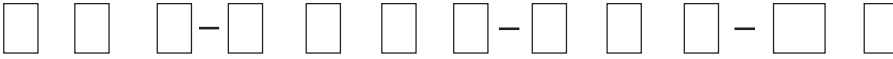


**Axial Piston Pumps
Variable Displacement
Worldcup****Series
P6, 7 & 8W Design B****Service Instructions****CONTENTS**

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Example: **P 6 W - 1 R 1 B - C O O - BB 0**



PUMP SERIES

DISPLACEMENT MAX.
 6-6.0 in³/rev 98 cc/rev
 7-7.25 in³/rev 119 cc/rev
 8-8.0 in³/rev 131 cc/rev

W-WORLD CUP SERIES

SHAFT SAE-D STANDARD
 1. SAE SPLINED
 2. KEYED

SHAFT ROTATION
 (VIEWED FROM SHAFT END)
 R-CW
 L-CCW

FLUID CLASS
 1. BUNA-N
 4. EPR
 5. VITON

DESIGN LETTER
 (ASSIGNED BY MFG.)

PRIMARY CONTROLS
 C. COMPENSATOR
 E. ELECTRO/HYDRAULIC STROKER
 H. HYDRAULIC STROKER
 R. ROTARY SERVO
 L. LOAD SENSE COMPENSATOR
 T. TORQUE LIMITER

PRIMARY CONTROLS OPTIONS
 0. NONE
 1. MAXIMUM VOLUME SCREW
 2. MAXIMUM VOLUME HANDWHEEL
 3. REMOTE HYDRAULIC/MAX. VOLUME
 4. MAX./MIN. VOLUME STOPS
 (CONTROL CODES "R", "H" & "E" ONLY)
 5. MINIMUM VOLUME STOP CAP. USE
 WITH MAX VOLUME SCREW C-F-L-T
 CONTROLS ONLY

SECONDARY CONTROLS
 O. NONE
 P. PRESSURE COMPENSATOR
 T. TORQUE LIMITER OVERRIDE
 R-E-H CONTROLS ONLY

MODIFICATION
 0. NO PUMP MOUNTED.
 1. (IF REAR PUMP IS TO BE MOUNTED, IT MUST BE DESIGNATED AS SEPARATE LINE ITEM ON ORDER).**

REARDRIVE*
 0 = NONE
 B = SAE-B
 (T6C, T6CC, PV10, PV15)
 BB = SAE-BB
 C = SAE-C
 (T6D, T6E, T6DC, T6EC, T6ED, T6DCC, PV20, PV29, P6, P7)
 D = SAE-D
 (P6W, P7W)

* APPROPRIATE COUPLING AND SEALS ARE INCLUDED IN SHIPMENT
 ** USER MUST SUBMIT DRAWING SHOWING ATTITUDE OF REAR PUMP MOUNTING

General

The Denison Worldcup 6, 7 and 8 axial piston pumps feature advance design concepts which are time proven and provide for advance pumping and control concepts. The instructions contained in this manual cover complete disassembly and reassembly of the unit. Before proceeding with the disassembly or reassembly of any unit, this manual should be studied in order to become familiar with proper order and parts nomenclature.

Description

The main rotating group is the same as in the Goldcup hydrostatic transmissions that have been in service for more than 15 years.

Standard control for the Worldcup units is a pressure Compensator. Additional optional controls are also available.

TABLE I TYPICAL CHARACTERISTICS

Specification	Term	Series 6	Series 7	Series 8
Displacement (theoretical) zero (bar)	in ³ /rev cm ³ /rev	6 (98)	7.25 (119)	8.0 (131)
Pressure Continuous	psi bar	5000 (345)	5000 (345)	<u>3600</u> <u>(248)</u>
Intermittent	psi bar	6000 (414)	6000 (414)	<u>4500</u> <u>(310)</u>
Speed Maximum	rev/min	3000	3000	1800
At "O" Inlet	rev/min	2100	2100	1800
Mounting Standard, 4 Bolt	SAE	D	D	D
Fluid Connections Inlet: SAE-4 Bolt Pad for 3000 PSI (207 bar) split flange	in. mm	2-1/2 (62.5)	2-1/2 (62.5)	2-1/2 (62.5)
Outlet: SAE-4 Bolt Pad for 6000 PSI (414 bar) split flange	in. mm	1-1/4 (31.25)	1-1/4 (31.25)	1-1/4 (31.25)
Rotating Inertia	lb. in ² kg. m ²	92 (0.027)	92 (0.027)	92 (0.027)
Compensator Response Off-Stroke	sec	0.100	0.100	0.100
On-Stroke	sec	0.150	0.150	0.150
Weight	lbs kg	180 (81)	180 (81)	180 (81)

Mounting

This pump is designed to operate in any position. The mounting hub and four bolt mounting flange are in full conformance with SAE standard. The pump shaft must be in alignment with the shaft of the driven load and should be checked with a dial indicator. The mounting pad or adaptor into which the fluid pump pilots must be concentric with the pump shaft to prevent bearing failure. This concentricity is particularly important if the shaft is rigidly connected to the driven load without a flexible coupling.

Shaft Information

Splined: The shafts will accept a maximum misalignment of 0.006" TIR (.15 mm). Angular misalignment at the male and female spline axes must be less than $\pm .002$ (0.5 mm) per one inch radius. The coupling interface must be lubricated. Denison recommends lithium molydisulfate or similar grease. The female coupling should be hardened to 27-45 Rc and must conform to SAE-J498B (1971) Class 1 flat root side fit.

Keyed: High strength heat treated keys must be used. Replacement keys must be hardened to 27-34 Rc. The key corners must be chamfered .030"-.040" (.75-1 mm) at 45° to clear radii that exist in the keyway.

Splined or Keyed: Both types of shafts will accept a side load of 875 lbs. (396 kg) at the center of the spline or key, with a B10 life of 10,000 hours at 1800 RPM.

Piping

Connect inlet and outlet lines to the port block of the pump. The fluid connections are

Inlet: 21/2" (62.5 mm), 3000 PSI (207 bar), SAE 4 bolt flange, Code 61

Outlet: 11/4" (31.25 mm), 6000 PSI (414 bar), SAE 4 bolt flange, Code 62

Other: SAE straight thread, O-ring seal.

See installation drawing for sizes.

The maximum case pressure is 75 PSI (5.17 bar) continuous, 125 PSI (8.6 bar) intermittent. Case pressures must never exceed inlet pressure by more than 25 PSI (1.7 bar). When connecting case drain line make certain that drain plumbing passes above highest point of the pump before passing to the reservoir. If not, install a 5 PSI (.3 bar) case pressure check valve to be certain the case is filled with oil at all times.

The case leakage line must be of sufficient size to prevent back pressure in excess of 75 PSI (5.7 bar) and returned to the reservoir below the surface of the oil as far from the supply suction as possible. All fluid lines, whether pipe, tubing, or hose must be adequate size and strength to assure free flow through the pump. An undersize inlet line will prevent the pump from reaching full speed and torque. An undersized outlet line will create back pressure and cause improper operation. Flexible hose lines are recommended. If rigid piping is used, the workmanship must be accurate to eliminate strain on the pump port block or to the fluid connections. Sharp bends in the lines must be eliminated wherever possible. All system piping must be cleaned with solvent or equivalent before installing pump. Make sure the entire hydraulic system is free of dirt, lint, scale, or other foreign material.

Caution: Do not use galvanized pipe. Galvanized coating can flake off with continued use.

Service Information

These hydraulic products are designed to give long dependable service when properly applied and their systems properly maintained. These general instructions apply to typical systems. Specific instructions for particular equipment can be developed from them.

Compensator adjustment: Approximately 2000 PSI (138 bar) per turn.

Maximum volume adjustment: 16 turns, zero to full stroke.

Minimum compensator pressure: 150 PSI (10 bar)

Recommended Fluids

See Denison Hydraulics bulletin SPO-AM305 for more details.

Maintenance

This pump is self-lubricating and preventative maintenance is limited to keeping system fluid clean by changing filters frequently. Keep all fittings and screws tight. Do not operate at pressures and speeds in excess of the recommended limit. If the pump does not operate properly, check the Trouble Shooting Chart before attempting to overhaul the unit. Overhauling is relatively simple and may be accomplished by referring to the Disassembly, Rework Limits of Wear Parts and Assembly Procedures.

Fluid Cleanliness

Fluid must be cleaned before and continuously during operation by filters that maintain a cleanliness level of NAS 1638 Class 8.

Start Up Procedure for New Installation

1. Read and understand the instruction manual. Identify components and their function.
2. Visually inspect components and lines for possible damage.
3. Check reservoir for cleanliness and drain and clean as required.
4. Check fluid level and fill as required with filtered fluid at least as clean as that recommended. Fill pump case with clean oil prior to starting.
5. Check alignment of drive.
6. Check oil cooler and activate it, if included in circuit. Check fluid temperature.
7. Reduce pressure settings of relief valve. Make sure accurate pressure readings can be made at appropriate places.
8. If solenoids in system, check for actuation.
9. Start pump drive. Make sure pump and motor fill properly.
10. Bleed system of air. Recheck fluid level.
11. Cycle unloaded machine at low pressure and observe actuation (at low speed, if possible).
12. Increase pressure settings gradually in steps. Check for leaks in all lines especially in pump and motor inlet lines.
13. Make correct pressure adjustments.
14. Gradually increase speed. Be alert for trouble as indicated by changes in sounds, system shocks and air in fluid.
15. Equipment is operational.

Trouble Shooting

Component problems and circuit problems are often inter-related. An improper circuit may operate with apparent success but will cause failure of a particular component within it. The component failure is the effect, not the cause of the problem. This general guide is offered to help in locating and eliminating the cause of problems by studying their effects.

Effect of Trouble	Possible Cause	Fault Which Needs Remedy
Noisy pump	Air in fluid	Leak in suction line Leak at shaft seal Low fluid level Turbulent fluid Return lines above fluid level Gas leak from accumulator Excessive pressure drop in the inlet line from a pressurized reservoir. Suction line strainer acting as air trap
	Cavitation in pump rotating group	Fluid too cold Fluid too viscous Fluid too heavy Shaft speed too high Suction line too small Suction strainer too small Suction strainer too dirty Operating altitude too high Boost or replenishment pressure too low Replenishment flow too small for dynamic conditions
	Misaligned shaft	Faulty installation Distortion in mounting Axial interference Faulty coupling Excessive overhung loads
	Mechanical fault in pump	Piston and shoe looseness or failure Bearing failure Incorrect port plate selection or index Eroded or worn parts in the displacement control
Erosion on barrel ports and port plate	Air in fluid	See above
	Cavitation	See above
High wear in pump	Excessive Loads	Reduce pressure settings Reduce speeds

(Continued)

Effect of Trouble	Possible Cause	Fault Which Needs Remedy
High wear in pump	Contamination particles in fluid	Improper filter maintenance Filters too coarse Introduction of dirty fluid to system Reservoir openings Reservoir breather Improper line replacement
	Improper fluid	Fluid too thin or thick for operating temperature range Breakdown of fluid with time/temperature/shearing effects Incorrect additives in new fluid Destruction of additive effectiveness with chemical aging
	Improper repair	Incorrect parts Incorrect procedures, dimensions finishes
	Unwanted water in fluid	Condensation Faulty breather, strainer Heat exchanger leakage Faulty clean-up practice Water in make-up fluid
Pressure shocks	Cogging load Worn relief valve	Mechanical considerations Needed repairs
	Worn compensator Slow response in check valves	Needed repairs Replace or relocate
	Excessive decompression energy rates	Improve decompression control
	Excessive line capacitance (line volume, line stretch, accumulator effects)	Reduce line size or lengths. Eliminate hose
	Barrel blow-off	Recheck pump holddown, rotating group drain pressure
Heating of fluid	Excessive pump leakage	Recheck case drain flow and repair as required Fluid too thin Improper assembly, port timing
	Relief valve	Set too low (compared to load or compensator) Instability caused by back pressure, worn parts
	Compensator	Set too high (compared to relief) Worn parts
	Pump too large for fluid needs	Select smaller pump displacement
	Heat exchanger	Water turned off or too little flow Water too hot Fan clogged or restricted Efficiency reduced by mud or scale deposits Intermittent hydraulic fluid flow
	Reservoir	Too little fluid Improper baffles Insulating air blanket that prevents heat rejection Heat pickup from adjacent equipment

General

The instructions contained in this section cover a complete teardown of the subject pump. Disassemble only as far as necessary to replace or repair any worn parts.

Disassembly (Standard Housing, No Rear Drive)

Clean outside surface of the pump before disassembly. Disassembly area should be clean. A bench or similar suitable surface capable of supporting unit should be used. Unit weighs 180 lbs. (81.6 kg).

Port Block

1. Remove eight soc. hd. cap screws (12, fig. 1) that secures the port block (8) to the housing (38, fig. 2).
2. Remove port block assembly from housing.

Caution: Port plate will in some instances adhere to port block upon disassembly. Be careful that port plate does not drop and become nicked or scratched.

3. Remove port plate (11) and port plate pins (10).

Port Block and Drive Shaft

1. Remove snap ring (1, fig. 1) from port block.
2. Support port block and press on small end of shaft (4) assembly to remove it from port block.
3. Carefully remove shaft seal (2) from the shaft.
4. To replace shaft bearing (7) remove retaining ring (5) and press bearing from shaft.
5. Remove O-ring (3) from bore in port block.

Trunnion Cover

1. Remove the ten hex. hd. cap screws (24, fig. 2) to remove cover (25) from housing (36).
2. Remove O-ring (26) from pilot of cover.

Compensator Cover

1. Remove the ten hex hd. cap screws (24, fig. 2) to remove the compensator cover (39) from the housing (36).
2. Remove O-ring (1, fig.6) from pilot of cover.
3. Remove plug (19) and O-ring (20) from vent port.
4. Remove plug (21) and O-ring (5).

5. Remove plug (6) and O-ring (5).

6. Remove spring (4) and spool (3).

7. Loosen nut (15) and remove knob and adjusting screw assembly (16), (18), and (14).

8. Remove housing (13) and O-ring (5). Insert a small brass rod through the hole in the housing and tap out piston (11) and O-ring (12).

9. Remove spring (10) and cone (9).

10. A hex socket wrench must be used to remove seat (8) and O-ring (7).

Barrel, Holddown and Pistons, Retainer and Shoes

1. Reach through one of the trunnion bores on side of housing (38, fig. 2). Grasp one of the trunnion bearings (29) by the inner and outer race and partially remove.

Caution: The inner and outer bearing assembly are retained in one direction only. They can separate, allowing the rollers to fall out.

2. Remove face plate (13) from barrel (14).

3. Remove three face plates pins (10) from barrel.

4. Lift the barrel out of the housing (38).

5. Remove the six Belleville washers (15), spring retainer (16), holddown bearing (17) and holddown ball (18).

6. Remove pistons, shoes and retainer (23) and holddown socket (19).

7. Remove trunnion bearings (29).

Note: It may be necessary to insert a brass rod through the opposite side trunnion bore to carefully tap the bearings out.

Caution: The inner and outer bearing races are retained in one direction only. They can separate allowing the rollers to fall out.

8. Remove barrel bearing (30).

Spring and Max Volume Caps

1. Remove four hex. hd. cap screws (32, fig. 2) and remove spring cap (31).

Note: The spring Cap is under a light spring load.

- 2. Remove inner (33) and outer (34) springs.
- 3. Remove O-rings (35) and (41).
- 4. Slide the control piston (30) to approximately center or zero position.

