PRODUCTIVITY SERIES HYDRAULICS

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TORO®

PRODUCTIVITY SERIES

HYDRAULICS

SAFETY INFORMATION

This symbol means WARNING or PERSONAL SAFETY INSTRUCTION - read the instruction because it has to do with your safety. Failure to comply with the instruction may result in personal injury or even death.

Aways read and follow the safety instructions provided in the applicable service manual or operators manual for the equipment you are working on. Service Manuals and Operator's Manuals are available through your local Toro distributor or by writing to:

The Toro Company
Publications Department
8111 Lydale Avanue South
Bloomington, MN 55420

Avoid injury from high pressure oil...

Keep body and hands away from pin hole leaks or nozzles that eject high pressure oil. Use cardboard or paper to locate hydraulic leaks. Oil escaping under high pressure can penetrate the skin and cause injury. Oil accidentally injected into the skin must be surgically removed within a few hours by a doctor familiar with this form of injury or gangrene may result.

Avoid unexpected starting of engine...

Always turn off the engine and disconnect the spark plug wire(s) before cleaning, adjusting or repairing.

Avoid lacerations and amputations...

Stay clear of all moving parts whenever the engine is running. Treat all normally moving parts as if they were moving whenever the engine is running or has the potential to start.

Avoid burns...

Do not touch the engine, muffler, or other components which may increase in temperature during operation, while the unit is running or shortly after it has been running.

Avoid fires and explosions...

Avoid spilling fuel and never smoke while working with any type of fuel or lubricant. Wipe up any spilled fuel or oil immediately. Never remove the fuel cap or add fuel when the engine is running. Always use approved, labeled containers for storing or transporting fuel and lubricants.

Avoid Asphyxiation...

Never operate an engine in a confined area without proper ventilation.

Avoid injury from batteries...

Battery acid is poisonous and can cause burns. Avoid contact with skin, eyes and clothing. Battery gases can explode. Keep cigarettes, sparks and flames away from the battery.

Avoid injury due to inferior parts...

Use only original equipment parts to ensure that important safety criteria are met.

Avoid injury to bystanders...

Always clear the area of bystanders before starting or testing powered equipment.

Avoid injury due to projectiles...

Always clear the area of sticks, rocks or any other debris that could be picked up and thrown by the powered equipment.

Avoid modifications...

Never alter or modify any part unless it is a factory approved procedure.

Avoid unsafe operation...

Always test the safety interlock system after making adjustments or repairs on the machine. Refer to the electrical chapter later in this manual for more information.

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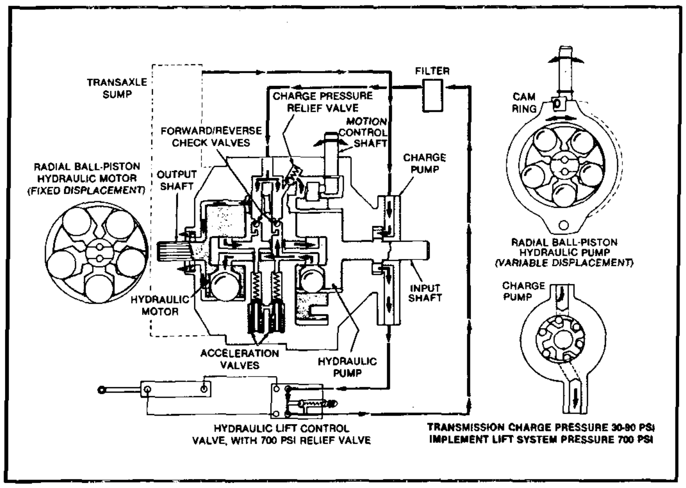
What's In This Book?

This publication is designed to familiarize the reader with basic hydraulics. It starts by defining common terms and components used with hydraulics. The components are then put together to show how they function in a hydraulic circuit.

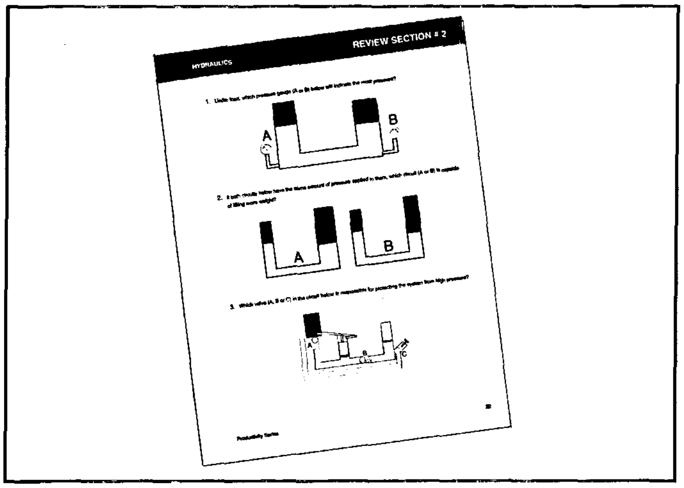
Once you are familiar with the basics, the book will review some of the systems that are used on TORO® equipment. A section on problem solving covers what to do when you encounter a problem. Test equipment is also reviewed to ensure you can properly diagnose and repair hydraulic systems.



For detailed service information on a specific unit, please refer to the appropriate service and repair manual.

This publication uses a building block approach. It is necessary to understand the information in the front of the book to better understand information presented later. Review sections throughout the book include questions which involve the key concepts presented. If some questions are difficult to answer, review the information again before proceeding.

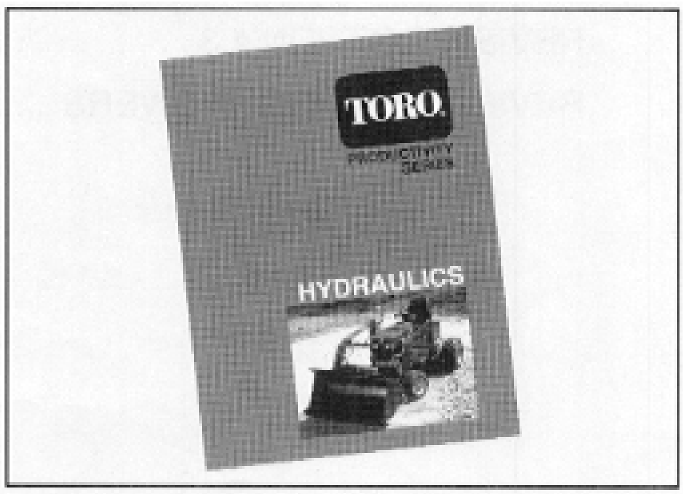
Answers to the review questions are provided near the end of the book.



Why Should I Read This Book?

Hydraulics make up an important and expensive part of many of our products. Mis-diagnosing a problem causes frustration for you and your customer, not to mention unnecessary repair bills.

Understanding the basic principles of hydraulics and the components used in these systems will improve your ability to properly diagnose and repair hydraulic systems. The information presented in this book will give you the basic fundamentals needed to become an expert in hydraulics.



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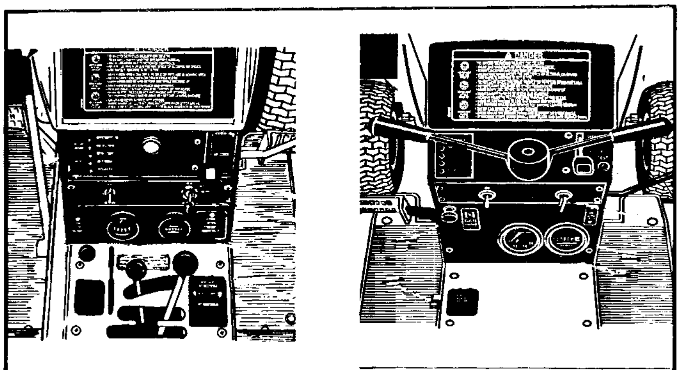
The Basic Principle of Hydraulics

Hydraulics refer to the use of liquids to transmit energy. In hydrostatic systems, mechanical energy from an external source is converted into hydraulic pressure. The pressure is then transferred through a circuit and re-converted into mechanical energy.

In our products, the mechanical energy is supplied by an engine and the liquid used to transfer energy is oil.



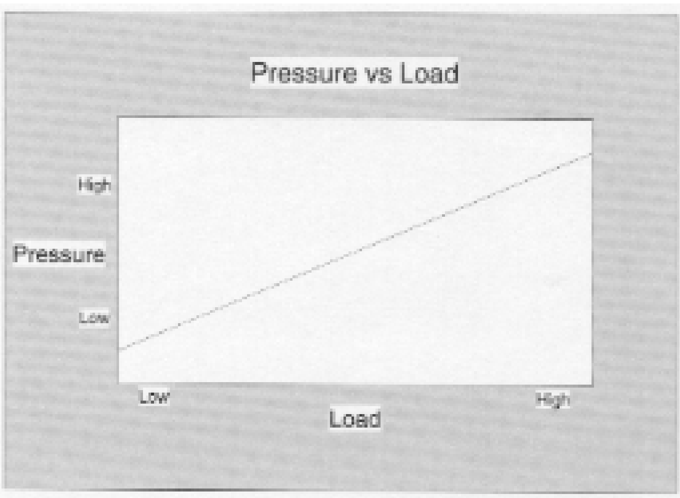
Gear Drive

Hydrostatic Drive

Benefits of Hydraulics

Let's look at some of the benefits of using hydraulics to transmit power as compared to a mechanical system.

- Hydrostatic transmissions provide for infinite variation of output speed. A mechanical transmission is limited by the number of gear ratios it has.
- Hydraulic hoses or lines can be routed around corners. A mechanical system would require a complex belt, chain or gear system to accomplish this.



- The same fluid that transfers the energy also provides lubrication for moving parts. There is a greater need for lubrication between moving parts under heavy load. With hydraulics, as the load increases, so does the operating pressure. This automatically provides maximum lubrication during periods of higher loads.

How We Use Hydraulics

Applications for hydraulics are diverse throughout industry. With lawn and garden equipment, the main uses are to:

1. Propel the unit
2. Lift implements attached to the unit

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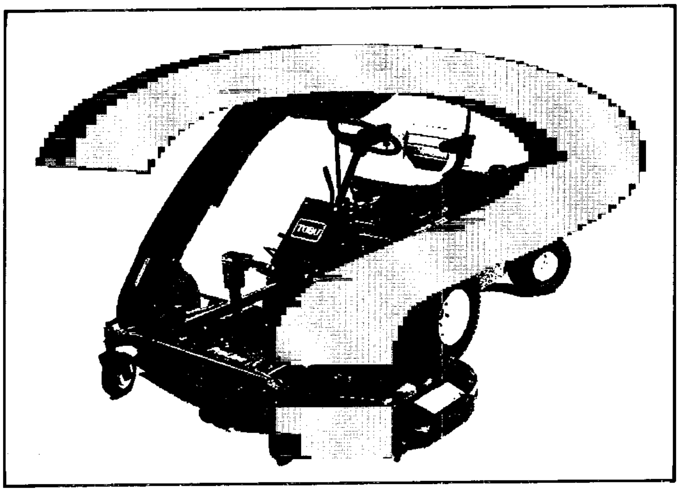
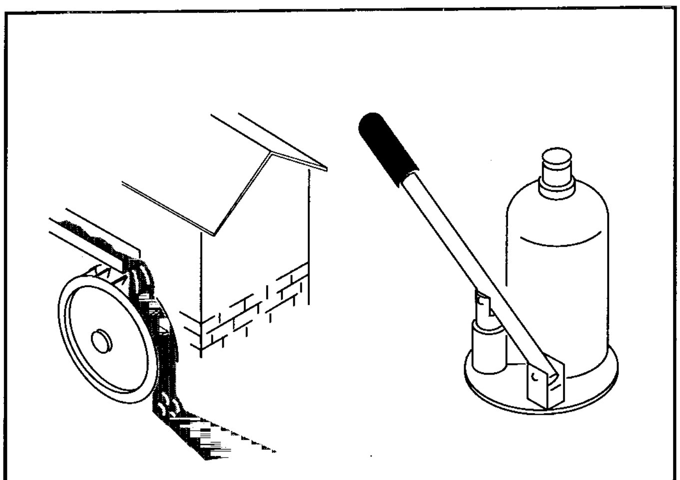


The first step in becoming comfortable with hydraulics is to learn the language. This section provides descriptions and examples of common hydraulic terms and components.

We will first define some of the common terms used when working with hydraulics. Then we will describe the components which are included in many of the hydraulic systems you encounter.

The review section at the end of the chapter will test your knowledge of the terms and components.

HYDRAULIC TERMS



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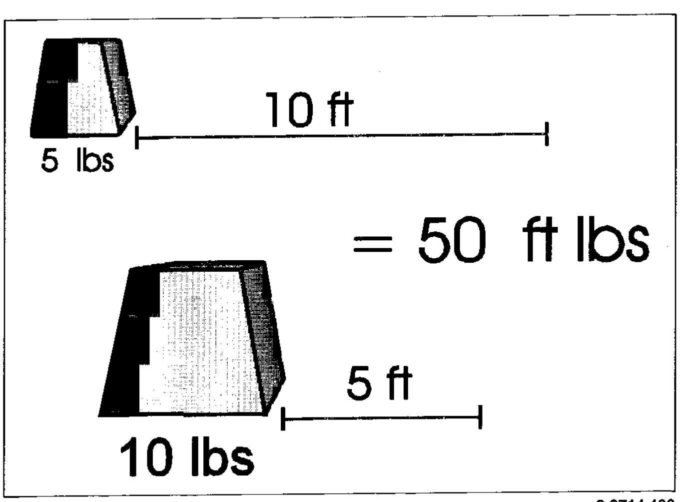
Hydraulics / Hydrodynamics / Hydrostatics

Hydraulics refer to applications of liquids in motion. In all of our uses, liquids refer to oil.

