

TWIN DISC
INCORPORATED



Service Manual

Marine Transmission

Model:
MG-514C

Document Number: 1015425

NOTICE

Twin Disc, Incorporated makes no warranty or guaranty of any kind, expressed, implied or otherwise, with regard to the information contained within this manual. Twin Disc, Incorporated has developed this manual through research and testing of the information contained therein. Twin Disc, Incorporated assumes no responsibility for any errors that may appear in this manual and shall not be liable under any circumstances for incidental, consequential or punitive damages in connection with, or arising out of, the use of this manual. The information contained within this manual is subject to change without notice.

SERVICE MANUAL

SM-227

#1015425

**MODEL MG-514C
MARINE
TRANSMISSION**

ORIGINAL ISSUE

May 1980

Revision B, December 1983

Reissue, August 1995

Twin Disc, Incorporated

1328 Racine Street

Racine, Wisconsin, 53403

U.S.A.

Printed in U.S.A.

REVISION AND REISSUE DATA

Revision A, April 1982
Pages Changed: 1-1, 1-2, 12-2
Pages Removed: Warranty

Revision B, December 1983. Pages changed: 1-1, 1-2, 2-8, 9-3, 9-10, 9-11, 9-12, 9-13, 9-14,
11-7, 12-6, 12-8 and 12-9.

A NOTE: "Flagging" indicates area revised.



TWIN DISC, INCORPORATED **EXCLUSIVE LIMITED WARRANTY-** **COMMERCIAL MARINE TRANSMISSION,** **SURFACE DRIVE, and ELECTRONIC CONTROL SYSTEMS**

A. Twin Disc, Incorporated warrants all assembled products and parts, (except component products or parts on which written warranties issued by the respective manufacturers thereof are furnished to the original customer, as to which Twin Disc, Incorporated makes no warranty and assumes no liability) against defective materials or workmanship *for a period of twenty-four (24) months from the date of shipment by Twin Disc, Incorporated to original customer, but not to exceed twelve (12) months of service, whichever occurs first.* **This is the only warranty made by Twin Disc, Incorporated and is in lieu of any and all other warranties, express or implied, including the warranties of merchantability or fitness for a particular purpose and no other warranties are implied or intended to be given by Twin Disc, Incorporated.**

The original customer does not rely upon any tests or inspections by Twin Disc, Incorporated or on Twin Disc, Incorporated's application engineering. Twin Disc, Incorporated is not responsible for any specific application, installation or performance standard. Any analysis program by Twin Disc, Incorporated based upon customer supplied information is done solely as an accommodation to the customer and is not to be interpreted or construed as an approval for specific application or installation or a guarantee of performance.

B. The exclusive remedy provided by Twin Disc, Incorporated whether arising out of warranty within the applicable warranty period as specified, or otherwise (including tort liability), shall at the sole option of Twin Disc, Incorporated be either the repair or replacement of any Twin Disc, Incorporated part or product found by Twin Disc, Incorporated to be defective and the labor to perform that work and to remove and reinstall (or equivalent credit). In this context, labor is defined as the flat rate labor hours established by Twin Disc, Incorporated in the published Twin Disc Flat Rate Schedule, required to remove, disassemble, inspect, repair, reassemble, reinstall and test the Twin Disc, Incorporated product only. Authorized reasonable travel and living expenses will be considered for payment on all Commercial Marine Products except on Electronic Control Systems. . Under no circumstances, including a failure of the exclusive remedy, shall Twin Disc, Incorporated be liable for economic loss, consequential, incidental or punitive damages.

The above warranty and remedy are subject to the following terms and conditions:

1. Complete parts or products upon request must be returned transportation prepaid and also the claims submitted to Twin Disc, Incorporated within sixty (60) days after completion of the in warranty repair.
2. The warranty is void if, in the opinion of Twin Disc, Incorporated, the failure of the part or product resulted from abuse, neglect, improper maintenance or accident.
3. The warranty is void if any modifications are made to any product or part without the prior written consent of Twin Disc, Incorporated.
4. The warranty is void unless the product or part is properly transported, stored and cared for from the date of shipment to the date placed in service.
5. The warranty is void unless the product or part is properly installed and maintained within the rated capacity of the product or part with installations properly engineered and in accordance with the practices, methods and instructions approved or provided by Twin Disc, Incorporated.
6. The warranty is void unless all required replacement parts or products are of Twin Disc origin or equal, and otherwise identical with components of the original equipment. Replacement parts or products not of Twin Disc origin are not warranted by Twin Disc, Incorporated.

C. As consideration for this warranty, the original customer and subsequent purchaser agree to indemnify and hold Twin Disc, Incorporated harmless from and against all and any loss, liability, damages or expenses for injury to persons or property, including without limitation, the original customer's and subsequent purchaser's employees and property, due to their acts or omissions or the acts or omissions of their agents, and employees in the installation, transportation, maintenance, use and operation of said equipment.

D. Only a Twin Disc, Incorporated authorized factory representative shall have authority to assume any cost or expense in the service, repair or replacement of any part or product within the warranty period, except when such cost or expense is authorized in advance in writing by Twin Disc, Incorporated.

E. Twin Disc, Incorporated reserves the right to improve the product through changes in design or materials without being obligated to incorporate such changes in products of prior manufacture. The original customer and subsequent purchasers will not use any such changes as evidence of insufficiency or inadequacy of prior designs or materials.

F. If failure occurs within the warranty period, and constitutes a breach of warranty, repair or replacement parts will be furnished on a no charge basis and these parts will be covered by the remainder of the unexpired warranty which remains in effect on the complete unit.



FLAT RATE SCHEDULE FOR COMMERCIAL MARINE TRANSMISSION

(Hourly Labor Rate Must be Acceptable to Twin Disc, Incorporated.)

Product Code / Model Series	R&R	Unit Rebuild	Clutch Repair (both packs)	R&R Pump	R&R Valve	Rebuild Valve
0432 - MG5010 & MG5011 SERIES	10.0	8.0	2.0	1.0	1.0	0.5
0401 - MG506 SERIES	10.0	11.0	4.0	1.0	1.0	0.5
0435 - MG5050 SERIES	10.0	11.0	4.0	1.0	1.0	0.5
0437 - MG5061 & MG5062V SERIES	10.0	11.0	4.0	1.0	1.0	0.5
0453 - MG5055A SERIES	10.0	11.0	4.0	1.0	1.0	0.5
1706 - MG5065A SERIES	10.0	11.0	4.0	1.0	1.0	0.5
1707 - MG5065SC SERIES	10.0	11.0	4.0	1.0	1.0	0.5
0425 - MG5085 SERIES	10.0	12.0	4.0	1.0	1.0	0.5
0442 - MG5075A SERIES	10.0	12.0	4.0	1.0	1.0	0.5
0443 - MG5075SC SERIES	10.0	12.0	4.0	1.0	1.0	0.5
0476 - MG5082 SERIES	10.0	12.0	4.0	1.0	1.0	0.5
0419 - MG5114 SERIES	10.0	17.0	5.0	1.0	1.0	0.5
0433 - MG5090 SERIES	10.0	17.0	5.0	1.0	1.0	0.5
0489 - MGX5114A SERIES	10.0	17.0	5.0	1.0	1.0	0.5
0490 - MGX5114SC SERIES	10.0	17.0	5.0	1.0	1.0	0.5
0491 - MGX5114IV SERIES	10.0	17.0	5.0	1.0	1.0	0.5
1719 - MGX5095A SERIES	10.0	17.0	5.0	1.0	1.0	0.5
1728 - MG5095A SERIES	10.0	17.0	5.0	1.0	1.0	0.5
1729 - MG5095SC SERIES	10.0	17.0	5.0	1.0	1.0	0.5
0405 - MG514 SERIES	10.0	25.0	6.0	1.0	1.0	0.5
0447 - MG5145A SERIES	10.0	25.0	6.0	1.0	1.0	0.5
0448 - MG5145SC SERIES	10.0	25.0	6.0	1.0	1.0	0.5
0492 - MGX5135A SERIES	10.0	25.0	6.0	1.0	1.0	0.5
0494 - MGX5145SC SERIES	10.0	25.0	6.0	1.0	1.0	0.5
0426 - MG516 & MG5170 SERIES	10.0	28.0	8.0	1.0	1.0	0.5
0477 - MG5170 SERIES	10.0	28.0	8.0	1.0	1.0	0.5
0412 - MG5200 SERIES	10.0	32.0	10.0	1.0	1.0	0.5
0416 - MG518 SERIES	10.0	32.0	10.0	1.0	1.0	0.5
0459 - MG6557SC SERIES	10.0	32.0	10.0	1.0	1.0	0.5
0461 - MG6557RV SERIES	10.0	32.0	10.0	1.0	1.0	0.5
0473 - MG-520-1HP SERIES	10.0	32.0	10.0	1.0	1.0	0.5
0479 - MG-5222DC SERIES	10.0	32.0	10.0	1.0	1.0	0.5
0480 - MG-5225DC SERIES	10.0	32.0	10.0	1.0	1.0	0.5
1743 - MGX-5225DC SERIES	10.0	32.0	10.0	1.0	1.0	0.5
0441 - MG-6650-00-SC SERIES	12.0	32.0	16.0	1.0	1.0	0.5
0446 - MG-6848-00-SC SERIES	12.0	32.0	16.0	1.0	1.0	0.5
0478 - MG-6690SC SERIES	12.0	32.0	16.0	1.0	1.0	0.5
0484 - MGX-61500SC SERIES	12.0	32.0	16.0	1.0	1.0	0.5
0485 - MGX-6650 SERIES	12.0	32.0	16.0	1.0	1.0	0.5
0487 - MGX-6690SC SERIES	12.0	32.0	16.0	1.0	1.0	0.5
0488 - MGX-6848SC SERIES	12.0	32.0	16.0	1.0	1.0	0.5
1711 - MG-5321 SERIES	12.0	32.0	16.0	1.0	1.0	0.5
1721 - MGX-6620SC SERIES	12.0	32.0	16.0	1.0	1.0	0.5
1732 - MGX-5321DC SERIES	12.0	32.0	16.0	1.0	1.0	0.5
1737 - MGX-6599A SERIES	12.0	32.0	16.0	1.0	1.0	0.5
0408 - MG540 SERIES	20.0	62.0	20.0	1.0	1.0	0.5
0418 - MG5600 SERIES	20.0	62.0	20.0	1.0	1.0	0.5
1741 - MGX-5600 SERIES	20.0	62.0	20.0	1.0	1.0	0.5



FLAT RATE HOUR ALLOWANCE COMMERCIAL MARINE SURFACE DRIVE

(Hourly Labor Rate Must be Acceptable to Twin Disc, Incorporated.)

Description of Flat Rate Labor	ASD6	ASD8	ASD 10	ASD 11	ASD1 2	ASD 14	ASD 15	ASD 16
Removal and Reinstallation	2	3	3	3	4	6	8	8
Recondition complete unit and test for leaks	5	6	6	6	6	6	8	8
Replace front oil seal	1	1	1	1	1	1	1	1
Replace input shaft	1	3	3	3	3	4	4	4
Replace input gear/sprocket	1	3	3	3	-	-	-	-
Replace Chain	1	4	4	4	-	-	-	-
Replace H-Joint	2	2	2	2	3	3	3	3
Replace thrust ball	2	2	2	2	3	3	3	3
Replace retainer ring	2	2	2	2	2	2	2	2
Replace propeller shaft	2	3	3	3	3	4	4	4
Replace thrust tube	2	3	3	3	4	5	6	6
Replace rear oil seal	1	1	1	1	1	1	1	1
Replace steer cylinder	1	1	1	1	1	1	1	1
Replace power steer pump	1	1	1	1	1	1	1	1
Replace trim pump	1	1	1	1	1	1	1	1
Replace Ball Boot	2	2	2	2	2	2	2	2
Replace and align driveline	1	2	2	2	2	3	3	3

FLAT RATE HOUR ALLOWANCE COMMERCIAL MARINE ELECTRONIC CONTROL SYSTEMS

(Hourly Labor Rate Must be Acceptable to Twin Disc, Incorporated.)

*** Travel and related expenses are not included as a part of Twin Disc Electronic Control Warranty.**

Description of Flat Rate Labor (hours allowed for function to the right =>)	EC075	EC200	EC250	EC300	External Sensor
Removal and Reinstallation and Test	3	3	3	3	1
Electronic Control Repair * * there are no serviceable internal components	0	0	0	0	0

TABLE OF CONTENTS

Section 1.	INTRODUCTION	1-1
Section 2.	DESCRIPTION AND SPECIFICATIONS	2-1
Section 3.	OPERATION	3-1
Section 4.	PREVENTIVE MAINTENANCE	4-1
Section 5.	TROUBLE SHOOTING	5-1
Section 6.	REMOVAL AND UNIT DISASSEMBLY	6-1
Section 7.	CLEANING AND INSPECTION	7-1
Section 8.	SUBASSEMBLIES	8-1
Section 9.	UNIT ASSEMBLY AND INSTALLATION	9-1
Section 10.	ACCESSORIES AND OPTIONAL EQUIPMENT	10-1
Section 11.	SPECIAL TOOLS	11-1
Section 12.	DRAWINGS AND DATA	12-1

TORSIONAL COUPLING CONSIDERATIONS FOR MARINE TRANSMISSIONS

Some marine transmissions may incorporate the use of a torsional coupling in place of a rubber block drive between the engine and transmission. The different styles are shown on the last two sheets of the applicable marine transmission assembly drawings.

Flywheel housing vents should have no restrictions which would prevent the free flow of air for cooling the coupling. The ambient temperature of the air around the coupling has an operating range between -22° F (-6° C) and 176° F (80° C). Care should be taken to have the baffles installed properly so that hot air is ported out of the housing.

The element should be visually inspected following the first 100 hours of operation and every 2000 hours or every six months, whichever comes first thereafter. Torsional vibration, misalignment, degradation by contaminants (oil), heat, ultraviolet radiation, and excessive system torque can cause cracks or other signs of distress to appear on the surface of the rubber. The above described items affect the life of the coupling element.

Section 1.

INTRODUCTION

GENERAL INFORMATION.

Scope.

This publication provides the information necessary for the operation and maintenance of the Twin Disc, Incorporated equipment specified on the cover of this manual. Specific engineering details and performance characteristics can be obtained from the Service Engineering Department of Twin Disc, Incorporated, Racine, Wisconsin, U.S.A.

Operation and maintenance personnel responsible for this equipment should have this manual at their disposal and be familiar with its contents. Applying the information in the manual will result in consistent performance from the unit and help reduce downtime.

Special Tools.

Engineering drawings are included for the fabrication of special tools that should be used during disassembly and assembly of a unit. Repair of this equipment should not be attempted without special tools. Twin Disc does not manufacture these tools for general use.

REPLACEMENT PARTS.

Parts Lists.

Illustrations with complete parts listings are provided in appropriate sections of the manual to facilitate ordering spare or replacement parts.

WARNING

All replacement parts or products (including hoses and fittings) must be of Twin Disc origin or equal, and otherwise identical with components of the original equipment. Use of any other parts or products will void the warranty and may result in malfunction or accident, causing injury to personnel and/or serious damage to the equipment.

Ordering Parts.

Renewal Parts and Service Parts Kits, may be obtained from any authorized Twin Disc distributor or

service dealer. They are listed under POWER TRANSMISSION EQUIPMENT in the Yellow Pages of most metropolitan telephone directories.

NOTE

Do NOT use planographs included in this manual for ordering parts. Parts must be ordered from the bill of material. Bill of material numbers are stamped on the unit's nameplate.

If the bill of material sheet from which part numbers are obtained is unavailable, proceed as follows:

1. Provide the figure number of the illustration containing the part, the item number of the part, the description of the part, and the quantity required.
2. Do not use the word "complete", but state exactly each item wanted.
3. Do not designate the quantity by "sets", but specify the part required.
4. Specify the model, bill of material, and serial number of the unit involved. These numbers are stamped on the unit's nameplate.

Parts Shipment.

Furnish the complete shipping destination and postal address. All parts shipments made from the factory will be F.O.B. factory location, U.S.A. State specifically whether the parts are to be shipped by freight, express, etc. If shipping instructions are not specified on the order, the equipment will be shipped the best way, considering time and expense. Twin Disc, Incorporated will not be responsible for any charges incurred by this procedure.

Twin Disc, Incorporated, having stipulated the bill of material number of the unit's nameplate, absolves itself of any responsibility resulting from any external, internal, or installation changes made in the field without the express written approval of Twin Disc. All returned parts, new or old, emanating from any of the above stated changes will not be accepted for credit. Furthermore, any equipment which has been subjected to such changes will not be covered by a Twin Disc Warranty.

PREVENTIVE MAINTENANCE — TROUBLE SHOOTING.

Frequent reference to the information provided in this manual regarding daily operation and limitations of this equipment will assist in obtaining trouble free operation. Schedules are provided for the recommended maintenance of the equipment, and if observed, minimum repairs, aside from normal wear, will result.

In the event a malfunction does occur, a trouble shooting table is provided to help identify the problem area, and list information that will help determine the extent of the repairs necessary to get a unit back into operation.

LIFTING BOLT HOLES.

Most Twin Disc products have provisions for attaching lifting bolts. The holes provided are always of adequate size and number to safely lift the Twin Disc product.

CAUTION

These lifting points must not be used to lift the complete power unit. Lifting excessive loads at these points could cause failure at the lift point (or points) and result in damage or personal injury.

CAUTION

Select lifting eyebolts to obtain maximum thread engagement with bolt shoulder tight against housing. Bolts should be near but should not contact bottom of bolt hole.

SAFETY.

General.

Safe operating practices should be employed by all personnel servicing this unit. Twin Disc, Incorporated will not be responsible for personal injury

resulting from careless use of hand tools, lifting equipment, power tools, or unaccepted maintenance /working practices.

Important Safety Notice.

Because of the possible danger to person(s) or property from accidents which may result from the use of manufactured products, it is important that correct procedures be followed. Products must be used in accordance with the engineering information specified. Proper installation, maintenance, and operation procedures must be observed. Inspection should be made as necessary to assure safe operations under prevailing conditions. Proper guards and other suitable safety devices or procedures that may be desirable or specified in safety codes should be provided. These devices are neither provided by Twin Disc, Incorporated nor are they the responsibility of Twin Disc, Incorporated.

SOURCE OF SERVICE INFORMATION.

Each series of maintenance manuals issued by Twin Disc, Incorporated is current at the time of printing. When required, changes are made to reflect advancing technology and improvements in state of the art.

Individual product service bulletins are issued to provide the field with immediate notice of new service information. These service bulletins are distributed to all the Twin Disc distributorships throughout the United States and in many foreign countries.

For the latest service information on Twin Disc products, contact any Twin Disc Distributor, or write to the Service Engineering Department, Twin Disc, Incorporated, Racine, Wisconsin, U.S.A.

WARRANTY.

Equipment for which this manual was written has a limited warranty. For details of the warranty, contact any Twin Disc Distributor, service dealer, or the Warranty Administration Department, Twin Disc, Incorporated, Racine, Wisconsin, U.S.A.

Section 2.

DESCRIPTION AND SPECIFICATIONS

GENERAL.

1. Model MG-514C marine transmissions are reverse and reduction units, available in four ratios in the deep case: 4.13:1, 4.50:1, 5.16:1, and 6.00:1. Five ratios are also available in the shallow case: 1.512:1, 2.00:1, 2.50:1, 3.00:1, and 3.50:1.

NOTE

Deep case units are illustrated and discussed throughout this manual. However, the shallow and deep case units are very similar. See specifications for the differences.

2. This transmission is controlled completely hydraulically. See figure 2-8. Both the forward and reverse clutches are operated by main pressure oil

supply. The bearings, clutches, and gears are lubricated and cooled with low pressure oil.

Changing Rotation. (Figure 2-1).

When shipped from the factory, each unit is designated for use with a particular engine rotation. Within their rated capacities, these units may be operated continuously in either forward or reverse. The unit can be adapted to either left or right-hand engine rotation. To adapt to opposite engine rotation, remove the oil strainer housing with oil inlet hose attached. Remove the oil outlet hose. Remove the oil pump, turn it 180 degrees and re-install it. Install the oil strainer housing where the oil outlet hose was and the oil outlet hose where the oil strainer housing was. Remove the rotation indicator, turn it 180 degrees and reinstall it. See Figure 2-2.

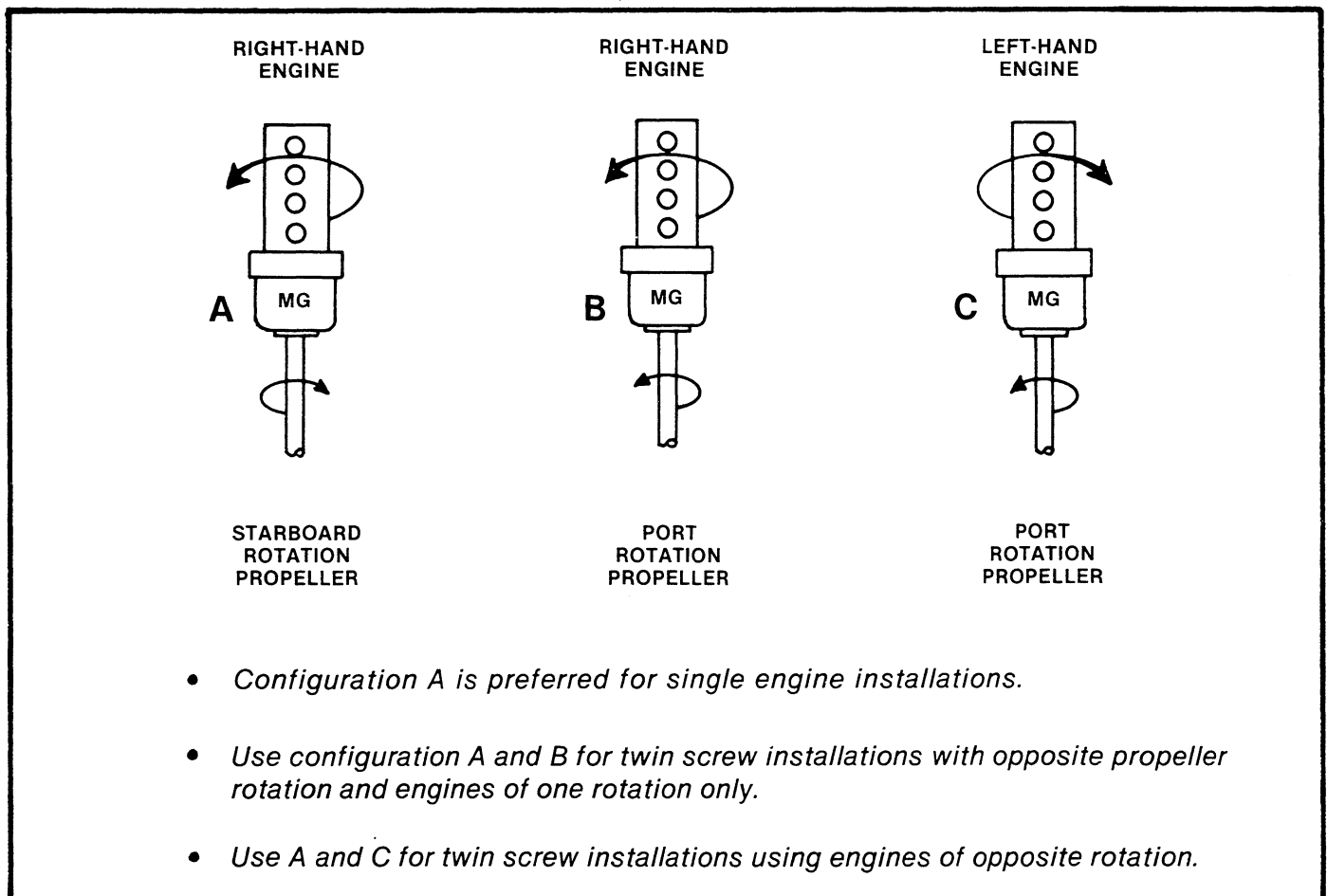


Figure 2-1. Marine Transmission Configurations for Right and Left-Hand Engines.

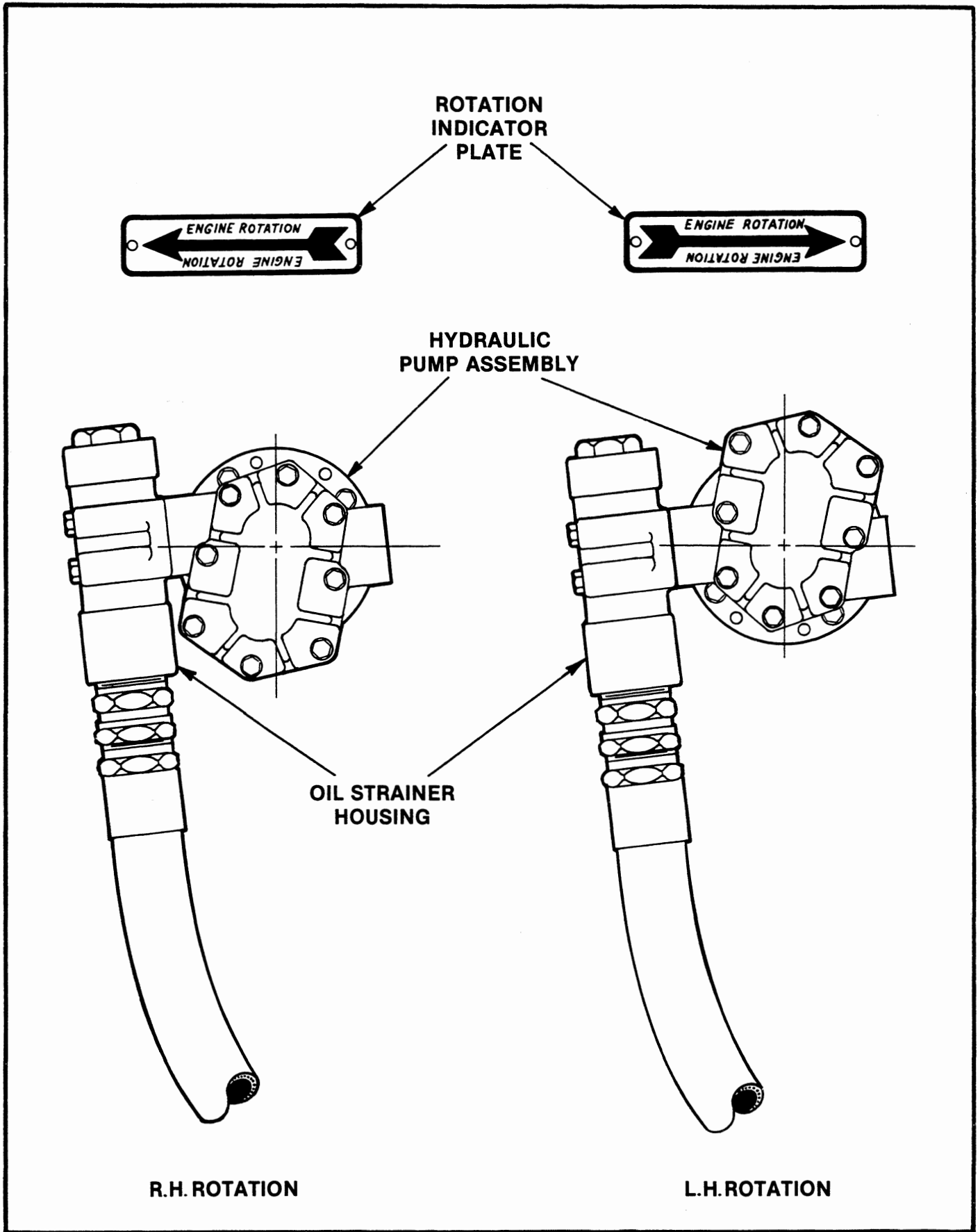


Figure 2-2. Relationship of Rotation Indicator and Pump Suction Strainer for Right and Left-Hand Engine Rotation. Aft of Transmission Looking Forward.

DIRECTION OF DRIVE

The forward (input) clutch shaft and driving transfer gear (see Figure 2-3) always rotate in engine direction. The reverse clutch shaft and driven transfer gear always rotate in anti-engine direction because the driven transfer gear is meshed with the driving transfer gear on the forward clutch shaft. When the forward

clutch is engaged, the forward input pinion rotates in engine direction. The output gear, which is secured to the output shaft, is meshed with the forward input pinion and the output gear and shaft are driven in anti-engine direction. When the reverse clutch is engaged, the reverse input pinion rotates in anti-engine direction. The output gear is meshed with the reverse input pinion and, therefore, the output gear and shaft are driven engine direction.

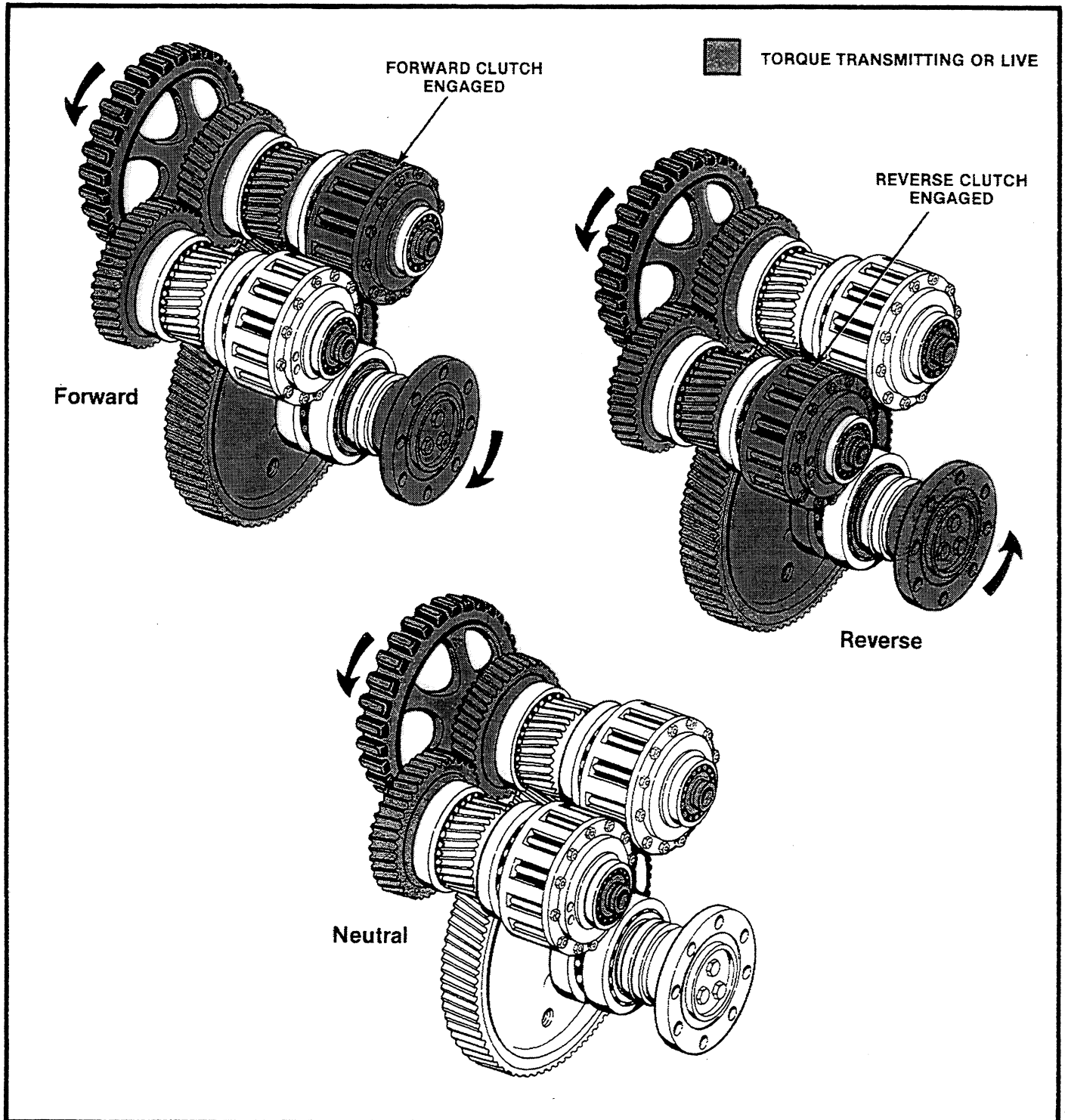


Figure 2-3. MG-514C Power Flow Diagram (Right-Hand Engine Rotation).

EMERGENCY MECHANICAL LOCKUP (COME HOME) FEATURE.

In the event of a hydraulic pressure to clutch failure, the transmission has an emergency mechanical lockup (come home) feature. Four socket-head screws equally spaced in the clutch cylinder provide the means for this lockup. To use this feature, remove the two access plugs from the manifold for the forward or reverse clutch cylinder. Bar the engine over to align two of the come home screws with the plug openings. Tighten the two come home screws securely. Bar the engine over to align the two remaining screws and tighten them securely. Replace the two access plugs. The drive and driven clutch plates are now mechanically clamped together for solid drive through the clutch. The transmission is always in gear.

CAUTION

Operate engine at reduced speed and do not attempt to use hydraulic engaging during solid drive. When using mechanical lockup with a twin engine arrangement, be sure the direction of drive of the two units is compatible. Repair the transmission as soon as possible.

CONSTRUCTION FEATURES. See Figures 2-4 and 2-5.

Housings.

The MG-514C housing consist of a one-piece main housing, a bottom cover, and an SAE No. 0 or No. 1 front housing. The manifold on the rear completes the housing. The manifold is sealed to the main housing with anaerobic plastic gasket compound.

In-Boat Maintenance.

Some repairs such as changing clutch plates, oil seals, and seal rings can be made without removing the transmission from the boat. See Section 6 for more details.

Taper Roller Bearings.

The forward, reverse and output shafts have taper roller bearings which require shimming to adjust end-play of the respective shafts.

Oil Pump Drive.

The oil pump is spline-connected and driven by the reverse clutch shaft.

Lubrication Features.

A lube tube extending fore and aft, near the top of the housing, serves as an oil distribution medium. From this tube, oil is directed by ports in the housing to the front roller bearings on the forward and reverse clutch shafts. Oil is also directed from the lube tube into the tube carrier assembly and sprayed onto the front roller bearings and rear ball bearings on the forward and reverse clutch pinions. The rear taper roller bearings on the forward and reverse shafts are lubed through orifices from the lube passage in the center of the output ends of the shafts.

Oil Strainer.

The unit has an oil strainer mounted to the inlet side of the oil pump. The strainer is between the sump and oil pump in the hydraulic circuit.

Filter Assembly.

An internal filter assembly is installed toward the rear of the main housing. The filter element provided has a 25 Micron nominal rating.

Companion Flange.

A companion flange is furnished that must be bored by the customer to fit his shaft.

Special Construction Features.

The driving and driven transfer gears are mounted on keyless tapers. The output gear is mounted on a keyed taper. "L" shaped steel clutch plates are used to give wider internal tooth area. This reduces unit load on the teeth and reduces the likelihood of the steel plates notching the hub.

HEAT EXCHANGER.

For Heat Exchanger requirements and general data see Figure 2-6.

SPECIFICATIONS.

The following provides operating specifications for the MG-514C. Frequent reference to this data and application of the information contained therein will result in better service from the transmission.

Oil Pressure.

The following tables give oil pressure at different speeds and ranges. See Figures 2-7 for location of oil pressure check points.

Oil Capacity.

9.0 U.S. gallons, (34 L) plus hoses and heat exchanger, (Deep case).
 6.0 U.S. Gallons, (22.7 L) plus hoses and heat exchanger, (Shallow case).

Oil Pump Capacity.

18.7 GPM at 2,500 RPM.
 70.8 LPM at 2,500 RPM.

Minimum Control Valve Oil Pressure When Cruising.

With 200 psi springs: 185 psi
 With 230 psi springs: 215 psi

Maximum Input Speed.

2500 rpm

Dry Weight.

Deep Case (5.16:1 ratio): 1449 lb. (657.25 Kg.)
 Shallow Case (2.00:1 ratio): 1155 lb. (523.9 Kg.)

***FOR MG-514C X9784C and X9786C ONLY, WITH 200 PSI SPRINGS.**

INPUT RPM SHIFT	PSI X Valve		PSI Z _F Forward Min. C	PSI Z _R Reverse Min. D
	Min A	Max. B		
1800				
F	200	227	195	0
N	60	98	0	0
R	200	227	0	195
600				
F	195	222	190	0
N	42	73	0	0
R	195	222	0	190

****FOR MG-514C X9784C and X9784C ONLY, WITH 230 PSI SHIMMED**

INPUT RPM SHIFT	PSI X Valve		PSI Z _F Forward Min. C	PSI Z _R Reverse Min. D
	Min A	Max. B		
1800				
F	234	244	229	0
N	55	105	0	0
R	234	244	0	229
600				
F	216	242	211	0
N	27	73	0	0
R	216	242	0	211

* For standard MG-514C transmission.

**For pleasure craft high performance units.

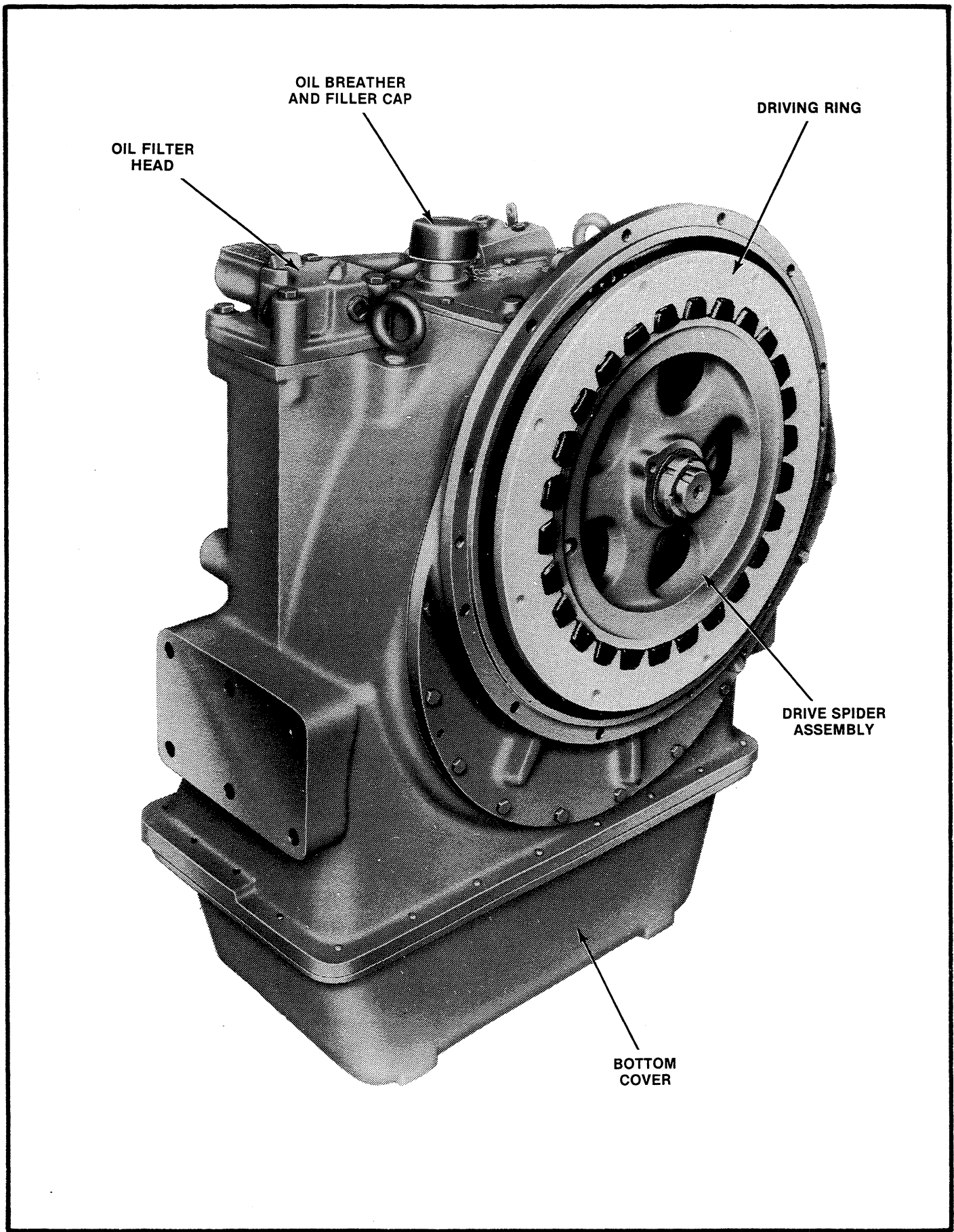


Figure 2-4. MG-514C Marine Transmission—Front View.

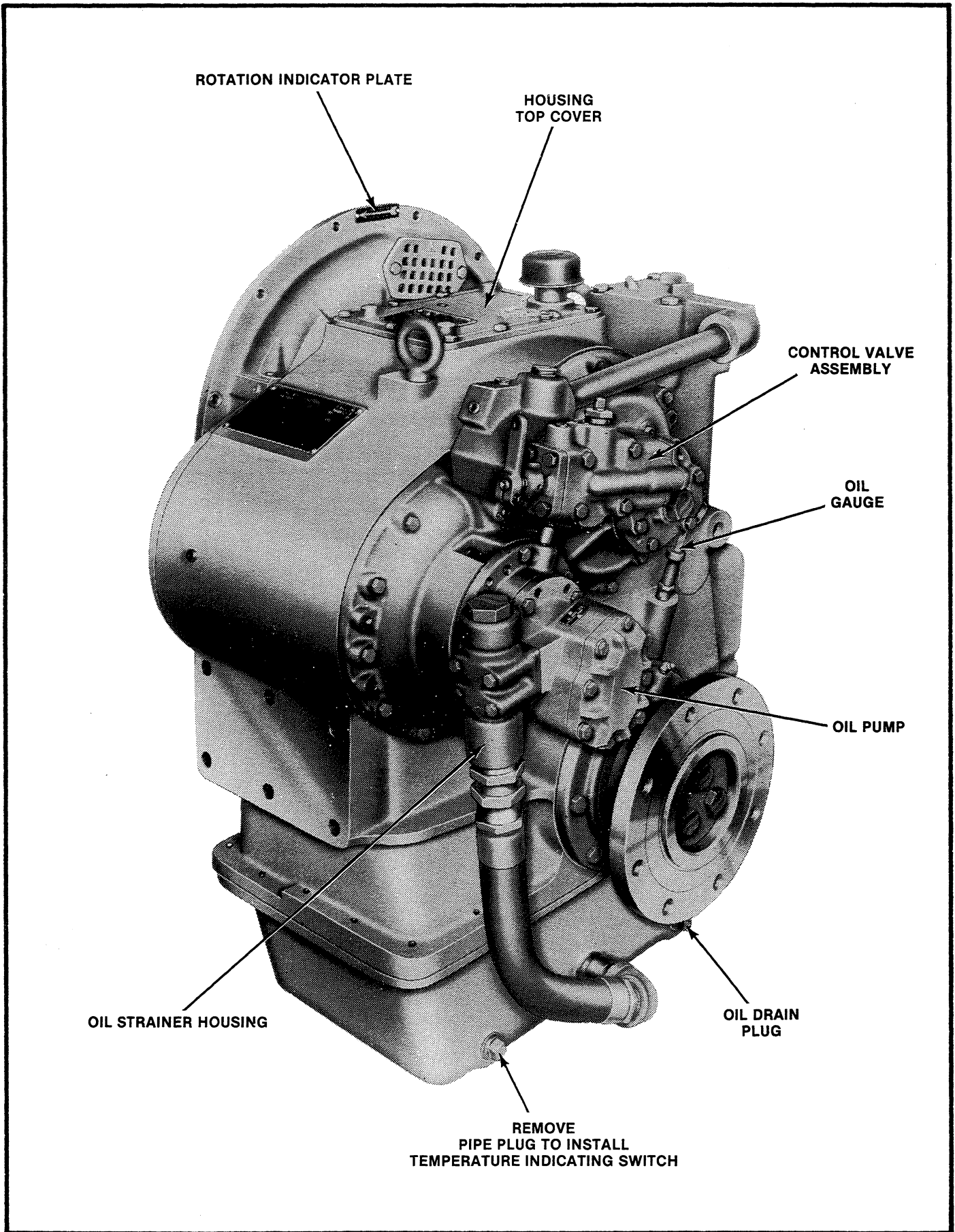


Figure 2-5. MG-514C Marine Transmission—Rear View.

HEAT EXCHANGER (H.E.) REQUIREMENTS

PERMISSIBLE OIL TEMPERATURE INTO H.E.	210° F. MAX. — 150° F. MIN.
MIN. HEAT TRANSFER CAPACITY (MULTIPLY BY 1.25 FOR FRESH WATER) (MULTIPLY BY 2.00 FOR RAW WATER)	BTU PER MIN. PER ENGINE RTD. HP.: CONTINUOUS DUTY: 1.484 P.C. & INT. DUTY: 1.272
APPROXIMATE OIL FLOW TO H.E.	.748 G.P.M. PER 100 ENGINE R.P.M.
PEAK OIL PRESSURE AT H.E. (PROOF TEST H.E. AT 1.5 × P.S.I.)	285 P.S.I.
MAX. ALLOWABLE OIL PRESSURE DROP ACROSS H.E. WITH 300 SUS OIL AT RATED ENGINE RPM	30 P.S.I.
WATER FLOW TO H.E.	USE 1.5 TO 3.0 TIMES OIL G.P.M.
H.E. WATER PRESSURE RATING, MIN.	= 1.5 × H.E. INLET WATER P.S.I.

DATA H.E. PURCHASER MUST ALSO TELL VENDOR

STATE IF RAW (OPEN CHANNEL & SEA) OR FRESH (CLOSED ENGINE JACKET & KEEL COOLER) WATER WILL COOL HEAT EXCHANGER

STATE MAX. WATER TEMPERATURE INTO HEAT EXCHANGER

TYPICAL: RAW WATER - 85° F.
KEEL COOLER WATER - 140° F.
ENGINE JACKET WATER - 180° F.

STATE MIN., ALSO MAX. G.P.M. OF WATER FLOW TO HEAT EXCHANGER

H.E. INSTALLATION & SERVICE REQUIREMENTS

OIL LINES, TRANSMISSION TO HEAT EXCHANGER AND RETURN —

- (1) MAX. VELOCITY IN FITTINGS, PIPE, HOSE AND TUBES — 25 FT./SEC.
- (2) BURST PRESSURE MIN. = 10 × PEAK OIL PRESSURE AT H.E.
- (3) HOSE — SAE J517 100R1 MEETING USCG 46CFR 56.60-25(C), 275° F. TEMP. RATING
- (4) PROTECT LINES FROM MECHANICAL DAMAGE.
ZINC ANODES PROTECT H.E. RAW WATER PASSAGES FROM CORROSION.
CHECK AND REPLACE THEM FREQUENTLY.

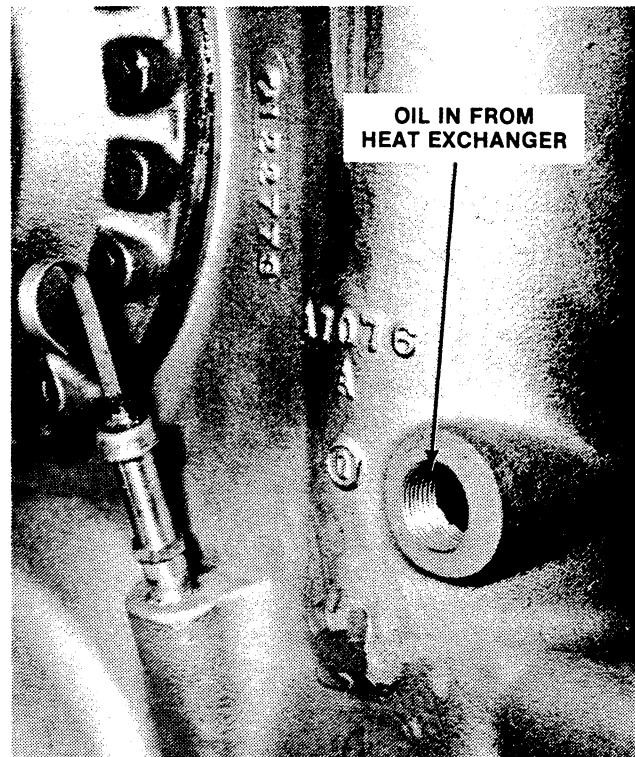
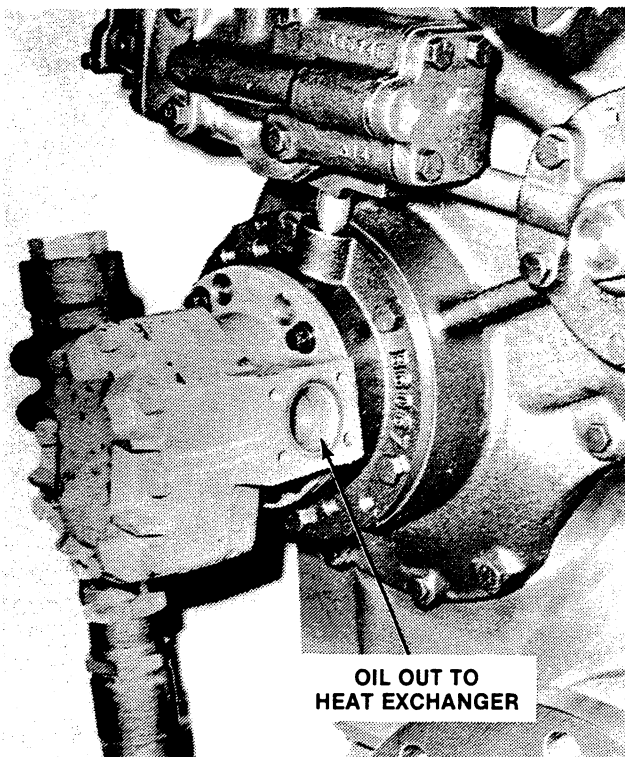


Figure 2-6. Heat Exchanger Requirements and General Data.