5. Remove four hex hd. cap screws (32) and remove maximum volume cap (40).

6. Remove O-rings (41) and (35).

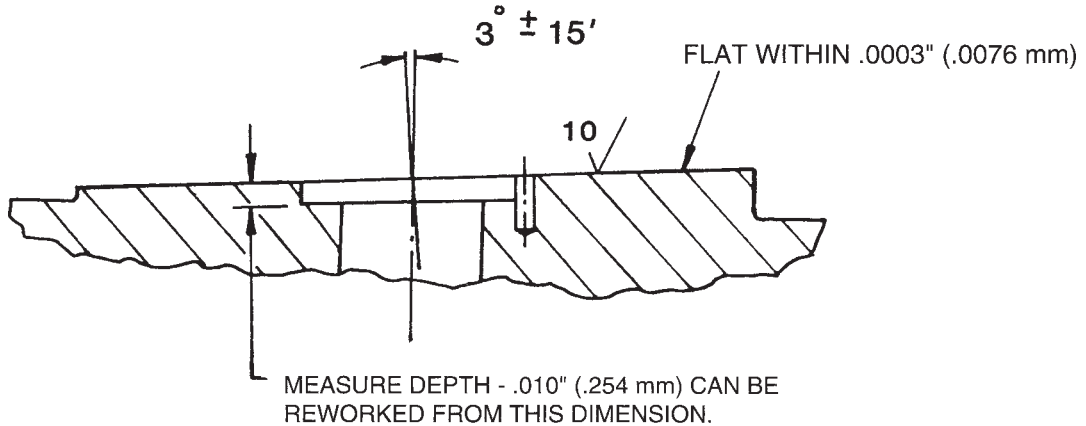
Hanger and Control Piston

1. Lift hanger (20), wavy washer-old/Belleville-new (21) and slide link (22) out of housing.

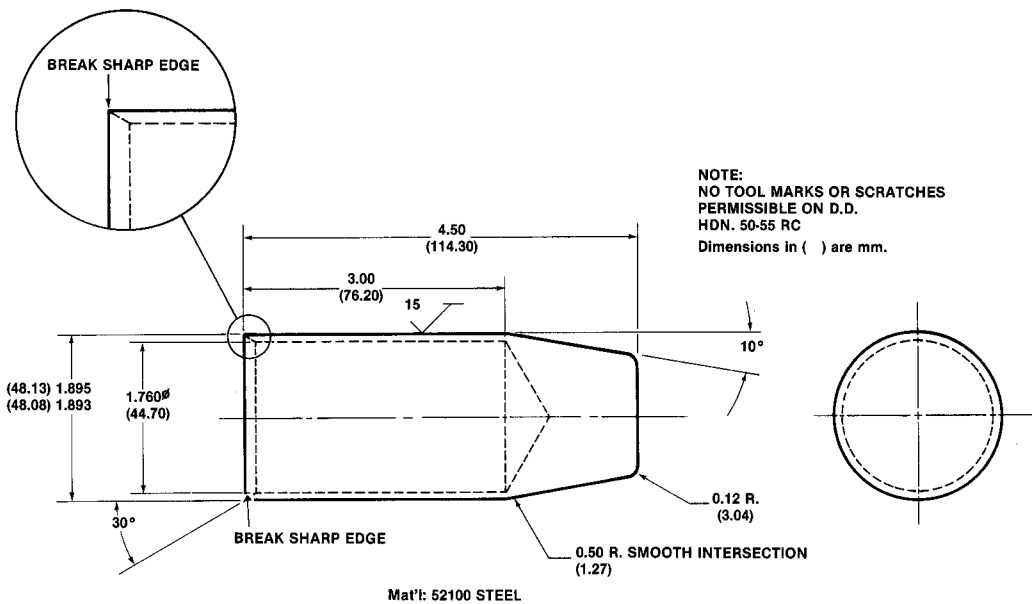
TABLE IV

Rework Limits of Wear Parts						
6, 7.25 & 8 in ³	Original Dimension		Max. Rework From Original Dimension		Min. Dimension After Rework	
	Port plate face	.315/.305"	(8/7.7 mm)	.010"	(.254 mm)	295"
Cylinder barrel face	4.480"	(113.79 mm)	.010"	(.254 mm)	4.470"	(113.5)
Shoe retainer face	—		*		Replace	
Piston shoe face	—		*		Replace	
Face Plate	N/A		None		Replace	

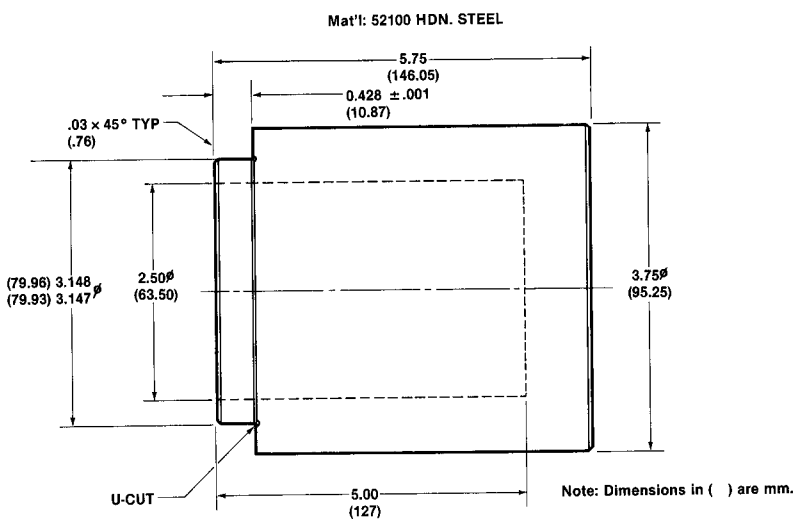
* Any rework to these parts on will result in increased holddown clearance and leakage will be higher



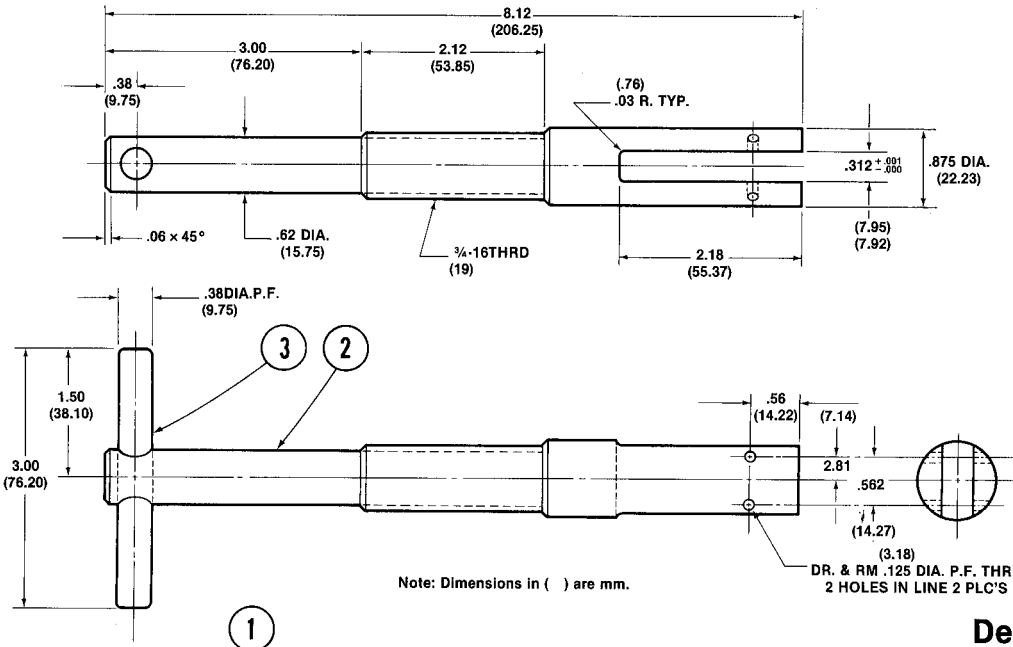
ROCKER CAM FACE



T-1



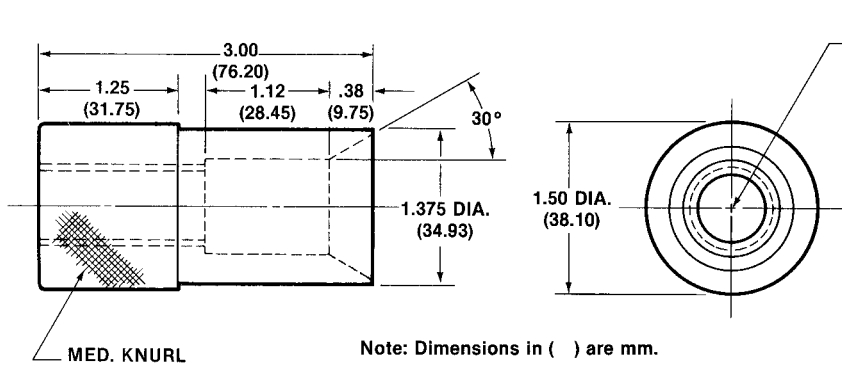
T-2



Note: Dimensions in () are mm.

DR. & RM. .125 DIA. P.F. THRU 2 HOLES IN LINE 2 PLC'S

Detail 1-2-3
213-0-004071



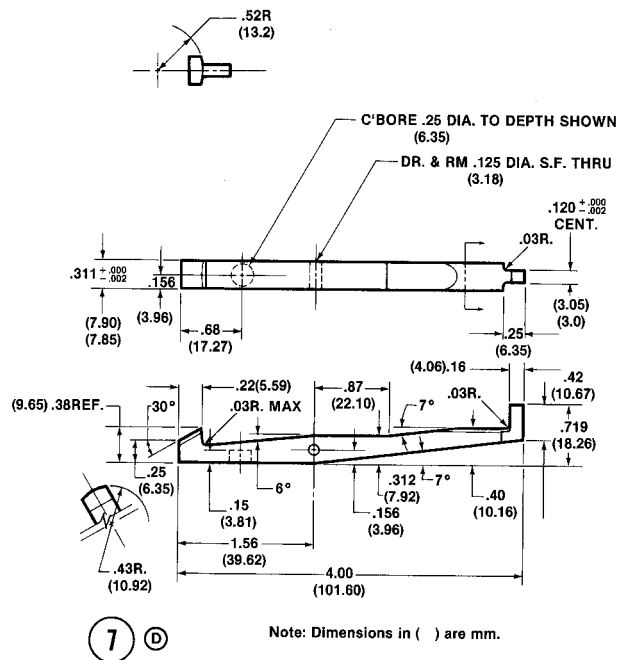
MED. KNURL

Note: Dimensions in () are mm.

(22.23) (38.10)
BORE .875 DIA. x 1.50 DP. S.F. FOR
DET. 1 - C' SINK AS SHOWN. DR. &
TAP 1/4 -16 THRU
(19)

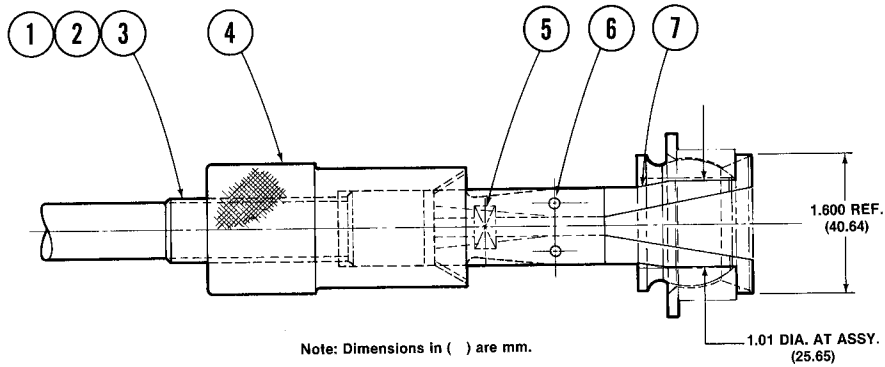
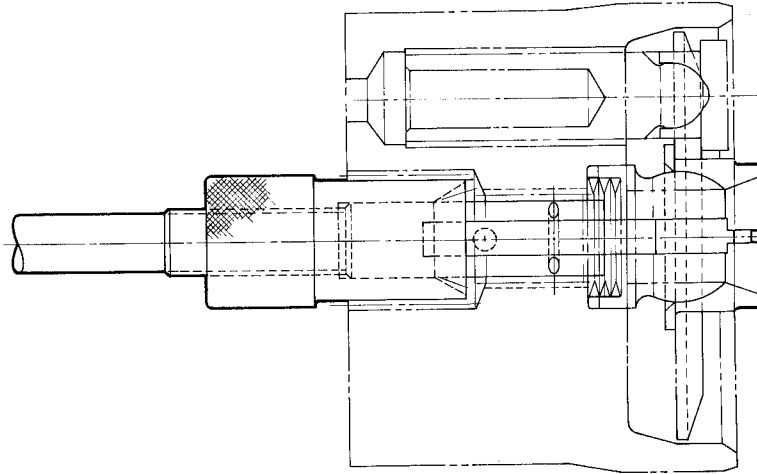
4

Detail 4
213-0-004071



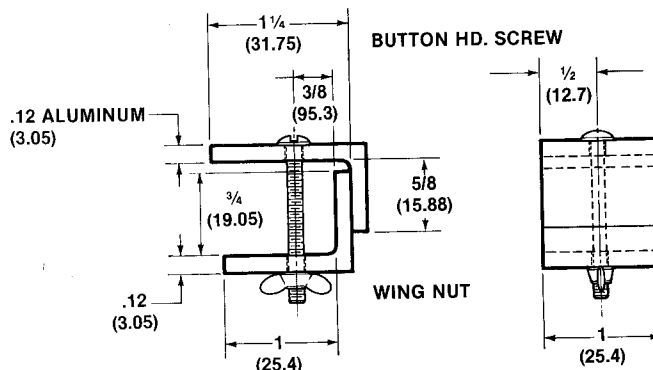
Note: Dimensions in () are mm.

Detail 7
213-0-004071

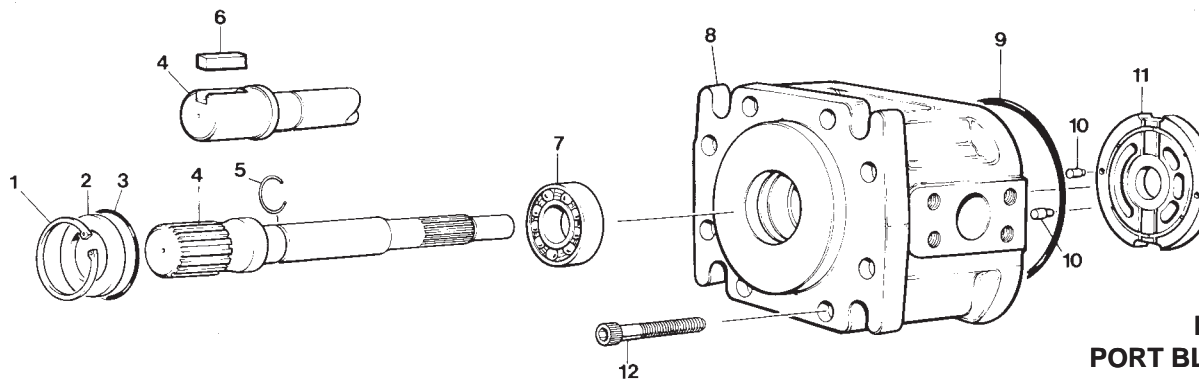


Det.	No.	Description
1	1	Sub-Assy c/of Det's 2&3
2	1	52100 Steel
3	1	CRS
4	1	52100 Steel
5	1	Lee Spring Cat. #LC-032C-8
6	2	Dowel 1/8 Dia x 5/8 Lg (3.18 x 15.88)
7	2	HRS

ASSY.
213-0-004071



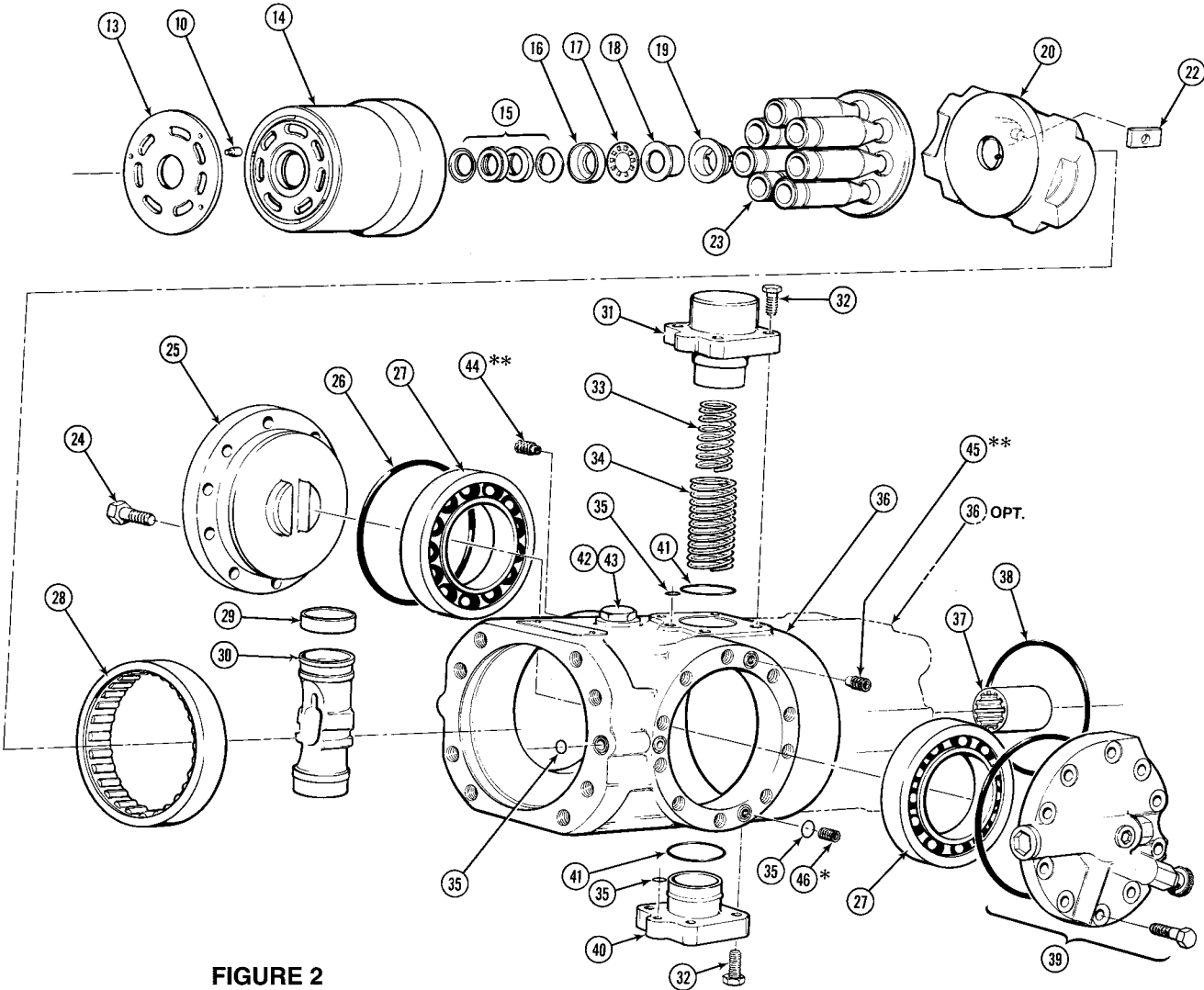
Note: Dimensions in () are mm.