Hydrodynamics refer to hydraulic systems which primarily use fluid flow to transfer energy. This includes applications such as a water wheel or a torque converter.

Hydrostatics refer to hydraulic systems which primarily use fluid pressure to transfer energy. This includes applications such as a hydraulic lift system or fluid powered transmission.

All of our applications involve hydrostatics.



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Work

Work is the application of a force through a distance. For any work to be accomplished, movement is needed. Work is typically measured in foot pounds (ft lbs).

Work = Force X Distance

Example: The same amount of work is done if a 5 pound object is moved 10 feet or if a 10 pound object is moved 5 feet.

HYDRAULIC TERMS (cont'd)

Power

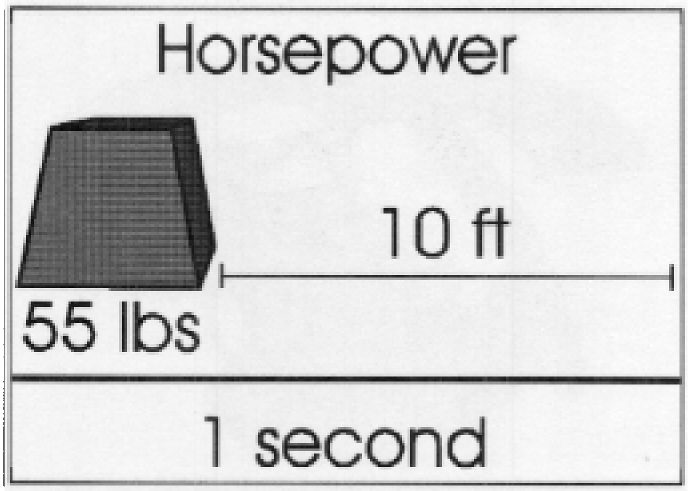
Power is the rate at which work is done or energy is transferred. Power is measured in foot pounds per second (ft lbs/sec).

Power = Work / Time

One horsepower is equal to 550 ft lbs/sec. Moving 55 pounds 10 feet in one second takes one horsepower.

In hydraulics, to transmit power two factors must be present; pressure and flow.

Power = Pressure X Flow



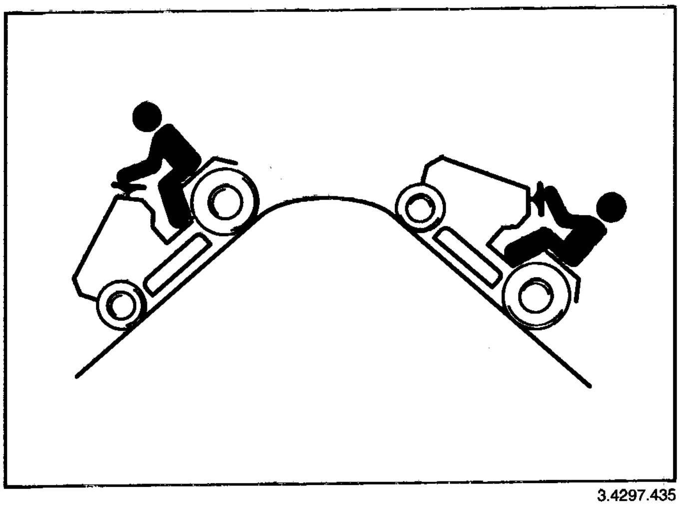
Pressure

Pressure provides the potential to transmit energy. It is determined by the force across an area. Pressure is measured in pounds per square inch (psi).

Pressure = Force / Area

Ten pounds of force acting on one square inch provides 10 psi of pressure.

Increasing the load on a hydraulic system will increase the operating pressure of the system. In a hydrostatic transmission, higher pressures will be generated going uphill as compared to going downhill.



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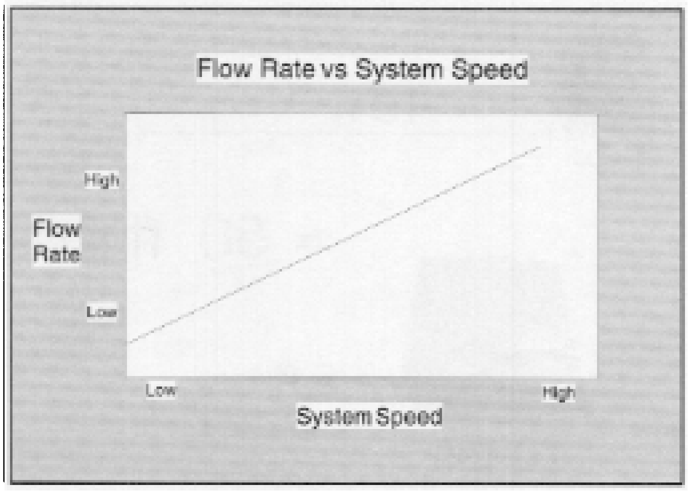
Flow

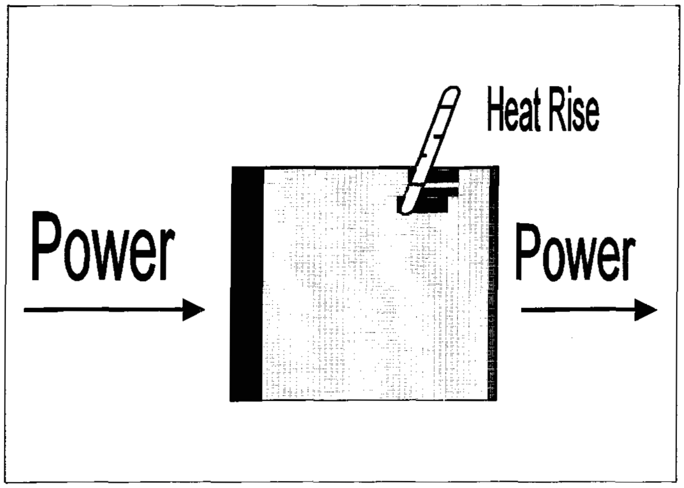
Flow measures the transfer rate (velocity) of a liquid passing through a given cross-sectional area. Flow is measured in gallons per minute (gpm).

Flow = Area X Velocity

Flow = Volume / Time

The flow rate of a hydraulic system determines the speed at which the system operates.





Efficiency

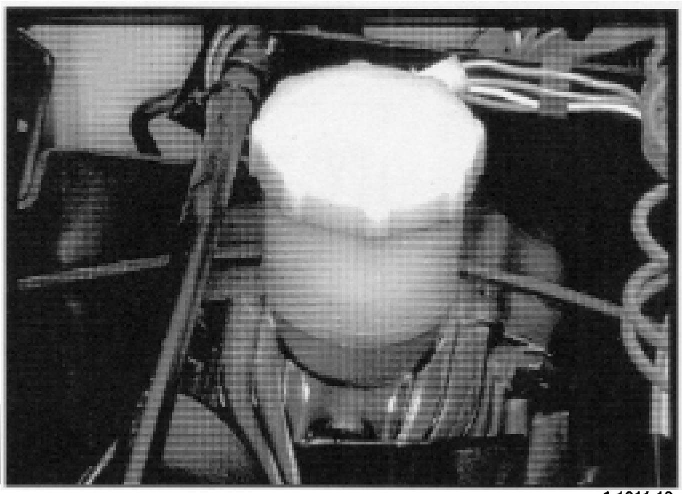
Efficiency describes the amount of power output from the hydraulic system as compared to the amount of power put into it.

Most hydraulic pumps and motors operate between 80% to 90% efficiency. The loss of power is made up by leakage and fluid friction. This friction causes a heat rise in the system.

As a pump or motor wears internally, it becomes less efficient and the operating temperature increases.

Power In = Power Out + Heat Rise

HYDRAULIC COMPONENTS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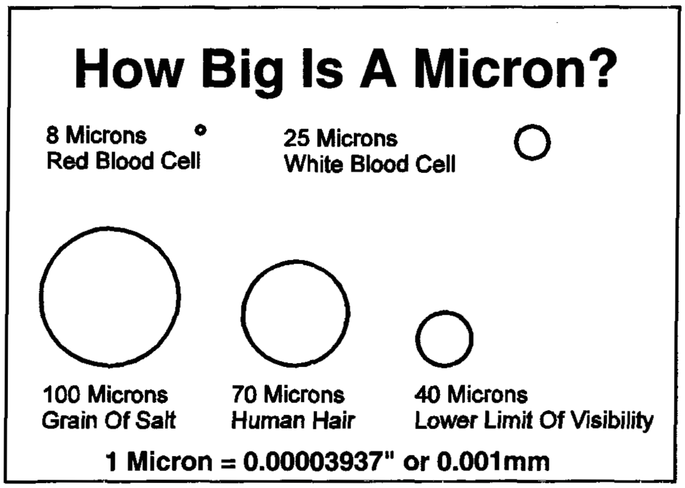
Reservoir

The reservoir is a simple, yet very important component of any hydraulic system. It serves as an expansion chamber, and separates trapped air from the fluid.

Some systems use the gear case as a reservoir. This allows dirt and metal filings to settle out of the fluid. This type of reservoir allows for more fluid capacity which in turn assists in keeping the system properly cooled.

Reservoirs are generally vented and should prevent dirt or water from entering the system.



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Filter

Hydraulic filters are special purpose filters which are able to entrap extremely small particles of dirt. A typical hydraulic filter will trap particles as small as 25 microns or less. Most engine oil filters only trap particles larger than 70 microns.

Hydraulic filters <u>do not</u> have a bypass valve like an engine oil filter. When a hydraulic filter becomes clogged, oil flow is reduced and erratic operation will be evident.

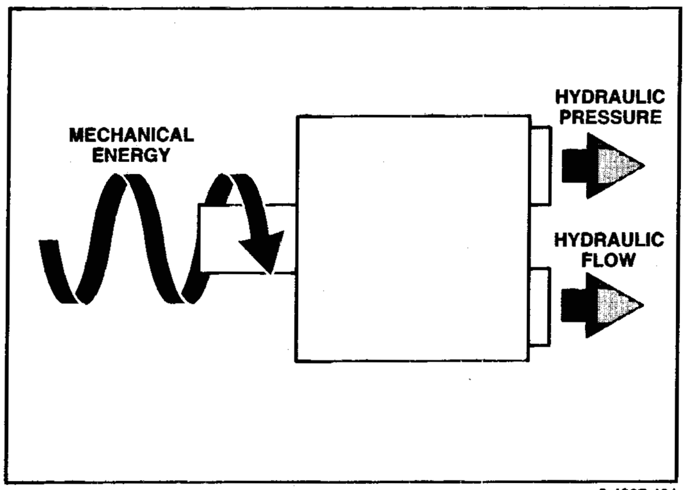
HYDRAULIC COMPONENTS (cont'd)

Pump - Function

A pump is a device that transfers fluids by either suction, pressure or both. A pump converts mechanical energy into hydraulic pressure and flow. Pumps can either be fixed or variable displacement.

A **fixed (constant) displacement pump** transfers a set amount of fluid during each revolution. To change the output, the speed at which the pump operates must be changed.

A **variable displacement pump** can change its output per revolution.



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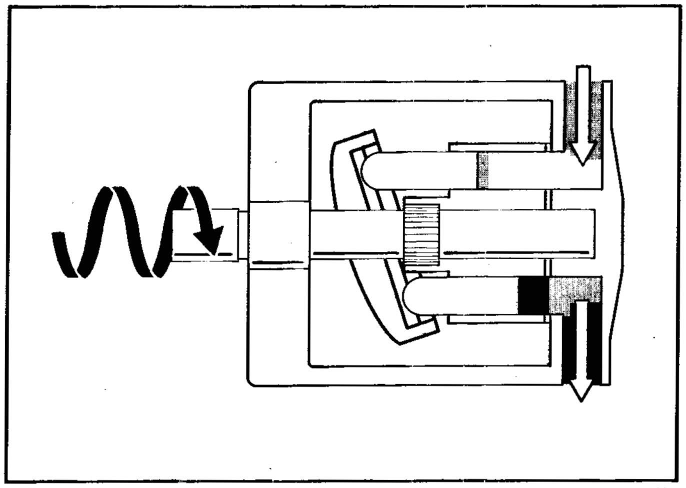
Pumps - By Type

Axial Piston design pumps use a set of pistons rotating in a cylinder block. The cylinder block is rotated by the input shaft. The end of the pistons contact a swashplate. The swashplate may be a fixed angle (constant displacement) or adjustable to a range of angles (variable displacement).

As the cylinder block rotates, the piston (either pulled by the swashplate or pushed by spring pressure) extends out of the cylinder block and draws oil into the chamber. On the opposite side, the swashplate forces the piston in, displacing oil from the base of the cylinder block.