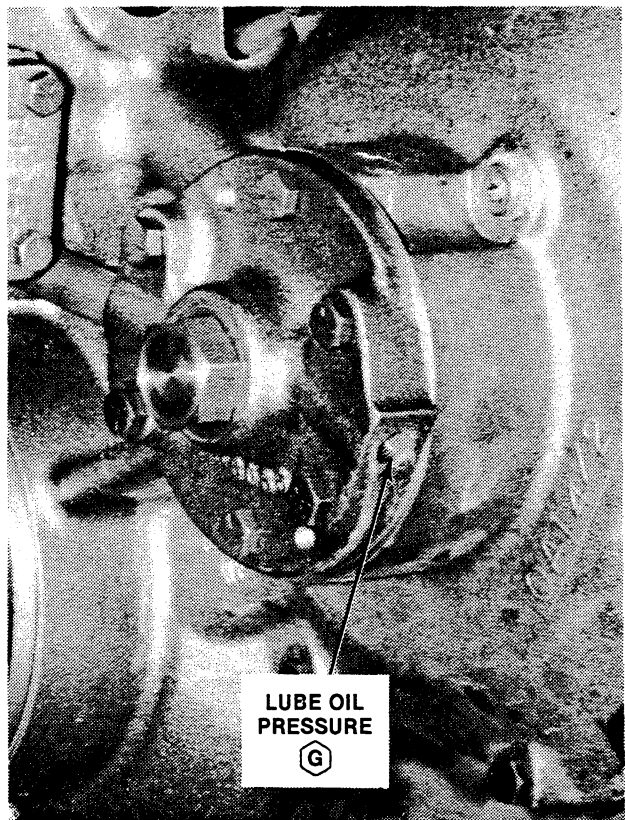
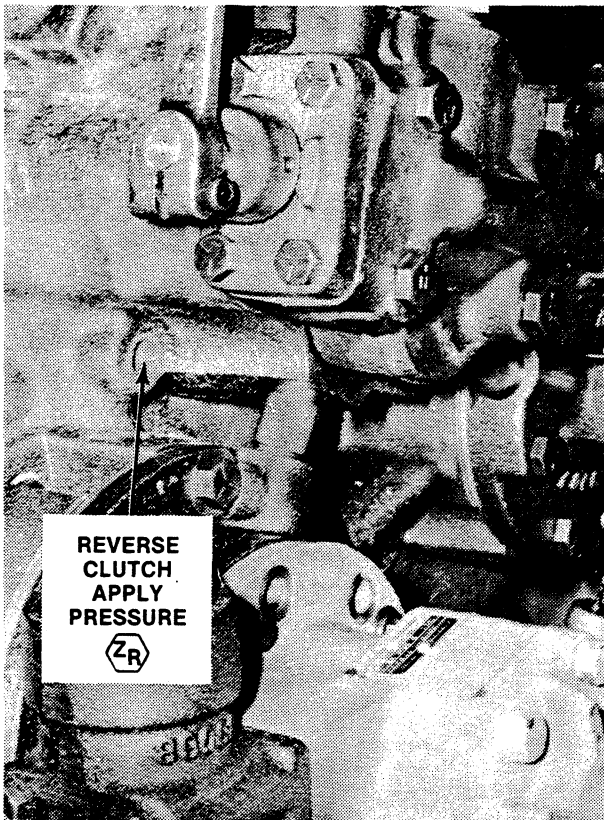
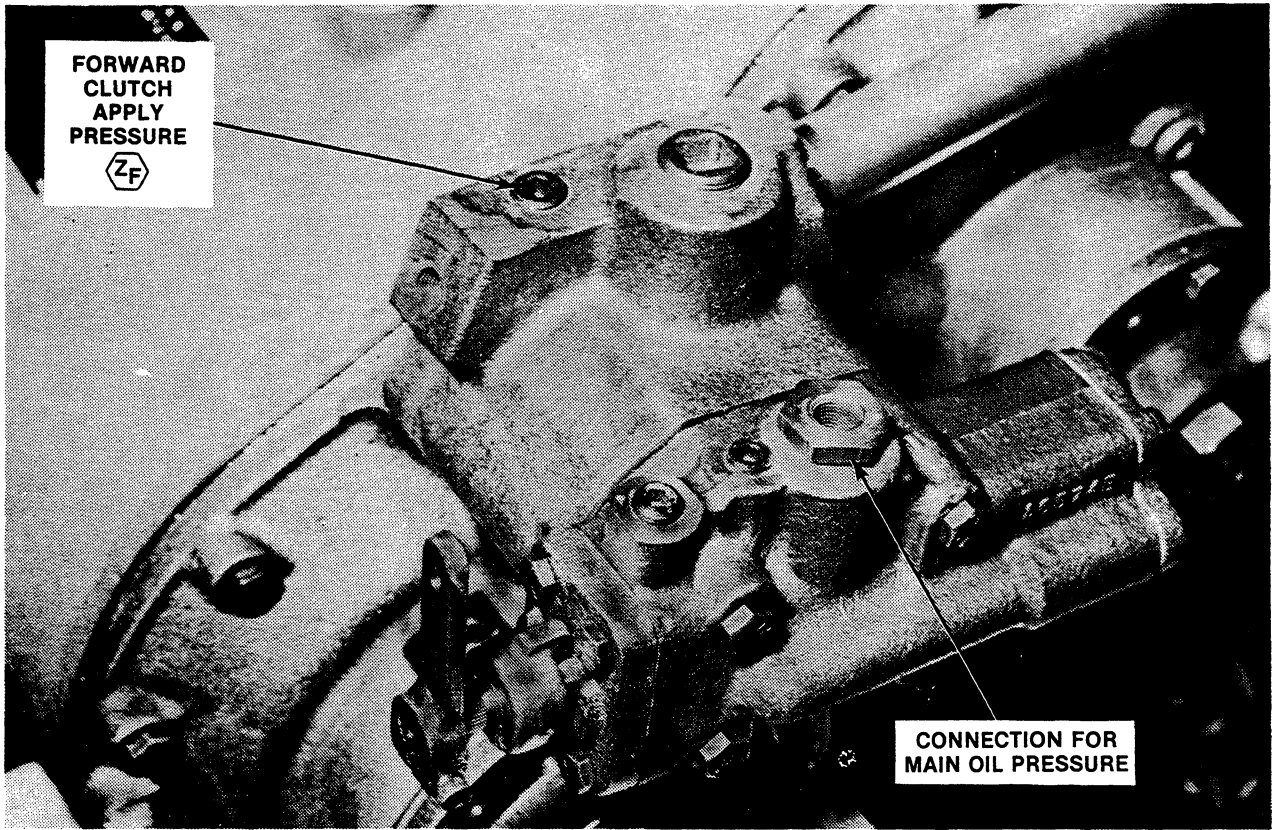
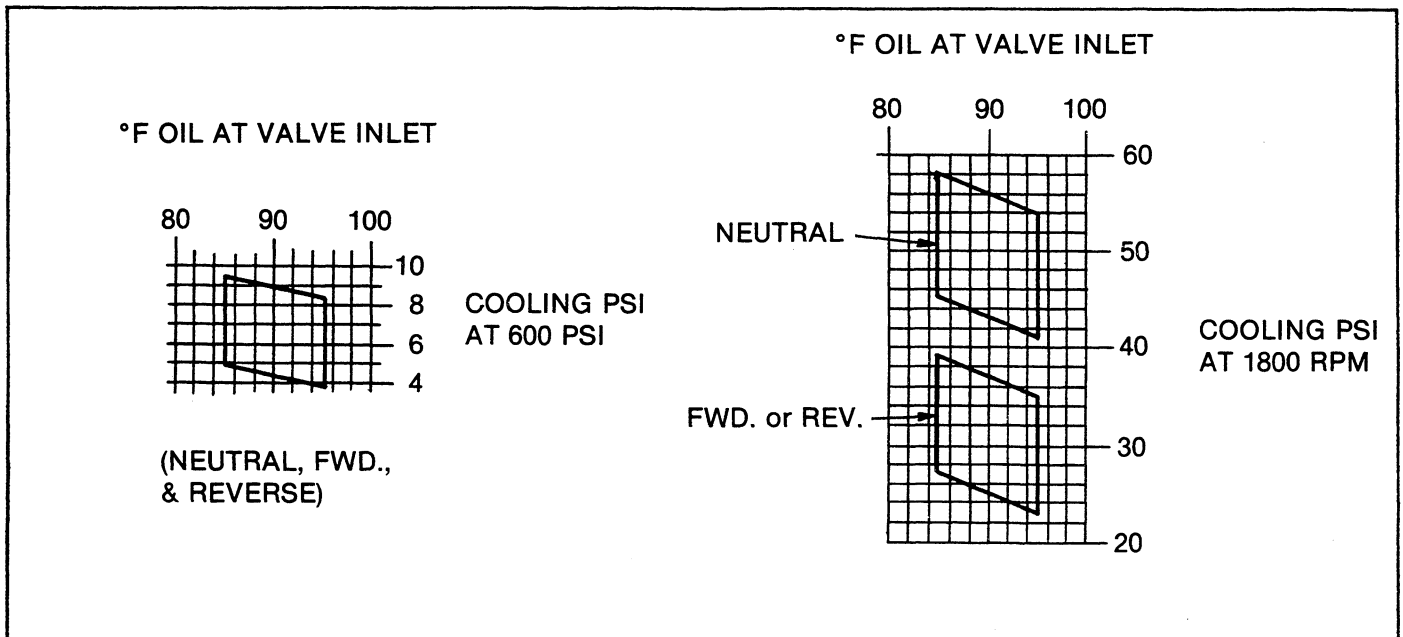


Figure 2-7. Location of Oil Pressure Check Points.



Required: The cooling pressure must be inside the solid blocks on the graphs above. For a given marine transmission, forward and reverse cooling pressures must be within 6 psi of each other.

OIL RECOMMENDATION.

Use only SAE-AP1 service class CD engine oil certified to meet TO-2 transmission oil specification or Type C-3 transmission fluid.

Also approved is SAE-AP1 service class CC engine oil.

NOTE

Multi Viscosity Oils (i.e. 10W-20 etc.) should not be used in Twin Disc Marine Transmissions.

Oil Viscosity.

Sump Temperature and Oil Temperature into Heat Exchanger		Recommended Oil Viscosity
During Start-up	Steady Operating Conditions	
	Below 150° F.	This operating condition is <i>not</i> approved.
32° F. Minimum	150°-185° F.	SAE viscosity number 30 engine oil.
32° Minimum	175°-210° F.	SAE viscosity number 40 engine oil.
	Above 210° F.	This operating condition is <i>not</i> approved.

OIL CHANGE INTERVAL.

Check oil level every 10 hours and change oil and filter every six months or 1000 hours, whichever comes first. Drain the oil by removing the oil drain plug (See Figure-2-5) on the rear of the transmission. Collect oil in container and dispose of it according to government regulations.

FILTER CHANGE INTERVAL.

1. With a new transmission, change the filter element within 50 hours service. Change the element after each 1000 hours of service thereafter, or more often if conditions warrant.
2. For a rebuilt transmission, check the filter element after 8 hours operation. If the filter is clean, install a new filter element and then change filter elements after 1000 hours service. If the filter is dirty, change the element and operate for another 8 hours. Check the filter again. Continue this cycle until the filter is clean and then change the element after 1000 hours service, or more often if conditions warrant.

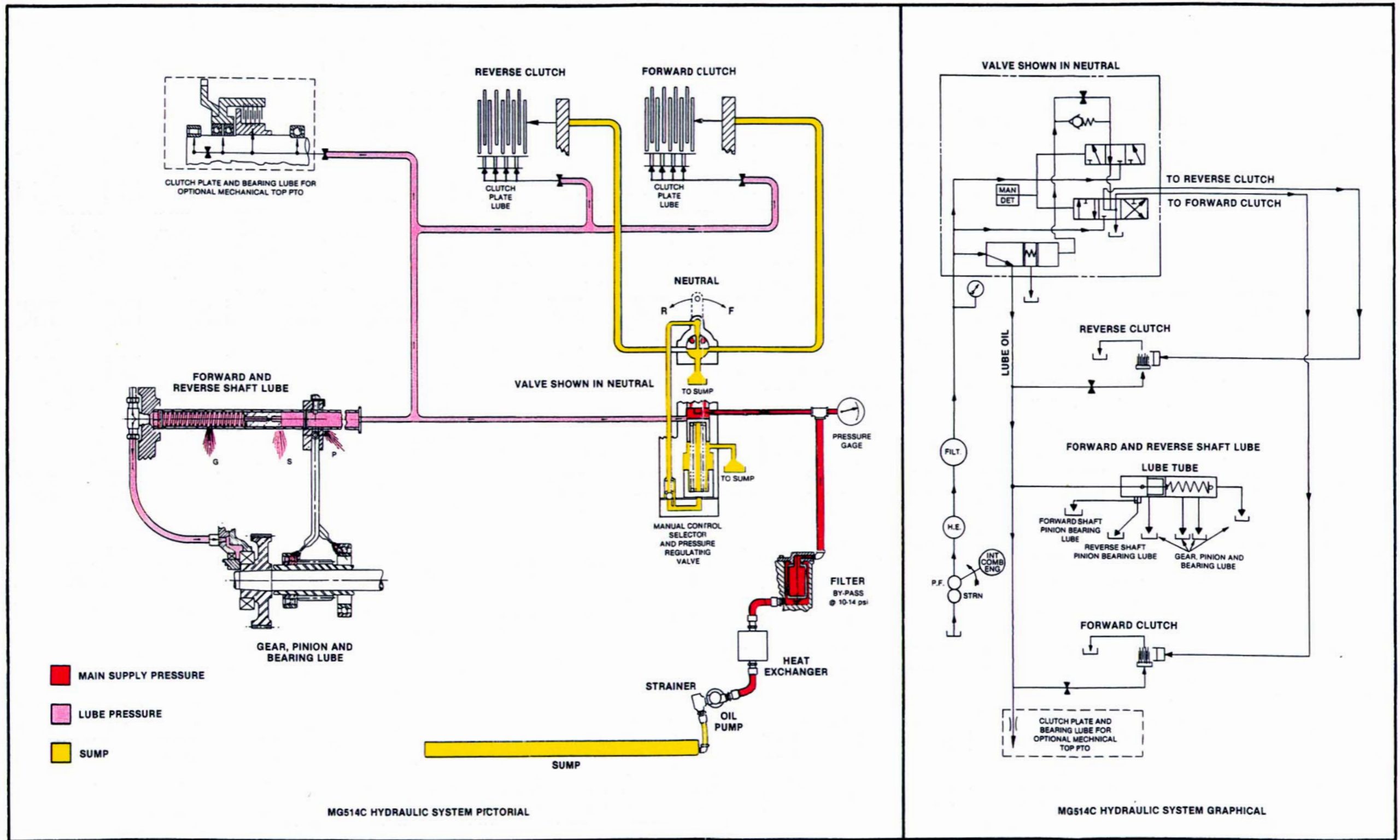


Figure 2-8. Hydraulic System Diagram.

Section 3.

OPERATION

GENERAL.

This marine transmission has forward, neutral and reverse positions obtained by means of the control valve. When these positions are selected, the control valve directs high pressure oil through internal passages to operate the clutches.

HYDRAULIC SYSTEM.

Oil is pumped through the system by the gear-type pump. The oil is taken from the sump through the strainer by the pump, and discharged through the heat exchanger and filter to the combination control and pressure regulating valve. The oil enters the pressure regulating area of the valve where main pressure is regulated by cascading excess oil into the lube circuit. Lube oil is distributed through fixed controlled orifices to lubricate bearings and cool the clutches. Lube pressure is controlled by a piston in the oil return pipe assembly.

In neutral, the inlet ports to the clutches are blocked, the clutches are disengaged, and the area behind the clutch pistons is open to sump. Oil is distributed through the lubrication system.

When the control valve is shifted to engage either clutch, the control valve directs main pressure to engage the selected clutch pack. Oil is also directed through a port in the control valve spool to a fixed orifice in the orifice plate causing a controlled flow of

oil to unseat the rate-of-rise piston and move it to seat on a shoulder in the rate-of-rise piston bore compressing the pressure regulator springs. This progressively increases the clutch engaging pressure causing the clutches to engage at a controlled rate. Overage oil becomes lube oil. The control valve allows only one clutch to be engaged at a time, and the oil from the disengaged clutch is dumped to sump. When a clutch is disengaged, any centrifugal pressure head existing behind the clutch apply piston is relieved to sump through the control valve. This allows the return springs to move the clutch piston to the disengaged position to prevent clutch drag. A lube priority system is incorporated in each clutch. In the disengaged position, a flange on the clutch piston covers two orificed ports in the front of the clutch cylinder. When a clutch is engaged, the clutch piston moves toward the clutch plates, uncovering the two orificed ports. Additional oil for cooling the engaged clutch plates is supplied through the orificed ports.

CONTROL VALVE ASSEMBLY.

General.

The control valve assembly contains passages and ports for the transmission and direction of pressurized oil within the hydraulic system. The pressure rate control piston within the control valve assembly provides a rapid, yet smooth, pressure rise for the hydraulic system during clutch engagement. See Figure 12-6.

Control Valve-Neutral (Figures 3-1 and 3-2).

Oil enters the control valve body through passage A and fills chamber B. The oil causes the pressure regulating piston to partially compress the piston outer and inner springs against the pressure rate control piston. This pressurizes the oil in chamber B. This pressure varies with engine speed.

The movement of the pressure regulation piston against the springs exposes port C in the valve body. Port C directs overage oil to lubrication and clutch cooling system. Passage D (which is the engaging outlet to the forward clutch) and Passage E (which is the engaging outlet to the reverse clutch) are interconnected by slot F in the control valve stem when in the neutral position. The slot is aligned with a drilled hole and cored cavity in the front face of the valve body. The drilled hole and cored cavity are aligned with drilled holes that pass through the valve and filter carrier assembly and the main housing to sump. Therefore, passages D and E are at atmospheric pressure at this time. Also, passage J is at atmospheric pressure since port H inter-connects with slot F. This area between the pistons and around the springs is vented to the sump through drilled holes in the front face of the valve body, the valve and filter carrier assembly, and the

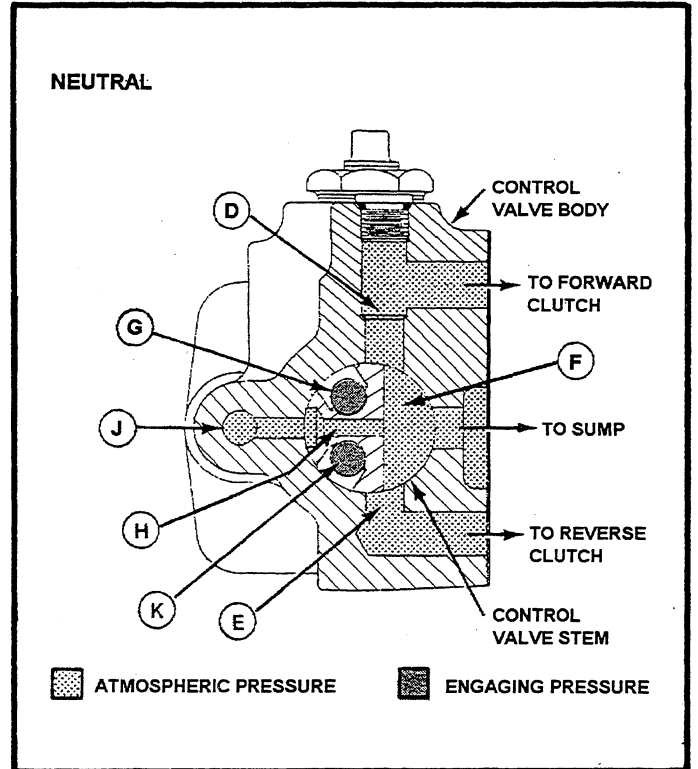


Figure 3-1. Control Valve-Neutral-Sectional View.

main housing. This area is at atmospheric pressure at all times permitting the return to sump of any leakage oil past the pistons.

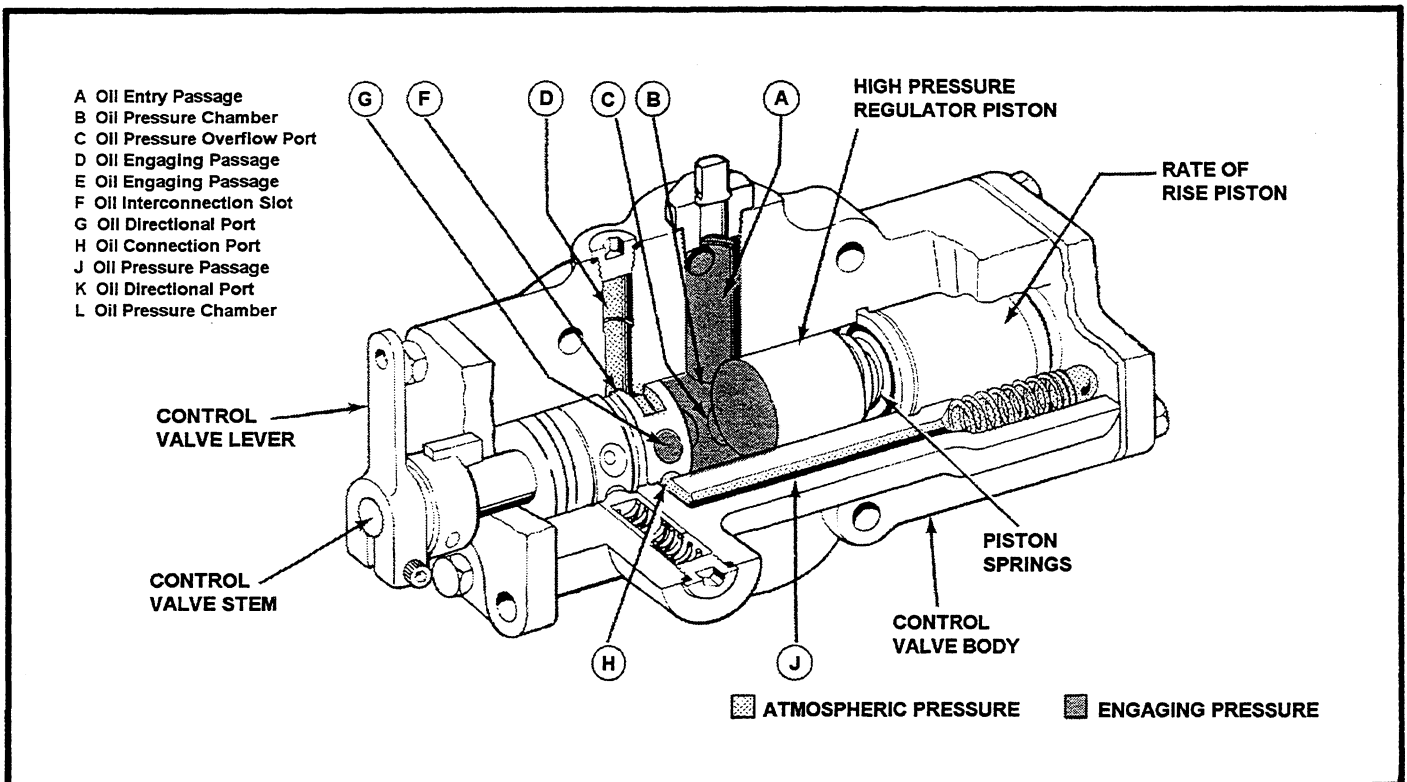


Figure 3-2. Control Valve—Neutral—Cutaway View.

Control Valve-Forward (Figure 3-3 and 3-4).

When a shift to the forward position is desired, the control valve lever is moved away from the engine. The shift causes the control valve stem to rotate and assume the position indicated in Figures 3-3 and 3-4. The pressurized oil in chamber B is directed through ports G and K to passages D and J. Passage D is aligned with a drilled hole and a channel in the valve and filter carrier directing main pressure to the forward clutch. Pressurized oil from port K travels through passage J and enters chamber L through an orifice in the orifice plate. The orifice in this plate meters the oil for a steady, smooth pressure rise in chamber L. As chamber L fills with oil, the pressure rate control piston moves against the springs until the piston is stopped by a shoulder in the valve body. This causes the pressure in chamber B to rise to clutch engaging pressure. When in forward, passage E remains at atmospheric pressure since slot F remains open to sump.

When a shift is made from forward to neutral, the valve stem is rotated to the position illustrated by figures 3-1 and 3-2. Under these conditions, passage D is connected to sump by slot F. Passage J also is connected to sump by port H in the valve stem. Since passage D is connected to slot F, oil drains rapidly from the forward clutch to sump. Since passage J is now at atmospheric pressure, the oil pressure in chamber L unseats the

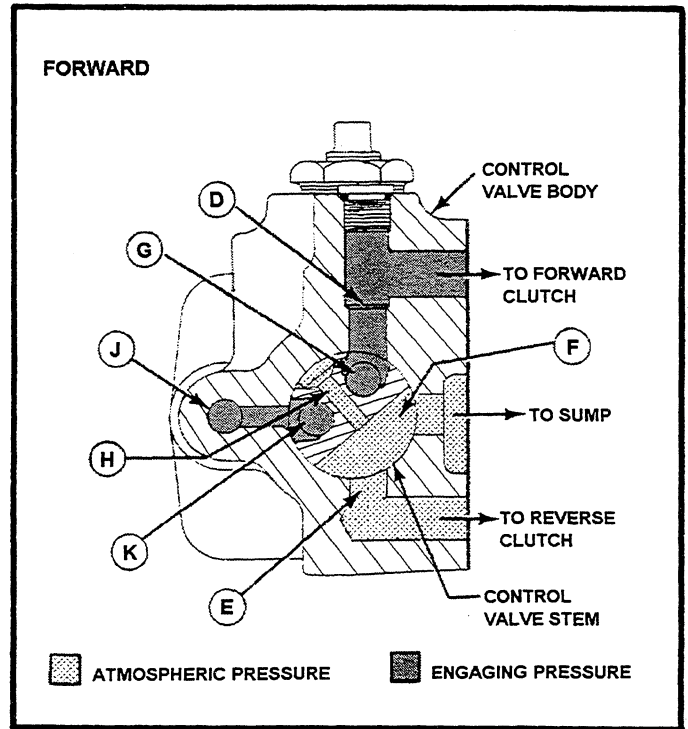


Figure 3-3. Control Valve-Forward-Sectional View.

steel ball against the compression springs, permitting a rapid oil drain from chamber L to sump and allowing the pressure rate control piston to move back against the orifice plate. The forward clutch is now disengaged and main system pressure reduced to neutral.

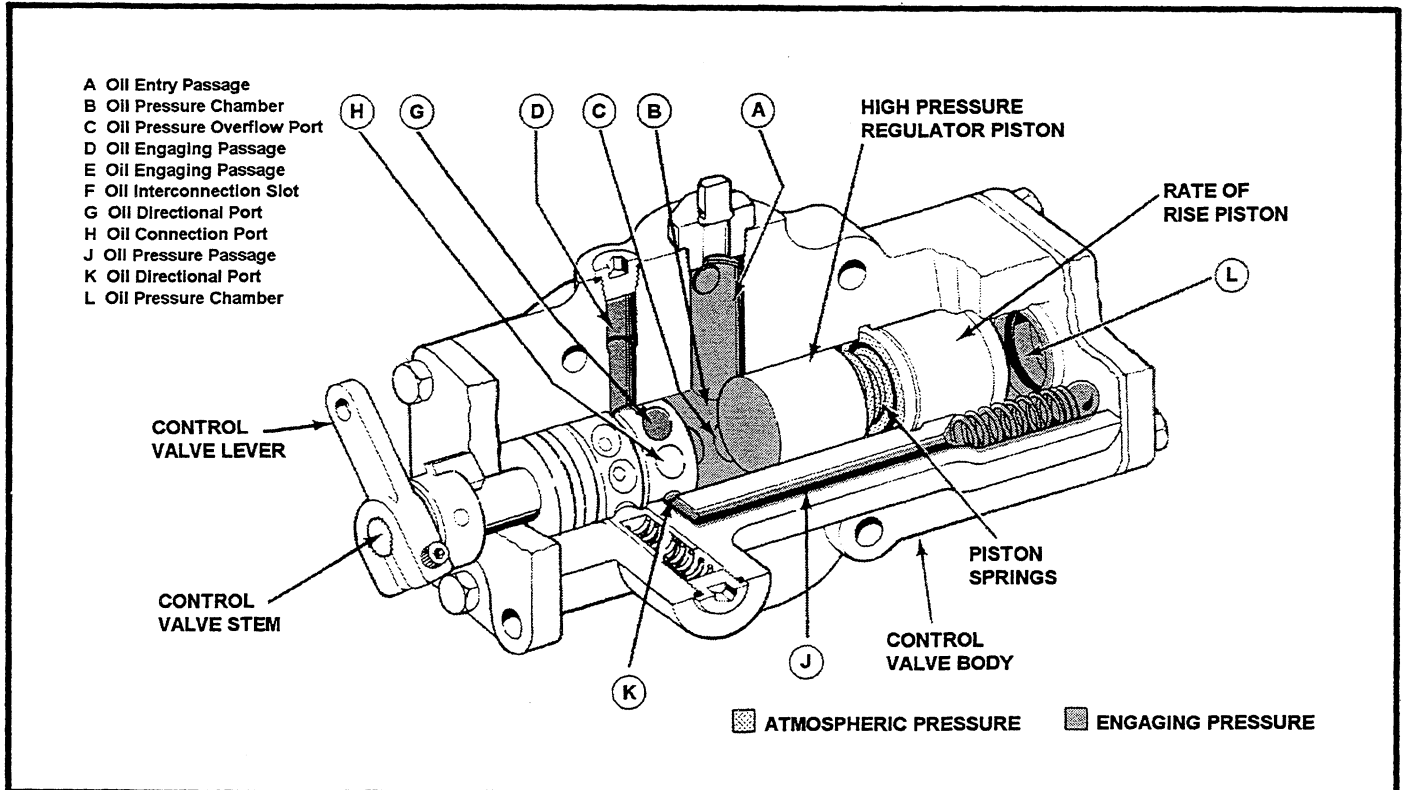


Figure 3-4. Control Valve—Forward—Cutaway View.

Control Valve-Reverse (Figures 3-5 and 3-6).

When a shift to the reverse position is desired, the control valve lever is moved toward the engine. The shift causes the control valve stem to rotate and assume the position indicated in Figures 3-5 and 3-6. The pressurized oil in chamber B is directed through ports G and K to passages E and J. Passage E is aligned with a drilled hole and a channel in the valve and filter carrier directing main pressure to the reverse clutch. Pressurized oil from port G travels through passage J and enters chamber L through an orifice in the orifice plate.

The orifice in the plate meters the oil for a steady, smooth pressure rise in chamber L. As chamber L fills with oil, the pressure rate control piston moves against the springs until the piston is stopped by a shoulder in the valve body. This causes the pressure in chamber B to rise to clutch engaging pressure.

When in reverse, passage D remains at atmospheric pressure since slot F remains open to sump. When a shift is made from reverse to neutral, the valve stem is rotated to the position illustrated by Figures 3-1 and 3-2. Under these conditions, passage E is connected to sump by slot F. Passage J is also connected to sump by port H in the valve stem. Since passage E is connected to slot F, oil drains rapidly from the reverse clutch to sump. Since passage J is now at atmospheric

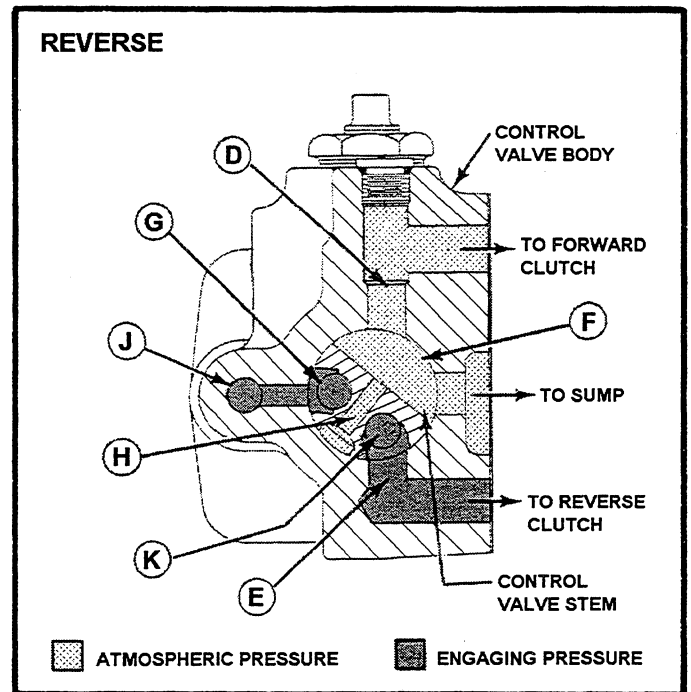


Figure 3-5. Control Valve-Reverse-Sectional View.

pressure, the oil pressure in chamber L unseats the steel ball against the compression spring permitting a rapid oil drain from chamber L to sump and allowing the pressure rate control piston to move back against the orifice plate. The reverse clutch is now disengaged and main system pressure reduced to neutral pressure.

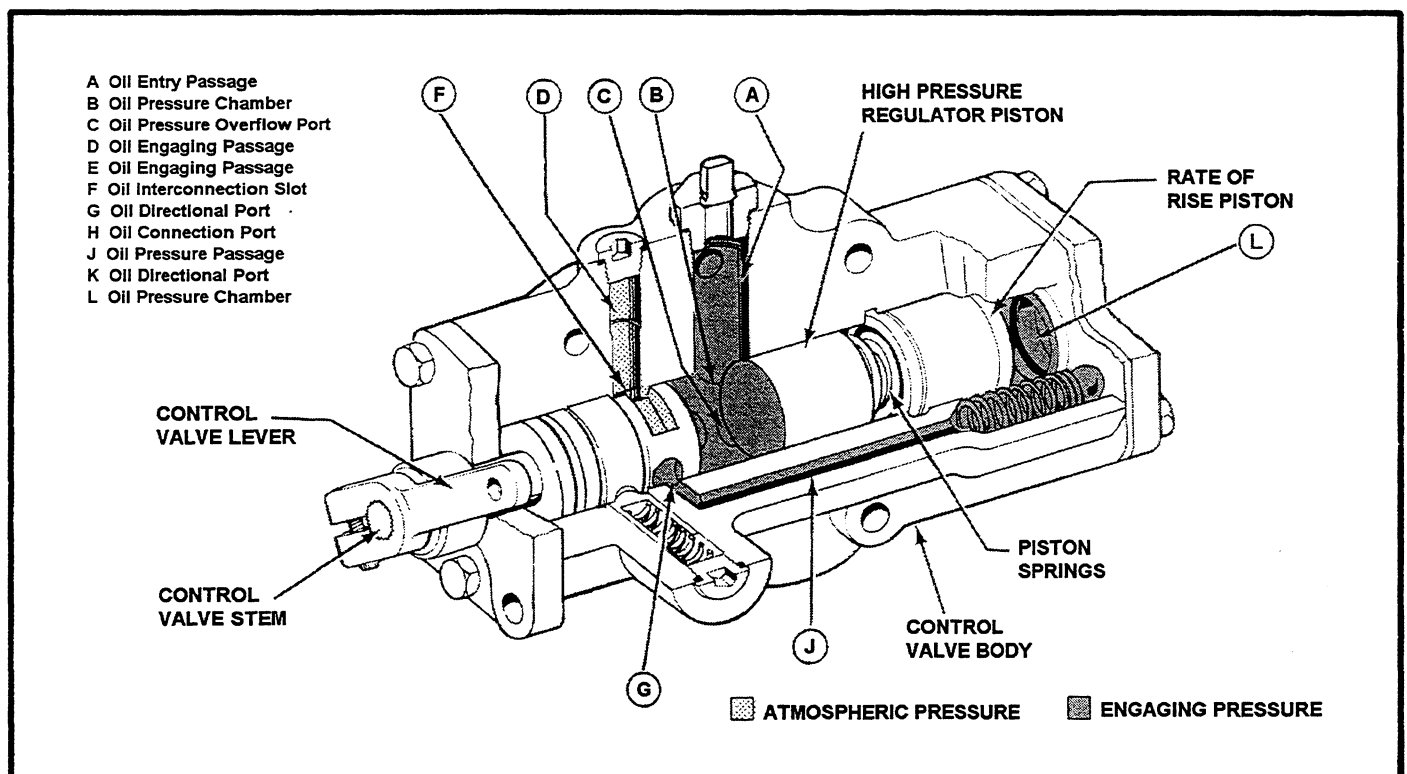


Figure 3.6. Control Valve—Reverse—Cutaway View.

POWER FLOW (See Figure 2-3).

Neutral.

When in neutral, the forward and reverse shafts, transfer gears, and steel clutch plates rotate at engine speed. Other parts including the output shaft do not turn.

Forward.

In forward, the same parts are turning that were turning in neutral. When the forward position is selected, hydraulic pressure is applied to the forward clutch piston clamping the friction and steel clutch plates together. The forward input pinion will then rotate at engine speed and direction, because the friction plates are spline-connected through the clutch drive sleeve to the pinion. Since the forward input pinion is in

mesh with the output gear, the output gear and shaft will rotate in anti-engine direction. The reverse input pinion will be back-driven (engine direction) when the unit is in forward.

Reverse.

In reverse, the same parts are turning that were turning in neutral. When the reverse position is selected, hydraulic pressure is applied to the reverse clutch piston clamping the friction and steel plates together. The reverse input pinion will then rotate at engine speed and anti-engine direction, because the friction clutch plates are spline-connected through the clutch drive sleeve to the input pinion. Since the reverse input pinion is in mesh with the output gear, the output gear and shaft will rotate in engine direction. The forward input pinion will be back-driven (anti-engine direction) when the unit is in reverse.

Section 4.

PREVENTIVE MAINTENANCE

GENERAL.

Lubrication.

Grease the oil seals on the output end of the output shaft through the grease fitting with water pump grease. Apply grease once a week. Grease the seals at the same time the oil is changed.

No other lubrication is required beyond the daily oil check.

Overhaul Interval.

A complete overhaul of the unit should be made at the same time that the engine is overhauled.

OIL SYSTEM.

Oil Level.

The oil level should be checked daily. Check the oil level with the engine running at low idle and the marine transmission in neutral. Oil temperature should be in normal operating range prior to checking oil level.

Oil and Filter Change Interval (Maximum).

The oil and oil filter must be changed every 1000 hours of operation or more often if conditions warrant.

Draining.

Drain the transmission by removing the O-ring plug on the rear side at the bottom. See Figure 2-5.

Filling.

1. Remove the breather (see figure 2-4) from the top of the main housing assembly.
2. Pour the oil through the breather opening.
3. Fill the sump with 9 U.S. gallons (34 liters) for deep case or 6.0 U.S. gallons (22.7 liters) for shallow case of

the proper weight and type oil. See Section 2 for proper oil.

4. Start the engine and let it idle with transmission in neutral until oil is circulated throughout the hydraulic system.

5. With the oil at operating temperature, transmission in neutral and the engine running at low idle, check the oil level with the oil gauge (see figure 2-5).

6. Add oil as necessary to bring the oil level up to "FULL" on the oil gauge.

Oil Screen Filter.

Remove and clean the oil strainer at every oil change or sooner if necessary. See Figure 4-1 and 4-2.

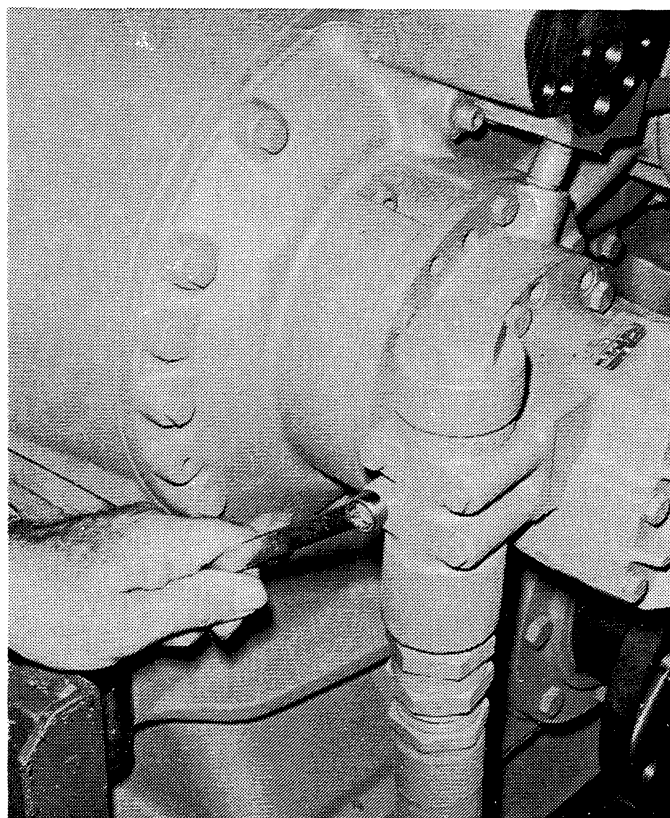


Figure 4-1. Removing Oil Strainer Housing.

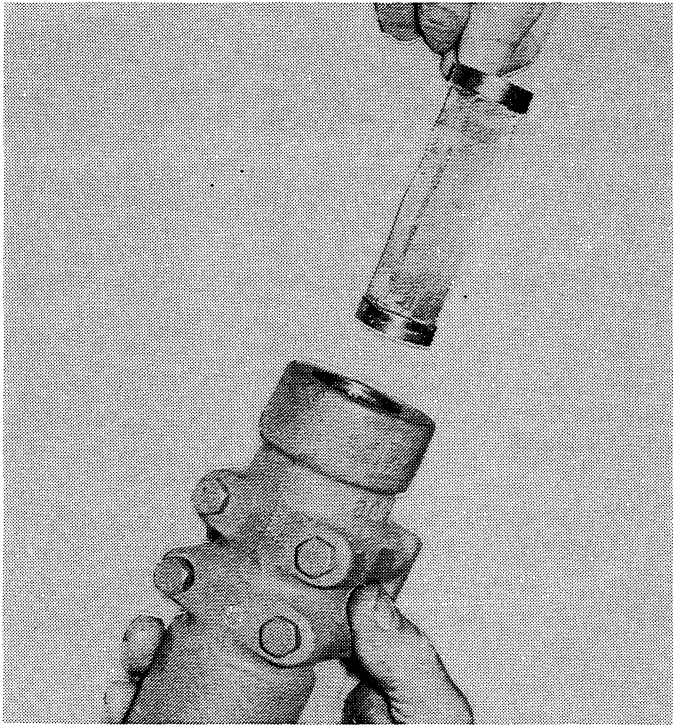


Figure 4-2. Removing Oil Strainer from Housing.

PERIODIC VISUAL INSPECTION.

1. Check the mountings for tightness or damage such as cracks. Tighten loose mountings and replace damaged parts.
2. Inspect heat exchanger oil lines for leaky connections, kinks, cracks or other damage. Replace damaged lines.
3. Check pressure and temperature gauges where applicable.
4. Remove the ventilating cover (Figure 12-1, 59) and inspect the rubber blocks (Figure 12-2, 38) for wear or damage. Replace worn or damaged rubber blocks.
5. Periodically, inspect the drive line and the input and output shaft oil seals for leakage. Replace parts as required.

Section 5. TROUBLE SHOOTING

GENERAL.

This section of the maintenance manual has been prepared to assist maintenance personnel in trouble shooting equipment discussed in the manual. When trouble shooting the equipment, always remember to consider the entire power package.

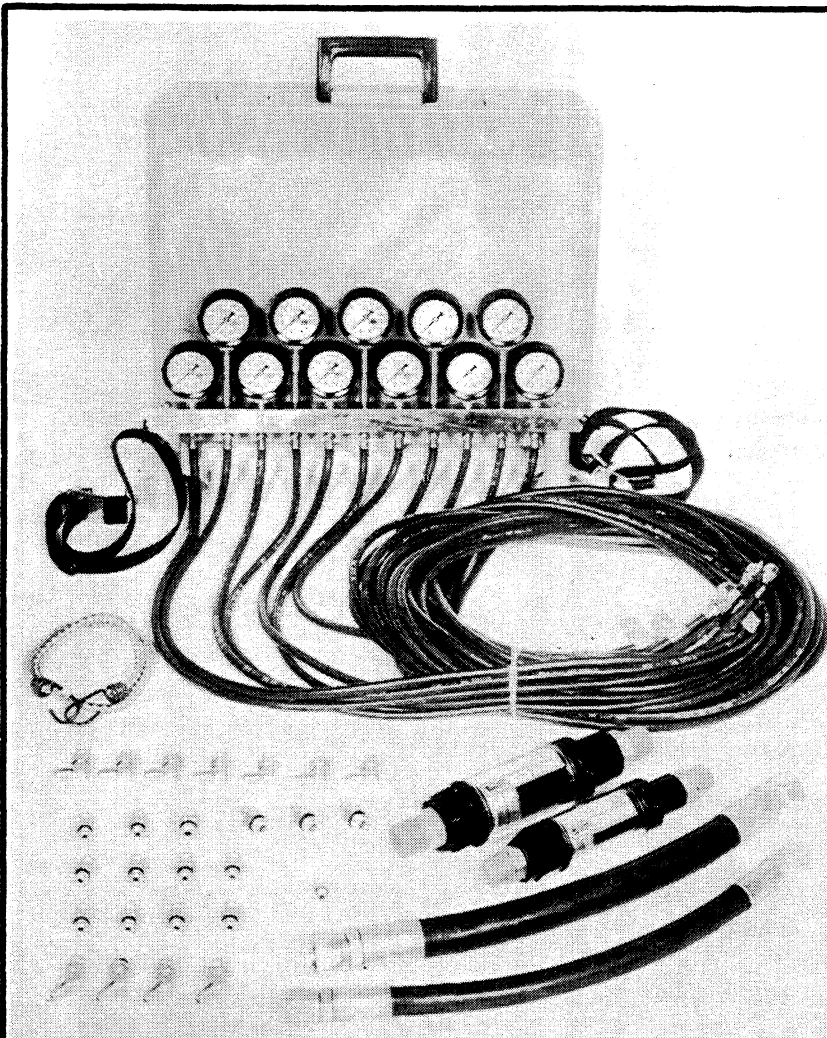
PRESSURE AND FLOW TEST KIT.

A portable pressure and flow test kit NU2451 is available and contains the necessary equipment to accurately test and trouble shoot the hydraulic system of this

Twin Disc unit. The kit is ruggedly constructed for field use and contains pressure gauges, hoses, adapters, flow meters, straps, clips, etc. Contact the Twin Disc Service Engineering Department, Racine, Wisconsin, for specific information concerning this test kit.

TROUBLE SHOOTING CHART.

The trouble shooting chart (Table 5-1) is organized in three columns. Proper use of the chart will aid in the rapid determination and repair of functional difficulties that may occur.



CONTENTS OF OTC #NU 2451 PRESSURE FLOW & TEST KIT

<u>OTC Part No.</u>	<u>Qty.</u>	<u>Description</u>
NU 6652	01	Gauge Bar
303402	07	Gauge, 400 psi
15343	02	Gauge, 100 psi
46938	01	Gauge, 60 psi
303434	01	Gauge, 30 psi
303238	11	Hose, 10 ft. Long
207606	02	"D" Clip
10473	01	Sash Chain, 2 ft.
208054	02	Bushing
NU 0802	01	Stretch Cord
19754	02	Suction Cup
207895	05	Nipples NPT-2
210458	05	Coupler NPT-2
15665	02	S-Hook
11017	02	Screw, 1/4-20 x 2 3/4" long
202868	07	90° Elbow, 4 SAE x 4 JIC M
202867	10	Adapter, 4 SAE x 4 JIC M
202854	01	Adapter, 3 SAE x 4 JIC M
205977	03	Adapter, 6 SAE x 4 JIC M
202853	01	Adapter, 5 SAE x 4 JIC M
NU 6655	01	Flow Meter, 30 GPM
HED-600010	01	Flow Meter, 10 GPM
NU 6657	01	#10 Hose - 100R1 18" Long
NU 6658	01	#12 Hose - 100R1 18" Long
203220	02	Adapter 10 SAE M x 10 JIC M
205951	02	Adapter 12 SAE M x 12 JIC M
206938	04	Adapter, 45° 4 SAE x 4 JIC M
213137	01	Storage Box With Fills

NOTE: Twin Disc will not stock or sell this kit.

Manufactured for Twin Disc, Incorporated by Owatonna Tool Co., 2013 4th St. N.W., Owatonna, Minnesota 55060, 1-800-553-5338

Figure 5-1. Pressure and Flow Test Kit 2451.

Table 5-1. Trouble Shooting Chart

SYMPTOM	CAUSE	REMEDY
<p>1. Low clutch apply oil pressure.</p>	<p>1-1. Partially clogged oil strainer.</p> <p>1-2. Stuck pressure regulation piston.</p> <p>1-3. Broken piston rings on clutch cylinder(s).</p> <p>1-4. Damaged or worn oil pump assembly.</p> <p>1-5. Incorrect linkage adjustment to control valve assembly.</p> <p>1-6. Clogged or plugged orifice in orifice plate of control valve assembly.</p> <p>1-7. Shimming required between inner and outer springs and rate-of-rise piston.</p> <p>1-8. Broken or worn piston rings on the front hub of the clutch cylinder.</p> <p>1-9. Loose come-home screws in the clutch cylinder.</p> <p>1-10. Faulty Pressure Gauges.</p>	<p>1-1. Remove and clean oil strainer (see Section 6).</p> <p>1-2. Disassemble the control valve (Section 8) and clean the piston.</p> <p>1-3. Remove the manifold (see Section 6) and inspect piston rings. Replace broken piston rings.</p> <p>1-4. Replace damaged or worn oil pump assembly (see Section 6).</p> <p>1-5. Adjust linkage so that control valve stem is indexed properly by detent.</p> <p>1-6. Remove orifice plate cover (see Section 8). Clean parts.</p> <p>1-7. Shim as required.</p> <p>1-8. Replace piston rings.</p> <p>1-9. Back come-home screws out until roll-pins contact clutch cylinder. Back out another quarter turn to lock.</p> <p>1-10. Replace pressure gauges.</p>
<p>2. No oil pressure, or erratic low pressure at control valve tap.</p>	<p>2-1. Oil pump suction strainer plugged.</p> <p>2-2. Oil level low.</p> <p>2-3. Air leak on suction side of pump.</p> <p>2-4. Pump drive on reverse clutch shaft broken</p> <p>2-5. Regulating valve stuck in open position.</p> <p>2-6. Oil pump defective.</p>	<p>2-1. Remove and clean strainer.</p> <p>2-2. Check oil level and correct.</p> <p>2-3. Correct cause of air leak.</p> <p>2-4. Disassemble and repair as required.</p> <p>2-5. Remove, disassemble, clean and repair the regulating valve.</p> <p>2-6. Replace oil pump.</p>

Table 5-1. Trouble Shooting Chart

SYMPTOM	CAUSE	REMEDY
3. High main oil pressure.	3-1. Regulating valve stuck. 3-2. Faulty spring.	3-1. Remove and clean regulating valve. 3-2. Check and possibly replace spring.
4. High temperature.	4-1. Improper oil level. 4-2. Faulty heat exchanger 4-3. Clutches slipping. 4-4. Bearing failure. 4-5. Faulty temperature gauges.	4-1. Check and fill with proper oil to the correct level. 4-2. Inspect, repair or replace heat exchanger. 4-3. Check clutch apply oil pressure. If pressure is normal, remove, disassemble and repair slipping clutch. 4-4. Overhaul marine transmission. 4-5. Replace temperature gauges.
5. Excessive noise.	5-1. Bearing failure. 5-2. Worn or damaged rubber blocks.	5-1. Remove marine transmission (see Section 6). Disassemble marine transmission (see Section 6), and replace damaged or worn parts. 5-2. Remove marine transmission (see Section 6). Replace worn or damaged rubber blocks.
6. No neutral.	6-1. Clutch plates warped. 6-2. Control valve linkage rigged incorrectly. Valve not in detent.	6-1. Replace clutch plates. Overhaul unit. (see Sections 6, 7, 8 and 9). 6-2. Check and adjust control valve linkage.
7. Harsh engagement.	7-1. Regulating piston or rate-of-rise piston stuck. 7-2. Orifice plate ball in control valve not seating properly.	7-1. Disassemble control valve (see Section 8). Clean parts. Replace parts if necessary. 7-2. Remove orifice plate cover (see Section 8). Clean parts. Replace parts if necessary.
8. Low lube oil pressure.	8-1. Pump GPM output too low. 8-2. Pump suction strainer plugged. 8-3. Air leak on suction side of pump. 8-4. Lube regulator valve stuck. 8-5. Leaking piston rings on shaft.	8-1. Replace pump. 8-2. Remove, clean, inspect and install the suction screen. 8-3. Inspect for and correct air leak. 8-4. Remove and clean or replace parts as necessary. 8-5. Replace piston rings.

Section 6.

REMOVAL AND UNIT DISASSEMBLY

IN BOAT MAINTENANCE.

Items listed below can be repaired without removing the transmission from the boat. See Section 6 for disassembly and Section 9 for assembly of these areas.

1. Changing output shaft oil seals.
2. Changing seal rings on the clutch cylinder and piston.
3. Changing clutch plates.

PRIOR TO REMOVAL.

1. Drain the oil from the transmission by removing O-ring plug on the rear side at the bottom. See Figure 2-5.
2. Mark the output flange and companion flange so they will always be assembled identically.

NOTE

The output and companion flanges are match-reamed. Thus, the same holes must be aligned on reassembly.

3. Disconnect the output and companion flanges.
4. Disconnect linkage, wiring, and plumbing and remove any units that would interfere with the removal of the transmission.
5. Support the transmission with a hoist and remove the mounting hex-head screws.
6. Support the rear of the engine with blocks if necessary.
7. Remove the hex-head screws that secure the transmission to the engine.
8. Push the transmission away from the engine to separate the drive spider from the driving ring.

REMOVAL OF EXTERNAL PARTS.

1. Remove the four hex-head screws (Figure 12-1, 49 and 52) that secure the control valve to the manifold and remove the control valve and gasket. See Figure 6-1.

NOTE

If the transmission is being disassembled due to a failure that would contaminate the oil, the oil filter and oil strainer must be cleaned out and a new filter element installed. See Figure 6-3 and 6-8.

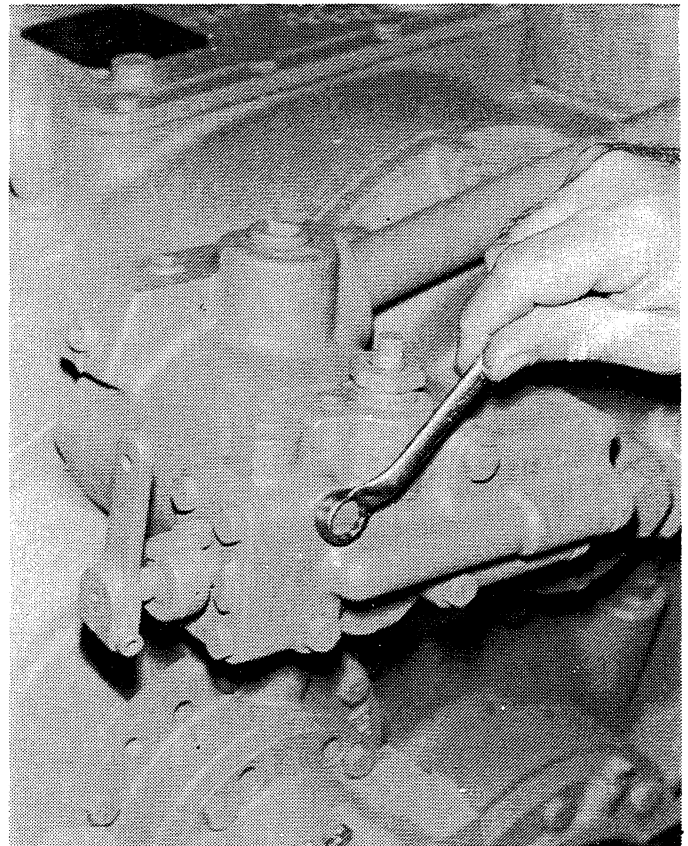


Figure 6-1. Removing or Installing Control Valve.

