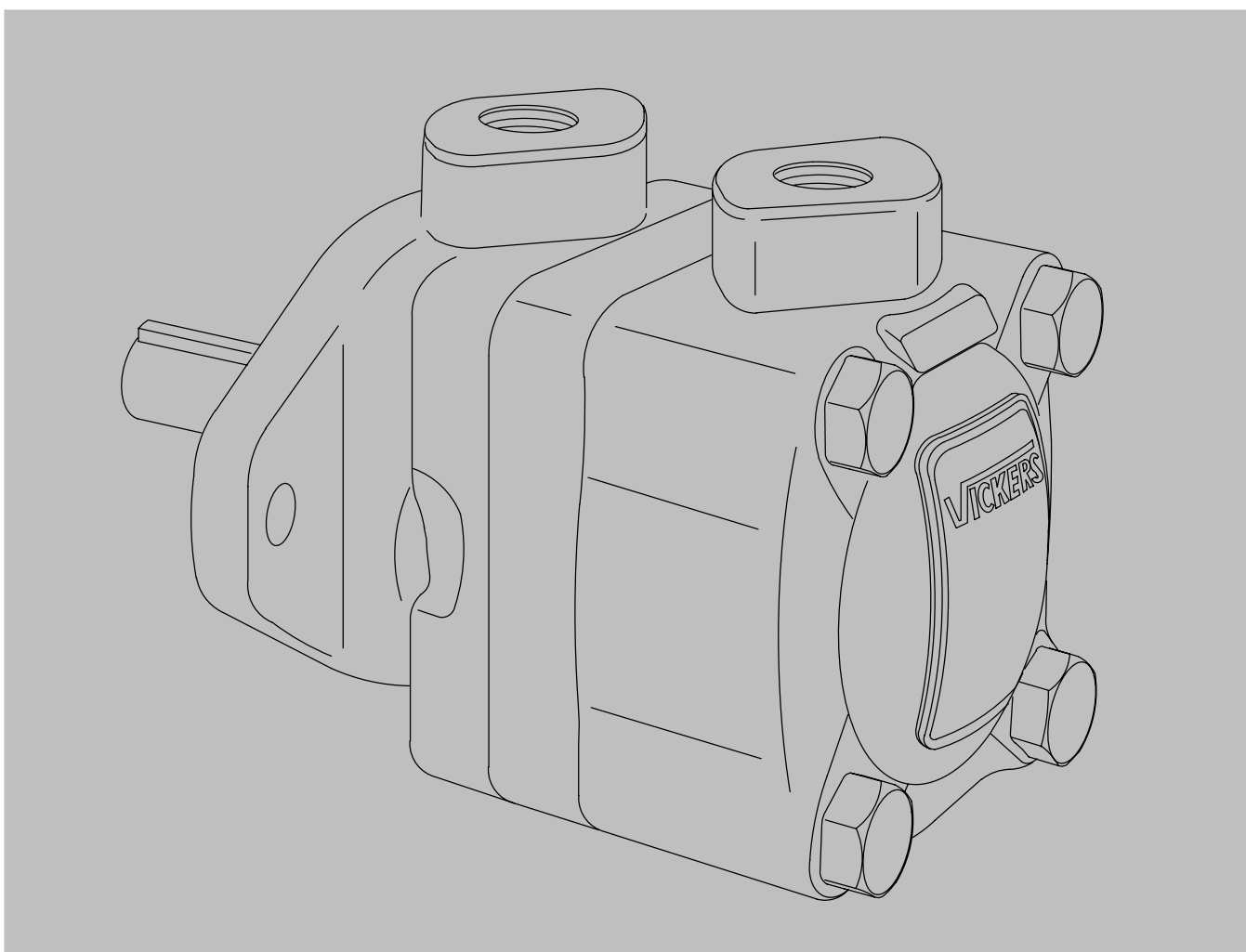




## Vane Motors

M2-200, M2-300, M2-400  
and M2-500 Series



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# Section I – Introduction

## A. Purpose of Manual

This manual has been prepared to assist the users of Vickers M2 series balanced vane type motors in properly installing, maintaining and repairing their units. The vane motors are described in detail and their theory of operation is discussed, in addition to instructions for installation, maintenance and overhaul.

## B. General Information

**Related Publications** – Service parts information and installation dimensions are not contained in this manual. The parts catalogs and installation drawings listed in Table 1 are available from Vickers sales engineers.

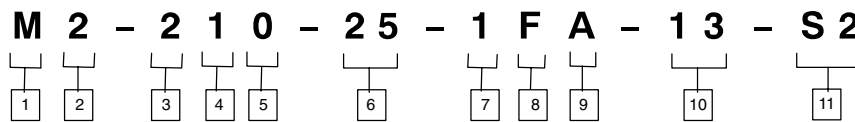
**Model Codes** – There are many variations within each basic model series, which are covered by variables in the model

code. A complete breakdown of the codes covering these units are in Table 2. Service inquiries should always include the complete unit model number as stamped on the motor cover.

Motors of the -13 design will be referred to in the discussion which follows in Sections II through VII, but information is essentially the same for the -11 and -12 designs. Section VIII describes the differences between the three designs.