**FIGURE 1
PORT BLOCK ASSEMBLY**

ITEM	DESCRIPTION	PART NO.	QTY.	
1	Ring, Retainer .105/.106 (2.67/2.69 mm) White dot	031-57476	1	
	Ring, Retainer .090/.091 (2.28/2.31 mm) Blue dot	031-57477		
2	Seal, Shaft (Teflon)	620-82080	1	
3	O-ring	671-00235	1	
4	Shaft, Sub-Assembly (Includes items 5 & 7)		1	
	STANDARD			
	Keyed	S21-11377		
	Splined	S21-11378		
	Shaft— <i>(Only)</i>			
	Keyed	031-57100		
	Splined	031-57089		
	Sub-Assembly <i>FOR SAE AUX. DRIVE (Mod. 'A' & Mod.'B')</i>			
	(Includes items 5 & 7)			
	"B" MOUNT	B-B' MOUNT	'C AND D' MOUNT	
	Keyed	S21-11415	S21-11447	S21-11557
	Splined	S21-11416	S21-11448	S21-11558
	Shaft— <i>(Only)</i>			
	Keyed	031-57101	031-57172	031-57219
	Splined	031-57104	031-57173	031-57175

ITEM	DESCRIPTION	PART NO.	QTY.
5	Ring, Retaining	033-70817	1
6	Key	034-29899	1
7	Bearing	230-82193	1
8	Port Block	031-57119	1
9	O-ring	671-00166	1
10	Pins	035-49825	5
11	Port plate RH, 6.0 (For C.W. Rotation)	031-59333	1
	Port plate LH, 6.0 (For C.C.W. Rotation)	031-59368	
	Port plate RH, 7.25 (For C.W. Rotation)	031-54508	
	Port plate LH, 7.25 (For C.C.W. Rotation)	031-54509	
	Port plate RH, 8.0 (For C.W. Rotation)	031-57372	
	Port plate LH, 8.0 (For C.C.W. Rotation)	031-57379	
12	Screws, S.H.C.S.	358-20400	8



*Always positioned on max. vol. cap side of housing. (Override controls only)

**Always positioned on spring cap side of housing. (Override controls only)

FIGURE 2
HOUSING & ROTATING GROUP ASSEMBLY
(CW PUMP w/COMPENSATOR CONTROL SHOWN)
(Items 47 and 48 not shown)

ITEM	DESCRIPTION	PART NO.	QTY.
13	Face Plate, (6.0)	033-71530	1
	Face Plate, (7.25 & 8.0)	033-72532	
14	Barrel & Sleeve Assembly, (6.0)	S21-03652	1
	Barrel & Sleeve Assembly, (7.25)	S21-03651	
	Barrel & Sleeve Assembly, (8.0)	S21-11648	
15	Washers, Belleville	<u>033-59743</u>	6
16	Spring Retainer	031-57097	1
17	Bearing, Holddown	230-82164	1
18	Ball, Holddown	031-57128	1
19	Socket, Holddown	031-57092	1
20	Hanger, Assembly (Standard)	<u>S21-12237</u>	1
	Hanger & Guide Ass'y (Used w/Torque Limiter Only) (Comp. Control)	<u>S21-12443</u>	
	Hanger, Assembly (Used w/Servo) CW	S21-12446	
	Hanger, Assembly (Used w/Servo) CCW	S21-12447	
	Hanger, Assembly (Used w/Servo and Torque Limiter) CW	S21-12448	
	Hanger, Assembly (Used w/Servo and Torque Limiter) CCW	S21-12444	
21	Washer, Belleville	Not Used	1
22	Slide, Link	031-57993	1
23	Piston, Shoe & Retainer Sub-Assembly, (6.0)	S13-45375	1
	(Piston & Shoe)	S13-45372	
	(Retainer)	033-54290	
	Piston, Shoe & Retainer Sub-Assembly, (7.25)	S13-47873	
	(Piston & Shoe)	S13-47872	
	(Retainer)	033-54290	

ITEM	DESCRIPTION	PART NO.	QTY.
	Piston, Shoe & Retainer Sub-Assembly, (8.0)	S21-11650	
	(Piston & Shoe)	S21-11649	
	(Retainer)	031-57376	
24	Screws, HHCS (use w/Trunnion Cover)	306-40124	10
25	Trunnion, Cover (Fig. 2)	031-57514	1
	Rotary Servo (R00) (Fig. 10)	S23-11560	
	Rotary Servo (R10) (Fig. 11)	S23-11608	
	Hydraulic Stroker (CCW) (Fig. 12)	S23-11571	
	Hydraulic Stroker (CW)	S23-11591	
	Electro-Hyd Stroker (CW) (Fig. 13)	S23-11593	
	Electro-Hyd Stroker (CCW)	S23-11701	
26	O-Ring	671-00254	1
27	Bearing, Trunnion	230-82194	2
28	Barrel Bearing	033-91107	1
	Pin(Barrel Bearing retainer)	031-91106	1
	O-ring (Barrel Bearing retainer)	671-00908	1
29	Ring, Piston	031-59338	2
30	Piston, Control (Comp Control)	031-57992	1
	Piston, Control (Servo Control)	<u>031-91093</u>	1
31	Cap, For Servo Control Units	S21-11610	1
	(w/Fixed Zero Volume Stop)		
	Cap, For Comp. Control Units	031-57094	
	(w/Fixed Zero Volume Stop)		
	Cap, w/Adjust Minimum Volume Stop	S21-11992*	
	*Caution: *Must use S21-11996, S21-11998 or		
	S21-11999 with this Control w/SAE-4		
	Relief Valve Port.		

ITEM	DESCRIPTION	PART NO.	QTY.
32	Screw, H.H.C. (w/Fixed Zero Vol. Stop)	306-40047	8
*	Screw, S.H.C. (w/Adj. Min. Vol. Stop)	See note	
33	Spring, Inner	032-59359	1
34	Spring, Outer	032-59356	1
35	O-Ring	691-00013	7
36	Housing, <i>Standard</i> For Compensator Control	031-91116	1
	Housing, <i>Standard</i> For Servo Control	031-91120	
	Housing, "B" Rear Pad For Compensator Control	031-91117	
	Housing, "B" Rear Pad For Servo Control	031-91121	
	Housing, "C" Rear Pad For Compensator Control	031-91119	
	Housing, "C" Rear Pad For Servo Control	031-91122	
	Housing, "D" Rear Pad For Compensator Control	031-91118	
	Housing, "D" Rear Pad For Servo Control	031-91123	
37	Coupling, SAE "B" (Rear Drive)	031-57170	1
	Coupling, SAE "B-B" (Rear Drive)	031-57171	
	Coupling, SAE "B-B" To SAE-C (Rear Drive)	031-57190	
	Coupling, SAE "B-B" To SAE-D (Rear Drive)	031-57191	
38	"O" Ring (Aux. Port) SAE-B, B-B (Rear Drive)	671-00155	1
	"O" Ring (Aux. Port) SAE "C" (Rear Drive)	671-00159	
	"O" Ring (Aux. Port) SAE "D" (Rear Drive)	671-00163	
39	Compensator (Fig. 6)	S23-11380	1
	Compensator, Low Flow (Fig. 7)	S23-11619	
	Load Sense (Fig. 8)	S23-11640	

***NOTE:** When cap w/Adj. Min Vol. Stop is used,
use (4) 306-4007 and (4) 358-16220 S.H.C. Screws.

ITEM	DESCRIPTION	PART NO.	QTY.
	Torque Limiter (Fig. 9)	S23-11651	
	Trunnion Cover	031-57514	
40	Cap, Max Volume w/Fixed Maximum Volume Stop	<u>031-57098</u>	1
	Use w/031-57094 (Min. Volume Cap)		
	Cap, Max Volume w/ SAE-4 Port	S21-11996	
	Use w/S21-11922 (Min. Volume Stop)		
	Cap, Max Volume, Screw Adjust	<u>S21-12361</u>	
	Use w/ <u>S21-57094</u> (Min. Volume Cap)		
	Cap., Max Volume, Screw Adjust, w/SAE-4 Port	S21-11998	
	Use w/031-57094 (Min. Volume Cap)		
	Cap, Max Volume, Handwheel Adjust	S21-11382	
	Use w/ <u>S21-11932</u> (Min. Volume Cap)		
	Cap, Max Volume, Handwheel Adjust, w/SAE-4 Port—Use w/S21-11992	S21-11999	
	(Min. Volume Stop)		
41	O-Ring	671-00037	2
42	Plug, Hex	488-35009	2
43	O-Ring	691-00916	2
44	Check Valve	S13-40266	1
45	Check Valve w/Orifice	S23-11615	1
46	Screw, S.S. (Plug)	312-15060	1
47	Plate, Name (Not Shown)	031-57189	1
48	Screws, Drive (For name plate, Not Shown)	320-10203	4

Seal Kit (Std.)	S-1	S21-11544-1
	S-4	S21-11544-4
	S-5	S21-11544-5

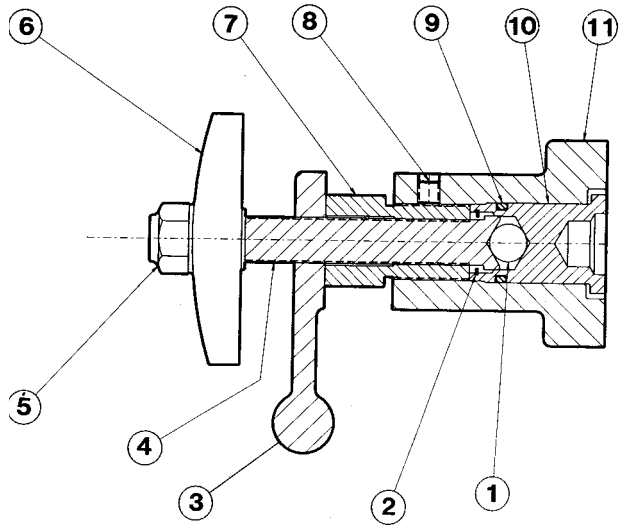


FIGURE 4
MAX. VOL. HANDWHEEL ADJUSTMENT CAP
(S21-11382)

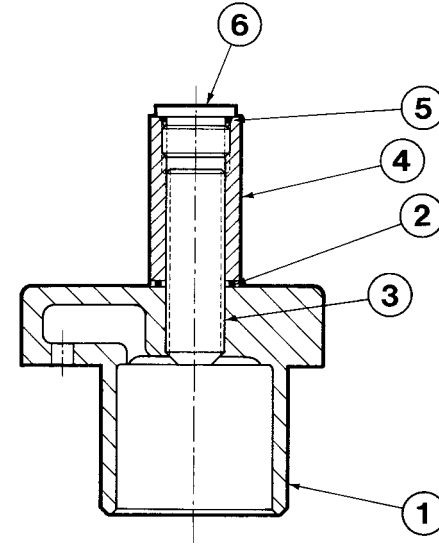


FIGURE 3
MAX. VOL. SCREW ADJUSTMENT CAP
(S21-12361)

ITEM	DESCRIPTION	PART NO.	QTY.
1	Ball	201-20001	1
2	Retaining ring	356-32100	1
3	Lever	032-59910	1
4	Shaft	032-59907	1
5	Nut	331-20100	1
6	Handwheel	032-59911	1
7	Stop	032-59908	1
8	Soc. set screw	312-15060	1
9	O-ring	671-00025	1
10	Piston stop	032-59909	1
11	Cap	031-57133	1

ITEM	DESCRIPTION	PART NO.	QTY.
1	Cap	031-57132	1
2	O-Ring	671-00118	1
3	Screw S.H.S.	311-26282	1
4	Nut, 3/4-10 UNC Hex	031-91049	1
5	O-Ring	691-00910	1
6	Plug	488-35055	1

**Pump with Pressure Compensator Control
(Standard) S21-11380**

Operation

The compensator automatically regulates the volume delivered by changing the length of stroke of the pumping pistons. Stroke change is controlled solely by the system pressure in such a manner that when the pump is operating at a pressure less than the maximum setting of the compensator, the pump delivers full volume. When the compensator presetting is reached, the volume is automatically reduced to the amount of flow required to maintain this pressure throughout the working system. The pressure at which these changes take place is easily regulated by a knurled knob adjustment which is similar to the control of a relief valve. The pressure adjustment range is 150 PSI (10.3 bar) to 6000 PSI (414 bar).

Assembly (Fig. 2)

- 1.1 Place housing (36) with barrel bore facing up on bench. Find three O-ring grooves around trunnion bore and face that bore to 12 o'clock.
- 1.2 Install two O-rings (41); one in each control piston bore.
- 1.3 Install two O-rings (35); one in each groove by control piston bore. Coat with vaseline.
- 1.4 Install maximum volume cap (40) onto control piston bore. (CCW pumps install on left side, CW on right side.)
- 1.5 Secure minimum volume cap with four HHC screws (32) (306-40047); torqued to 30 ft. lbs. (40.8Nm).
- 1.6 Place control piston (30) on bench.
- 1.7 Install two piston rings (29); one on each end of control piston. Check the fit of the piston with rings assembly by sliding both ends of the piston into cap (40). Piston with rings should slide freely without binding, sticking, or hanging up.
- 1.8 Install control piston into housing, plugged end into bore of minimum volume cap. Locate so slide-link slot is in middle of housing.
- 1.9 Place hanger assembly (20) on bench.
- 1.10 Check that dowel pin length is .30 to .32 inches (.76 to .81mm). Check that slide link (22) is free to move in control piston. Install belleville washer (21) over dowel pin in ear of hanger assembly with O.D. of belleville contacting ear.
- 1.11 Install slide link (22) over dowel pin in ear of hanger assembly, and it should be free to turn.
- 1.12 Place hanger assembly into housing and locate slide link into slot in control piston. High side of hanger must be on 12 o'clock side of pump.
- 2.1 Install barrel bearing (28) onto housing bore. Seat with brass rod if required.
- 2.2 Place bearing clamps T-3 on trunnion bearings (27).

- 2.3 Install trunnion bearing into housing bore under hanger contour. (Install bearing with side that retains rollers facing cover as shown (Per Fig. 5.)

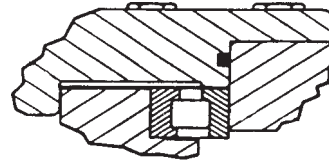
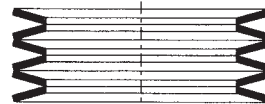


Figure 5

- 2.4 Install trunnion bearing partially into housing bore under hanger contour. (Install bearing with side that retains rollers facing cover as shown (Per Fig. 5).
- 3.1 Place barrel and sleeve assembly (14) on bench port face down.
- 3.2 Install six Belleville washers (15) opposed to form spring into counterbore around shaft bore of barrel assembly (Per Fig. 6).



**Figure 6
Proper Assembly of Belleville Washers**

- 3.3 Install spring retainer (16) into counterbore around shaft bore of barrel assembly covering Belleville washers.
- 3.4 Place holddown bearing (17) on top of spring retainer.
- 3.5 Place holddown ball (18) on top of holddown bearing.
- 3.6 Place holddown socket (19) on top of holddown ball.
- 3.7 Apply vaseline liberally to seven piston bores of barrel assembly.
- 3.8 Install piston-shoe and retainer sub-assembly (23) into bores of barrel. Notched lip of holddown socket should protrude thru I.D. of retainer.
- 3.9 Place barrel assembly on side, insert assembly tool #213-0-004071 from port face end through spline bore and locate tool into notches in lip of holddown socket.

3.12 Install three face plate pins (10, Fig. 1) into face of barrel.

3.13 Place face plate (13) over pins onto port face of barrel, coated side up.

4.1 Install inner spring (33) into recess bore of control piston through I.D. of outer spring (34).

4.2 Install spring cap (31) over inner and outer springs into bore of housing.

4.3 Secure spring cap with two HHC screws (32), torqued to 30 ft. lbs. (40.8Nm). Remove assembly tool.

4.4 Install remaining two HHC screws (32), torqued to 30 ft. lbs. (40.0 Nm).

4.5 Peer into trunnion bore, making sure socket (19) is properly engaged in hanger (20) pilot and pin. If properly engaged, shoe retainer plate (23) should only have .003 (.076mm) play from the back of the shoe soles.

4.6 Install three O-rings (35) into three grooves around housing trunnion bore.

4.7 Install O-ring (1, Fig. 6) on cover (39), also see Fig. 6) for compensator and install in housing trunnion bore.

4.8 Secure compensator cover (39) with ten HHC screws (23, Fig. 6) for compensator (24, Fig. 2) for trunnion cover (39), torque to 10 ft. lbs. (13.6Nm) evenly in diagonal pattern.

4.9 Install O-ring (26) on cover (25) and install in housing trunnion bore-opposite side.

4.10 Secure cover with ten HHC screws (26), torque to 10 ft. lbs. (13.6Nm) evenly in diagonal pattern.

5.1 Place port block flange (8, Fig. 1) on bench.

5.2 Install seal (2) on shaft and bearing sub-assembly (4). Use seal installment cap T-1 to protect seal. Rotate seal while installing seal from cap onto shaft.

5.3 Place port block (8) on arbor press, flange side up. Install O-ring (3) in bore of port block.

5.4 Using bearing press, install shaft and bearing and seal assembly in port block using seal and bearing installation sleeve T-2. Secure with the thickest retaining ring (1). If it will not go into the groove, use retaining ring, (031-57477).

