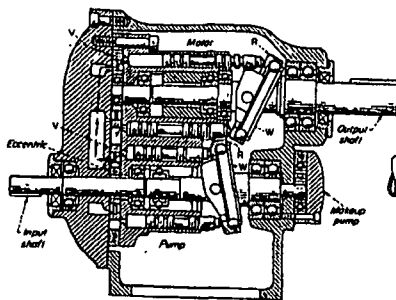
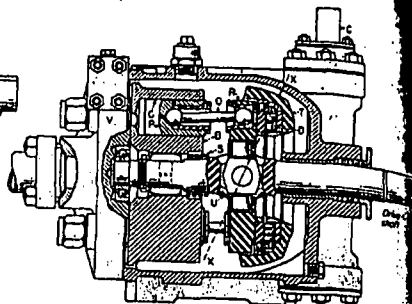
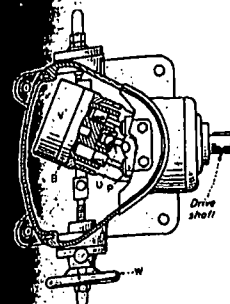




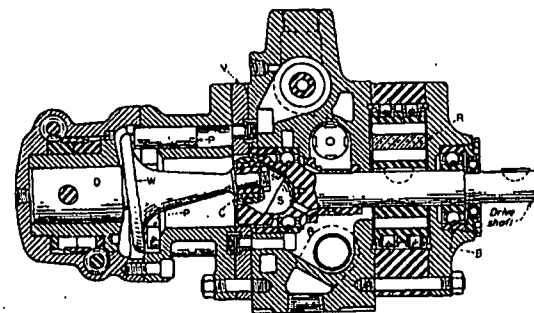
1 Displacement of pump and hydraulic motor of this variable-speed drive is changed by adjusting the wobbler plate W



2 Parallel-piston variable-displacement pump in which cylinder barrel with its pistons rotates with drive shaft



3 In this pump the cylinder barrel with its pistons swings at an angle to the drive shaft to adjust discharge rate



4 Variable-displacement wobbler-plate pump in which the wobbler plate marked W does not rotate with the drive shaft

Variable-Displacement Pumps Control Fluid Delivery to Meet Load Needs

Here's how to apply variable-delivery pumps to those jobs where fluid flow must be held within close limits. Read on—these solid facts will be a big help to you

By F A ANNETT, Contributing Editor

Discharge of centrifugal pumps can be adjusted by throttling, if they run at constant speed, but output of constant-delivery pumps cannot be throttled. If their discharge has to be adjusted, pump must provide some means for doing this. About every type of constant-delivery pump has been developed in variable-displacement designs. These include rotary-piston, plunger, rotary, diaphragm and pulsating types.

Rotary-piston pumps are made in several designs for variable-displacement service. They are used as part of variable-speed power transmissions for starters, paper machines, machine tools, and many other units, and to supply pressure fluid to hydraulic cylinders in presses, ship-steering gears, steel-lance chargers, bulldozers and other applications. These pumps are of two general designs: parallel-piston and radial-piston.

Parallel-Piston Types. Fig. 1 is a cross-section of a hydraulic variable-speed transmission and torque converter. It has a variable-displacement multipiston pump, which delivers oil to a variable-displacement fluid motor of the

same design. The piston barrels do not rotate, nor are the pistons connected to wobbler plates *W*. Free ends of the pistons are spherical and ride against ring *R* that rests against a ball-thrust bearing on the wobbler plate.

A small makeup pump, driven by the input shaft, supplies oil from a reservoir for charging pump's pistons to hold them on their return stroke against wobbler-plate face. It also supplies oil lost by piston leakage or slippage in the closed circuit between pump and motor. Oil not required to replace the leakage is bypassed through a relief valve and used to lubricate the wobbler and bearings of pump and motor.

Eccentric on pump and motor shafts actuates circular valves *V* to control oil flow from pump to motor. These valves do not rotate but are given a gyrating motion as the shafts turn, to open and close ports leading to pump and motor cylinders.

How It Works. In Fig. 1 the pump's bottom piston has completed its suction stroke, and the top one its discharge stroke. The path of this discharge is indicated by arrows to the top piston, which has completed its driving stroke.

When the pump wobbler plate makes one-half revolution its top piston will have completed its suction stroke and the bottom piston its discharge stroke. During this period, if pump and motor wobblers have the same angle, the motor shaft makes half a revolution. In doing this the motor's top piston moves to full discharge and its bottom piston to full driving position.