Model	Parts Drawing	Installation Drawing
25M, 26M -20	M-2741-S	MB-185
35M, 36M -20	M-2742-S	
45M, 46M -20	M-2743-S	
50M, 51M -20	M-2744-S	

Table 1. Parts and Installation Drawings



**1 Vane Type Motor**

**2 Reversible**

**3 Series**

- 2 – Small
- 3 – Medium
- 4 – Large
- 5 – Extra Large

**4 Body Type**

- 1 – Standard with Threaded Connections
- 3 – Face Mounted with Threaded Connections
- 4 – Face Mounted with Flange Connections

**5 Mounting**

- 0 – None
- 4 – Foot
- 5 – Flange

**6 Torque in Inch Pounds/100 psi**

**7 Shaft**

- 1 – Straight with Square Key
- 3 – Threaded with Woodruff Key
- 6 – Straight with Woodruff Key
- 9 – Splined

**8 Flange Connections**

**9 Port Positions (See Figure 6)**

**10 Design**

**11 Special Features**

- S2 – Vane Base Feed

Table 2. Model Code Breakdown

# Section II – Description

## A. General

All motors covered in this manual are basically identical in construction. Variables in the model numbers cover different sizes, mounting and port connections. Motors are of three basic sizes: small series M2-200, intermediate series M2-300 and large series M2-400 and M2-500. Sizes are progressively rated in torque.

Motors are designed for installation in a hydraulic circuit requiring rotary mechanical power. Their operating characteristics are of the variable horsepower class in that horsepower output is in proportion to rpm so long as operating pressure is constant. These motors can be used for reversing service and can be stalled under load without damage.

Construction is such that the output capacity can be varied (within a series) to suit the particular needs of the user. This is accomplished by changing the ring and rotor sub-assembly (Section VI).

## B. Assembly and Construction

Basic motor construction is illustrated in Figure 1. The unit consists principally of a body, cover, drive cartridge, pressure plate, drive shaft and bearings. The cartridge consists of a ring, rotor, twelve vanes and twelve rocker arms. The vanes slide radially in the rotor slots to follow the cam contour of the ring. Rocker arms hold the vanes out against the ring.

The rotor is splined to the output shaft. The shaft is supported by two bearings.

The cartridge is adjoined by the pressure plate on one side and the body on the other. The pressure plate is housed in the cover and loaded against the cartridge by a spring washer (not visible in Figure 1). The cover and body each incorporate an oil port used as system connections to direct oil to and from the motor.

Locating pins position the ring with respect to the pressure plate and body. The shaft seal prevents leakage of oil out of the system at the shaft and the entry of air into the system.

## C. S2 Motors

These motors differ from standard units in that the vanes are held out against the ring by oil pressure. Pressure is fed in through a connection in the cover and through a special pressure plate. Rocker arms are not used.

## D. Mounting and Drive Connections

Units can be either face or foot mounted. The rugged two bearing construction permits the motors to be used in direct or indirect drive installations.

## E. Applications

For motor ratings and applications, consult a Vickers application engineer.

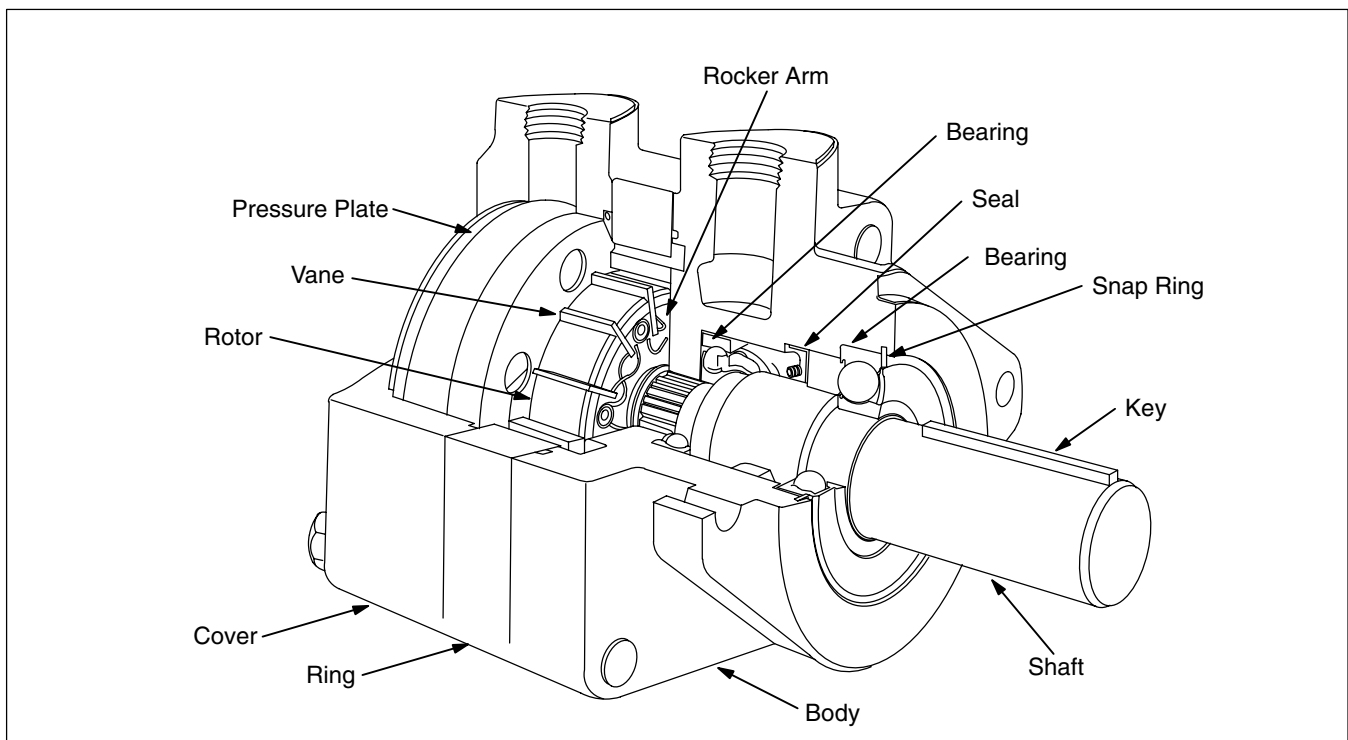


Figure 1. Cutaway View of Vane Motor

# Section III – Principles of Operation

## A. General

Rotation of the motor shaft is caused by fluid flow through the motor exerting a force against the vanes. This force is in effect tangential to the rotor and causes the rotor to turn, carrying the motor shaft with it.