2. Remove four hex-head screws (see Figure 6-2) and disconnect the oil strainer housing and flexible hose from the oil pump.

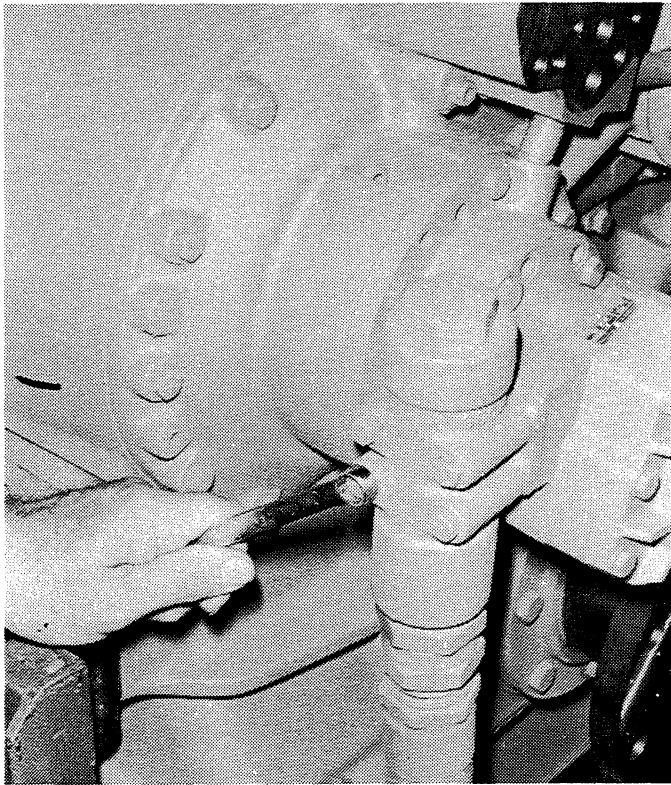


Figure 6-2. *Removing or Installing Oil Strainer Assembly.*

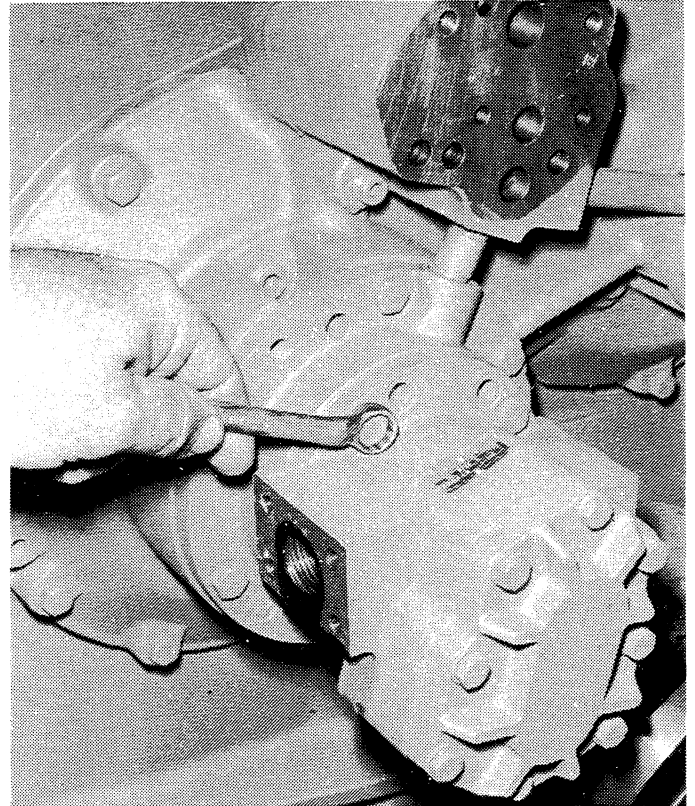


Figure 6-4. *Removing or Installing Oil Pump.*

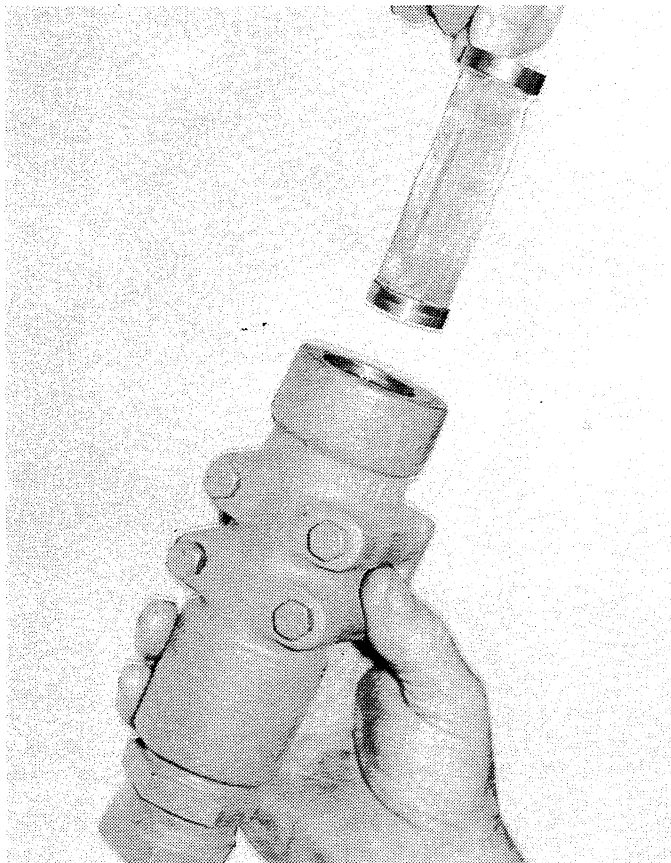


Figure 6-3. *Oil Strainer Removed.*

3. Remove four hex-head screws (see Figure 6-4) and remove the oil pump and gasket.

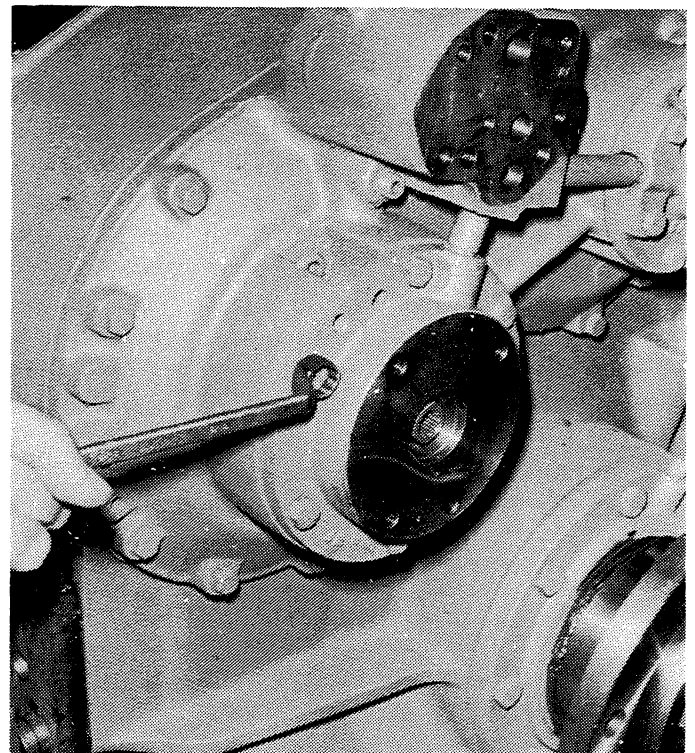


Figure 6-5. *Removing or Installing Pump Support Retaining Screws.*

4. Remove six hex-head screws (see Figure 6-5) and use two of the screws as pushers to remove the pump support. See Figure 6-6. The oil lube tube with an O-ring on each end will come off.

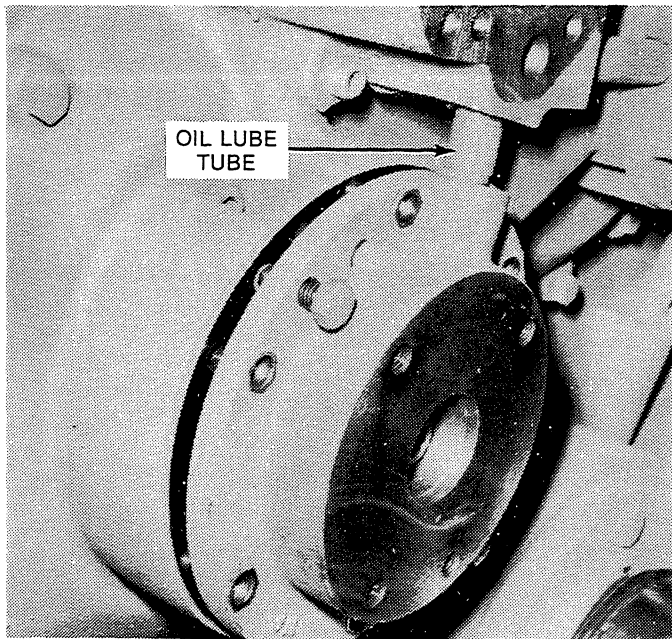


Figure 6-6. Removing Pump Support with Pusher Screws.

5. Remove six hex-head screws from the bearing retainer at the rear of the input shaft. See Figure 6-7.

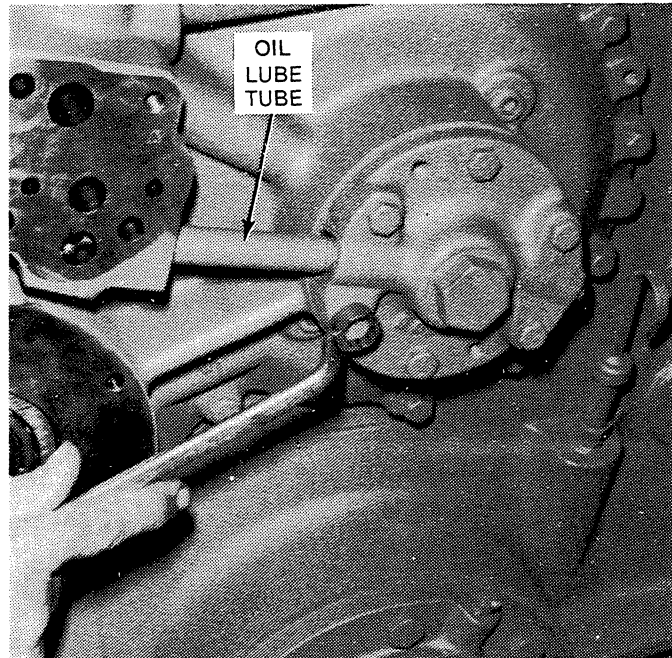


Figure 6-7. Removing or Installing Bearing Retainer over Rear of Forward Shaft.

6. Remove the four hex-head screws from the filter head and remove the filter head and element. See Figure 6-8.

7. Remove sixteen hex-head screws (Figure 12-1, 48) from the manifold (31) and use two of the screws as pushers to remove the manifold.

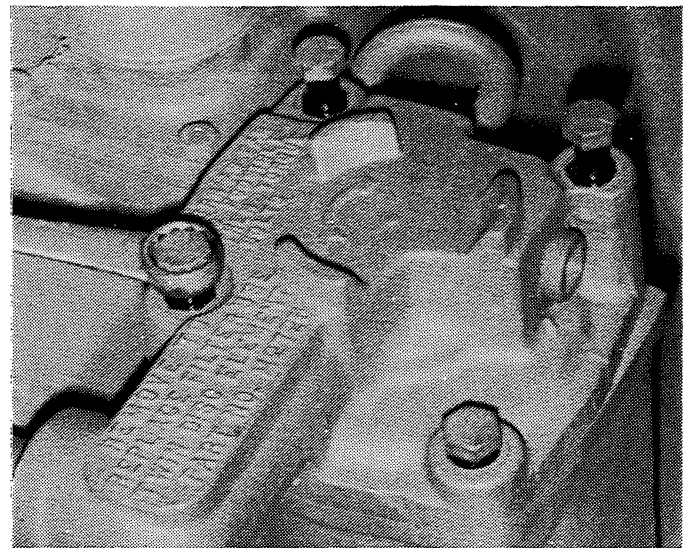


Figure 6-8. Removing or Installing Filter Head.

8. Remove ten hex-head screws (55) and remove top cover (56) and gasket (57). See Figure 6-9.

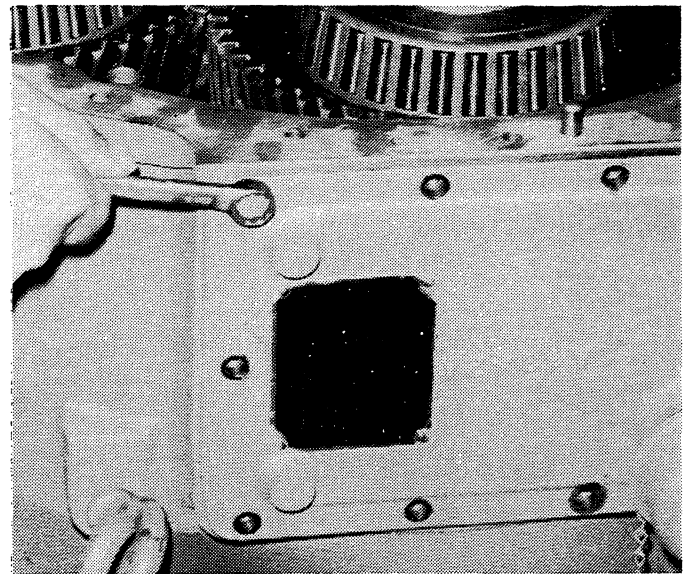


Figure 6-9. Removing or Installing Top Cover.

9. Bend down the tab on screw lock (Figure 12-3, 4) and loosen hex-head screw (3) so that oil return pipe assembly (5) can be removed. Remove oil return pipe and tube carrier.

10. Remove gasket (1).

NOTE

Do not remove rollpins, piston, and spring from the oil return pipe assembly unless parts are being replaced.

FORWARD AND REVERSE CLUTCH ASSEMBLIES.

1. Bend the tabs down on screw locks (Figure 12-2, 6) that lock the nut (7) on the clutch cylinder and remove the twelve nuts and six screw locks. See Figure 6-10.

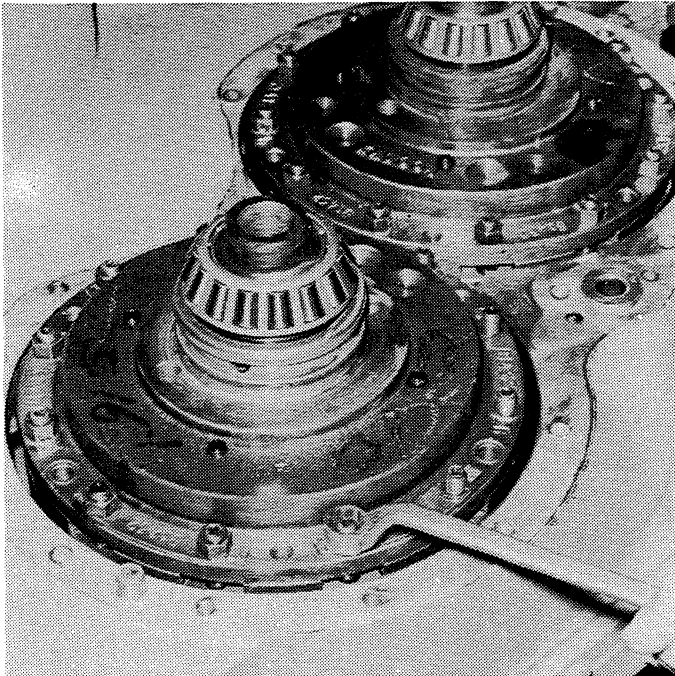


Figure 6-10. Removing or Installing Screws on Clutch Cylinder.

2. Remove the piston ring (Figure 12-2, 15) from the rear end of the input shaft. See Figure 6-11.

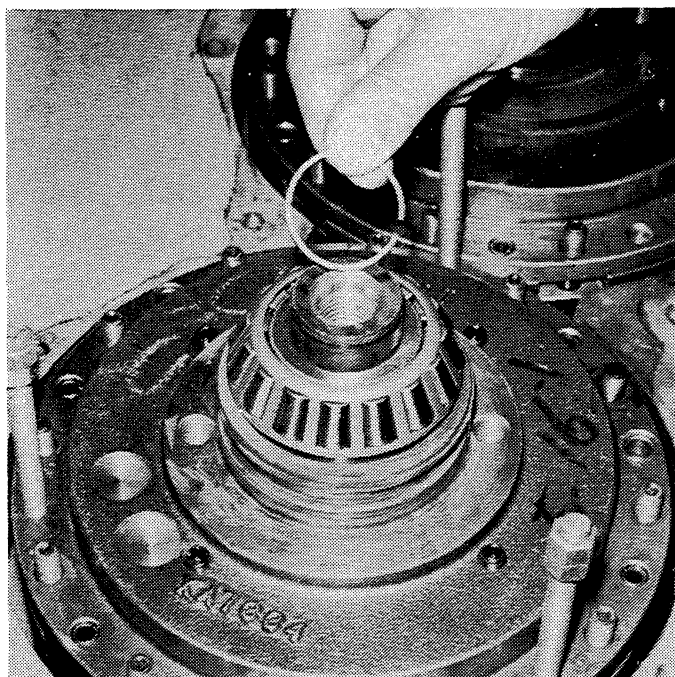


Figure 6-11. Piston Ring Removed from Forward Shaft.

3. Use three 3/8-16 x 3 in. screws as pushers to loosen the clutch cylinder (Figure 12-2, 11). Use a puller to remove the clutch cylinder. See Figure 6-12. Roller bearing (Figure 12-2, 19) inner race will be forced off the clutch shaft with the clutch cylinder.

4. Remove the bearing spacer (20).

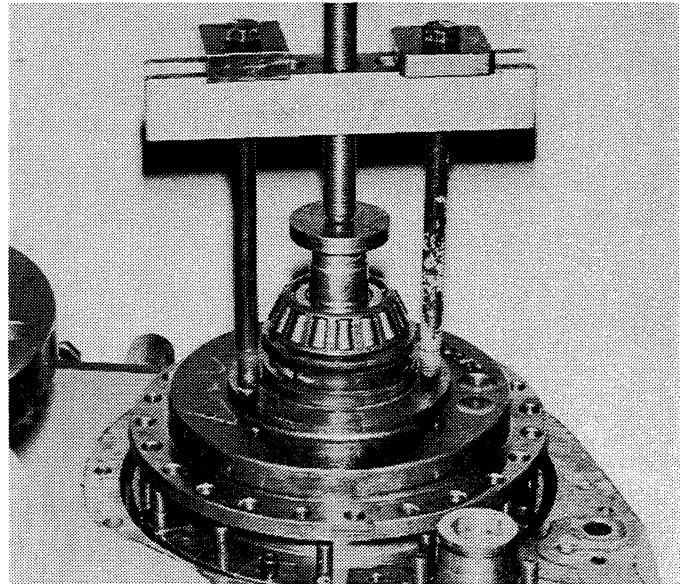


Figure 6-12. Removing Clutch Cylinder and Roller Bearing.

5. Remove the clutch piston (9) from the clutch cylinder. See Figure 6-13.

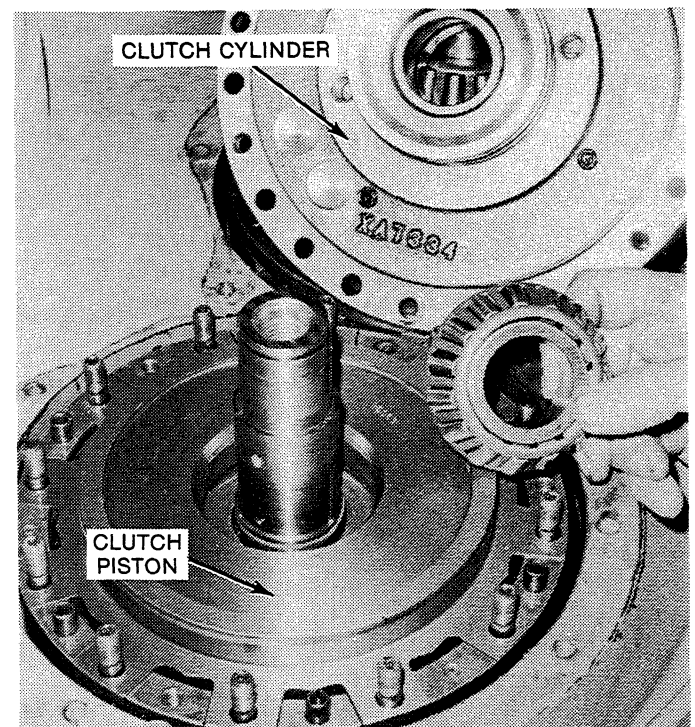


Figure 6-13. Cylinder and Roller Bearing Removed.

6. Remove the piston ring from the clutch piston. See Figure 6-14.

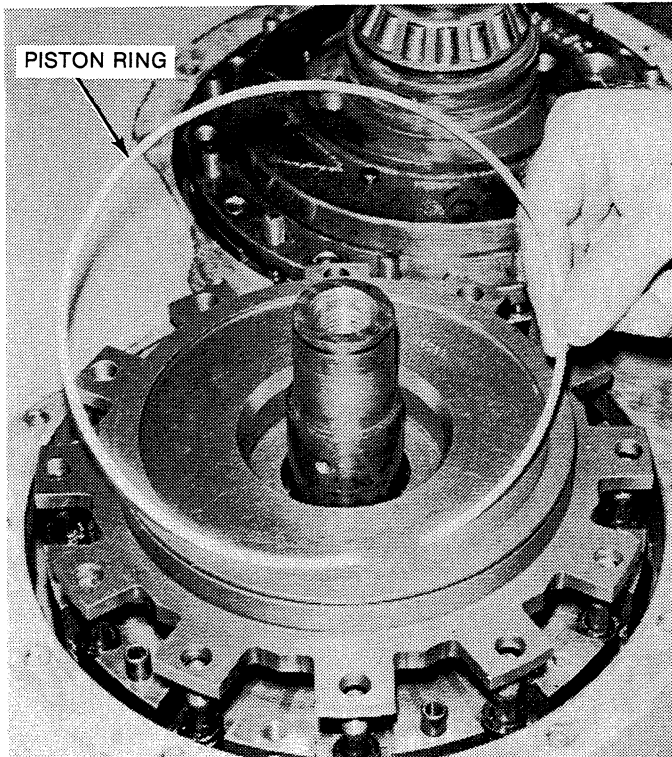


Figure 6-14. Piston Ring Removed from Clutch Piston.

7. Remove the clutch release springs and release spring sleeves. See Figure 6-15.

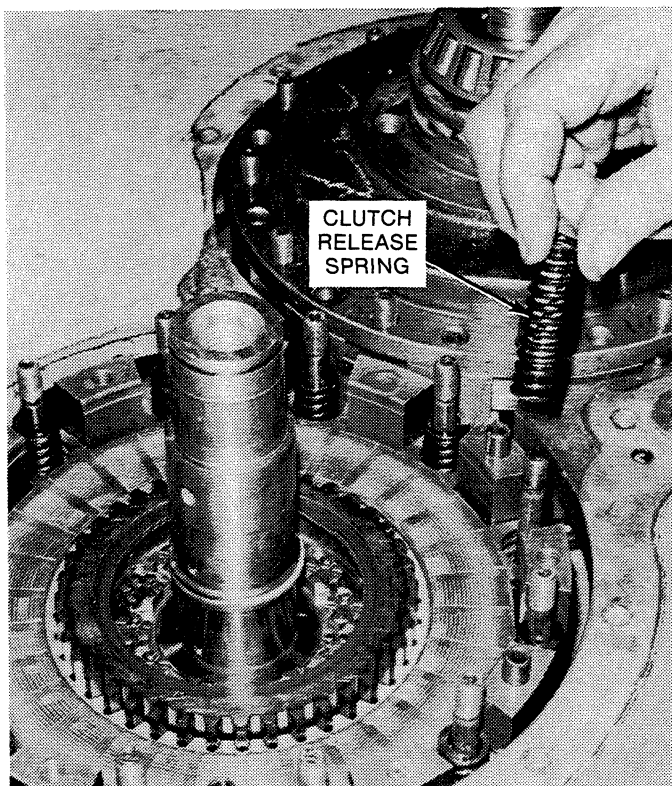


Figure 6-15. Removing or Installing Clutch Release Springs.

8. Remove the driven (steel) (Figure 12-2, 28) and driving (sintered) clutch plates (29). See Figure 6-16.

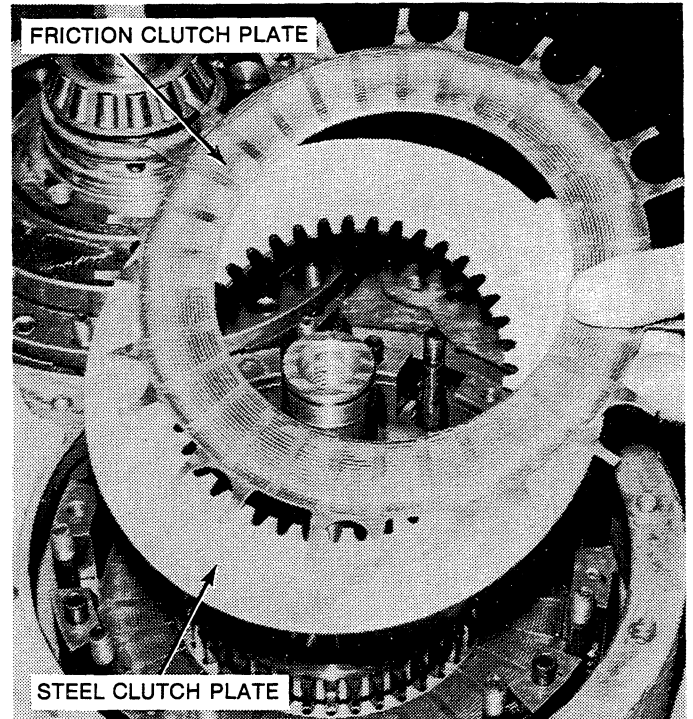


Figure 6-16. Removing or Installing Clutch Plates.

9. Remove retainer ring (oil dam) (Figure 12-2, 25) from the ID of the clutch hub (30). See Figure 6-17.

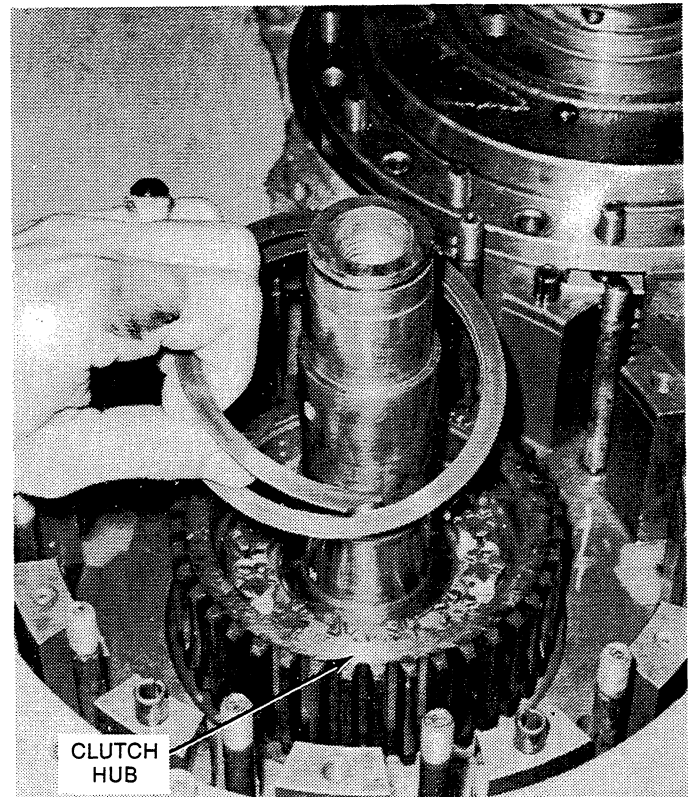


Figure 6-17. Removing or Installing Retaining Ring (Oil Dam) from Clutch Hub.

10. Remove twelve place-head screws from the clutch hub. See Figure 6-18.

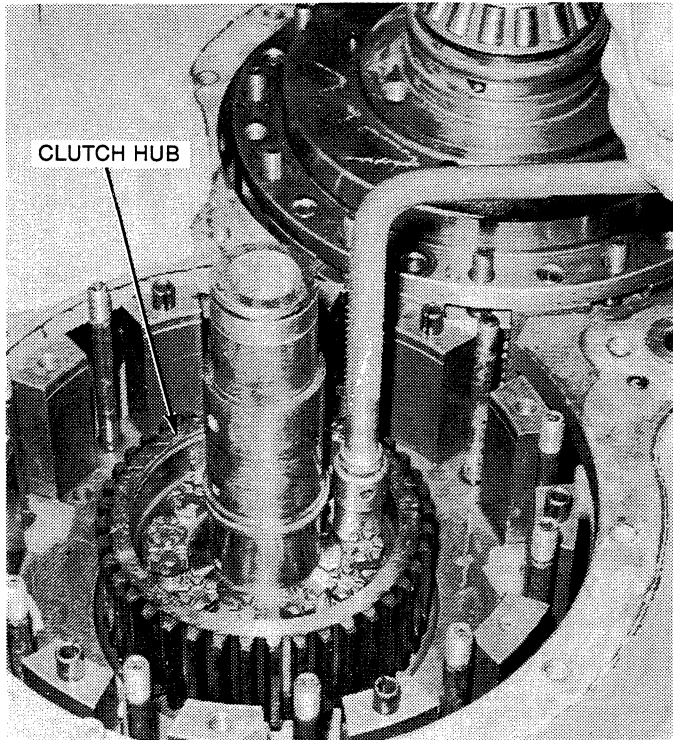


Figure 6-18. Removing or Installing Screws from Clutch Hub.

11. Use two 5/16-18 x 2 in. screws as pushers to remove the clutch hub. See Figure 6-19.

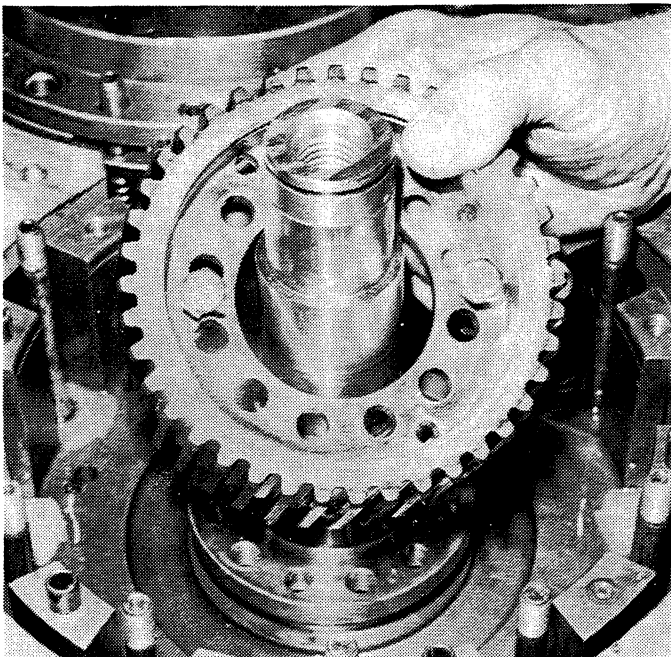


Figure 6-19. Removing or Installing Clutch Hub.

12. Remove retainer ring (Figure 12-4, 24), pin (23), and pump drive sleeve (22) from the reverse shaft.

13. Repeat steps 1 through 11 above using Figure 12-4 on the reverse clutch.

EXTERNAL OUTPUT PARTS.

1. Remove three hex-head screws (Figure 12-5, 3) from retainer washer (4) on the output flange (8) and remove the retainer washer, rubber seal (6), and shims (5). See Figure 6-20.

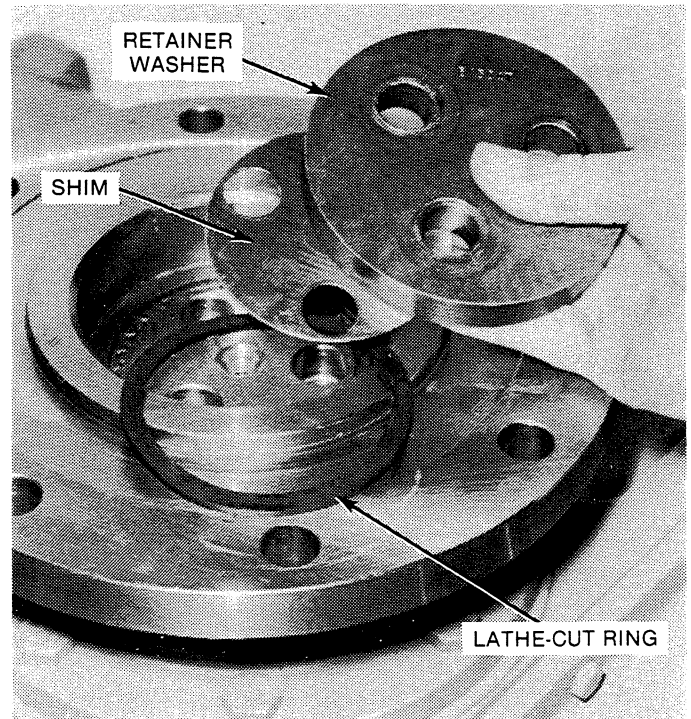


Figure 6-20. Retainer Washer, Shim, and Rubber Seal Removed.

2. Remove the output flange. See Figure 6-21.

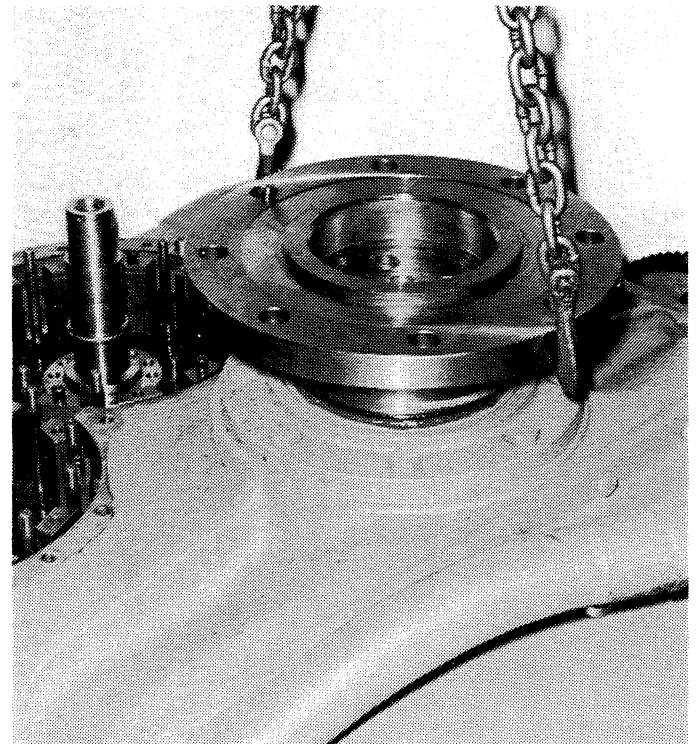


Figure 6-21. Removing or Installing Output Flange.

3. Remove eight hex-head screws (Figure 12-5, 12) from bearing retainer (2). See Figure 6-22. Remove the retainer.

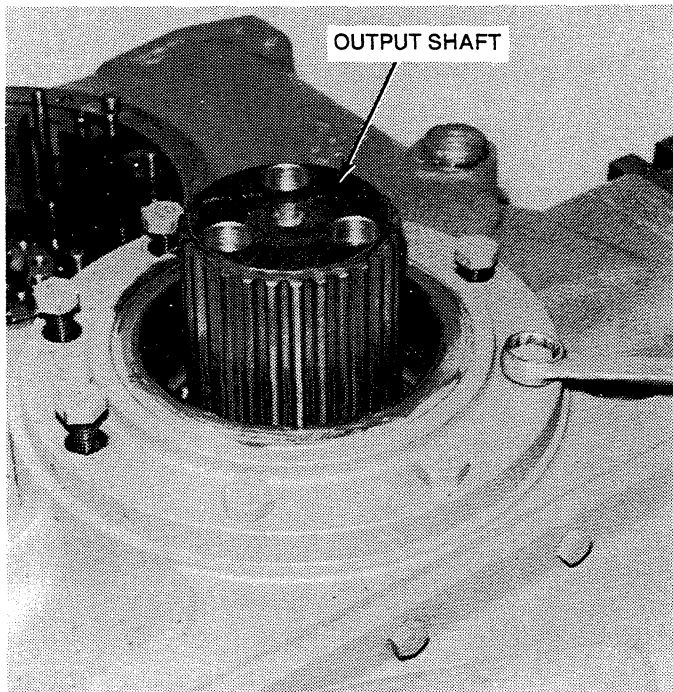


Figure 6-22. Removing or Installing Screws on Bearing Retainer.

4. Remove rubber seal (Figure 12-5, 13) from the retainer (2). See Figure 6-23.

5. If necessary, remove oil seals (Figure 12-5, 11) from the bore of the retainer. See Figure 6-23.

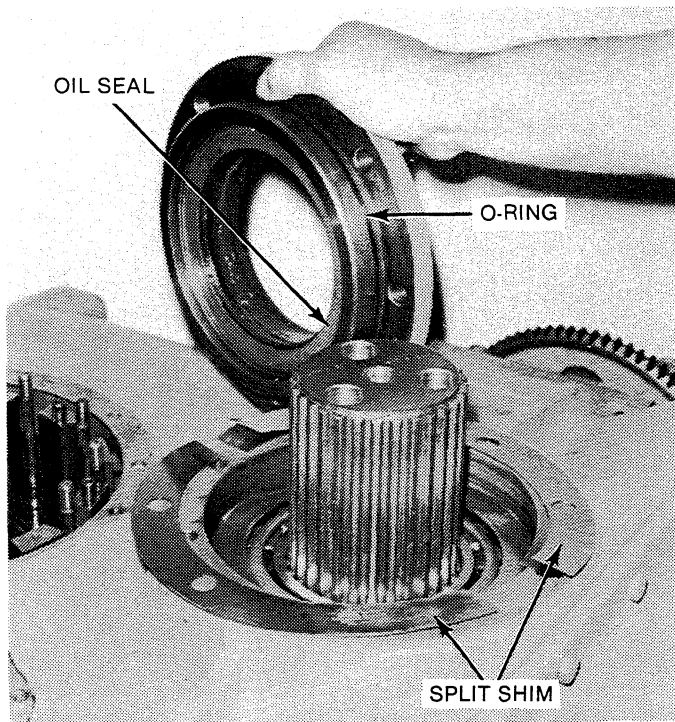


Figure 6-23. Bearing Retainer Removed.

6. Support the bottom cover (Figure 12-5, 17) with a sling and remove twenty-two hex-head screws (19) that secure the bottom cover to the main housing. See Figure 6-24.

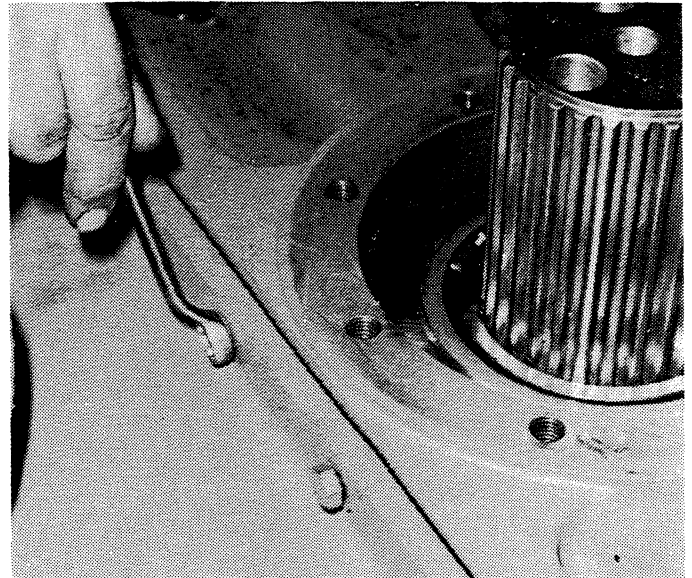


Figure 6-24. Removing or Installing Screws on Bottom Cover.

7. Remove the bottom cover and gasket (Figure 12-5, 20).

NOTE

Gear pan (18) need not be removed unless parts are being replaced.

8. If necessary, bend down the lock tabs, remove the four hex-head screws and remove the gear pan. See Figure 6-25.

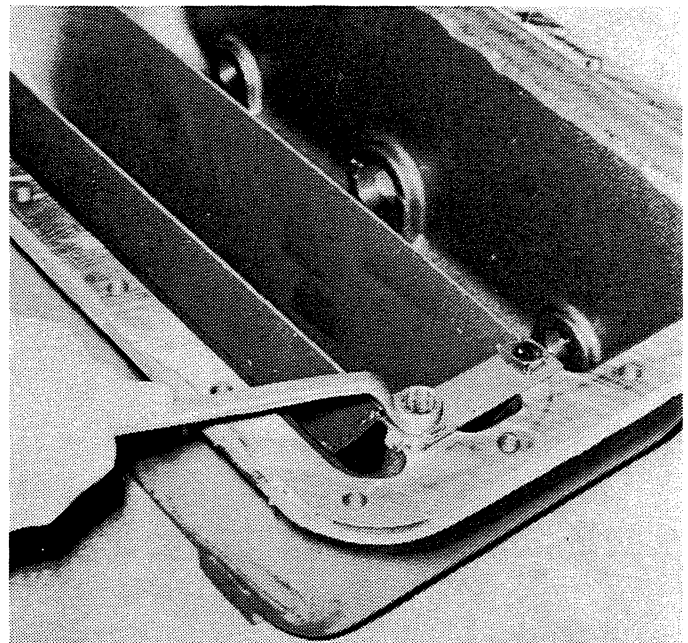


Figure 6-25. Removing or Installing Gear Pan.

9. Turn the unit over and remove dog-point setscrew (Figure 12-2, 45) from the bearing locknut (41) on the forward shaft (44). See Figure 6-26.

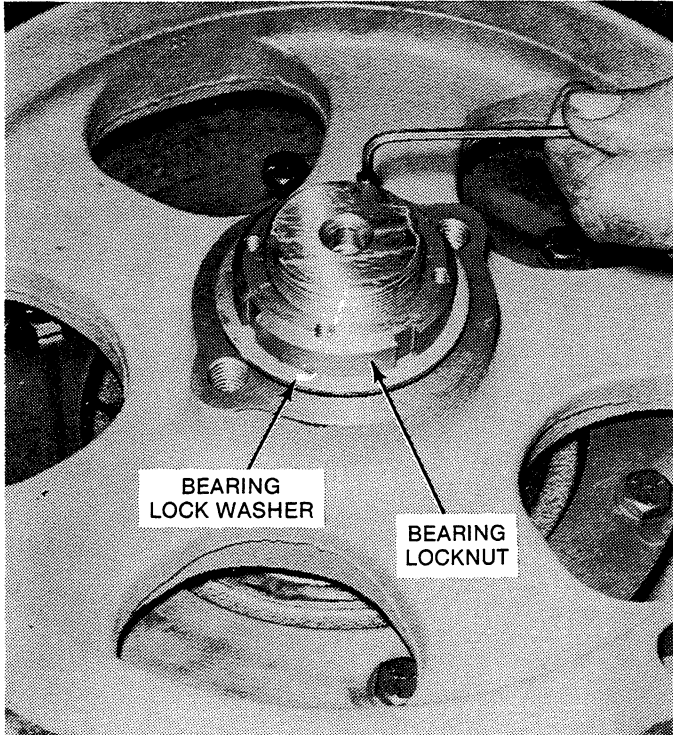


Figure 6-26. Removing or Installing Dog-Point Screws on Bearing Locknut.

10. Remove the bearing locknut. See Figure 6-27.

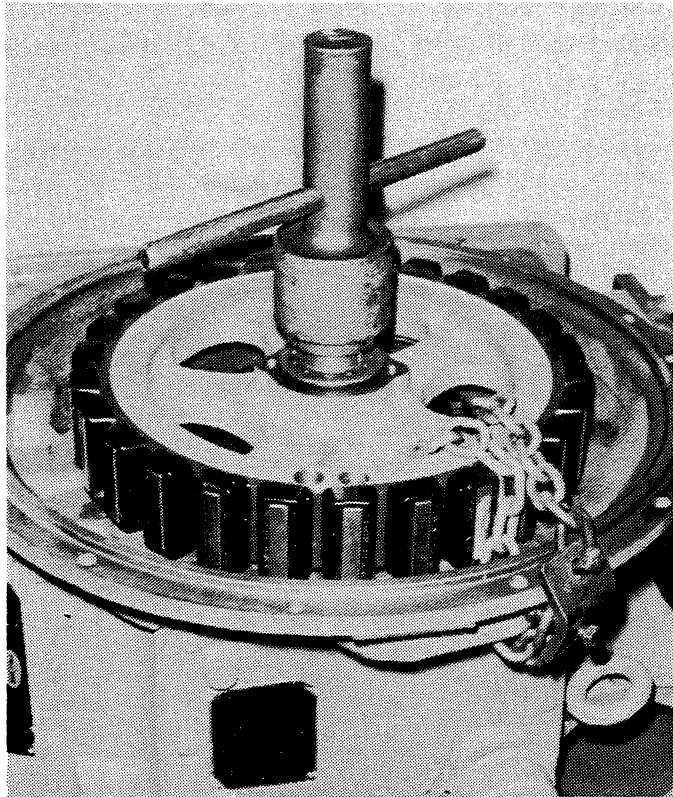


Figure 6-27. Removing or Installing Bearing Locknut.

11. Remove the bearing lockwasher (Figure 12-2, 46) and stamped washer (42). See Figure 6-28.

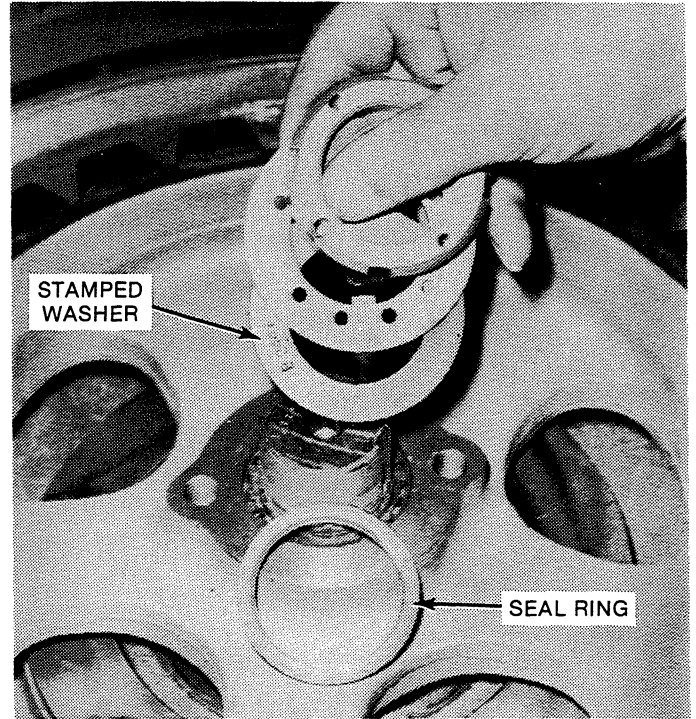


Figure 6-28. Bearing Locknut, Bearing Lockwasher, Stamped Washer, and Rectangular Seal Ring Removed.

12. Use a puller to remove the drive spider (Figure 12-2, 40). See Figure 6-29.

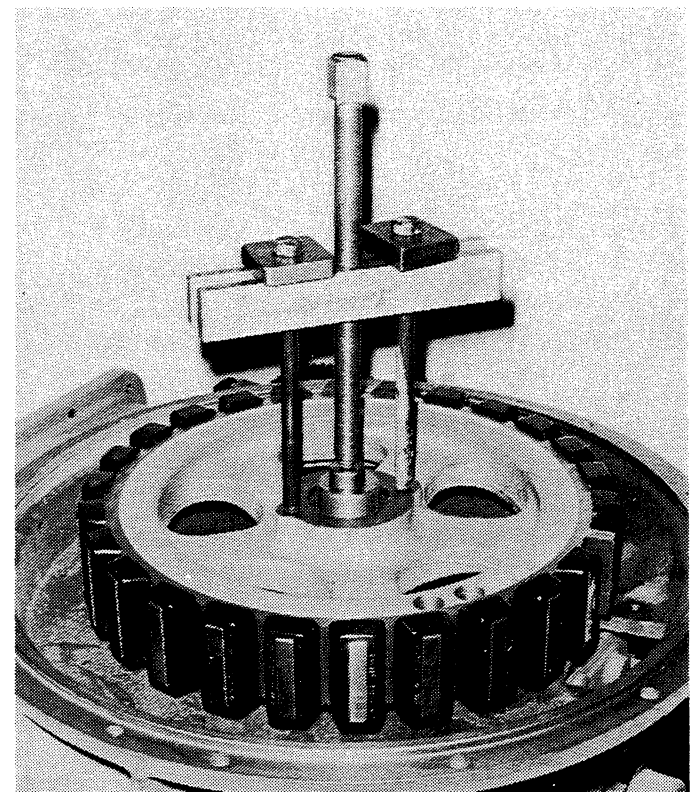


Figure 6-29. Removing Drive Spider Assembly.

Bearing Retainer, Front Housing, and Transfer Gears.

1. Remove six hex-head screws (Figure 12-2, 52) from the bearing retainer (49) on the forward shaft and remove the bearing retainer. See Figure 6-30.

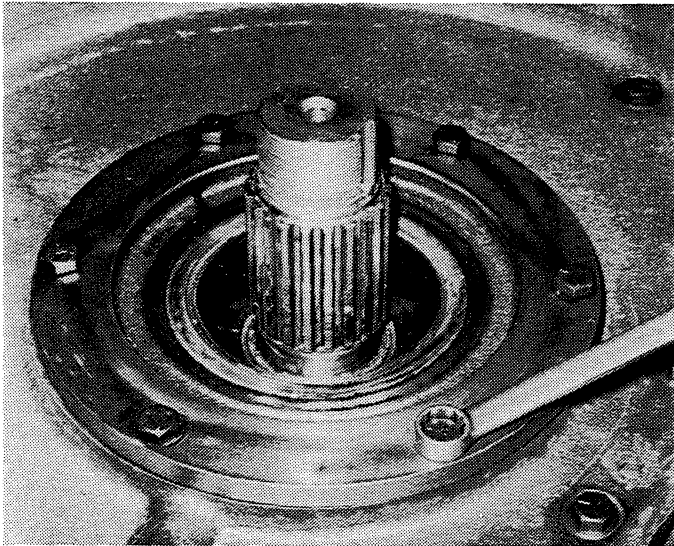


Figure 6-30. Removing or Installing Bearing Retainer.

2. Remove O-ring (Figure 12-2, 51) from the O.D. and oil seal (48) from the bore of the bearing retainer. See Figure 6-31.

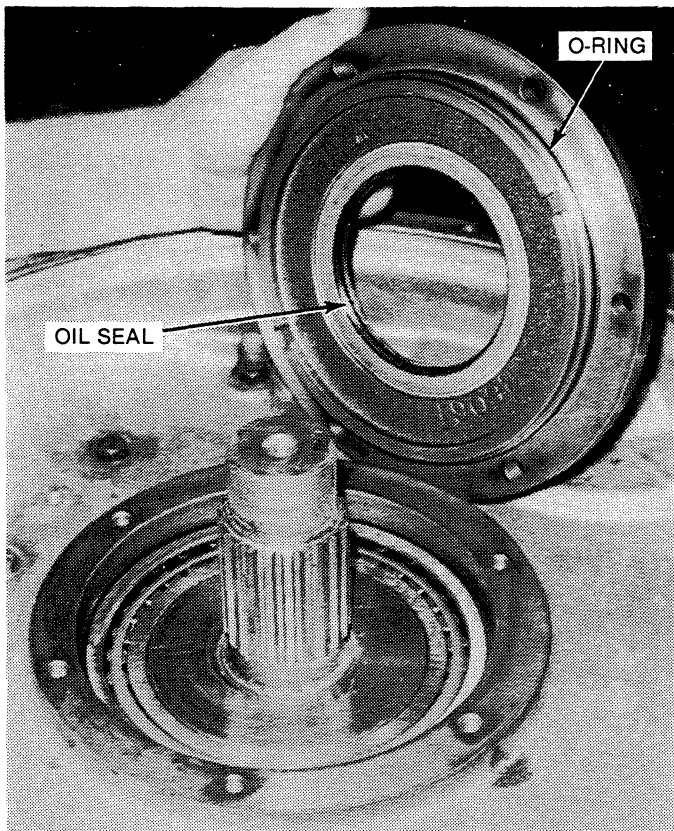


Figure 6-31. Bearing Retainer Removed.