If pump's wobbler is set at an angle to give its piston one-half the stroke length of the motor, the motor shaft rotates at one-half pump speed, but output torque is double input torque. But if pump's wobbler is set for full stroke and that of motor for half stroke, motor speed will be double pump speed, and motor will develop one-half the torque of the pump. Hydraulic-control mechanism regulates angle of wobbler plates.

Tilting Plate. In the pump, Fig. 2, the cylinder barrel with its pistons rotates with drive shaft. It consists of a tilting-box *T* in which socket ring *R* revolves. Box *T* is held stationary by a connection to control worm *C*. Socket ring *R* connects to input shaft through a universal joint *U* and rests on roller thrust bearing *B* in tilting box *T*, so which it revolves.

Socket ring has seven or nine bronze sockets for an equal number of piston-connecting rods *O* with spherical ends. Pistons *P* and cylinders *C* are ground to a good fit, which keeps leakage low without use of piston rings.

Spiral spring *S*, between cylinder barrel *B* and a collar on input shaft, holds

barrel against valve plate *V* when they are not under pressure. When pump is running, the barrel is held against valve plate by pressure resulting from the difference in the valve-plate and cylinder-port areas. Two semicircular ports in valve plate connect to suction and discharge ports in the cylinder-barrel face. Each valve-plate port extends about 120 deg on the cylinder side. Barrel *B* has as many equally spaced semicircular ports as it has cylinders. As barrel revolves with input shaft, its ports pass in succession over the valve-plate ports. One of these acts as a suction and the other as a discharge port for the pump cylinders.

Piston Discharge. Tilting Box *T* and socket ring *R* are in the vertical (neutral) position in Fig. 2. If input shaft turns socket ring *R*, cylinder barrel *B* turns with it, but the pistons have no motion in their cylinders. Turning control *C* until socket ring *R* takes position *XX* pulls the top pistons farther out of the cylinders and pushes bottom ones in.

With socket plate tilted to *XX* when socket ring and cylinder barrel turn half a revolution, pistons that were on top will be at the bottom and those at the bottom will be on top. During this change, pistons that were on top are pushed in as they move to the bottom. Those at the bottom are pulled out as they move to the top. So by rotating the socket plate and cylinder barrel, when the former is tilted, the pistons are moved in and out of the cylinders to produce a pumping action.

Assume you are looking at the drive shaft end of the unit when shaft turns clockwise. As cylinder barrel and socket ring turn, pistons and cylinders move up on the left and down on the right. This causes the left-hand pistons to pull out of their cylinders and draw fluid into them from valve plate. On the right, the pistons move into the cylinders and force fluid out through valve-plate port into the discharge.

Socket-Ring Adjustment. Amount of pump-piston motion and quantity of fluid pumped depends on socket-plate angle. When socket plate is at an angle of 20 deg with the vertical, pump output is maximum. As socket plate is moved toward the vertical or neutral position, pump discharge decreases, until it becomes zero. By adjusting position of socket-ring *R*, pump discharge can be varied from maximum to zero in infinite changes. Fluid motor similar to pump can be combined with it to form variable-speed transmission, Fig. 1.

High Speed. Pump in Fig. 3 operates similarly to the unit in Fig. 2, but instead of having a tilting plate its socket-ring cylinder block *B* with its pistons, swings at an angle with the drive shaft and piston connecting-rod socket plate *P*. Until pump is running, a spring holds the cylinder-block ported face against valve-plate *V* in which it is supported by a stub shaft in a bearing. Socket-plate *P* is part of drive shaft *S* and is supported in two radial roller bearings and a ball-thrust bearing.

A floating universal-joint shaft *U*

connects the cylinder block with the drive shaft and socket-plate flange so they all revolve at drive-shaft speed. Valve plate *V*, against which cylinder-block *B* rides, is fixed in pump yoke, not shown. Two semicircular ports in valve plate mate with passages in pump yoke, which conducts fluid to swivel connections that serve as yoke pinlets.

With the cylinder barrel at an angle with drive shaft as shown, the top piston is in full-discharge position and the bottom one on suction. When pump makes half a revolution, bottom piston will be at the top on full discharge and top piston at bottom on suction. Each piston thus functions to create suction during one-half revolution to fill the cylinders with fluid. This is followed by a pressure stroke.

Zero Discharge. If cylinder barrel and valve plate are swung to where face is parallel with the socket flange on drive shaft, the assembly revolves without causing any piston motion. Discharge is zero. Length of piston stroke then depends on angle formed between cylinder block and drive-shaft axis. An infinite range of fluid delivery up to maximum rated capacity can be had by varying angular position of cylinder barrel relative to drive-shaft axis.

Control of pump discharge can be manual by using handwheel *W*, as in Fig. 3, or by mechanical, hydraulic or electric means. Reverse pumping action is obtained by swinging the cylinder block to the other side of the center

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