Bulletin SFM-M4DC (Rev.C)
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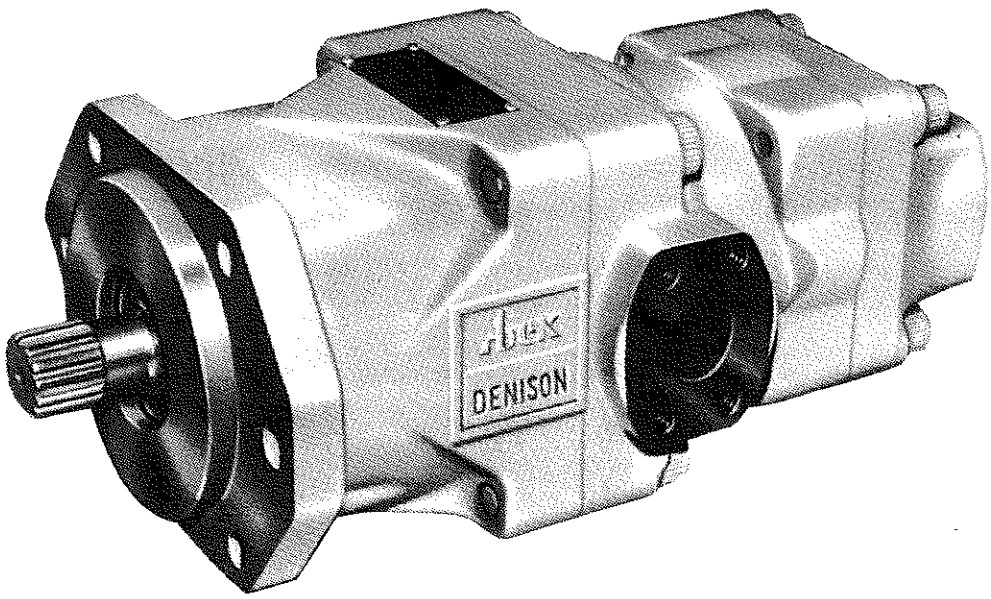
HÄGGLUNDS | DENISON | SERVICE LITERATURE

Vane Type Tandem Fluid Motor

Model M4DC, M4DC1
M4SDC, M4SDC1
MODEL "A" AND MODEL "B"

INSTALLATION, OPERATION AND OVERHAUL INSTRUCTIONS



Tandem Motor

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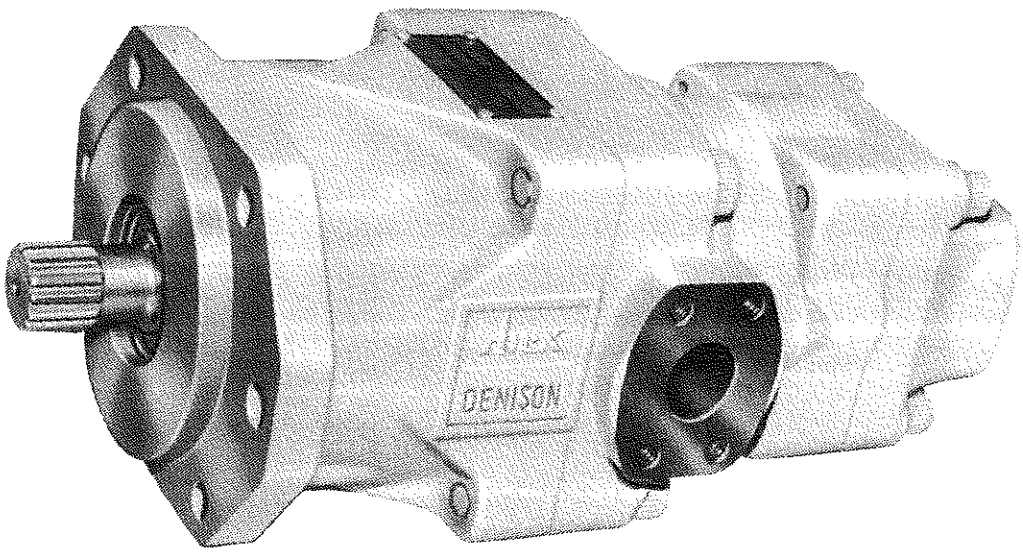


Figure 1

General

This bulletin contains installation, operating, maintenance and overhaul instructions for the Abex/Denison M4DC and M4DC1 and the severe duty models M4SDC and M4SDC1 tandem fluid motors.

Description

This fixed displacement vane type motor is a tandem unit capable of two-speed operation in converting hydraulic forces into rotary mechanical motion. Three basic configurations are available:

4-port model
2-speed motor ("D" cartridge out)
2-speed motor ("C" cartridge out)

The basic 4-port motor is available as an externally drained (M4DC) or an internally drained (M4DC1) unit.

This tandem motor utilizes the Series M4C end cap and cartridge, and the Series M4D cartridge and housing. Five porting options are available:

End ported SAE 1″ 4-bolt
End ported SAE straight thread
Side ported SAE 1″ 4-bolt
Side ported SAE straight thread
Opposed side ported SAE 1¼ 4-bolt

Two-Speed Version

Two-speed operation is accomplished by connecting the motor cartridges in parallel for low speed/high torque output. The front cartridge "D" is larger than the "C" cartridge so, as a consequence, by dropping out the "D" cartridge or the "C" cartridge, two additional (and different) high speed/low torque speeds are obtained. Selection of the mode of operation is accomplished by customer furnished valves.

GENERAL CHARACTERISTICS

Cartridge	"C"		"D"	
Torque (theoretical)	in-lb 100psiΔP 24-69	nm/barΔP .40-1.13	in-lb 100psiΔP 62.1-140.2	nm/barΔP 1.02-2.30
Specific power (Theoretical)	HP/100RPM-100 psi .038-.110	KW/100-RPM 6.9 bar .004-.012	HP/100RPM-100 psi .101-.223	KW/100RPM-6.9 bar .011-.024
Displacement (Theoretical)	in^3/rev 1.49-4.34	ML/rev 24.4-71.1	in^3/rev 3.90-8.81	ML/rev 63.9-144.4
Moment of inertia (WR^2)	2.7 lb-in^2	7.9 Kg cm^2	7.3 lb-in^2	21.8 Kg cm^2
Weight (approx) M4DC	88 lbs.		39.9 Kg	

Speed-Max Intermittent	4000 RPM
Mounting	SAE-C 2 Bolt/4 Bolt
Shaft	SAE-C Keyed or Splined
Fluid Connections	Center SAE 4 Bolt
	End Cap SAE 4 Bolt or SAE Str. Thread
Drain	External or Internal
Ports	Center Opposite Sides
	End Cap End/Same Side/Opposite Sides
Port Alignment	Variable 90° Increments
Seals	S-1 and S-5

OPERATING CHARACTERISTICS

Maximum Pressures and Speeds

Fluid Type	Denison Fluid Spec.	M4DC Continuous			M4DC Intermittent[1]			M4SDC Continuous			M4SDC Intermittent[1]		
		Speed RPM	Pressure PSI	Pressure BAR	Speed RPM	Pressure PSI	Pressure BAR	Speed RPM	Pressure PSI	Pressure BAR	Speed RPM	Pressure PSI	Pressure BAR
Antiwear Petroleum Base	HF-0 HF-2	3600 3000 2500	500 2000 2500	35 138 172	4000 3000	500 2500	35 172	3600 3000 2500	500 2000 2500	35 138 172	4000 3000	500 2500	35 172
Crankcase Oils	HF-6	3600 3000 2500	500 2000 2500	35 138 172	4000 3000	500 2500	35 172	3600 3000 2500	500 2000 2500	35 138 172	4000 3000	500 2500	35 172
Non-Antiwear Petroleum Base	HF-1	2000	2000	138	2500	2500	172	2000	2000	138	2500	2500	172
Water-in-oil Emulsions	HF-3	—	—	—	—	—	—	2000	2000	138	2500	2500	172
Water Glycols	HF-4	—	—	—	—	—	—	2000	2000	138	2500	2000	138
Synthetic Fluids	HF-5	—	—	—	—	—	—	2000	2000	138	2500	2500	172

[1] Not to exceed 6 seconds per minute of operation.