If fluid is directed into the motor from the body port (see Figure 2), shaft rotation, as viewed from the head end, is counterclockwise. When the cover port is used for the inlet, rotation clockwise as viewed from the cover end. Changing the direction of fluid flow thus changes the direction of motor rotation. This is usually accomplished by the use of a suitable directional control valve. With either port open to pressure, the other port becomes the return port.

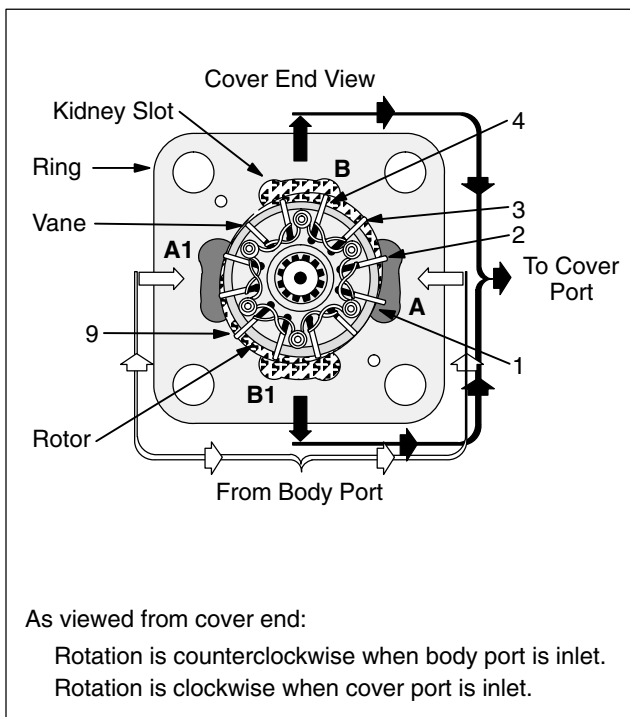


Figure 2.

## B. Cartridge Action

High pressure oil entering the body port (see Figure 3) is divided by internal coring and is directed into chambers between the vanes through kidney slots A and A1 (see Figure 2). The chambers between vane 2 and vane 3 are supplied with high pressure oil from port A. The chambers between vane 3 and vane 4 are at a lower pressure because they are open to discharge port B. Counterclockwise rotation of the rotor and vane assembly results from the difference in pressure across vane 3. This action is duplicated on vane 9.

As any two successive vanes pass the A and A1 slots, fluid between them is trapped and carried to the B and B1 slots. Here, the distance between the rotor and ring is decreasing, and the fluid flows into low pressure kidney slots and is directed through internal coring to tank.

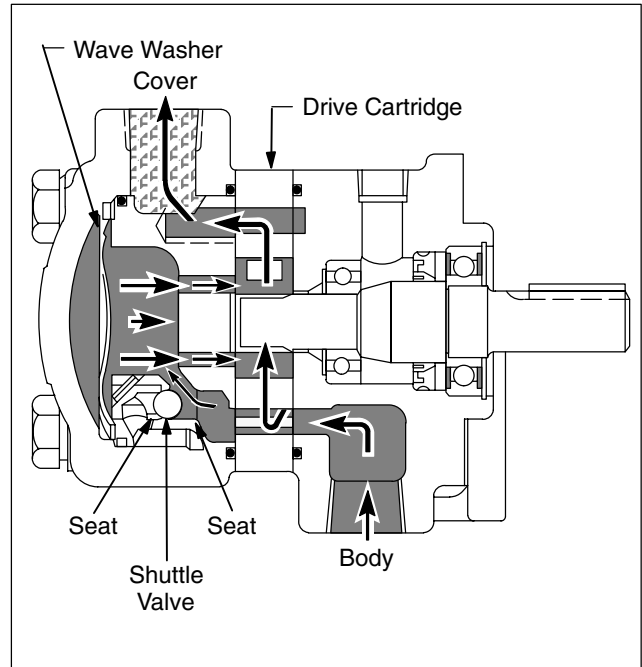


Figure 3.

It can be readily seen from Figure 2 that if the direction of flow is reversed, B and B1 will become pressure chambers and the direction of shaft rotation will be reversed.

## C. Hydraulic Balance

Regardless of whether A and A1 or B and B1 are high pressure chambers, equal pressure will always be present in any two chambers 180 degrees apart. Thus, hydraulic loads against the shaft cancel each other out and the unit is in hydraulic balance.

## D. Rocker Arms

Rocker arms (Figure 4) are required to hold the vanes outward against the ring until system pressure builds up. They also aid in keeping the vanes against the ring when the pressure is at a high level (see **E. Pressure Plate** below). These arms move about a pivot pin attached to the rotor. The ends of each arm support two vanes 90 degrees apart.

Action is such that as one vane (A) is being forced into its rotor slot by the ring, the other (B) is forced out by the rocker arm. Although the arm exerts a certain amount of spring tension against the vanes, flexing is virtually eliminated by the rocking action as the arm swivels on its pin.