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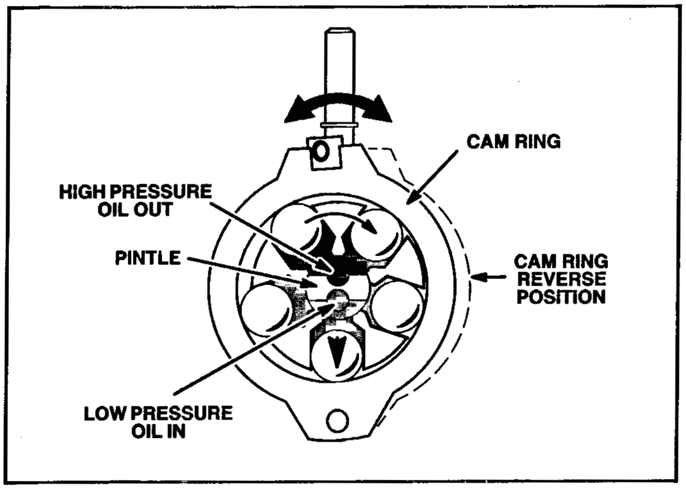
Radial-Ball Piston pumps use several balls which travel through bores inside a rotor. As the rotor is turned by the input shaft, centrifugal force throws the balls out against a cam ring. Oil from a passage in the pintle flows into the chamber behind the ball.

With the cam ring offset, the ball is pushed back into the bore as it rotates past the narrow side. This forces oil back into a second passage in the pintle.

The cam ring offset can be either fixed to provide a constant output, or adjustable to provide variable output.



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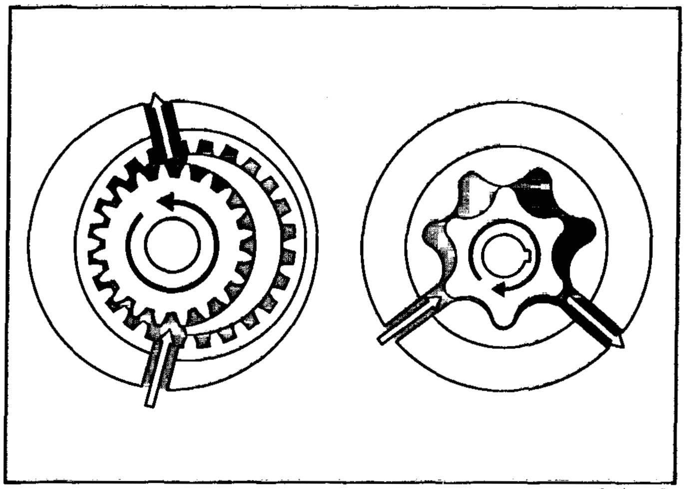

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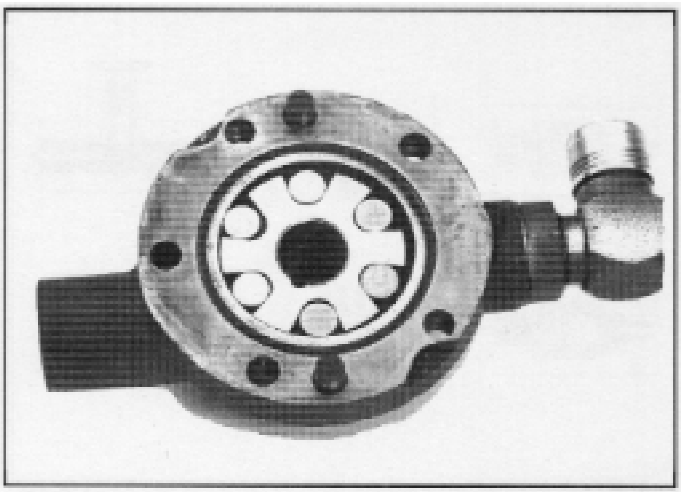
An **Internal Gear (Gerotor)** pump uses two gears to provide a constant output of oil per revolution. The inner gear is offset from the pump's center and is driven by the input shaft. A larger internal toothed gear or rotor surrounds the inner gear, providing a rotating mesh point to trap oil.

True internal gear pumps use a crescent seal which provides a sealing area between both gears . Gerotor pumps utilize rounded teeth which do not require a crescent for sealing.



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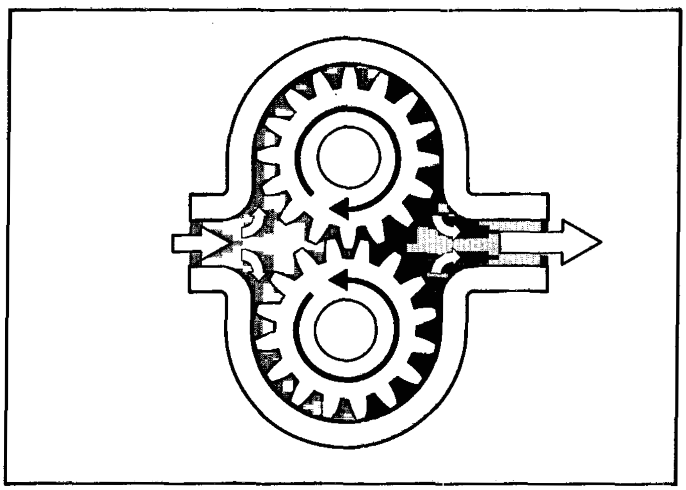
A **Roller Bearing** pump is a variation of the internal gear pump. Instead of using two gears, rollers are placed between the teeth of the driven gear. This also provides a constant displacement of oil.



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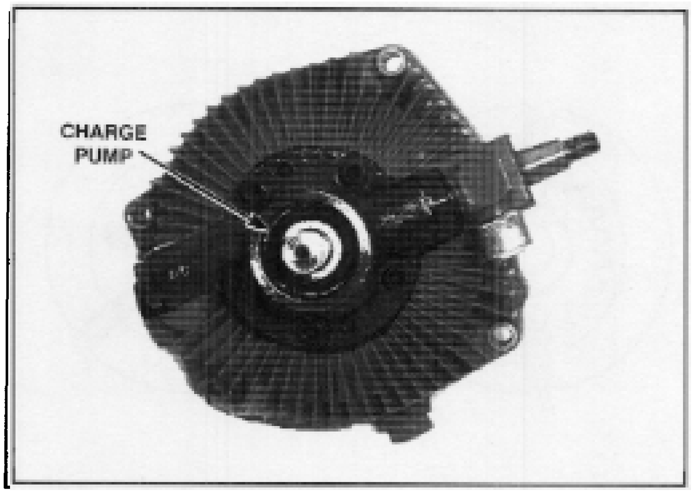
External Gear pumps use two tightly meshed gears to produce a constant displacement of oil per revolution. The input shaft drives one of the gears which in turn drives the second gear. The opposed gear rotation draws oil from the inlet port and traps it between the gear teeth and the pump body. As the teeth come together near the outlet port, the area is reduced and oil is forced out of the pump.

HYDRAULIC COMPONENTS (cont'd)

A **Charge Pump** is a small constant displacement pump which is driven by the input shaft. It provides a base circuit pressure and flow which can be used for the following functions:

- Transferring oil from the reservoir to the hydrostatic pump
- Pushing oil through a system filter
- Supplying oil to remote lift cylinders



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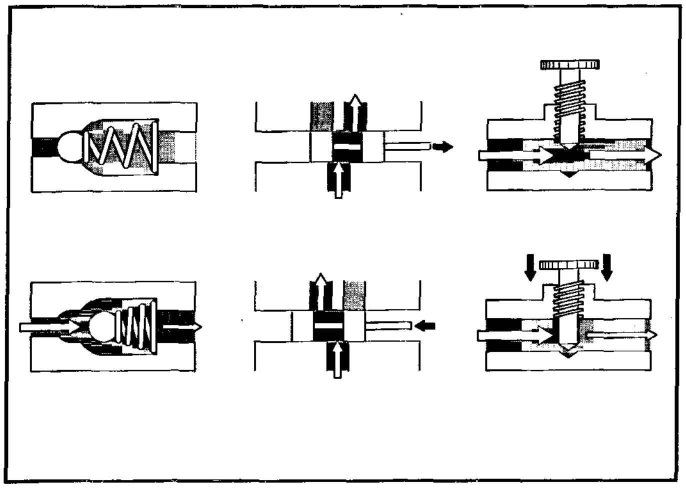
Valve - Function

Valves are used to provide control in a hydraulic system. They can be used to control:

- Pressure
- Direction Of Flow
- Volume Of Flow

We will first review these three functions of valves and then review some of the common types of valves you may encounter.



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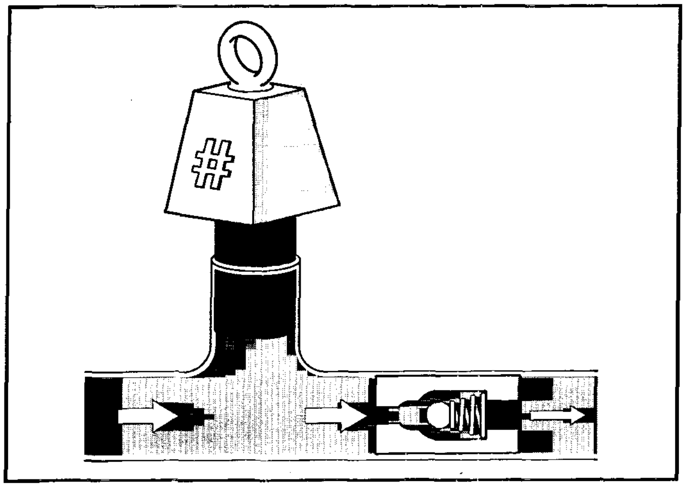
Pressure Control valves may be used to provide an upper pressure limit or to maintain a minimum pressure in a circuit.

For an example, let's look at a lift system. High pressure is generated when objects heavier than the system design are encountered or when a cylinder reaches the end of its stroke. The pressure control (relief) valve opens when the upper pressure limit of the system is reached.

With the valve open, a pressure escape path routes the oil back into the low pressure side of the circuit, protecting the system components from damage.



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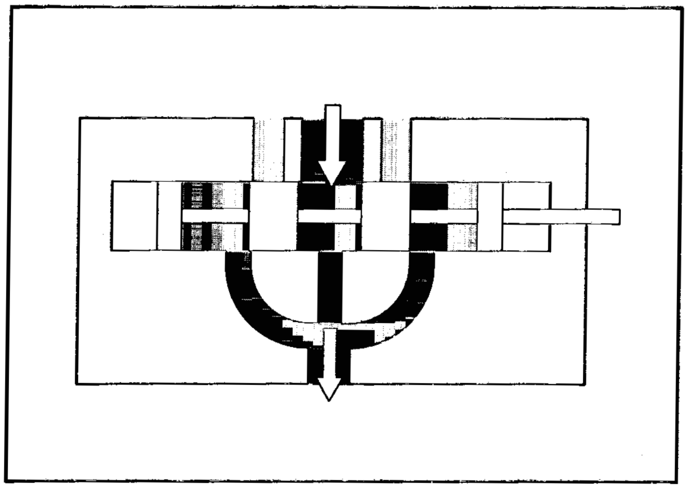

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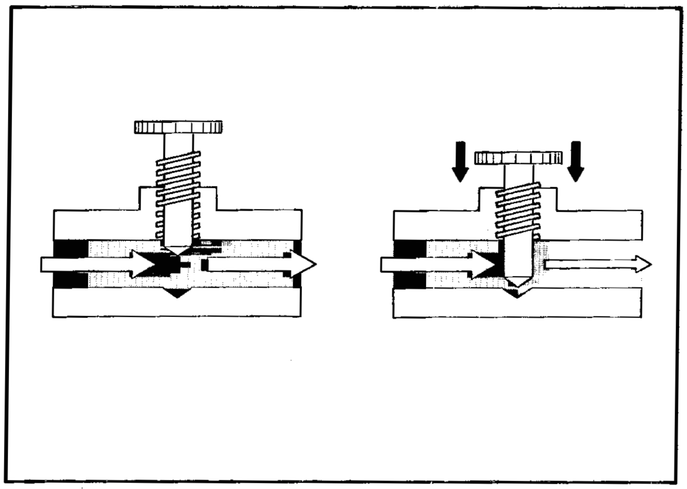
Directional Valves are used to control the direction or path of fluid flow in a hydraulic system. This may consist of a check valve preventing backflow through a line or a spool valve diverting the fluid's path to a remote cylinder.



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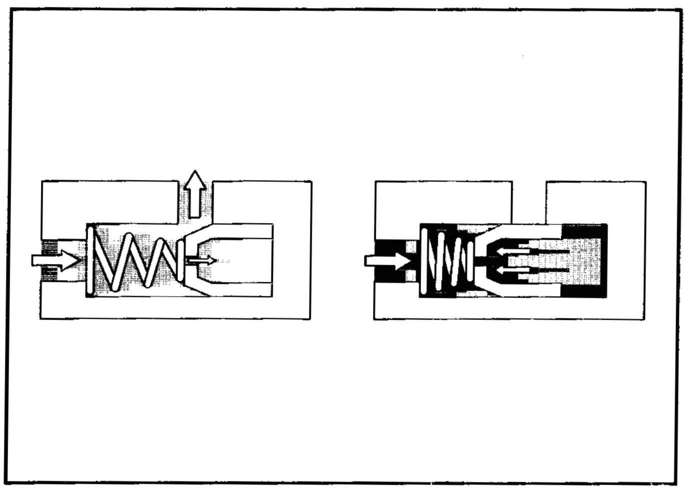
Flow Control valves are used to regulate flow into or out of a hydraulic component.