"D" CARTRIDGE

PERFORMANCE, THEORETICAL

Code	Displacement[1]						Torque[2]				Specific Power[3]	
	$\frac{in.^3}{rev.}$	$\frac{ml}{rev.}$	$\frac{gpm}{100\ rpm}$	$\frac{lpm}{100\ rpm}$	$\frac{gpm}{4000\ rpm}$	$\frac{lpm}{4000\ rpm}$	$\frac{in.\#}{100\ psi}$	$\frac{nm}{bar\ \Delta P}$	$\frac{in.\#}{2500\ psi}$	$\frac{nm}{172\ bar}$	$\frac{hp}{100\ rpm\ 100\ psi\Delta P}$	$\frac{kw}{100\ rpm\ bar\ \Delta P}$
062	3.90	63.9	1.69	6.4	67.5	256	62.1	1.02	1552	175	.101	.011
074	4.79	78.5	2.07	7.8	82.9	314	76.3	1.25	1907	215	.121	.013
088	5.56	91.1	2.41	9.1	96.3	365	88.5	1.45	2213	249	.140	.015
102	6.40	104.9	2.77	10.5	110.8	419	102.0	1.67	2550	287	.162	.018
113	7.12	116.7	3.08	11.7	123.3	467	113.4	1.86	2835	320	.180	.020
128	8.08	132.4	3.50	13.3	140.0	530	128.7	2.11	3218	363	.204	.022
138	8.81	144.4	3.61	14.2	152.6	578	140.2	2.30	3505	396	.223	.024

"C" CARTRIDGE

PERFORMANCE, THEORETICAL

Code	Displacement[1]						Torque[2]				Specific Power[3]	
	$\frac{in.^3}{rev.}$	$\frac{ml}{rev.}$	$\frac{gpm}{100\ rpm}$	$\frac{lpm}{100\ rpm}$	$\frac{gpm}{4000\ rpm}$	$\frac{lpm}{4000\ rpm}$	$\frac{in.\#}{100\ psi}$	$\frac{nm}{bar}$	$\frac{in.\#}{2500\ psi}$	$\frac{nm}{172\ bar}$	$\frac{hp}{100\ rpm\ 100\ psi.\Delta P}$	$\frac{kw}{100\ rpm,\ bar\ \Delta P}$
024	1.49	24.4	0.6	2.4	26	98	24	.40			.038	.004
031	2.13	34.9	0.9	3.4	36	136	34	.56	850	96	.054	.006
043	2.84	46.6	1.2	4.5	48	182	45	.74	1125	127	.071	.008
055	3.59	58.8	1.6	6.1	64	242	57	.94	1425	161	.090	.010
067	4.34	71.1	1.9	7.2	76	288	69	1.13	1752	195	.110	.012
075	4.89	80.2	2.12	8.0	85	318	77.8	1.27	1945	220	.124	.014

[1] Actual motor speed and displacement will vary with load.

[2] At 2500 psi (172 Bars) pressure drop actual values for running torque are typically 90% of theoretical and starting torque is 90% of running torque.

[3] Actual power is proportional to the product of speed and actual torque.

SECTION II
INSTALLATION

Mounting

This motor is designed to operate in any position.

The motor shaft must be in alignment with the shaft of the driven load and should be checked with a dial indicator. The mounting pad or adapter into which the fluid motor pilots must be concentric with the motor shaft within 0.010 TIR to prevent bearing failures. This concentricity is particularly important if the fluid motor shaft is rigidly connected to the driven load without a flexible coupling.

Piping

The externally drained model must have a drain line connected to the center housing drain connection of sufficient size to prevent back pressure in excess of 50 PSI, and returned to the reservoir below the surface of the oil as far away from the supply pump suction as possible. Model M4DC1 does not require an external drain line, however, the outlet pressure must not exceed 50 PSI.

All fluid lines either pipe, tubing or hose, must be of adequate size and strength to assure free flow through the motor. An undersize inlet line will prevent the motor from reaching full speed and will not develop sufficient torque. An undersized outlet line will create back pressure in the motor and prevent proper operation. Flexible hose lines are recommended. If rigid pipe or tubing is used, the workmanship must be accurate in order to eliminate strain on the motor end cap or the fluid connectors. Sharp bends in the lines should be eliminated whenever possible. All system piping must be cleaned with solvent or equivalent before the motor is connected. Be sure that the entire hydraulic system is free from dirt, lint, scale and other foreign material. DO NOT USE GALVANIZED PIPE. Galvanized coating may flake off after continued use.

In the high speed mode, the recirculating cartridge must be replenished with suitable pressure to prevent cavitation. Required replenishment pressures are indicated in Table I, Page 6.

Recommended Fluids

Petroleum Based Antiwear R & O Fluids are the recommended fluids for M4 series motors. Maximum catolog ratings and performance data are based on operation with these fluids. These fluids are covered by Denison HF-2 specification.

Acceptable Alternate Fluids — The use of fluids other than petroleum based antiwear R & O fluids requires that the maximum ratings of the motors be reduced. In some cases the minimum replenishment pressures must be increased. Refer to the following chart and the Operating Characteristics Chart for each M4 motor model for specific details of the reduced ratings.

Fluid Type	Denison† Spec	Motor Series Usable	Max Temp °F	Max Temp °C	Replen Pressure Multiplier
Antiwear Petroleum Base Fluids	HF-2 HF-0	M4 & M4S	210	100	1.0
Non-antiwear Petroleum Base Fluids	HF-1	M4 & M4S	210	100	1.0
Crankcase Oils	HF-6	M4 & M4S	210	100	1.0
Water-in-oil invert emulsions	HF-3	M4S only	120	49	1.25
Water Glycols	HF-4	M4S only	120	49	1.25
Synthetic Fluids* (Phosphate Ester & Blends)	HF-5	M4S only	160	71	1.35

†See Denison Fluids Bulletin 2002 for further information.

*The standard Viton A type seals are not recommended for certain fluids of this general class including Monsanto PYDRAUL 10E, Monsanto SYKDROL and Stauffer Blend "G" and others.

VISCOSITY

Max (cold start, low speed & pressure)	4000 SUS (862 CS)
Max (full speed & pressure)	500 SUS (108 CS)
Optimum (max life)	140 SUS (30 CS)
Min (full speed & pressure)	60 SUS (10 CS)

VISCOSITY INDEX — 90 min. Higher values extend range of operating temperatures.

FLUID CLEANLINESS

The fluid must be cleaned before and during operation to maintain a contamination level of NAS 1638 class 8 (or SAE class 4) or better. Filters with 25 micron (or, better, 10 micron) nominal ratings may be adequate but do not guarantee the required cleanliness levels.

SECTION III
OPERATION

M4DC

During operation, oil under pressure is directed through the end cap and the center housing and is directed to both sides of the cam rings in each cartridge. The pressure applied against the vanes forces the rotor to turn and thus rotate the shaft.

As the rotor turns, oil moves to the discharge ports in the port plates and discharges through the end cap and center housing.

Replenishment Pressure

In the high speed mode sufficient replenishment pressure at the inlet port must be maintained.

TABLE I

MINIMUM REPLENISHMENT PRESSURE

M4DC	SPEED, RPM									
	500		1000		2000		3000		3600	
	Psi	Bar	Psi	Bar	Psi	Bar	Psi	Bar	Psi	Bar
	10	0.7	20	1.4	45	3.1	80	5.5	135	9.3

SECTION IV
MAINTENANCE

Since this motor is self-lubricating, preventative maintenance is limited to keeping the fluid in the system clean by changing filters frequently. Do not allow dirt to accumulate on the motor, especially around the shaft seal. Keep all fittings and screws tightened. Do not operate the motor at pressures or speeds in excess of the recommended limit.

