

# HYDRAULICS AND HWH SYSTEMS – 26APR11

## 1. PREFACE

This is a discussion of basic hydraulics which can help with the diagnostics and repair of HWH hydraulic leveling and room extension systems. The first section of this school, “INTRODUCTION TO HYDRAULICS” is a more in-depth study of general hydraulics and should be studied before continuing in this section. “ADAPTATION OF HYDRAULICS” will repeat or review topics that were discussed in “INTRODUCTION TO HYDRAULICS” but is directed more at the way HWH adapts hydraulics to our leveling and room extension systems.

Although a complete understanding of hydraulics is important, there are several principles which can ease the diagnostics of most hydraulic problems in a HWH hydraulic leveling or room extension system. It is also important to understand how the different components in the systems work. This will all be discussed in this study along with the value of using schematics to understand and diagnose hydraulic systems.

## 2. HYDRAULIC PRINCIPLES

**2-1 First**, liquids are practically incompressible. Example: If you have a glass jar filled to the top with a liquid, you will not be able to put a stopper in the jar. If you force the stopper in, the jar will shatter.

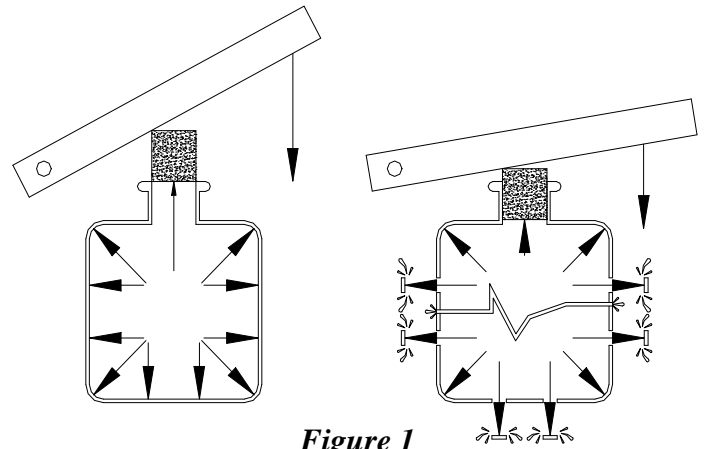


Figure 1

What this means in a HWH hydraulic system is if the pump is running, the fluid has to go somewhere. If the system is functioning properly, a jack should be extending or a room extension should be extending or retracting. If nothing is moving with the pump running, the system pressure should rise to the point where the fluid will flow across a relief valve back to the pump reservoir.

**“Simply put, if a hydraulic cylinder is moving, the fluid in the system is moving OR to make a hydraulic cylinder move, the fluid in the system has to move.”**

**2-2 Second**, fluids transmit pressure in all directions. *Pressure in fluid has no one specific direction.* The flow of fluid is directional. The direction fluid flows in a system can be changed by opening or closing valves but pressure in the system just is. In the drawing below, the piston is pushing the fluid out of the cylinder. The direction of flow is to the hole in the end of the cylinder but the pressure in the cylinder is the same at the piston and on the walls of the cylinder as it is at the hole in the end of the cylinder.