3. Remove nineteen hex-head screws (Figure 12-5, 26) from the front housing assembly. See Figure 6-32.

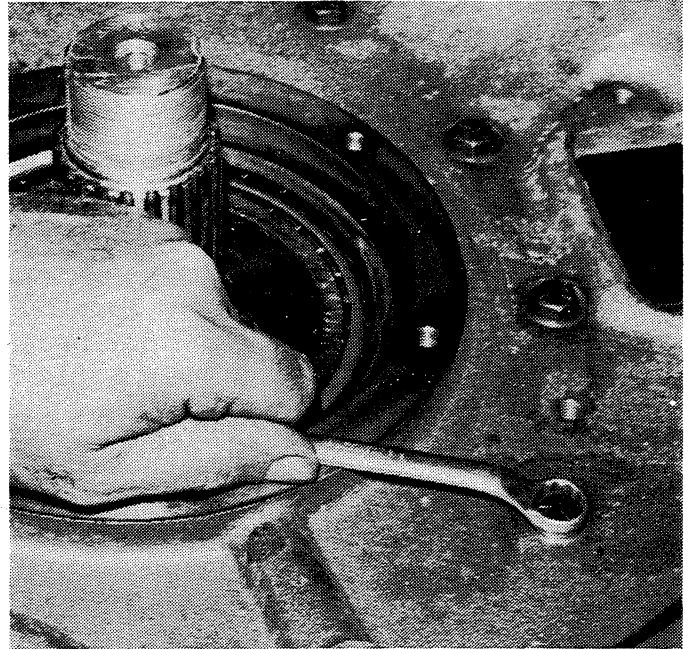


Figure 6-32. Removing or Installing Screws on Front Housing.

4. Use two of the screws as pushers to loosen the housing.

5. Install eyebolts into the front housing assembly and hoist it from the main housing assembly. See Figure 6-33.

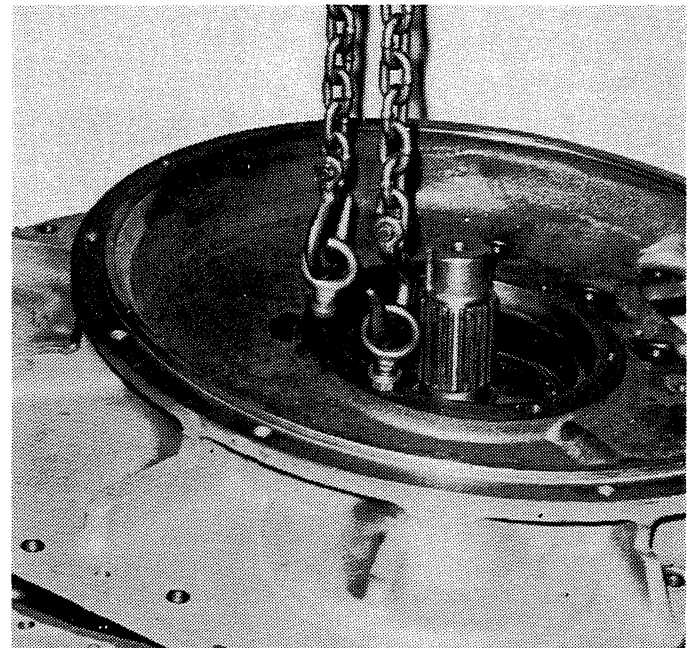


Figure 6-33. Removing or Installing Front Housing.

6. Remove gasket (Figure 12-5, 24).

7. Remove dog-point screws from the bearing locknut (Figure 12-4, 44) on the reverse clutch shaft (43).

8. Loosen the bearing locknut but do not remove it until the driven transfer gear (42) has been loosened.

CAUTION

When removing driving transfer gear, install steel tubing and locknut (44) to allow approximately 1/8-inch clearance between the gear and tubing. This is to restrain the gear when it pops loose.

9. Fill the passage in the end of the input shaft with oil.

10. Wrap 3/8-16 hex-head screw with teflon tape. Thread the hex-head screw into the oil passage very rapidly.

11. If the gear does not pop loose, repeat steps 8 thru 10 above.

12. Remove the driving transfer gear.

13. Repeat step 8 thru 11 above on the reverse shaft (Figure 12-4, 43) to remove the driven transfer gear (42).

14. Remove the forward and reverse shafts. See Figure 6-34.

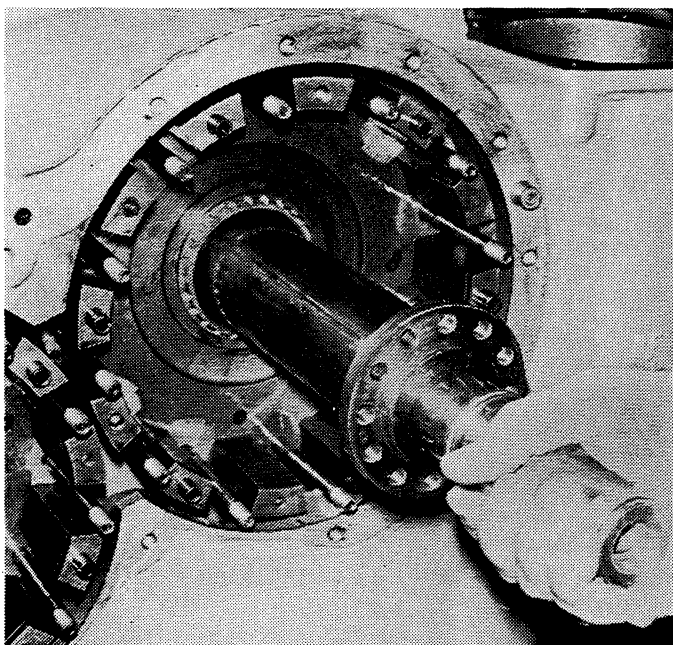


Figure 6-34. Removing or Installing Forward Shaft.

Output Group.

1. Remove three externally wrenched screws (Figure 12-5, 27), (See Figure 6-35) from the retainer washer (29) on the front of the output shaft (28) and remove the retainer washer.

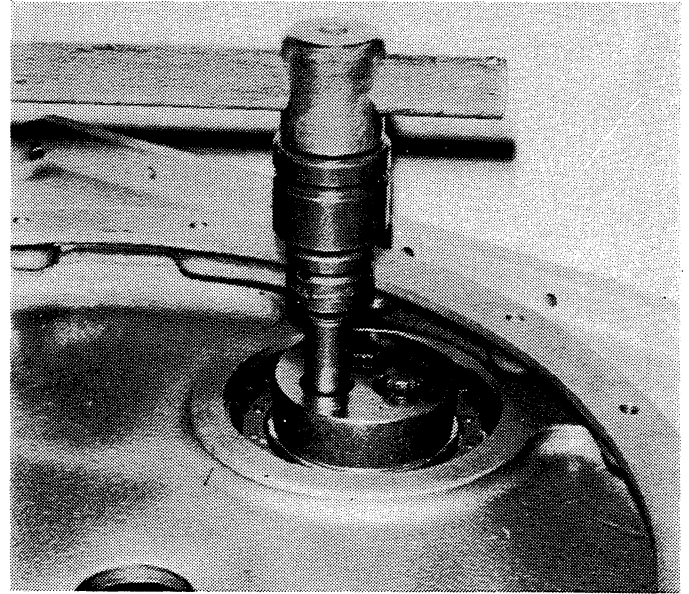


Figure 6-35. Removing or Installing Screws on Retainer Washer on Front of Output Shaft.

NOTE

Pipe plug (Figure 12-5, 21) spring (22), and rollpin (23) need not be removed from the housing at the front of the output shaft unless roller bearing (25) is being replaced. See Figure 6-36.

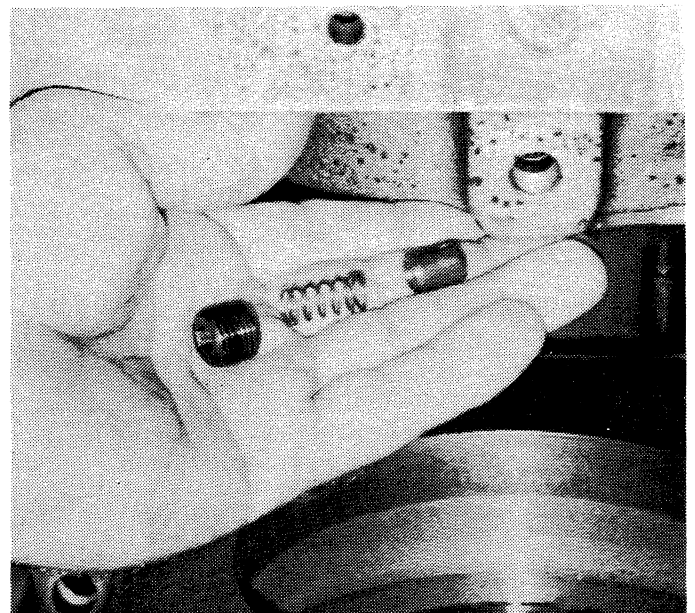


Figure 6-36. Rollpin, Spring, and Pipe Plug Removed.

2. Secure special tool T-18648 to the rear end of the output shaft with three 3/4 x 3.50 inch hex-head screws. Torque the screws 240 lb. ft.
3. Thread a leg of a portable hydraulic press into the hole in the center of the special tool.
4. Mount a portable hydraulic press so that the thrust is against the main housing and the output shaft is pulled rearward.
5. Insert two pieces of flat metal with combined thickness to fit snugly into the space at the rear of the output gear. This space varies in thickness.
6. Remove the output shaft. Rear roller bearing outer and inner race (Figure 12-5, 15) and front roller bearing inner race (15) will remain on the shaft. Roller bearing (25) will be removed from the front of the shaft when the shaft is removed.
7. Remove the output gear (31).

Input Pinions.

1. Remove six place-head screws (Figure 12-2, 1) from bearing retainer (2). See Figure 6-37.

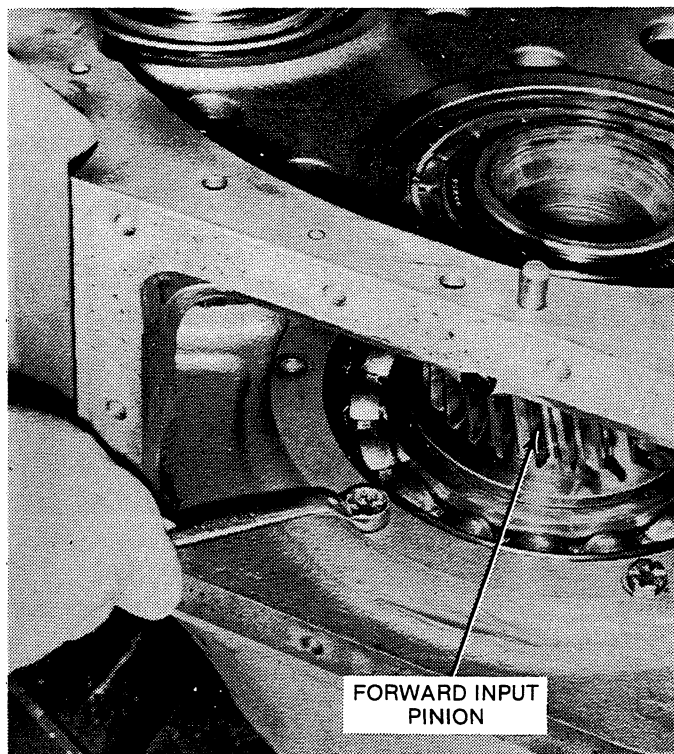


Figure 6-37. Removing or Installing Screws on Bearing Retainer.

2. Remove pipe plug (Figure 12-2, 59), spring (60), and rollpin (61) from the housing at the front of input pinion (34) only if roller bearing (47) is being replaced.

3. Remove the input pinion, drive spider, and attached parts as an assembly by pulling it rearward from the housing. See Figure 6-38.

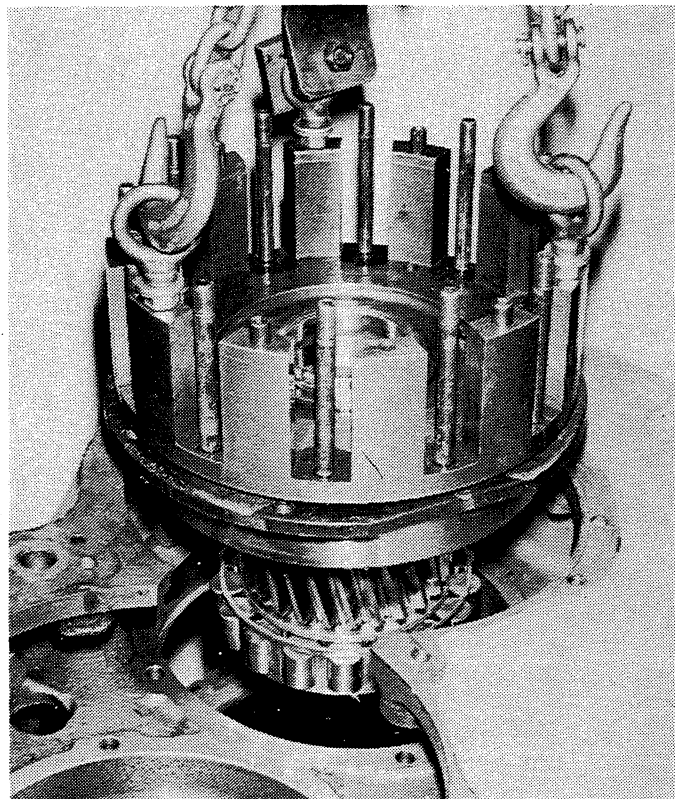


Figure 6-38. Removing or Installing Drive Spider, Input Pinion and Attached Parts.

4. If front roller bearing (Figure 12-2, 47) requires replacing, remove snap ring (36) from sleeve on the front of the input pinion. See Figure 6-39.

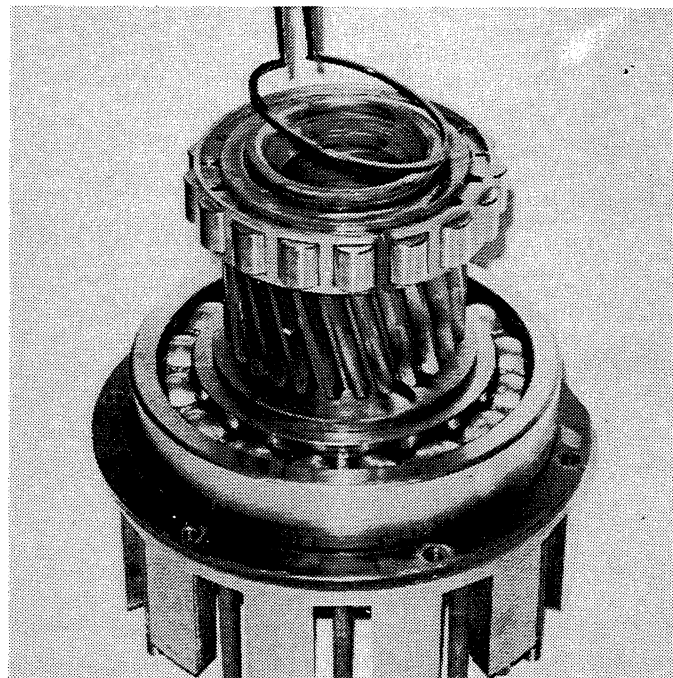


Figure 6-39. Removing or Installing Snap Ring on Front of Input Pinion.

5. Remove selective retainer ring from rear of input pinion. See Figure 6-40.

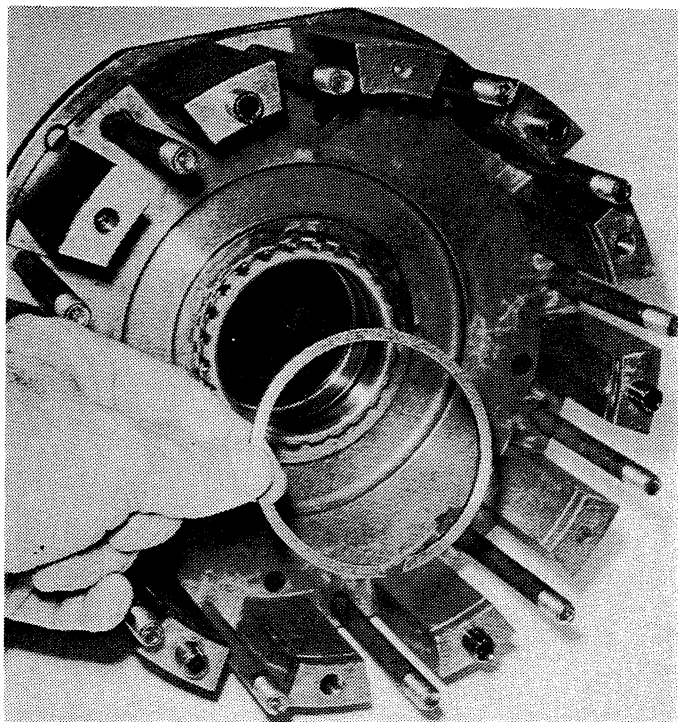


Figure 6-40. Selective Retaining Ring Removed.

6. Press the input pinion out of the drive spider assembly (Figure 12-2, 4). See Figure 6-41.

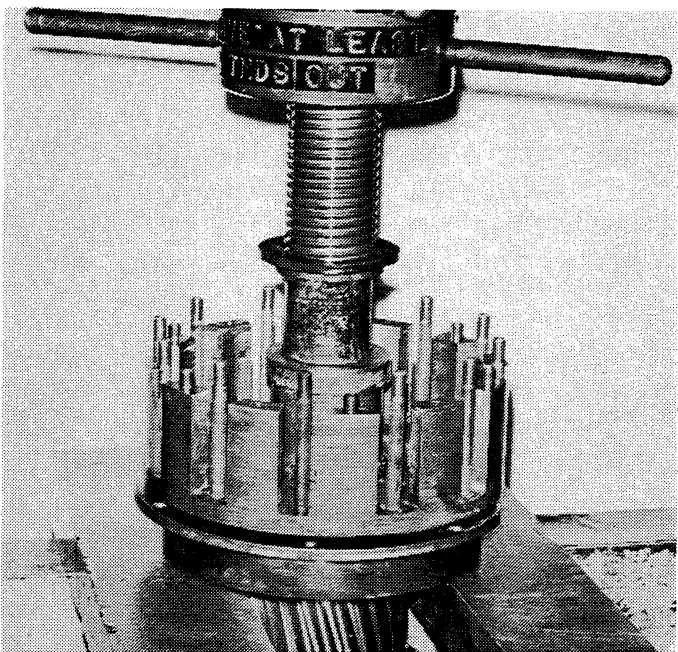


Figure 6-41. Pressing Input Pinion from Drive Spider Assembly.

7. Remove bearing retainer (Figure 12-2, 2).

8. If ball bearing (32) on the rear of the input pinion requires replacement, press the bearing carrier (33) with the ball bearing on it off from the input pinions. See

Figure 6-42. Press the ball bearing from the bearing carriers.

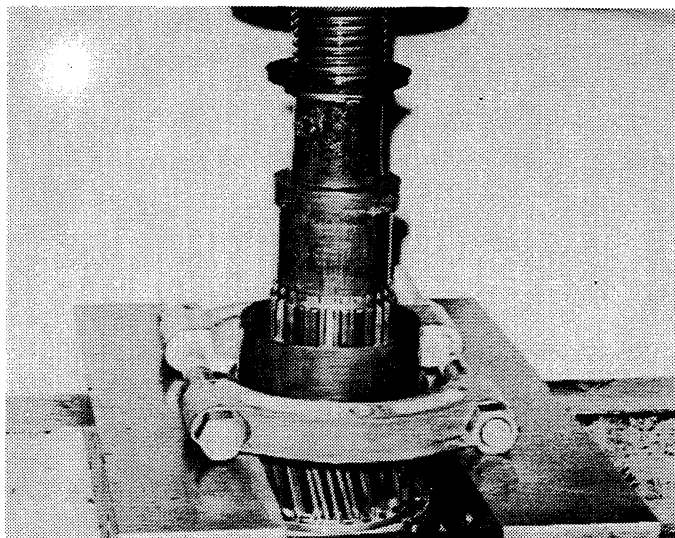


Figure 6-42. Pressing Ball Bearing and Bearing Carrier from Rear of Input Pinion.

9. If roller bearing (Figure 12-2, 47) on the front of the input pinions need replacing, proceed as follows:

a. Press the inner race off from the input pinion. See Figure 6-43.

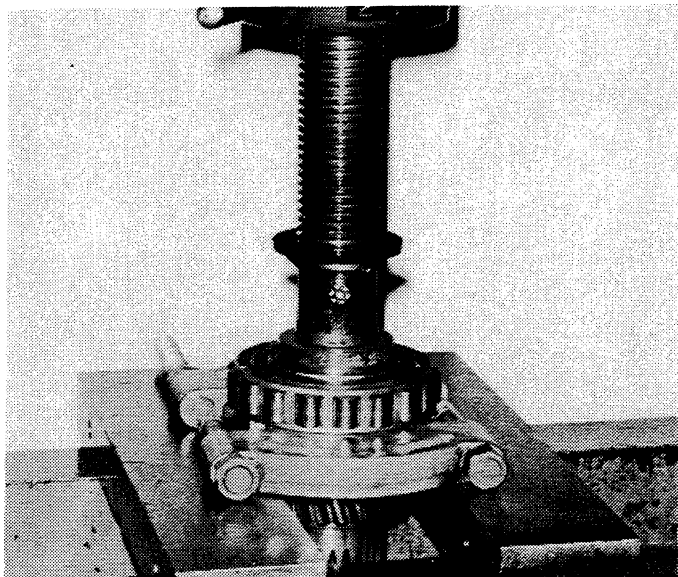


Figure 6-43. Pressing Inner Race of Roller Bearing from Front of Input Pinion.

b. Press the outer race from the housing.

NOTE

Sleeve (Figure 12-2, 35) is a not-serviced separately item and is not to be removed.

10. Repeat steps 1 through 9b above on the reverse input pinion.

Section 7.

CLEANING AND INSPECTION

CLEANING

General.

NOTE

Replace all oil seals including O-rings, hook rings, piston rings, and gaskets.

1. Using Stoddard® solvent, or equivalent or steam cleaning, clean all parts. Parts cleaned with solvent or steam cleaned must be dried and oiled immediately.
2. Examine all parts carefully for grit, dirt and abrasives and reclean them if necessary.
3. Clean all oil passages by working a piece of wire back and forth through the passages and then flushing them with cleaning solvent.
4. Use clean solvent to flush oil pumps, valves, etc.
5. Flush all hoses, tubing, coolers, etc., particularly if the unit is being disassembled due to an internal failure.

Cleaning Bearings.

Do not remove grease in which new bearings are packed. Thoroughly wash bearings that have been in service, in clean solvent. Soak bearing in solvent if they are particularly dirty or filled with hardened grease.

CAUTION

Never dry bearing with compressed air. Do not spin bearings while they are not lubricated. Oil bearings with SAE 10 engine oil immediately after cleaning. Be sure bearings are oiled before inspection.

Preventing Entrance of Dirt into Bearings.

Dirt and grit in bearings are often responsible for bearing failure; consequently, it is important to keep bear-

ings clean. Do not remove grease from new bearings. Keep the wrapper on new bearings until they are to be installed. Do not expose clean bearings if they are not to be assembled at once. Wrap them with a clean lint-free cloth or paper to keep out dust.

Previously Sealed Joints.

1. For previously sealed joints, scrape surfaces to remove old gasket material. Gel-type paint removers containing methylene chloride can be used to wipe off cured sealant.
2. Clean surfaces with 1, 1, 1-trichloroethane to remove oil and grease residue.
3. Test for clean surfaces by applying a few drops of cool water to the surfaces. Parts are sufficiently clean if water covers the surface of the part in a film. If the water puddles or forms beads, use fresh solvent and reclean.

INSPECTION.

Housings, Cast Parts, and Machined Surfaces.

NOTE

Units with matched housings require replacement of both halves. These must be kept in matched halves.

1. Replace cast parts or housings that are cracked.
2. Inspect bores for wear, grooves, scratches and dirt. Remove burrs and scratches with crocus cloth or soft stone. Replace parts that are deeply grooved or scratched.
3. Inspect oil passages for obstructions. If an obstruction is found, remove it with compressed air or by working a wire back and forth through the passage and flushing it with solvent.

4. Inspect machined surfaces for burrs, scratches, nicks and foreign matter. If such defects cannot be removed with crocus cloth or a soft stone, replace the part.

5. Inspect threaded openings for damaged threads. Chase damaged threads with a tap of the correct size.

6. Inspect studs for damaged threads and looseness. Replace defective studs.

7. Inspect dowel pins for wear or damage. Replace defective dowels. This applies where matched set of parts is not involved.

8. Inspect dowel pin holes for wear due to movement between mating parts. If a dowel pin hole is worn, rebore and sleeve the hole when possible. Otherwise, replace the parts. This applies where matched set of parts is not involved.

Valve Seats.

Inspect valve seats for burrs, nicks and scratches. If these defects cannot be removed with a crocus cloth, replace the part. Check to see that the valve is seating properly after reworking the valve seat.

Bearings.

1. Inspect bearings for roughness of rotation. Replace the bearing if the rotation is rough.

2. Inspect bearings for corrosion, scored, scratched, cracked, pitted or chipped races, and for indication of excessive wear of balls or rollers. If one of these defects is found, replace the bearing.

3. Inspect bearing bores and shafts for grooved, burred, or galled conditions that would indicate that the bearing has been turning in its housing or on its shaft. If the damage cannot be repaired with a crocus cloth, replace the part.

Bushings and Sleeves.

Inspect bushings for size and out-of-roundness, scores, burrs, sharp edges, and evidence of overheating. Remove scores with a crocus cloth. If the bushing is out-of-round, deeply scored, or excessively worn, replace it.

Thrust Washers and Spacers.

Inspect thrust washers for distortion, scores, burrs and wear. Rework or replace any defective thrust washers or spacers.

Gears.

1. Inspect gears for scuffed, nicked, burred or broken teeth. If the defect cannot be removed with a soft stone, replace the gear.

2. Inspect gear teeth for wear that may have destroyed the original tooth shape. If this condition is found, replace the gear.

3. Inspect thrust faces of gears for scores, scratches and burrs. If these defects cannot be removed with a soft stone, replace the gear.

Splined Parts.

Inspect splined parts for stripped, twisted, chipped or burred splines. Remove burrs with a soft stone. Replace the part if other defects are found.

Clutch Plates.

1. Inspect the clutch driving plates for cracked or glazed surfaces, or for cracked, worn or broken teeth. Check for excessive wear. Replace damaged or worn driving plates.

2. Inspect the clutch steel plates for discoloration and warpage. Replace damaged steel plates.

Snap Ring.

Replace damaged or distorted snap rings.

Springs.

Inspect springs for broken or distorted coils. Replace the spring if either of these defects are found.

Flexible Hoses.

Inspect all flexible hoses for cracks and sponginess. Replace damaged hoses.

Section 8.

SUBASSEMBLIES

CONTROL VALVE DISASSEMBLY

NOTE

Orifice plate ball (Figure 12-6, 9) is under pressure from spring (10). Care must be taken when removing the orifice plate cover (4) so that the ball will not be lost.

1. Remove the hex-head screws (3) that secure the cover (4) and gasket (8).
2. Remove the orifice plate (6), gasket (8), orifice plate ball (9), and spring (10).
3. Remove the rate-of-rise piston (5) and springs (1 and 2).
4. Remove pipe plug (25), spring (24), and detent (23).
5. Remove the hex-head screws (3) that secure the valve cover (16).
6. Remove the valve cover (16), gasket (15), stem (14), and attached parts as an assembly.

NOTE

Do not disassemble the valve stem assembly unless parts are being replaced.

7. Remove the high pressure regulation piston (12).
8. If parts are being replaced, disassemble the valve stem assembly as follows:
 - a. Loosen socket-head screw (17) and remove the shift lever (20).
 - b. Drive rollpin (19) out of the stop collar (21) and remove the stop collar.
 - c. Remove the valve cover (16) from the valve stem.
 - d. Remove the O-ring (18) from the bore in the cover.
 - e. Remove the ball bearing (22).

CLEANING AND INSPECTION.

See Section 7 for cleaning and inspection instructions.

ASSEMBLY OF CONTROL VALVE.

1. If the valve stem assembly was disassembled, proceed as follows:
 - a. Install O-ring (Figure 12-6, 18) into the bore in the cover (16).
 - b. Press the ball bearing (22) onto the valve stem (14), applying pressure on the inner race only.
 - c. Install cover (16) over stem (14) seating ball bearing in bore in cover.
 - d. Install stop collar (21) over stem (14) and secure it with rollpin (19).
 - e. Install shift lever (20) and tighten the socket-head screw (17).
2. Install high pressure regulation piston (12).
3. Install the valve cover gasket (15).
4. Install the valve stem and cover assembly and secure it with four hex-head screws (3). Torque the screws 17 lb. ft.
5. Install the detent (23), detent spring (24), and pipe plug (25).
6. Install inner spring (2) and outer springs (1).
7. Install shims (7) inside the rate-of-rise piston (5), install the piston.
8. Install the orifice plate spring (10) and ball (9).
9. Install the orifice plate (6) with gaskets (8) on each side.
10. Install orifice plate cover (4) and secure it with hex-head screws (3). Torque the screws 17 lb. ft.

Section 9.

UNIT ASSEMBLY AND INSTALLATION

NOTE

Place the inner race of all roller bearings in a 275 degree F. oven for 30 minutes minimum.

CAUTION

Submerge all friction clutch plates in transmission oil for one hour minimum before installing.

NOTE

Oil torque values are given for all screws; therefore, screws should be oiled before installing.

NOTE

In the discussion that follows, the input side of the transmission is the front and the output side is the rear.

ASSEMBLY (Input Pinions).

1. Install ball bearing (Figure 12-2, 32) onto bearing carrier (33).

2. Install bearing carrier (33) and ball bearing (32) onto the rear of the forward clutch input pinion (34).

3. Install the outer race of roller bearing (47), if removed, into the housing, aligning the recess in the O.D. of the outer race with the threaded hole in the housing.

4. Install rollpin (61) into the threaded hole, making certain that the rollpin fits into the recess in the outer race.

5. Install spring (60) and pipe plug (59) over the rollpin.

6. Place bearing retainer (2) over the rear of the input pinion (counterbore toward bearing) and press clutch drive spider (4) onto the input pinion.

7. Install selective retainer ring (31) into the groove provided in the rear of the input pinion.

NOTE

If parts are being replaced such as the input pinion, ball bearing, bearing carrier, or clutch spider, use the maximum thickness selective retainer ring that can be installed. This may mean selecting a different ring. Rings with the following nominal thicknesses are available: 0.150, 0.145, 0.140, 0.135, and 0.130.

NOTE

These rings can be made by grinding the 0.150-inch ring to the desired thickness.

8. Install inner race of roller bearing (47) onto the sleeve (35) on the front of the input pinion.

9. Install snap ring (36) into the groove in the sleeve (35). See Figure 6-39.

10. Install the forward input pinion.

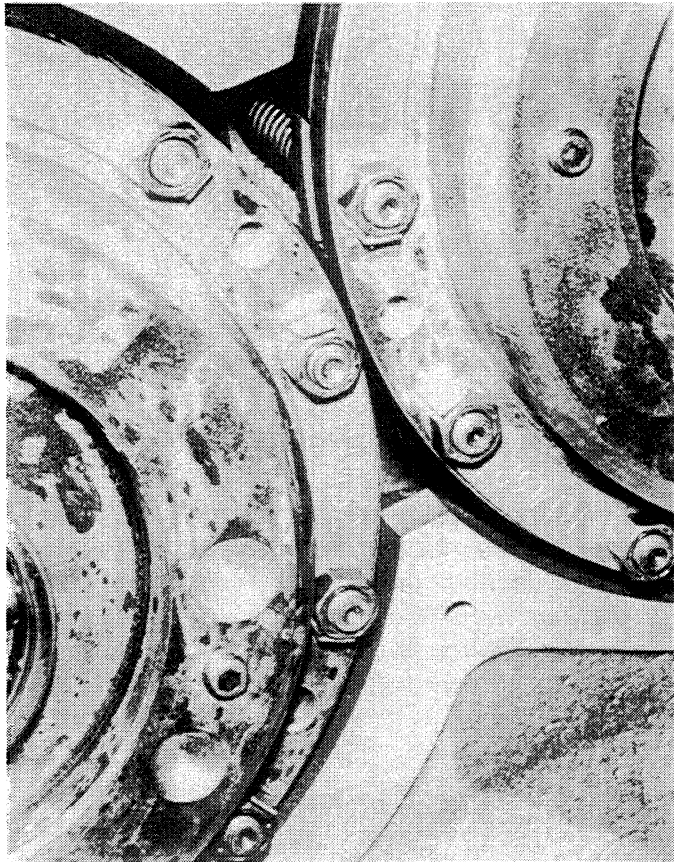
11. Secure bearing retainer (Figure 12-2, 2) with six place-head screws (1). See Figure 6-37.

12. Torque the screws 38 ± 3 lb. ft.

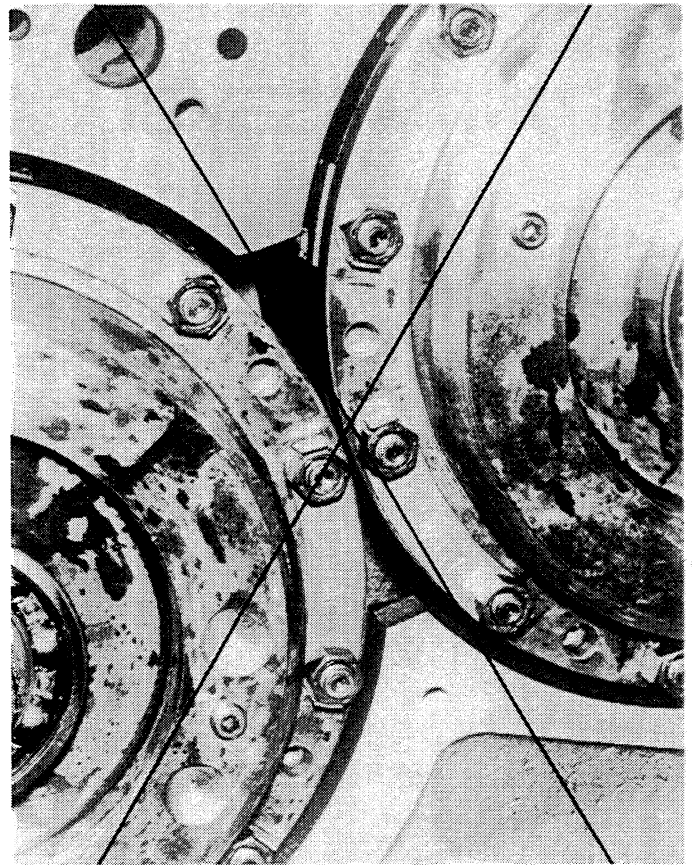
NOTE

The forward and reverse clutches must be indexed to each other so that a release spring in one clutch aligns with the space between springs in the other as the clutches are rotated. Figure 9-1 shows proper and improper indexing. A tool like T-18476 can be used to hold the clutches in proper position before the output gear is meshed with the forward and reverse pinions. See Figure 9-2.

13. Repeat steps 1 through 12 on the reverse pinions.



RIGHT



WRONG

Figure 9-1. Right and Wrong Indexing of Forward and Reverse Clutches.

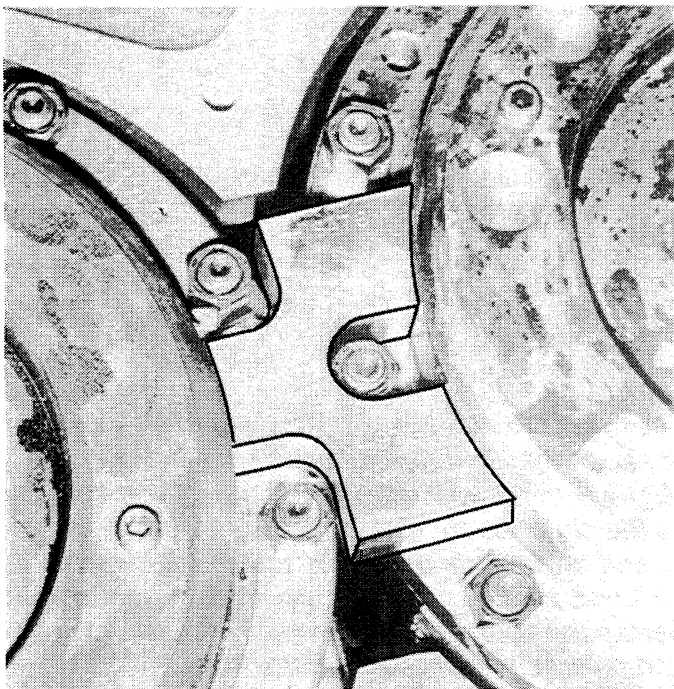


Figure 9-2. Special Tool T-18476 Installed.

Output Shaft.

1. If roller bearings (Figure 12-5, 15) were removed from the rear of the output shaft, proceed as follows:

NOTE

These two bearings are identical and are further identified as front and rear.

a. Press the outer race of the front roller bearing into the bore against the shoulder in the housing.

b. Press inner race of the front roller bearing onto the rear of the output shaft against the shoulder on the output shaft.

c. Press inner race of the rear roller bearing onto the output shaft against inner race of the front roller bearing.

d. Install outer race of roller bearing (25) into the housing at the front of the output shaft.

NOTE

Be sure recess in the OD of the outer race is aligned with the threaded hole in the housing.

e. Install rollpin (23) into the threaded hole in the housing. See Figure 6-36. Be sure the rollpin fits into the recess in the OD of the bearing outer race.

f. Install spring (22) and pipe plug (21) over the rollpin. See Figure 6-36. Tighten the plug securely.

g. Install the output gear (Figure 12-5, 31) through the bottom of the housing, using two flat steel bars as guides to keep the output gear from bumping the pinion bearings.

2. Install output shaft gear key (30) into the slot in the output shaft (28).

3. Install the output shaft using a hoist and aligning key with keyway in the gear.

4. Install inner race of roller bearing (25) onto the front end of the output shaft.

5. Install retainer washer (29) onto the front of the output shaft and secure it with three externally wrenched screws (27). See Figure 6-35. Extra long screws may have to be used to push the gear on far enough for externally wrenched screws (Figure 12-5, 27) to be started.

6. Advance the output gear on its taper by tightening the externally wrenched screws alternately to 180 ± 15 lb. ft. Each screw will have to be torqued several times.

7. Install the outer race of roller bearing (15).

8. Install bearing retainer (2) without shims (14), rubber seal (13), or oil seals (11), if removed. See Figures 6-22 and 6-23.

9. Secure the retainer with hex-head screws (12), tightened finger tight.

10. Use a thickness gauge to determine the gap between the bearing retainer and the main housing assembly. See Figure 9-3. Measure the gap in four equally spaced places. Take an average of these measurements, and add 0.003 to 0.006 inch to determine the amount of shim for a trial shim-pack.

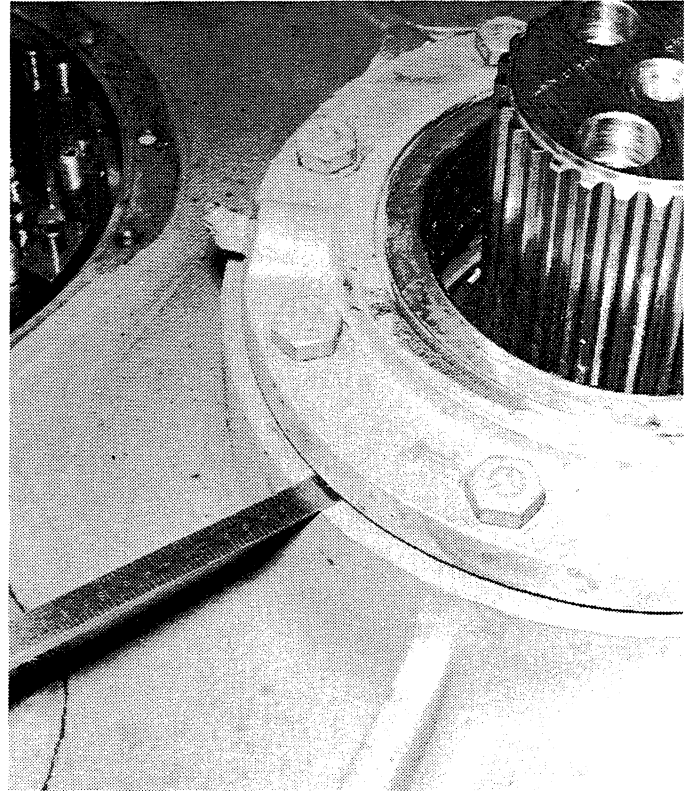


Figure 9-3. Measuring Gap Between Bearing Retainer and Main Housing.

11. Install two oil seals (Figure 12-5, 11) if removed, into the bore of bearing retainer. See Figure 6-23. The lip of the forward seal faces forward; the lip of the rear seal faces rearward. Press in the seals so that the forward seal is flush with the front of the bore and the rear seal is flush with the rear of the bore. This leaves space for grease between the seals.

12. Fill the space between the seals with grease.

13. Install calculated shim pack (Figure 12-5, 14) and rubber seal (13) onto the bearing retainer (2).

14. Secure the bearing retainer with eight hex-head screws (12). See Figure 6-22. Torque the screws 65 ± 5 lb. ft.

15. Check the endplay as follows:

a. Install a piece of steel tubing over the output shaft with I.D. slightly larger than the shaft and O.D. smaller than the bearing cage. The tubing must extend beyond the end of the shaft .020 to .030 inch.

b. Install special tool T-18648 over the steel tubing and bolt the tool to the end of the output shaft (see Figure 9-4).

c. Apply 300 - 900 lbs. downward thrust to the output shaft.

B

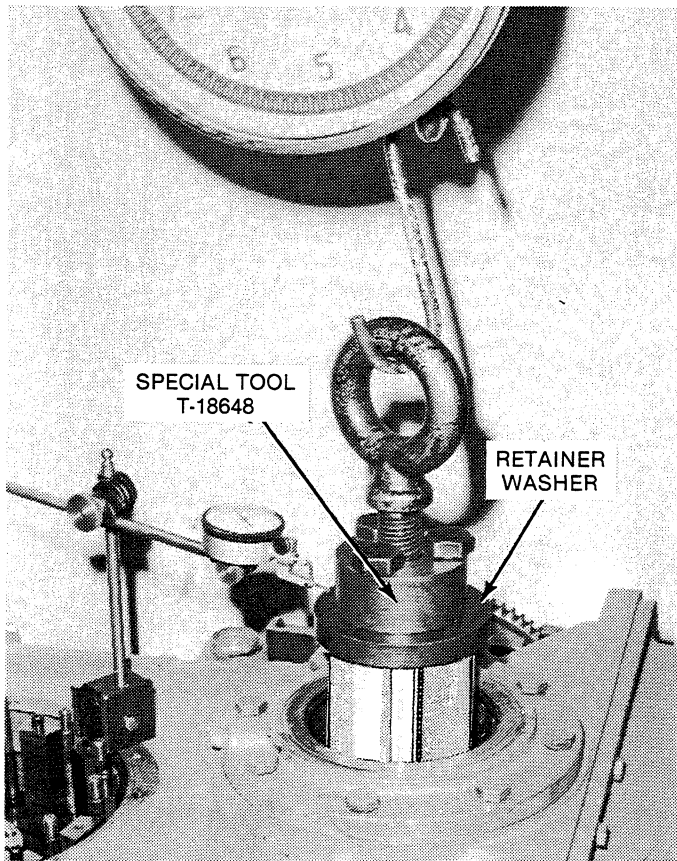


Figure 9-4. Checking Endplay of Output Shaft.

d. With the thrust applied, rotate the shaft several times in each direction.

e. Install dial indicator onto the housing with the finger resting on the retainer washer on rear of output shaft (see Figure 9-4).

f. Zero the indicator and mark the spot with a felt marker where the reading was taken.

g. Remove the downward thrust.

B h. Install an eyebolt into the special tool. Attach a sling to the eyebolts and use a hoist and fish scales to apply 1500 to 1700 lb. upward thrust on the shaft. See Figure 9-4.

i. Rotate the shaft several times in each direction. Stop with the finger on the spot previously marked.

j. The indicator reading is the endplay.

k. Remove or add shims to adjust the endplay to 0.003 to 0.006 inch.

l. If shims are removed or added, recheck the endplay using the procedure in steps a through l above.

Forward Shaft and Driving Transfer Gear.

1. Install roller bearing (Figure 12-2, 50) inner race onto the driving transfer gear (53) and install the outer race into the front housing assembly (Figure 12-5, 32).

2. Install the driving transfer gear onto the forward shaft (Figure 12-2, 53) as follows:

NOTE

Do not heat the gear nor chill the shaft. Gear and shaft must be at room temperature during assembly process.

a. Clean the mating tapered surfaces of the shaft and gear with 1, 1, 1-trichloroethane which meets OSHA requirements.

CAUTION

Mating tapered surfaces must be absolutely clean and free from grease.

b. Place the gear in position in the housing and install the forward shaft. See Figure 6-34.

c. Seat the gear on the shaft taper using 50-100 lb. force.

d. Measure and record the distance from the front end of the forward shaft to the front face of the driving transfer gear.

e. Measure the distance from the front end of the forward shaft to the shoulder on the shaft at the rear of the splines.

f. The difference between these two measurements is the distance the driving transfer gear will advance on the taper. The advance must be between 0.058 and 0.098 inch.

g. Install special tool T-18410-2 detail 4 (See Section 11 for tool drawing) over end of the shaft aligning splines on the shaft and tool.

h. Install detail 1 threading it onto the end of the shaft.

i. Install detail 3 over detail 1.

j. Install a portable hydraulic press over detail 1 and thread detail 2 onto the end of detail 1.

k. Shim the press so that it is pressing on detail 3 and pulling on detail 1 against the heavy hex nut, detail 2.

l. Detail 4 will butt against the shoulder on the forward shaft when the driving transfer gear is fully advanced. The gear must be flush with the shoulder to within ± 0.002 inch.

Reverse Shaft and Driven Transfer Gear.

1. Repeat steps 1 thru 2c above on the reverse shaft (Figure 12-4, 43) and driven transfer gear (42) and then proceed as follows:

a. Measure and record the distance from the front end of the reverse shaft to the front face of the driven transfer gear.

b. Measure the distance from the front end of the reverse shaft to the shoulder on the shaft at the rear of the threaded area.

c. The difference between these two measurements is the distance the driven transfer gear will advance on the taper. The advance must be between 0.058 and 0.098 inch.

d. Install special tool T-18410-2 detail 5 over the end of the reverse shaft.

e. Thread detail 1 onto the end of the shaft.

f. Install detail 3 over detail 1.

g. Install a portable hydraulic press onto detail 1.

h. Install detail 2 onto the end of detail 1.

i. Shim the press so that it is pressing on detail 3 and pulling on detail 1 against the heavy hex nut, detail 2.

j. Detail 5 will butt against the shoulder on the reverse shaft when the driven transfer gear is fully advanced. The gear must be flush with the shoulder to within ± 0.002 inch.

2. Install bearing lockwasher (Figure 12-4, 45) and bearing locknut (44) using special tool T-18589-1. Torque bearing lock nut 290-320 lb. ft. Tighten further to align a threaded hole in locknut and lockwasher.

3. Install dog-point setscrew (Figure 12-2, 45). Tighten the setscrew and stake metal over the end of the setscrew in two places.

Front Housing Assembly.

1. If the ventilating cover (Figure 12-1, 59) was removed, install it. Secure with two hex-head screws (58). Torque the screws 27 ± 2 lb. ft.

2. Install front housing gasket (Figure 12-5, 24).

3. Hoist the front housing onto the main housing (see Figure 6-33) being careful not to bump the bearing outer races in the front housing and the inner races on the forward and reverse shafts.

4. Secure the front housing with nineteen hex-head screws (Figure 12-5, 26). See Figure 6-32. Torque the screws 27 ± 2 lb. ft.

Bearing Retainer and Drive Spider.

1. Install oil seal (Figure 12-2, 48) into the bore of bearing retainer (49) with the lip toward the oil being retained. See Figure 6-31.

2. Install O-ring (Figure 12-2, 51) onto the bearing retainer. See Figure 6-31.

3. Install the bearing retainer and secure with six hex-head screws (Figure 12-2, 52). See Figure 6-30. Torque the screws 27 ± 2 lb. ft.

4. If wear sleeve (Figure 12-2, 39) was removed from the drive spider (40), press on a new wear sleeve using special tool T-18050-20.

5. Lubricate the spline on the forward shaft with white lead and, using special tool T-18720-2, press on the drive spider assembly. The drive spider fits tightly against the driving transfer gear.

6. Install rectangular seal ring (43) into the front end of the drive spider bore. See Figure 6-28.

7. Install stamped washer (Figure 12-2, 42), bearing lockwasher (46), and bearing locknut (41) onto the front end of the forward shaft. See Figure 6-28.

8. Using special tool T-18589-1, torque the locknut 290-320 lb. ft. Tighten further to align one of the threaded holes in the locknut with a hole in lockwasher.

9. Install a dog-point setscrew (Figure 12-2, 45) into the threaded hole in the locknut. See Figure 6-26. Tighten the setscrew and stake metal over it in two places.

Oil Return Pipe Assembly, Top and Bottom Covers.

1. Install gasket (Figure 12-3, 1) and oil return pipe assembly (5) aligning gasket and return pipe with rollpin (2). Insert the oil return pipe assembly into the tube carrier assembly (10).
2. Align the screw in the tube carrier with the hole provided in the oil return pipe.
3. Torque the screw 7 ± 1 lb. ft. and bend the screw lock to lock the screw.
4. Install gasket (Figure 12-1, 57) and top cover (56). See Figure 6-9. Secure with ten hex-head screws (Figure 12-1, 55). Torque the screws 27 ± 2 lb. ft.
5. Install O-ring (Figure 12-2, 58) if removed, into the breather hole in the top cover.
6. Install the breather assembly (Figure 12-1, 3).
7. Install gear pan (Figure 12-5, 18) if removed. Install four lock plates (Figure 12-1, 35) and hex-head screws (36). See Figure 6-25. Torque the screws 27 ± 2 lb. ft. and bend the tabs on the lock plates to lock the screws.
8. Install gasket (Figure 12-5, 20) and bottom cover (17).
9. Secure the bottom cover to the main housing with twenty-two hex-head screws (19). See Figure 6-24. Torque the screws 27 ± 2 lb. ft.

Forward Clutch.

1. Install the forward clutch hub (Figure 12-2, 30) and secure it to forward shaft with twelve place-head screws (26). See Figure 6-18. Torque the screws 38 ± 3 lb. ft.
2. Install retaining ring (oil dam) (Figure 12-2, 25) if removed into the bore of the clutch hub (30). See Figure 6-17.
3. Install the clutch plates, beginning with a driving (sintered) plate (Figure 12-2, 29) alternating with a driven (steel) plate (28). See Figure 6-16. These are "L" shaped steel plates and must be assembled with the offset facing forward (toward the engine). There are eight driving (sintered) plates and seven driven (steel) plates.

4. Install twelve clutch release springs (Figure 12-2, 3) and release springs sleeves (8). See Figure 6-15.
5. If disassembled, assemble the clutch cylinder (Figure 12-2, 11) and piston (9) assembly as follows:
 - a. Install piston ring (24) on the front hub of the cylinder assembly.
 - b. Install piston ring (10) on the clutch piston. See Figure 6-14.
 - c. If removed, install four setscrews (Figure 12-2, 12) (come-home) into the clutch cylinder by first installing rollpins (13). Thread the setscrews in from the front side of the clutch cylinder until the rollpins are tight against the cylinder. Lock the setscrews by giving them another quarter turn.
 - d. Install the clutch piston into the clutch cylinder.
 - e. Install two piston rings (22) onto the rear hub of the clutch cylinder.
5. Install piston ring (Figure 12-2, 15 and 23) onto the forward shaft. See Figure 6-11.
6. Install the clutch piston and clutch cylinder as an assembly.
7. Secure the assembly with screw locks (Figure 12-2, 6) and hex nuts (7). See Figure 6-10. Torque the nuts 27 ± 2 lb. ft.