If the motor does not operate properly, check the "Trouble Shooting Chart" in Table II before attempting an overhaul.

Overhaul is relatively simple and may be accomplished by following the procedure in Section V.

TABLE II
TROUBLE-SHOOTING CHART

Trouble	Probable Cause	Possible Remedy
1. External Leakage	a. Seal failure b. Defective casting	a. Replace seal b. Replace casting
2. Leakage At Fittings	a. Cracked casting b. Defective threads c. Damaged "O" Ring d. Burr	a. Replace b. Replace c. Replace d. Stone or file flat.
3. Loss In Speed Under Load	a. Low inlet pressure b. Excessive back-pressure at outlet. c. Scored port plate or end cap d. High oil temperature	a. Check Pressure b. Check pressure-increase line size. c. Relap flat to clean up. d. Use heavier oil; use oil cooler; adjust relief valve setting.
4. Poor Speed Control	a. Insufficient fluid supply b. Worn rotating group	a. Use more efficient pump. Use larger pump. Use flow control valve. b. Replace
5. Motor Fails to Start Turning	a. Insufficient torque b. Excessive motor leakage. c. Worn port plates. d. Worn rotating group e. Defective "O" ring on O.D. of front port plate. f. Insufficient pump delivery g. Motor too small	a. Increase relief valve pressure setting. b. Check flow from motor outlet if excessive check valve adaptor in front port plate, pressure not loading plate causing plate to move away from cam ring. c. Replace d. Replace e. Replace "O" ring if damaged. f. Pump worn or too small. g. Use larger size cam ring.

TABLE II
Trouble-Shooting Chart (cont'd)

Trouble	Probable Cause	Possible Remedy
6. Shaft Play	a. Worn bearings b. Excessive side load or end load on shaft c. Hammering coupling on shaft	a. Replace. b. Design problem; consult engineer. c. Coupling bore should be slip fit on shaft.
7. Bursting of Fluid Supply Inlet or Outlet Lines	a. Excessive pressure	a. If high inertia load over runs motor relief valve protection is required in one or possibly both lines between directional valve and motor. Use closed center valve with caution. Relief valve protection probably required as described above.
8. Excessive Noise	a. Worn or damaged internal parts. b. Air in System	a. Disassemble to remove rotor, vane, cam ring assembly. Inspect for excessive wear. Check condition of faces of port plate and end cap. Rework (lap) or replace if scuffed. b. Bleed air off-check fittings for tightness.
9. Seal Failure	a. High drain line pressure on externally drained unit. b. High outlet pressure on internally drained unit.	a. Provide larger drain line. Provide shorter less restricted drain line. b. Revise circuit to reduce back pressure. Increase line size.

Problems encountered not indicated in this table should be referred to the Customer Service Center or nearest Abex/Denison representative.

SECTION V
OVERHAUL

General

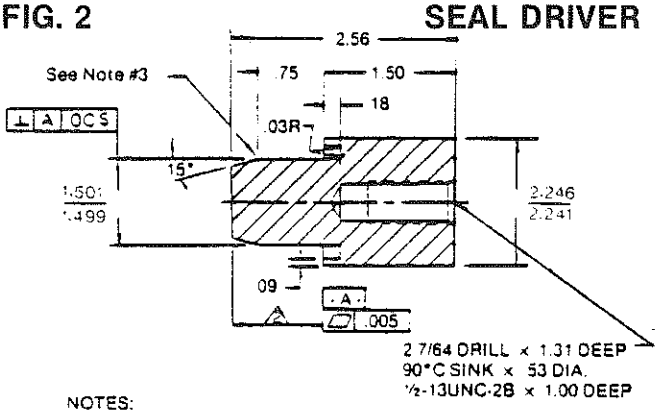
The instructions contained in this section cover a complete disassembly, inspection and assembly of the vane type fluid motor.

Drain all fluid from the motor and thoroughly clean the exterior surface. Prepare a clean, lint-free surface on which to lay the internal parts of the motor.

Special Tools

No special tools, other than shaft seal tools, are required to repair these motors. These tools must be used to install the shaft seal properly. See Figures 2 and 3 for information required to make these special tools.

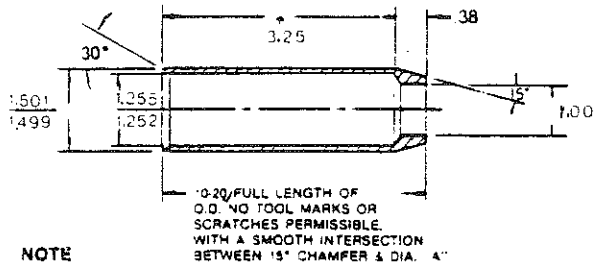
FIG. 2 **SEAL DRIVER**



NOTES:
1. Remove all burrs and break sharp edges .010/.005R.
2. Length ⏥ to be heat treated to RC 50-55.
3. Length ⏥ to have a 10-20 √ full length, with a smooth intersection between chamfer and dia. "A"
4. Grease O.D. of length ⏥ before installing shaft seal onto tool to prevent damage to the seal.

Material 4140 or equivalent.

FIG. 3 **PROTECTIVE CONE**



NOTE
1. Remove all burrs and break sharp edges .010/.005R.
2. Teflon preferred, alternate 4140 treated after machining to RC 50-55.
3. Install protective cone over shaft extension and grease O.D. to prevent damage to shaft seal.

Disassembly—"C" Cartridge End

See Figures 5 & 6, Pages 15 & 17 for item numbers listed below.

1. Secure the motor in a vise or other suitable holding fixture with the shaft (4) extended down.
2. Remove screws (28) and remove the end cap (3) from the center housing (1).
3. Remove the rubber seal ring (21) from the end cap (3).
4. Check the needle bearing (25) in the end cap. If it is worn or damaged, remove it.
5. Remove the dowel pin (24) from the cam ring assembly (22).
6. Thread two #10-24 screws in the two tapped holes provided as puller holes in the cam ring (22a) and remove the cam ring assembly (22) as a unit (22a, 22b, 22c, 22d).

NOTE:

If resistance is encountered when lifting the cam ring assembly, lightly tap the outside of the body while lifting the assembly. This will help in removing the cam ring, rotor, vanes and springs as a unit.

"WARNING"

The vanes are held against the cam ring by tension from the springs in the rotor. If the rotor is pulled from the cam ring with no protection, tension from the springs will throw the vanes out in all directions. The following procedure must be followed when disassembling the rotor and vanes from the cam ring:

Place the cam ring assembly on a clean, flat surface. Push the rotor and vanes from the cam ring far enough to secure a piston ring compressor over the vanes and around the rotor.

After the compressor is in place, push the rotor and vanes the remainder of the way out of the cam ring.

7. Release the tension on the compressor and remove the vanes (22b) and vane springs (22c) from the rotor (22d).
8. Remove dowel pin (24) from the port plate assembly.
9. Thread two #10-24 screws into the puller holes in the port plate assembly (23) and remove it from the center housing (1).
10. Grasp the port plate assembly (23) and shake it vigorously. If the ball check valve (12) is free to move it need not be removed for further inspection.
11. Remove the rubber seals (19 and 20).

NOTE:

Internally drained motors have two check valves (27) located in the center housing (1). When disassembling such motors, remove valves (27) from the housing (1) and inspect them visually for evidence of wear or contamination. Replace valves (27) as complete units if necessary or clean and replace upon reassembly. **Do not disassemble valves.**

Disassembly—"D" Cartridge End

See Figures 5 & 6, Pages 15 & 17 for item numbers listed below.

1. Remove screws (18) and remove the center housing (1) from the housing (2).
2. Remove the rubber seal ring (17) from the center housing (1).
3. Check the needle bearing (16) in the center housing. If it is worn or damaged, remove it.
4. Remove the dowel pin (15) from the cam ring assembly (14).
5. Thread two #10-24 screws in the two tapped holes provided as puller holes in the cam ring (14a) and remove the cam ring assembly (14) as a unit (14a, 14b, 14c, 14d).