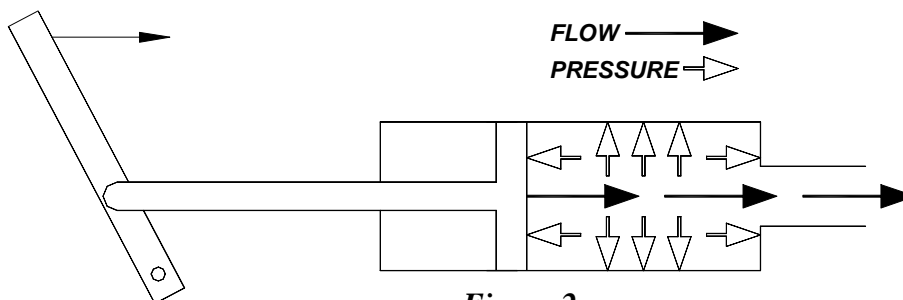
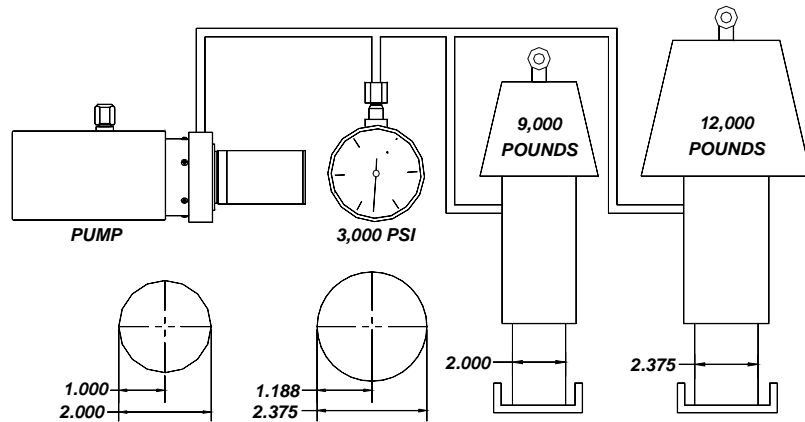


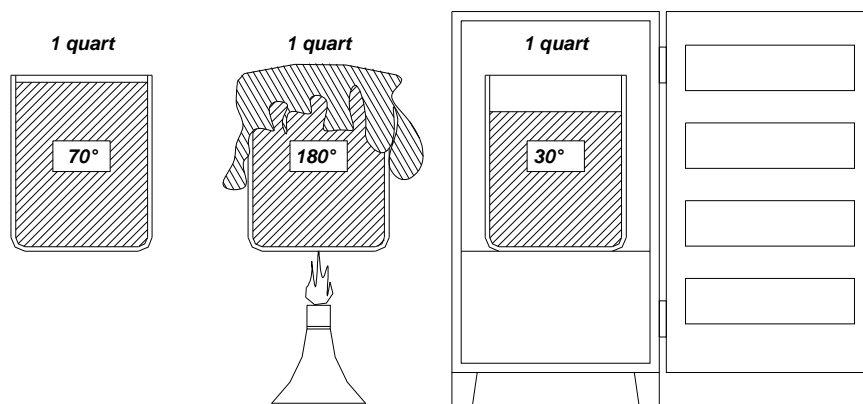
Figure 2

**2-3 Third**, fluid can provide a great increase in work force. This is the main reason HWH has chosen to use hydraulic systems instead of electric motors, electric actuators, pulley and gear systems, etc. The formula used to calculate force is:  $F$  (force) =  $P$  (pressure) x  $A$  (area). Force is figured in pounds, pressure is figured in psi (pounds per square inch) and area is the square inches of the movable rod or piston in the cylinder. Area can be any shape but for this study we are dealing with circles. The area of a circle is  $\pi(r^2)$ . The value of  $\pi$  is 3.14 and  $r$  is the radius of a circle or  $\frac{1}{2}$  the diameter of the circle. Example: The rod in a 9,000# capacity jack has a diameter of 2 inches. The radius of that rod is 1 inch. The area of the rod is  $3.14 (\pi) \times (1 \times 1) (r^2) = 3.14$  sq.in. Although most of the pumps HWH uses have a relief set at 3,500 psi, the working pressure HWH uses when figuring jack capacity is 3,000 psi.  $3,000$  (pressure) x  $3.14$  (area) =  $9,420\#$  (force) or 9,000 pounds of lifting capacity. I guess we could call it a 9420 pound jack but instead we round the figure down. The capacity of a leveling jack or room mechanism is essential knowledge when figuring the correct jack or mechanism needed to lift and level a coach or move a room.