## E. Pressure Plate

The pressure plate serves two purposes. It seals the cover end of the cartridge against internal leakage and it contains porting to feed system pressure to the base of the vanes to hold them out against the ring.

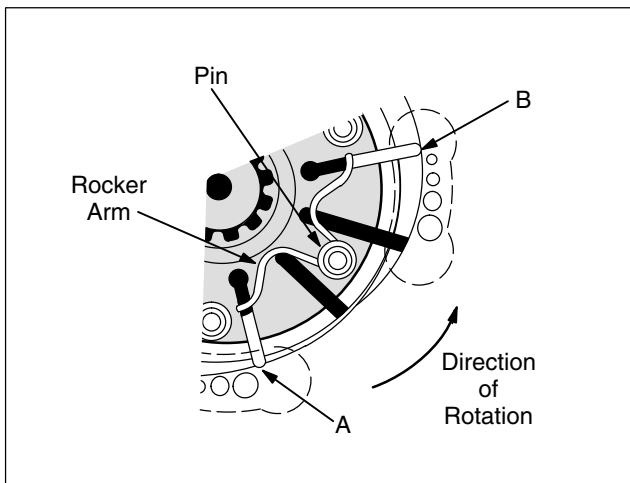


Figure 4.

Before pressure builds up, the pressure plate is held against the cartridge by a wave (spring) washer (Figure 3). As system pressure builds up, shuttle valves (1 in Figure 3) in the pressure plate permit system pressure at the inlet port to act on the cover end of the pressure plate (chamber A). This provides a force necessary to overcome the axial separating forces within the rotating group. Pressure ported by these shuttle valves is also supplied to the under side of the vanes (through passage B).

The shuttle valve seals against one or the other of the seats (depending on the direction of flow) and prevents pressure fluid from escaping to the outlet port without going through the cartridge.

## F. S2 Motors

In these motors, a pressure 30 psi higher than system pressure is continually fed to the base of the vanes and to the front of the pressure plate. This is accomplished by connecting an external pressure source to the motor cover and feeding pressure oil directly behind the pressure plate.

Rocker arms are not required, and so a pump rotor is used. The special pressure plate has porting to feed pressure under the vanes thus eliminating the need for shuttle valves (see Figure 5).

Pressure 30 psi higher than system pressure is obtained by placing a 30 psi check valve between the pump and directional valve and sampling pressure ahead of the check valve (see Figure 5).

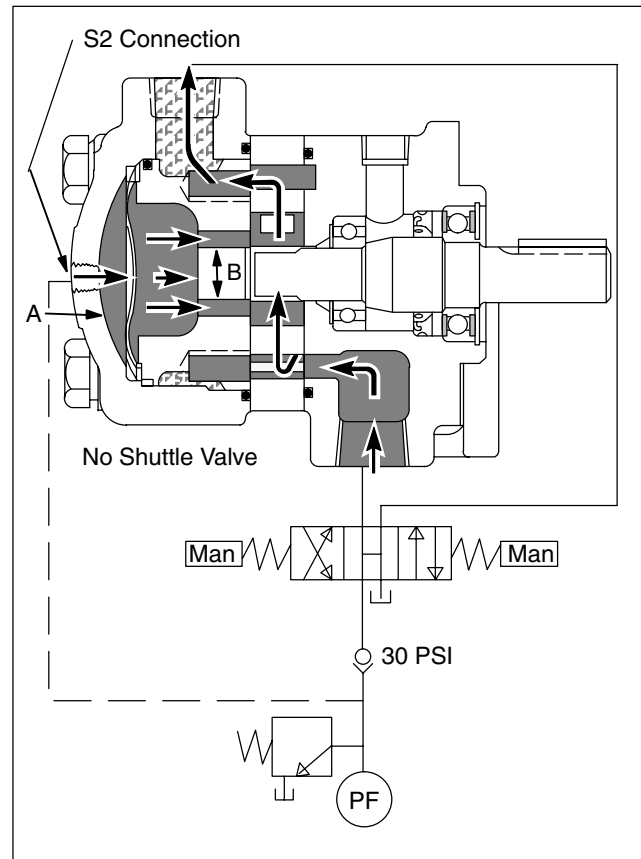


Figure 5.

# Section IV – Installation and Operating Instructions

## A. Installation Drawings

The installation drawings listed in Table 1 give correct installation dimensions and instructions.

## B. Drive Connections

1. **Direct Mounting.** Motors so connected are mechanically linked by shaft couplings to the work load. Care should be exercised in tightening all flange mounting screws to prevent misalignment of shaft connections.

If gaskets are used between mounting flanges of motors and work load, they should be installed to lay flat and the same

care should be taken in tightening the flange screws evenly. Shaft connecting devices that are specified for a particular motor, i.e., keys, collars, or tongued shafts, must be properly seated to avoid slippage and possible shearing of the shafts.

2. **Indirect Mounting.** Motors mounted indirectly to work load employ the use of pulleys and “V” belts or chain and/or spur gear arrangements. Because of slippage possibilities, it is not recommended that flat belts be used. It is important to check for correct alignment and excessive belt tension for any drive coupling arrangement employed on these motors. This is necessary to prevent excessive side loads imposed on the drive shaft bearings.

## C. Shaft Rotation

Motors can be driven in either direction of rotation without changing their construction or assembly.

## D. Hydraulic Tubing

1. All tubing must be thoroughly cleaned before installation. Recommended methods of cleaning are sandblasting, wirebrushing and pickling.

2. To minimize flow resistance and the possibility of leakage, use only as many fittings and connections as necessary for proper installation.