Reverse Clutch.

1. Repeat steps 1 through 5 above on the reverse clutch and then proceed as follows:
 - a. Install the clutch piston and clutch cylinder as an assembly.

NOTE

If the output gear is assembled after the clutch cylinders, special tool T-18476 can be installed to keep the clutch cylinders in proper alignment while the output gear is being installed. See Figure 9-2.

- a. Secure the assembly with screw locks (Figure 12-4, 28) and hex nuts (12). Torque the nuts 27 ± 2 lb. ft.

Rear Bearings, Manifold, and Bearing Retainers.

1. Install bearing spacers (Figure 12-2, 20 and Figure 12-4, 26), one on the forward shaft and one on the reverse shaft.
2. Install roller bearing (Figure 12-2, 19 and Figure 2-4, 25) inner races onto the forward and reverse shafts.
3. Press roller bearing outer races into the bores of the manifold.
4. Install the manifold assembly (Figure 12-1, 31) as follows:
 - a. Clean the mating surfaces on the manifold and the main housing per Section 7, Previously Sealed Joints.
 - b. Use Twin Disc primer MA579 (Locquic T) or equivalent primer on both mating surfaces. Allow primer to dry. This usually takes three to four minutes. Keep surfaces clean and free of oil and grease from this point on.
 - c. Apply a 1/16-inch continuous bead of Twin Disc M2828A anaerobic plastic sealant to one surface on the side of bolt holes towards fluid being retained. Be certain that narrow overlap areas are covered. It is optional to spread material into a thin film just before mating surfaces are assembled.
 - d. Install the manifold aligning the dowel pins.
 - e. Secure the manifold with sixteen hex-head screws (Figure 12-1, 48). Torque the screws 27 ± 2 lb. ft.

Shimming Forward Shaft Bearings.

1. Shim the forward shaft bearings by either the push-pull method or by the acro-set method both of which are described below.

Push-Pull Method.

- a. Install bearing retainer (Figure 12-1, 30) without O-ring (Figure 12-2, 18), O-ring plug (16), O-ring (17), and oil lube tube (Figure 12-1, 22).
- b. Secure the bearing retainer with four hex-head screws (21) and two hex-head screws (19) tightened finger tight.
- c. Measure the gap between the manifold and bearing retainer with a thickness gauge at four equally spaced

places around the bearing retainer. Find the average of these four measurements. Install a shim pack equal to this average plus 0.0045 inch under the bearing retainer.

- d. Install O-ring (Figure 12-2, 18) onto the bearing retainer.
- e. Install O-rings (Figure 12-1, 46) onto the oil lube tube (22) and install the bearing retainer and oil lube tube. The bearing retainer may have to be rotated in order to install the oil lube tube.
- f. Secure with four hex-head screws (21) and two hex-head screws (19). Torque the screws 27 ± 2 lb. ft.
- g. Thread special tool T-18646 into the end of the forward shaft through the hole in the bearing retainer. See Figure 9-5.

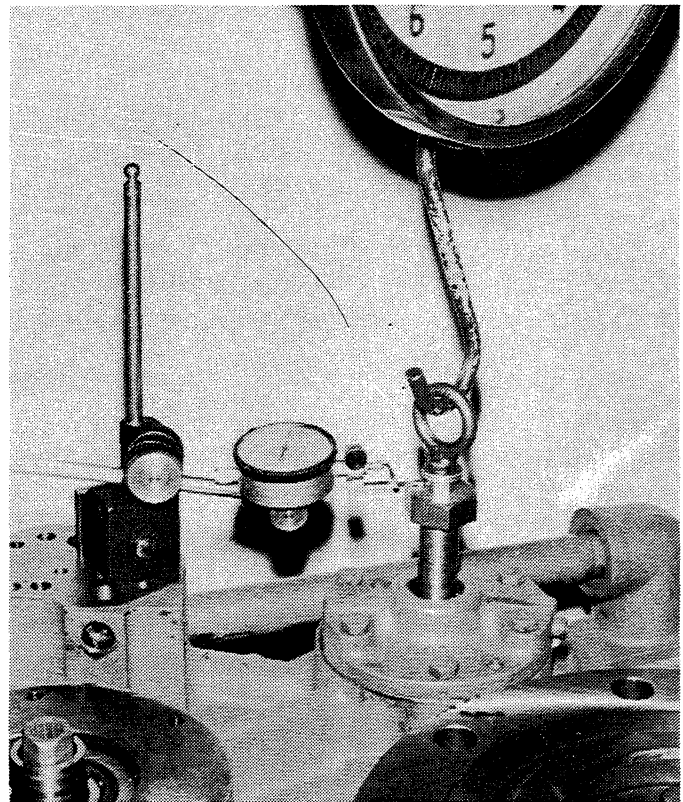


Figure 9-5. Checking Endplay of Forward Shaft.

- h. Apply 150 lb. downward force onto the forward shaft.
- i. Rotate the shaft several times in each direction by means of the output flange.
- j. Attach a dial indicator to a machined area of the manifold and rest the finger on the machined surface on the end of the special tool. See Figure 9-5.

k. Zero the indicator and mark the spot on the tool where the finger rests.

NOTE

Be careful not to bump the indicator from this point on.

l. Remove the downward force and install an eyebolt into the threaded hole in the special tool.

m. Use a hoist and fish scales to apply 250 lb. upward force on the forward shaft.

n. Rotate the shaft several times in each direction and stop with the finger on the spot previously marked. The indicator reading is the endplay.

o. Add or remove shims if necessary to adjust the endplay to 0.0025-0.0065 inch.

Acro-Set Method (Alternate method).

1. Install the bearing retainer (Figure 12-1, 30) without O-ring (18), oil lube tube (22) or shims.

2. Secure with two hex-head screws (21) 180° apart. Torque the screws 60 lb. in. Rotate the forward shaft a minimum of two revolutions and retorque the screws to 60 lb. in.

3. Measure with a taper gauge the gap between the bearing retainer and manifold at each screw. Average the gap measurement readings. Add constant 0.013 inch to the average to determine the desired shim pack.

4. Measure the shim pack thickness to ensure that it is within ± 0.001 inch of the desired thickness.

5. Remove the bearing retainer and ensure that the bearing cage rotates freely.

6. Install piston ring (Figure 12-2, 15) if removed onto the forward shaft.

7. Install O-ring (18) onto the bearing retainer.

8. Install two O-rings (Figure 12-1, 46) onto oil lube tube (22) and install the lube tube into the manifold.

9. Install the shim pack and bearing retainer. It will be necessary to rotate the bearing retainer to install lube tube (22) into the bearing retainer. Secure with four

hex-head screws (21) and two hex-head screws (19). Torque the screws 27 ± 2 lb. ft.

Shimming Reverse Shaft Bearings.

1. Push-Pull Method:

a. Install pump support (figure 12-4, 20) without pin (23), pump drive sleeve (22), retaining ring (24), shims (17), O-ring (15), and oil lube tube (Figure 12-1, 47).

b. Secure the pump support with four equally spaced hex-head screws (Figure 12-4, 18) tightened finger tight.

c. Measure with a thickness gauge the gap between the pump support and the manifold at four equally spaced places around the pump support. Find the average of these four measurements. Install a shim pack equal to this average plus 0.0045 inch under the pump support.

d. Secure with six hex-head screws (Figure 12-4, 18). Torque the screws 27 ± 2 lb. ft.

e. Thread special tool T-18646 into the end of the reverse shaft.

f. Apply 150 lb. downward force onto the reverse shaft.

g. Rotate the shaft several times in each direction by means of the output flange.

h. Attach a dial indicator to a machined area of the manifold and rest the finger on the machined surface on the end of the special tool.

i. Zero the indicator and mark the spot on the tool where the finger rests.

NOTE

Do not bump the indicator from this point on.

j. Remove the downward force and install an eyebolt into the end of the special tool.

k. Use a hoist and fish scales to apply 250 lb. upward force on the reverse shaft.

l. Rotate the shaft several times in each direction and stop with the finger on the spot previously marked. The indicator reading is the endplay.

m. Add or remove shims as necessary to adjust the endplay to 0.0025-0.0065 inch.

n. Remove the pump support.

o. Install pump drive sleeve (Figure 12-4, 22) and press pin (23) through the drive sleeve and reverse shaft.

p. Install retaining ring (24) so that ring ends are 90° from the pin hole.

q. Install piston ring (16) in its groove in the reverse shaft.

r. Install O-ring (15) onto the pump support.

s. Install O-ring (Figure 12-1, 46) onto oil lube tube (47) and install lube tube into the manifold.

t. Install shim pack and pump support. It will be necessary to rotate the pump support to insert the oil lube tube into the pump support. Secure with six hex-head screws (18). Torque the screws 27 ± 2 lb. ft.

Acro-Set Method (Alternate Method).

1. Install pump drive Sleeve (Figure 12-4, 22) and press pin (23) through the drive sleeve and reverse shaft.

2. Install retaining ring (24) with ring ends 90° from the pin hole.

3. Install pump support (20) without O-ring (15) or shims (17).

4. Secure the pump support with two hex-head screws (18) 180° apart. Torque the screws 60 lb. in.

5. Rotate the reverse shaft a minimum of two revolutions and retorque the screws to 60 lb. in.

6. Measure with a taper gauge the gap between the pump support and manifold at each screw. Average the gap measurement readings. Add constant 0.013 inch to the average to determine the desired shim pack.

7. Measure the shim pack thickness to ensure that it is within ± 0.001 inch of the desired thickness.

8. Remove the pump support and ensure that the bearing cage rotates freely.

9. Install piston ring (16) onto the reverse shaft.

10. Install O-ring onto the pump support.

11. Install O-ring (Figure 12-1, 46) onto oil lube tube (47) and install oil lube tube into the manifold.

12. Install the pump support and shims. Rotation of the pump support will be necessary in order to insert oil lube tube into the pump support. Secure with six hex-head screws (Figure 12-4, 18). Torque the screws 27 ± 2 lb. ft.

Oil Filter.

1. Remove the hold-down bolt (Figure 12-1, 25) and spring (26) and install a new filter element (23).

2. Install piston (8), spring (9), and pipe plug (10) if removed into the filter head (7).

3. Install filter mounting gasket (13).

4. Install O-rings (14) (one on each end) onto connector tube (15).

5. Install the connector tube into the filter head.

6. Install the filter head and connector tube. See Figure 6-8.

7. Secure the filter head with three hex-head screws (Figure 12-1, 6) and one hex-head screw (11). Torque the screws 65 ± 5 lb. ft.

Oil Pump.

1. Install gasket (Figure 12-4, 21) and oil pump, indexing the spline on the pump drive shaft with the pump drive sleeve (22).

2. Secure with four 12-point head screws (19). See Figure 6-4. Torque the screws 27 ± 2 lb. ft.

Oil Strainer, Strainer Housing, and Hose.

1. Install oil strainer (Figure 12-1, 42) if removed into the oil strainer housing (38). See Figure 6-3.

2. Secure with plug (Figure 12-1, 45) and O-ring (44).

3. Install suction hose (34) onto strainer housing.

4. Install the strainer housing and gasket (43) onto oil pump (40).
5. Secure with four hex-head screws (39). See Figure 6-2. Torque the screws 15 ± 2 lb. ft.

Control Valve.

CAUTION

The control valve on the MG-514C and the control valve on other models of the MG-514 (e.g., MG-514, MG-514B, etc.) are not interchangeable.

1. Install gasket (Figure 12-6, 11) and control valve (Figure 12-1, 60).
2. Secure with two hex-head screws (49) and two hex-head screws (52). See Figure 6-1. Torque the screws 13 to 20 lb. ft.

Output Flange and Companion Flange.

1. Use a portable hydraulic press to install the output flange (Figure 12-5, 8) and seat it tightly against the bearing inner race.
2. Measure the gap between the rear end of the output shaft and the counterbore of the output flange. Use shims (5) 0.010-0.015 inch thinner than the gap.
3. Install rubber seal (6).
4. Install the shims and retainer washer (4). See Figure 6-20.
5. Secure with three hex-head screws (Figure 12-5, 3). Torque the screws 225 ± 20 lb. ft.

NOTE

Bolt holes in the companion flange (7), and output flange (8), are line reamed and match marked. The holes with the match marks must be aligned on assembly.

6. Install the companion flange and secure it with eight hex-head screws (10) and hex-nuts (9). Torque the nuts 225 ± 20 lb. ft.

PRIOR TO INSTALLATION

CAUTION

Most Twin Disc products mount directly onto the flywheel of the engine. Flywheel-to-driven-component interference is possible due to mismatch of components or other reasons. Therefore, engine crankshaft endplay as well as flywheel alignment checks must be made before the driven component is installed.

After installation of the driven component, crankshaft endplay should be measured again. Endplay at the second measurement should be the same as the first. A difference in these two endplay measurements could be an indication of interference. Consequently, the driven component should be removed and the source of interference found and corrected.

Twin Disc will not be responsible for system damage caused by engine to Twin Disc component interference regardless of the cause of interference. This engine crankshaft endplay check is considered mandatory.

General.

The marine transmission flange and pilot, and the engine flywheel and flywheel housing must be checked for trueness. Make certain the engine flywheel and the flywheel housing are clean prior to making the tests.

Checking the Marine Transmission Flange.

With the output shaft horizontal, bolt a thousandths indicator or gauge to the drive spider so that the indicator is perpendicular to the face of the housing, and the indicator stem is riding on the face of the flange (Figure 9-6). Rotate the drive spider and note the face runout of the transmission flange. The face runout must not exceed .012 inch maximum total indicator reading for the SAE No. 0 flange, or a .010 inch maximum total indicator reading for the SAE No. 1 flange.

Checking Marine Transmission Pilot Ring.

With the indicator bolted as in the paragraph above, adjust the indicator stem so that it will ride on the pilot surface of the flange (Figure 9-7). Rotate the drive spider and note the pilot surface runout must not ex-

ceed .008 inch for the SAE No. 0 flange, or .008 inch for the SAE No. 1 flange. This applies to a continuous 270 degree arc if the balance of the pilot surface is negative in reading; otherwise, it means all 360 degrees.

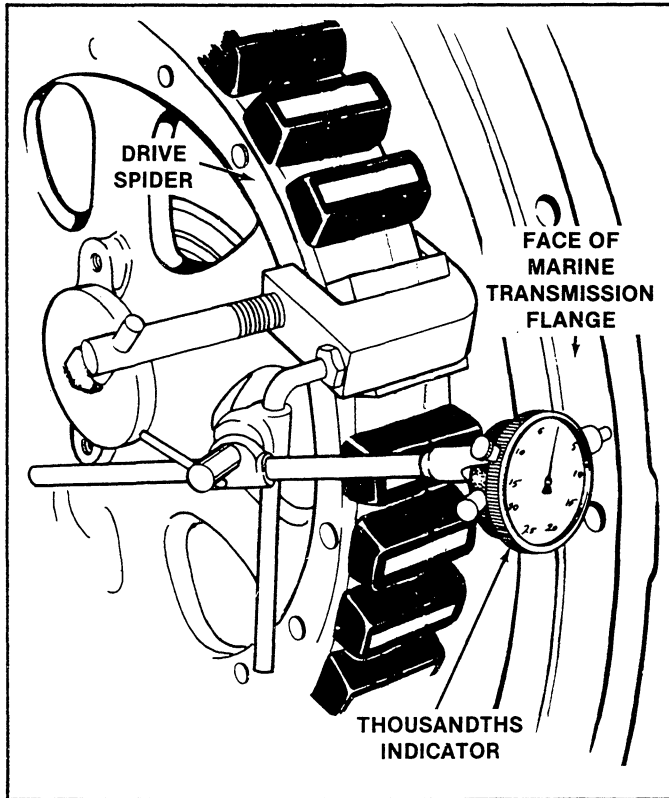


Figure 9-6. Checking the Face of the Front Housing Flange for Runout.

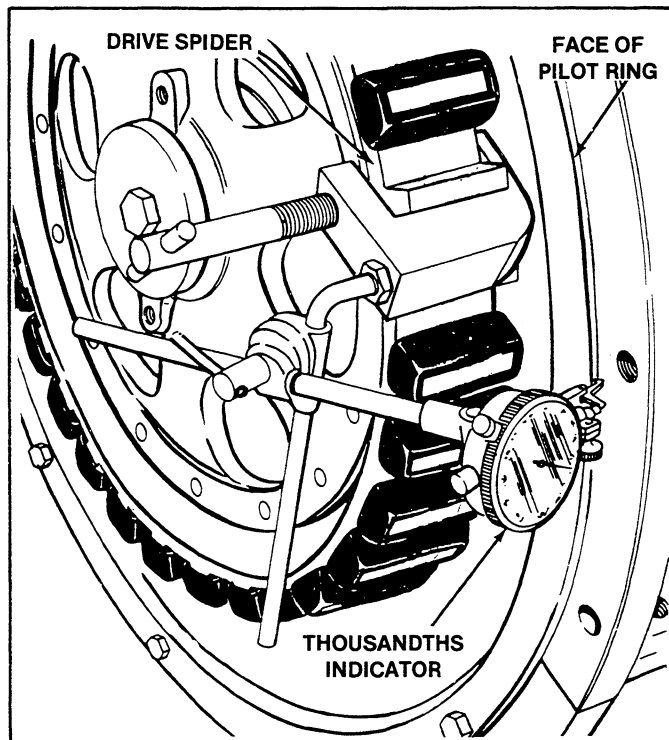


Figure 9-7. Checking the Pilot Ring for Runout.

Checking Face of the Propeller Flange.

Attach an indicator to the housing and check the propeller flange runout. Check the runout near the O.D. of the propeller flange. Runout must not exceed .005 inch.

Checking Pilot of Propeller Flange.

With the indicator attached to the housing, check the runout of the pilot of the propeller flange. Runout must not exceed .004 inch. If the runout is over tolerance on either of these propeller flange checks, remove the propeller flange, turn it 180 degrees and re-install it. If this does not correct the problem, replace the propeller flange.

ALIGNMENT.—(Also reference SAE J-1033)

1. Bolt a thousandths increment dial indicator or gauge to the engine flywheel so that the indicator is perpendicular to the face of the engine flywheel housing, and the indicator stem is riding on the face of the flange. See Figure 9-8.

2. Rotate the engine flywheel, always keeping a thrust in the same direction, and note the face deviation of the engine flywheel housing flange. The face deviation must not exceed the figures given in Table 9-1.

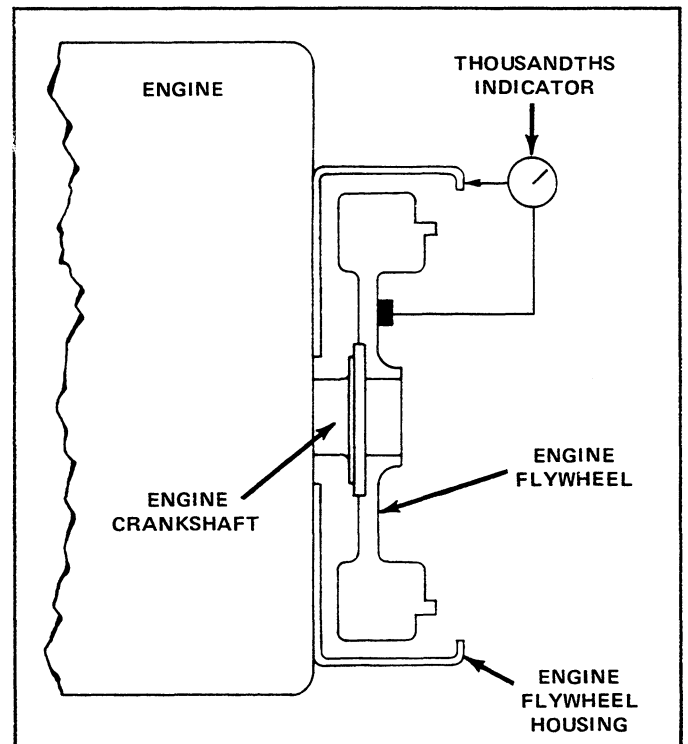


Figure 9-8. Checking the Face of Engine Flywheel Housing.

All figures are Total Indicator Readings.

SAE Housing No.	Face Deviations	Bore Eccentricity
00	.012	.012
0	.010	.010
½	.010	.010
1	.008	.008
2	.008	.008
3	.008	.008
4	.006	.006
5	.006	.006
6	.006	.006

Table 9-1. Flywheel Housing Tolerances

3. With the indicator mounted as in the above paragraph, adjust the indicator stem so that it will ride on the bore of the engine flywheel housing. See Figure 9-9.

4. Rotate the engine flywheel and note the bore eccentricity of the engine flywheel housing bore. See Table 9-1.

5. Bolt a thousandths dial indicator or gauge to the engine flywheel housing so that the indicator is perpendicular to the engine flywheel, and the indicator stem is riding on the inner face of the flywheel. See Figure 9-10. Rotate the flywheel. The variation of the face runout of the surface to which the driving ring is bolted should not exceed 0.0005 per inch of diameter.

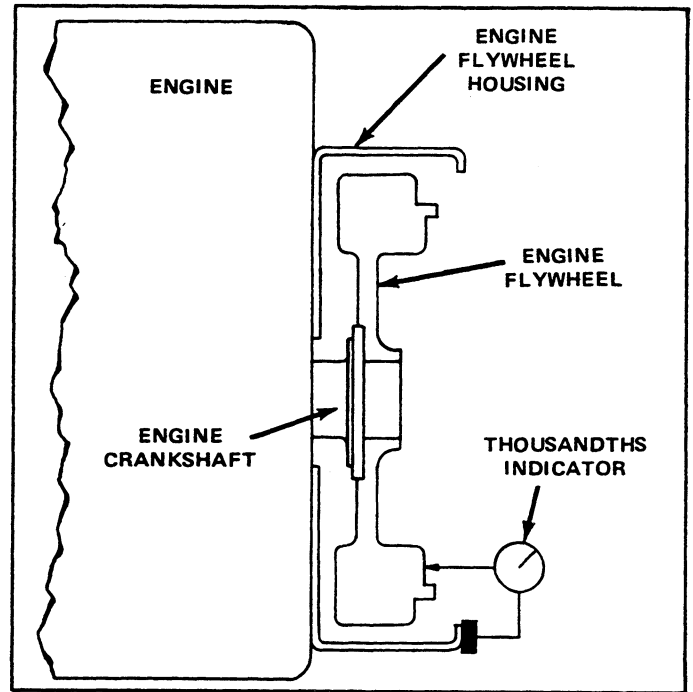


Figure 9-10. Checking the Driving Ring Surface of Engine Flywheel.

6. With the indicator mounted as in the paragraph above, adjust the indicator stem so that it will ride on the driving ring pilot bore of the engine flywheel. See Figure 9-11. Rotate the flywheel. The driving ring pilot bore eccentricity of the engine flywheel should not exceed 0.005 inch maximum total indicator reading. Thrust on the flywheel should be in one direction at all times to obtain a correct reading.

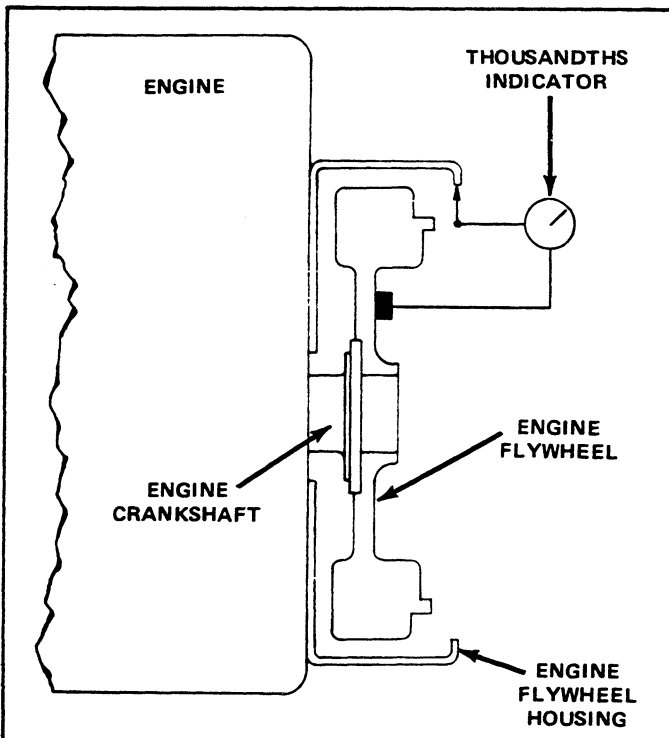


Figure 9-9. Checking the Bore of Engine Flywheel Housing.

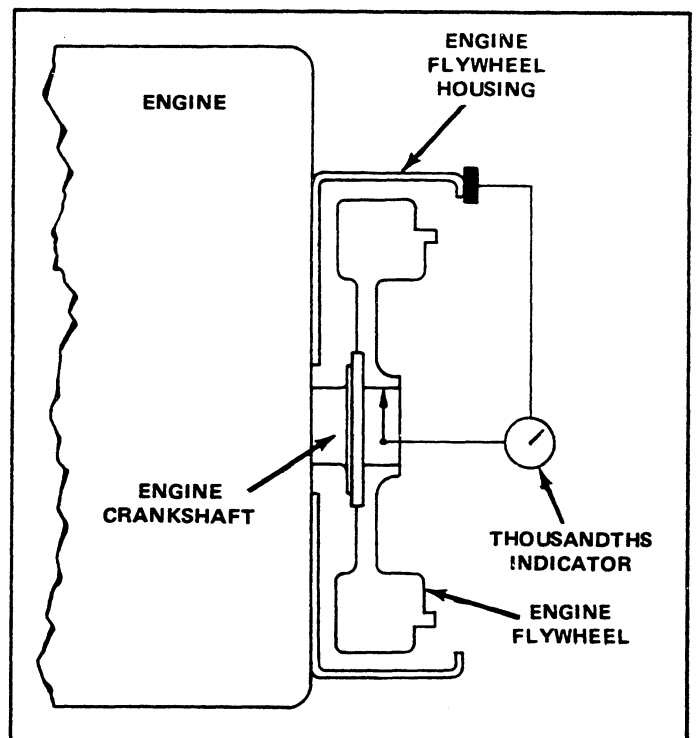
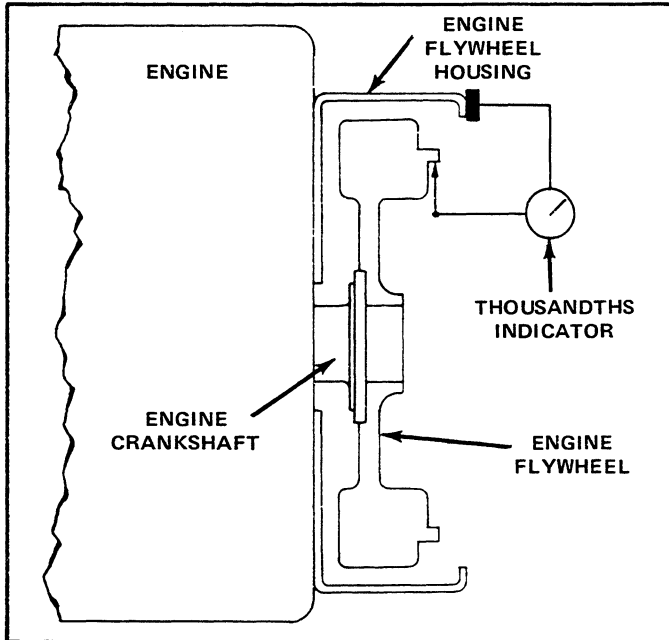


Figure 9-11. Checking the Driving Ring Pilot Bore of Engine Flywheel.

7. Readjust the indicator so that the stem will ride on the pilot bearing bore of the flywheel. See Figure 9-12. Rotate the flywheel. The eccentricity of the pilot bearing bore should not exceed 0.005 maximum total indicator reading. Eccentricity between the driving ring pilot bore (Figure 9-11 and pilot bearing bore (Figure 9-12) should not exceed 0.009 inch total indicator reading.



B Figure 9-12. *Checking Pilot Bearing Bore of Engine Flywheel.*

INSTALLATION.

Alignment.

Proper alignment of an engine and marine unit is critical . . . both during the initial installation and at frequent intervals during the life of the boat. It is rather common for a boat to change its form with various loads and with age. A bend is actually formed in the keel which changes the original engine and shaft alignment. The following steps may be taken to secure proper marine transmission alignment.

NOTE

The transmission output flange and companion flange are match reamed. Therefore, the index mark that was made on these flanges during disassembly must be aligned.

Propeller Shaft Installation.

1. A wire is run through the shaft log and secured to a brace near the engine bed, giving the wire a position equivalent to the shaft centerline.
2. The stern bearing and stuffing box are installed and bolted into position with the wire passing through each in the exact center of the bore. With the bearing and stuffing box in place, the wire is then removed.

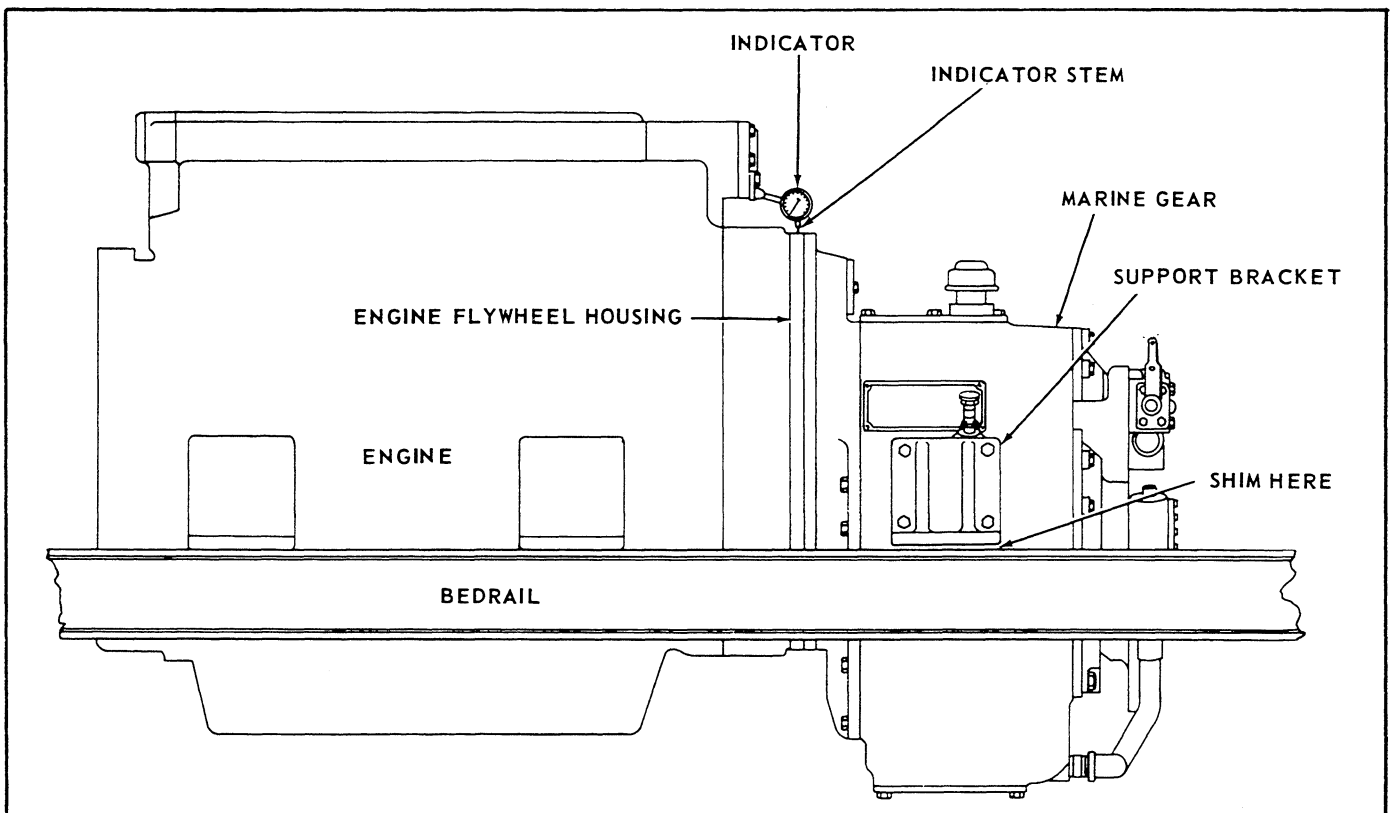


Figure 9-13. *Alignment of Engine and Marine Transmission—Schematic View.*

3. The propeller shaft is then installed in its proper position.

4. If an intermediate shaft is used, it is blocked into position and its coupling is aligned with the propeller shaft coupling (see the following section — “Engine and Marine Transmission Alignment”). If there is an intermediate bearing in the line, this is installed and positioned with shims during the alignment process.

5. If a light shaft is used without an intermediate bearing, the shaft must be centered and supported to take out the droop while alignment of the flange couplings is being made.

Engine and Marine Transmission Alignment to Propeller Shaft. See Figure 9-13.

1. It is important to align the engine and transmission, only when the boat is afloat, and NOT in dry-dock. During this alignment period, it is also advisable to fill the fuel tanks and add any other ballast that will be used when the boat is in service. With the engine and transmission in position on the engine bed, arrangements must be made to have a controlled lifting or lowering of each of the four corners of the engine. If threaded holes are provided in each of the engine mounts, jacking screws can be used in them. The engine can be raised by screwing down, or lowered by backing off the desired amount. Steel plates must be inserted under the jacking screws so that the bolts will not damage the engine bed. Lifting can also be accomplished by the use of chain hoists or properly placed jacks. Adjustable shims also are available and can simplify the whole problem, particularly for future realignment.

2. It will also be necessary to move the engine and transmission from one side or the other on the bed to obtain horizontal alignment. This can be done with a jack placed horizontally between the engine and the foundation. At the same time, a straight edge is laid across the edges of the flanges at the top and side to check the parallel alignment of the coupling edges. See Figure 9-14.

3. As the engine and marine transmission come into their aligned position, it will be possible to match the output flange and propeller coupling, and prepare for bolting together. Care should be taken not to burr or mar this connection because the fit is very critical. Place a 0.002-inch feeler gauge between the flanges of the coupling. The feeler gauge is moved (slid) completely around the coupling.

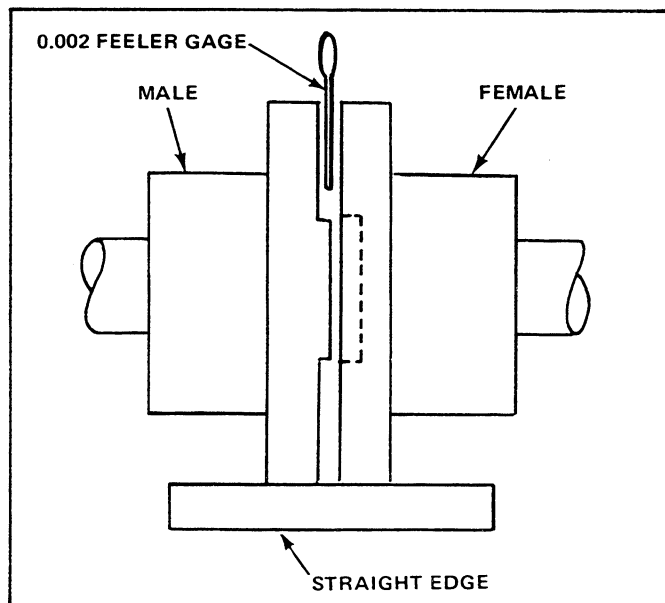


Figure 9-14 Checking Alignment (Parallelism) of Coupling and Propeller Flanges.

4. Then the marine transmission flange coupling is rotated 90, 180 and 270 degrees with the feeler blade being moved around the flange again in each successive position. If the alignment is correct, the feeler gauge will fit snugly, with the same tension, all around the flange coupling.

5. If the alignment varies during rotation, then further alignment is necessary, or the marine transmission and shaft couplings should be checked for improper face runout. Face runout on the marine transmission output flange can usually be corrected by repositioning the coupling on its spline. Shaft coupling runout is usually due to inaccuracy of taper fit or key interference.

6. Some boats are not structurally rigid and some carry their load in such a way that they will “hog” or go out of normal shape with every loading and unloading. Where this condition exists, it may be necessary to make a compromise between the top and bottom coupling clearance by leaving a greater clearance at the bottom of the marine transmission output flange and propeller coupling. This clearance might be 0.005 to 0.007-inch while the top would maintain the standard 0.002-inch.

7. During the process of securing final alignment, it may be necessary to shift the engine many times. When it becomes apparent that the alignment is reasonably close, the holes for the lag studs are marked and drilled. Then with final alignment secured, the necessary steel or hardwood shims are made up and

the engine and transmission is fastened in place. The alignment is then rechecked, and if satisfactory, the coupling is bolted together.

8. Although it is not necessary to align a flexible coupling as accurately as a solid coupling, the closer it is in the initial alignment, the more vibration-free it will be. The most accurate method of alignment is to align the shaft on to the marine transmission with flexible coupling out of the system. This can be done with a spacer the same size as the coupling but not flexible in nature. Flexible couplings are used only for noise and vibration

dampening . . . and not to correct inadequate alignment.

9. When a heavy boat is dry-docked, it naturally undergoes some bending. Therefore, it is always good practice to unbolt the marine transmission coupling and prevent bending of the shaft.

CAUTION

Be sure the transmission is filled with oil before starting. See Section 4 for proper oil and filling procedure.

Section 10.

ACCESSORIES AND OPTIONAL EQUIPMENT

ACCESSORIES

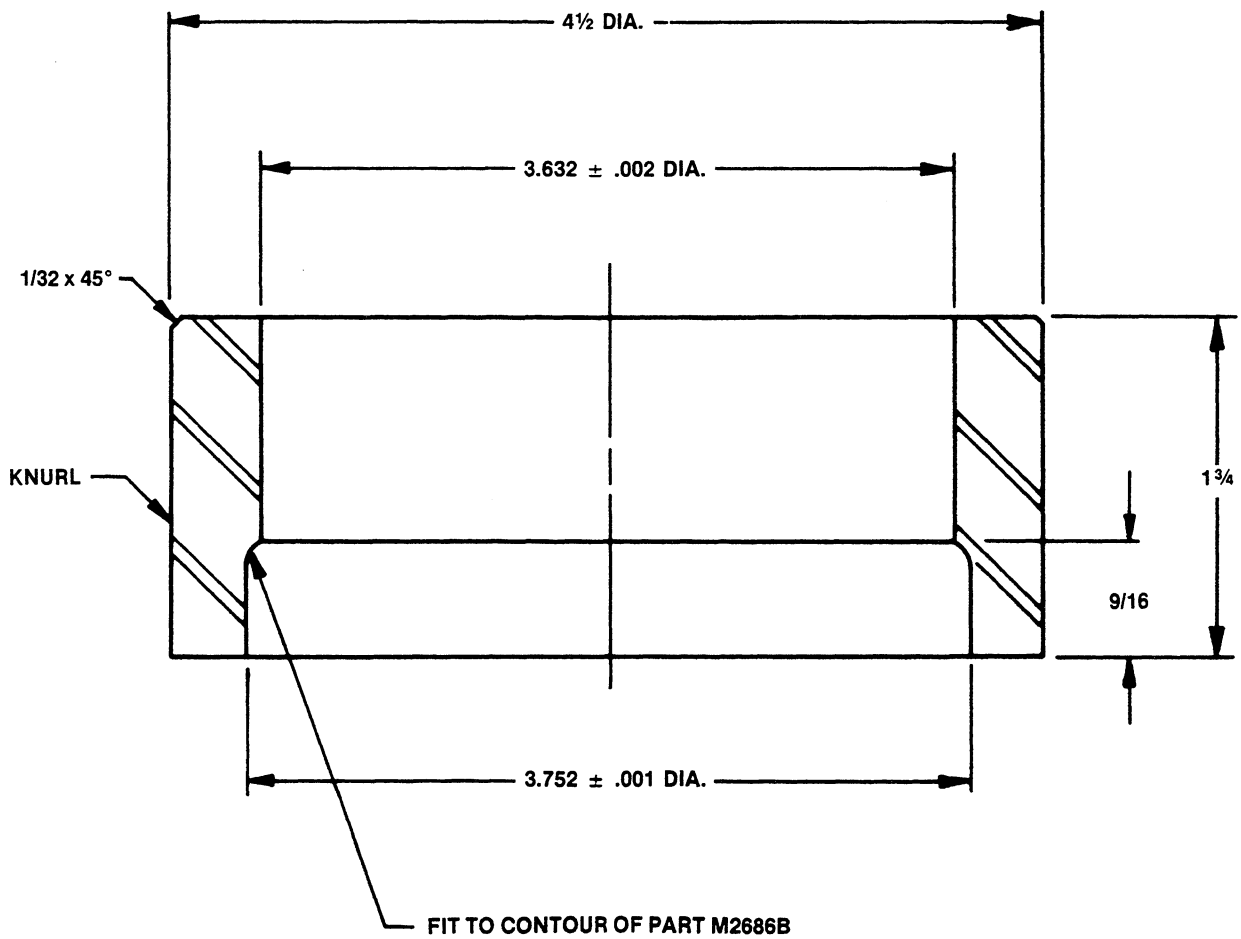
Twin Disc, Incorporated power takeoff unit P/N XA7297C is available for use with the MG-514C marine transmission.

Section 11.

SPECIAL TOOLS

SPECIAL TOOLS

Drawings in this section identify the special tool by tool number. All pertinent information necessary for tool fabrication is shown on each drawing. These tools are intended primarily to make maintenance procedures easier. Twin Disc will not manufacture these tools for general use.



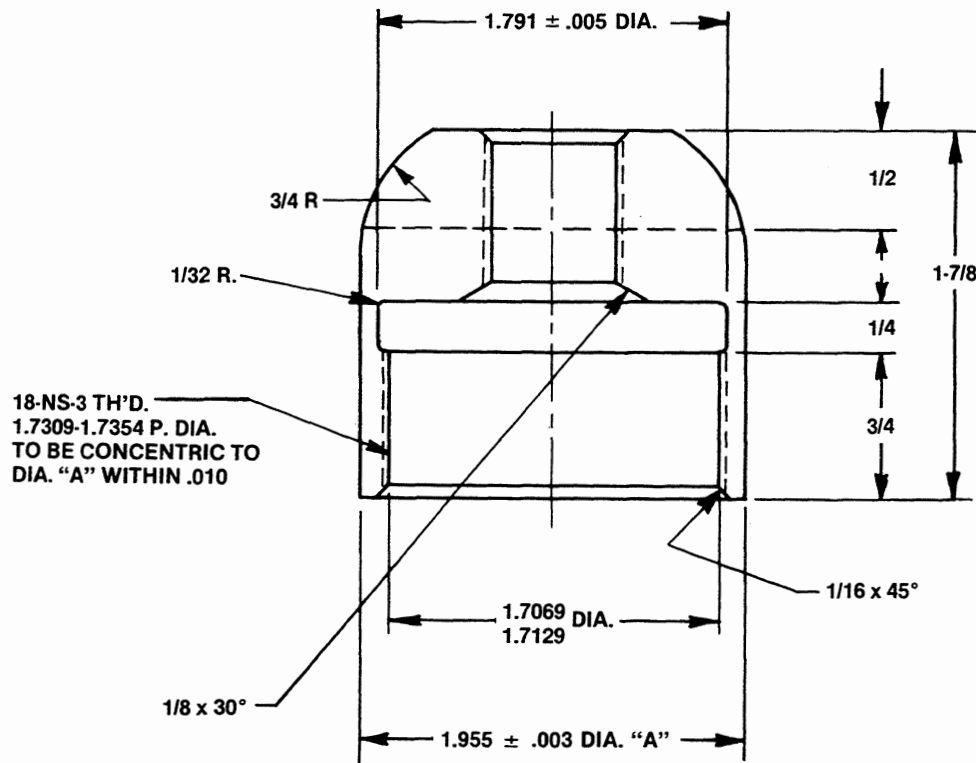
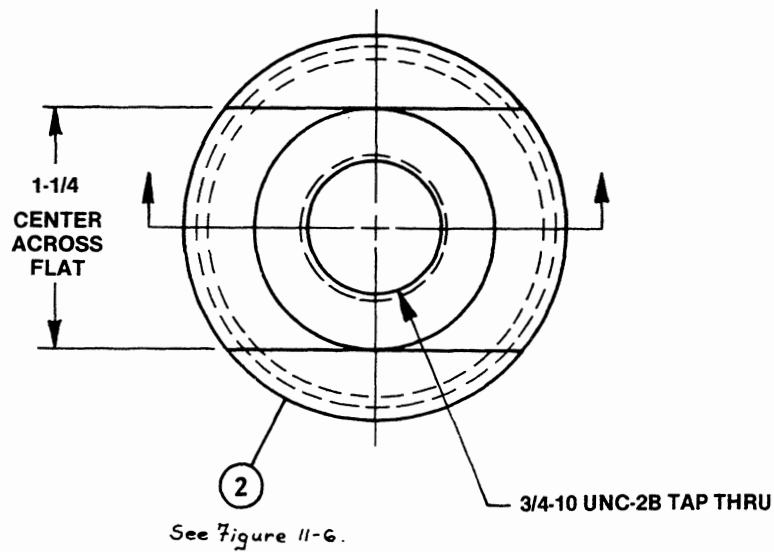
ASSEM. PT. M26868 & B6059

STAMP: T-18050-20

PT. X9786C

MAT'L-FIRMEX

Figure 11-1. Wear Sleeve Driver T-18050-20.

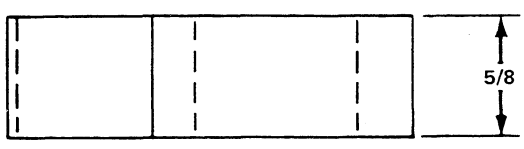
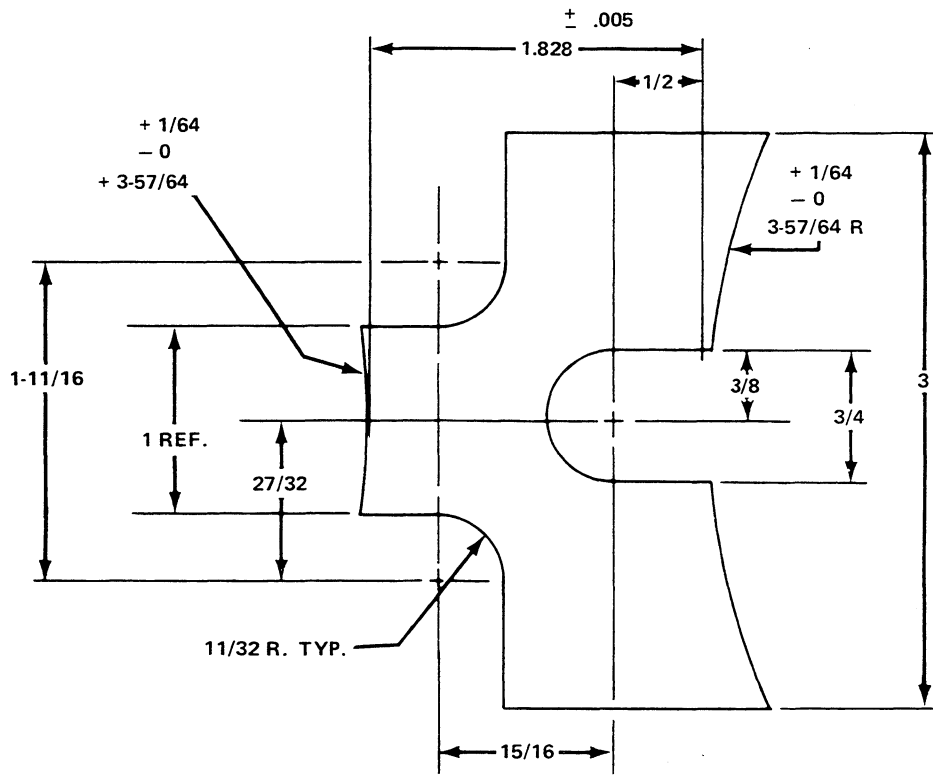


USED WITH OWATONNA
PULLER ROD Y-15-12

MAT'L 1141 OR 1144

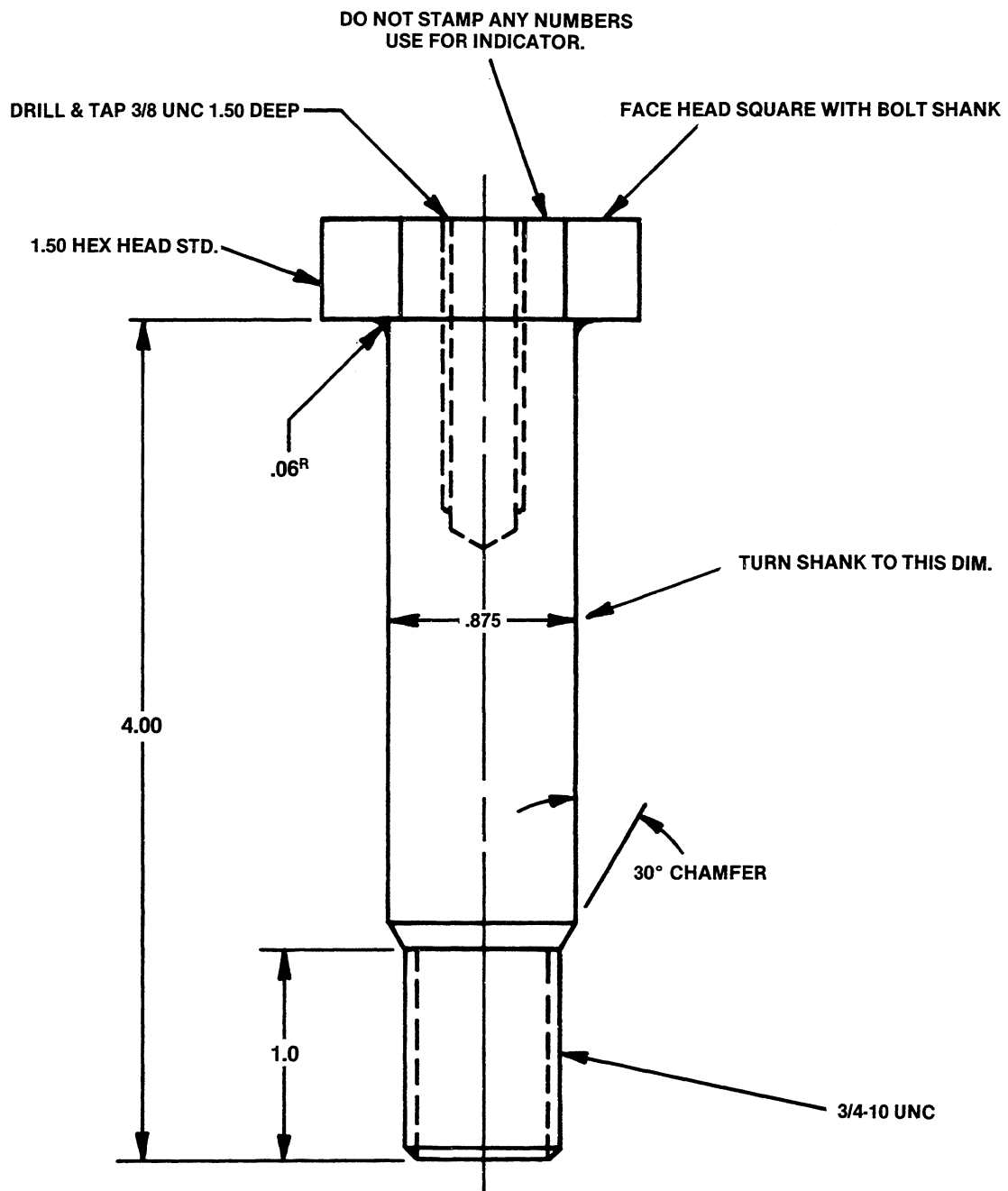
STAMP: T-18720-2 DET. 2

Figure 11-2. Assembly Spacer and Puller Nut T-18720-2.