**Figure 3**

**2-4 Fourth**, is the effect change in temperature can have on fluid. Note that water reacts differently than oil. When the temperature of a fluid is increased (gets hotter), the volume of the fluid increases. As the temperature decreases (cools), the volume of the fluid decreases. This is called “thermal expansion or contraction”. If you take a jar filled with fluid at room temperature and place it over a burner, the fluid will flow over the side of the jar as the temperature of the fluid increases. If you take a jar filled with fluid at room temperature and put it in the freezer, the level of the fluid will drop as the fluid cools. The same thing happens in our hydraulic systems. The thermal expansion and contraction can make the leveling jacks extend or retract slightly and to a lesser extent cause some issues in room extension systems.



**Figure 4**

**Remember, if the temperature of the fluid in a system increases, the volume of the fluid in that system increases the pressure in the system can also increase. That extra fluid has to go somewhere! If the temperature decreases, the volume of fluid decreases. That would be the same as the fluid moving. It is possible that a cylinder may move.**

### 3. HOW HYDRAULICS WORKS

**3-1** Pressure and flow are the key ingredients to a hydraulic system. Pressure, along with the size of the cylinders dictates the force the system has available to use. This was explained in the third principal. The amount of fluid the pump can move dictates how fast a cylinder will move. This is measured in GPM or gallons per minute. It should be noted at this time that all a hydraulic pump does is move the fluid through the system. Pumps will only create pressure if there is resistance to the moving fluid. *So in a given system, the more pressure the system will produce, the more force the cylinders can create. The more fluid the pump moves, GPM, the quicker the cylinders can move.*

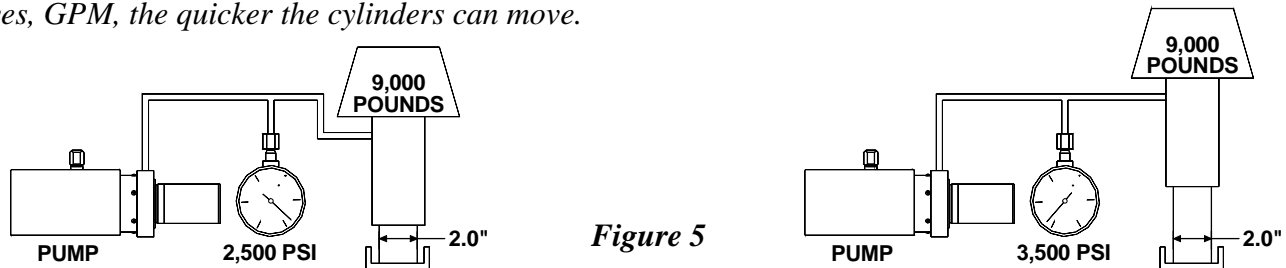


Figure 5

**3-2** Fluid will always take the path of least resistance. If two cylinders of equal size are connected to a single supply line, they will produce the same force. If one of the cylinders is trying to lift 500 pounds and the other cylinder is trying to lift 1500 pounds, fluid will flow to the cylinder that is lifting 500 pounds while the other cylinder does not move. The system will only produce enough pressure to lift the lighter weight. Pressure in the system will not increase until the resistance to the flow increases, in this case when the first cylinder is fully extended. When the first cylinder is fully extended, the pressure will start to increase and the second cylinder can now lift the 1500 pounds as long as the system can develop adequate pressure and there is plenty of fluid in the reservoir.