3. The number of bends in hydraulic lines should be kept to a minimum to prevent excessive turbulence and friction of oil flow and to minimize pressure drop in the lines. Tubing must not be bent too sharply. The recommended radius for bends is three times the inside diameter of the tube.

## E. Hydraulic Fluid Recommendations

### General Data

Oil in a hydraulic system performs the dual function of lubrication and transmission of power. It constitutes a vital factor in a hydraulic system and careful selection of it should be made with the assistance of a reputable supplier. Proper selection of oil assures satisfactory life and operation of system components with particular emphasis on hydraulic motors.

### Two Important Factors in Selecting Oil

1. **Antiwear Additives** – The oil selected must contain the necessary additives to insure high antiwear characteristics.
2. **Viscosity** – The oil selected must have proper viscosity to maintain adequate lubricating film at system operating temperature.

### Suitable Types of Oil

1. Crankcase oil meeting API service classification MS (most severe). The MS classification is the key to proper selection of crankcase oils for Mobile hydraulic systems.
2. Antiwear type hydraulic oils produced by all major oil suppliers and provide the antiwear qualities of MS crankcase oils. There is no common designation for oils of this type.
3. Certain other types of petroleum oils are suitable for Mobile hydraulic service if they meet the following provisions:
  - a. Contain the type and content of antiwear compounding found in MS crankcase oils or have passed pump tests similar to those used in developing the antiwear type hydraulic oils.
  - b. Meet the viscosity recommendations shown in Table 3. This table summarizes oil types recommended for use with Vickers equipment in Mobile hydraulic systems by viscosity and service classification.

Hydraulic System Operating Temperature Range (Min. to Max.)*	SAE Viscosity Designation	American Petroleum Institute (API) Service Classification
0°F to 180°F	10W	MS
0°F to 210°F	10W-30**	MS
50°F to 210°F	20-20W	MS

\*Ambient start up temperature

\*\*See paragraph on Viscosity Index

Table 3

c. Have sufficient chemical stability for Mobile hydraulic system service.

The following types of oil are suitable if they meet the above three provisions:

- Series 3 Diesel Engine Oil
- Automatic Transmission Fluid Types A, F and DEXRON
- Hydraulic Transmission Fluid Types C-1 and C-2

### Operating Temperature

The temperatures shown in Table 3 are cold start-up to maximum operating. Suitable start-up procedures must be followed to insure adequate lubrication during system warm-up.

### Arctic Conditions

Arctic conditions represent a specialized field where extensive use is made of heating equipment before starting. If necessary, this, and judicious use of SAE 5W or SAE 5W-20 oil in line with the viscosity guide lines shown in Table 3, may be used. Dilution of SAE 10W (MS) oil with maximum of 20% by volume of kerosene or low temperature diesel fuel is permissible.

During cold start-up, avoid high speed operation of hydraulic system components until the system is warmed up to provide adequate lubrication. Operating temperature should be closely monitored to avoid exceeding a temperature of 130°F with any of these light weight or diluted oils.

### Other Factors in Selecting an Oil

1. **Viscosity** – Viscosity is the measure of fluidity. In addition to dynamic lubricating properties, oil must have sufficient body to provide adequate sealing effect between working parts of pumps, valves, cylinders and motors, but not enough to cause pump cavitation or sluggish valve action. Optimum operating viscosity of the oil should be between 80 SSU and 180 SSU. During sustained high temperature operation, viscosity should not fall below 60 SSU.

2. **Viscosity Index** – Viscosity index reflects the way viscosity changes with temperature. The smaller the viscosity change the higher the viscosity index. The viscosity index of hydraulic system oil should not be less than 90. Multiple viscosity oils, such as SAE 10W-30, incorporate additives to improve viscosity index (polymer thickened). Oils of this type generally exhibit both temporary and permanent decrease in viscosity due to the oil shear encountered in the operating hydraulic system. Accordingly, when such oils are selected, it is desirable to use those with high shear stability to insure that viscosity remains within recommended limits.

3. **Additives** – Research has developed a number of additive agents which materially improve various characteristics of oil for hydraulic systems. These additives are selected to reduce wear, increase chemical stability, inhibit corrosion and depress the pour point. The most desirable oils for hydraulic service contain higher amounts of antiwear compounding.

### Special Requirements

Where special considerations indicate a need to depart from the recommended oils or operating conditions, see a Vickers sales representative.

### Cleanliness

Clean fluid is the best insurance for long service life. To insure your hydraulic system is clean, perform the following steps.

1. Clean (flush) entire system to remove paint, metal chips, welding shot, etc.
2. Filter each change of oil to prevent introduction of contaminants into the system.
3. Provide continuous oil filtration to remove sludge and products of wear and corrosion generated during the life of the system.
4. Provide continuous protection of system from entry of airborne contamination, by sealing the system and/or by proper filtration of the air.
5. Proper oil filling and servicing of filters, breathers, reservoirs, etc., cannot be overemphasized.

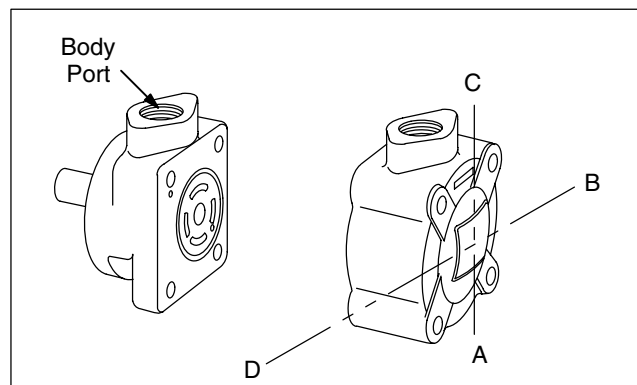
6. Good system and reservoir design will insure that aeration of the oil is kept to a minimum.