NOTE:

If resistance is encountered when lifting the cam ring assembly, lightly tap the outside of the body while lifting the assembly. This will help in removing the cam ring, rotor, vanes and springs as a unit.

"WARNING"

The vanes are held against the cam ring by tension from the springs in the rotor. See "Warning" under "Disassembly—C Cartridge End".

6. Release the tension on the compressor and remove the vanes (14c) and vane springs (14d) from the rotor (14b).
7. Remove dowel pin (15) from the port plate assembly.
8. Thread two #10-24 screws into the puller holes in the port plate assembly (10) and remove it from the housing (2).
9. Grasp the port plate assembly (10) and shake vigorously. If the ball check valve (12) is free to move it need not be removed for further inspection.
10. Remove the seals (8 and 9).
11. Remove the snap ring (7) from the housing (2).
12. Press on external end of the shaft (4c) and remove shaft and bearing (4b) from the body.
13. Remove the external snap ring (4a) and press the bearing from the shaft.
14. Remove the felt wiper (5) and shaft seal (6) from the body.

Cleaning And Inspection

1. Wash all metal parts in cleaning solvent (Stoddard Solvent or equal) and dry thoroughly.

2. Inspection of Parts.

(a) Inspect the seals for wear, breaks, cuts and brittleness. Check closely the shaft seal for scratches and cracks. Discard and replace all defective seals.

(b) Inspect all springs for wear on the O.D., for cracks or permanent set. Replace all defective springs.

(c) Inspect bearings for wear or flat spots. If the bearings are rough or loose they must be replaced.

(d) Inspect the cam ring for excessive wear (ripples or washboard marks on the contour). Replace a badly worn or defective cam ring.

(e) Inspect the rotor for scored, marred or scratched (faces and vane slots) surfaces. Replace a defective rotor.

(f) Inspect the vanes for excessive wear marks (burrs, nicks and scoring). Replace defective vanes.

(g) Inspect the wear surfaces of the port plate and end cap for deep scratches. Replace if defective.

(h) Inspect the body and end cap for cracks or other casting damage. Replace all damaged castings.

(i) Inspect the shaft for excessive wear (internal spline, bearing surface and drive end). Replace if defective.

"CAUTION"

Dirt is a major cause of wear and motor failure. Cover all parts after cleaning to prevent dust and dirt from settling on them. All surfaces should be coated with a film of hydraulic lubricating oil after they have been cleaned.

Lubrication

No external lubrication is required. The hydraulic fluid which operates the motor provides adequate internal lubrication.

REASSEMBLY

NOTE:

Because of the three different basic "C" end cap configurations, there are twelve different porting combinations available. For porting combinations other than "00" described here, see Figure 4, Page 12.

Cleanliness

The proper functioning and performance of these units requires that a very close tolerance and minimum running clearance exists in the pumping cartridge components. Therefore, it is mandatory that all parts be cleaned thoroughly with solvent and compressed air and then assembled on an absolutely clean bench, free from any grit, chips or foreign material.

"D"—Pumping Cartridge Sub-Assembly:

1. Being careful not to damage the top lips of the vanes (14b) set them on the top lips with the spring holes up. Install the springs (14c) in the spring holes in the vanes (14b).

2. Lay rotor (14d) face down on a clean flat surface. Install the vanes (14b) and the springs (14c) in the rotor slots making certain each spring engages the spring hole at the base of the rotor slot.

NOTE:

When all the springs (14c) are properly engaged in the spring holes in the rotor (14d) the vane (14b) will extend into the rotor slot approx. half the height of the vane (14b).

3. After all the vanes (14b) and springs (14c) are installed in the rotor (14d), place a ring compress or hose clamp around the vanes (14b) and draw up to completely compress the vanes (14b) in rotor slots.

4. With the side of the cam ring (14a) that is marked with the cam size facing you, lay cam ring (14a) on a clean flat surface. Then using a backup plate to prevent the vanes from sliding endwise in the rotor slots, carefully with one quick continuous motion, insert the rotor (14d) and vanes (14b) in the cam ring.

"D"—Port Plate Sub-Assembly:

CAUTION:

Check port plate (10) for the check valve drilling to make certain the passages are clean and are connected.

With the port plate (10) positioned so the check valve drilling is vertical, insert one 3/16 dia. ball item (12). With the chamfered end first, insert the adaptor valve item (11) next. Install item (13) socket set screw till it bottoms against the adaptor valve item (11) and firmly hand tighten. This should jam the chamfered end of the adaptor item (11) into the chamfered seat between the #4 drill and the Q drill in the port plate item (10) to create a metal to metal seal.

Shaft Sub-Assembly:

CAUTION:

There is an intentional interference fit between the ball bearing inner race and the shaft O.D., therefore, when the ball bearing is installed, the mounting force should be applied against the ring, and only the ring, which is being press-fitted.

By pressing on the ball bearing inner race only, press the ball bearing on the shaft till it bottoms out against the shoulder on the shaft. Then install round section retaining ring.

CAUTION:

Retaining ring must be fully seated in the groove on the shaft!

Housing Sub-Assembly

With housing item (2) center line vertical small bore up, press felt wiper (5) into bore till it is flush with counter bore in housing.

NOTE:

Use an installation tool that holds the I.D. of the felt wiper and has a shoulder dia. large enough to act as a stop at the bottom of the c'bore at the front of the housing. Felt wiper should be saturated with oil before installing.

IMPORTANT:

If an O.D. sealant is not furnished on the O.D. of the shaft seal (6), apply a light coat of Chicago Rawhide "Bore Tite" or John Crane "PLS Sealing Compound" or Permatex "Form-a-Gasket #2" to the shaft seal bore of housing (2).

CAUTION:

Extreme care must be taken to avoid depositing any of the sealing compound on the seal element or the shaft (4). Special care must be taken to keep all foreign matter from sealing lips of the seal (6) to prevent cuts or abrasions on these edges.

1. Set housing (2) with center line vertical, large bore up. Using the proper installation tool, and with the open face of the shaft seal (6) toward the shoulder on the installation tool, press shaft seal (6) into bore of housing (2) against the shoulder provided. Grease seal lips.
2. With a cone shaped sleeve over the external drive spline, to protect the shaft seal lips, insert the shaft and bearing assembly into the housing until it interferes, then pressing on the outer race of ball bearing only, press shaft and bearing assembly into the housing (2) until it shoulders against the bottom of the housing bore. Install retaining ring (7) to hold shaft and bearing assembly in place.

CAUTION:

Retaining ring must be fully seated in the groove.

3. Install square section seal (8) on the small diameter of the port plate (10). Carefully stretch o-ring (9) onto the O.D. of port plate (10), do not roll the o-ring. Grease both seals (8 and 9).
4. Set the housing (2) large bore up and the drilled holes for the nameplate away from you. Using two 10-24 screws in the tapped holes in the bottom of the cast ports in the front port plate (10), set the front port plate (10) over the shaft and down in the housing (2) as far as it will go without forcing it. Line up the dowel pin hole in the front port plate (10) with the threaded hole at the lower right hand corner of the housing (2). Using the special tool (Fig. 2), press the front port plate (10) into housing (2) as far as it will go. Install dowel pin (15) in the dowel pin hole in port plate (10). Lubricate port plate (10) wear face with clean 150 SSU oil or petroleum jelly.
5. Insert two 10-24 screws in the tapped holes on the side of the cam (14) that is marked with the cam size. Install the cartridge over the shaft and lower into housing (2) engaging the dowel pin (15) in port plate (10) in the dowel hole in cam ring (14). Install remaining dowel pin (15) in cam ring (14). Lubricate the side of the rotor (14d) and the vanes (14b) with clean oil.

Center Housing Sub-Assembly:

Set the center housing (1) so that the wear face for the "D" cartridge is up. Using the recommended tool and with the stamped end of the needle bearing (16) against the shoulder of the pressing tool, press the needle bearing (16) into

the center housing (1) until it is flush with c'bore approx. 1/16" below wear face. Grease the needle bearing.