With a lift cylinder, a flow control valve can control the rate at which oil enters or leaves the cylinder. This allows the speed at which the cylinder extends or retracts to be regulated.

With a transaxle, a flow control valve may restrict flow through a passage completely during normal operation, but when activated, allow oil to pass through so the unit can be hand pushed.



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Valves - By Name

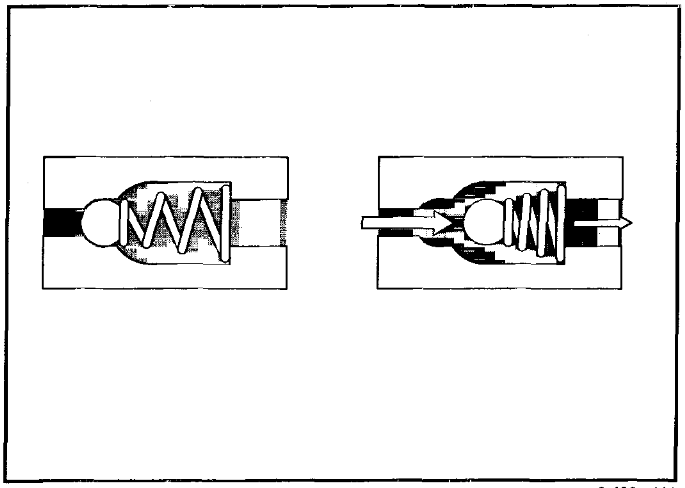
Acceleration Valve - An acceleration valve is a special flow control valve used in some hydrostatic transmissions to smooth changes in speed or direction. A common way to do this is by temporarily allowing some oil to escape from the high pressure side to the low pressure side of the pump/motor circuit.

One example of an acceleration valve uses a small metering hole which slowly allows high pressure oil to enter the cavity behind the valve. As the cavity is filled, the valve advances and closes the passage between the high and low pressure circuits.

HYDRAULIC COMPONENTS (cont'd)

Check Valve - A check valve can be used for pressure control or directional control. It usually consists of a ball and seat area. A spring may be used to hold the ball on the seat.

Some check valves are adjustable. This is accomplished by using a spring with a different rate, shimming the existing spring or compressing the spring with a threaded adjuster.



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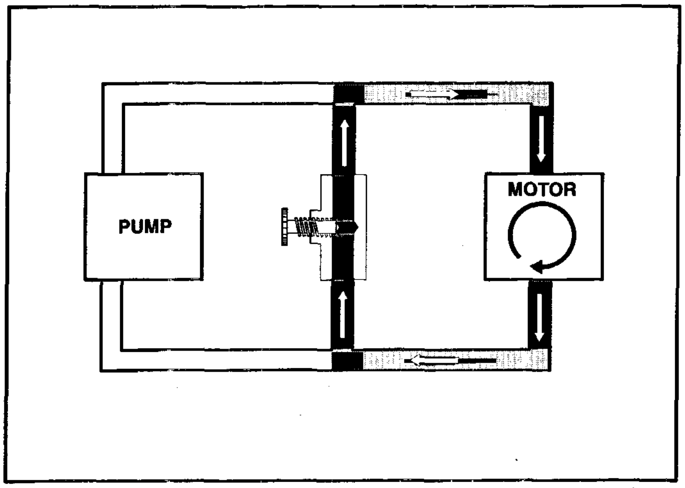
Push Valve - A push valve is a flow control valve used to open a pump/motor circuit. Manually opening the circuit allows oil to bypass from one side of the circuit to the other or allows oil to escape back to the reservoir.

The push valve allows the unit to be moved without starting the engine. Most, but not all hydrostatic transmissions use a push valve.



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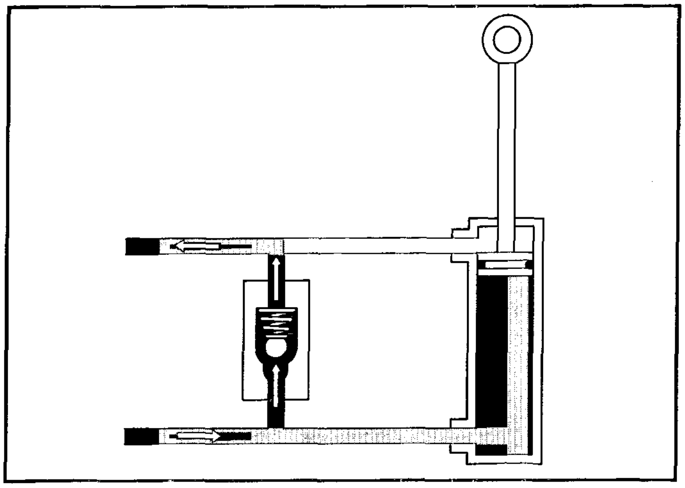
Relief Valve - A relief valve is a pressure control valve which is used to protect a hydraulic circuit from pressures which are higher than the circuit's design.



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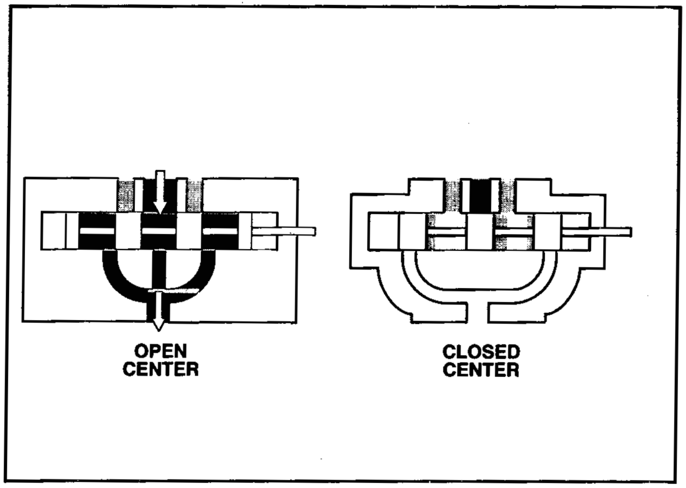

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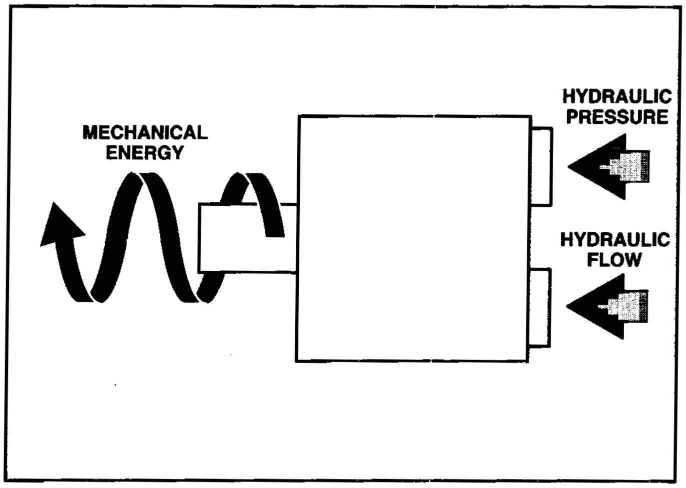
Spool Valve - A spool valve is a directional valve used to control oil flow. There are two types of spool valves: open center and closed center. Both types allow oil flow to be diverted to a remote circuit when the spool is not centered.

A closed center spool valve stops flow from the pump when it is centered. This type of valve is not used with a positive displacement pump.

An open center spool valve allows oil from the pump to pass through the valve when the spool is centered.



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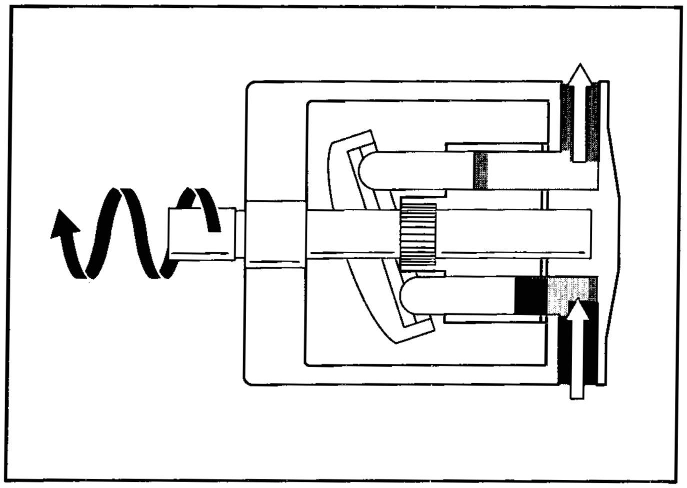
Actuator

A hydraulic actuator is a device which converts hydraulic pressure and flow into mechanical energy. The two most common types of actuators are hydrostatic motors and hydraulic cylinders.



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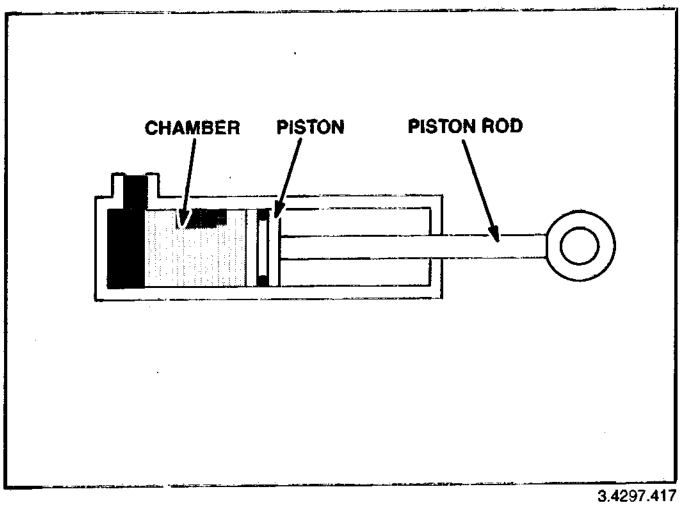
Actuators - By Type

A **Motor** is simply a pump used backwards. It takes hydraulic pressure and flow from a pump and converts it back into rotary mechanical energy.

Due to their similarities in function, many motors use designs similar to pumps. In some cases, the exact same configuration can be used as a pump or motor.

HYDRAULIC COMPONENTS (cont'd)

Hydraulic Cylinder - A hydraulic cylinder converts hydraulic pressure and flow into linear mechanical energy. It consists of a sealed chamber, piston, and piston rod. Cylinders can be either single action or dual action.



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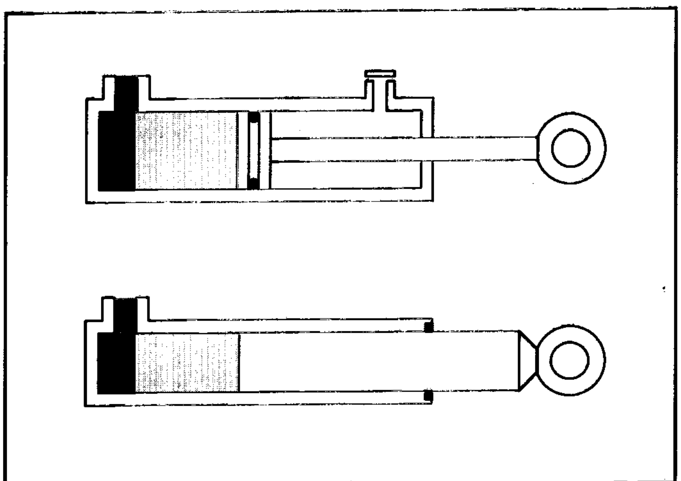
Single Action Cylinder - Single action cylinders can only be powered in one direction. Gravity or spring pressure is used to retract the cylinder after extension.

These cylinders come in two different styles.

The typical version has a hydraulic line connected on one side of the piston and is vented to the atmosphere on the opposite side.

A displacement cylinder uses a large shaft called a ram which replaces the piston and piston rod. It can be serviced externally and eliminates the need for an atmospheric vent.



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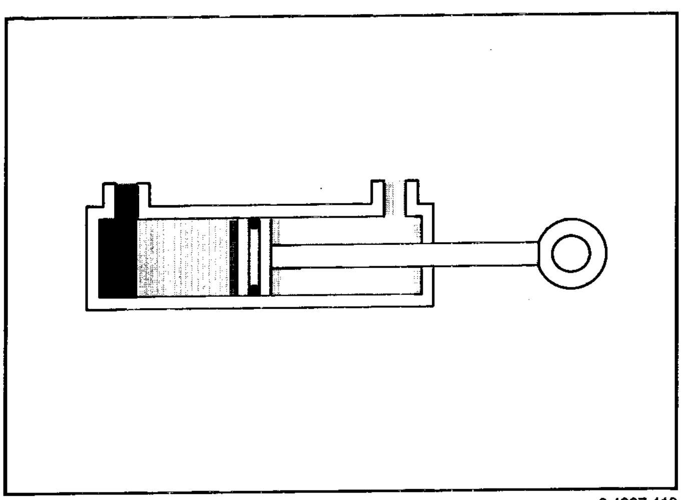
Dual Action Cylinder - A dual action cylinder can be filled with oil on either side of the piston. To extend the piston rod, oil is forced into the bottom end of the cylinder and oil ahead of the piston is pushed out of the cylinder. During retraction, this process is reversed, allowing the piston rod to be powered in both directions.

