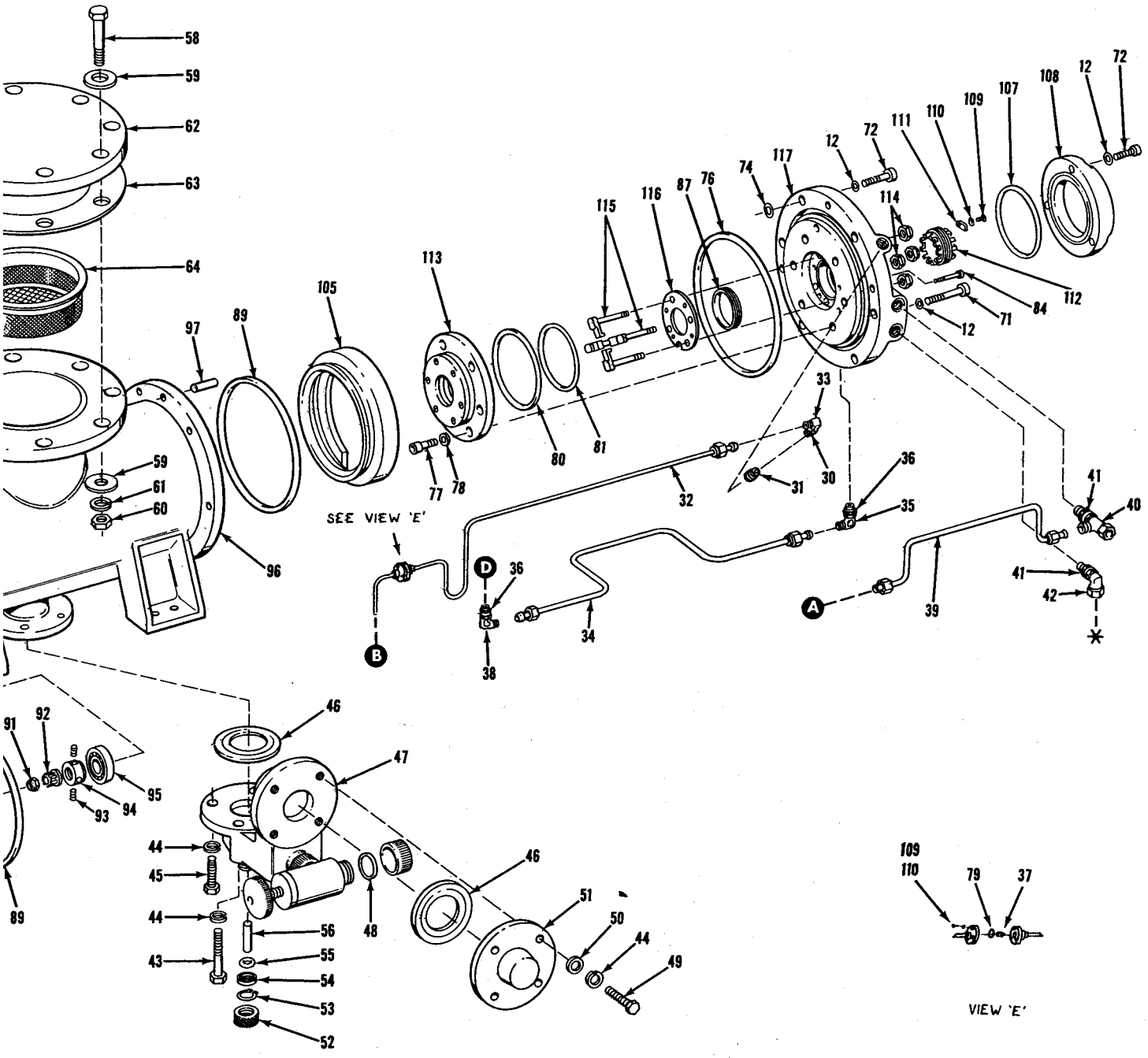

FIG. 18. TURBO-MOLECULAR PUMP ASSEMBLY.