5.5 Place port block and shaft assembly on bench.

5.6 Install two port plate pins (10) into face of port block.

5.7 Install port plate (11) onto face of port block. Locate port plate so that webbed ports are to the high pressure side and tip of bleed slot is in center line of block. Secure with vaseline.

5.8 Install O-ring (9) onto port block and housing pilot of port

block. Secure with vaseline.

5.9 Install O-ring (35, Fig. 2) into housing counterbore. Secure with vaseline.

5.10 Make sure spring washers are aligned in spring retainer.

5.11 Install port block and shaft assembly onto housing. Make sure shaft spline aligns with barrel spline. Locate so low pressure side of port block is on side of unit opposite of compensator assembly in cover. Torque with 120 ft. lbs. (163.2Nm).

6.1 Upon completion of testing, install protective covers, plugs, O-rings, and couplings where applicable.

Pump Assembly Procedure with Servo Controls

1.1 Place housing (36) with barrel bore facing up on bench. Find three O-ring grooves around trunnion bore and face that bore to 12 o'clock.

1.2 Install two O-rings (41); one in each control piston bore.

1.3 Install two O-rings (35); one in each groove by control piston bore. Coat with vaseline.

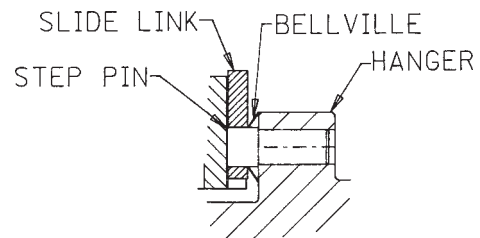
1.4 Install cap (40) onto control piston bore. (CW pumps install on left side, CCW on right side.)

1.5 Secure cap with four HHC screws (32); torqued to 30 ft. lbs. (40.8Nm).

1.6 Place control piston (30) on bench.

1.7 Install two piston rings (29); one on each end of control piston. Check the fit of the piston with rings assembly by sliding both ends of the piston into cap (40). Piston with rings should slide freely without binding, sticking or hanging up.

1.8 Install control piston into housing, plugged end into bore of cap (40). Locate so slide-link slot is in middle of housing.



1.9 Place hanger assembly (20) on bench.

1.10 Install Belleville washer (21) over dowel pin in ear of hanger assembly with O.D. of Belleville contacting ear.

1.11 Install slide link (22) over dowel pin in ear of hanger assembly. It should be free to turn.

1.12 Place hanger assembly into housing and locate slide link into slot in control piston. High side of hanger must be on 12 o'clock side of pump. Place housing assembly so spring cap is on assemblers right.

2.1 Install barrel bearing (28) onto housing bore. Seat with brass rod if required. Rotate housing assembly 90° away from assembler.

2.2 Place bearing clamps T-3 on trunnion bearings (27).

2.3 Install trunnion bearing into housing bore under hanger contour. (Install bearing with double lip facing out.)

2.4 On opposite side, install trunnion bearing partially into housing bore under hanger contour. (Install bearing with double lip facing out. (Per fig. 5.) Rotate housing assembly 90° away from assembler.

3.1 Place barrel and sleeve assembly (14) on bench, port face down.

3.2 Install six Belleville washers (15) opposed to form spring into counterbore around shaft bore of barrel assembly. (Per fig. 6).

3.3 Install spring retainer (16) into counterbore around shaft bore of barrel assembly covering Belleville washers.

3.4 Place holddown bearing (17) on top of spring retainer.

3.5 Place holddown ball (18) on top of holddown bearing.

3.6 Place holddown socket (19) on top of holddown ball.

3.7 Apply vaseline liberally to seven piston bores of barrel assembly.

3.8 Install piston-shoe and retainer sub-assembly (23) into bores of barrel. Notched lip of holddown socket should protrude thru I.D. of retainer.

3.9 Place barrel assembly on side, insert assembly tool (#213-0-004071) from port face end through spline bore and locate tool ends into notches in lip of holddown socket.

3.10 Place vaseline into orifice hole in each shoe to provide suction.

3.11 Place barrel assembly into housing and locate lip of holddown socket into recessed counterbore of hanger. Align notch in lip of holddown socket with dowel pin in hanger counterbore and release assembly tool. Lay tool aside. Check assembly by rotating the barrel, it should rotate freely. When properly assembled, the measurement from the barrel arcuate face to the housing face will be .530-.570"(13.5-14.5mm). This measurement insures the socket has been seated into hanger pilot.

3.12 Install three face plate pins (10, Fig. 1) into face of barrel.

3.13 Place face plate (13) over pins onto port face of barrel, coated side up.

4.1 Install inner spring (33) into recess bore of control piston through I.D. of outer spring (34).

4.2 Install spring cap (31) over inner and outer springs into bore of housing.

4.3 Secure spring cap with two HHC screws (32) (306-40047), torqued to 30 ft. lbs. (40.8Nm).

4.4 Install remaining two HHC screws (32), torqued to 30 ft. lbs. (40.8Nm). Rotate unit 90° toward assembler.

4.5 Peer trunnion bore, making sure socket (19) is properly engaged in hanger (20) pilot and pin. If properly engaged shoe retainer plate (23) should only have .003" (.076mm) play from the back of the shoe soles.

4.6 Install two O-rings (35) into two grooves around housing trunnion bore. (Right hand units only). Install three O-rings (35) into three grooves around housing trunnion bore (Left hand units only).

4.7 Install screw (46) into threaded hole around housing trunnion bore into hole closest to cap (40) and check valve (45) into threaded hole around housing trunnion bore into hole closest to spring cap (31) (units with compensator override only) or install check valve (44) into threaded hole around housing trunnion bore into hole closest to spring cap (31) (Right hand units with compensator override only).

4.8 Check to make sure servo sleeve is smooth and free by placing a small screw driver or pin into the slot of the sleeve and rotate it within the range of the arcuate of the cover. Operation should be smooth and free. Install O-ring (26) on servo control sub-assembly (25) (Right hand unit) or trunnion cover sub-assembly (25)/compensator sub-assembly (39) (Left hand units) and install into housing trunnion bore.

Note: Pin on the side of the hanger assembly (20) must engage slot of sleeve in servo control (25).

4.9 Secure compensator/cover (39) with ten HHC screws (23, Fig. 6) for compensator or (24, Fig. 2) for covers, torque to 10 ft. lbs. (13.6Nm) evenly in diagonal pattern.

4.10 Install O-ring (26) on servo/cover (25) and install into housing trunnion bore.

4.11 On trunnion face with two O-ring grooves, secure servo/cover (25) with HHC screws (see control figures for proper screws) torque to 10 ft lbs. (13.6Nm). Make sure feedback pin on hanger gets properly engaged.

5.1 Place port block flange (8, Fig. 1) on bench.

5.2 Install seal (2) on shaft and bearing sub-assembly (4). Use seal installation cap T-1 to protect seal. Rotate seal while installing seal from cap onto shaft.

5.3 Place port block (8) on arbor press, flange side up. Install O-ring (3) in bore of port block.

5.4 Using bearing press, install shaft and bearing and seal assembly in port block using seal and bearing installation sleeve T-2. Secure with the thickest retaining ring (1). If it will not go into the groove use retaining ring, (031-57477).

5.5 Place port block and shaft assembly on bench.

5.6 Install two port plate pins (10) into face of port block.

5.7 Install port plate (11) onto face of port block. Locate port plate so that webbed ports are to the high pressure side and tip of bleed slot is on center line of block. Secure with vaseline.

5.8 Install O-ring (9), onto port block and housing pilot of port block. Secure with vaseline.

5.9 Install O-ring (35) into housing counterbore. Secure with vaseline.

5.10 Make sure spring washers are aligned in spring retainer.

5.11 Install port block and shaft assembly onto housing. Make sure shaft spline aligns with barrel spline. Locate so low pressure side of port block is on side of unit assembly in cover. Torque with 120 ft. lbs. (163.2Nm).

6.1 Upon completion of testing, install protective covers, plugs, O-rings, and couplings, where applicable.

6.0, 7.25 & 8.0 — CIPR World Cup Test Procedure w/Servo Controls

1. Test	RPM	1750 ±50 RPM
Conditions:	Inlet Press.	10±5 PSI (.69±.34 bar)
	Inlet Temp.	130±10°F (54±2.8C)
	Oil @	100°F (37.7C) 200SSU
	Case Press.	50±10PSI (3.4±.69 bar)
	Servo Source	400±20 PSI (27.5±1.4 bar)

2. Pre-Adjustment:

1. Adjust zero volume adjusting screw on control piston cap all the way in.
2. Start unit and set system pressure to 500 PSI (34.4 bar).
3. Using the servo shaft, direct pump toward zero stroke.
4. Back out zero volume adjusting screw on control piston cap until systm pressure is 0 PSI (0 bar).
5. Lock nut on zero volume adjusting screw to 50 ft. lbs. (68Nm).
6. Rotate servo shaft to full stroke, then rotate toward zero stroke.

***Steps 7 through 12 are for hydraulic and electrohydraulic strokers only.**

- *7. When system pressure just reaches zero, lock shaft in place and shut test stand.
- *8. Remove either cover or force motor from control.
- *9. **On electro-hydraulic strokers only**, adjust max volume adjusting screw in until the spool contacts the cover plate on the opposite end.
- *10. Lock clamp onto servo shaft by tightening clamp screw to 72 in. lbs. (8Nm).
- *11. Replace cover or force motor from step 8 and torque: cover—20 ft. lbs. (27.2Nm). force motor—10 ft. lbs. (13.6Nm).
- *12. **On electro-hydraulic strokers only**, back out max volume adjusting screw of step 9.

3. Break-In:

7.25-6.0	8.0
1 min. @ 500 PSI (34.5 bar)	1 min. @ 500 PSI (34.5 bar)
1 min. @ 1000 PSI (69 bar)	2 mins. @ 1000 PSI (69 bar)
1 min. @ 2500 PSI (172 bar)	2 mins. @ 2000 PSI (138 bar)
1 min. @ 4000 PSI (276 bar)	
1 min. @ 5000 PSI (345 bar)	

While breaking in, destroke the pump two or three times at each pressure setting.

Code C-Compensator Control

The compensator control is located in the cover assembly, it consists of a compensator spool and a pilot head.

The stroking cylinder is connected to the output port of the compensator spool. The compensator pressure port is internally connected to the discharge port of the pump is internally connected to the discharge port of the case drain. The compensator pressure is internally connected to the discharge port of the pump and the tank port is internally connected to the case drain. The compensator pressure is set at the pilot-head by an adjustable spring.

When the pump operating pressure is below the compensator setting, springs push the stroking piston and the hanger to full stroke. The stroking cylinder is connected to the case drain via the compensator spool.

When the pump operating pressure reaches the compensator pressure setting, the pilot head opens and a pressure drop is created over the orifice, causing the compensator spool to move against the spring force, directing pump discharge pressure to the stroking cylinder. The pump will destroke to maintain set pressure.

When the pump operating pressure decreases below the compensator setting, the pilot-head will close and the compensator spool will move under spring force to its offset position, connecting the stroking cylinder to case. The springs will move the stroking piston to full displacement again.

The compensator can be remotely controlled via the vent connection, which also allows for a load sensing circuit. Minimum compensating pressure or vented pressure is approximately 180 PSI (12.4 bar).

Code R-Rotary Servo Control

The rotary servo control consists of a four-port rotary servo which directs servo pressure from an external source to the top stroking cylinder or the bottom stroking cylinder. It requires 1 GPM minimum (3.8L/min) servo flow at a minimum pressure of 300 PSI (20.6 bar). Normal recommended servo pressure is minimum 300 PSI (20.6 bar) with a maximum pressure of 1000 PSI (69 bar). Response can be increased by adding more flow under higher pressure.

The servo shaft takes a torque of 5-10 in lbs. (.57-1.1 Nm) to rotate at 300 PSI (20.6 bar) servo pressure. If we turn the rotary servo shaft counterclockwise, servo pressure port "A" is connected with the top cylinder port "B" and the bottom cylinder port "C" is connected with drain port "D". This means the stroking piston will move down, causing the hanger to move counterclockwise, reducing the displacement. The rotary servo moves "0" to full angle approximately 38 degrees.

As it moves the hanger will move the rotary servo sleeve counterclockwise until the servo pressure port "A" is closed again by the rotary servo shaft, thus cancelling the input signal after the commanded angle has been followed-up by the stroking mechanism.

Note: This control requires a minimum servo pressure of 300 PSI (20.6 bar). This must be supplied by the customer or via a rear driven pump.

Code E-Electrohydraulic Stroker Control

This electrohydraulic control actuates the rotary input shaft by means of a hydraulic position. In the zero current condition the jet pipe is centered over the two receiver orifices and generates equal pressure in each receiver. The jet pipe is held in this position by the feedback spring from the piston and the null adjust spring which counter each other and result in a net force of zero on the jet pipe. Assume the current is increased in a polarity that causes the jet pipe to move to the right. This will cause the pressure to increase on the right receiver and fall in the left receiver. Since these pressures are communicated to opposite ends of the piston it will move and in turn move the rotary servo through the arm connecting the piston and rotary servo shaft. The feedback spring is also connected to the arm which continues to move until the force balance recenters the jet pipe. Thus a new steady state condition is achieved. The control shaft can be manually operated without servo pressure applied to the jet pipe. Spring centering is also available to center the pump when servo pressure is removed from the servo control.

Note: The electrohydraulic control cannot be used if water glycol fluid is used in the system.

Note: This control requires a minimum servo pressure of 300 PSI (20.6 bar) and a maximum of 1000 PSI (69 bar). This must be supplied by the customer or via a rear driven pump.

Code H-Hydraulic Stroker Control

This control actuates the rotary input shaft by means of a hydraulic piston, which is pressurized by an external pressure source. The piston is trapped between two caged springs, which are set to provide zero displacement. When the external pressure is introduced into one of the two control ports, the piston exerts a force on one of the springs. When this force exceeds the precompression force of the spring, the piston begins to move, rotating the rotary servo shaft in proportion to pressure.

Removing or reducing the input pressure allows the spring to move the servo shaft back toward zero displacement position. Pressurizing the opposite control port causes the pump to increase displacement on the opposite side of center.

Code L-Load Sensing Compensator

The compensator has a separate load sensing port with an isolation valve between the spool and the load sense port, so that the load sense port sees zero flow. The vent port is still available and can be used for remote control purposes. When used as a load sense compensator, the added valve bypasses the flow from the spool to the case of the pump, rather than allowing it to pass out the load sense port. In this way, the external load sensing valves see no flow and there is no associated pressure drop, so they become a pure pressure control.

Code T-Torque Limiter

This control is a combined compensator and torque limiter, or, if used as an override, it is a combined override and torque limiter override. The torque limiter control valve is mechanically driven by a hanger to provide the proper pressure vs. flow relationship to give constant torque. This valve operates in parallel with the standard compensator valve and controls the displacement of the pump through the compensator as a function of pressure.

The torque limiter control used as the primary control on the pump provides both pressure compensator functions and torque limiting functions.

Primary Control Options**Code 1-Maximum Volume Screw Control**

Screw control is similar in action to the handwheel control described in following paragraph wherein the adjustment is made by raising or lowering the maximum volume stops to regulate pump delivery.

Code 2-Maximum Volume Handwheel Control

This control provides a means of manually setting the maximum volume delivered by the pump. Setting is made by use of the handwheel which positions the cam plate in the desired position.

Code 4-Maximum and Minimum Volume Stops for the Control Codes "R", "H" and "E" Only

The maximum and minimum stops limit the angle of the rotary servo shaft, replacing the Code 1 or Code 2 stops. These stops are fully adjustable and are located in the control cover assembly.

Secondary Control Options**Code P-Pressure Compensator Override**

The pressure compensator override is an optional control, used when needed with the rotary, electrohydraulic or hydraulic servo strokers.

In this control the stroking cylinder is spring offset to the zero position. It has the same rotary servo described previously, but in addition, a cover assembly containing the compensator override on the opposite side of the pump.

The compensator override control is similar to the compensator control as described before, except the override path to the top stroking control cylinder is provided with a check valve and orifice to limit the losses from the top stroking cylinder.

The bottom stroking cylinder is interconnected to the rotary servo port "C" but plugged-off from the compensator override.

If the pump operating pressure reaches the compensator pressure setting, discharge is directed to the top of the stroking cylinder. This causes the stroking piston and hanger to destroke, and the rotary servo sleeve to turn counterclockwise. Now servo pressure is connected via port "A" and port "C" to the bottom stroking cylinder and port "B" to port "D" connecting the top stroking cylinder to case, ready to upstroke to the commanded position, as soon as the operating pressure falls below the override setting.

Code T-Torque Limiter Override

This option can be used as an output control with a rotary servo, hydraulic stroker or electrohydraulic stroker as an override when both pressure compensator and torque limiter overrides are available.