### F. Overload Protection

A relief valve must be installed in the system to limit pressure to a prescribed maximum. This protects the system components from excessive pressure. The setting of the relief valve depends on the work requirements of the system and the maximum pressure ratings of the system components.

### G. Port Positions

Covers can be assembled in four positions with respect to bodies as shown in Figure 6. To change the relative location of the ports, it is necessary only to remove the four cover bolts and rotate the cover to the desired position. Cover bolts must be tightened to the torque specified in Figure 7 at reassembly.



Model Code	Cover Port Position (viewed from cover)
A	Opposite body port
B	90° clockwise from body port
C	In line with body port
D	90° counterclockwise from body port

Figure 6.

## Section V – Service, Inspection and Maintenance

### A. Service Tools

No special tools are required to service these units.

### B. Inspection

Periodic inspection of oil condition and tubing connections can save time-consuming breakdowns and unnecessary parts replacement. The following should be checked regularly.

1. All hydraulic connections must be kept tight. A loose connection in a pressure line will permit the fluid to leak out. Loose connections in other lines can permit air to be drawn into the system, resulting in noisy and/or erratic operation.

2. Clean fluid is the best insurance for long service life. Therefore, the reservoir should be checked periodically for dirt or other contaminants. If the fluid becomes contaminated, the system should be thoroughly drained and the reservoir cleaned before new fluid is added.



## C. Adding Fluid To The System

When hydraulic fluid is added to replenish the system, it should always be poured through a fine wire screen (200 mesh or finer).

It is important that the fluid be clean and free of any substance which could cause improper operation or wear of the motor or other hydraulic units. Therefore, the use of cloth to strain the fluid should be avoided to prevent lint from getting into the system.

## D. Lubrication

Internal lubrication is provided by system oil flow.

## E. Replacement Parts

Reliable operation throughout the specified operating range is assured only if genuine Vickers parts are used. Part numbers are shown in the parts drawings listed in Table 1.

## F. Product Life

The longevity of these products is dependent upon environment, duty cycle, operating parameters and system cleanliness. Since these parameters vary from application to application, the ultimate user must determine and establish the periodic maintenance required to maximize life and detect potential component failure.

## G. Troubleshooting

Table 4 lists the common difficulties experienced with vane motors and hydraulic systems. It also indicates the probable causes and remedies for each of the troubles listed.

It should always be remembered that many apparent motor failures are actually due to the failure of other parts of the system. The cause of improper operation is best diagnosed with adequate testing equipment and a thorough understanding of the complete hydraulic system.

TROUBLE	PROBABLE CAUSE	REMEDY
Motor not developing sufficient speed or torque.	Insufficient fluid pressure.	Check delivery of motor. Make certain sufficient hydraulic fluid is available to the motor. Check motor drive speed.
	System overload relief valve set too low.	Check pressure and reset relief valve.
	Motor requiring excessive torque.	Remove motor and check torque requirements of drive shaft.
	Parts of motor cartridge scored due to excessive pressure or foreign matter in oil.	Remove motor for overhaul.
Motor shaft continuing to rotate when control is in 'OFF' position.	Control valve is not functioning properly.	Check control valve for correct spool and leakage.
Motor turning in wrong direction.	Improper port connections at valve plate.	Reverse port connections.
	Components in system not functioning as intended.	Check complete system for proper operation.

Table 5. Troubleshooting Chart.

# Section VI – Overhaul

## A. General

Plug all removed units and cap all lines to prevent the entry of dirt into the system during shutdown. During disassembly, pay particular attention to identification of the parts for correct assembly.

Figure 7 is an exploded view which shows the proper relationship of the parts for disassembly and assembly. Figure 1 can be referred to for the correct assembled relationship.

## B. Disassembly

Be certain the unit is not subjected to pressure. Disconnect and cap all lines before removing the motor from its

mounting. Remove the flanges, screws and o-rings from M2-500 series motors.

1. **Cover End.** Place the motor on blocks cover end up. Remove the four cover screws and washers and lift off the cover.

Remove the o-ring from the groove in the cover. Remove the pressure plate and wave washer from the cover and remove the o-ring from the pressure plate. *Do not* disassemble the shuttle valves unless it is necessary to replace them because of leakage.

Lift off the ring and locating pins. Remove the vanes and rotor sub-assembly.

---

2. **Shaft End.** Remove the shaft key and foot mounting (if used). Remove the snap ring from the body and tap the cover end of the shaft to force out the shaft and front bearing. If it is necessary to remove the bearing from the shaft, support the inner race in an arbor press while pressing the shaft out.

Remove the oil seal and tap out the inner bearing by inserting a punch in the cover end of the body.

## C. Inspection and Repair

1. Discard the used oil seal and o-rings. Clean all parts in mineral oil solvent and place them on a clean surface for inspection.

2. Check for wearing surfaces of the body, pressure plate, ring and rotor for scoring and excessive wear. Remove light scoring by lapping. Replace any scored or worn parts.

3. Inspect the vanes for burrs, wear and excessive play in the rotor slots. Check that vanes do not stick in the rotor slots. They should move from their own weight when both rotor and vanes are dry. Replace any defective vanes.

4. Rotate the bearing on the shaft while applying pressure to check for wear, looseness, roughness and pitted or cracked races.

5. Inspect the oil seal journal on the shaft for scoring or wear. Replace the shaft if marks cannot be removed by light lapping.