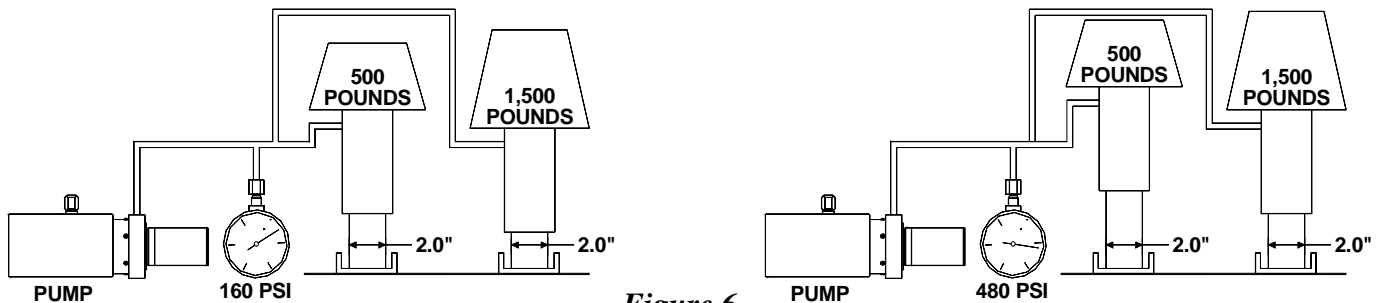


Figure 6

**3-3** One of the hardest issues to overcome when designing and building a hydraulic system is trying to make two cylinders move at the same speed. Because fluid flow dictates how fast a cylinder moves, resistance to that flow can change the speed of a cylinder. Resistance to the flow of fluid can be many different things. The weight a cylinder is trying to move creates resistance. As the weight a cylinder is trying to move increases, the resistance to the movement increases. The smaller the orifice size of a valve or fitting, the greater the resistance is to the flow through the valve or fitting. The same is true of the internal size of a hose or steel line. The smaller the hose or line diameter, the greater the resistance is to the flow of fluid. The length and routing of a hose or steel line will create resistance in the system. The longer the hose or line, the greater the resistance is. A tight radius in the routing can cause more resistance. Normal routing of hoses including gradual curves and bends will probably not affect the flow noticeably but the straighter the runs the better. Finally, one of the most overlooked factors that can cause resistance in a system is manufacturing tolerances. I know of no industry that works without tolerances. To build two of the same item that would be perfectly the same in all dimensions would be very difficult. To mass produce perfectly like items in great quantities would not only be cost prohibitive but probably impossible. One valve may have a needle that moves a little farther than another valve. The first valve may flow a little more fluid. One jack may have a rod machined to the high side of the tolerance. That may give that jack a little greater seal squeeze. That jack will create more resistance. As more components with more tolerances are put together in systems, the performance between two of the same systems or even between like components in the same system can vary.

**3-4** When none of the cylinders in a HWH hydraulic system are moving, the system is static. When a system is static, the pressure in the system to all parts that are hydraulically connected is the same. It does not matter how small an orifice connects two parts of the system if the system is static, the pressure is the same. If a cylinder is moving the pressure can be different in different parts of the system. The inlet side of an orifice or valve can be greater than the outlet side. There will also be a pressure drop through a hose or tube. The longer the hose or tube the more the pressure drops. The pressure reading at the inlet end of a hose will be greater than a pressure reading at the outlet end of a hose if whatever is connected to the hose is moving. If a part of the system is isolated from the pump with a valve, that part of the system can maintain pressure or have zero pressure no matter what the rest of the system is doing as long as the valve stays closed.