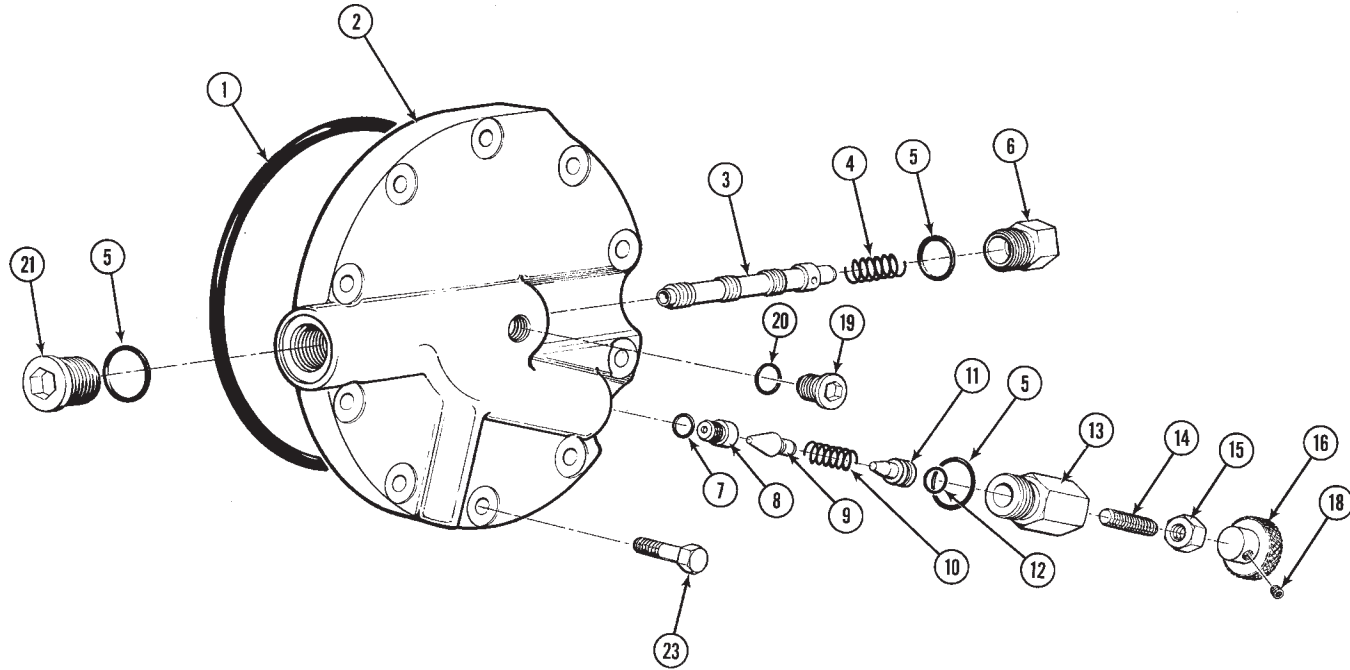


FIGURE 6
COMPENSATOR (C *O)
(S21-11380)

ITEM	DESCRIPTION	PART NO.	QTY.
1	O-ring	671-00254	1
2	Cover and sleeve	S21-11449	1
3	Spool, compensator	031-59365	1
4	Spring	031-59366	1
5	O-ring	671-00910	3
6	Plug	031-57090	1
7	O-ring	671-00903	1
8	Seat, compensator	031-59397	1
9	Cone	036-12288	1
10	Spring	036-12289	1
11	Piston seal	031-59367	1
12	O-ring	671-00012	1

ITEM	DESCRIPTION	PART NO.	QTY.
13	Guide, housing	033-70545	1
14	Screw	312-13200	1
15	Hex jam nut	335-13100	1
16	Knob	036-24504	1
17	Not used		
18	Screw	312-09041	1
19	Plug	488-35041	1
20	O-ring	671-00906	1
21	Plug	488-35055	1
22	Not used		
23	Hex hd. cap screw	306-40188	10

Compensator (S21-11380, Fig. 6)**I. Preparing parts prior to assembly**

1. All parts are to be inspected and be free of material defects, dirt, scratches, or any foreign material.
2. All parts to be cleaned with a suitable cleaning solvent and all parts with cores or passages be blown out with dry, clean, compressed air.
3. After cleaning and inspection, all parts are to be covered with a light film of oil and should be protected from dirt and excessive handling until assembled.
4. During assembly, lapped and ground surfaces should be kept lubricated with clean oil and protected from nicks and surface damage.

II. Assembly

1. Place spring (4) onto spool (3) and into plug (6). Ensure that both ends on spring coils are fully engaged over centering shoulders. Lubricate the three spool lands. Install O-ring (5) on plug (6). Screw into housing (2) and tighten to 100 ft. lbs. (136 Nm). Check for free operation by pressing on spool stem through plug (21) opening.
2. Install O-ring (5) on plug (21). Screw into housing (2) and tighten to 75 ft. lbs. (102 Nm).
3. Install O-ring (7) on seat (8). Screw into housing (2) and tighten to 15 ft. lbs. (20.4 Nm). (Do not use impact wrench.)
4. Pre-assemble control knob parts (11) through (18) as shown. Install O-ring (12) on piston seal (11). Lubricate and slide into guide housing (13). Screw socket set screw (14) into guide housing (13). Install jam nut (15) and tighten against guide housing (13). Screw knob control (16) into set screw (14). Screw socket set screw (18) into knob control (16) and tighten.
5. Place cone (9) into spring (10) and insert cone into seat (8). Install O-ring (5) on housing (13). Insert guide housing (13) over spring (10). Screw into housing (2) and tighten to 75 ft. lbs. (102 Nm).
6. Install O-ring (20) on plug (19). Screw into housing (2) and tighten to 15 ft. lbs. (20.4 Nm).
7. Install O-ring (1) on housing (2) pilot.

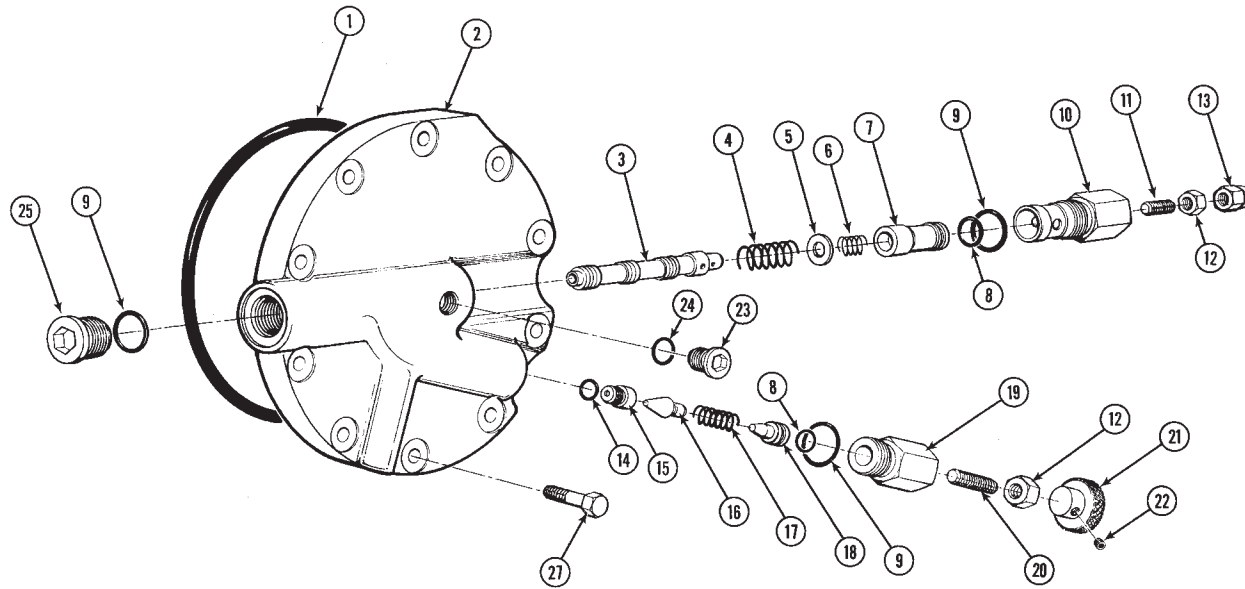


FIGURE 7
COMPENSATOR, LOW PILOT FLOW (F*O)
(S21-11619)

ITEM	DESCRIPTION	PART NO.	QTY.
1	O-ring	671-00254	1
2	Cover, compensator	S21-11351	1
3	Spool	032-59482	1
4	Spring	032-57292	1
5	Washer	031-57294	1
6	Spring	031-57296	1
7	Retainer	031-57295	1
8	O-ring	671-00012	2
9	O-ring	671-00910	3
10	Plug, compensator	031-57293	1
11	Screw	312-13160	1
12	Hex. jam nut	335-13100	2
13	Acorn nut	327-25006	1

ITEM	DESCRIPTION	PART NO.	QTY.
14	O-ring	671-00903	1
15	Seat compensator	032-59513	1
16	Cone	036-12288	1
17	Spring	036-12289	1
18	Piston seal	031-59367	1
19	Guide, housing	033-70545	1
20	Screw	312-13200	1
21	Knob	036-24504	1
22	Screw	312-09041	1
23	Plug	488-35041	1
24	O-ring	671-00906	1
25	Plug	488-35055	1
26	Not used		
27	Screw, HHC	306-40188	10

**Compensator, Low Pilot Flow (F*O)
(S21-11619, Fig. 7)****I. Preparing parts prior to assembly**

1. All parts are to be inspected and be free of material defects, dirt, scratches, or any foreign material.
2. All parts to be cleaned with a suitable cleaning solvent and all parts with cores or passages be blown out with dry, clean, compressed air.
3. After cleaning and inspection, all parts are to be covered with a light film of oil and should be protected from dirt and excessive handling until assembled.
4. During assembly, lapped and ground surfaces should be kept lubricated with clean oil and protected from nicks and surface damage.

II. Assembly

1. Place O-rings (8 & 9) on retainer (7) and compensator plug (10). Insert retainer with O-ring into compensator plug.
2. Insert .43 dia. spring (6), washer (5), .57 dia. spring (4) and spool (3), in this order, into compensator plug (10), being sure springs are properly seated.
3. Lubricate spool lands before installing spool with compensator plug assembly into housing (2). Tighten compensator plug.
4. Thread set screw (11) into plug (10) until it bottoms out. Back out set screw five complete turns, and lock in place with jam nut (12) and acorn nut (13).
5. Install O-ring (9) on plug (25). Screw into housing (2) and tighten.
6. Install O-ring (14) on seat (15). Screw into housing (2) and tighten.
7. Pre-assemble control knob parts (18) thru (22) as shown. Install O-ring (8) on piston seal (18). Lubricate and slide into guide housing (19). Screw socket set screw (20) into guide housing (19). Install jam nut (12) and tighten against guide housing (19). Screw knob control (21) into set screw (20). Screw socket set screw (22) into knob control (21) and tighten.
8. Place cone (16) into spring (17) and insert cone into seat (15). Insert guide housing (19) over spring (17). Install O-ring (9) on guide housing (19) and screw into housing (2) and tighten.
9. Install O-ring (24) on plug (23) and screw into housing (2) and tighten.
10. Install O-ring (1) on housing (2) pilot.

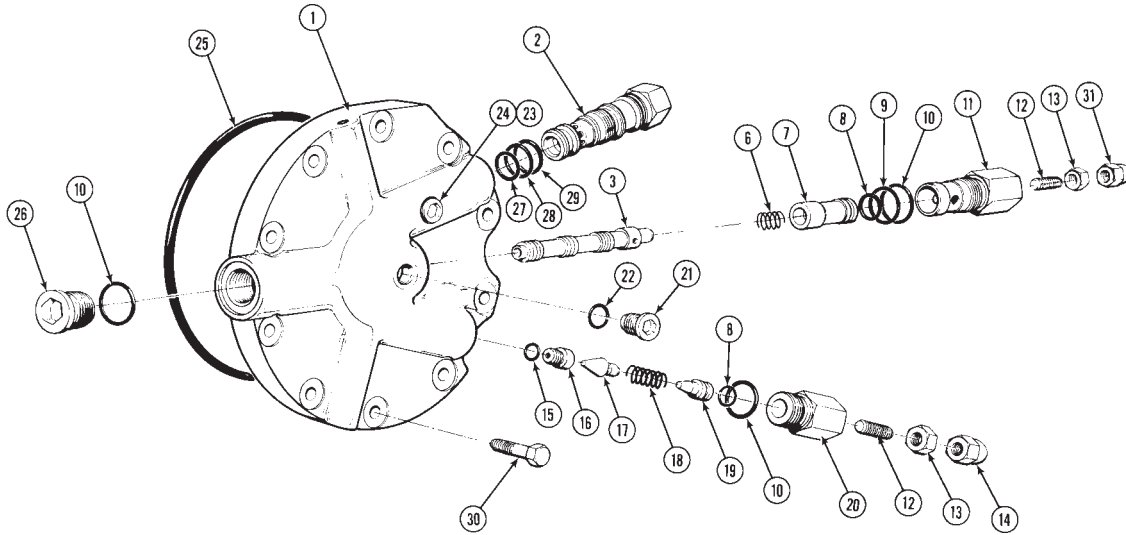


FIGURE 8
LOAD SENSING (L *O)
(S21-11640)

ITEM	DESCRIPTION	PART NO.	QTY.
1	Cover w/sleeve	S21-11639	1
2	Valve, modulating	517-00063	1
3	Spool	032-59482	1
4	<u>Not used</u>		
5	<u>Not used</u>		
6	Spring	<u>033-71086</u>	1
7	Retainer	<u>032-91305</u>	1
8	O-ring	<u>691-00012</u>	2
9	O-ring	<u>671-00017</u>	1
10	O-ring	<u>671-00910</u>	3
11	Plug	031-57368	1
12	Screw	312-13160	2
13	Hex jam nut	335-13100	2
14	Acorn nut	327-25006	1
15	O-ring	<u>671-00903</u>	1

ITEM	DISCRIPTION	PART NO.	QTY.
16	Seat	033-70508	1
17	Cone	036-12288	1
18	Spring	<u>032-91298</u>	1
19	Piston seal	031-59367	1
20	6.0 Guide-housing	033-70545	1
21	Plug	488-35041	1
22	O-ring	<u>671-00906</u>	1
23	Plug	488-35001	1
24	O-ring	<u>671-00904</u>	1
25	O-ring	<u>671-00254</u>	1
26	Plug	488-35055	1
27	O-ring	671-00015	1
28	O-ring	671-00016	1
29	O-ring	671-00018	1
30	Screw	306-40188	10
31	Cap	<u>449-00612</u>	1

**Load Sensing L*O
(S21-11640, Fig. 8)****I. Preparing parts prior to assembly**

1. All parts are to be inspected and be free of material defects, dirt, scratches, or any foreign material.
2. All parts to be cleaned with a suitable cleaning solvent and all parts with cores or passages be blown out with dry, clean, compressed air.
3. After cleaning and inspection, all parts are to be covered with a light film of oil and should be protected from dirt and excessive handling until assembled.
4. During assembly, lapped and ground surfaces should be kept lubricated with clean oil and protected from nicks and surface damage.

II. Assembly

1. Place O-rings (8, 9 & 10) on retainer (7) and compensator plug (10). Insert retainer with O-ring into compensator plug.
2. Insert .43 dia. spring (6), washer (5), .57 dia. spring (4) and spool (3), in this order, into compensator plug (11), being sure springs are properly seated.
3. Lubricate spool lands before installing spool with compensator plug assembly into housing (1). Tighten compensator plug.
4. Thread set screw (12) into plug (11) until it bottoms out. Back out set screw five complete turns, and lock in place with jam nut (13) and acorn nut (14).
5. Install O-ring (10) on plug (26). Screw into housing (1) and tighten.
6. Install O-ring (15) on seat (16). Screw into housing (1) and tighten.
7. Pre-assembly control knob parts (19) thru (14) as shown. Install O-ring (8) on piston seal (19). Lubricate and slide into guide housing (20). Screw socket set screw (12) into guide housing (20). Install jam nut (13) and tighten against guide housing (20). Screw acorn nut (14) on set screw (12) and tighten.
8. Place cone (17) into spring (18) and insert cone into seat (16). Insert guide housing (20) over spring (18). Install O-ring (10) on guide housing (20) and screw into housing (1) and tighten.
9. Install O-ring (22) on plug (21) and screw into housing (1) and tighten.
10. Install O-ring (27), (28) and (29) onto modulating valve and screw into housing (1) and tighten.
11. Install O-ring (25) on housing (1) pilot.