NOTE:

If the motor being assembled is an M4DC1, which is an internally drained motor, install SAE plug with o-ring item (26) in drain port in the side of the center housing (1). Then install two check valves (27) inside the center housing (1) at each port.

1. Grease and install square section seal (17) over large hub of center housing (1).
2. Being careful not to damage the bearing or the shaft, assemble the center housing (1) over the end of the shaft and engage the dowel pin (15) in the dowel hole in the "D" port face of the center housing (1).
3. Attach center housing (1) to housing (2) by installing four socket head cap screws item (18). Alternately tighten and torque all four screws to 130 ft. lbs.

"C"—Port Plate Sub-Assembly:

1. Grease and install square section seal (19) on hub of port plate (23). Install square section seal (20) in the bottom of the center housing bore.
2. Using two 10-24 screws in the tapped holes in the bottom of the cast ports in the front port plate (23), set the front port plate (23) over the shaft and down in the center housing (1). With the drilled holes for the nameplate away from you, line up the dowel hole in the port plate (23) with the threaded hole for the end cap (3) at the lower right corner of the center housing (1).

Install dowel pin (24) in dowel hole in port plate (23).

"C"—Pumping Cartridge Sub-Assembly:

1. Being careful not to damage the top lips of the vanes (22b) set them on the top lips with the spring holes up. Install the springs (22c) in the spring holes in the vanes (22b).
2. Lay rotor (22d) face down on a clean flat surface. Install the vanes (22b) and the springs (22c) in the rotor slots making certain each spring engages the spring hole at the base of the rotor slot.

NOTE:

When all the springs (22c) are properly engaged in the spring holes in the rotor (22d), the vane (22b) will extend into the rotor slot approx. half the height of the vane.

3. After all the vanes (22b) and springs (22c) are installed in the rotor (22d), place a ring compressor or hose clamp around the vanes (22b) and draw up to completely compress the vanes in the rotor slots.
4. With the side of the cam ring (22a) that is marked with the cam size facing you, lay the cam ring (22a) on a clean flat surface. Then using a backup plate to prevent the vanes from sliding endwise in the rotor slots, carefully with one quick continuous motion, insert the rotor (22d) and vanes (22b) in the cam ring (22a). Insert remaining dowel pin (24) in dowel hole in cam ring.
5. Lubricate port plate (23) wear face with clean 150 SSU oil or petroleum jelly.
6. Insert two 10-24 screws in the tapped holes on the side of the cam (22a) that is marked with the cam size. Install the cartridge over the shaft and lower into center housing (1) engaging the dowel pin (24) in the port plate (23) in the dowel hole in the cam ring (22a). Lubricate the side of the rotor (22d) and the vanes (22b) with clean oil.

"C"—End Cap Sub-Assembly

Set the "C" end cap (3) so the wear face for the "C" cartridge is up. With the stamped end of the needle bearing (25) against the shoulder of the pressing tool, press the needle bearing (25) into the "C" end cap (3) until it is flush with the c'bore approx. 1/32 below wear face. Grease the needle bearing.

1. Install square section seal (21) to hub of end cap (3).
2. Install end cap (3) over the end of the shaft (4) engaging the dowel pin (24). Install two screws (28) at opposite corners and wrench down together to prevent cocking the cap (3) until it bottoms evenly on the center housing (1). Install remaining screws (28). Torque all four screws evenly to 70-80 ft./lbs.

SPECIAL INSTRUCTIONS MODEL "B"

1. **Replacing "D" Section Cartridge Kit** - When necessary to change only the cartridge kit (cam ring, vanes and springs, rotor), an "A" Model cartridge kit made with an "A" Model cam ring may be used. No other changes necessary.
2. **Changing "D" Section Pressure Plate End Caps and Cartridge** - When necessary to change the cartridge kit, end cap and pressure plate, "B" Model cartridge kits and end caps **must** be used and the thicker tetraseal and Belleville washer **must** be used.
3. **Changing "D" Section Cartridge Kit and End Cap** -When necessary to change only the cartridge kit and end cap, "B" Model cartridge and end cap **must** be used, but the "A" Model port plate can remain. In this case, the "A" Model tetraseal must be used.
4. The "C" section is unchanged and interchangeable with the "A" Model parts.

NOTE: When ordering parts the "A" or "B" Model must be designated.

Assembly Procedure — Porting Combinations

1. Locate the desired porting combinations below.
2. Position the mounting flange to correspond with the diagram.

PORTING DIAGRAMS

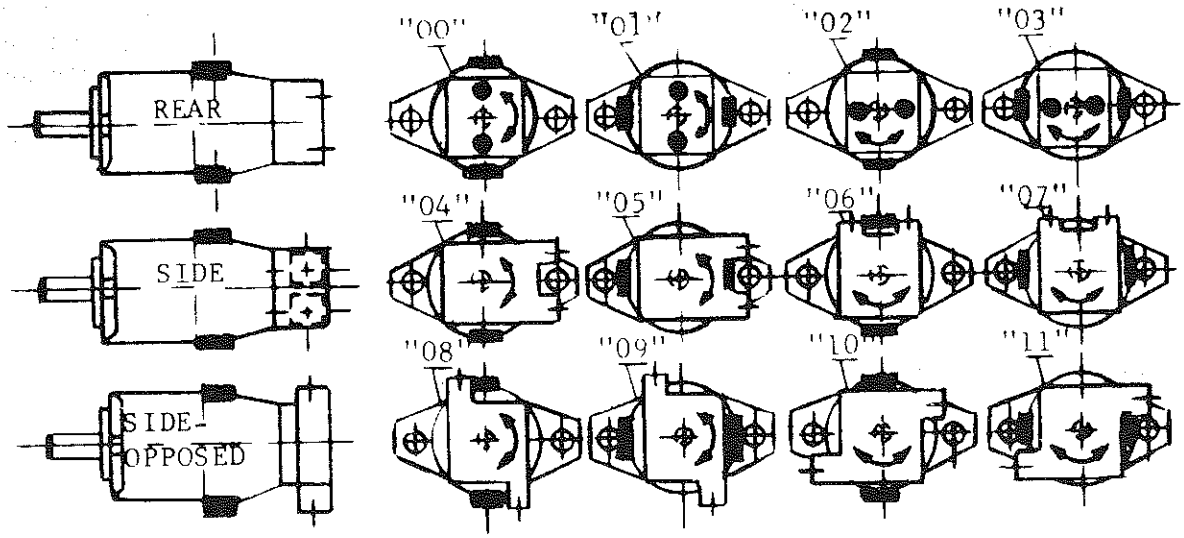


Figure 4

Positioning Center Housing Ports:

3. Remove the four 5/8″ socket head cap screws (18). Without disengaging the center housing (1) from the front section of the motor, rotate the center housing (1) and the "C" end cap to the required position for the center housing ports only. Install the 5/8″ socket head cap screws (18) and torque to 130 ft. lbs.

Positioning "C" End Cap Ports:

4. Remove the four 1/2″ socket head cap screws (28). Without disengaging the end cap (3), rotate the cap to the required position. Install the 1/2″ socket head cap screws and torque to 70-80 ft. lbs.