6. Inspect vane rocker arms for wear and loss of tension. Replace the rotor sub-assembly if rocker arms are defective.

## D. Reassembly

Coat all parts with clean hydraulic oil to facilitate reassembly and provide initial lubrication.

1. **Shaft End.** Place the body on a block, shaft end up. With a driver which contacts the outer race only, seat the inner bearing in the body.

Press the shaft seal into the body with the sealing lip facing the cover end. Use a driver which will apply force only near the seal periphery. Be certain the seal is firmly in place and is not cocked.

Press the outer bearing onto the shaft while supporting the inner race. Cover the shaft splines with tape or a bullet and install the shaft. The outer bearing must seal firmly in the body. Install the snap ring which retains the shaft and bearing. If a mounting bracket is used, it can be installed now. Tighten the screws evenly to prevent cocking. Install the shaft key.

3. **Cover End.** Place the unit on blocks, shaft end down. Install the o-ring in the groove in the body. Insert both locating pins in the body face. Place the ring on a clean smooth surface and insert the rotor inside the ring. Insert the vanes into the rotor slots, being sure the rocker arm is properly located behind each individual vane on both sides of the rotor. The ring, rotor and vanes are now installed on the locating pins.

### NOTE

On -13 design models, pin location makes it impossible to assemble the ring incorrectly.

When installing the vanes, be certain they rest squarely in the slots and not on the rocker arms. Check this by turning the shaft by hand and noting whether any vane extends beyond the side of the rotor.

Position the pressure plate on the locating pins and install the pressure plate o-ring and the wave washer. Install the o-ring in the cover and carefully place the cover over the plate and wave washer against the ring. Be sure the washer and o-ring are not dislocated. slowly rotate the cover to its correct position with relation to the body (see Figure 6). Install the cover screws and washers and tighten them to the torque shown in Figure 7. Turn the shaft by hand to be certain there is no binding.

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## Section VII – Testing

Vickers Mobile application engineering personnel should be consulted for test stand circuit requirements and construction. If test equipment is available, the motor should be tested at recommended speeds and pressures shown on installation drawings (see Table 1).

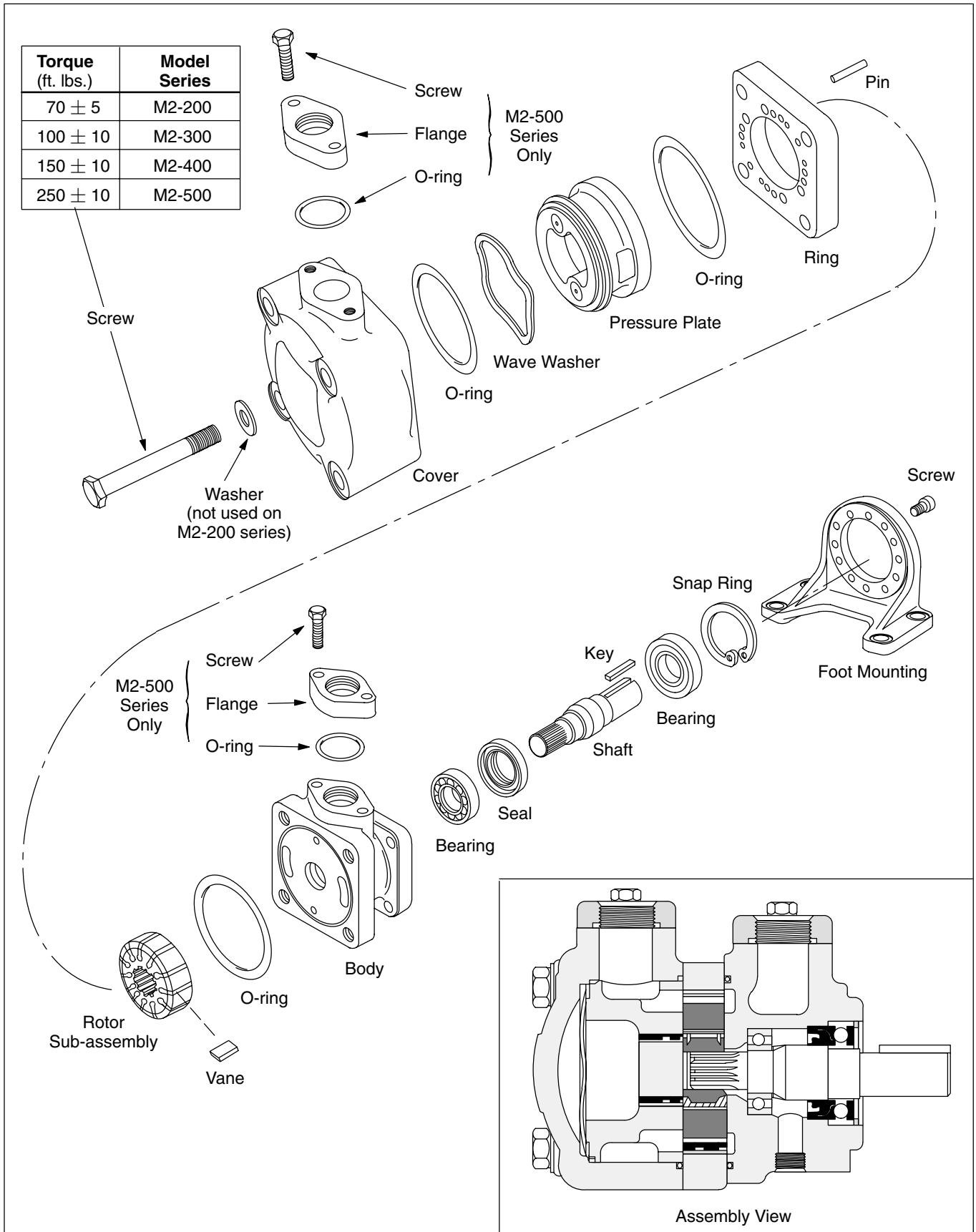


Figure 7.