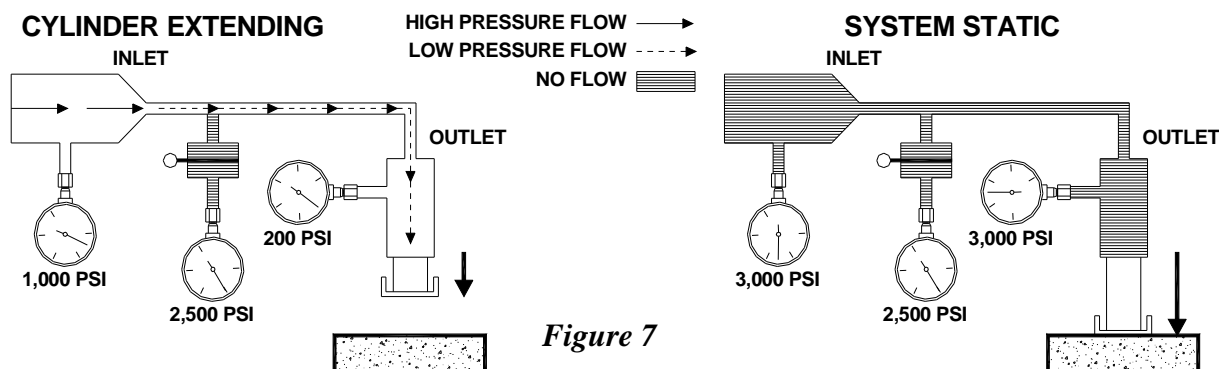


Figure 7

The shuttle valve is a good example of this. The shuttle valve will be explained in greater detail later. It takes approximately 800psi to open the shuttle valve. This lets fluid into the manifold. When a valve opens, fluid is directed to a jack or room extension cylinder. It takes less than 100psi to make a jack start to extend. When starting to extend a jack if you check the pressure between the pump and shuttle valve, you would have approximately 800psi. If you check the pressure between the valve and jack at the same time, you may only have 70 or 80psi. It is very important to know what system relief valves and/or pressure reducing valves are set at. It also is important to know where and when to check pressures and what pressure should be expected when checking.

## 4. HYDRAULIC COMPONENTS

One of the keys to diagnosing anything is understanding what the different components of the system are used for and how they function. There are four main parts to a HWH hydraulic system, the pump, which moves the fluid, the valves, which direct the fluid, the hoses, which transfer the fluid and the cylinders, which transform the moving fluid into a function such as leveling a vehicle or moving a room. In this section we will study the components of the HWH hydraulic leveling and room extension systems.

**4-1 PUMPS:** The pump in a hydraulic system creates flow, moves the oil through the system. Pressure is created when there is resistance to the flow the pump creates. The pumps used by HWH are fixed displacement, external gear pumps. A fixed displacement pump moves the same volume of oil every time the gears make a revolution. The volume of oil being moved changes with the speed the gears turn. The faster they turn the greater the volume of oil that is moved.

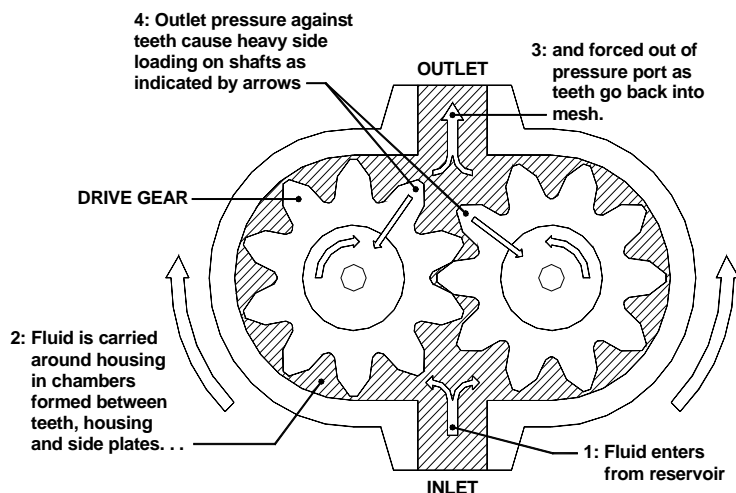
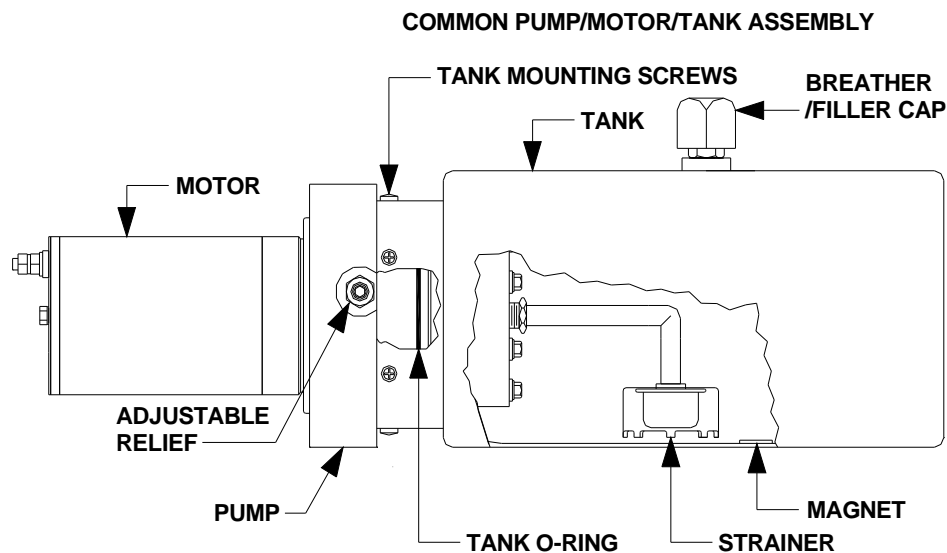