MODEL CODE

M4DC - 138 - 031 - IN00 - A101 -

Motor Series
M4DC, M4SDC
M4DC1, M4SDC1

Torque

Code "D" Cart.	in-lb 100 psi	nm bar	Code "C" Cart.	in-lb 100 psi	nm bar
062	62.1	1.02	024	24	.40
074	76.3	1.25	031	34	.56
088	88.5	1.45	043	45	.74
102	102.0	1.67	055	57	.94
113	113.4	1.86	067	69	1.13
128	128.7	2.11	075	78	1.28
138	140.2	2.30	—	—	—

Shaft
1 — keyed, SAE-C
3 — splined, SAE-C

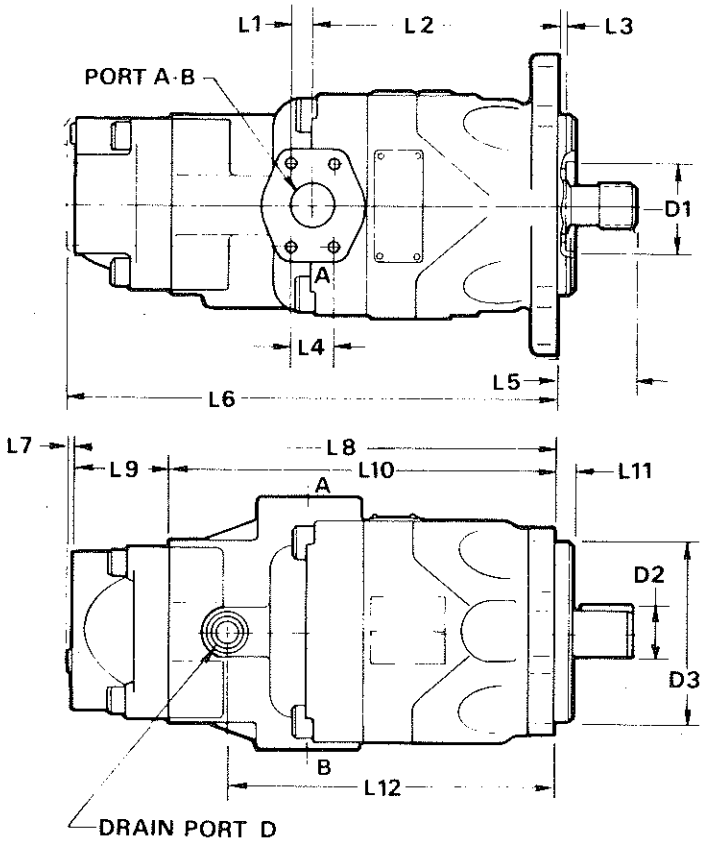
Rotation-bidirectional

Porting combinations — see drawing

End Cap Options
01 — SAE-16 (tap 1⅝-12 UNF)
02 — Pad for SAE 4-bolt flanges

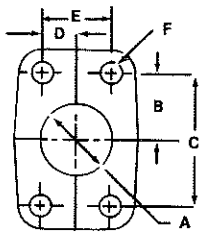
Seal Class
1 — Buna-N
5 — Vinton

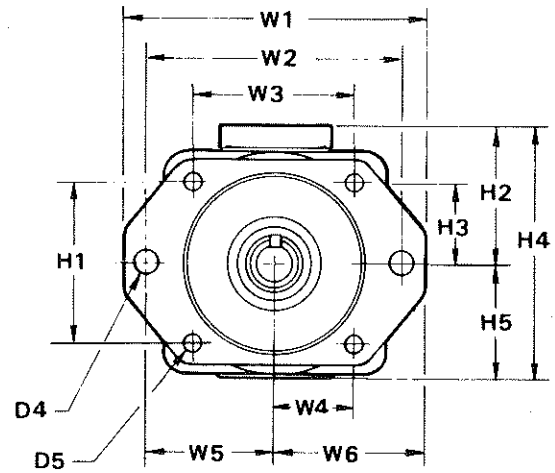
Design letter assigned by manufacturer



PORT DIMENSIONS
Pressure/Suction

	A & B Center Housing	End Cap Side Ports	End Cap Opposed Ports
A	1.25	1.00	1.25
B	1.16	1.03	1.16
C	2.31	2.06	2.31
D	.59	.52	.59
E	1.19	1.03	1.19
F	7/16-14 UNC-2 B THD x 0.88 DP	3/8-16 UNC-2 B THD x 0.75 DP	7/16-14 UNC-2 B THD x 0.88 DP





Installation Dimensions

	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12
Inch	.59	6.84	.25	1.188	2.19	13.69	.06	13.47	2.69	10.78	.50	8.72
mm	15.0	173.7	6.4	30.2	55.6	347.7	1.5	342.1	68.3	273.8	12.7	221.5

	W1	W2	W3	W4	W5	W6
Inch	8.36	7.125	4.508	2.254	3.562	4.18
mm	212.3	181.0	114.5	57.3	90.5	106.2

	H1	H2	H3	H4	H5
Inch	4.508	3.75	2.254	7.00	3.25
mm	114.5	95.3	57.3	177.8	82.6

	D1	D2	D3	D4	D5
Inch	2.50	1.389 / 1.382	5.000 / 4.998	.69	.56
mm	63.5	35.28 / 35.10	127.00 / 126.95	17.5	14.2

Shaft Dimensions

Shaft Code	Shaft Type	Shaft Std.	Dim.	Lgth. L5	Key Shaft Dimensions				Spline Shaft Dimensions					
					Dia.	Sq. Key Section	Dia. over Key	Key lgth.	Major Dia.	Minor Dia.	No. Teeth	Pitch	Pressure Angle	Spline Lgth.
1	Keyed	SAE-C	Inch	2.19	1.250 / 1.248	.3125 / .3105	1.389 / 1.382	1.5	X	X	X	X	X	X
			mm	55.6	31.75 / 31.70	7.94 / 7.89	35.28 / 35.10	38.1						
3	Splined	SAE-C	Inch	2.19	X	X	X	X	1.2293 / 1.2243	1.0627 / 1.0497	14	12/24	30°	1.00
			mm	55.6					31.22 / 31.10	26.99 / 26.66	14	12/24	30°	25.4

PARTS LISTS MODELS "A" & "B"

Item	Qty	Part No.	Description
1	1	034-59002	Housing, center (internally drained) Model "A"
		034-59001	Housing, center (externally drained) Model "A"
1	1	034-59898	Housing, center (internally drained) Model "B"
		034-59897	Housing, center (externally drained) Model "B"
2	1	034-49756	Housing
3	1	034-49804	Cap, end SAE 4-bolt conn (rear porting)
		034-49806	Cap, end SAE str. thd. conn (rear porting)
		034-71150	Cap, end SAE 4-bolt conn (side porting)
		034-71151	Cap, end SAE str. thd. conn (side porting)
		034-71509	Cap, end SAE 4-bolt conn (opposed side porting)
4	1	S24-10000	Shaft, splined SAE-C)
		S24-10001	Shaft, keyed SAE-C
5	1	605-10020	Wiper, felt
6	1	637-00003	Seal, shaft
7	1	356-32283	Ring, retaining
8	1	691-10232	Seal, sq. section Model "A"
		695-10232	Seal, sq. section, severe service S-5 seals Model "A"
		691-10335	Seal, sq. section Model "B"
		695-10335	Seal, sq. section, severe service S-5 seals Model"B"
9	1	691-00246	O-ring
		695-00246	O-ring, severe service S-5 seals
10	1	034-53343	Plate, front port ("D") Model "A"
		034-59852	Plate, front port ("D") Model "B"
11	2	034-53346	Adapter-valve (not shown in Figure 5)
12	2	201-06001	Ball (not shown in Figure 5)
13	2	312-35056	Screw, soc. set (not shown in Figure 5).
14	1	See Page 16	Cam ring assembly ("D" cartridge)
15	2	324-21612	Pin, dowel Model "A"
16	1	230-82002	Bearing, needle
17	1	691-10250	Seal, sq. section
		695-10250	Seal, sq. section, severe service S-5 seals
18	4	358-24300	Screw, S.H.C.
19	1	691-10226	Seal, sq. section
		695-20226	Seal, sq. section, severe service S-5 seals
20	1	691-10238	Seal, sq. section
		695-20238	Seal, sq. section, severe service S-5 seals
21	1	691-10242	Seal, sq. section
		695-10242	Seal, sq. section, severe service S-5 seals
22	1	See Page 16	Cam ring assembly ("C" cartridge)
23	1	034-53342	Port plate ("C")
24	2	324-21210	Pin, dowel
25	1	230-82008	Bearing, needle
26	1	488-35044	Plug, w/o-ring (internally drained motor)
27	2	S14-01257	Valve, check (internally drained motor)
28	4	358-20240	Screw, S.H.C. 1/2-13 UNC x 2" lg. (rear ported caps)
		358-20330	Screw, S.H.C. 1/2-12 UNC x 3¼" Lg. (side ported caps)
30		034-59843	Belleville washer "B" Model only