A typical double action cylinder can exert more force during extension than it can during retraction. This is because the piston rod takes away from the piston surface area used to retract the cylinder.

Force = Pressure X Area



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REVIEW SECTION # 1

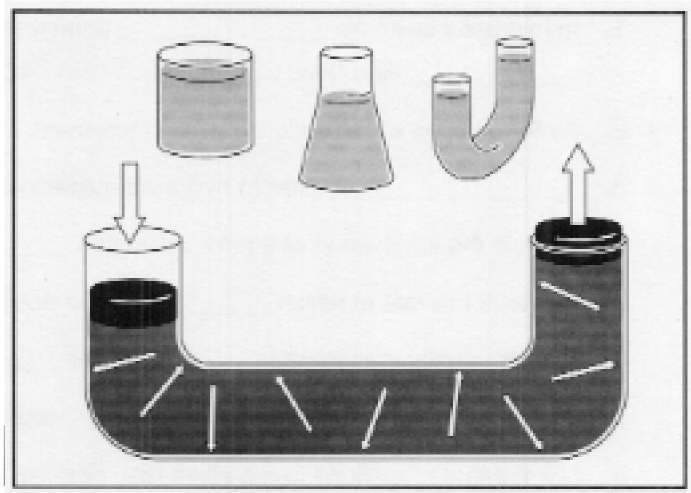
1. In hydraulic systems, ______________ energy from an external source is converted into hydraulic ____________ and flow.
2. As the load on a hydraulic system is increased, the operating _______________ increases.
3. _________________ refer to hydraulic systems which primarily use fluid pressure to transfer energy.
4. Work is the application of a force through a _________________.
5. Power is the rate at which ____________ is done or energy is transferred.
6. Flow is usually measured in _________ per __________.
7. An external gear pump is a __ __________ displacement pump.
8. List the three functions that a valve may perform.
   1. ____________________ 2.____________________ 3. _____________________
9. A hydraulic actuator converts hydraulic pressure and flow into ____________ _______________.
10. A __________ ___________ cylinder can only be powered in one direction.

Properties Of Liquids

A liquid has no shape, it always assumes the shape of its container.

Unlike air, liquids compress only slightly under pressure.

A force applied to a contained liquid will exert equal pressure in all directions within the container.



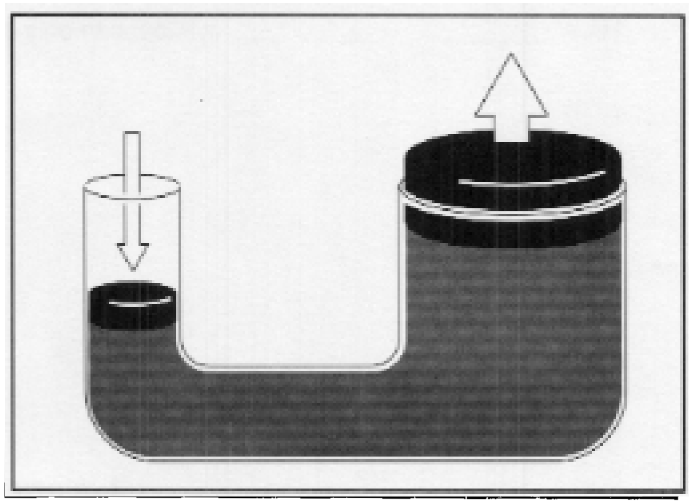
3.4297.420

Force Magnification

To gain a mechanical advantage, the size of the ends of the container can be varied.

Example:: The pump has an area of 1 square inch. The cylinder has an area of 10 square inches. If 10 pounds of force is applied to the pump, 100 pounds of force is exerted on the cylinder.

If the amount of work put into the system equals the amount of work out of the system [100% efficient], the pump will travel 10 times farther than the cylinder.

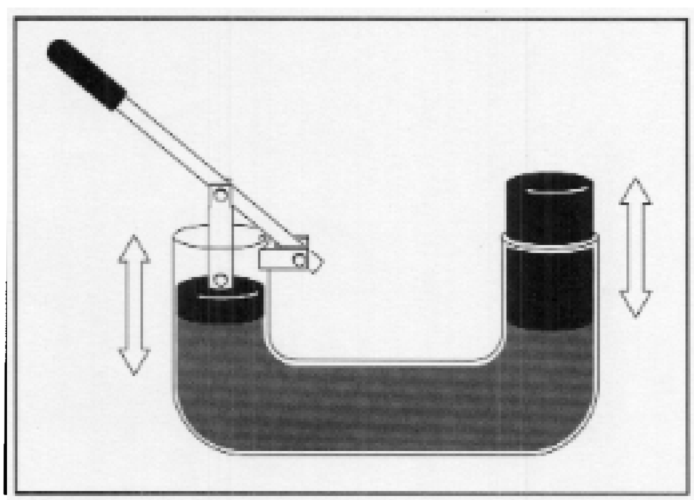


3.4297.421

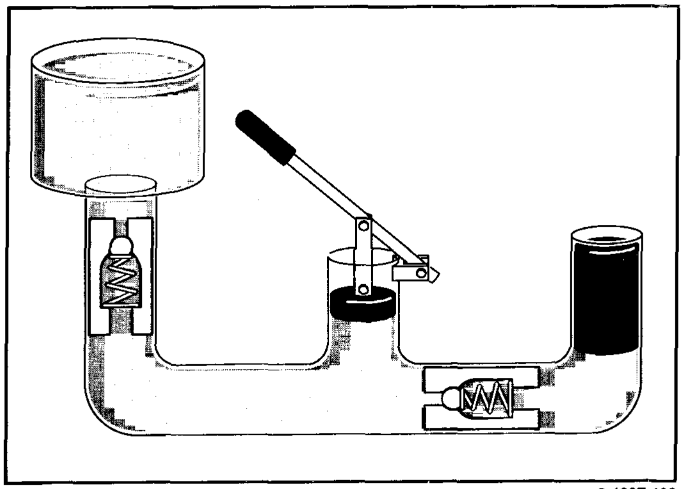
Building A Basic Circuit

Let's put together a simple circuit using some basic hydraulic components. We will start out with a simple pump and cylinder connected by a line.

As you can see, there are some flaws in this design. There is not extra oil so that the pump can continue raising the cylinder after the first stroke. Also, when the pump handle is raised, the cylinder drops.

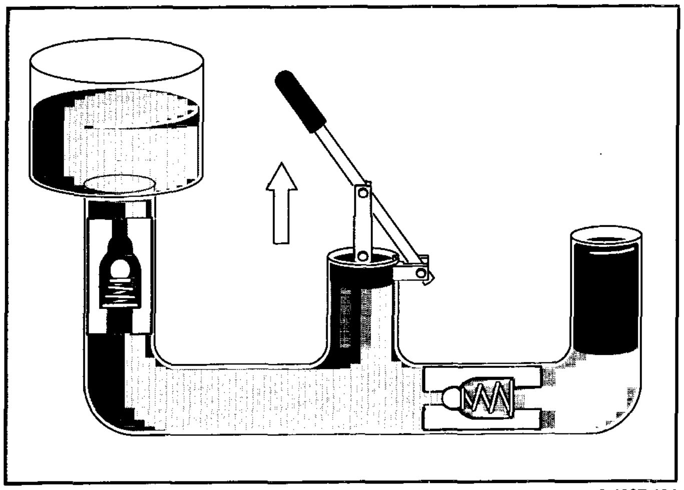


3.4297.422


3.4297.423

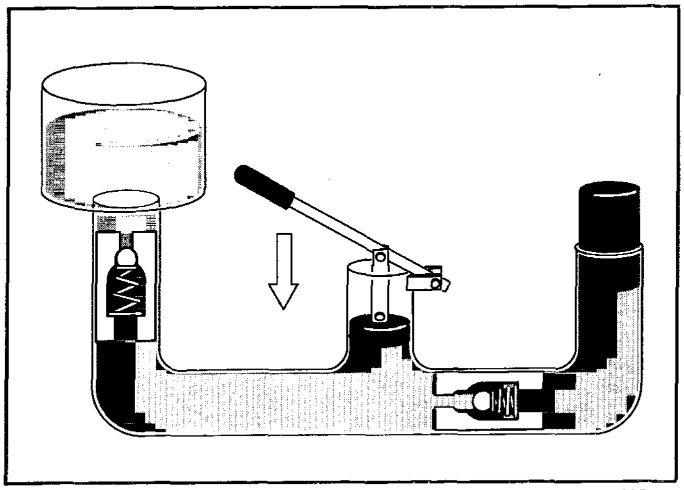
The flaws can be corrected by installing a reservoir and two check valves. One check valve will keep oil from being forced back into the reservoir and the second will keep the oil under the cylinder when the pump handle is raised.

When the pump arm is raised, the surface area of the chamber between the check valves increases. As the area increases, pressure acting on the surfaces inside the chamber decreases. When the pressure in the reservoir becomes greater than the spring pressure on the check valve and the pressure in the chamber; the check valve moves off its seat.


3.4297.424

As oil flows into the chamber, the pressure begins to increase. As the handle is pushed downward, the pressure inside the chamber increases and closes the check ball under the reservoir.

The second check ball now opens allowing the oil to flow into the chamber under the cylinder ram.


3.4297.425

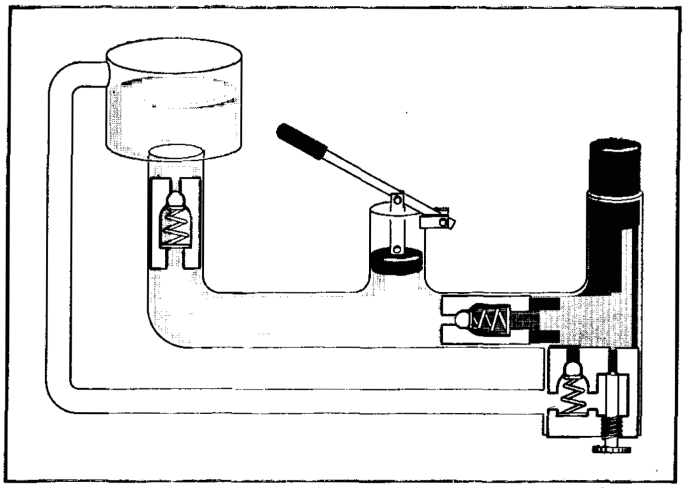
The force needed to extend the cylinder ram is dependent on the amount of weight on the ram.

A five pound weight requires five pounds of force to lift. Because the size (area) of the cylinder can not be changed, adding more weight to the cylinder requires a higher pressure to achieve movement.

When the pump reaches the end of its stroke, pressure under the pump and cylinder equalizes, allowing the check valve to close and trapping the oil under the cylinder.

Building A Basic Circuit (Cont'd)

This cycle is repeated until the cylinder ram is fully extended. Notice in the simplified system, the ram can not be let down. To accomplish this, we need to add a second valve under the cylinder. This valve should not open unless the pressure capacity of the system is met or it is manually opened to let the cylinder ram down. A return line will direct the oil from the cylinder back to the reservoir.

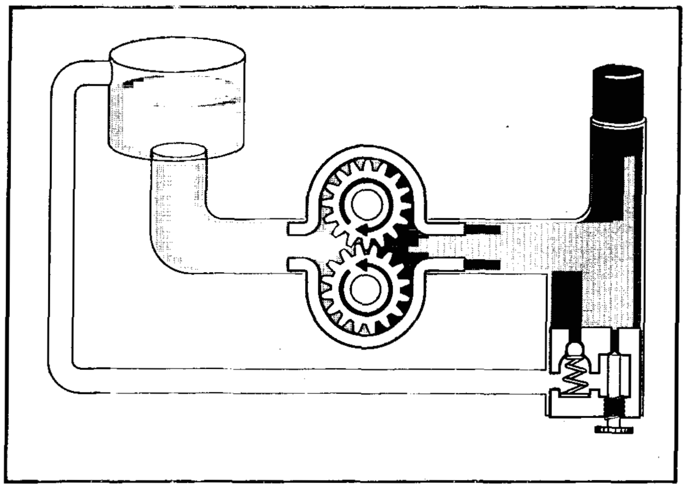


3.4297.426

Building A Lift System

Let's replace the hand pump with an external gear pump which is capable of providing constant displacement and more flow.