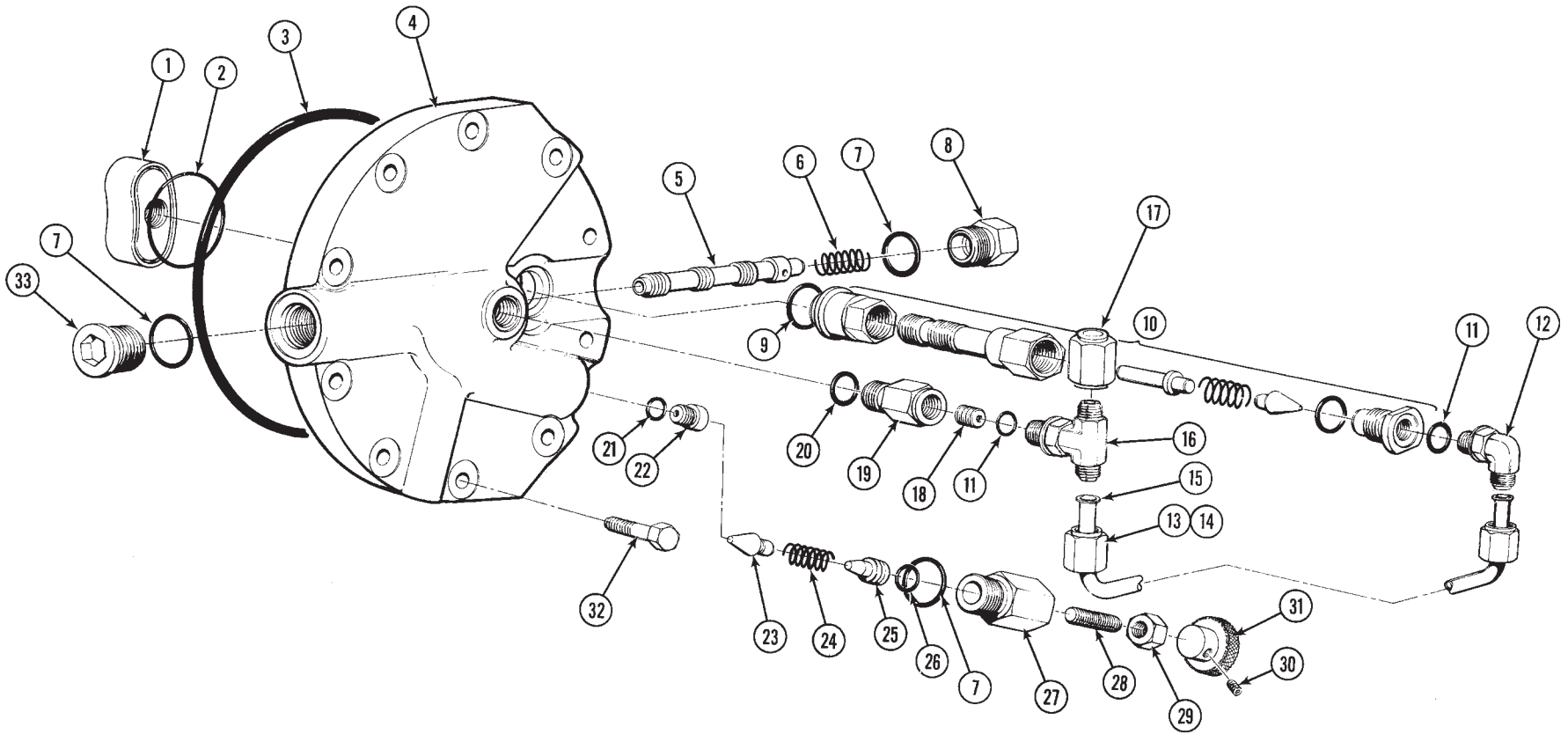


FIGURE 9
TORQUE LIMITER
(S21-11651)

FIGURE 9
S21-11651 TORQUE LIMITER

ITEM	DESCRIPTION	PART NO.	QTY.
1	Seal plate torque limiter	031-57391	1
2	O-ring	671-00031	1
3	O-ring	671-00254	1
4	Cover w/sleeve & plugs	S21-11655	1
5	Spool compensator	031-59365	1
6	Spring	031-59366	1
7	O-ring	671-00910	3
8	Plug	031-57090	1
9	O-ring	671-00908	1
10	Torque limiter cover	S21-11652	1
11	O-ring	671-00904	2
12	Fitting sw nut	498-00045	1
13	Nut	492-15175	2
14	Sleeve	492-15176	2
15	Tube, torque limiter	031-57392	1
* 16	Fitting, elbow	<u>031-91168</u>	1
17	Cap	482-55004	1

ITEM	DESCRIPTION	PART NO.	QTY.
18	Orifice #56 (.0465) 1/16pt	033-54579	1
19	Adapter	492-15335	1
20	O-ring	671-00906	1
21	O-ring	671-00903	1
22	Seat compensator	031-59397	1
23	Cone	036-12288	1
24	Spring	<u>032-91798</u>	1
25	Piston seal	031-59367	1
26	O-ring	671-00012	1
27	Guide, housing	033-70545	1
28	Screw	312-13200	1
29	Hex. jam nut	335-13100	1
30	Screw	312-09041	1
31	Knob	036-24504	1
32	Hex. hd. cap screw	306-40188	8
33	Plug	488-35055	1

* Item #16 is for the Torque Limiter 'T' fitting, allow venting of compensator.

**Compensator control w/torque limiter
(S21-11651, Fig. 9)**

I. Preparing parts prior to assembly

1. All parts are to be inspected and be free of material defects, dirt, scratches, or any foreign material.
2. All parts to be cleaned with a suitable cleaning solvent and all parts with cores or passages be blown out with dry, clean, compressed air.
3. After cleaning and inspection, all parts are to be covered with a light film of oil and should be protected from dirt and excessive handling until assembled.
4. During assembly, lapped and ground surfaces should be kept lubricated with clean oil and protected from nicks and surface damage.

II. Assembly

1. Assemble parts 3, 7, 8, 6, 4, 5, 33, 21, 22, 23, 24, 25, 26, 28, 29, 30, 31, & 27 per compensator assembly (S21-11380, Fig. 6).
2. Place greased O-ring (2) into groove of plate (1).
3. Place greased O-ring (9) onto torque limiter assembly (10).
4. Thread torque limiter assembly (10) into plate (1) thru the body of cover (4). Thread within 1/4" of bottom of the plate (1), then tighten nut of torque limiter assembly (10) until snug.
5. Place greased O-ring (20) onto adapter (19).
6. Thread adapter (19) into vent connection of cover (4). Torque to 35 ft. lbs. (47.6 Nm).
7. Thread orifice (18) into fitting (16). Torque to 10 ft. lbs. (13.6 Nm).
8. Place greased O-ring (11) onto fitting (16).
9. Thread fitting (16) into adapter (19). Tighten nut until snug.
10. Place greased O-ring (11) onto assembly (10). Tighten nut until snug.
11. Thread fitting (12) into assembly (10). Tighten nut until snug.
12. Place nuts (13) and ferrules (14) onto the ends of tube (15). Place the ends of tube (15) into fittings (16) and (12). Thread nuts (13) until finger-tight, then wrench nuts down 1-3/4 turns to set the ferrules (14).

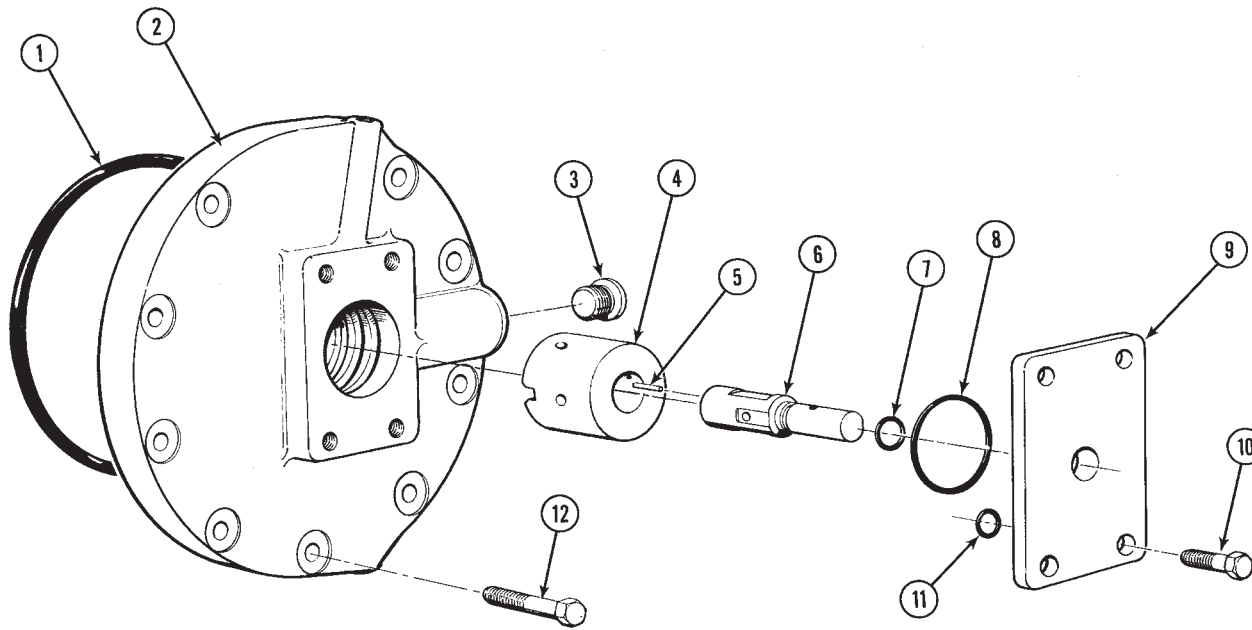


FIGURE 10
ROTARY SERVO w/o MAX VOLUME STOPS (R00)
(S21-11560)

ITEM	DESCRIPTION	PART NO.	QTY.
1	O-ring	671-00254	1
2	Cover & plugs	S21-11597	1
3	Plug	449-00015	1
4	Sleeve, rotary servo	031-57274	1
5	Pin, roll	325-06080	1
6	Shaft, rotary servo	031-57273	1
7	O-ring	671-00012	1
8	O-ring	671-00030	1
9	Retainer plate	031-57278	1
10	Screw	306-12120	4
11	O-ring	671-00013	2
12	Screw, HHC	306-40188	10

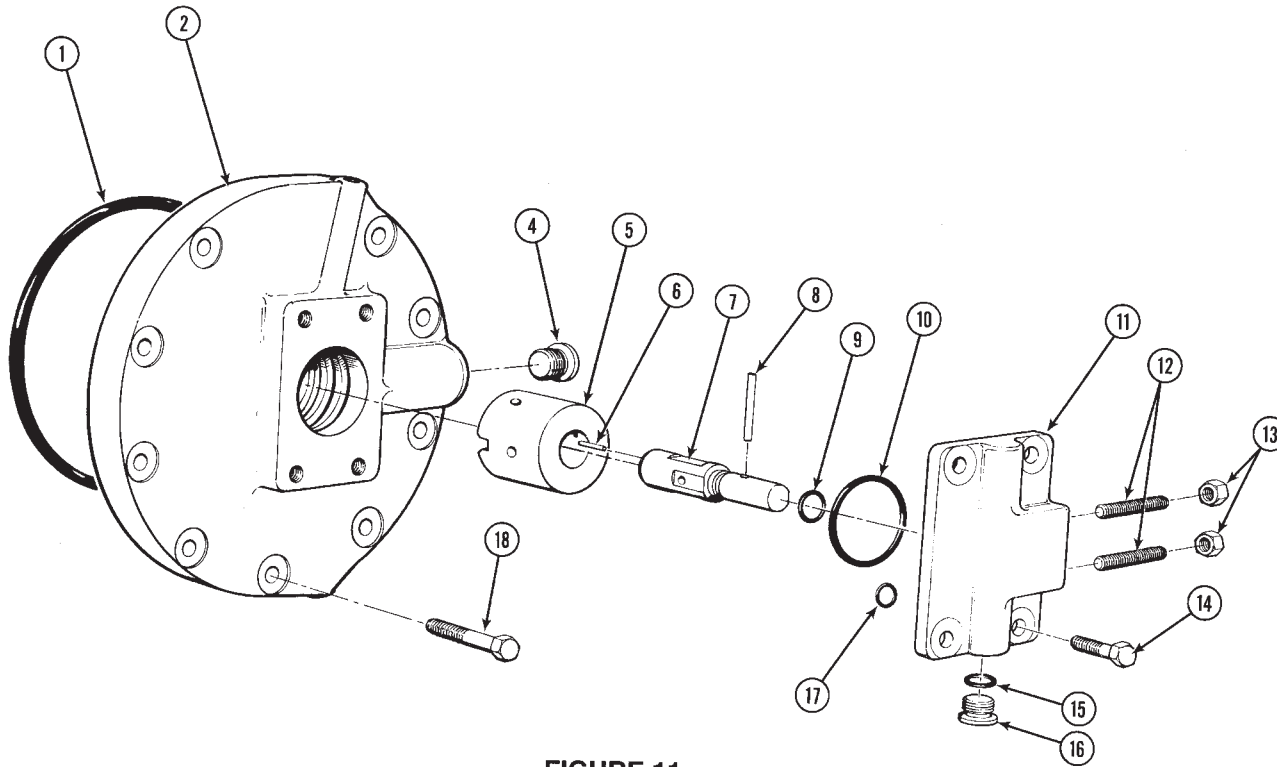


FIGURE 11
ROTARY SERVO w/MAX. VOL. STOPS (R10)
(S21-11608)

ITEM	DESCRIPTION	PART NO.	QTY.
1	O-ring	671-00254	1
2	Cover & plugs	S21-11597	1
3	Not used		
4	Plug	449-00015	1
5	Sleeve, rotary servo	031-57274	1
6	Roll pin	325-06080	1
7	Shaft, rotary servo	031-57273	1
8	Roll pin	325-08160	1
9	O-ring	671-00012	1

ITEM	DESCRIPTION	PART NO.	QTY.
10	O-ring	671-00030	1
11	Plate, retainer	031-57302	1
12	Screw	311-12200	2
13	Nut, hex. reg.	333-12614	2
14	HHC, screw	306-12120	4
15	O-ring	671-00906	1
16	Plug	488-35041	1
17	O-ring	671-00013	2
18	Screw, HHC	306-40188	10

**Assembly Procedure for Rotary Servo
(S21-11560, Fig. 10)
& Rotary Servo w/min & max stops
(S21-11608, Fig. 11)**

I. Preparing parts prior to assembly

1. All parts are to be inspected and be free of material defects, dirt, scratches, or any foreign material.
2. All parts to be cleaned with a suitable cleaning solvent and all parts with cores or passages be blown out with dry, clean, compressed air.
3. After cleaning and inspection, all parts are to be covered with a light film of oil and should be protected from dirt and excessive handling until assembled.
4. During assembly, lapped and ground surfaces should be kept lubricated with clean oil and protected from nicks and surface damage.

II. Assembly

1. Press roll pin (5) into hole of shaft (6).
2. Place sleeve (4) into cover (2) so that slot in sleeve (4) is visible through arcuate of cover (2).
3. Place greased O-ring (7) into groove of shaft (6).
4. Slip shaft (6) into sleeve (4) so that roll pin (5) fits into arcuate of cover (2).
5. Place two greased O-rings (11) and greased O-ring (8) into groove of plate (9).
6. Place plate (9) over shaft (6) and pilot into cover (2). Secure with four screws (14) to cover (2). Tighten to 9 ft. lbs. (12.2 Nm).
7. Place greased O-ring (1) and shipping plugs (3) onto cover (2).

***Steps 8 through 10 for control S21-11608-C, (Fig. 11) only.**

- *8. Through the hole in plate (11), press pin (8) through hole in shaft (7) so that pin (8) extends evenly from both sides of shaft (7) $\pm 1/32"$ (± 0.8 mm).
- *9. Thread plug (15) with O-ring (16) into plate (11). Tighten to 9 ft. lbs. (12.2 Nm).
- *10. Start nuts (13) onto screws (12) and thread screws (12) about five turns into plate (11). Finger tighten.

III. Check

1. Place a small screw driver or pin into the slot in sleeve (5) and rotate it within the range of the arcuate of cover (22). Operation should be smooth and free.

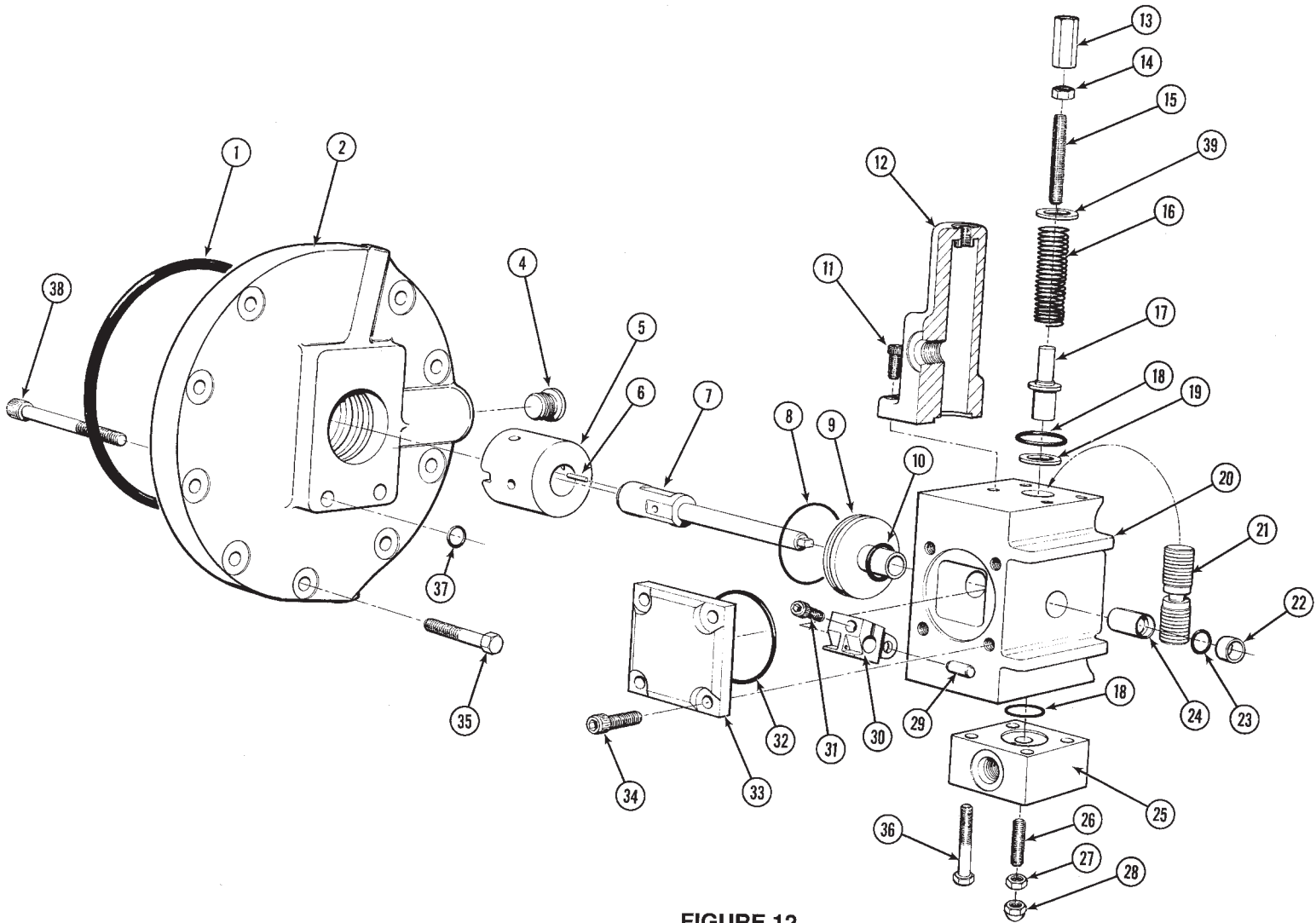


FIGURE 12
HYDRAULIC STROKER (CCW) (S21-12285)
HYDRAULIC STROKER (CW) (S21-12286)