SHAFT ASSEMBLIES

Shaft No. & Type	Code No. #4	These Parts Are A Complete Shaft Assembly			
		Snap Ring #4a	Ball Bearing #4b	Shaft #4c	Key #4d
(#1) w/¼" key way	S24-10001	034-70853	230-00207	034-59004	034-49676
(#3) SAE-C Spline 14T	S24-10000	034-70853	230-00207	034-59003	—
Quantity		1	1	1	1

OTHER KITS AND OPTIONS

Port Plate (M4D)—Model "A"	S14-26066
Port Plate (M4D)—Model "B"	S24-10905
Port Plate (M4C)—all versions	S14-29880
S-1 Seal Kit—all versions	S24-10957
S-5 Seal Kit—all versions	S24-10957-5

Center Housing & Bearing—	
Internally Drained Model "A"	S24-10014
Externally Drained Model "A"	S24-10002
Internally Drained Model "B"	S24-10959
Externally Drained Model "B"	S24-10958
Foot Mount—all versions (includes Soc. Hd screws, lockwashers and nuts)	S14-02519

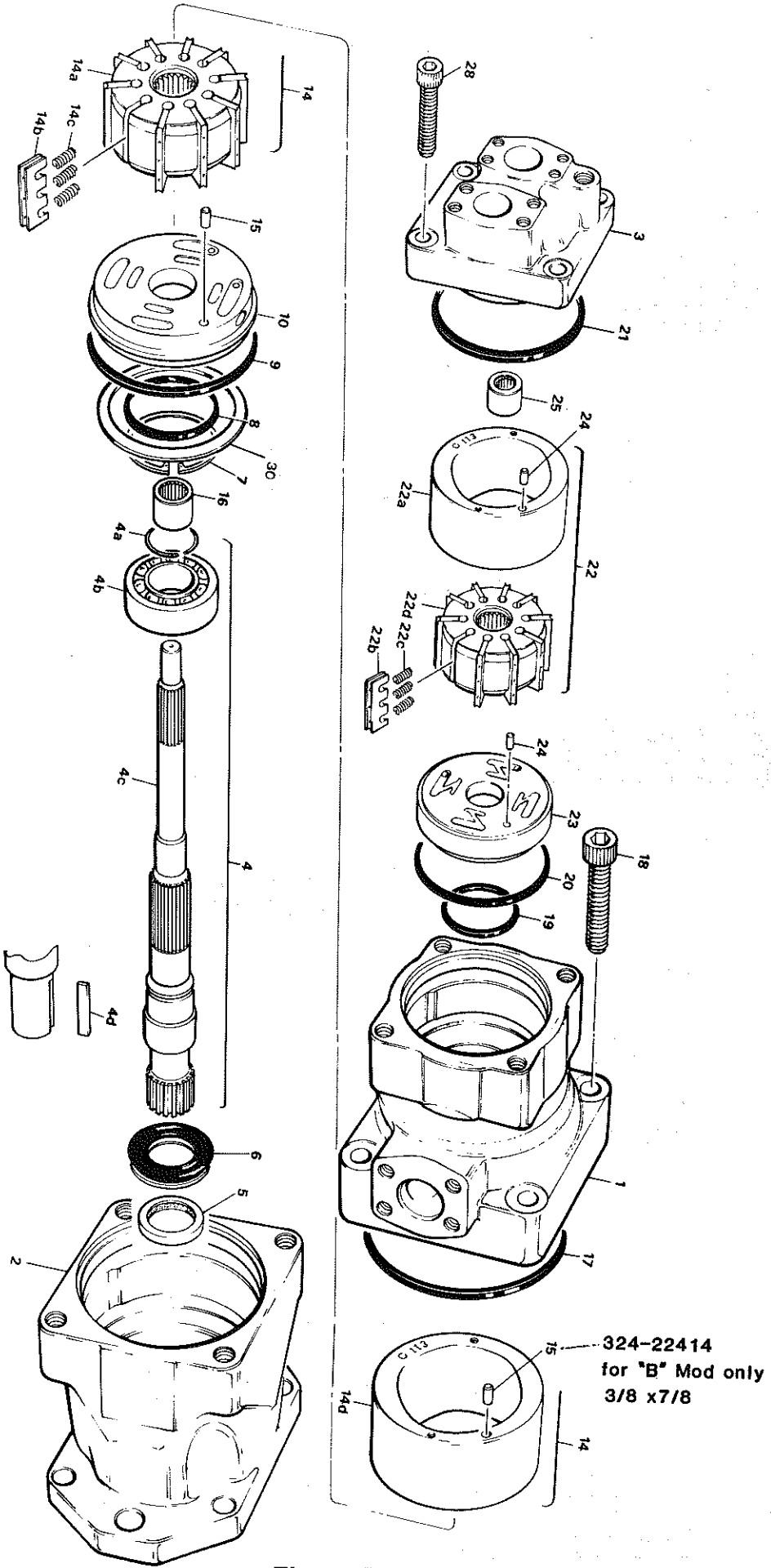

14a
14c
14b
14
15
10
9
8
30
7
16
4a
4b
4c
4
4d
6
5
2
28
3
21
25
24
22a
22
22d
22c
22b
24
23
18
20
19
1
17
15
14d
14
324-22414
for "B" Mod only
3/8 x7/8

Figure 5

"D" CARTRIDGE
CAM RING ASSEMBLIES

Model No.	#14 Code No. "A" Model	"B" Model	These Parts Are A Complete Cam Ring Assembly				
			#14a "A" Mod. Cam Ring	#14a "B" Mod. Cam Ring	#14b Vanes	#14c Vane Springs	#14d Rotor
	Quantity		1	1	10	30	1
M4DC or M4DC1-062	S14-29863	S24-10620	034-70730	034-59680			
M4DC or M4DC1-074	S14-26710	S24-10621	034-49748	034-59681			
M4DC or M4DC1-088	S14-28764	S24-10622	034-70320	034-59682			
M4DC or M4DC1-102	S14-26711	S24-10623	034-49749	034-59683	034-49746	034-49743	034-49747
M4DC or M4DC1-113	S14-26712	S24-10624	034-49750	034-59684			
M4DC or M4DC1-128	S14-26713	S24-10625	034-49751	034-59685			
M4DC or M4DC1-138	S14-26714	S24-10626	034-43760	034-59686			

"D" CARTRIDGE
SEVERE SERVICE
CAM RING ASSEMBLIES

Model No.	#14 Code No. "A" Model	"B" Model	These Parts Are A Complete Cam Ring Assembly				
			#14a "A" Mod. Cam Ring	#14a "B" Mod. Cam Ring	#14b Vanes	#14c Vane Springs	#14d Rotor
	Quantity		1	1	10	30	1
M4SDC or M4DSC1-062	S14-29865	S24-10627	034-70731	034-59687			
M4SDC or M4SDC1-074	S14-26715	S24-10628	034-49782	034-59688			
M4SDC or M4SDC1-088	S14-28787	S24-10629	034-70339	034-59689			
M4SDC or M4SDC1-102	S14-26716	S24-10630	034-49783	034-59690	034-49746	034-49743	034-49747
M4SDC or M4SDC1-113	S14-26717	S24-10631	034-49784	034-59691			
M4SDC or M4SDC1-128	S14-26718	S24-10632	034-49785	034-59692			
M4SDC or M4SDC1-138	S14-26719	S24-10633	034-43786	034-59693			