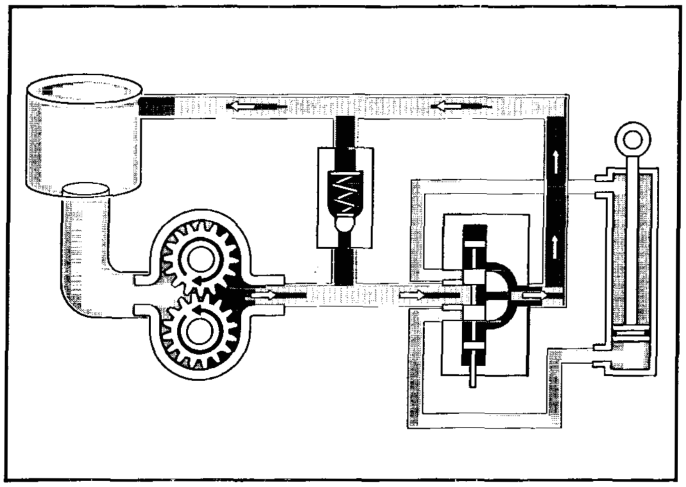
By placing the pump in-line, we no longer need the check valves to provide directional control. The greater output of this pump will extend the cylinder much faster. When the cylinder ram reaches the end of its stroke, pressure will increase and open the relief valve.



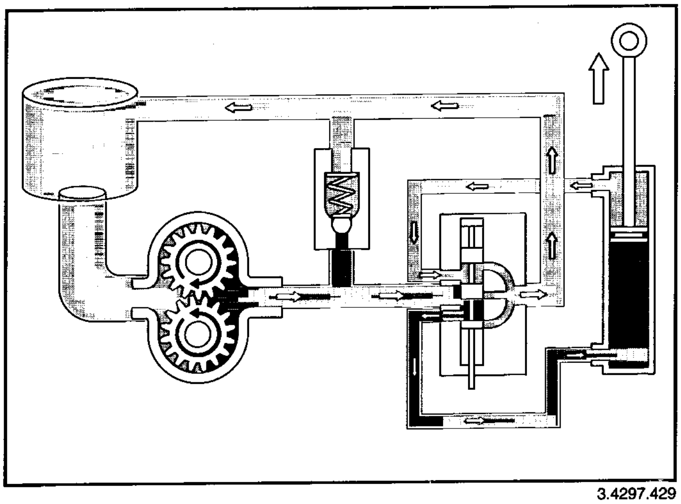
3.4297.427

If we replace the single action cylinder with an open center spool valve and a dual action cylinder, we have a basic lift system.

When the spool valve is centered, the oil passes directly through it and returns to the reservoir.

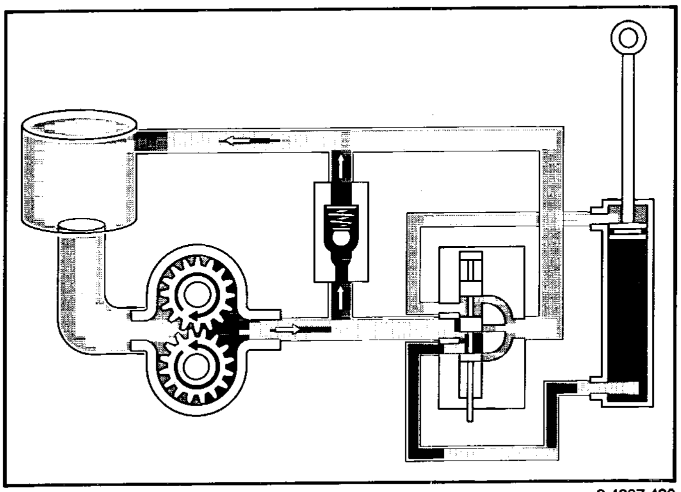


3.4297.428



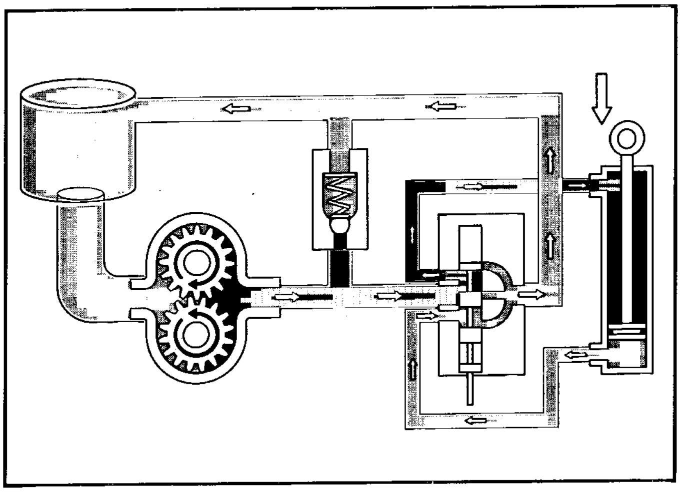
3.4297.429

When the spool valve is offset, oil is directed into the bottom end of the cylinder and the piston rod is extended. Notice that oil from the opposite side of the piston also passes through the spool valve and back to the reservoir.



3.4297.430

When the pressure in the cylinder reaches the setting of the pressure relief valve, the valve opens and directs the oil flow back to the reservoir. This happens when a high resistance is met, such as the cylinder reaching the end of its stroke.



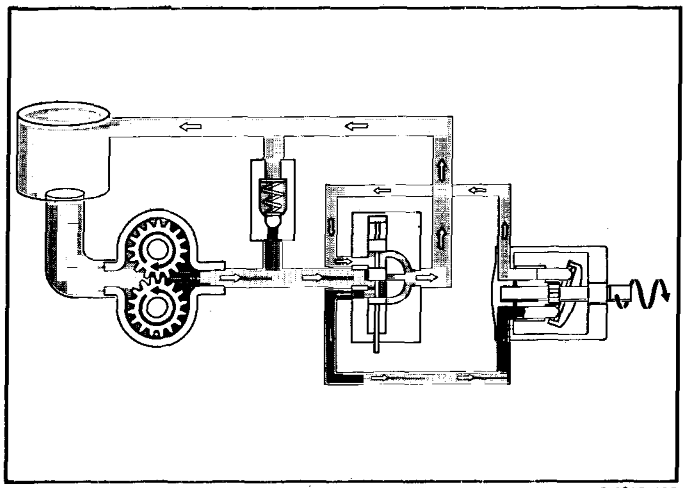
3.4297.431

When the spool valve is offset in the opposite direction, the oil flow through the valve and cylinder is reversed.

Building A Drive System

Let's replace the cylinder with another type of actuator -- a fixed displacement hydraulic motor. With the motor in place, this system will provide the continuous mechanical energy output needed to propel lawn and garden equipment.

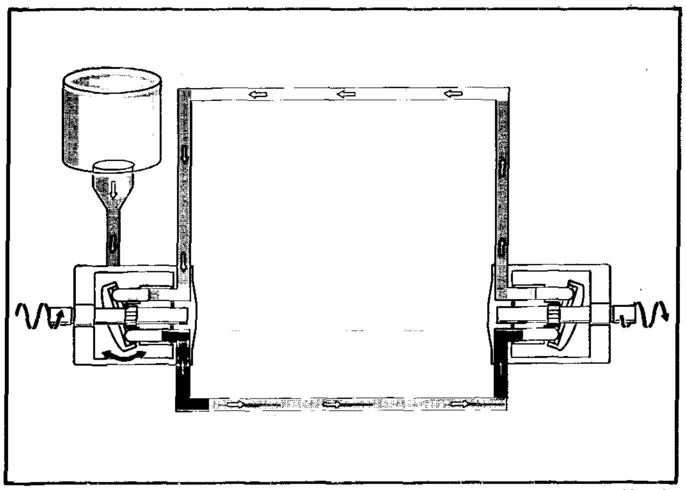
This system can reverse the direction of travel by changing the spool offset and reversing the oil flow through the motor. Notice that there is nothing in this system that will allow the output speed to be changed.



3.4297.432

Our hydrostatic drive systems use a variable displacement pump and a fixed displacement motor.

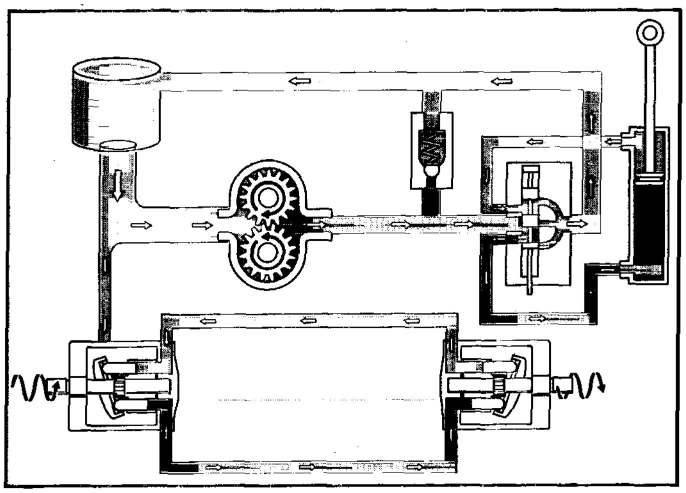
With variable output from the pump, the spool valve is no longer needed to control the direction of oil flow. The speed can also be changed with this variable output pump.



3.4297.433

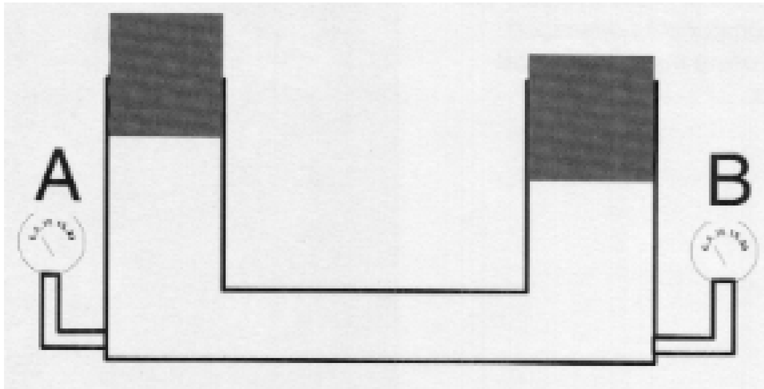
The Real Thing

If we combine the drive system with the lift system we had previously, the result is a hydraulic system similar to systems on many of the larger tractors in use today.

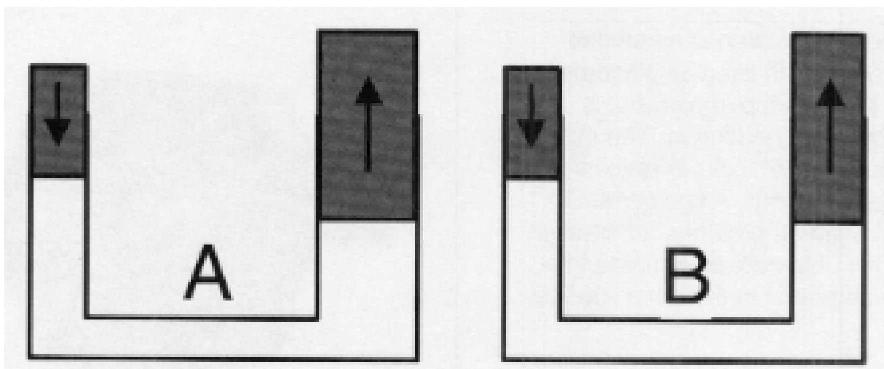


3.4297.434

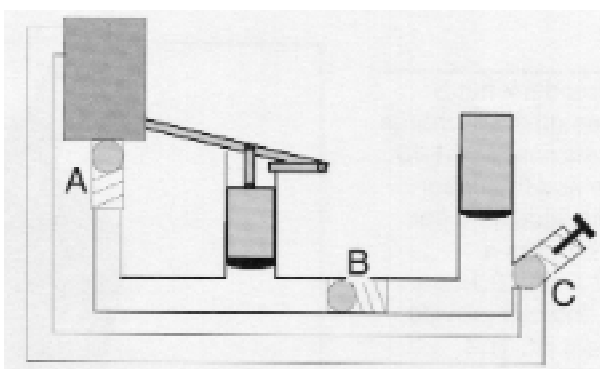
1. Under load, which pressure gauge (A or B) below will indicate the most pressure?



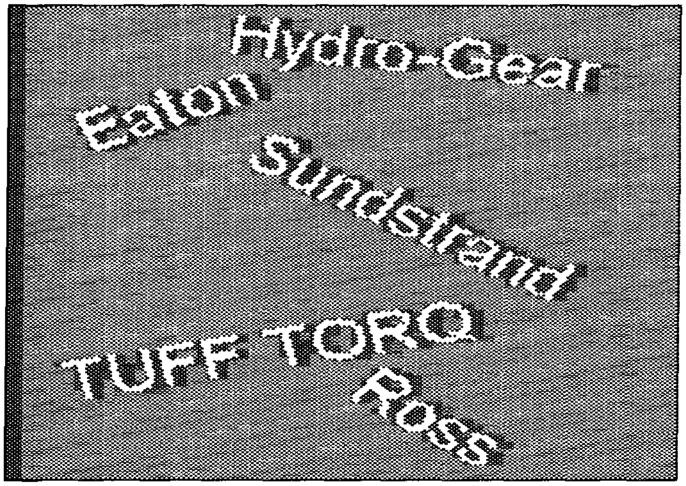
2. If both circuits below have the same amount of pressure applied to them, which circuit (A or B) is capable of lifting more weight?