# Section VIII – Design Changes

## A. Change from -11 to -12 Design

Changes between the -11 and -12 designs were made to improve pressure distribution (hydraulic balance) in the motor, strengthen the pressure plate and rocker arms, permit reversal of the motor without reversing the ring and improve retention of the rocker arms. Parts involved in the change were the pressure plate sub-assembly, rotor sub-assembly and ring and, in some cases, the body and cover (see Table 5).

Parts are interchangeable between the -11 and -12 design. Customers who wish to incorporate the improved parts in -11 design motors can do so without concern.

## B. Change from -12 to -13 Design

This change increased the size of flow passages and added eight overpass holes in the ring (see Figure 8). Also, the ring locating pins were moved 45 degrees. This makes it impossible to assemble the ring incorrectly.

Parts involved in the change are listed in Table 5. Pressure plates, rings and bodies are not interchangeable (except as a group) because of the pin location. All other parts are interchangeable.

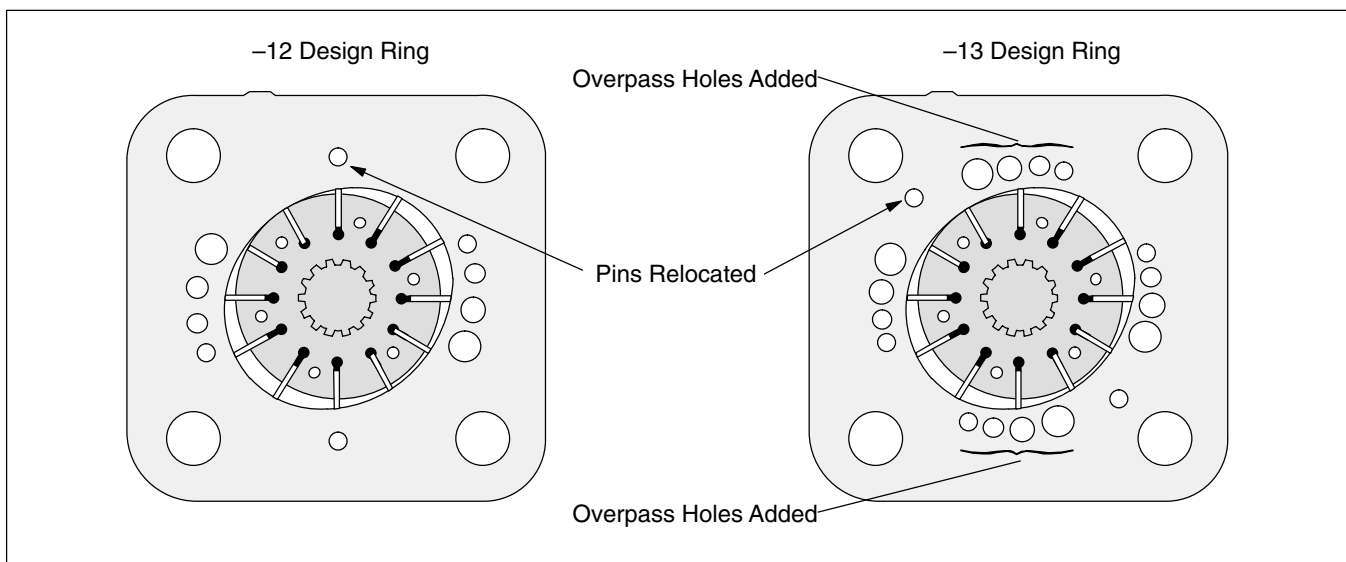


Figure 8. Change from -12 to -13 Design.

Series	Nomenclature	Design			Series	Nomenclature	Design		
		-11	-12	-13			-11	-12	-13
M2-200	Cover	137569	153998	153998	M2-400	Cover	138110	138110	138110
	Press plate sub-assy.	137570	153570	168450		Press plate sub-assy.	138108	153778	172467
	Ring 25	137576	153766	168419		Ring 90	128553	153775	172469
	Ring 35	160795	153765	168418		Ring 115	126507	153776	172470
	Rotor sub-assy. 25	137573	168439	168439		Rotor 90	170404	170404	170404
	Rotor sub-assy. 35	137573	168440	168440		Rotor 115	170403	170403	170403
	Body	127225	153698	168417		Body	138111	153760	172465
M2-300	Cover	137696	137696	137696	M2-500	Cover	137281	137281	137281
	Press plate sub-assy.	137690	153767	172412		Press plate	137420	153783	168601
	Ring 45	126023	153774	172410		Ring 150	115768	153784	168596
	Ring 60	126024	153773	172409		Ring 200	152381	153785	168597
	Ring 75	126025	153772	172411		Rotor 150	137325	168598	168598
	Rotor sub-assy. 45	137689	170402	170402		Rotor 200	137325	168599	168599
	Rotor sub-assy. 60	137689	170405	170405		Body	126676	153790	168595
	Rotor sub-assy. 75	137689	170405	170405		Pin	39780	39780	187259
	Body	137693	153761	172407					

Table 5. Conversion Data

**Eaton Hydraulics**

15151 Highway 5  
Eden Prairie, MN 55344  
Telephone: 612 937-7254  
Fax: 612 937-7130  
[www.eatonhydraulics.com](http://www.eatonhydraulics.com)

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