(Note: Parts list same, assembly different)

PARTS LIST FOR FIGURE 12
HYDRAULIC STROKER (CCW) (S21-12285)
HYDRAULIC STROKER (CW) (S21-12286)
 (Note: Part list same, assembly different)

ITEM	DESCRIPTION	PART NO.	QTY.
1	O-Ring	671-00254	1
2	Cover	S21-11597	1
3	Not used		
4	Plug	449-00015	1
5	Sleeve	031-57274	1
6	Roll pin	325-06080	1
7	Shaft	031-57276	1
8	Ring	671-00029	1
9	Bushing	031-57277	1
10	O-ring	671-00017	1
11	Screw, SHC	358-12120	4
12	End connection	031-57280	1
13	Cover nut	033-54537	1
14	Nut	332-00036	1
15	Screw	312-11260	1
16	Spring	031-57281	1
17	Spring guide	031-57279	1
18	O-ring	671-00022	2
19	Thrust washer	031-53421	1

ITEM	DESCRIPTION	PART NO.	QTY.
20	Body	033-57342	1
21	Spool	033-53439	1
22	Bushing	031-53422	1
23	O-ring	671-00110	1
24	Bearing	230-00610	1
25	Cover	033-53879	1
26	Screw	311-12200	1
27	Nut	332-00034	1
28	Nut, acorn	327-12505	1
29	Pin dowel (Special)	033-53894	1
30	Clamp	033-72111	1
31	Screw, SHC	358-10100	1
32	O-ring	671-00133	1
33	Cover	031-53148	1
34	Screw, SHC	358-12100	4
35	Screw, HHC	306-40188	9
36	Screw, HHC	306-12200	4
37	O-ring	671-00012	2
38	Screw	031-57282	2
39	Shim	033-53453	1

Assembly Procedure for World Cup Hydraulic Stroker (S21-12285 & S21-12286, Fig. 12)

I. Preparing parts prior to assembly

1. All parts are to be inspected and be free of material defects, dirt, scratches, or any foreign material.
2. All parts to be cleaned with a suitable cleaning solvent and all parts with cores or passages be blown out with dry, clean, compressed air.
3. After cleaning and inspection, all parts are to be covered with a light film of oil and should be protected from dirt and excessive handling until assembled.
4. During assembly, lapped and ground surfaces should be kept lubricated with clean oil and protected from nicks and surface damage.

II. Assembly

1. Press bearing (24) into body (20).
2. Place greased O-ring (23) into body (20).
3. Press bushing (22) into body (20).
4. Place greased O-ring (10) into groove in body (20), then press bushing (9) into body (20).
5. Lubricate spool (21) and install into lubricated bore of body (20).
6. Place greased O-rings (37) into body (20).
7. Press pin (29) to .500 from bottom of clamp (30). Install screw (31) into clamp (30). Do not torque down. Place assembled clamp into the cored opening of the body (20). Index the clamp so that the pin (29) is riding in the slot of spool (21).
8. Place sleeve (5) into cover (2) so that slot in sleeve (5) is visible through arcuate of cover (2).
9. Slip shaft (7) through bushing (9), clamp (30), bearing (24), O-ring (23) and bushing (9) of body (20). Do **not** tighten screw (31).
10. Slip body assembly with shaft into sleeve (5) in cover (2) and pilot bushing (9).
11. Torque body assembly to cover (2) using screws (38) to 15 ft. lbs. (20.4 Nm).
12. Place cover/body assembly with opening to clamp (30) at the 12 o'clock position. Place cover (25) with greased O-ring (18) onto the right hand side of body (20) for CW rotation units, (Place on left hand side of body (20) for CCW rotation units). Torque in place with screws (36) to 9 ft. lbs. (12.2 Nm).
13. Place washer (19) onto guide (17).
14. Place spring (16) onto guide (17), then placing into connection (12).
15. Grease O-ring (18), placing into connection (12), then attach connection, spring, guide, washer assembly onto body (20), using screws (11). Torque to 9 ft. lbs. (12.2 Nm).
16. Install O-ring (32), cover (33) with screws (34). Torque to 9 ft. lbs. (12.2 Nm).
17. Install adjusting screws (15), (26); nuts (27), (14) and acorn nuts (28), (13).
18. Place greased O-ring (1) and shipping plug (4), onto cover (20).

III. Check

1. Place a small screwdriver or pin into the slot in sleeve (5) and rotate it within the range of the arcuate of cover (20). Operation should be smooth and free.

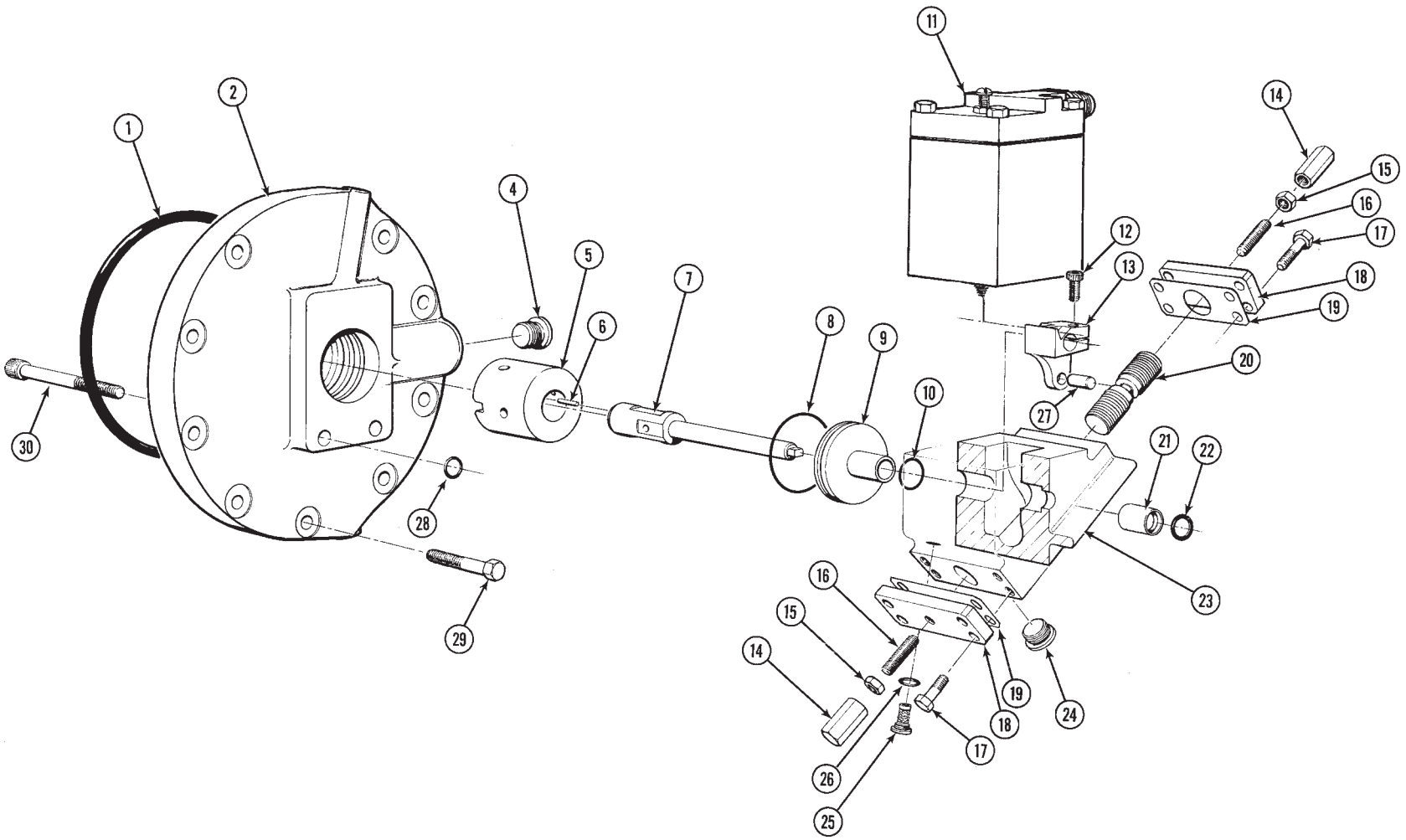


FIGURE 13
ELECTRO-HYDRAULIC STROKER (CW) (S21-12307)
ELECTRO-HYDRAULIC STROKER (CCW) (S21-12308)

PARTS LIST FOR FIGURE 13
ELECTRO-HYDRAULIC STROKER (CW) (S21-12307)
ELECTRO-HYDRAULIC STROKER (CCW) (S21-12308)

ITEM	DESCRIPTION	PART NO.	QTY.
1	O-ring	671-00254	1
2	Cover & Plugs	S21-11597	1
3	Not used		
4	Plug	449-00015	1
5	Sleeve, rotary servo	031-57274	1
6	Roll pin	325-06080	1
7	Shaft, rotary servo	031-57276	1
8	O-ring	671-00029	1
9	Bushing	031-57277	1
10	O-ring	671-00017	1
11	Force motor (300 MA)	S21-11606	1
12	Screw, SHC	358-10100	1
13	Clamp	033-72111	1
14	Cover nut	033-54537	2
15	Nut	332-00036	2

ITEM	DESCRIPTION	PART NO.	QTY.
16	Screw	312-11180	2
17	Screw, SHC	358-12120	8
18	Cover plate	033-54538	2
19	Gasket	033-72109	4
20	Spool	033-53439	1
21	Bearing	230-00610	1
22	O-ring	671-00110	1
23	Body	033-72117	1
24	Plug	449-00013	1
25	Cart. filter	S13-46097	1
26	O-ring	671-00904	1
27	Pin dowel, (Special)	033-53894	1
28	O-ring	671-00012	2
29	Screw, HHC	306-40188	9
30	Screw	031-57282	2

Assembly Procedure for Electro-Hydraulic Stroker (S21-12307, C.W. & S21-12308, C.C.W. Rotation Pump, Fig. 13)

I. Preparing parts prior to assembly

1. All parts are to be inspected and be free of material defects, dirt, scratches, or any foreign material.
2. All parts to be cleaned with a suitable cleaning solvent and all parts with cores or passages be blown out with dry, clean, compressed air.
3. After cleaning and inspection, all parts are to be covered with a light film of oil and should be protected from dirt and excessive handling until assembled.
4. During assembly, lapped and ground surfaces should be kept lubricated with clean oil and protected from nicks and surface damage.

II. Assembly

1. Press bearing (21) into the bore of body (23) to a depth of approximately flush with cast surface.
2. Place greased O-ring (10) into groove in body (23), then press bushing (9) into the bore of body (23).
3. Lubricate O-ring (26) and install to filter assembly (25). Install filter assembly to body (23).
4. Lubricate spool (20) and install into lubricated bore of body (23).
5. Lubricate O-rings (22), (8) and (28) and install.
6. Press pin (27) into clamp (13), .500 from bottom of clamp (13). Install screw (12) into the clamp (13). Do not torque down. Place the assembled clamp into the cored opening of the body (23). Index the clamp so that the pin (27) is riding in the slot of spool (20).
7. Place sleeve (5) into cover (2) so that slot in sleeve (5) is visible thru arcuate of cover (2). Locate slot in sleeve 1/4 inch from end of slot in cover. For clockwise assembly, slot is toward 3/8 mtg. bolts. For C.C.W. assembly, slot is away from mtg. bolts.

8. Slip shaft (7) thru bushing (9), clamp (13) bearing (21) and O-ring (22) of body (23). Do **not** tighten screw (12).

9. Slip body assembly with shaft into sleeve (5) in cover (2) and pilot bushing (9).

10. Torque body assembly to cover (2) using screws (30) to 15 ft. lbs. (20.4 Nm).

11. With the force motor (11) opening in the body (23) at the 12 o'clock position. Slide the spool (20) towards the 8 o'clock position for C.W. rotation pumps or towards the 2 o'clock position for C.C.W. rotation pumps until flush with surface.

12. Remove compensator or trunnion cover from side opposite electro-hydraulic stroker control.

13. Plug tapped holes on face with 3/8-24 set screws.

14. Apply 500 psi (34.5 bar) to electro-hydraulic stroker control.

15. Rotate shaft on control. Observe hanger, when hanger reaches full stroke, repeat this step two or three times, then tighten clamp screw (12).

16. Remove plugs that were installed in step 14 and reassemble cover.

17. Pilot the force motor assembly (11) over the shoulder of body (23). Make sure that the feedback spring of the force motor is piloted into the 60° conical hole in the clamp (13), and that the 1/8" diameter roll pin is piloted into the hole located on the face of the body shoulder. The electrical connector will be positioned directly above the cover plate (2) when the force motor is correctly mounted.

18. Install two gaskets (19) to each end and cover plates (18) using screws (17). Torque to 9 ft. lbs. (12.2 Nm).

19. Install adjusting screws (16), nuts (15) and acorn nuts (14).

20. Place greased O-ring (1) and shipping plugs (4), (24) onto cover (2).

III. Check

1. Place a small screw driver or pin into the slot in 5) and rotate it within the range of the arcuate of cover (2). Operation should be smooth & free.

Servo Control Adjustment & Operational Test

A. Rotary Servo

1. During break-in, rotate pump servo input control shaft. The servo should control pump displacement through its full range. There should be no oscillation, sluggishness, or erratic movement of pump hanger as the input control is rotated. Check at several pressures between 500 and 5000 PSI (34.5-345 bar) for 6.0 and 7.25 or 500 to 2000 PSI (34.5-138 bar) for 8.0 and locked with the nuts to 50 in. lbs. (5.7 Nm).

2. (If equipped with stops 0- mechanical stops are preset at 19° and 0°). If something other than this is requested, the two adjusting screws on either end of the control can be turned to the desired flow or displacement and locked with the nuts to 50 in. lbs. (5.7 Nm).

B. Electro-hydraulic Stroker

1. Connect the servo pressure through a needle valve into the fitting on the side of the controller body.

2. Install a lever on the input shaft.

3. Connect the electrical connector. The power supply must have ±400 MA capability with a switch in series with the connector.

Operational Tests

1. Close the servo needle valve

2. Open the switch to the controller (0 current).

3. With the pump running, stroke the pump manually 1/2 to 3/4 volume.

4. Set test stand relief valve to 2000 PSI (138 bar).

5. Adjust the unit to center with the mechanical adjustment on the control cover plate. Pressure on the system port must be "0" PSI (0 bar). Manually stroke the pump and release. The pump must return to center.

6. Open the servo supply needle valve. Adjust the null screw at the top of the force motor (near connector) until the pump is at center.

7. Slowly apply current to the valve. Note the value of current at which pressure starts to build. (10 MA min., 50 MA max.) If tolerance is not met, re-adjust null screw.

8. Apply 400 MA to the control. The pump must go to full displacement. The max stop on the control may have to be adjusted. If the control does not stroke the pump to full, turn close the servo needle valve to the stroker and stroke the unit to full manually. If the pump goes to full, reject the control. If the pump does not go to full, the problem is in the pump.

9. Close the switch and stroke the unit to full displacement. Open the switch and observe the unit return to center.

10. Apply 400 MA to get full displacement, then close the servo needle valve. The control should spring to center in three seconds.

11. Open the needle valve. Apply +50 MA, then open the switch. Observe that the pump nulls in each case. If it does not, recheck the null per test 7.

12. The mechanical stops are pre-set to 19° and 0°. If something other than this is requested, the two adjusting screws on either end of the control can be turned to the desired flow or displacement.

C. Hydraulic Stroker

1. Connect external 400 PSI (28 bar) servo source to control ports on hydraulic stroker through a 4-way valve. Center position must dump both ports to tank at zero pressure.

2. Apply servo pressure to one port of stroker. Adjust pressure from minimum to maximum. Note the control pressure at which pump just starts to stroke, and the control pressure at which pump reaches full volume. The pressures must be within the following values:

	Control Pressure	
	Start	Full
	75±15 PSI (5±1 bar)	335±25 PSI (23±1.7 bar)

Note: If incorrect, add or delete shim washer to spring box assembly. One washer 033-53453 will alter control pressure by 20 PSI. (1.4 bar).

3. Observe stroker versus control pressure. Stroke shall change gradually with no jumps, from zero to full.

4. With minimum signal, pump shall return to zero pressure.

5. The mechanical stops are pre-set to 19° and 0°. If something other than this is requested, the two adjusting screws on either end of the control can be turned to the desired flow or displacement.