3. Which valve (A, B or C) in the circuit below is responsible for protecting the system from high pressure?

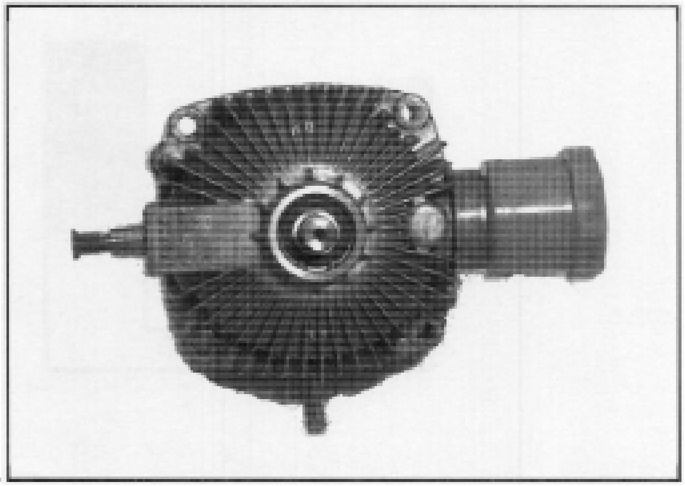


We use several different hydraulic systems across our product line. All of these systems are made from the basic components described earlier and operate by using the fundamental principles of hydraulics.



Eaton Model 7

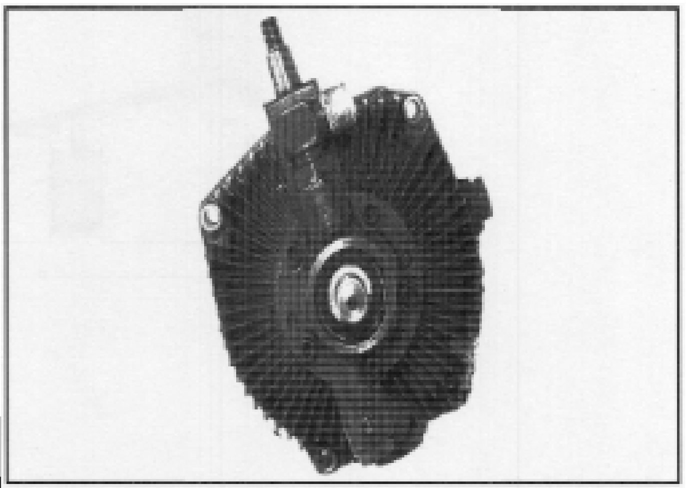
This hydrostatic transmission has a variable radial-ball piston pump and fixed displacement radial-ball motor. Maximum pump output is 0.465 cu. in.(7.62 cc) per revolution. The motor output is 0.767 cu. in (12.57 cc) per revolution. It does not use a charge pump. A fine screen at the bottom of the reservoir provides for filtration of incoming oil. This unit must be coupled to a final drive to provide power to the drive wheels.



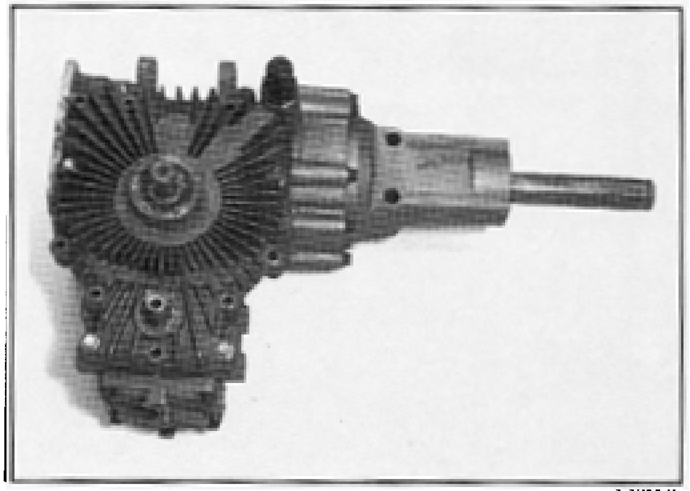
1.1311.2

Eaton Model 11

The Eaton 11 is similar to the model 7 but is considerably larger and uses an auxiliary charge pump. The pump displaces a maximum of 1.15 cu. in.(18.85 cc) per revolution and the motor has a 2.09 cu. in. (34.25 cc) displacement per revolution. The charge pump supplies a maximum flow of 1.5 gpm (5.7 l/min) [0.10 cu. in. per revolution (1.6 cc/rev)] and can provide power for a hydraulic attachment lift. This system is used with a separate filter and reservoir. Again, this unit must be coupled to a final drive to power the drive wheels.



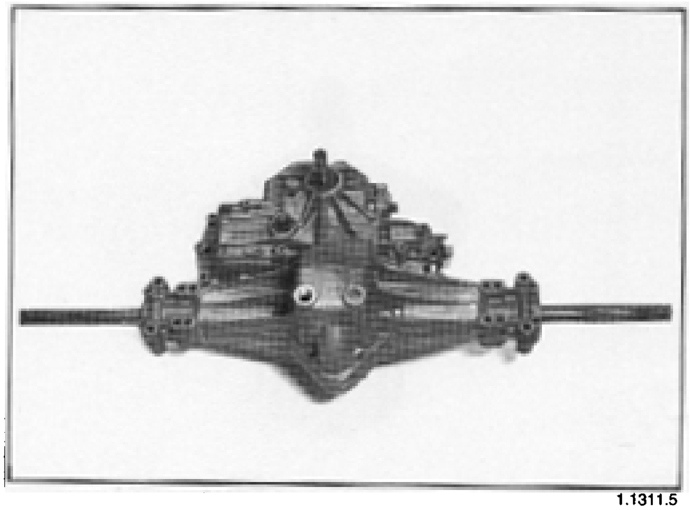
1.1311.4



1.1311.3

Eaton Model 781

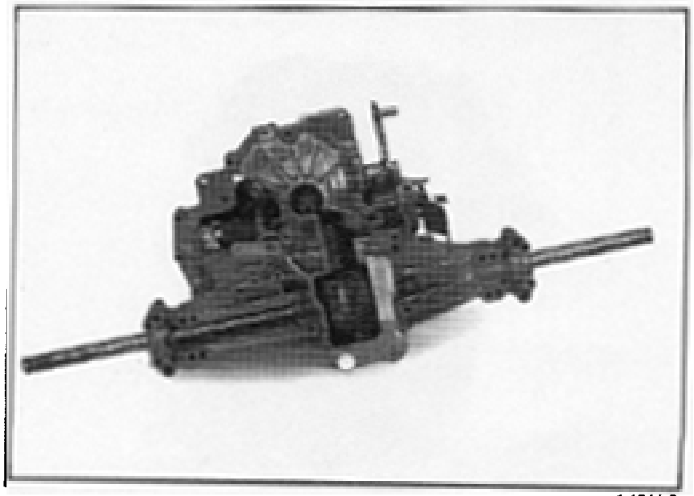
This transaxle is used as a pair (RH & LH) to make up a complete drive system. It has a variable radial-ball piston pump and fixed displacement radial-ball motor. Maximum pump output is 0.465 cu. in.(7.62 cc) per revolution. The motor output is 0.767 cu. in. (12.57 cc) per revolution. It does not use a charge pump. A remote expansion tank is used for a reservoir with a fine screen at the bottom of the inlet line providing the filtration of incoming oil. Two sets of planetary reduction gears provide power to the axle.



1.1311.5

Hydro-Gear 316-0500

This is a typical hydrostatic transaxle used in a lawn tractor . It is completely self-contained and has its own differential. This transaxle utilizes a variable axial piston pump with a maximum displacement of 0.61 cu. in. (10 cc) per revolution. The motor is also an axial piston design with a fixed displacement of 1.28 cu. in. (21 cc) per revolution.



1.1311.6

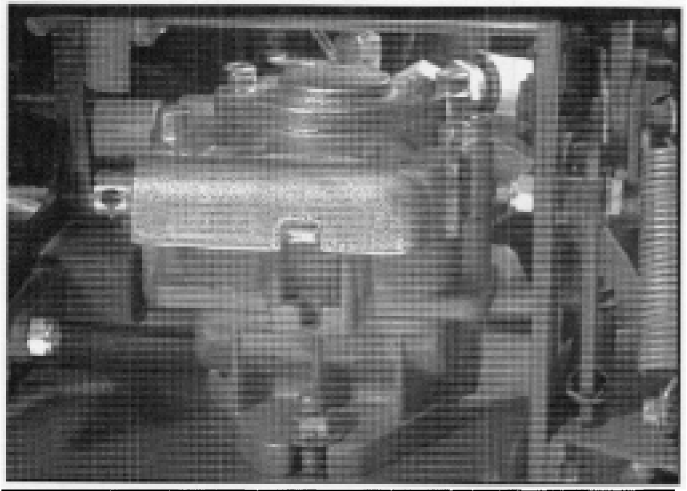
Hydro-Gear 316-0750

This hydrostatic transaxle is similar to the 316-0500. It uses a heavier differential to handle higher loads. This transaxle utilizes a variable axial piston pump with a maximum displacement of 0.61 cu. in. (10 cc) per revolution. The motor is also an axial piston design with a fixed displacement of 1.28 cu. in. (21 cc) per revolution.

Hydro-Gear BDP 10

This pump is a variable output axial piston design with a maximum output of 0.61 cu. in. (10 cc) per revolution. This pump uses a gerotor charge pump to pre-charge the system.

This is used in a separated pump and wheel motor system. Hydraulic lines connect the pump with a wheel motor.

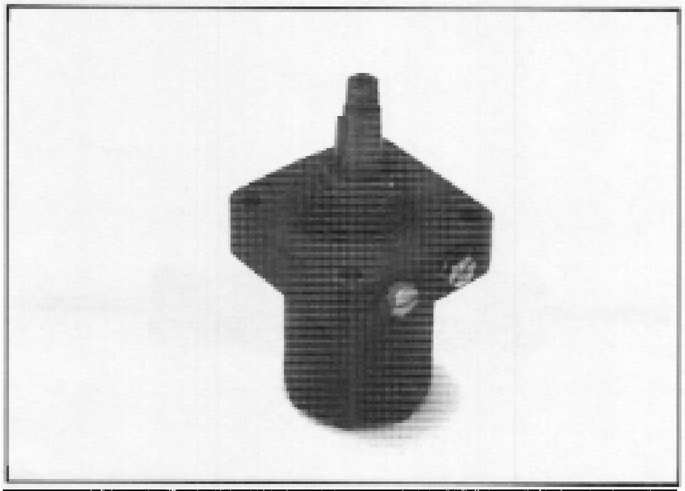


1.1311.10

Ross MF Series Wheel Motor

The Ross wheel motor is an internal gear (gerotor) design. The displacement is 12 cu. in./rev (196.7cc/rev). A separate pump is used to provide the pressure and flow to this motor.

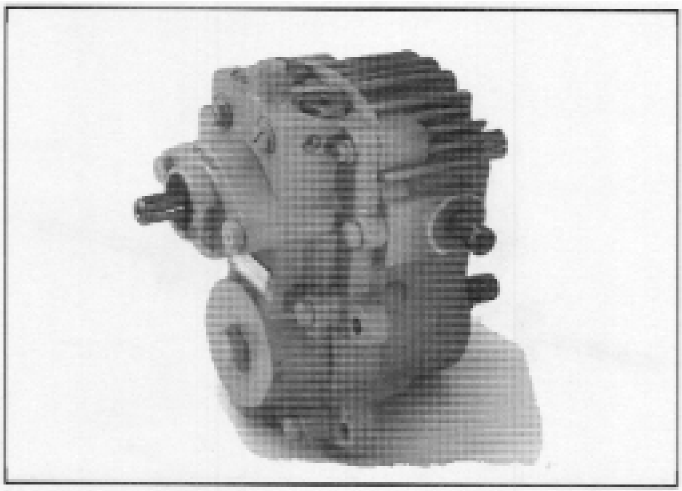
A small displacement pump is used to drive the wheel motor. The pump must complete several revolutions to displace enough oil to drive the wheel motor through one revolution. This provides a speed reduction similar to using reduction gears in a mechanical transmission.



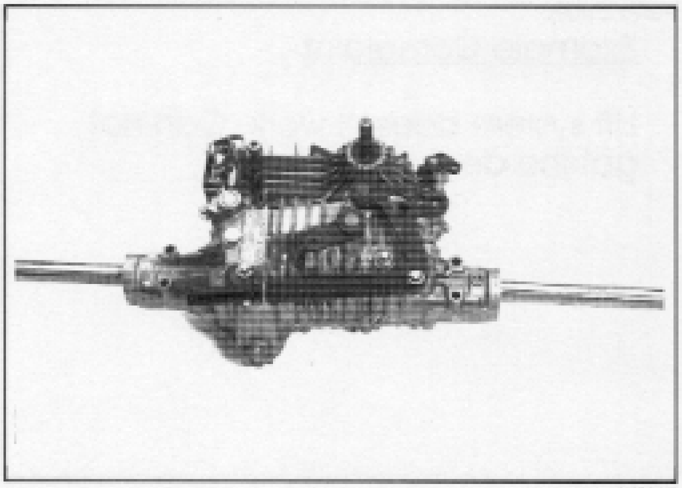
1.1311.11

Sundstrand Series 15

The Sundstrand Series 15 uses an axial piston variable pump with a fixed displacement axial piston motor. The maximum pump output is .91cu. in. (14.9 cc) per revolution and the motor displacement is .91cu. in. (14.9 cc) per revolution. An internal gear (gerotor) charge pump provides 4.6 gal/min(17.4 l/min). [.33 cu. in. per revolution (5.4 cc/rev)] flow for use with a hydraulic attachment lift.