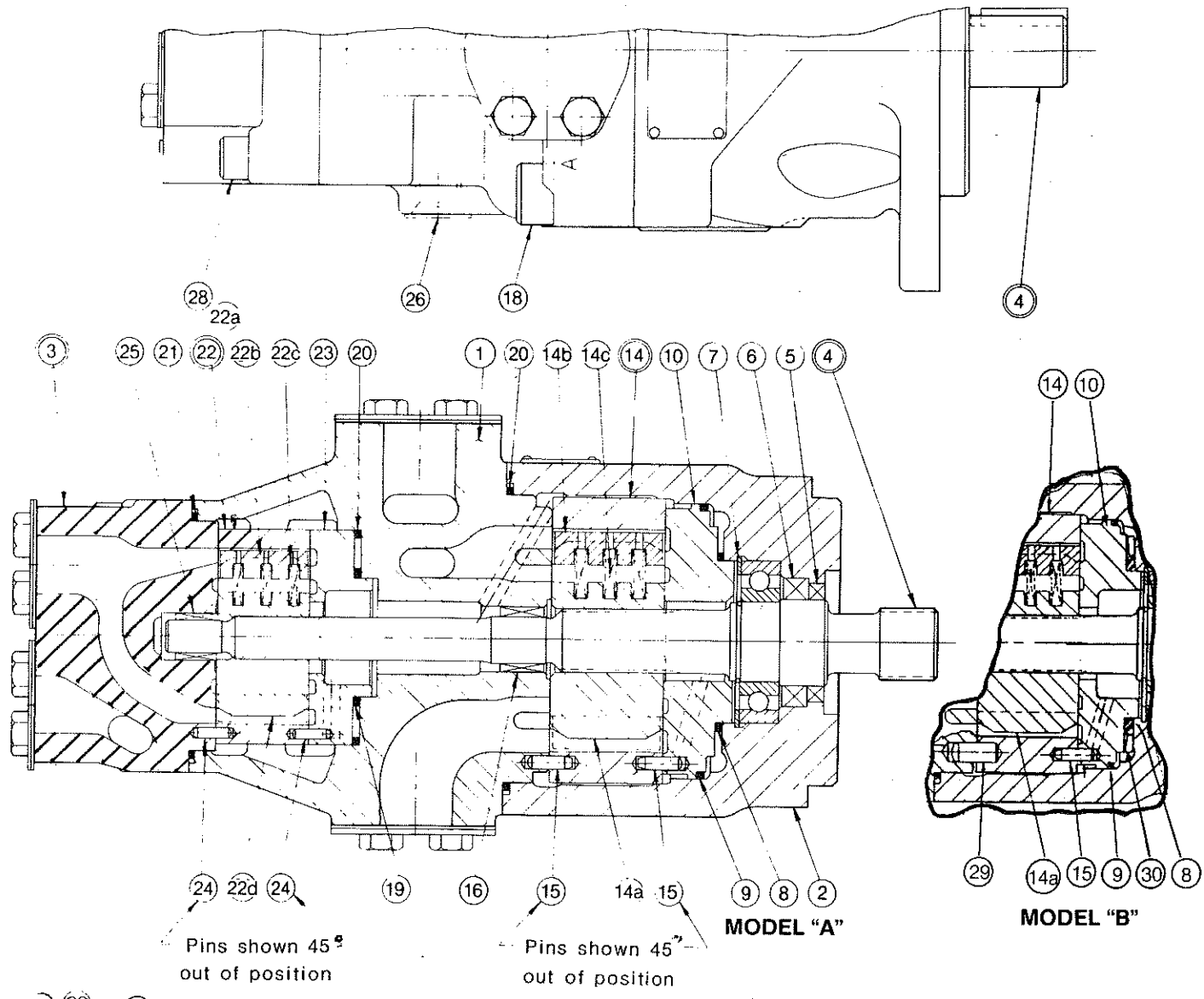
"C" CARTRIDGE
CAM RING ASSEMBLIES

Model No.	#22 Code No.	These Parts Are A Complete Cam Ring Assembly			
		#22a Cam Ring	#22b Vanes	#22c Vane Springs	#22d Rotor
	Quantity	1	10	30	1
M4DC or M4DC1-024	S14-45081	034-71871			
M4DC or M4DC1-031	S14-27027	034-48641			
M4DC or M4DC1-043	S14-27028	034-48642	034-49977	034-49978	034-49976
M4DC or M4DC1-055	S14-27029	034-48643			
M4DC or M4DC1-067	S14-27030	034-46809			
M4DC or M4DC1-075	S14-41505	034-71126			

"C" CARTRIDGE
SEVERE SERVICE
CAM RING ASSEMBLIES

Model No.	#22 Code No.	These Parts Are A Complete Cam Ring Assembly			
		#22a Cam Ring	#22b Vanes	#22c Vane Springs	#22d Rotor
	Quantity	1	10	30	1
M4SDC or M4SDC1-024	S14-45082	034-71884			
M4SDC or M4SDC1-031	S14-27031	034-49857			
M4SDC or M4SDC1-043	S14-27032	034-49856	034-49977	034-49978	034-49976
M4SDC or M4SDC1-055	S14-27033	034-49855			
M4SDC or M4SDC1-067	S14-27034	034-49854			
M4SDC or M4SDC1-075	S24-10022	034-59021			

SECTIONAL VIEW—MODEL "A"
INSET—MODEL "B"



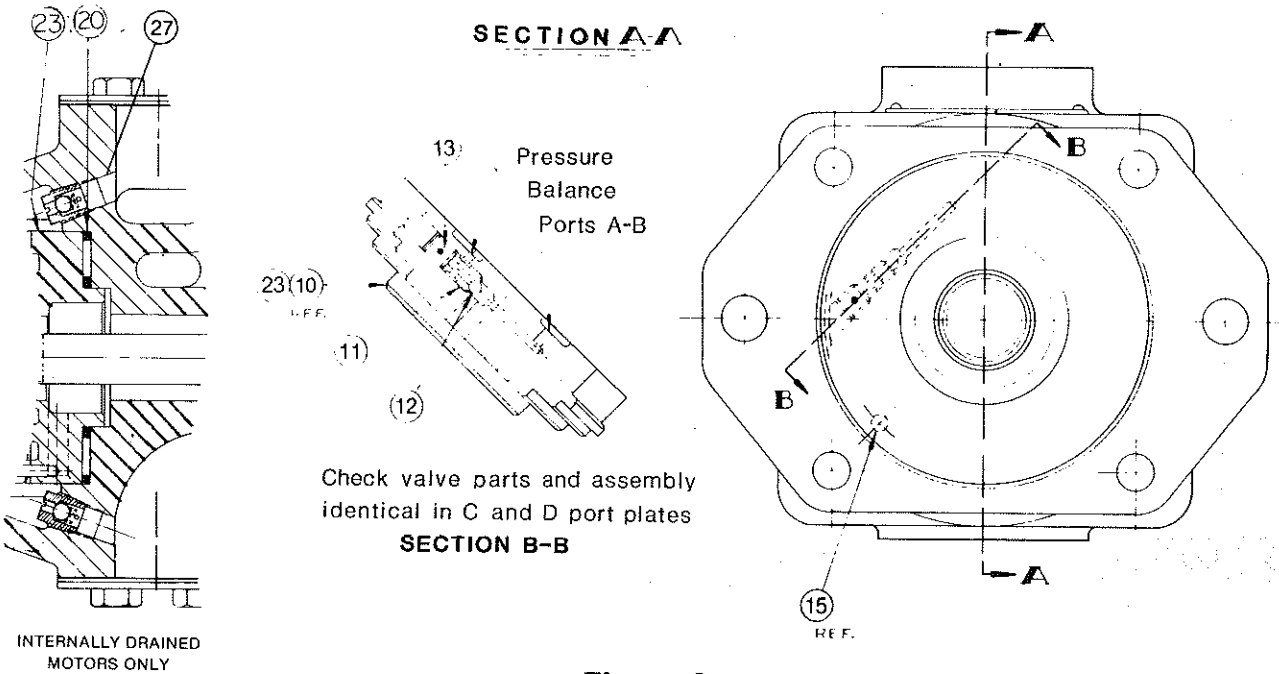


Figure 6

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