Acceptance Values:

Place pump at full stroke.

Output flow:

(7.25/6.0)
50/41 GPM (189/155 L/m Minimum @ 5000 PSI (345 bar)

(8.0)
60 GPM (227 L/m) Minimum @ 2000 PSI (138 bar)

Case leakage:

(7.25/6.0)
3.6/3.0 GPM (13.6/11.4 L/m) Minimum @ 5000 PSI (345 bar)

(8.0)
2.5 GPM (9.5 L/m) Maximum @ 2000 PSI (138 bar)

External Leaks

- A. No external leaks permitted
- B. Shaft seal can be damp but no leakage is acceptable.

The Denison World Cup units are available with three basic types of control options.

- 1) Pressure Controls
- 2) Servo Controls
- 3) Combination of Pressure and Servo Controls

Pressure Controls:

- 1) Compensator (C*O) and (F*O)
- 2) Load Sensing (L*O)
- 3) Torque Limiter (T*O)

Typical Characteristics:

- 1) Control Piston is spring loaded to full volume
- 2) Pressure required to change to destroke
- 3) Control is mounted on pressure side of unit
- 4) Torque limiter or load sensing always have a compensator

Servo Controls

- 1) Rotary Servo (R00)
- 2) Rotary Servo with minimum and maximum volume and stops use (R40)
- 3) Hydraulic (H40)
- 4) Electro/Hydraulic (E40)

Typical Characteristics:

- 1) Unit is spring loaded to zero stroke.
- 2) Servo pressure is required to "stroke" unit to full stroke.
- 3) Unit requires a servo supply source of 300 PSI. min (20.7 bar), 1000 PSI max (70 bar)
- 4) Control is mounted on the suction side of unit.
- 5) Feedback is required.
- 6) Servo pressure is also required for the electro-hydraulic stroker.

Combination of Pressure and Servo Control

* See table V for Control Combinations

Typical Characteristics

- 1) Pressure Compensation overrides the Servo input at the compensator setting
- 2) All other characteristics same as servo characteristics.

Table V lists all control combinations in conjunction with the many control assemblies they are also other components affected when performing conversions such as:

- 1) Control Pistons
- 2) Hanger
- 3) Pump Housing
- 4) Spring Caps
- 5) Logic Change

Control Piston

Two types, (1) the compensator control piston is solid on one end with a spring cavity that is open to case on the opposite end. (2) The servo control piston is solid, on both ends, with a spring cavity on both ends. Spring cavities are not open to case.

Housings

Two types, the compensator type of housing has drilled passages on the pressure side only to the top of the control piston. The servo type housing has drilled passages on both sides of the control mounting pads to both the top and bottom of the control piston.

Hangers

Three types, the hanger for the TLO has an angle ramp for the TLO pin, hanger for servo control has a feedback pin for the servo control. The hanger for the pressure controls standards without any ramps or feed back pins. There are six different configurations of hangers as outlined in table VI.

Pump Housings

Four types, but eight configurations as outlined in table VI.

Spring Caps

Two types, one has a fluid control passage to the control piston and is used for servo control units. The other has no fluid control passage and is used with the pressure controls.

Logic Change

See fig. 14 for complete circuit when changing from a pressure control unit to a servo or combination pressure and servo control.

Servo Control Pump Logic

See page 45 for complete logic relating to servo and main pump shaft rotation with electro hydraulic stroker polarity.

Shafts

Ten different shafts are available in both spline and keyed. All thru shafts are fitted with a coupling to adapt to SAE 'B', 'BB', 'C' or 'D' rear mounted pump. See table VI.

World Cup Control Conversion Parts Table V

Series P6, 7 & 8W

Control and Code	Pressure Controls	Servo Controls	Control Piston	Hanger	Standard Housing
Compensator C*O	S21-11380-0	x	031-57992	S21-12237	031-91116
Low Flow Compensator **F*0	S21-11619-0	x	031-57992	S21-12237	031-91116
Load Sensing Compensator L*0	S21-11640-0	x	031-57992	S21-12237	031-91116
Torque Limiter with Compensator T*0	S21-11651-0	x	031-57992	S21-12443	031-91116
Rotary Servo CW R0	x	S21-11560-0	031-91093	S21-12446	031-91120
Rotary Servo CCW R00	x	S21-11560-0	031-91093	S21-12447	031-91120
Rotary Servo with Stops CW R40	x	S21-11608-0	031-91093	S21-12446	031-91120
Rotary Servo with Stops CCW R40	x	S21-11608-0	031-91093	S21-12447	031-91120
Hydraulic Stroker CW H40	x	<u>S21-12286-0</u>	031-91093	S21-12446	031-91120
Hydraulic Stroker CCW H40	x	<u>S21-12285-0</u>	031-91093	S21-12447	031-91120
Electro Hydraulic Stroker CW E40	x	<u>S21-12307-0</u>	031-91093	S21-12446	031-91120
Electro Hydraulic Stroker CCW E40	x	<u>S21-12308-0</u>	031-91093	S21-12447	031-91120
Rotary Servo with Compensator override CW R4P	S21-11380-0	S21-11608-0	031-91093	S21-12446	031-91120
Rotary Servo with Compensator override CCW R4P	S21-11380-0	S21-11608-0	031-91093	S21-12447	031-91120
Hydraulic Stroker with Compensator override CW H4P	S21-11380-0	<u>S21-12286-0</u>	031-91093	S21-12446	031-91120
Hydraulic Stroker with Compensator override CCW H4P	S21-11380-0	<u>S21-12285-0</u>	031-91093	S21-12447	031-91120
Electrohydraulic Stroker with Compensator override CW E4P	S21-11380-0	<u>S21-12307-0</u>	031-91093	S21-12446	031-91120
Electrohydraulic Stroker with Compensator override CCW E4P	S21-11380-0	<u>S21-12308-0</u>	031-91093	S21-12447	031-91120
Rotary Servo with Torque Limiter override CW R4T	S21-11651-0	S21-11608-0	031-91093	S21-12445	031-91120
Rotary Servo with Torque Limiter override CCW R4T	S21-11651-0	S21-11608-0	031-91093	S21-12444	031-91120
Hydraulic Stroker with Torque Limiter override CW H4T	S21-11651-0	<u>S21-12286-0</u>	031-91093	S21-12445	031-91120
Hydraulic Stroker with Torque Limiter override CCW H4T	S21-11651-0	<u>S21-12285-0</u>	031-91093	S21-12444	031-91120
Electrohydraulic Stroker with Torque Limiter override CW E4T	S21-11651-0	<u>S21-12307-0</u>	031-91093	S21-12445	031-91120
Electrohydraulic Stroker with Torque Limiter override CCW E4T	S21-11651-0	<u>S21-12308-0</u>	031-91093	S21-12444	031-91120

* shaft rotation

** TLO and Load Sense not available with 'F' compensator

2) See Table VI for Housings with B, C, D Housings and B, BB, C and 'D' Shafts.

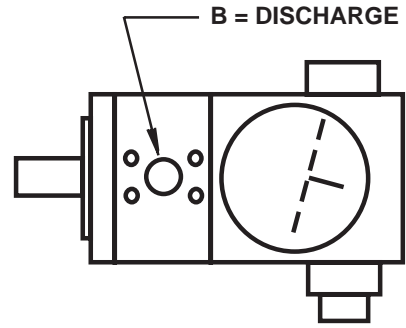
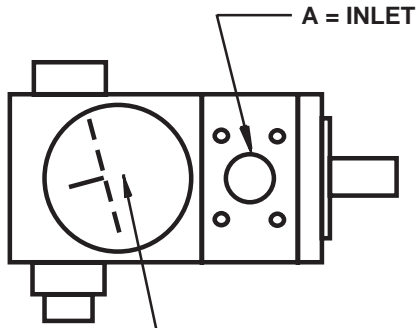
Max. Vol. Stop	<u>S21-12361-0</u>		
Max. Vol. Handwheel	<u>S21-11382-0</u>		
Min. Vol. Stop	<u>S21-11992-0</u>		
Remote Control	<u>S21-11594-0</u>		
Rear Drive	Splined Shaft & brg Assy.	Rear Drive Coupling	Keyed Shaft & brg Assy
0	S21-11378-0	None	0 S21-11377-0
SAE 'B'	S21-11416-0	031-57170-0	SAE 'B' S21-11415-0
SAE 'B-B'	S21-11448-0	031-57171-0	SAE 'B-B' S21-11447-0
SAE 'C'	S21-11558-0	031-57190-0	SAE 'C' S21-11557-0
SAE 'D'	S21-11558-0	031-57191-0	SAE 'D' S21-11557-0
Rear Drive Cover Plate			
SAE 'B' & 'B-B'	<u>S21-04526-0</u>		
SAE 'C'	<u>S21-04527-0</u>		
SAE 'D'	<u>S21-04528-0</u>		
Rear Drive 'O' Ring Seal			
SAE 'B' & 'B-B'	671-00155-0		
SAE 'C'	671-00159-0		
SAE 'D'	671-00163-0		
Rear Drive Mounting Bolt Kit			
SAE 'B' & 'B-B'	S24-11031-0		
SAE 'C'	S24-11032-0		
SAE 'D'	<u>S21-11609-0</u>		

Housing Combinations		
	Standard with Compensator Control	Special with Servo Control
No Boost	031-91116	031-91120
"B" Pad	031-91117	031-91121
"C" Pad	031-91119	031-91122
"D" Pad	031-91118	031-91123

Hanger Assemblies	Part Numbers
Standard (C, F, L)	S21-12237
Cam-for TLO (T**)	S21-12443
Feedback CW (R**)	S21-12446
Feedback CCW (R**)	S21-12447
Cam Feedback CW(R*T)	S21-12445
Cam Feedback CCW (R*T)	S21-12444

SERVO CONTROL PUMPS

PORTS:



ROTARY SERVO

PUMP ROTATION

R = CW
 R = CW
 L = CCW
 L = CCW

HANGER

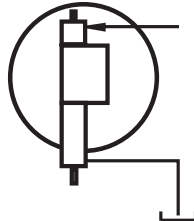
BELOW CTR
 BELOW CTR
 ABOVE CTR
 ABOVE CTR

SERVO SHAFT

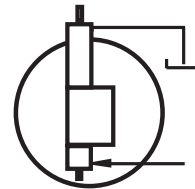
CCW INCREASE FLOW
 CW DECREASE FLOW
 CW INCREASE FLOW
 CCW DECREASE FLOW

HYDRAULIC STROKER

R = CW PUMP
S21-12286-0

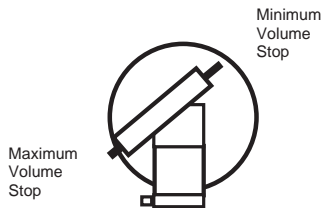


L = CCW PUMP
S21-12285-0

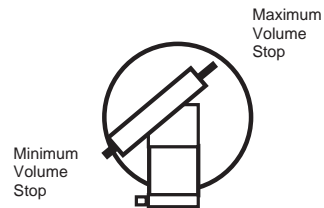


ELECTROHYDRAULIC STROKER

R = CW PUMP
S21-12307-0



L = CCW PUMP
S21-12308-0



ELECTRICAL CONNECTION

CW PUMP
 CCW PUMP

A	B
+	-
-	+

Logic Change:

The Term Logic Change refers to the addition of a ball check 1) ball check with orifice and a plug 2) that are required for special housings. (Special housings are with R, H, and E controls.) This requirement is the result of servo supply being routed to both the control piston with the following servo controls:

- 1) Rotary Servo-(R00)
- 2) Hydraulic-(H40)
- 3) Electro/hydraulic-(E40)

see below

- 1) Ball Check, S23-40266
- 2) Ball Check with orifices, S23-11615
- 3) Plug, 312-15010

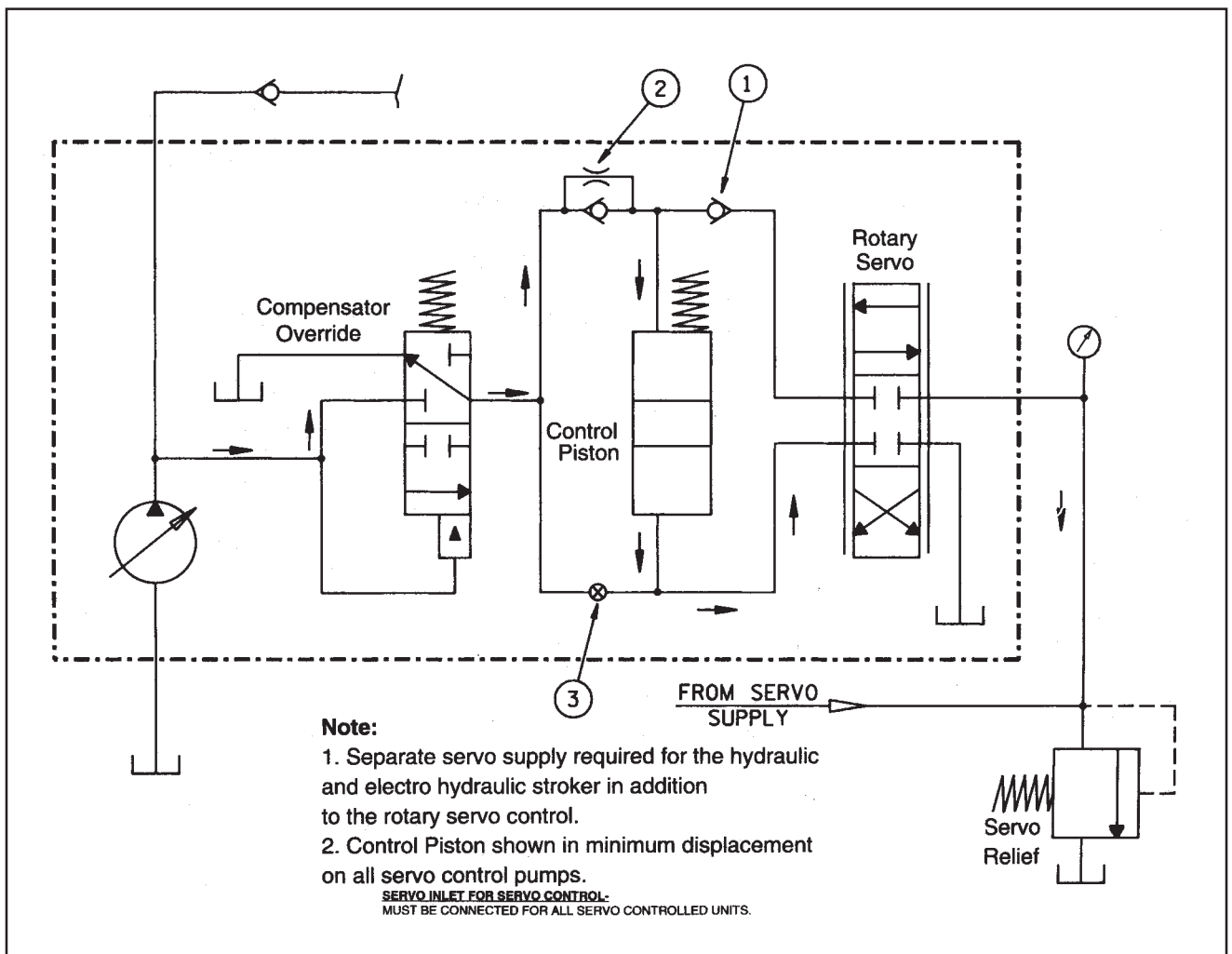


FIG 14

Specification	Symbol for Unit	SI Unit	American Unit
Displacement	V_i	cm ³ /rev	in ³ /rev
Pressure	p	bar	psi
Pressure Drop	Δp_d	bar	psi
Charge Pressure	p_c	bar	psi
Speed (rotation)	n	rev/min	rev/min
Power	P	kW	hp
Torque (output)	M_v	Nm (da)	lbf•ft (in/lbs)
Torque (Specific)	m_v	Nm/bar	lbf•ft/1000 psi
Force	F	N	lbf
Flow	Q	l/min	GPM
Total Volumetric Loss	Q_l	l/min	GPM
Moment of Inertia	I	kg.m ₂	lb.in ²
Temperature	T	°C	°F
Viscosity (kinematic)	ν	cSt	SSU
Dimensions		mm	inch
Weight		kg	lbs

Definition & Unit

Example

DISPLACEMENT cm³/rev

1 in³/rev = 16.387 cm³/rev

40 cm³/rev = 2.44 in³/rev

FLOW l/min

1 gpm = 3.78 l/min

148 l/min = 39.15 GPM

POWER kW

1 hp = 0.7457 kW

25 kW = 33.52 hp

TORQUE Nm

1 ft-lb = 1.3567 Nm

63 Nm = 46.46 ft-lbs

PRESSURE bar

1 psi = 0.069 bar

100 bar = 1450 psi

WEIGHT kg

1 lb = 0.455 kg

29 kg = 63.7 lbs

FORCE N

1 lb = 1.55 N

600 N = 131.87 lbs

VOLUME cm³

1 in³ = 16.387 cm³

1000 cm³ = 61 in³

AREA cm²

1 in² = 6.45 cm²

50 cm² = 7.75 in²

DISTANCE mm

1 in = 25.4 mm

101.6 mm = 4 in

TEMPERATURE °C

Deg. F = $\frac{9 \times \text{Deg. C}}{5} + 32$

50°C = 122 ° F

VISCOSITY mm²/sec (equivalent to cSt)

60 SSU = 10 mm²/sec

25 mm²/sec = 130 SSU

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