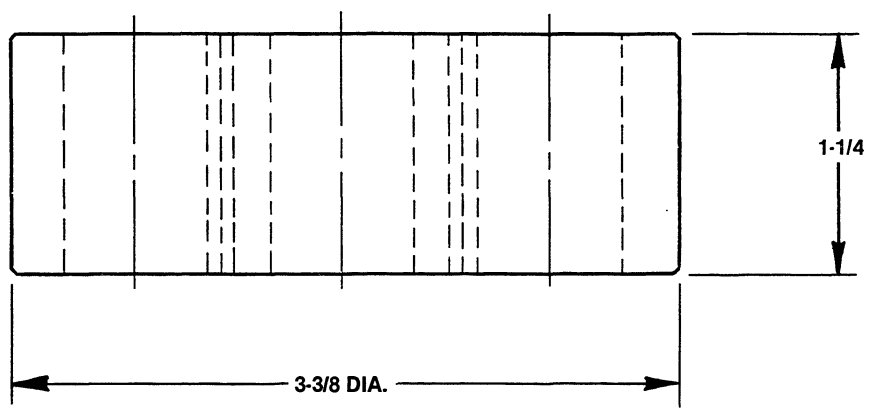
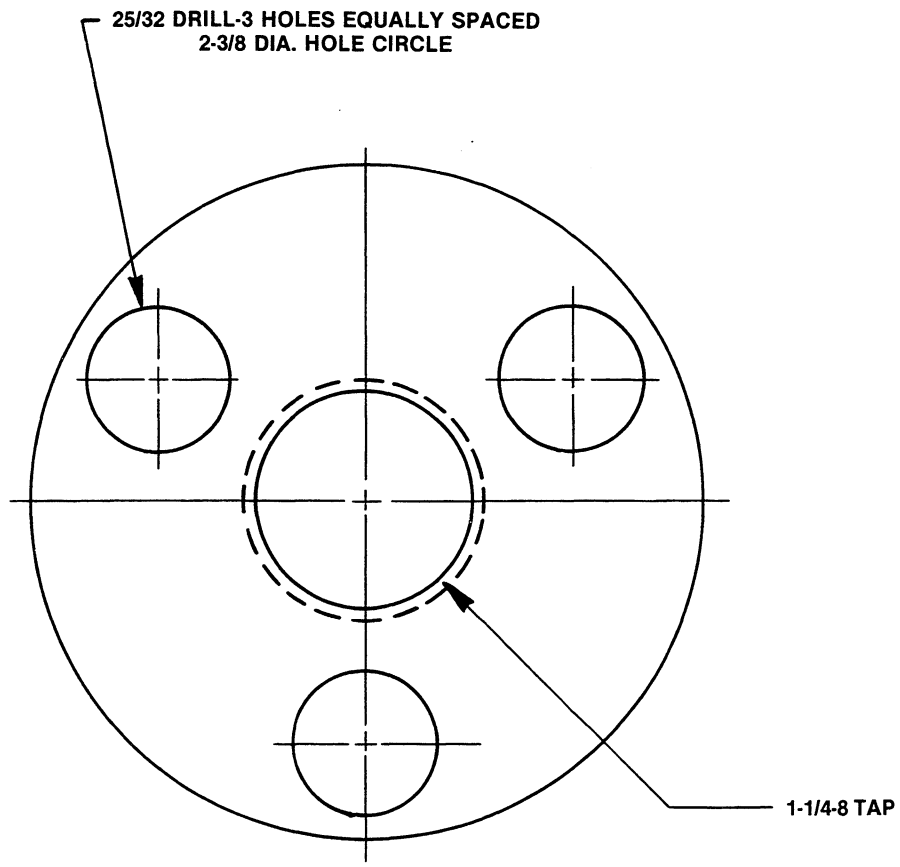
MATERIAL – MILD STEEL

Figure 11-3. Spider Indexing Tool T-18476.



MAKE FROM
M2009M CAPSCREW
1 x 4" OR EQUIV.

Figure 11-4. Clutch Endplay Fixture Tool T-18646.

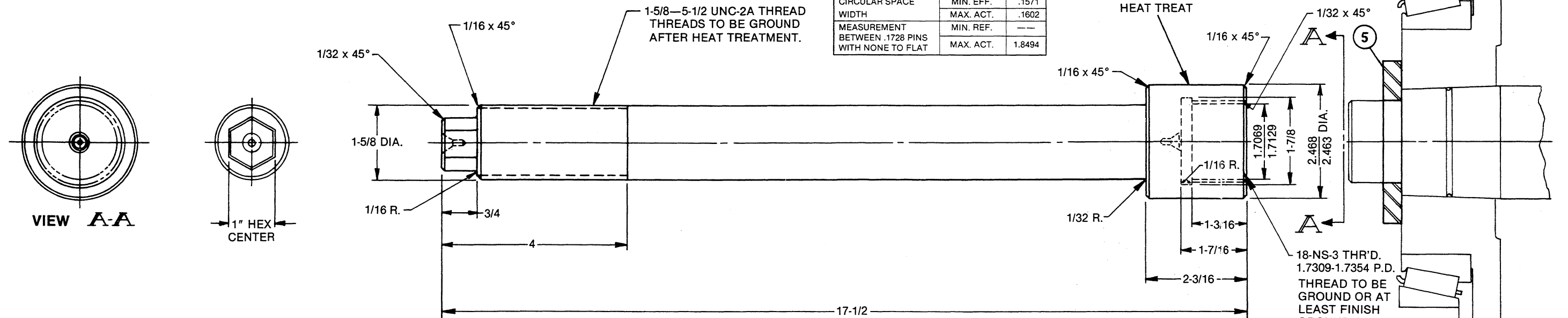


SHAFT, OUTPUT NO. A6979

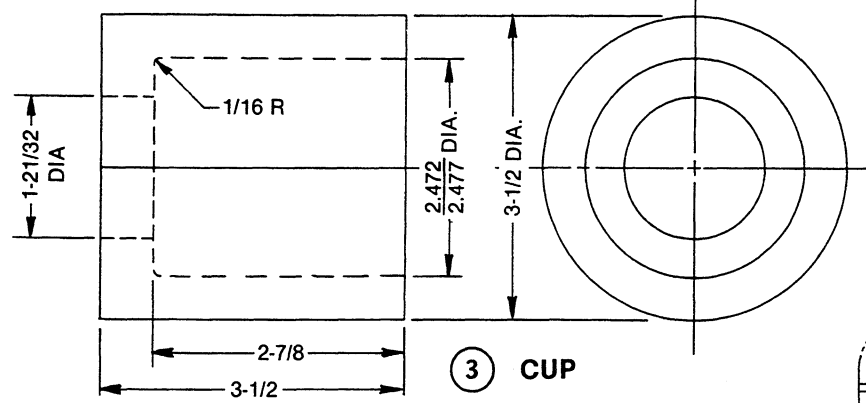
MAT: MACH. STEEL

Figure 11-5. Endplay Check Fixture T-18648.

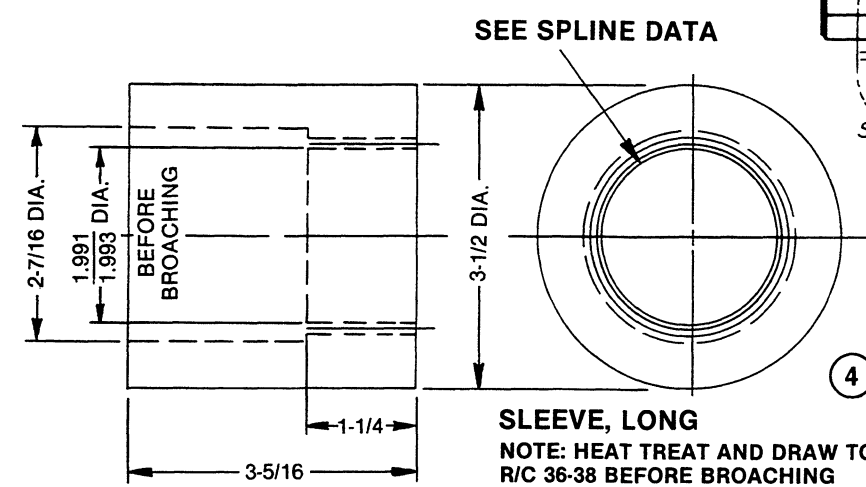
INTERNAL SPLINE DATA SEE S-435		
FLAT ROOT	PRESS. ANGLE = 30°	
NUMBER OF TEETH 21 PITCH 10/20		
PITCH DIA.(REF.) 2.100 MIN. FORM DIA. 2.1802		
MAJ. DIA. MAX.		2.2010
CIRCULAR SPACE	MIN. EFF.	.1571
WIDTH	MAX. ACT.	.1602
MEASUREMENT BETWEEN .1728 PINS WITH NONE TO FLAT	MIN. REF.	---
	MAX. ACT.	1.8494



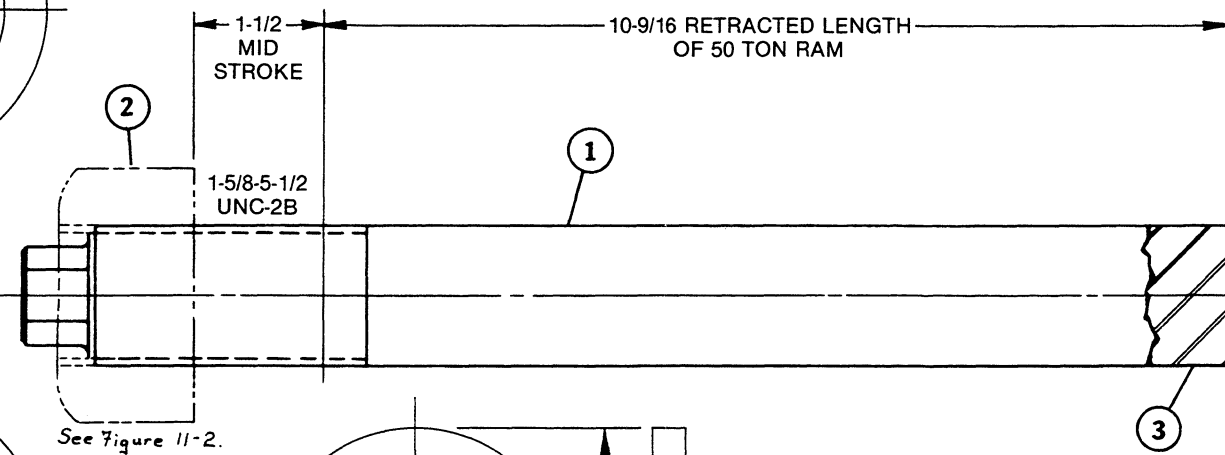
① PULLER ROD—MAT'L—SAE NO. 4340H (AIRCRAFT QUALITY).
 HEAT TREATMENT—
 HARDEN AND TEMPER PER S439-1 TO R/C 44-48
 CHECK HARDNESS ON 1-5/8 DIA. ONLY, DO NOT TOUCH THREADS.
 INSPECTION— .CHECK ALL SURFACES WITH MAGNIFLO EQUIPMENT.



③ CUP



④ SLEEVE, LONG
 NOTE: HEAT TREAT AND DRAW TO R/C 36-38 BEFORE BROACHING
 HEAT TREAT MUST BE HELD

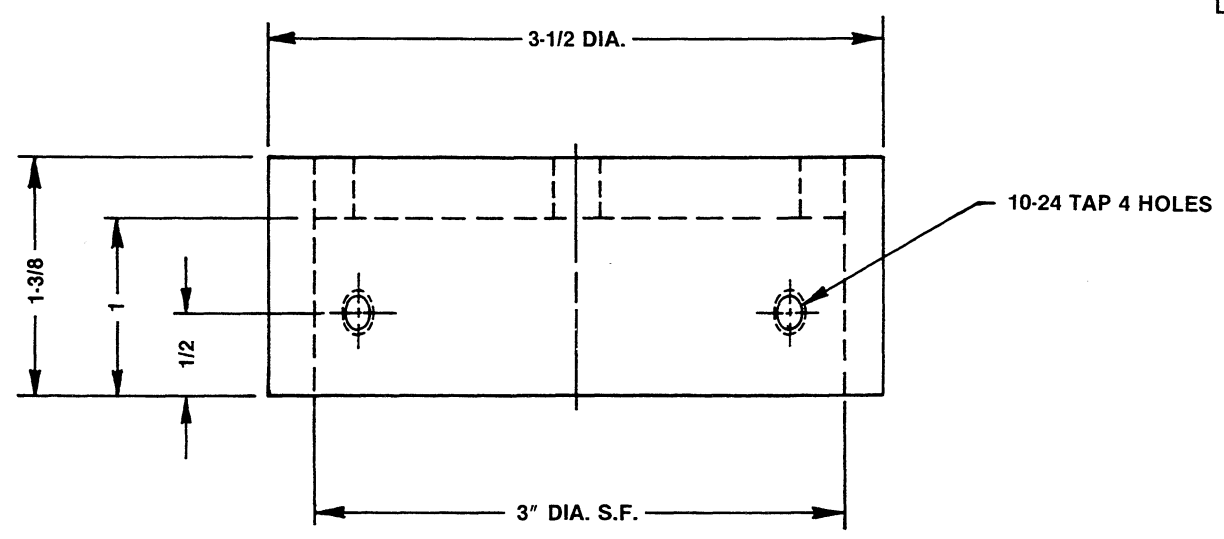
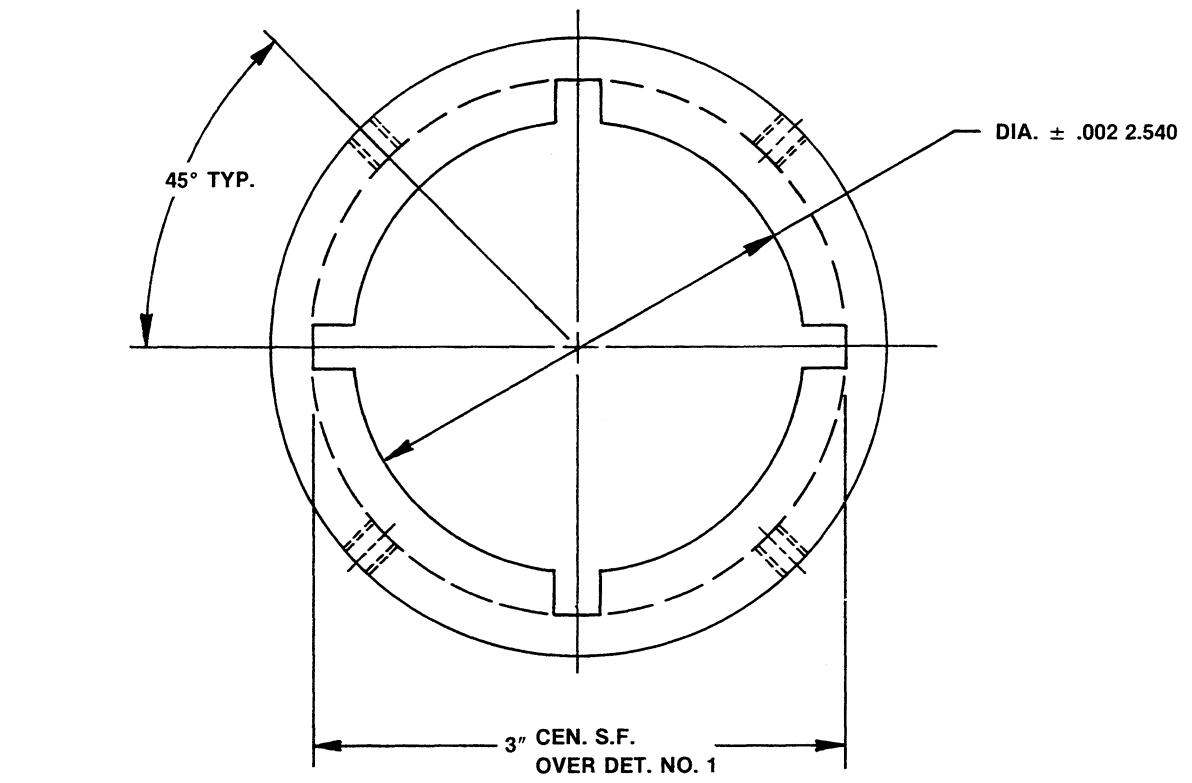


⑤ SLEEVE, SHORT
 HARDEN AND DRAW TO R/C 36-38

DET.	REQ.	MAT.	DESCRIPTION	STOCK SIZE
1	1	SEE NOTE	PULLER ROD	2-1/2" DIA. x 20" LONG
2	1	PUR.	HEAVY HEX. NUT	1-5/8-5-1/2 UNC-2B BETH. STEEL
3	1	4140	CUP	3-3/4 DIA. x 4-1/2" LONG
4	1	4140	SLEEVE, LONG (SEE NOTE)	3-3/4 DIA. x 4" LONG
5	1	4140	SLEEVE, SHORT (SEE NOTE)	3-3/4 DIA. x 3/4" LONG

PURCHASE FROM: CROWN
 SCREW AND BOLT CO.
 12550 ROBIN LANE, MILW. WI

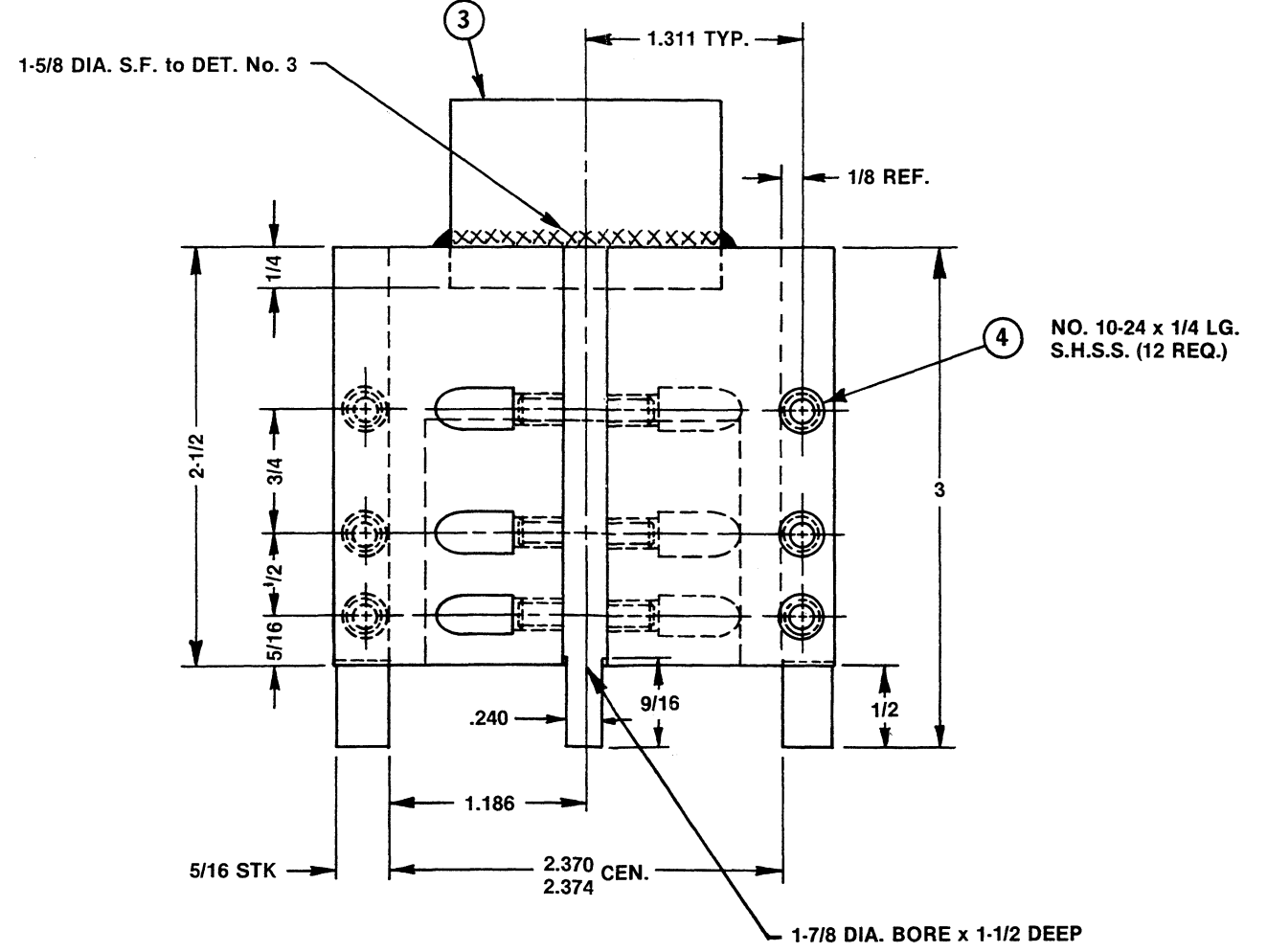
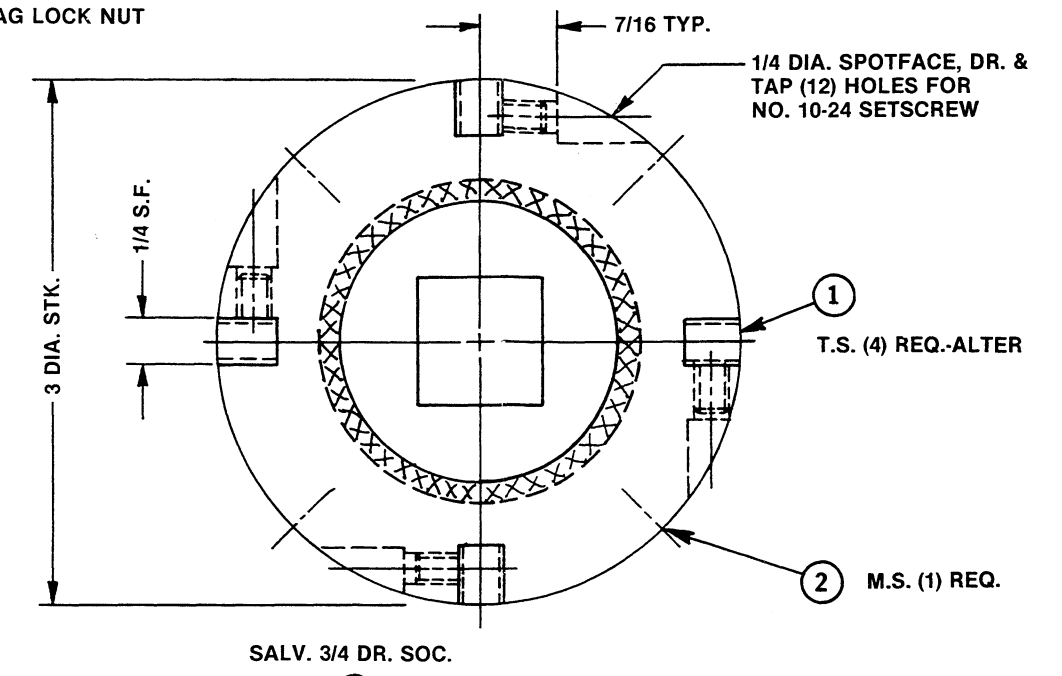
Figure 11-6. Forward & Reverse Shaft Gear Puller T-18410-2.



5
C.R.S.

SPOT (4) HOLES FOR 10-24 5CR LOCATE FROM DET. 5

ASS'Y M-2281-AG LOCK NUT



STAMP: T-18589-1 PT. NO. X9786C

Figure 11-7. Spanner Wrench T-18589-1.




Section 12.

DRAWINGS AND DATA

The following drawings and data of the product for which this manual was written are included for your convenience.

TORQUE VALUES

FOR TIGHTENING CAPSCREWS, BOLTS, NUTS, TUBE FITTINGS AND PLUGS.

CAP SCREWS, BOLTS & NUTS					
TORQUE (LB. FT.) FOR COURSE AND FINE THREADS (1)					
NOMINAL THREAD DIAMETER	SAE GRADE 5		SAE GRADE 8		Screws for Universal Joint Bearing Caps
	AS (2) RECEIVED	LUBRI- (3) CATED	AS (2) RECEIVED	LUBRI- (3) CATED	
1/4	9 ± 1	7 ± 1	14 ± 1	11 ± 1	----
5/16	19 ± 2	15 ± 2	27 ± 2	22 ± 2	----
3/8	33 ± 3	27 ± 2	46 ± 4	38 ± 3	----
7/16	52 ± 4	40 ± 3	73 ± 6	60 ± 5	64 ± 4
1/2	80 ± 6	65 ± 5	112 ± 8	90 ± 7	100 ± 7
9/16	112 ± 8	90 ± 8	158 ± 12	130 ± 10	----
5/8	158 ± 12	130 ± 10	224 ± 16	180 ± 15	190 ± 10
3/4	280 ± 20	225 ± 20	390 ± 30	320 ± 25	330 ± 17
7/8	448 ± 32	360 ± 30	630 ± 50	510 ± 40	510 ± 25
1	680 ± 50	540 ± 45	960 ± 70	775 ± 60	----
1 1/8	850 ± 60	675 ± 60	1360 ± 100	1100 ± 85	----
1 1/4	1175 ± 85	925 ± 75	1850 ± 150	1500 ± 125	----
	3 DASHES 120° APART 		6 DASHES 60° APART 		
	SAE STANDARD HEX BOLT HEAD MARKINGS				

TAPERED PIPE PLUGS		
RECOMMENDED TORQUE (LB. FT.)		
NPTF SIZE	LUBRICATED (a)	
	In Cast Iron or Steel	In Aluminum
1/16-27	8.5 ± 1.0	5.5 ± 0.7
1/8-27	10.5 ± 1.3	6.5 ± 0.8
1/4-18	25 ± 3	16 ± 2
3/8-18	27 ± 3	17 ± 2
1/2-14	50 ± 6	30 ± 4
3/4-14	54 ± 7	34 ± 4
1 -11 1/2	80 ± 10	50 ± 6
1 1/4-11 1/2	85 ± 10	55 ± 7
1 1/2-11 1/2	85 ± 10	55 ± 7

(a) THE LUBRICANT IS TO BE JOHN CRANE INSOLUBLE PLASTIC LEAD SEAL NO. 2 OR EQUIVALENT OR LOCTITE NO. 92 OR EQUIVALENT AND PLUGS ARE TO BE CAPABLE OF REMOVAL WITHOUT DAMAGE. OVERTIGHTENING MAY CAUSE INITIAL LEAKAGE PLUS POTENTIAL REMOVAL DAMAGE. AN OPTION OF A MAX. OF TWO FULL TURNS AFTER FINGER TIGHTENING THE PLUG MAY BE USED IF REQUIRED AND IF REMOVAL CONDITIONS ARE MET.

(1) THESE TORQUE VALUES APPLY TO USE OF IRONS, STEELS AND ALUMINUM TAPPED HOLES.

THE THREAD ENGAGEMENT LENGTH IN ALUMINUM IS TO BE TWICE THE NOMINAL THREAD DIAMETER AND ENGAGEMENT LENGTH RATIO IS TO BE 1.5 FOR IRONS AND SOFT STEEL. WHEN ZINC PLATING IS USED, LUBRICATE THE ZINC PLATED SURFACES OF THE SCREWS AND/ OR NUTS AND USE SPECIAL TORQUE VALUES.

(2) USE FOR ALL CAPSCREWS, BOLTS AND NUTS COATED ONLY WITH THE FASTENER MANUFACTURER'S RUST PREVENTATIVE OIL AND USE FOR PARTS WIPED OR WASHED NEARLY FREE OF OIL. DO NOT USE FOR PLATED PARTS.

(3) USE FOR ALL CAPSCREWS AND NUTS WHOSE THREADS AND WASHER FACE ARE LUBRICATED, ALSO FOR SCREWS OR NUTS WHOSE WASHER FACE IS ASSEMBLED AGAINST A HARDENED WASHER OR SMOOTH FINISHED HARD PART. (Rc40 OR ABOVE AND 40AA MAX.). ALSO USE FOR PLATED SCREWS (EXCEPT ZINC PLATED). LUBRICATING THE THREADS AND SCREW OR NUT FACE WITH SAE 20 OR 30 OIL IS RECOMMENDED FOR BEST RESULTS FOR ALL THE GRADE 8 SCREWS AND IS REQUIRED FOR ALL THE UNIVERSAL JOINT BEARING CAPSCREWS.

DO NOT USE MOLY-DISULFIDE, WHITE LEAD, COPPER FILLED OR OTHER SUCH FILLED LUBRICANTS WITH THESE TORQUE VALUES. SUCH LUBRICANTS REQUIRE SPECIAL TORQUE VALUES.

(4) SOCKET HEAD SCREWS AND 12 POINT HEAD SCREWS WITH FULL BODY ARE GRADE 8 OR BETTER QUALITY AND ARE TO BE ASSEMBLED WITH THE ABOVE TORQUE VALUES.

BEARING LOCKNUT TORQUE

Size	M-2012	M-2281	(1) Torque Lb. Ft.	M2012	(1) Torque Lb. Ft.	M-2037	(1) Torque Lb. Ft.
01 03	BC A		15 ± 2 34 ± 5				
04 05 06	B C D	C	46 ± 6 75 ± 10 92 ± 12				
07 08	E F	F	125 ± 16 160 ± 20	AF	230 ± 30	E (3) F	150 ± 20 190 ± 25
09 10 11	G H J	G H J	200 ± 25 240 ± 30 290 ± 40	(2) AG AH AJ	300 ± 40 370 ± 50 440 ± 55	G H J	240 ± 30 290 ± 40 350 ± 45
12 13 14	K L M	K M	350 ± 45 400 ± 50 460 ± 60	AK AL AM	530 ± 70 600 ± 75 710 ± 90	K L M	430 ± 55 490 ± 65 580 ± 75
15 16 17	N P Q	AJ P	550 ± 70 660 ± 85 770 ± 100	AN AP AQ	830 ± 110 1000 ± 130 1200 ± 150	N & AN P Q	680 ± 85 800 ± 100 950 ± 120
18 19 20	R S T	— S & AH	900 ± 120 1000 ± 130 1150 ± 150	AR AS AT	1350 ± 170 1500 ± 190 1700 ± 225	R S T	1100 ± 140 1300 ± 170 1400 ± 180
21 22 24	U V W	V	1300 ± 170 1400 ± 180 1800 ± 225	AU AV AW	2000 ± 250 2200 ± 275 2700 ± 350	U V W	1600 ± 200 1800 ± 225 2200 ± 275
26 28 30	X Y Z	X	2200 ± 275 2600 ± 325 3100 ± 400	AX AY AZ	3300 ± 425 4000 ± 500 4800 ± 600	X Y Z	2700 ± 350 3300 ± 425 4000 ± 500

- (1) TORQUE VALUES APPLY TO SOLID SHAFTS.
TORQUE VALUES MAY OR MAY NOT BE SATISFACTORY ON THIN-WALLED SHAFTS.
TORQUE VALUES APPLY TO THREADS LUBRICATED WITH SAE 20 OR 30 OIL.
- (2) M-2281-AG IS TO HAVE SAME ASSEMBLY TORQUE AS M-2012-AG.
- (3) M-2037-AA IS TO HAVE 120 ± 15 LB. FT. ASSEMBLY TORQUE.

**STRAIGHT THREADED TUBE FITTINGS, HOSE FITTINGS
AND PLUGS WITH "O" RINGS.**

**FOR 37°, 45° AND INVERTED FLARED FITTINGS PER SAE STANDARDS
J512, J514, and J516 WITH LATEST SUFFIX.**

(1)

**FOR TAPER PIPE THREADED FITTINGS USE THE PIPE PLUG TORQUE
VALUES SHOWN ON PAGE 1.**

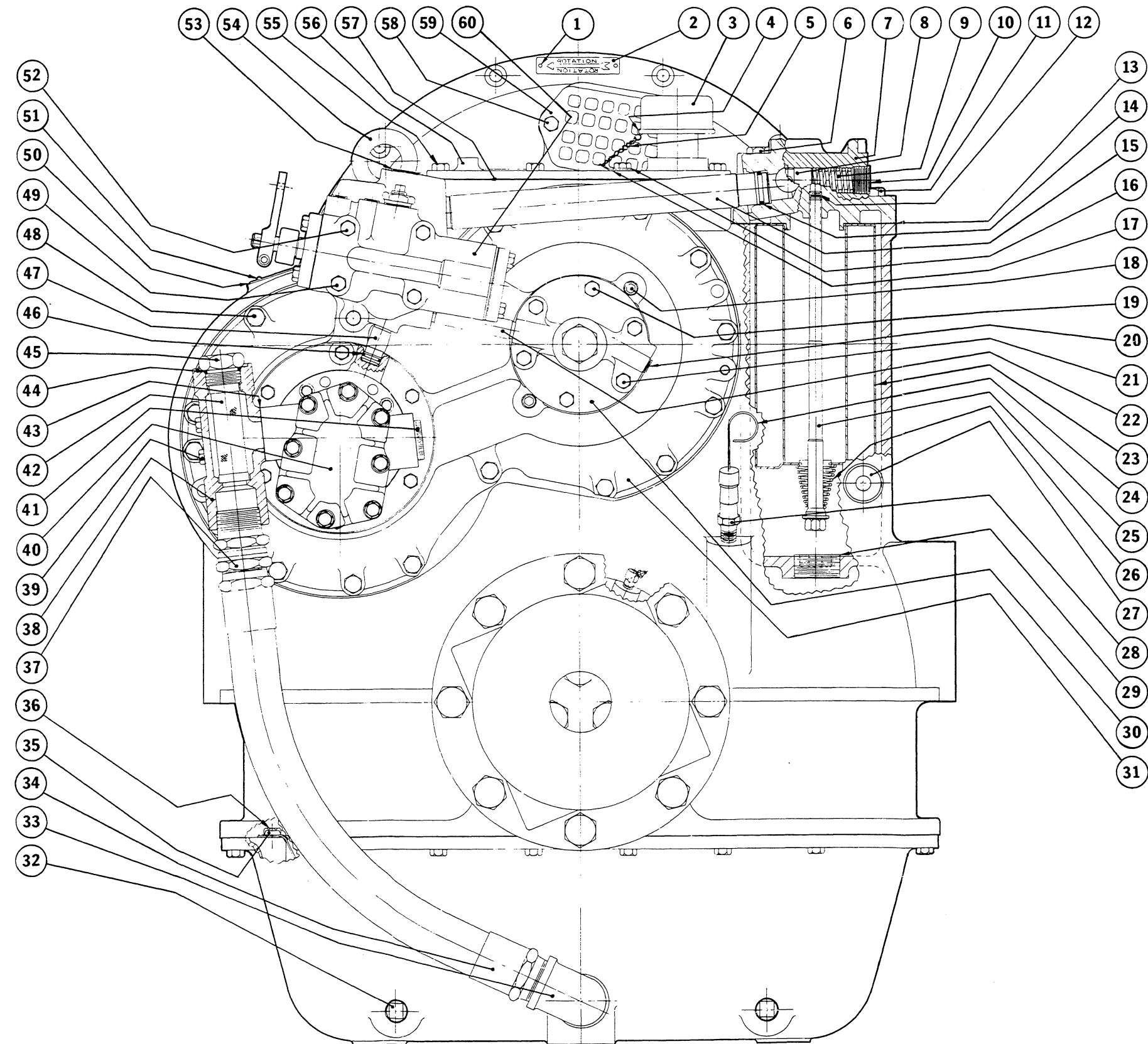
NOMINAL THREAD O.D.	NOMINAL TUBE SIZE	PLUG PART NUMBER (2)	TIGHTENING TORQUE, LB. FT. NUTS & PLUGS	TORQUE LB. IN. EQUIV.
5/16	1/8	---	3.6 ± 0.5	43 ± 6
3/8	3/16	M2080G	8.6 ± 1.0	103 ± 12
7/16	1/4	M2080E	12 ± 1.5	144 ± 18
1/2	5/16	M2080C	15 ± 2	180 ± 24
9/16 & 5/8	3/8	M2080A	18 ± 2	216 ± 24
11/16	7/16	---	25 ± 3	
3/4	1/2	M2080K	30 ± 4	
7/8	5/8	M2080M	40 ± 5	
1-1/16	3/4	M2080F	55 ± 7	
1-3/16 & 1-1/4	7/8	M2080N	65 ± 8	
1-5/16 & 1-3/8	1	M2080B	80 ± 10	
1-5/8	1-1/4	M2080J	100 ± 12	
1-7/8	1-1/2	M2080D	120 ± 15	
2-1/2	2	M2080X	230 ± 30	

(1) THIS CHART DOES NOT APPLY TO OTHER THAN THE 3 FLARED DESIGNS QUOTED.
THUS DO NOT USE THIS DATA FOR SLEEVED COMPRESSION TYPE FITTINGS,
REFRIGERATION TUBE FITTINGS, AIR LINE TUBE FITTINGS NOR THE MANY
FLARELESS FITTINGS.

(2) THIS IS A PARTIAL LIST. USE THREAD O.D. TO DETERMINE THE RECOMMENDED
ASSEMBLY TORQUE OF THE UNLISTED STRAIGHT THREAD "O" RING PLUGS.

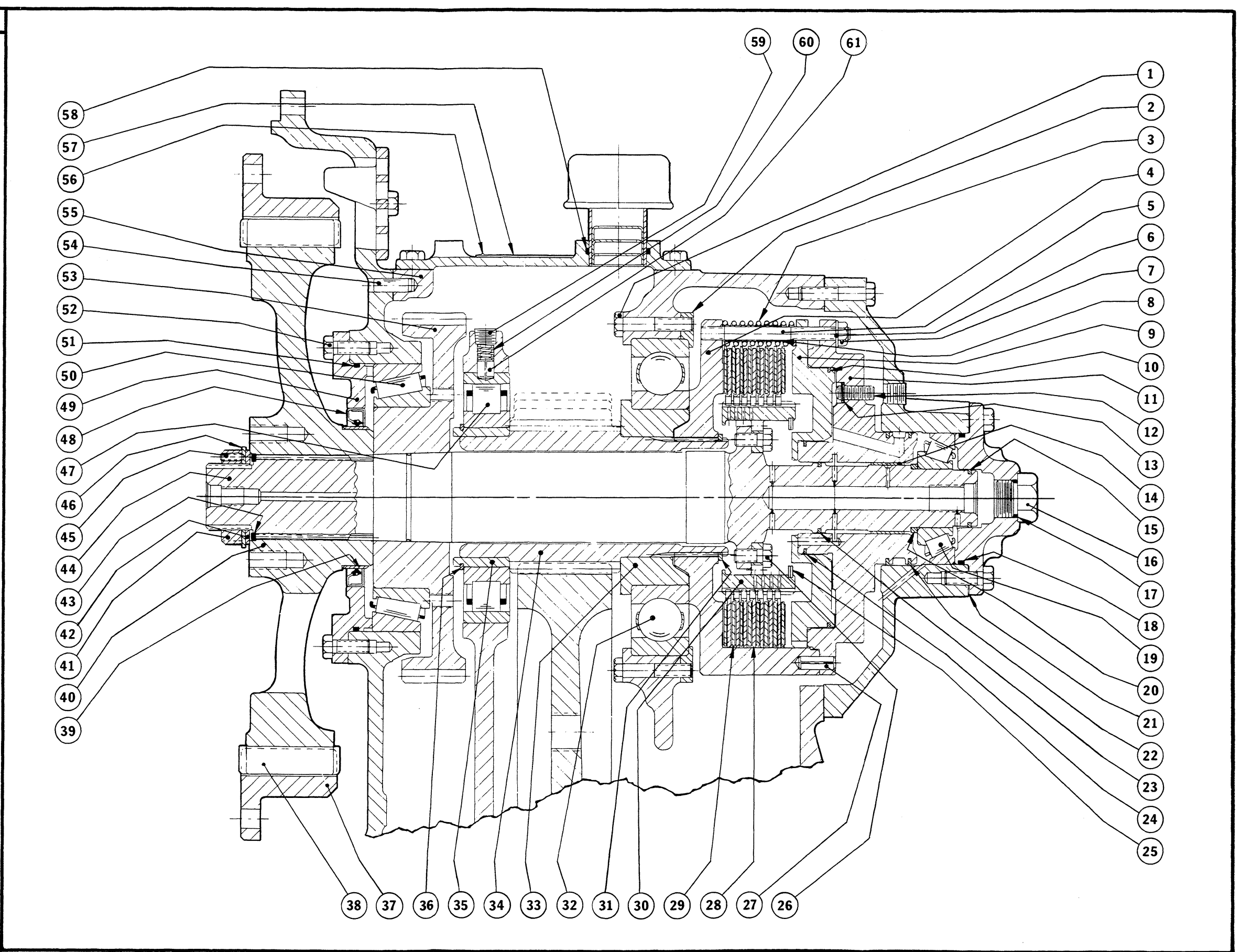
THE FLARELESS FITTINGS ARE BEST ASSEMBLED WITH NUMBER OF TURNS AFTER SOME
INITIAL TIGHTENING OR RUNNING TO THE STOP PROVIDED AND THEN TIGHTENING
WITH AN ADDITIONAL 5 TO 50 POUNDS FEET OF TORQUE. NO STANDARD DATA HAS
BEEN PREPARED FOR THE FLARELESS FITTINGS.

Item	Description	Qty
1	SCREW, Drive	2
2	PLATE, Rotation Indicator	1
3	BREATHER, Assembly	1
4	LINK, "S" Breather	1
5	CHAIN, Breather	1
6	SCREW, Hex-Head (1/2 x 3.25)	3
7	HEAD, Filter	1
8	PISTON	1
9	SPRING, Piston	1
10	PLUG, Pipe (3/4)	2
11	SCREW, Hex-Head (1/2 x 1.75)	1
12	SETSCREW (1/2 x 0.25)	1
13	GASKET, Filter Mounting	1
14	O-RING	2
15	TUBE, Connector	1
16	WASHER, Plain (3/8)	1
17	CLIP, Breather Chain	1
18	PLUG, Pipe (3/8) Come Home	4
19	SCREW, Hex-Head (3/8 x 1.00)	2
20	PLUG, Pipe (3/8 NPT)	1
21	SCREW, Hex-Head (3/8 x 1.50)	4
22	TUBE, Oil Lube	1
23	ELEMENT, Filter (25 Micron)	1
24	GAUGE, Oil Level	1
25	BOLT, Hold-Down (Filter)	1
26	SPRING, Hold-Down	1
27	PLUG, Thinwall	1
28	TUBE, Oil Gauge	1
29	PLUG, Pipe (1-1/2 NPT)	1
30	RETAINER, Bearing	1
31	MANIFOLD	1
32	PLUG, Pipe (3/4) Oil Drain	2
33	ELBOW, Suction Hose (1-1/4 x 90°)	1
34	HOSE, Suction (21-1/4 x 1-1/4 NPT)	1
35	LOCKPLATE, Gear Pan	4
36	SCREW, Hex-Head (3/8 x 0.625)	4
37	UNION, Adapter (1-1/4 NPT)	1
38	HOUSING, Strainer	1
39	SCREW, Hex-Head (5/16 x 2.75)	4
40	PUMP, Oil	1
41	PLUG, Thinwall	1
42	STRAINER, Oil	1
43	GASKET, Strainer Housing	1
44	O-RING	1
45	PLUG	1
46	O-RING	4
47	TUBE, Oil Lube	1
48	SCREW, Hex-Head (3/8 x 1.75)	16
49	SCREW, Hex-Head (3/8 x 8.0)	2
50	PLATE, Instruction	1
51	SCREW, Drive	4
52	SCREW, Hex-Head (3/8 x 2.75)	2
53	PLUG, Pipe (3/4)	1
54	EYEBOLT	2
55	SCREW, Hex-Head (3/8 x 0.875)	10
56	COVER, Top	1
57	GASKET, Top Cover	1
58	SCREW, Hex-Head (3/8 x 0.875)	2
59	COVER, Ventilating	1
60	VALVE Assembly, Control	1



Rear External Parts and Oil Filter Cross Section. Figure 12-1.

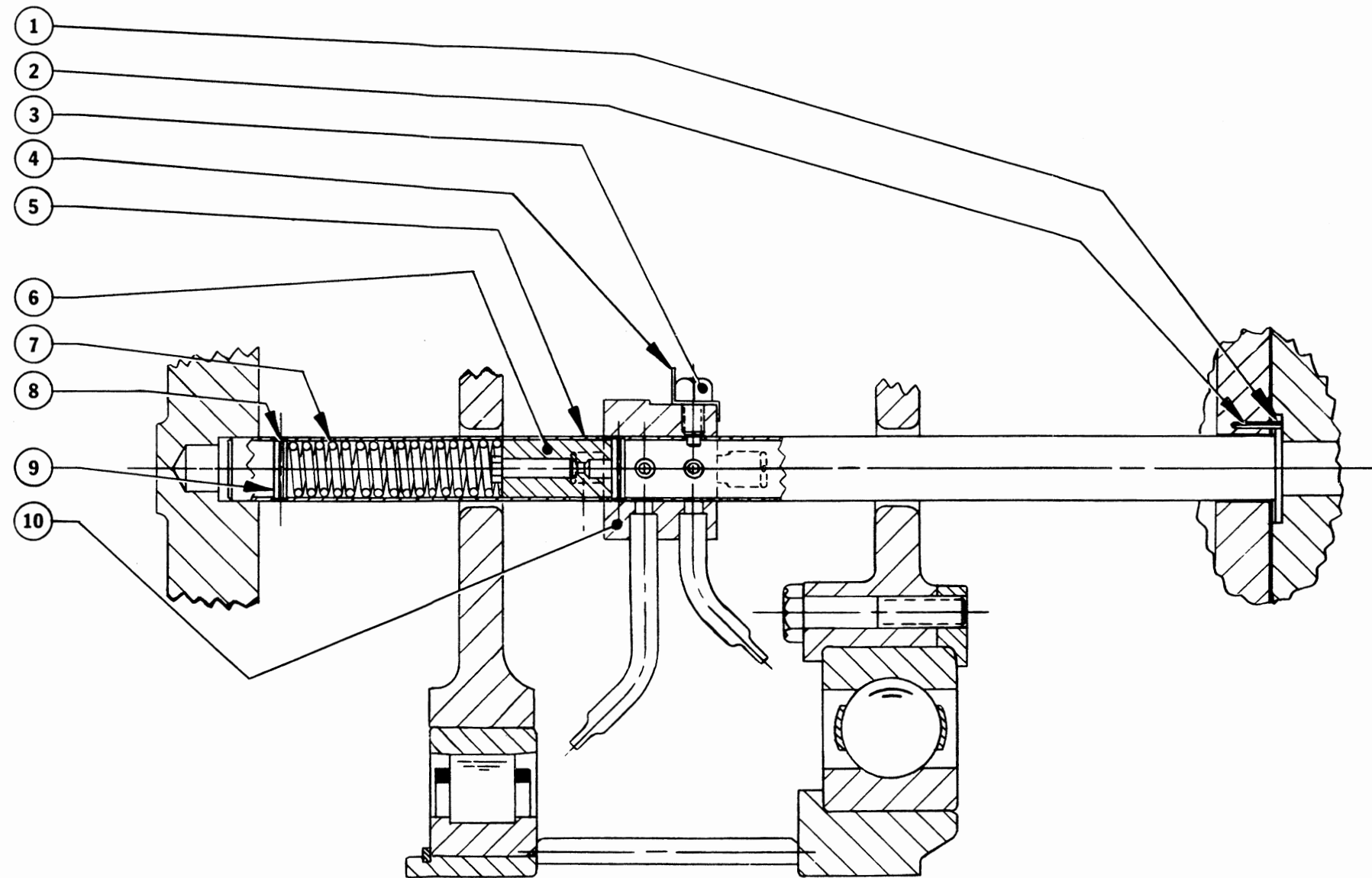
Item	Description	Qty
1	SCREW, Place-Head (3/8 x 1.875)	6
2	RETAINER, Bearing	1
3	SPRING, Clutch Release	12
4	SPIDER, Drive	1
5	STUD	6
6	LOCK, Screw	6
7	NUT, Hex (3/8-24)	12
8	SLEEVE, Release Spring	12
9	PISTON, Clutch	1
10	RING, Piston (7.00)	1
11	CYLINDER, Clutch	1
12	SETSCREW	2
13	ROLLPIN	2
14	BUSHING	1
15	RING, Piston (1.50)	1
16	PLUG, O-Ring	1
17	O-RING	1
18	O-RING	1
19	BEARING, Taper Roller	1
20	SPACER, Bearing	1
21	SHIM SHIM (.005, .007 and .020 inch)	A/R
22	RING, Piston (3.50)	2
23	RING, Piston (1.8750)	1
24	RING, Piston (3.00)	1
25	RING, Retaining	1
26	SCREW, Place Head (3/8 x 0.75)	12
27	ROLLPIN	12
28	PLATE, Driven (Steel)	7
29	PLATE, Driving (Sintered Lug Type)	8
30	HUB, Clutch	1
31	RING, Selective Retainer (.150 nom., .130 nom., .135 nom., .140 nom., .145 nom.)	1
32	BEARING, Ball	1
33	CARRIER, Bearing	1
34*	PINION, Input	1
35*	SLEEVE	1
36	SNAP RING	1
37	RING, Driving	1
38	BLOCK, Rubber	13
39	SLEEVE, Wear	1
40	SPIDER, Drive	1
41	NUT, Bearing Lock	1
42	WASHER, Stamped	1
43	RING, Rectangular Steel	1
44	SHAFT, Forward	1
45	SCREW, Dog-Point Set (1/4 x 0.50)	2
46	WASHER, Bearing Lock	1
47	BEARING, Roller	1
48	SEAL, Oil	1
49	RETAINER, Bearing	1
50	BEARING, Taper Roller	1
51	O-RING	1
52	SCREW, Hex-Head (3/8 x 1.00)	6
53	GEAR, Driving Transfer	1
54	PIN, Dowel	2
55	HOUSING, Main	1
56	SCREW, Drive	4
57	PLATE, Instruction	1
58	O-RING	1
59	PLUG, Pipe (1/4)	1
60	SPRING	1
61	ROLLPIN	1



* Not Serviced Separately.

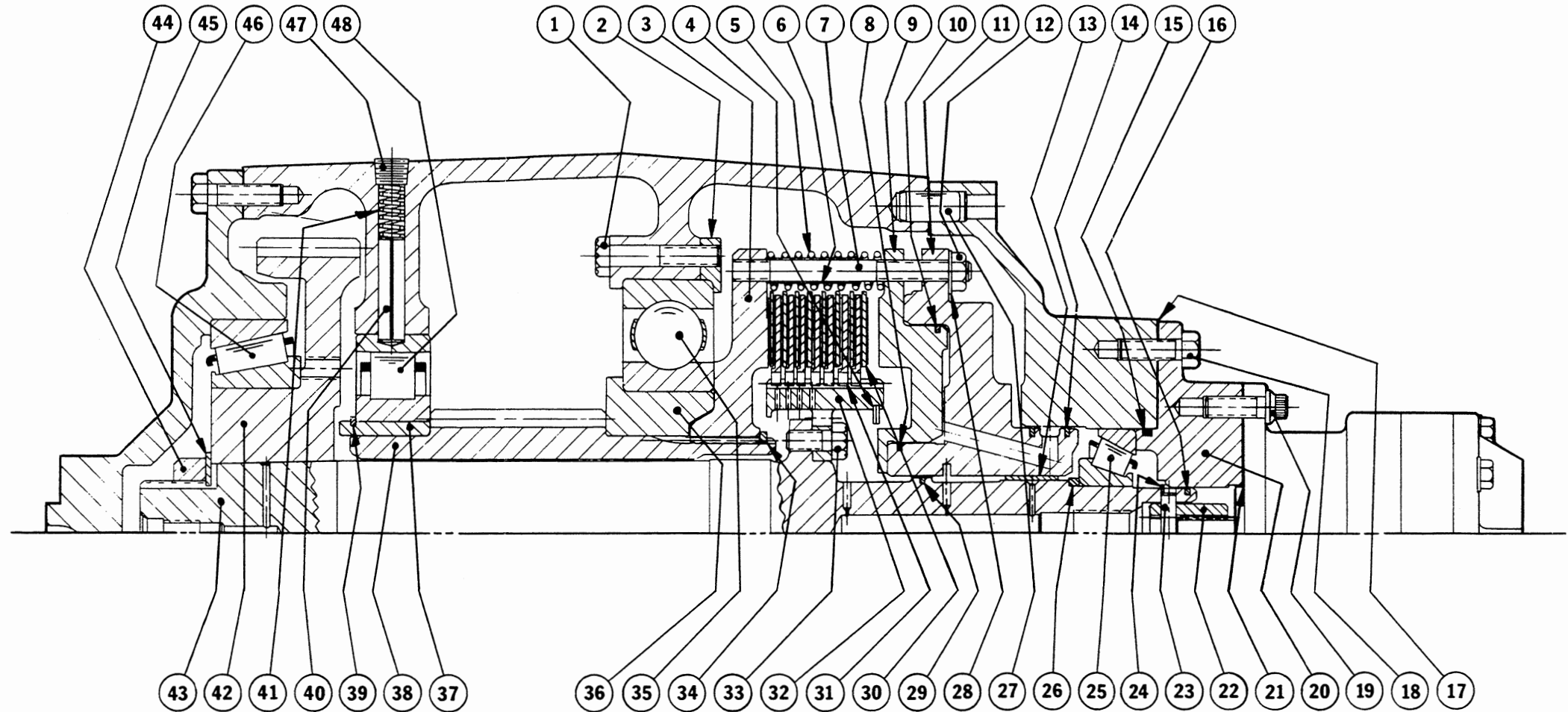
Forward Clutch and Associated Parts. Figure 12-2.