1.1311.8



1.1311.7

Tuff Torq K61A

This transaxle is completely self-contained and has its own differential. It utilizes a variable axial piston pump and with a fixed dispacement axial piston motor.

An internal spring assists in returning the control arm to neutral. A dampening piston is used on the motion control input arm to smooth directional changes.

Using a systematic approach makes hydraulic troubleshooting easy. By following a process which narrows down the possible causes, a problem can be pinpointed and confirmed.

Step 1: Ask the Operator
Step 2: Study the Available Information
Step 3: Inspect the Machine
Step 4: Operate the Machine to Verify Problem
Step 5: List the Possible Causes
Step 6: Test Possible Causes

Example Complaint

Lift system doesn't work. Can not get the deck to raise.

Step 1: Ask The Operator

A detailed problem description is a valuable diagnostic tool during troubleshooting.

Has there been oil loss from the system?
What type of terrain (slope) was the product used on?
How was the unit being used?
How warm was the fluid?
What type of maintenance has been performed?
Did anything unusual happen before the problem occurred?

Answers to these questions should be recorded on the work order.

Problem Description

Hasn't noticed oil loss.
Used on fairly flat yard for mowing only.
Same operation if hydro cold or warm.
Use 5 seasons - never serviced

Step 2: Study The Available Information

Review the technical information which applies to the hydraulic system you are working with. Flow diagrams will show which types of components are involved in the system.

Can the problem be related to a particular circuit or part of a circuit? Does the problem seem to be pressure related? Does the problem seem to be related to oil flow? What components are controlling these conditions?

Be sure to check for Service Bulletins which may apply to this system.

Circuit Involves

Charge Pump
Spool Valve
Lift Cylinder
Filter
Lines & Fittings
Control Linkage for spool valve

Step 3: Inspect The Machine

Its now time to collect physical evidence. Again, take notes on what you see.

Inspect the the oil in the unit.
Is the oil level correct? Does it look black(Dirt)? Does it look milky(Water)? Does it smell burnt(Overheated)? Are there bubbles in the reservoir(Air leak)?

Inspect the outside of the hydraulic system.
Does the control linkage work properly? Does it have full travel? Is it secure? Is there debris around the hydraulic components? Are the hoses/lines kinked? Are there any signs of leakage?

Inspection Results

Oil is fairly clean - no signs of water or overheating
Spool valve works smooth
Hydro is clean
Hoses appear in good shape

Inspect the drive for the system.
Does the input drive line look normal? Are there signs of slippage in the system?

Inspect the output drive .
Does everything seem secure? Are the drive keys in place? Can you push the unit without activating the push valve?

Does not apply - unit drives great so the problem is in the lift circuit.

Step 4: Operate the Machine to Verify

If the machine still operates, use the detailed problem description to verify what the operator experienced. Use circumstances similar to those provided in the problem description to reproduce the problem.

While operating the unit, note anything that may affect the hydraulic systems operation. How well does the engine run? Do the brakes work properly? Are there any belts slipping? Do the controls work smoothly? Does the system operate properly in one direction and not the other?

Be sure to record all your observations.

Operating Test Results

Drive operation OK
Engine runs OK.
Lift system does not work. Seems like it tries to raise deck.
Noisy when spool valve is off center.

Step 5: List The Possible Causes

Make a list of the possible causes for this problem. Use your notes to support your conclusions.

Which causes best match the description of the problem? Which causes can be easily verified?

Possible Causes

Charge pump failing - low output
Internal cylinder leakage
Spool valve problem
Hose kinked
Relief valve problem
Spool valve linkage

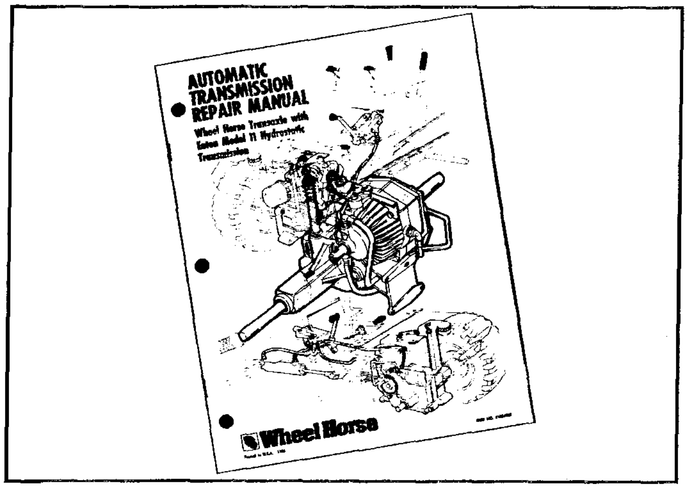
Step 6: Test Possible Causes

Using the technical information and the proper test equipment, test the possible causes to verify your conclusions. Start with the items on your list which are the easiest to check.

If it is not be possible to pinpoint the problem to one component, an internal inspection will be necessary.

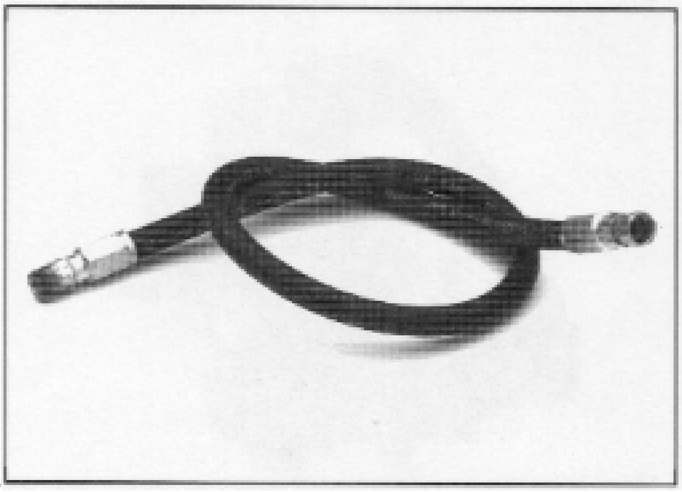
Check The Easy Things First

Hose kinked ✓easy
Spool valve linkage ✓easy
Charge pump failing - low output
Relief valve problem
Internal cylinder leakage
Spool valve problem



To properly troubleshoot many hydraulic systems, it is necessary to measure the pressure and or flow at various points in the system. This can only be done by using the proper test equipment.

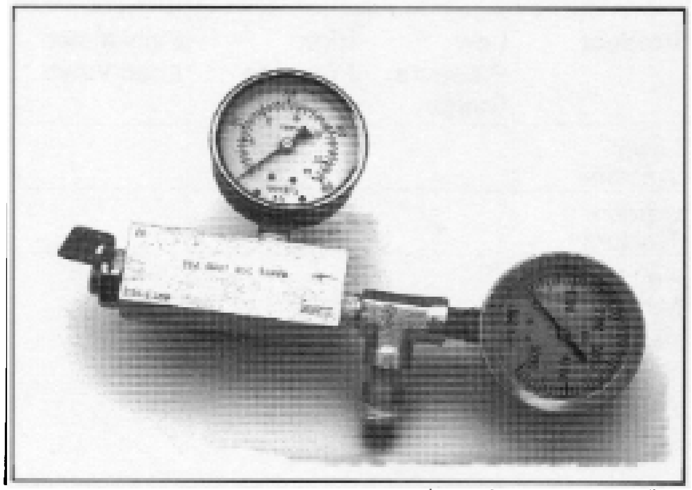
Service and repair manuals will indicate if there are specific tests which can be performed on a specific hydraulic system. The amount of pressure and or flow the system should be generating will determine the size and type of the equipment needed.



1.1311.14

Inlet/Outlet Hose

Hoses are used to connect your test equipment into the system you are testing. The hoses should be rated higher than any pressure that may be reached during testing. They should also be long enough to allow for easy reading of the test equipment. Adapter fittings may be needed to attach to different systems.



1.1311.15

Pressure Gauge

As you might expect, pressure gauges are used to measure the pressures experienced during certain phases of circuit operation.

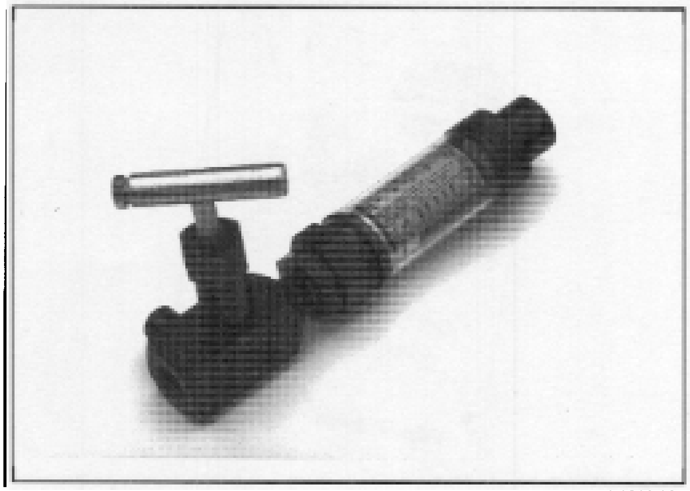
A good quality pressure gauge is usually liquid filled to stabilize the needle. Low pressure gauges for hydraulic testing will read from 0 to 1000 psi (70.3 kg/sq cm). A high pressure gauge normally allows for testing between 0 and 5000 psi (351.3 kg/sq cm).

Flow Meter / Load Valve

Flow Meters are used to measure the actual flow in a circuit during operation. The meter is placed inline and will indicate flow in gallons per minute (gpm).

A **Load Valve** is a flow control valve which can be used during testing to simulate a load. As the flow is restricted, a higher load is simulated.

Load valves are usually used in combination with a flow meter.



1.1311.16

Test Equipment Needs

The type of test equipment you need depends on the type of equipment being serviced in your shop. Generally, test gauges can be adapted to many different systems simply by using adapter fittings. Your test equipment should be capable of handling pressures greater than the pressure generated by the largest system you will need to test.

1.1311.20

A liquid filled gauge capable of 1000 psi (70.3 kg/sq cm) will be sufficient for testing hydraulic systems on TORO Wheel Horse riding products.

Some systems used on TORO ProLine equipment require a flow meter capable of measuring at least 7 GPM. A high pressure gauge may also be needed. When performing a traction test on a ProLine 220, pressures in excess of 4000 psi (281 kg/sq cm) will be experienced.

Product	Low Pressure Gauge	High Pressure Gauge	Flow Meter Load Valve
Lawn Tractors			
Garden Tractors	✓		
ProLine Mid-Size	✓		✓
ProLine 100 Series	✓		✓
ProLine 200 Series	✓	✓	✓

1. The first step in problem solving is to:
   A. Study the available information
   B. List the possible causes
   C. Inspect the machine
   D. Ask the operator
   E. Operate the machine to verify the problem
2. Oil which looks milky is most likely contaminated with:
   A. Milk
   B. Dirt
   C. Water
   D. Transmission fluid
   E. Nothing
3. An indicator of an overheated hydraulic system is:
   A. Burnt smelling fluid
   B. Oil loss in the system
   C. Loss of power as the system warms
   D. Air bubbles in the reservoir
   E. Black colored oil
4. When testing the possible causes of a hydraulic system problem, always test the ________ possibilities first.
5. When using a load valve during testing, as flow is restricted, a higher ________ is simulated.
6. The test equipment used in your shop should be capable of handling the ___________ generated by the largest hydraulic system you will need to test.

Review Section # 1

1. mechanical, pressure
2. pressure
3. Hydrostatics
4. distance
5. work
6. gallons, minute
7. fixed/constant
8. Pressure Control, Direction Of Flow, Volume Of Flow
9. mechanical energy
10. single action

Review Section # 2

1. Both gauges will read the same amount of pressure because they are in the same circuit.
2. Circuit A - Force is equal to pressure times the area on which it is acting. The pressure is the same in both circuits. The cylinder in circuit A is larger than the cylinder in circuit B. The same pressure times a larger area will generate the most force.
3. Valve C - Valve A is a check valve which keeps oils from returning to the reservoir during pumping. Valve B keeps the oil trapped under the lift cylinder. Valve C is used as a pressure relief valve and as a flow control valve to let the cylinder down.

Review Section # 3

1. D
2. C
3. A
4. easy
5. load
6. pressures

ABOUT THIS MANUAL

This Productivity Series Manual was written as a training guide for service technicians. Learning the fundamentals of a subject is a necessary step in becoming an expert in any area. This publication is designed to increase the readers knowledge on hydraulics. The Toro Company has made every effort to make the information in this manual complete and correct.

We are hopeful that you will find this manual a valuable addition to your service shop. If you have any questions or comments regarding this manual, please contact us at the following address:

The Toro Company
Consumer Service Training Department
8111 Lyndale Ave. S.
Bloomington, MN 55420

The Toro Company reserves the right to change product specifications or this manual without notice.