Item	Description	Qty
1	GASKET, Oil Return Pipe	1
2	ROLLPIN	1
3	SCREW, Hex-Head (1/4 x 0.50)	1
4	LOCK, Screw (Oil Return Pipe)	1
5	PIPE, Oil Return	1
6	PISTON	1
7	SPRING	1
8	ROLLPIN, Inner	2
9	ROLLPIN, Outer	2
10	CARRIER, Tube	1



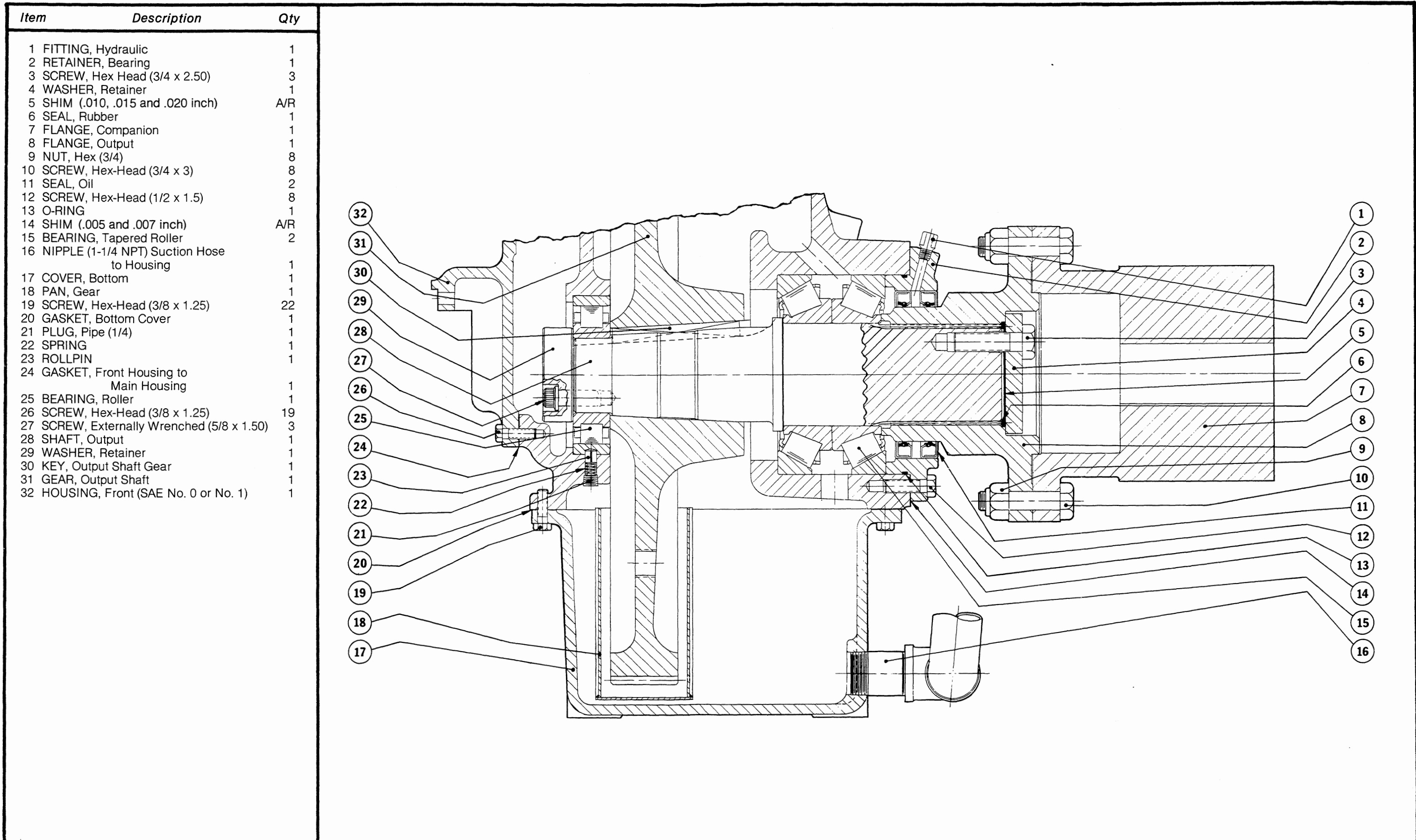
Lube Oil Distribution. Figure 12-3.

Item	Description	Qty
1	SCREW, Place-Head (3/8 x 1.875)	6
2	RETAINER, Bearing	1
3	SPIDER, Clutch	1
4	RING, Retaining	1
5	SPRING, Clutch Release	12
6	SLEEVE, Release Spring	12
7	STUD	6
8	RING, Piston (3.00)	1
9	PISTON, Clutch	1
10	RING, Piston (7.00)	1
11	CYLINDER, Clutch	1
12	NUT, Hex (3/8-24)	12
13	BUSHING	1
14	RING, Piston (3.50)	2
15	O-RING	1
16	RING, Piston (1.50)	1
17	SHIM (.005, .007, .020 and .050 inch)	A/R
18	SCREW, Hex-Head (3/8 x 1.00)	6
19	SCREW, 12-Point Head (3/8 x 1.00)	4
20	SUPPORT, Pump	1
21	GASKET (Pump to Pump Support)	1
22	SLEEVE, Pump Drive	1
23	PIN, (Pump Drive Sleeve)	1
24	RING, Retaining (Clutch Hub)	1
25	BEARING, Taper Roller	1
26	SPACER, Bearing	1
27	PIN, Dowel	1
28	LOCK, Screw	6
29	RING, Piston (1.8750)	1
30	PLATE, Driving (Sintered Lug Type)	8
31	PLATE, Driven (Steel)	7
32	HUB, Clutch	1
33	SCREW, Place-Head (3/8 x 0.75)	12
34	RING, Selective Retainer (.150 nom., .130 nom., .135 nom., .140 nom., .145 nom.)	1
35	BEARING, Ball	1
36	CARRIER, Bearing	1
37*	SLEEVE	1
38*	PINION, Input	1
39	SNAP RING	1
40	ROLLPIN	1
41	SPRING	1
42	GEAR, Driven Transfer	1
43	SHAFT, Reverse	1
44	NUT, Bearing Lock	1
45	WASHER, Bearing Lock	1
46	BEARING, Taper Roller	1
47	PLUG, Pipe (1/4)	1
48	BEARING, Roller	1



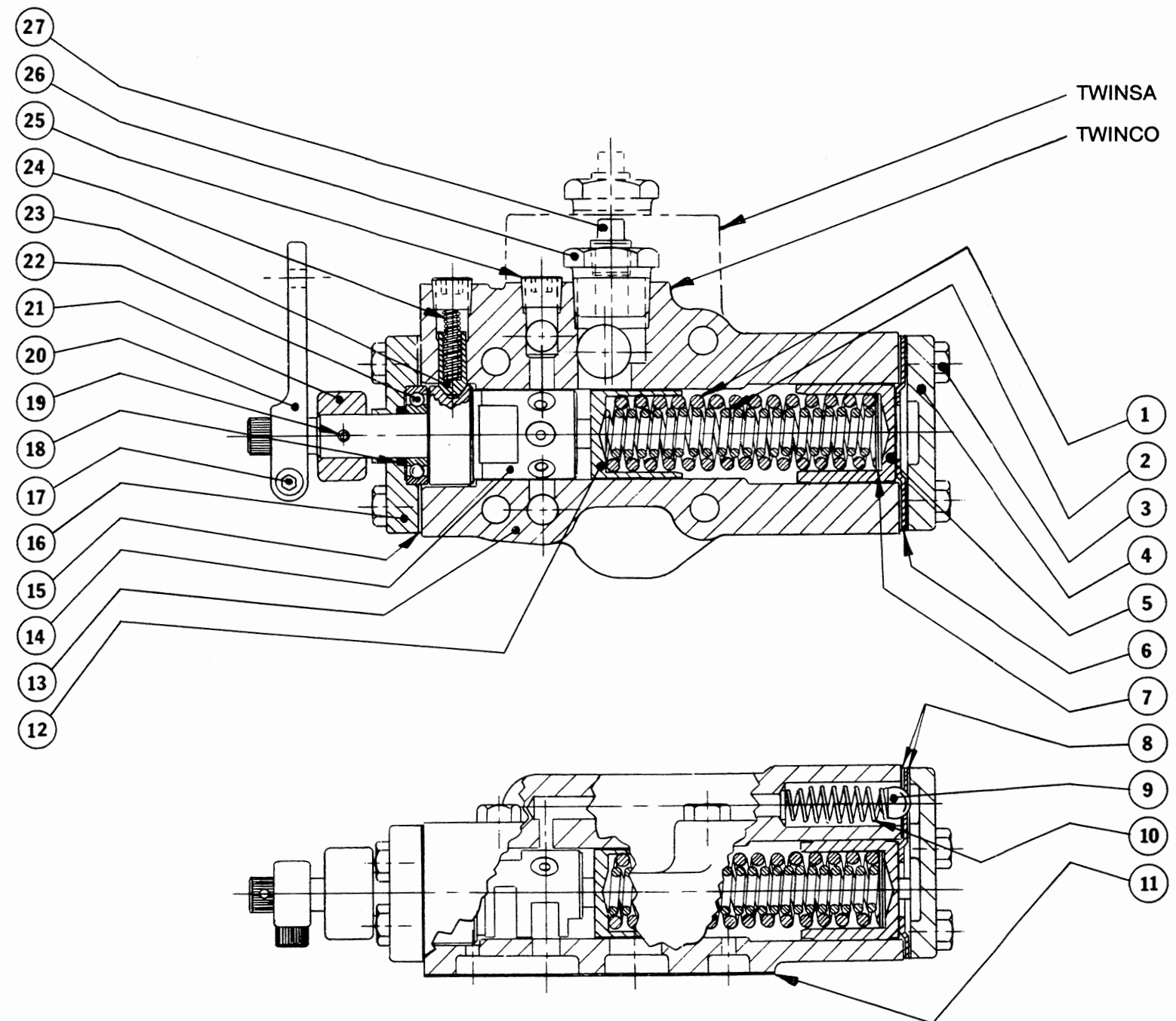
* Not Serviced Separately.

Reverse Clutch and Associated Parts. Figure 12-4.



Output Goup. Figure 12-5.

Item	Description	Qty
1	SPRING, Outer	1
2	SPRING, Inner	1
3	SCREW, Hex-Head (5/16 x 1)	8
4	COVER (Orifice Plate)	1
5	PISTON (Rate of Rise)	1
6	PLATE, Orifice	1
7	SHIM	A/R
8	GASKET, (Orifice Plate)	2
9	BALL, (Orifice Plate)	1
10	SPRING, (Orifice Plate)	1
11	GASKET, (Valve to Manifold)	1
12	PISTON, (High Pressure Regulator)	1
13	BODY, Valve	1
14	STEM, Valve	1
15	GASKET (Valve Cover)	1
16	COVER (Valve)	1
17	SCREW, Socket-Head (1/4-20 x 7/8)	1
18	O-RING	1
19	ROLLPIN	1
20	LEVER, Shift	1
21	COLLAR, Stop	1
22	BEARING, Ball	1
23	DETENT	1
24	SPRING, (Detent)	1
25	PLUG, Pipe (1/4)	2
26	BUSHING, Reducer	1
27	PLUG, Pipe	1



Control Valve. Figure 12-6.

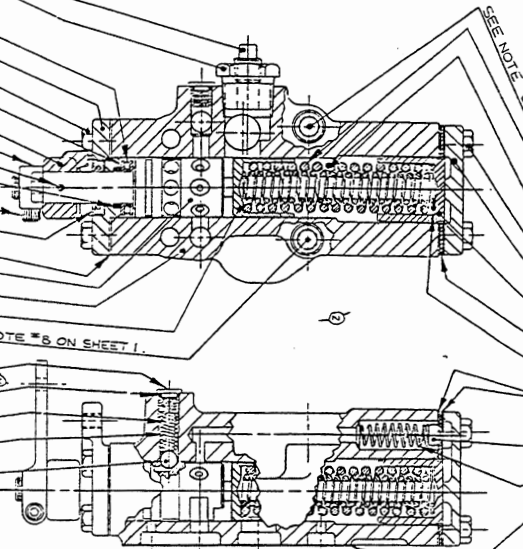
MOUNT LUBE INSTRUCTION PLATE (REF. B2411) WITH WORDS "MARINE TRANSMISSION LUBRICANT" TOWARD BREATHER.

SEE NOTE "d" ON SHEET 1

ROTATION NOT FLOW

XA7371B CONTROL VALVE ASS'Y.

M2051L	1
M2052AA	1
M2087K	1
B3574A	1
M2001M	4
M2086AV	2
B1867	1
204087	1
M1927B	1
A2916AT	1
M1731AF	1
MA778	1
B1334A	1
A4347J	1
A7361B	1
B1400B	1
M2089AG	2
M2067Q	2
M2782C	2
A2916DK	2
2039	1
A2702BP	1
M1990E	1



M2067Q	2
M2089F	2
XA2707AD	1
A2707AD	1
A2703AB	1
M2001P	4
B1333D	1
B1399C	1
B1397D	1
B2334	2
B1398E	2
M1990H	1
A2703P	1
B1337D	1

B1703D	1
PRESS. GAGE	1
M2051AA	1
M2051K	1
M422	4
B2387	1
M2051Q	1
B2432	1
A2916CF	4
M208CW	1
A2916CH	1
B2437	1
M2261A	1
M2702E	1
XB5958A	1
M2001BP	4
B606S	1

SEE NOTE "d" ON SHEET 1

M2055AY	1
M2031H	1
MA923Y	1

M422	2
201513	1
B1251A	1
A2007	1
M1072	1
M2004AW	3
A7336A	1
B1425	1
A2706X	1
M2051CD	2
M2004R	1
M2042AA	1
B1347A	1
A2916A	2
B2443A	1
1681	1
M1763	1
B3631E	1
MA730	1
XB2301H	1
MA656B	1

M2051S	4
M2002U	2
M2051K	1
M2002AG	4
B2432A	1
M2725	1
M2004EA	1
204369	1
M2702E	1
M2002AG	1
M1275	1
M2051AU	1
M2051AD	1
B2424	1
TEMP SWITCH	1
OPTIONAL	1

RELEASE SPRING STUDS

CLUTCH CYLINDERS

FWD.

REV.

11) THE FORWARD AND REVERSE CLUTCHES MUST BE INDEXED TO EACH OTHER AS SHOWN SO THAT A RELEASE SPRING IN ONE CLUTCH ALIGNS WITH THE SPACE BETWEEN SPRINGS IN THE OTHER CLUTCH.

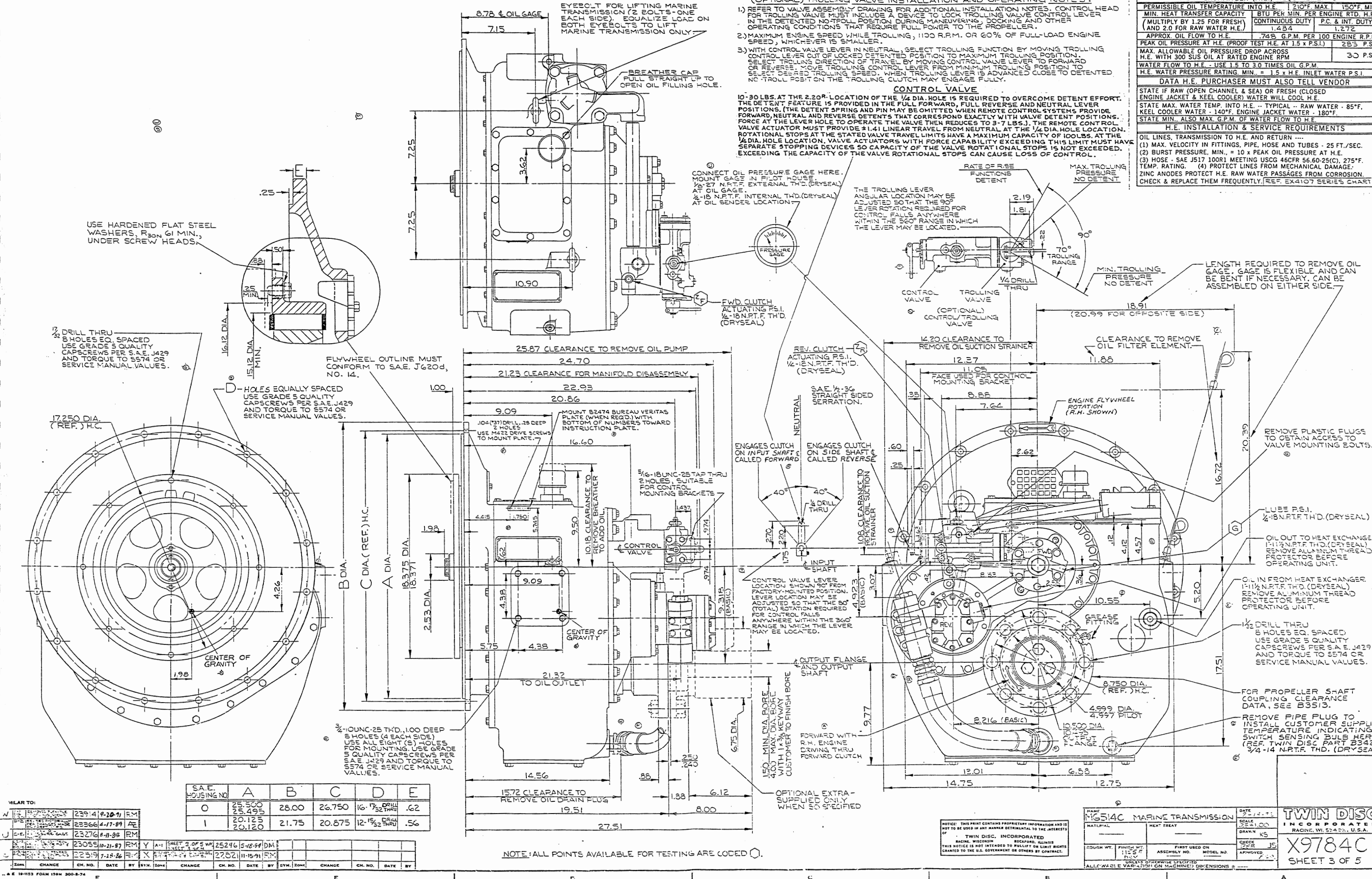
B1440	1
M1927L	1
B1814	1
B1815	1
A4331L	1

XA4834D	1
B2436A	1
B2435D	2
B2435E	1
B2435C	1
XA4834F	1
B2436A	1
B2435D	2
B2435E	2

REV.	DATE	BY	CHKD.	APP'D.	DESCRIPTION
AH A-9	25613	11-9-94	TBM		REV'D PIN
AS A-1	25246	5-18-94	DM		25246 5-18-94 DM
AF A-2	24289	1-19-93	RM		24289 1-19-93 RM
AE A-5	23756	1-24-92	KS		23756 1-24-92 KS
AD A-8	22821	11-15-91	RM		22821 11-15-91 RM

NOTICE: THIS PRINT CONTAINS PROPRIETARY INFORMATION AND IS NOT TO BE USED IN ANY MANNER DETRIMENTAL TO THE INTERESTS OF TWIN DISC, INCORPORATED RACINE, WISCONSIN ROCKFORD, ILLINOIS THIS NOTICE IS NOT INTENDED TO NULLIFY OR LIMIT RIGHTS GRANTED TO THE U.S. GOVERNMENT OR OTHERS BY CONTRACT.

NAME	M20514C MARINE TRANSMISSION	DATE	11-9-94
SCALE	AS SHOWN	DRAWN	KS
CHKD.	JS	APP'D.	KS
TWIN DISC, INCORPORATED RACINE, WISCONSIN ROCKFORD, ILLINOIS		X9784C	
SHEET 2 OF 5			

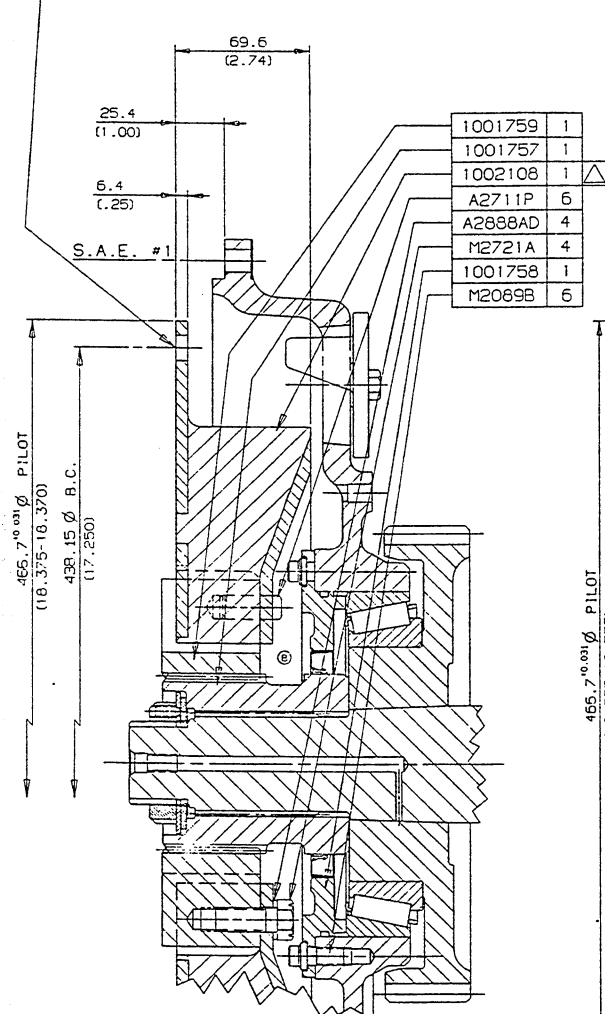


REVISIONS:

NO.	DATE	BY	DESCRIPTION
1	239-4-19-51	RM	
2	23366-4-17-89	AE	
3	23276-8-11-98	RM	
4	23055-10-21-87	RM	
5	22519-7-28-86	RM	

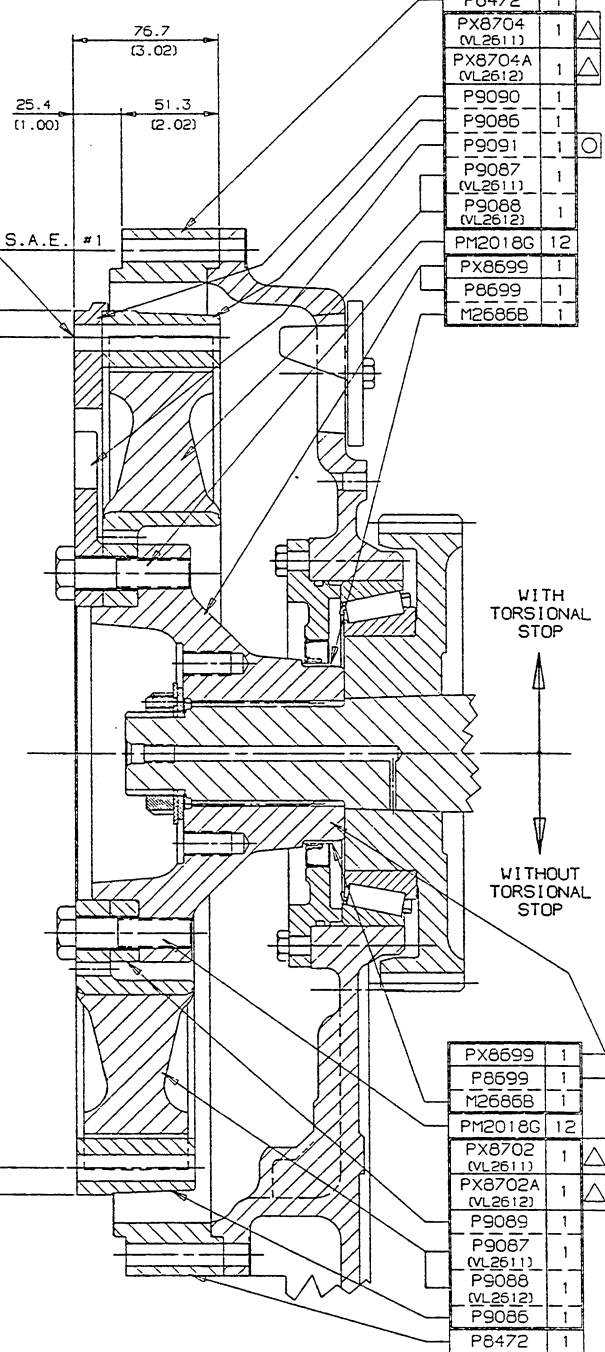
SAE HOUSING NO.	A	B	C	D	E
0	25.500 25.495	28.00	26.750	16-17/32 DRILL THRU	.62
1	20.125 20.120	21.75	20.875	12-15/32 DRILL THRU	.56

13.5mm (17/32) DIA. THRU 8 HOLES EQUALLY SPACED COUPLING "A" ONLY. USE GRADE 5 QUALITY CAPSCREWS PER S.A.E. J429 AND TORQUE TO S574 OR SERVICE MANUAL VALUES.



COUPLING "A"
FLEXIBLE COUPLING
LS14E-3701

14mm (.55) DIA. THRU 8 HOLES EQUALLY SPACED COUPLINGS "B", "C", "D", "E" & "F". USE GRADE 5 QUALITY CAPSCREWS PER S.A.E. J429 AND TORQUE TO S574 OR SERVICE MANUAL VALUES.

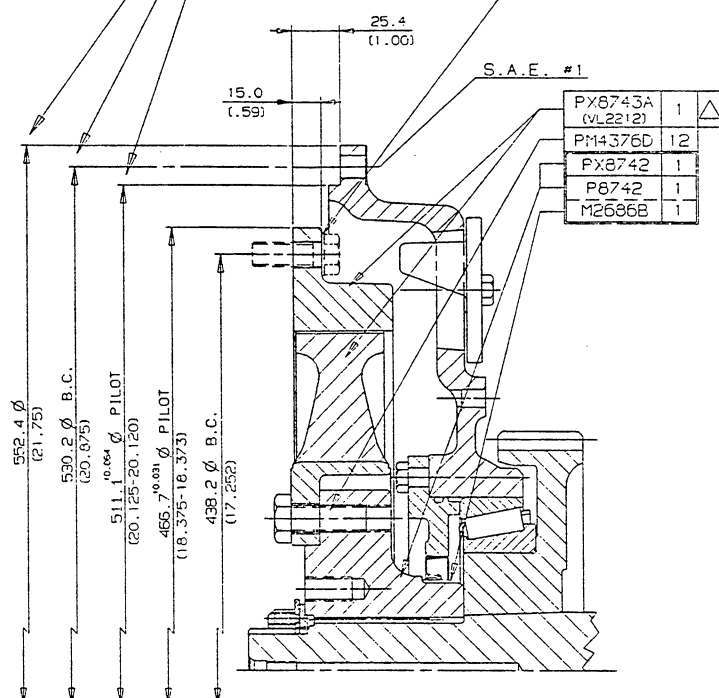


COUPLING "B"
VULASTIK VL2611
14"

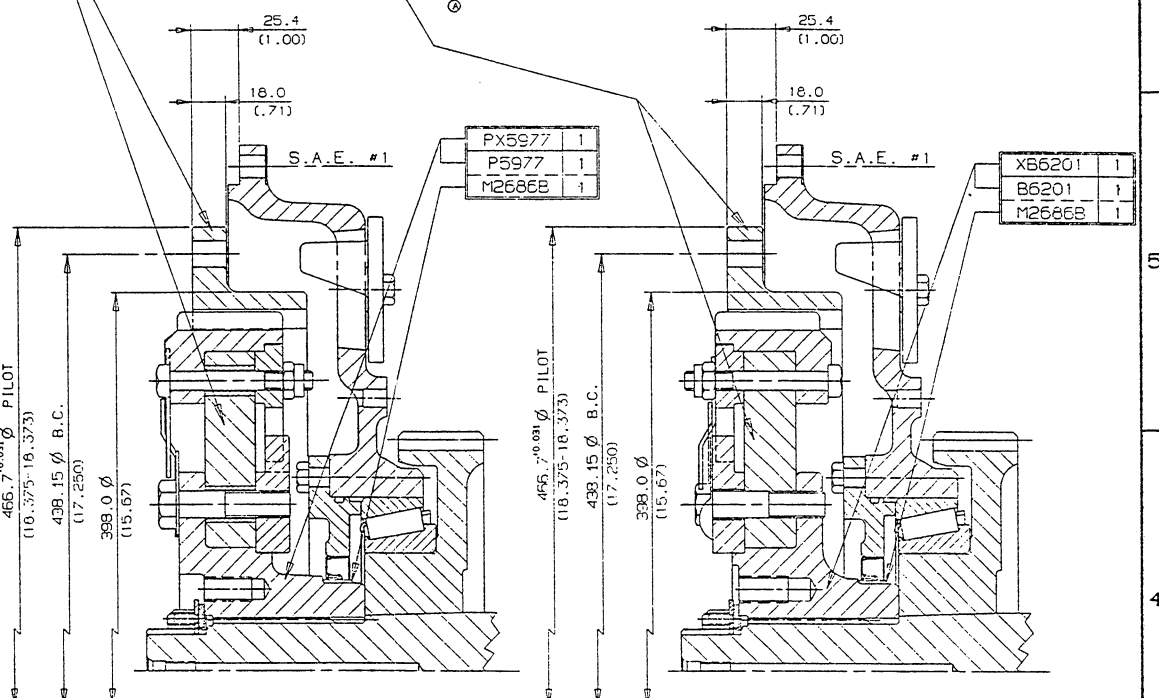
COUPLING "C"
VULASTIK VL2612
14"

NOTE:
DIMENSIONS SAME FOR ALL S.A.E. #1 HOUSINGS.

USE HARDENED FLAT STEEL WASHERS, R_{sp} 61 MIN., UNDER SCREW HEADS, FOR ALL FLEXIBLE COUPLINGS.



COUPLING "D"
VULASTIK VL2212
(WITHOUT TORSIONAL STOP)
14"



COUPLING "E"
VULASTIK P7500 SERIES
14"
ORIGINAL CONSTRUCTION

COUPLING "F"
VULASTIK P7500 SERIES
14"
PREFERRED CONSTRUCTION

COUPLING	MAX. COUPLING R.P.M. (REF.)	NOMINAL TORQUE	DYNAMIC TORSIONAL STIFFNESS	WR ² WITHOUT TORSIONAL STOP		WR ² WITH TORSIONAL STOP	
				OUTER PARTS	INNER PARTS	OUTER PARTS	INNER PARTS
A	2500	2.66 kN·m (23.54 x 10 ³ lbf·in)	21.2 kN·m/rod (188.00 x 10 ³ lbf·in/rod)	—	—	0.21 kg·m ² (718 lb·in ²)	0.19 kg·m ² (640 lb·in ²)
B	2700	2.00 kN·m (17.70 x 10 ³ lbf·in)	7.7 kN·m/rod (67.83 x 10 ³ lbf·in/rod)	0.32 kg·m ² (1094 lb·in ²)	0.20 kg·m ² (695 lb·in ²)	0.70 kg·m ² (2392 lb·in ²)	0.24 kg·m ² (835 lb·in ²)
C	2700	2.52 kN·m (22.30 x 10 ³ lbf·in)	13.0 kN·m/rod (115.04 x 10 ³ lbf·in/rod)	0.32 kg·m ² (1094 lb·in ²)	0.20 kg·m ² (695 lb·in ²)	0.70 kg·m ² (2392 lb·in ²)	0.24 kg·m ² (835 lb·in ²)
D	3200	2.00 kN·m (17.70 x 10 ³ lbf·in)	11.8 kN·m/rod (104.44 x 10 ³ lbf·in/rod)	0.24 kg·m ² (821 lb·in ²)	0.14 kg·m ² (495 lb·in ²)	—	—
E	2700	SEE CHART	SEE CHART	0.45 kg·m ² (1650 lb·in ²)	0.088 kg·m ² (300 lb·in ²)	0.49 kg·m ² (1663 lb·in ²)	0.088 kg·m ² (300 lb·in ²)
F	2700	SEE CHART	SEE CHART	0.45 kg·m ² (1650 lb·in ²)	0.088 kg·m ² (300 lb·in ²)	0.49 kg·m ² (1663 lb·in ²)	0.088 kg·m ² (300 lb·in ²)

• SEE SHEET 1 FOR MAXIMUM TRANSMISSION R.P.M.

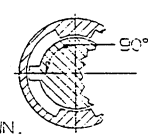
Ⓢ THE WR² OF INNER PARTS INCLUDES HUB, SCREWS AND SHAFT C₂ INSIDE HUB.
FOR OTHER TRANSMISSION MASS ELASTIC DATA, REFER TO B3504D.
FOR OTHER TRANSMISSION INSTALLATION DIMENSIONS, REFER TO X9784C, SHEET 3.

NOTE:
UNITS WITH THIS FLEXIBLE COUPLING ARE APPROVED FOR RIGHT-HAND ENGINE ROTATION ONLY DUE TO COUPLING RESTRICTION.

ADVANCE MARINE TRANSMISSION INTO POSITION WITH ENGINE FLYWHEEL HOUSING MOUNTING FLANGE. LINE UP INPUT SHAFT EXTERNAL SPLINE WITH INTERNAL SPLINE IN COUPLING HUB AND MOVE ENGINE AND MARINE TRANSMISSION TOGETHER MAINTAINING ENGINE FLYWHEEL HOUSING AND MARINE TRANSMISSION FLYWHEEL HOUSING MOUNTING FACES IN PARALLEL RELATIONSHIP. ENGAGE FLYWHEEL HOUSING PILOTS AND INSTALL ALL MOUNTING CAPSCREWS USING GRADE 5 QUALITY CAPSCREWS PER S.A.E. J429 TORQUED TO S574 OR SERVICE MANUAL VALUES.

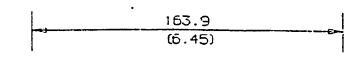
Ⓢ IMPORTANT:
WHEN INSTALLING TRANSMISSION TO ENGINE WITH TORSIONAL-STOP-EQUIPPED COUPLING, ROTATE TRANSMISSION INPUT HUB/INNER TORSIONAL STOP PLATE TO ORIENT LUGS ON INNER & OUTER TORSIONAL STOP PLATES 90° APART, AS SHOWN.

△ SECURE FLEXIBLE COUPLING TO HOUSING S.A.E. FLANGE HOLES, USING STANDARD METHOD, BEFORE SHIPMENT OF UNIT.



METRIC

INCH DIMENSIONS SHOWN IN BRACKETS:



SYMBOL	CHARACTERISTIC	SYMBOL	MODIFIER
□	FLATNESS	Ⓢ	MMC MAX. MATERIAL CONDITION
∥	PARALLELISM	Ⓢ	RFS (REGARDLESS OF FEATURE SIZE)
⊥	PERPENDICULARITY	Ⓢ	NAME
↗	CIRCULAR RUNOUT	Ⓢ	DATUM FEATURE
↘	TOTAL RUNOUT	Ⓢ	DIAMETER
⊕	POSITION		

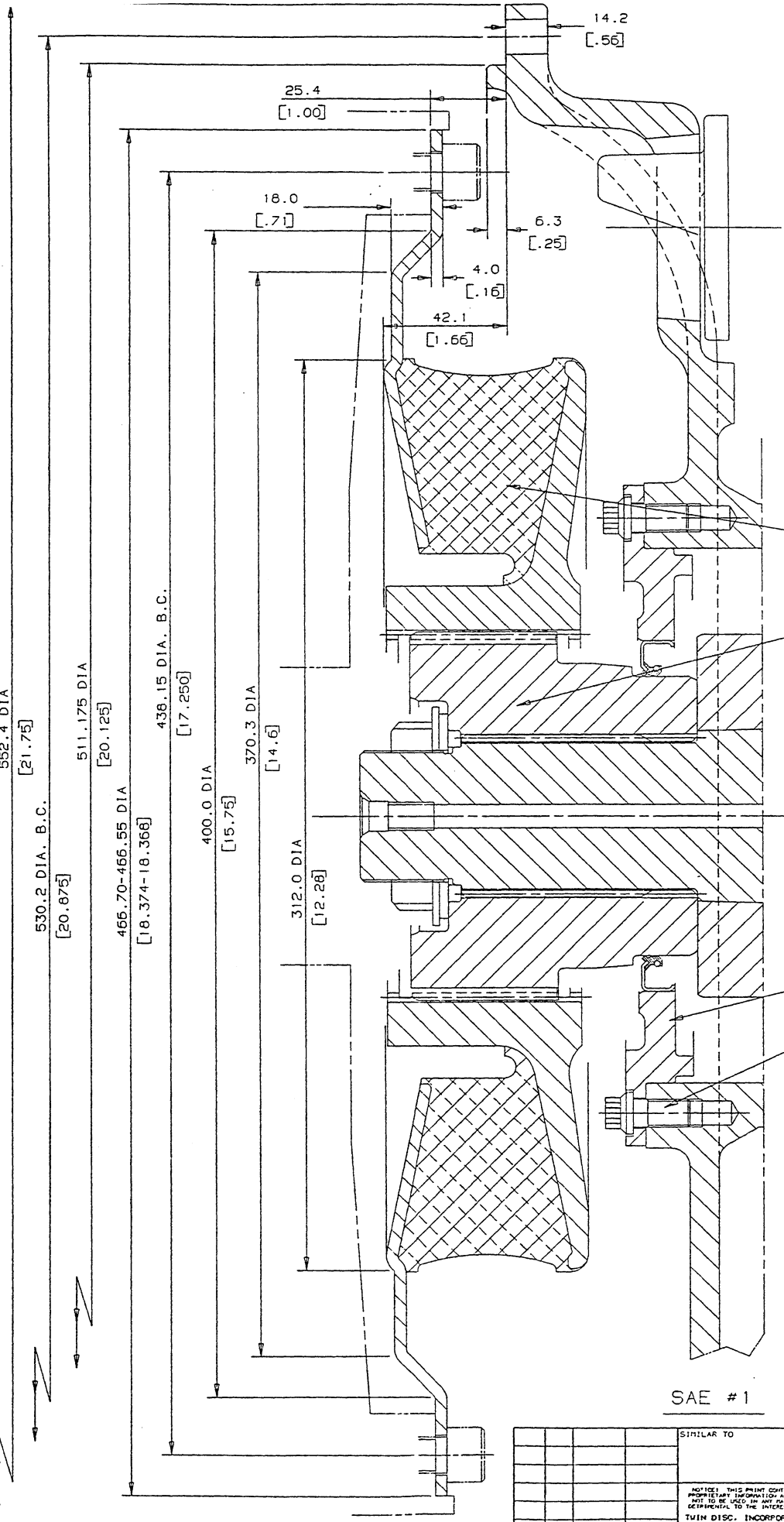
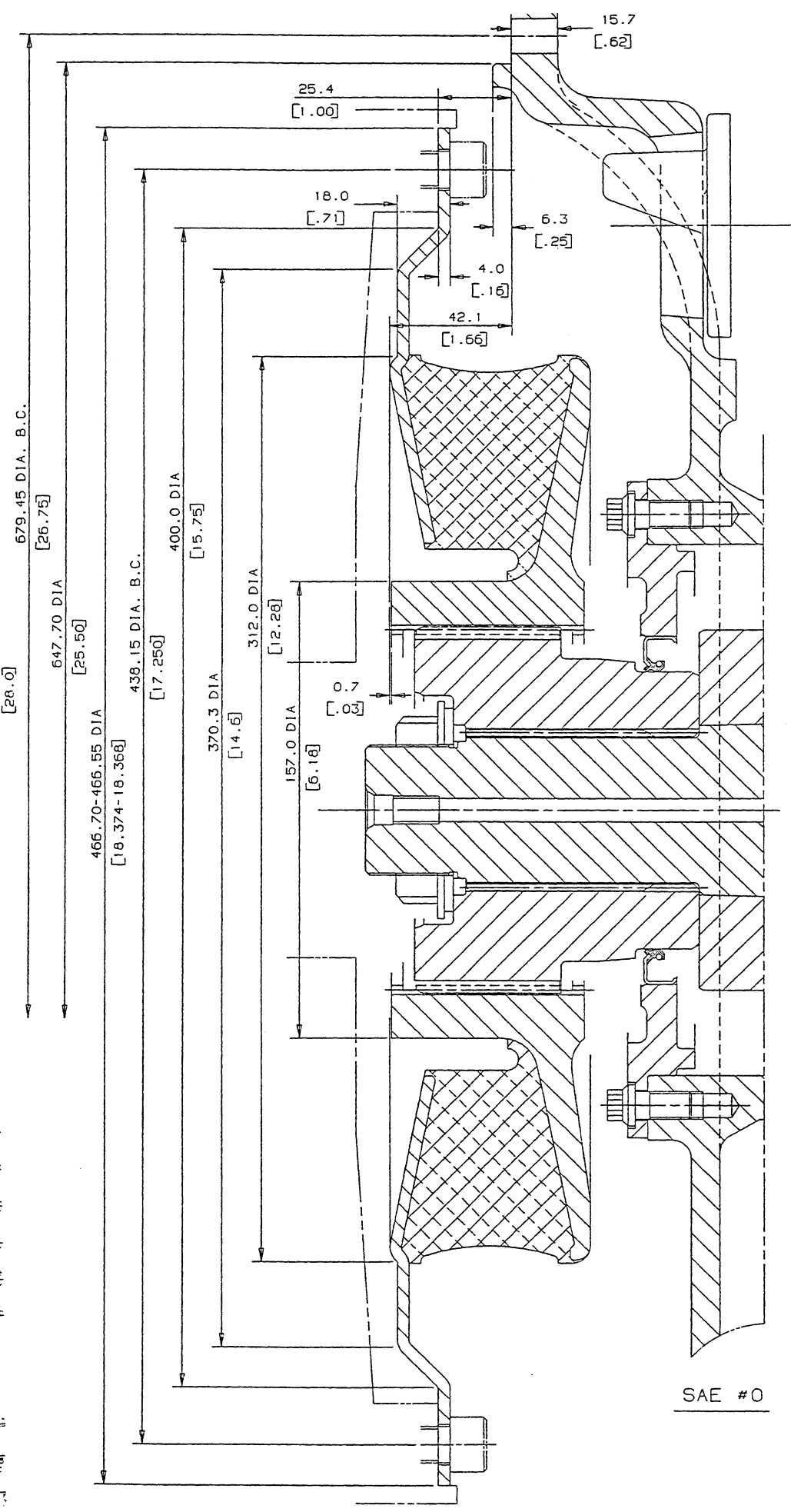
NOTE: UNTOLERANCED DIMENSIONS LOCATING TRUE POSITION ARE BASIC.

REV.	DATE	BY	CHK.	DESCRIPTION
C	A-1	4 OF 5 WAS 4 OF 4	25245	5-18-94 DM
B	A-1	REVISIONS	25118	6-16-93 RM
A	B-6	PX8127C WAS PX8127C	23965	11-4-91 KS

NOTICE: THIS PRINT CONTAINS PROPRIETARY INFORMATION AND IS NOT TO BE USED IN ANY MANNER DETRIMENTAL TO THE INTERESTS OF TWIN DISC, INCORPORATED RACINE, WISCONSIN TO THE U.S. GOVERNMENT OR OTHERS BY CONTRACT.

MATERIAL	HEAT TREAT	DATE	9-15-91
SURFACE TREATMENT	WEIGHT FIN.	SCALE	.50 ±1
UNLESS OTHERWISE SPECIFIED ALL DIMENSIONAL TOLERANCES ±.010 ALL ANGULAR TOLERANCES ±1°	FIRST USE ASSY. MODEL	APP. REV.	
NAME	MG514C MARINE TRANSMISSION (FLEXIBLE COUPLING INPUTS)	APP. TEC	
TWIN DISC INCORPORATED RACINE, WI 53403 - USA			X9784C SHEET 4 OF 5

SAE NO.	TYPE OF COUPLING	NOMINAL TORQUE	DYNAMIC TORSIONAL STIFFNESS	WR ²		MAX. COUPLING SPEED
				OUTER PARTS	INNER PARTS	
0 & 1	E-4011 P-9476	2.50KNm 22.1x10 ³ Lbsin	11.00 KNm/rod 97.33x10 ³ Lbsin/rod	0.18Kg ^m ² 615.4 Lb.in ²	0.11Kg ^m ² 376.1 Lb.in ²	3200 RPM
0 & 1	E-4014 P-9476	2.50KNm 22.1x10 ³ Lbsin	8.00 KNm/rod 70.78x10 ³ Lbsin/rod	0.18Kg ^m ² 615.4 Lb.in ²	0.11Kg ^m ² 376.1 Lb.in ²	3200 RPM
0 & 1	E-4012 P-9479	3.15KNm 27.9x10 ³ Lbsin	8.00 KNm/rod 70.78x10 ³ Lbsin/rod	0.18Kg ^m ² 615.4 Lb.in ²	0.11Kg ^m ² 376.1 Lb.in ²	3200 RPM



TYPE OF COUPLING AND NUMBER. (SEE CHART)	
P-9650	1

1001758	1
M-2089-B	6

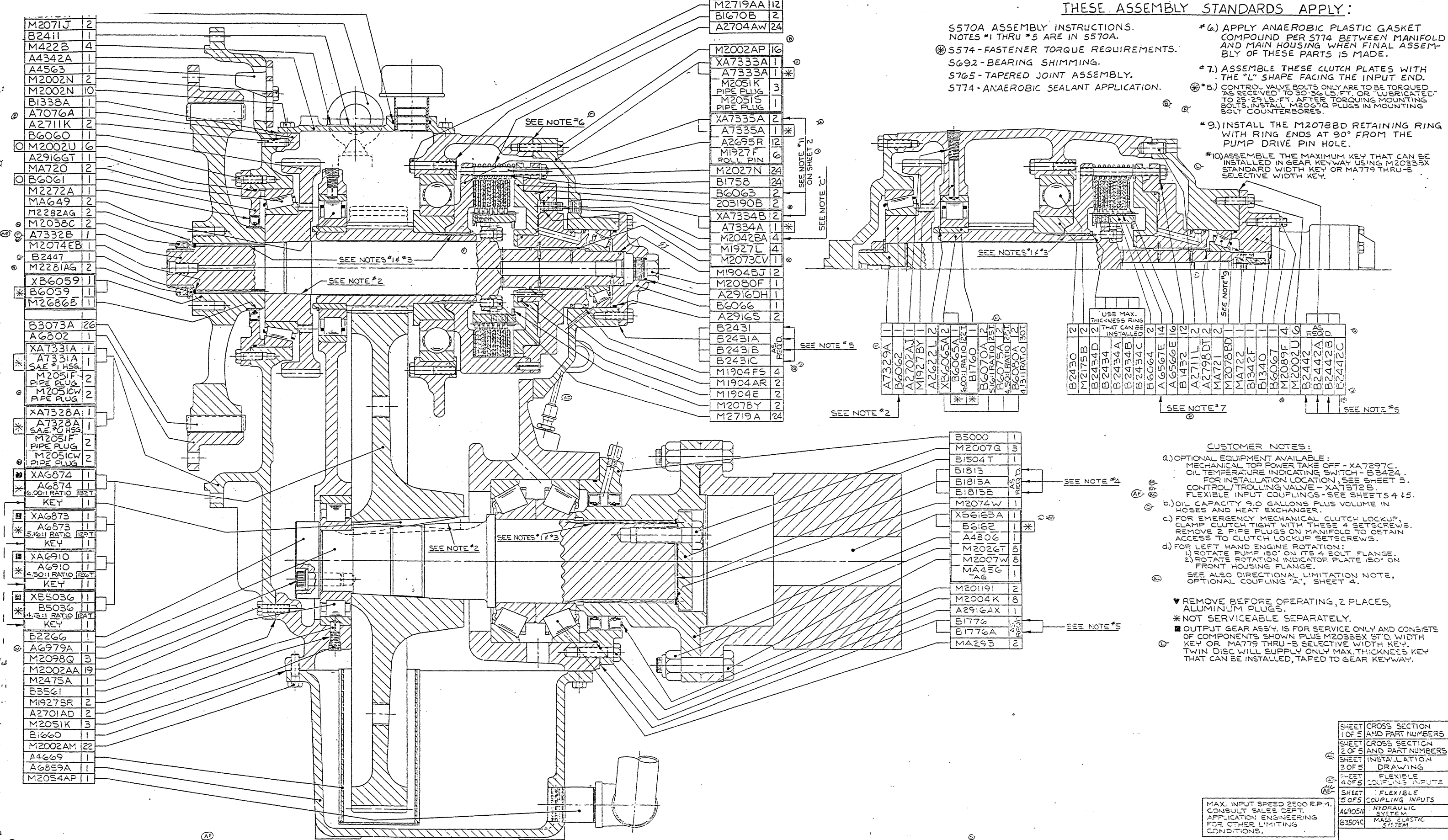
NOTE : FOR MISSING DIMENSIONS SEE SHEET 3 OF 5.
 • THE WR 2 OF INNER PARTS INCLUDES HUB AND 1/4 SHAFT C2.
 Δ SECURE FLEXIBLE COUPLING TO HOUSING S.A.E. FLANGE HOLES, USING STANDARD METHOD, BEFORE SHIPMENT OF UNIT.

METRIC - INCH DIMENSIONS SHOWN IN BRACKETS.

SIMILAR TO		MATERIAL		WEIGHT		UNLESS OTHERWISE SPECIFIED		DATE		TWIN DISC INCORPORATED RACINE, WI 53403 - USA	
				LBS. LBS. IN ³		MACHINED DIMENSIONS ±.010		3-29-54			
NOTICE: THIS PRINT CONTAINS PROPERTY OF TWIN DISC AND IS TO BE USED IN ANY MANNER DETRIMENTAL TO THE INTERESTS OF TWIN DISC, INCORPORATED.		HEAT TREAT		FIRST USE		ALL ANGULAR TOLERANCES ±1°		SCALE		X9784C SHEET 5 OF 5	
THIS NOTICE IS NOT INTENDED TO NEGATE OR LIMIT RIGHTS GRANTED TO THE U.S. GOVERNMENT OR OTHERS BY CONTRACT.				ASSY.		GEOMETRIC TOLERANCING PER ANSI Y14.5M 1982		1:00=1			
NAME		SURFACE TREATMENT		MODL		PERMITS		DRW.		SHEET 5 OF 5	
MG514C MARINE TRANSMISSION				CHK.		CHK.		KS			
DATE				APPD.		APPD.		TEM		SHEET 5 OF 5	

THESE ASSEMBLY STANDARDS APPLY:

- S570A ASSEMBLY INSTRUCTIONS. NOTES #1 THRU #5 ARE IN S570A.
- *S574 - FASTENER TORQUE REQUIREMENTS.
- S692 - BEARING SHIMMING.
- S765 - TAPERED JOINT ASSEMBLY.
- S774 - ANAEROBIC SEALANT APPLICATION.
- #6) APPLY ANAEROBIC PLASTIC GASKET COMPOUND PER S774 BETWEEN MANIFOLD AND MAIN HOUSING WHEN FINAL ASSEMBLY OF THESE PARTS IS MADE.
- #7) ASSEMBLE THESE CLUTCH PLATES WITH THE "L" SHAPE FACING THE INPUT END.
- #8) CONTROL VALVE BOLTS ONLY ARE TO BE TORQUED AS RECEIVED TO 30-36 LB.-FT. OR "LUBRICATED" TO 25-29 LB.-FT. AFTER TORQUING MOUNTING BOLTS, INSTALL M2066 PIPE PLUGS IN MOUNTING BOLT COUNTERBORES.
- #9) INSTALL THE M2078BD RETAINING RING WITH RING ENDS AT 90° FROM THE PUMP DRIVE PIN HOLE.
- #10) ASSEMBLE THE MAXIMUM KEY THAT CAN BE INSTALLED IN GEAR KEYWAY USING M2033BX STANDARD WIDTH KEY OR MA779 THRU-B SELECTIVE WIDTH KEY.



M2071J	2
B2411	1
M422B	4
A4342A	1
A4563	1
M2002N	2
M2002N	10
B1338A	1
A7076A	1
A2711K	2
B6060	1
M2002U	6
A2916GT	1
MA720	2
B6061	1
M2272A	1
MA649	2
M2282AG	2
M2038C	2
A7332B	1
M2074EB	1
B2447	1
M2281AG	2
XB6059J	1
B6059	1
M2686B	1
B3073A	26
AG802	1
XA7331A	1
A7331A	1
SAE #10 HSS	1
M2051F	2
PIPE PLUG	2
M2051CW	2
PIPE PLUG	2
XA7328A	1
A7328A	1
SAE #10 HSS	1
M2051F	2
PIPE PLUG	2
M2051CW	2
PIPE PLUG	2
XA6874	1
AG874	1
6.00:1 RATIO	1
KEY	1
XA6873	1
AG873	1
5.16:1 RATIO	1
KEY	1
XA6910	1
AG910	1
4.50:1 RATIO	1
KEY	1
XB5036	1
B5036	1
4.31:1 RATIO	1
KEY	1
E2266	1
AG979A	1
M2098Q	3
M2002AA	19
M2475A	1
B3561	1
M1927BR	2
A2701AD	2
M2051K	3
B1660	1
M2002AM	22
A4669	1
AG859A	1
M2054AP	1

M2719AA	12
B1670B	2
A2704AW	24
M2002AP	16
XA7333A	1
A7333A	1
M2051K	3
PIPE PLUG	3
M2051S	1
PIPE PLUG	1
XA7335A	2
A7335A	1
A2695R	12
M1927F	6
ROLL PIN	6
M2027N	24
B1758	24
B6063	2
203190B	2
XA7334B	2
A7334A	1
M2042BA	4
M1927L	4
M2073CV	1
M1904BJ	2
M2080F	1
A2916DH	1
B6066	1
A2916S	2
B2431	1
B2431A	1
B2431B	1
B2431C	1
M1904FS	4
M1904E	2
M1904E	2
M2078Y	2
M2719A	24

A7329A	1
B6062	1
A2702AJ	1
M1927BY	1
A2622L	2
XB6065A	2
B6065A	1
4.0:1 RATIO	1
B1760	1
B6070A	2
SIG. RATIO	1
B6075A	2
4.5:1 RATIO	1
B6080A	2
4.13:1 RATIO	1
B3073A	26

B2430	2
M2175B	2
B2434D	2
B2434	1
B2434A	1
B2434B	1
B2434C	1
B6064	2
A6567E	14
A6566E	10
B1432	12
A2711L	2
A2798DT	2
MA721	2
M2078BD	1
MA722	1
B1342F	1
B1340	1
B6067	1
M2089F	4
M2002U	6
B2442A	1
B2442B	1
B2442C	1

B5000	1
M2007G	3
B1504T	1
B1813	1
B1813A	1
B1813B	1
M2074W	1
XB6163A	1
B6162	1
A4806	1
M2026T	8
M2007W	8
MA456	1
TAG	1
M2019I	2
M2004K	8
A2916AX	1
B1776	1
B1776A	1
MA293	2

- CUSTOMER NOTES:**
- OPTIONAL EQUIPMENT AVAILABLE:
MECHANICAL TOP POWER TAKE OFF - XA7297C.
OIL TEMPERATURE INDICATING SWITCH - B3424.
FOR INSTALLATION LOCATION, SEE SHEET 3.
CONTROL TROLLING VALVE - XA7372B.
FLEXIBLE INPUT COUPLINGS - SEE SHEETS 4 & 5.
 - OIL CAPACITY 9.0 GALLONS PLUS VOLUME IN HOSES AND HEAT EXCHANGER.
 - FOR EMERGENCY MECHANICAL CLUTCH LOCKUP, CLAMP CLUTCH TIGHT WITH THESE 4 SETSCREWS. REMOVE 2 PIPE PLUGS ON MANIFOLD TO OBTAIN ACCESS TO CLUTCH LOCKUP SETSCREWS.
 - FOR LEFT HAND ENGINE ROTATION:
1) ROTATE PUMP 180° ON ITS 4 BOLT FLANGE.
2) ROTATE ROTATION INDICATOR PLATE 180° ON FRONT HOUSING FLANGE.
- SEE ALSO DIRECTIONAL LIMITATION NOTE, OPTIONAL COUPLING 'A', SHEET 4.
- ▼ REMOVE BEFORE OPERATING, 2 PLACES, ALUMINUM PLUGS.
* NOT SERVICEABLE SEPARATELY.
■ OUTPUT GEAR ASSY. IS FOR SERVICE ONLY AND CONSISTS OF COMPONENTS SHOWN PLUS M2033BX STD. WIDTH KEY OR MA779 THRU-B SELECTIVE WIDTH KEY. TWIN DISC WILL SUPPLY ONLY MAX. THICKNESS KEY THAT CAN BE INSTALLED, TAPED TO GEAR KEYWAY.

THESE PARTS MAY VARY DEPENDING UPON INPUT COUPLING. REFER TO SHEET 4 OR SHEET 5 AND APPLICABLE B.O.M.

2524	5-12-94	DM
24296	2-1-93	KS
22521	11-15-91	RM
23914	9-18-91	RM
22519	1-28-86	RM

CHANGE	CH. NO.	DATE	BY	SYN.	ZONE	CHANGE	CH. NO.	DATE	BY	SYN.	ZONE	CHANGE	CH. NO.	DATE	BY
--------	---------	------	----	------	------	--------	---------	------	----	------	------	--------	---------	------	----

NOTICE: THIS PRINT CONTAINS PROPRIETARY INFORMATION AND IS NOT TO BE USED IN ANY MANNER DETRIMENTAL TO THE INTERESTS OF TWIN DISC, INCORPORATED. FACINE, WISCONSIN, ROCKFORD, ILLINOIS. THIS NOTICE IS NOT INTENDED TO NULLIFY OR LIMIT RIGHTS GRANTED TO THE U.S. GOVERNMENT OR OTHERS BY CONTRACT.

NAME	M6514C MARINE TRANSMISSION	DATE	7-2-78
MATERIAL		SCALE	1:100
ROUGH WT.		FINISH WT.	
RATIOS		DRAWN	KS
	4.13:1	CHECK	JS
	4.50:1	APPROVED	
	5.16:1		
	6.00:1		

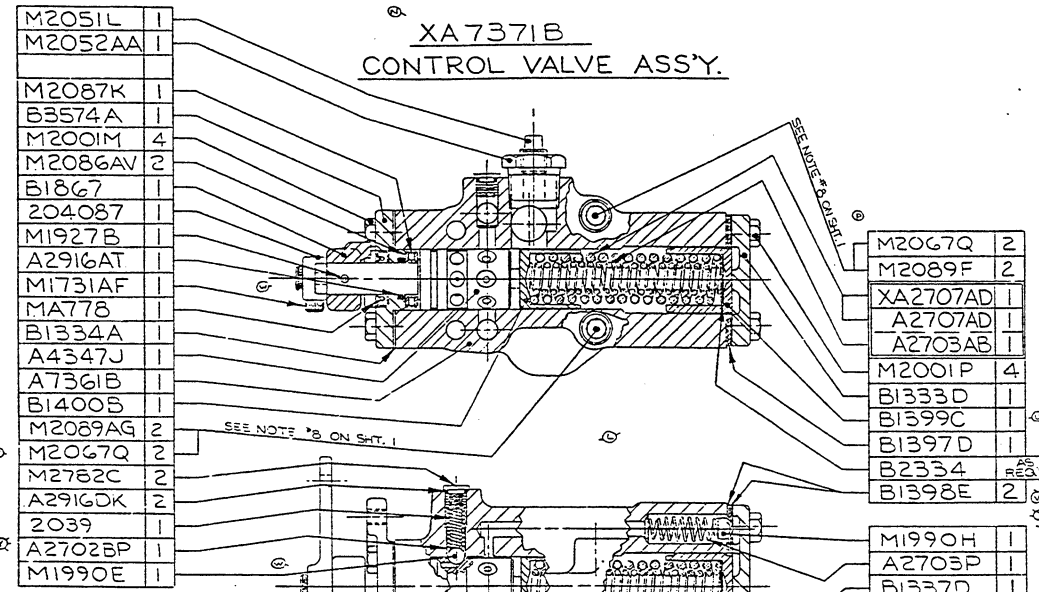
SHEET 1 OF 5	CROSS SECTION
SHEET 2 OF 5	CROSS SECTION
SHEET 3 OF 5	INSTALLATION DRAWING
SHEET 4 OF 5	FLEXIBLE COUPLING INPUTS
SHEET 5 OF 5	FLEXIBLE COUPLING INPUTS
AG905A	HYDRAULIC SYSTEM
B3504C	MASS ELASTIC SYSTEM

TWIN DISC INCORPORATED
RACINE, WISCONSIN U.S.A.
X9786C
SHEET 1 OF 5

MOUNT LUBE INSTRUCTION PLATE (REF. B2411) WITH WORDS "MARINE TRANSMISSION LUBRICANT" TOWARD BREATHER.

SEE NOTE "d" ON SHEET 1

XA 7371B CONTROL VALVE ASS'Y.



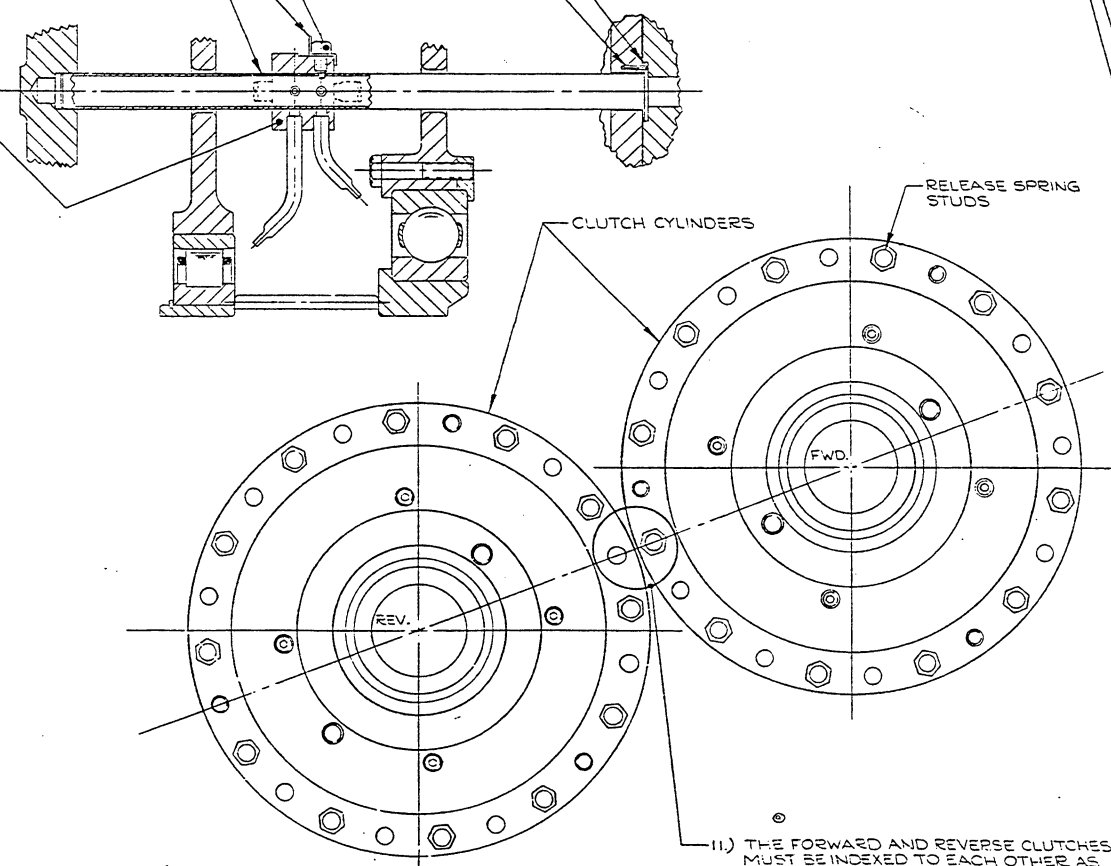
M2051L	1
M2052AA	1
M2087K	1
B3574A	1
M200IM	4
M2086AV	2
B1867	1
204087	1
M1927B	1
A2916AT	1
M1731AF	1
MA778	1
B1334A	1
A4347J	1
A7361B	1
B1400S	1
M2089AG	2
M2067Q	2
M2762C	2
A2916DK	2
2039	1
A2702BP	1
M1990E	1

M2067Q	2
M2089F	2
XA2707AD	1
A2707AD	1
A2703AB	1
M2001P	4
B1333D	1
B1599C	1
B1397D	1
B2334	2
B1398E	2
M1990H	1
A2703P	1
B1337D	1

B1703D	1
PRESS. GAUGE	1
M2051AA	1
M2051K	1
M422	4
B2387	1
B2432	1
A2916CF	4
M2080W	1
A2916CH	1
B2437	1
M2261A	1
M2702E	1
X85958A	1
M2001BP	4
B6068	1
M2031H	1
M2002D	4
M2305	4

B1440	1
M1927L	1
B1814	1
B1815	1
A4351L	1

XA4634D	1
B2436A	1
B2435D	1
OIL TUBE	2
B2435E	1
OIL TUBE	1
B2435C	1
OIL TUBE	1



11) THE FORWARD AND REVERSE CLUTCHES MUST BE INDEXED TO EACH OTHER AS SHOWN SO THAT A RELEASE SPRING IN ONE CLUTCH ALIGNS WITH THE SPACE BETWEEN SPRINGS IN THE OTHER CLUTCH.

M422	2
201513	1
B1251A	1
A2007	1
M1072	1
M2004AW	3
A7336A	1
B1425	1
A2706X	1
M2051C	2
M2004R	1
M2042AA	1
B1347A	1
A2916A	2
B2443	1
1681	1
M1763	1
M2051S	4
MA730	1
M2002U	2
M2051K	1
M2002AG	4
B2432A	1
M2725	1
B3631F	1
M2004EA	1
204369	1
M2702E	1
XE2301H	1
MAG56B	1
M2051AU	1
M1275	1
MA923X	1
M2055AV	1
M2051AD	2
B3424	1
TEMP SWITCH	1
OPTIONAL	1

REV	BY	DATE	CH. NO.	DATE	BY	DATE	CH. NO.	DATE	BY	DATE	CH. NO.
1	DM	11-9-99	25613	11-9-99	DM						
2	DM	5-18-99	25246	5-18-99	DM						
3	RM	1-19-93	24235	1-19-93	RM						
4	KS	1-24-92	23990	1-24-92	KS						
5	DM	11-15-91	22921	11-15-91	DM						

NOTICE: THIS PRINT CONTAINS PROPRIETARY INFORMATION AND IS NOT TO BE USED IN ANY MANNER DETRIMENTAL TO THE INTERESTS OF TWIN DISC, INCORPORATED RACINE, WISCONSIN ROCKFORD, ILLINOIS THIS NOTICE IS NOT INTENDED TO NULLIFY OR LIMIT RIGHTS GRANTED TO THE U.S. GOVERNMENT OR OTHERS BY CONTRACT.

NAME	MGS14C MARINE TRANSMISSION	DATE	2-5-78
SCALE	AS SHOWN	DRAWN	KS
CHECK	JS	APPROVED	PLA

TWIN DISC INCORPORATED RACINE, WI 53403 U.S.A. X9786C SHEET 2 OF 5

EYEBOLT FOR LIFTING MARINE TRANSMISSION (2 BOLTS ONE EACH SIDE) EQUALIZE LOAD ON BOTH EYEBOLTS TO LIFT MARINE TRANSMISSION ONLY.

USE HARDENED FLAT STEEL WASHERS, R₁ 61 MIN., UNDER SCREW HEADS.

D HOLES EQUALLY SPACED (SEE NOTE) USE GRADE 5 QUALITY CAPSCREWS PER S.A.E. J429 AND TORQUE TO S574 OR SERVICE MANUAL VALUES.

7/32 DRILL THE 8 HOLES EQUALLY SPACED USE GRADE 5 QUALITY CAPSCREWS PER S.A.E. J429 AND TORQUE TO S574 OR SERVICE MANUAL VALUES.

NOTE: THIS HOLE OMITTED FROM S.A.E. #1 HSG.

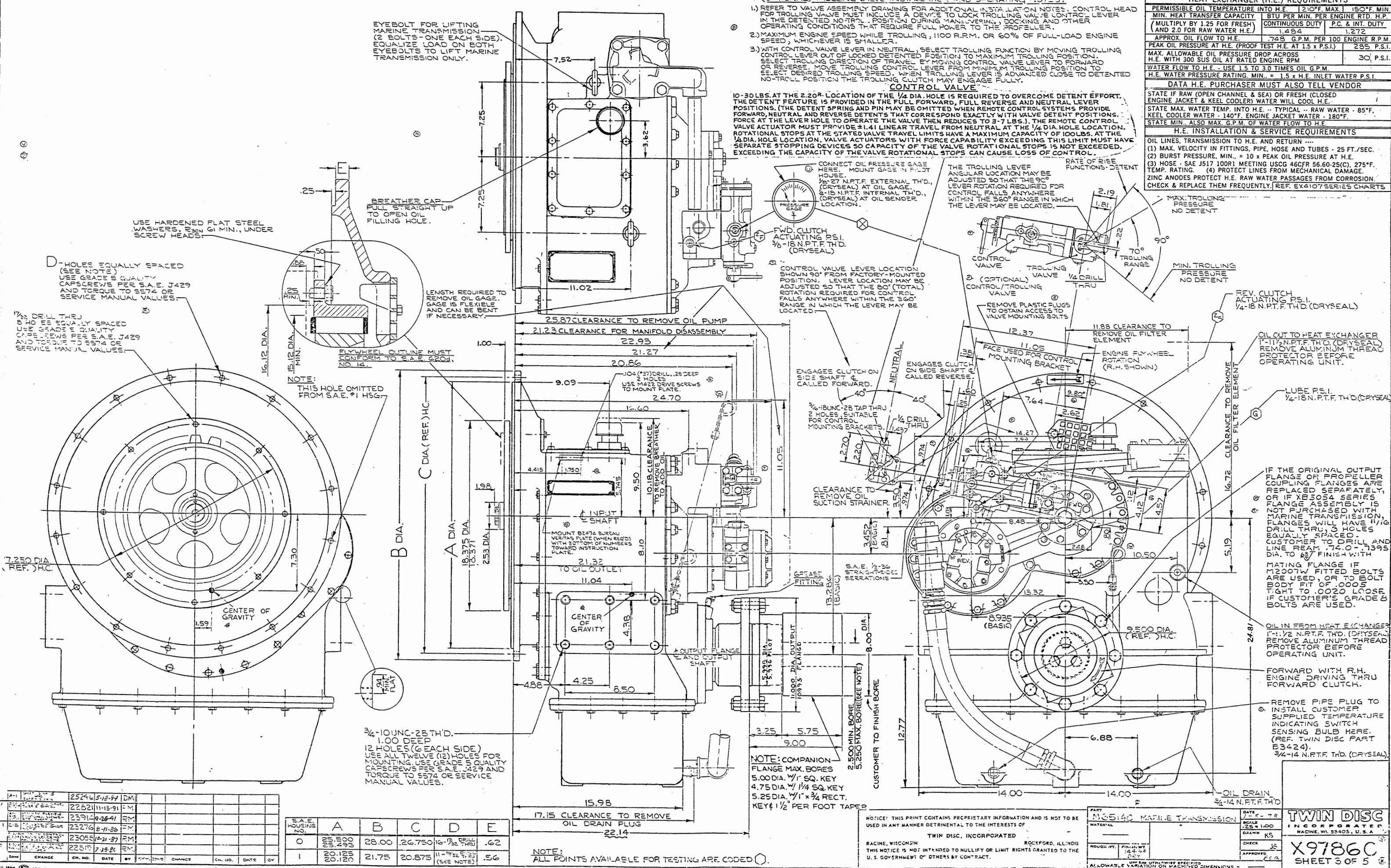
3/4-10UNC-28TH'D. 1.00 DEEP 12 HOLES (6 EACH SIDE) USE ALL TWELVE (12) HOLES FOR MOUNTING. USE GRADE 5 QUALITY CAPSCREWS PER S.A.E. J429 AND TORQUE TO S574 OR SERVICE MANUAL VALUES.

- (OPTIONAL) TROLLING VALVE INSTALLATION AND OPERATING NOTES:
- REFER TO VALVE ASSEMBLY DRAWING FOR ADDITIONAL INSTALLATION NOTES. CONTROL LEVER FOR TROLLING VALVE MUST INCLUDE A DEVICE TO LOCK TROLLING VALVE IN DETENT POSITION IN THE DETENTED NO-TROLL POSITION DURING MANUEVERING, DOCKING AND OTHER OPERATING CONDITIONS THAT REQUIRE FULL POWER TO THE PROPELLER.
 - MAXIMUM ENGINE SPEED WHILE TROLLING, 1100 R.P.M. OR 60% OF FULL-LOAD ENGINE SPEED, WHICHEVER IS SMALLER.
 - WITH CONTROL VALVE LEVER IN NEUTRAL, SELECT TROLLING FUNCTION BY MOVING TROLLING CONTROL LEVER OUT OF LOCKED DETENTED POSITION TO MAXIMUM TROLLING POSITION. SELECT TROLLING DIRECTION OF TRAVEL BY MOVING CONTROL VALVE LEVER TO FORWARD OR REVERSE. MOVE TROLLING CONTROL LEVER FROM MINIMUM TROLLING POSITION TO SELECT DESIRED TROLLING SPEED. WHEN TROLLING LEVER IS ADVANCED CLOSE TO DETENTED NO-TROLL POSITION THE TROLLING CLUTCH MAY ENGAGE FULLY.

CONTROL VALVE
 10-30 LBS. AT THE 2.20" LOCATION OF THE 1/4 DIA. HOLE IS REQUIRED TO OVERCOME DETENT EFFORT. THE DETENT FEATURE IS PROVIDED IN THE FULL FORWARD, FULL REVERSE AND NEUTRAL LEVER POSITIONS. (THE DETENT SPRING AND PIN MAY BE OMITTED WHEN REMOTE CONTROL SYSTEMS PROVIDE FORWARD, NEUTRAL AND REVERSE DETENTS THAT CORRESPOND EXACTLY WITH VALVE DETENT POSITIONS. FORCE AT THE LEVER HOLE TO OPERATE THE VALVE THEN REDUCES TO 3-7 LBS.). THE REMOTE CONTROL VALVE ACTUATOR MUST PROVIDE 2.41" LINEAR TRAVEL FROM NEUTRAL AT THE 1/4 DIA. HOLE LOCATION. ROTATIONAL STOPS AT THE STATED VALVE TRAVEL LIMITS HAVE A MAXIMUM CAPACITY OF 100 LBS. AT THE 1/4 DIA. HOLE LOCATION. VALVE ACTUATORS WITH FORCE CAPABILITY EXCEEDING THIS LIMIT MUST HAVE SEPARATE STOPPING DEVICES SO CAPACITY OF THE VALVE ROTATIONAL STOPS IS NOT EXCEEDED. EXCEEDING THE CAPACITY OF THE VALVE ROTATIONAL STOPS CAN CAUSE LOSS OF CONTROL.

HEAT EXCHANGER (H.E.) REQUIREMENTS		
PERMISSIBLE OIL TEMPERATURE INTO H.E.	210°F. MAX.	150°F. MIN.
MIN. HEAT TRANSFER CAPACITY	BTU PER MIN. PER ENGINE RTD. H.P.	
(MULTIPLY BY 1.25 FOR FRESH AND 2.0 FOR RAW WATER H.E.)	CONTINUOUS DUTY	P.C. & INT. DUTY
	1.484	1.272
APPROX. OIL FLOW TO H.E.	.745 G.P.M. PER 100 ENGINE R.P.M.	
PEAK OIL PRESSURE AT H.E. (PROOF TEST H.E. AT 1.5 x P.S.I.)	235 P.S.I.	
MAX. ALLOWABLE OIL PRESSURE DROP ACROSS H.E. WITH 300 SUS OIL AT RATED ENGINE RPM	30" P.S.I.	
WATER FLOW TO H.E. - USE 1.5 TO 3.0 TIMES OIL G.P.M.		
H.E. WATER PRESSURE RATING, MIN. = 1.5 x H.E. INLET WATER P.S.I.		

DATA H.E. PURCHASER MUST ALSO TELL VENDOR
 STATE IF RAW (OPEN CHANNEL & SEA) OR FRESH (CLOSED ENGINE JACKET & KEEL COOLER) WATER WILL COOL H.E.
 STATE MAX. WATER TEMP. INTO H.E. - TYPICAL - RAW WATER - 85°F. KEEL COOLER WATER - 140°F. ENGINE JACKET WATER - 180°F.
 STATE MIN. ALSO MAX. G.P.M. OF WATER FLOW TO H.E.
H.E. INSTALLATION & SERVICE REQUIREMENTS
 OIL LINES, TRANSMISSION TO H.E. AND RETURN -
 (1) MAX. VELOCITY IN FITTINGS, PIPE, HOSE AND TUBES - 25 FT./SEC.
 (2) BURST PRESSURE, MIN. = 10 x PEAK OIL PRESSURE AT H.E.
 (3) HOSE - SAE J517 100R1 MEETING USCG 46CFR 56.60-25(C), 275°F. TEMP. RATING. (4) PROTECT LINES FROM MECHANICAL DAMAGE.
 ZINC ANODES PROTECT H.E. RAW WATER PASSAGES FROM CORROSION. CHECK & REPLACE THEM FREQUENTLY. REF. EX4107 SERIES CHARTS.



REV.	DATE	BY	CHKD.	CHG. NO.	DATE	BY
1	25246	5-15-94	DM			
2	22521	11-15-91	EM			
3	2391	9-26-91	RM			
4	23276	8-11-88	EM			
5	23055	10-11-87	RM			
6	22517	7-19-86	RM			

S.A.E. HOUSING NO.	A	B	C	D	E
0	26.800 28.295	28.00	26.750	16-1/32 THRU	.62
1	20.125 20.120	21.75	20.875	11-1/32 THRU (SEE NOTE)	.56

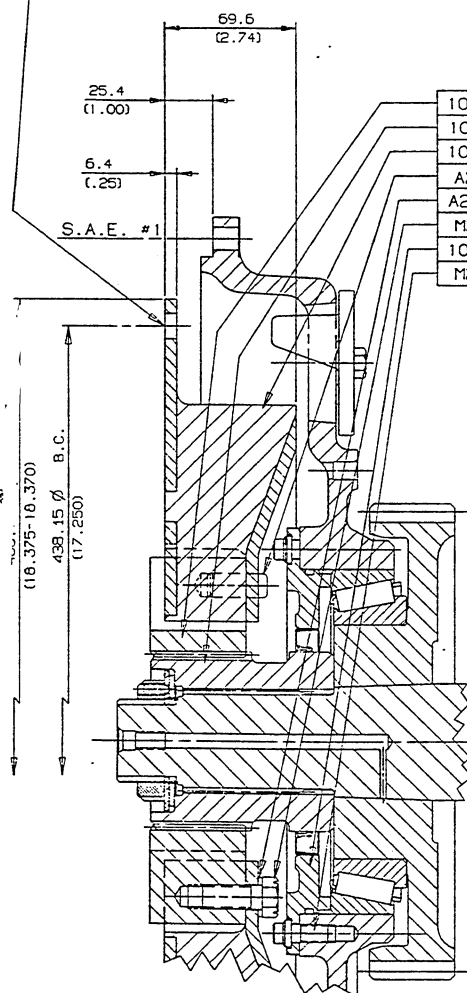
NOTE: ALL POINTS AVAILABLE FOR TESTING ARE CODED ○.

NOTE: THIS PRINT CONTAINS PROPRIETARY INFORMATION AND IS NOT TO BE USED IN ANY MANNER DETRIMENTAL TO THE INTERESTS OF TWIN DISC, INCORPORATED
 RACINE, WISCONSIN
 THIS NOTICE IS NOT INTENDED TO NULLIFY OR LIMIT RIGHTS GRANTED TO THE U. S. GOVERNMENT OR OTHERS BY CONTRACT.

PART: M35140 MARINE TRANSMISSION
 DATE: 2-78
 SCALE: 2.5:1
 DRAWN: KS
 CHECK: JS
 APPROVED: PEB

TWIN DISC INCORPORATED
 RACINE, WI 53403, U.S.A.
X9786C
 SHEET 3 OF 5

13.5mm (17/32) DIA. THRU 8 HOLES EQUALLY SPACED COUPLING "A" ONLY USE GRADE 5 QUALITY CAPSCREWS PER S.A.E. J429 AND TORQUE TO S574 OR SERVICE MANUAL VALUES.



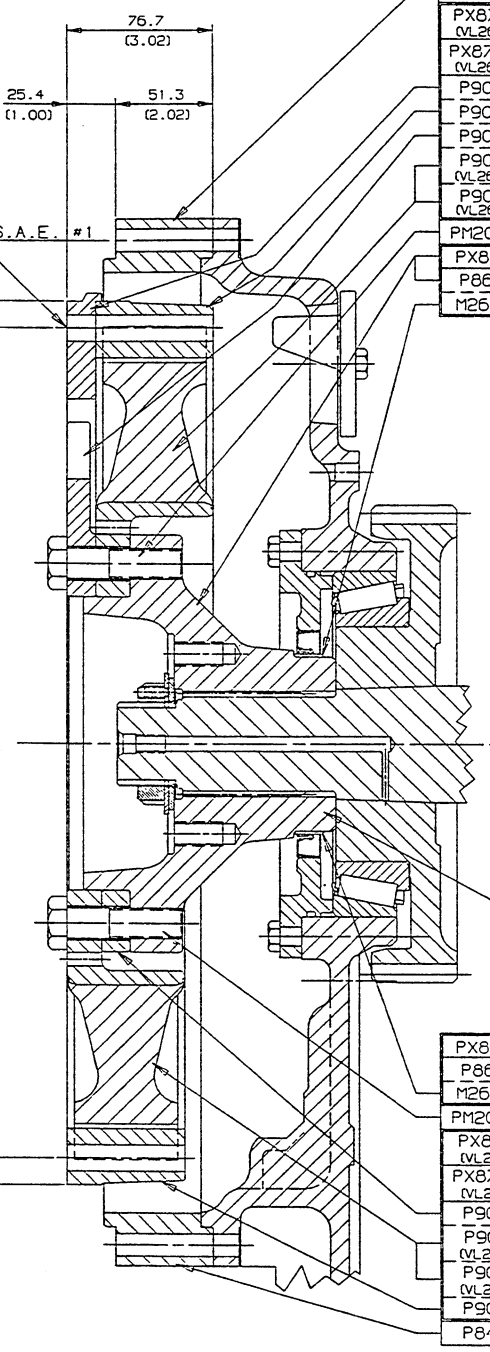
1001759	1
1001757	1
1002108	1
A2711P	6
A2888AD	4
M2721A	4
1001758	1
M20895	6

COUPLING "A"
FLEXIBLE COUPLING
LS14E-3701

NOTE:
UNITS WITH THIS FLEXIBLE COUPLING ARE APPROVED FOR RIGHT-HAND ENGINE ROTATION ONLY DUE TO COUPLING RESTRICTION.

ADVANCE MARINE TRANSMISSION INTO POSITION WITH ENGINE FLYWHEEL HOUSING MOUNTING FLANGE. LINE UP INPUT SHAFT EXTERNAL SPLINE WITH INTERNAL SPLINE IN COUPLING HUB AND MOVE ENGINE AND MARINE TRANSMISSION TOGETHER MAINTAINING ENGINE FLYWHEEL HOUSING AND MARINE TRANSMISSION FLYWHEEL HOUSING MOUNTING FACES IN PARALLEL RELATIONSHIP. ENGAGE FLYWHEEL HOUSING PILOTS AND INSTALL ALL MOUNTING CAPSCREWS USING GRADE 5 QUALITY CAPSCREWS PER S.A.E. J429 TORQUED TO S574 OR SERVICE MANUAL VALUES.

14mm (.55) DIA. THRU 8 HOLES EQUALLY SPACED COUPLINGS "B", "C", "D", "E" & "F" USE GRADE 5 QUALITY CAPSCREWS PER S.A.E. J429 AND TORQUE TO S574 OR SERVICE MANUAL VALUES.



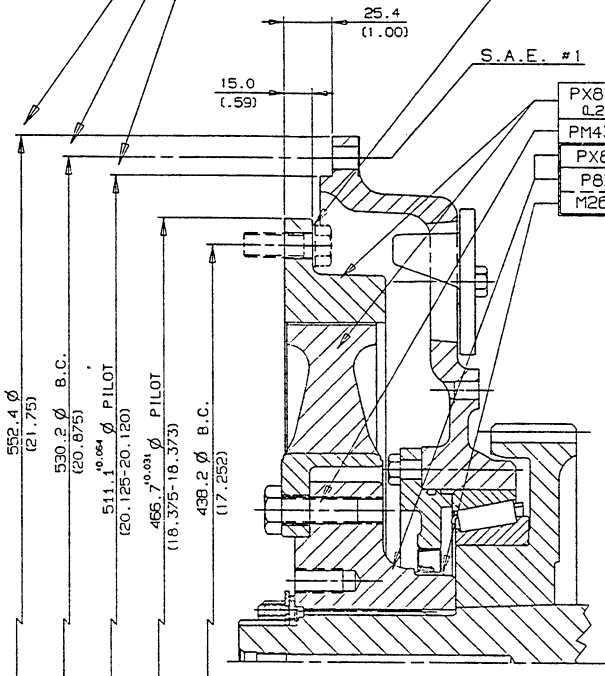
P8472	1
PX8704 (VL2511)	1
PX8704A (VL2512)	1
P9090	1
P9086	1
P9091	1
P9087 (VL2511)	1
P9088 (VL2512)	1
PM2018G	12
PX8699	1
P8699	1
M2666B	1

PX8699	1
P8699	1
M2666B	1
PM2018G	12
PX8702 (VL2511)	1
PX8702A (VL2512)	1
P9089	1
P9087 (VL2511)	1
P9088 (VL2512)	1
P9086	1
P8472	1

COUPLING "B"
VULASTIK
VL2511
14"

COUPLING "C"
VULASTIK
VL2512
14"

NOTE:
DIMENSIONS SAME FOR ALL S.A.E. #1 HOUSINGS.
USE HARDENED FLAT STEEL WASHERS, R_{min} 61 MIN. UNDER SCREW HEADS, FOR ALL FLEXIBLE COUPLINGS.



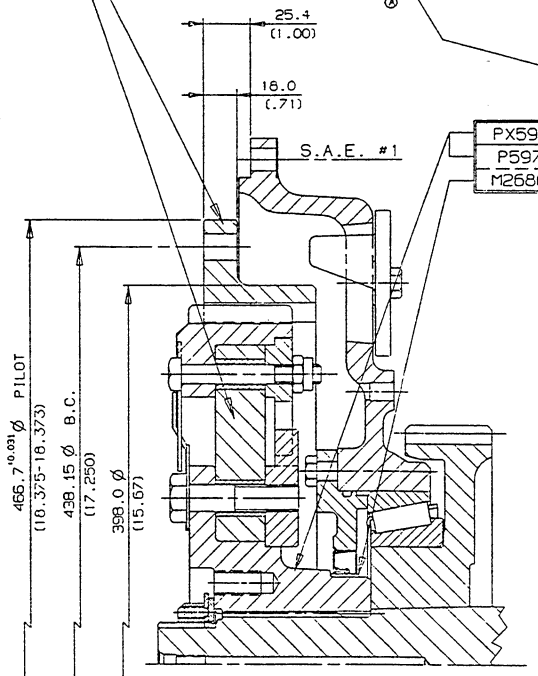
COUPLING "D"
VULASTIK
VL2212
(WITHOUT TORSIONAL STOP)
14"

ALL COUPLING DIMENSIONS SHOWN ARE FOR S.A.E. #14 FLYWHEEL.

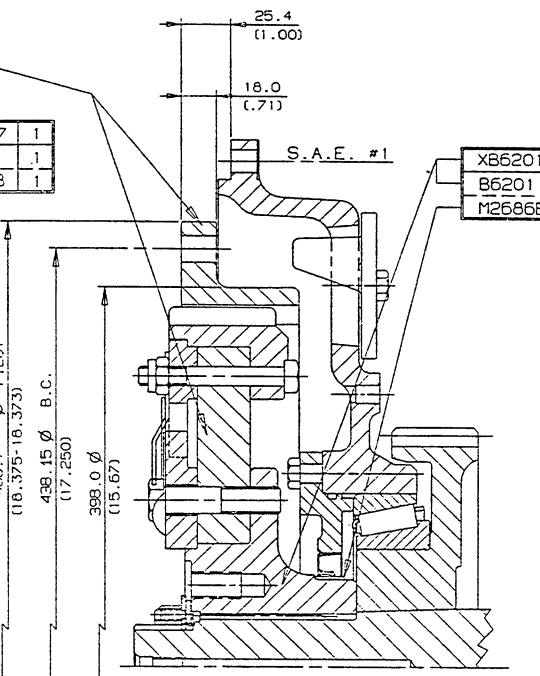
IMPORTANT:
WHEN INSTALLING TRANSMISSION TO ENGINE WITH TORSIONAL-STOP-EQUIPPED COUPLING, ROTATE TRANSMISSION INPUT HUB/INNER TORSIONAL STOP PLATE TO ORIENT LUGS ON INNER & OUTER TORSIONAL STOP PLATES 90° APART, AS SHOWN.

SECURE FLEXIBLE COUPLING TO HOUSING S.A.E. FLANGE HOLES, USING STANDARD METHOD, BEFORE SHIPMENT OF UNIT.

ELASTIC COUPLING	REPLACED BY:	QTY.	NOMINAL TORQUE	DYNAMIC TORSIONAL STIFFNESS
PM5978	PX8127	1	1.92 kN·m (17.01 x 10 ³ lb·in)	42.2 kN·m/rad (373.22 x 10 ³ lb·in/rad) WITH TORSIONAL STOP
PM5978A	PX8127D	1	1.92 kN·m (17.01 x 10 ³ lb·in)	42.2 kN·m/rad (373.22 x 10 ³ lb·in/rad) NO TORSIONAL STOP
PM5978B	PX8127A	1	2.45 kN·m (21.68 x 10 ³ lb·in)	100.0 kN·m/rad (885.10 x 10 ³ lb·in/rad) WITH TORSIONAL STOP
PM5978C	PX8127E	1	2.45 kN·m (21.68 x 10 ³ lb·in)	100.0 kN·m/rad (885.10 x 10 ³ lb·in/rad) NO TORSIONAL STOP
PM5978D	PX8127G	1	2.45 kN·m (21.68 x 10 ³ lb·in)	47.6 kN·m/rad (421.10 x 10 ³ lb·in/rad) TORSIONAL STOP



COUPLING "E"
VULASTIK
P7500 SERIES
14"
ORIGINAL CONSTRUCTION



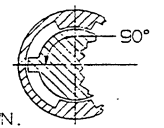
COUPLING "F"
VULASTIK
P7500 SERIES
14"
PREFERRED CONSTRUCTION

COUPLING	MAX. COUPLING R.P.M. (REF. 1)	NOMINAL TORQUE	DYNAMIC TORSIONAL STIFFNESS	WR ² WITHOUT TORSIONAL STOP		WR ² WITH TORSIONAL STOP	
				OUTER PARTS	INNER PARTS	OUTER PARTS	INNER PARTS
A	2500	2.66 kN·m (23.54 x 10 ³ lb·in)	21.2 kN·m/rad (188.00 x 10 ³ lb·in/rad)	—	—	0.21 kg·m ² (718 lb·in ²)	0.19 kg·m ² (640 lb·in ²)
B	2700	2.00 kN·m (17.70 x 10 ³ lb·in)	7.7 kN·m/rad (67.83 x 10 ³ lb·in/rad)	0.32 kg·m ² (1094 lb·in ²)	0.20 kg·m ² (695 lb·in ²)	0.70 kg·m ² (2392 lb·in ²)	0.24 kg·m ² (835 lb·in ²)
C	2700	2.52 kN·m (22.30 x 10 ³ lb·in)	13.0 kN·m/rad (115.04 x 10 ³ lb·in/rad)	0.32 kg·m ² (1094 lb·in ²)	0.20 kg·m ² (695 lb·in ²)	0.70 kg·m ² (2392 lb·in ²)	0.24 kg·m ² (835 lb·in ²)
D	3200	1.60 kN·m (14.17 x 10 ³ lb·in)	8.0 kN·m/rad (70.49 x 10 ³ lb·in/rad)	0.24 kg·m ² (821 lb·in ²)	0.14 kg·m ² (495 lb·in ²)	—	—
E	2700	SEE CHART	SEE CHART	0.48 kg·m ² (1650 lb·in ²)	0.088 kg·m ² (300 lb·in ²)	0.49 kg·m ² (1663 lb·in ²)	0.088 kg·m ² (300 lb·in ²)
F	2700	SEE CHART	SEE CHART	0.48 kg·m ² (1650 lb·in ²)	0.088 kg·m ² (300 lb·in ²)	0.49 kg·m ² (1663 lb·in ²)	0.088 kg·m ² (300 lb·in ²)

SEE SHEET 1 FOR MAXIMUM TRANSMISSION R.P.M.
THE WR² OF INNER PARTS INCLUDES HUB, SCREWS AND SHAFT C₂ INSIDE HUB.
FOR OTHER TRANSMISSION MASS ELASTIC DATA, REFER TO B3504C.
FOR OTHER TRANSMISSION INSTALLATION DIMENSIONS, REFER TO X9786C, SHEET 3.

METRIC

INCH DIMENSIONS SHOWN IN BRACKETS:



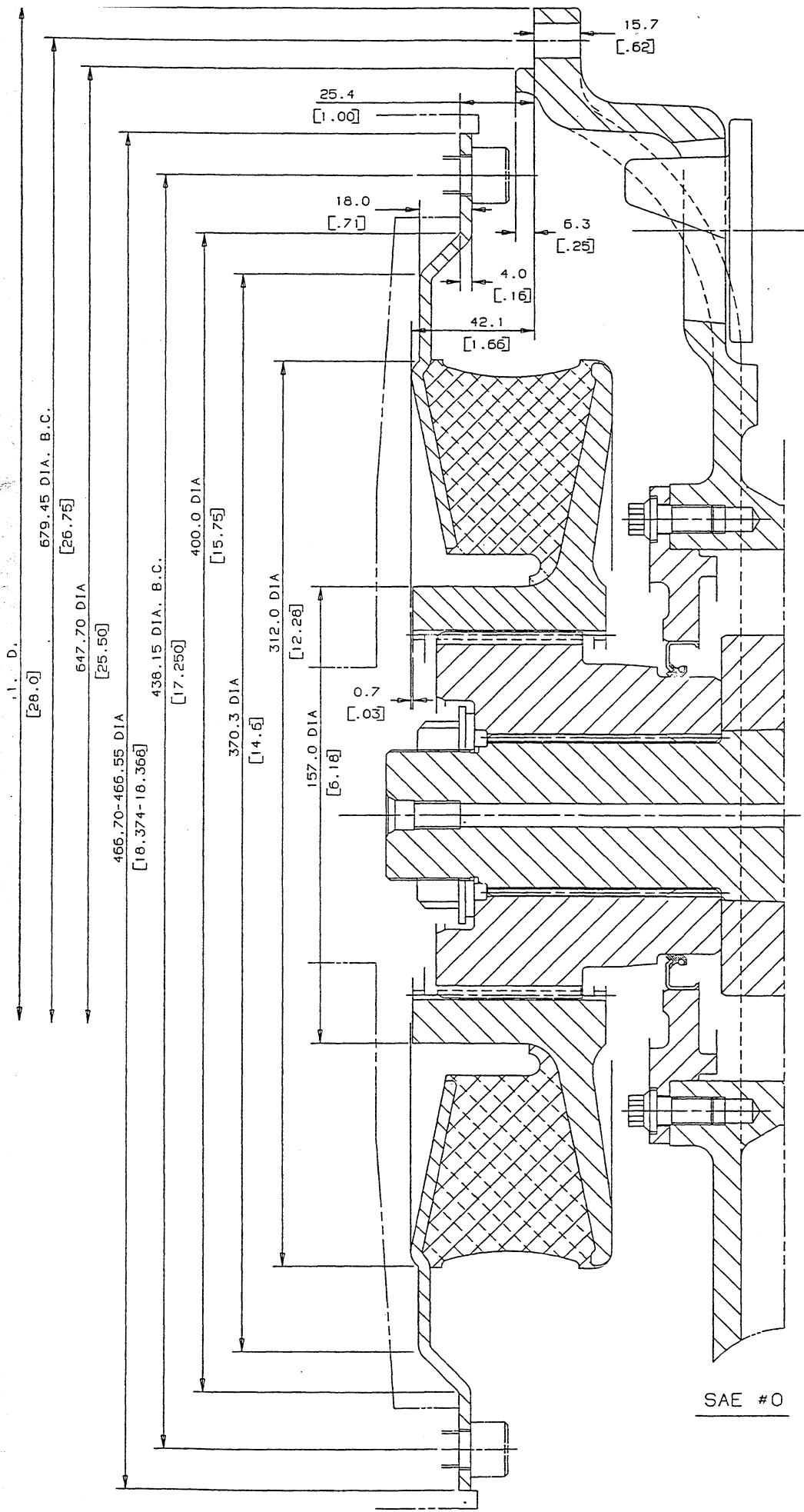
SYMBOL	CHARACTERISTIC	SYMBOL	MODIFIER
□	FLATNESS	⊕	MPC (MAX. MATERIAL CONDITION)
∥	PARALLELISM	⊙	RFS (REGARDLESS OF FEATURE SIZE)
⊥	PERPENDICULARITY	⊠	NAME
⊘	CIRCULAR RUNOUT	⊞	DATUM FEATURE
⊖	TOTAL RUNOUT	⊚	DIAMETER
⊙	POSITION		

NOTE: UNTOLERANCED DIMENSIONS LOCATING TRUE POSITION ARE BASIC.

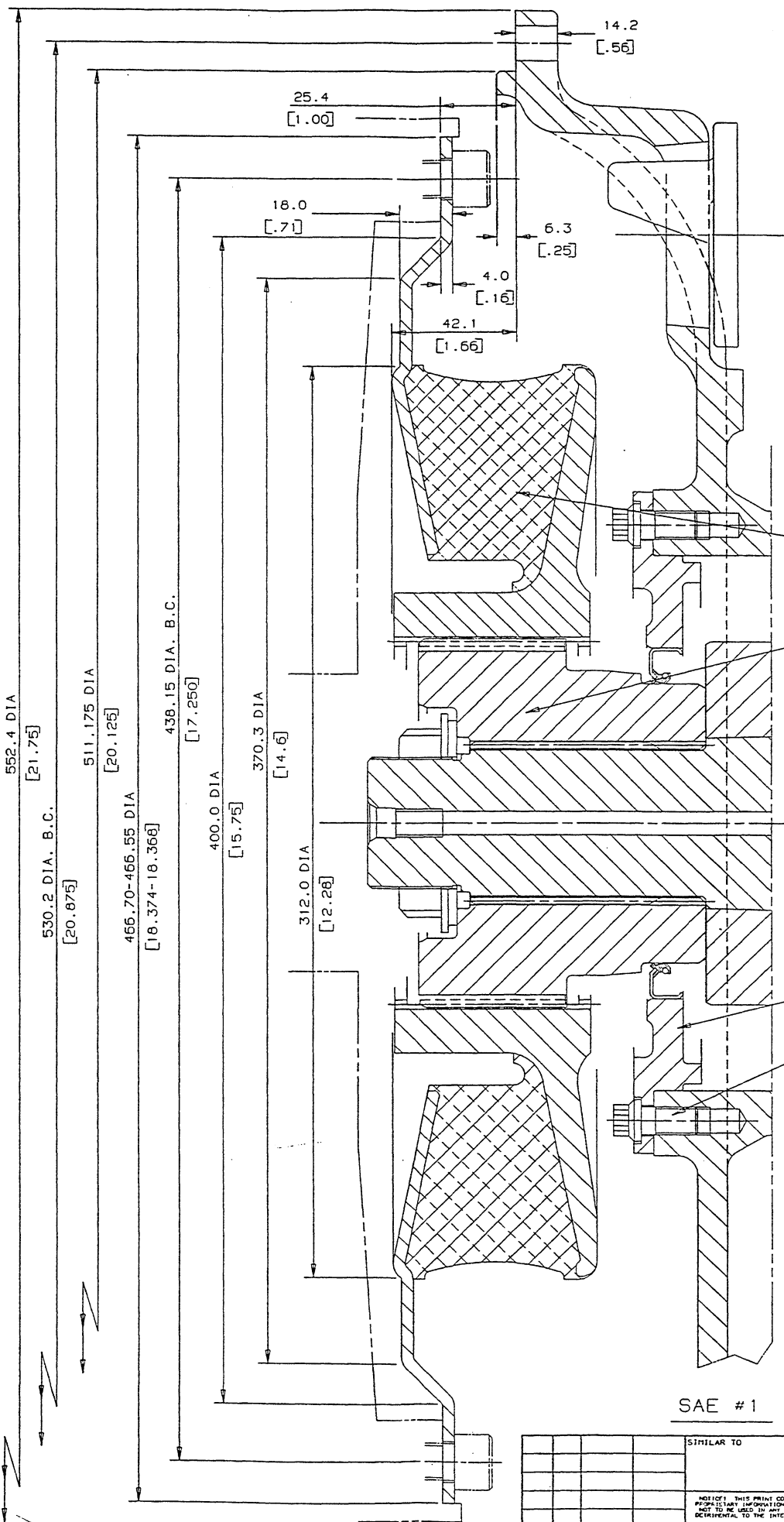
MATERIAL	HEAT TREAT	DATE	9-16-91
SURFACE TREATMENT	WEIGHT ROUGH FIN.	FIRST USE ASSY. MODEL	
UNLESS OTHERWISE SPECIFIED ALL DIMENSIONAL TOLERANCES ±.010 ALL ANGULAR TOLERANCES ±1°		NAME	MG514C MARINE TRANSMISSION (FLEXIBLE COUPLING INPUTS)
TWIN DISC INCORPORATED RACINE, WI 53403 - USA		DATE	9-16-91
X9786C SHEET 4 OF 5		SCALE	.50-1"

REV.	DATE	BY	CHKD.	APPD.	DESCRIPTION
1	5-18-91	DM			4 OF 5 WAS 4 OF 4
2	5-18-91	DM			REVISIONS
3	6-16-93	RM			REVISIONS
4	11-4-91	KS			PX8127C WAS PX8127C

NOTICE: THIS PRINT CONTAINS PROPRIETARY INFORMATION AND IS NOT TO BE USED IN ANY MANNER DETRIMENTAL TO THE INTERESTS OF TWIN DISC, INCORPORATED RACINE, WISCONSIN TO THE U.S. GOVERNMENT OR OTHERS BY CONTRACT.



SAE #0



SAE #1

SAE NO.	TYPE OF COUPLING	NOMINAL TORQUE	DYNAMIC TORSIONAL STIFFNESS	WR ²		COUPLING SPEED
				OUTER PARTS	INNER PARTS	
0 & 1	E-4011 P-9476	2.50KNm 22.1x10 ³ Lbsin	11.00 KNm/rod 97.33x10 ³ Lbsin/rod	0.18Kg ² 615.4 Lb.in ²	0.11Kg ² 376.1 Lb.in ²	3200 RPM
0 & 1	E-4014 P-9478	2.50KNm 22.1x10 ³ Lbsin	8.00 KNm/rod 70.78x10 ³ Lbsin/rod	0.18Kg ² 615.4 Lb.in ²	0.11Kg ² 376.1 Lb.in ²	3200 RPM
0 & 1	E-4012 P-9479	3.15KNm 27.9x10 ³ Lbsin	8.00 KNm/rod 70.78x10 ³ Lbsin/rod	0.18Kg ² 615.4 Lb.in ²	0.11Kg ² 376.1 Lb.in ²	3200 RPM

TYPE OF COUPLING AND NUMBER. (SEE CHART)	
P-9650	1

1001758	1
M-2089-B	6

NOTE : FOR MISSING DIMENSIONS SEE SHEET 3 OF 5.
 • THE WR 2 OF INNER PARTS INCLUDES HUB AND 1/4 SHAFT C2.
 △ SECURE FLEXIBLE COUPLING TO HOUSING S.A.E. FLANGE HOLES. USING STANDARD METHOD. BEFORE SHIPMENT OF UNIT.

METRIC - INCH DIMENSIONS SHOWN IN BRACKETS.

THIRD ANGLE PROJECTION

REV	ZONE	CH. NO.	DATE	SIMILAR TO	MATERIAL	WEIGHT LBS.	WR ² LBS. IN ²	UNLESS OTHERWISE SPECIFIED MACHINED DIMENSIONS ±.010	DATE 3-29-99	TWIN DISC INCORPORATED RACINE, WI 53403 - USA X9786C SHEET 5 OF 5
				HEAT TREAT	FIRST USE	ALL ANGULAR TOLERANCES ±1°		SCALE 1.00 = 1	DRN. KS	
				SURFACE TREATMENT	ASSEMBLY	GEOMETRIC TOLERANCING PER ANSI Y14.5M 1992		CHK. JS	APPD. EM	
				MG514C MARINE TRANSMISSION	NAME				SHEET 1 OF 1 REV	