Figure 8

**4-1.1** The pump is one of the few major components that HWH does not manufacture. HWH refers to this purchased assembly as the “Pump/Motor/Tank Assembly”. When other parts such as relays, fittings and manifolds are added to the Pump/Motor/ Tank Assembly, it is then referred to as a “Power Unit Assembly”. The Pump/Motor/Tank assembly is just what it says it is. This is what is sent out for a pump replacement. If the motor is bad, it can be replaced in most cases. If there is a problem with the tank, it also can be replaced. If it is diagnosed that the pump itself has a problem, the complete Pump/Motor/Tank assembly should be replaced. HWH has used many different styles and several different manufacturers of pumps. Some pumps have different flow rates, some have a different relief setting and some have a different capacity tank. There are 12 volt and 24 volt pumps. HWH has also used reversible flow pumps with some room extensions or generator slides. Reversible pumps have an internal check valve arrangement that allows fluid to exit or return to the pump through the same port as the pump gears are turned in opposite directions to reverse the flow from the pump. There will be different mounting dimensions and space requirements for different pumps. Many pumps have been discontinued and are no longer available. In the HWH parts manual there is a quick reference guide section. Refer to the “HWH Hydraulic Pump Quick Guide” for replacement information and links to parts pages that will give mounting and dimensional information.

**4-1.2** There are two main problems that are very damaging to a pump, contaminated or improper type of oil and cavitation. Contaminated oil should be an obvious problem. Contamination can damage the pump gears or interior pump housing surfaces. Cavitation occurs when there is an insufficient supply of oil to meet the needs of the pump (not enough fluid in the tank or a plugged breather cap). This allows air or vapor spaces in the oil as it goes through the pump gears and creates an absence of lubrication on pump components. This will cause flaking of the gears and pump housing surfaces, causing yet more damage. When gear and housing surfaces are damaged, this allows fluid to “slip” by the gears reducing the amount of flow the pump can create. This in turn can reduce the system pressure.

**4-1.3** Speaking of breather caps, it is important that the tank is vented. Fluid from the tank is forced into the pump with atmospheric pressure. If the tank fill hole is plugged, the fluid cannot flow into the pump. This can cause the jacks or a room to seem to move sluggishly. A plugged breather cap could cause cavitation which can damage the pump. A plugged breather cap can also slow the retraction of single acting cylinders by creating a back pressure in the tank. The diagnostics for the breather cap is most likely the simplest thing in our systems to diagnose. Just remove the breather cap and see if the system reacts better.



*Figure 9*

**4-2 VALVES:** Valves are separated into three basic categories, directional control valves, pressure control valves and flow or volume control valves. Valves are used to direct the flow of fluid and to control pressure or flow in the system.

**4-2.1 DIRECTIONAL CONTROL VALVES:** These valves simply control which way the fluid in the system goes. HWH uses three types of directional valves; lever operated manual valves, electrically controlled solenoid valves and valves operated with pressure.

**4-2.1.1 LEVER CONTROLLED VALVES** are simple valves that when a lever is moved it pushes a plunger that moves a ball off of a seat allowing fluid to move to or from a cylinder. When the lever is moved the other way, a spring returns the ball to the seat. The lever valves are mainly used to control leveling systems but can also be used to control room extensions.

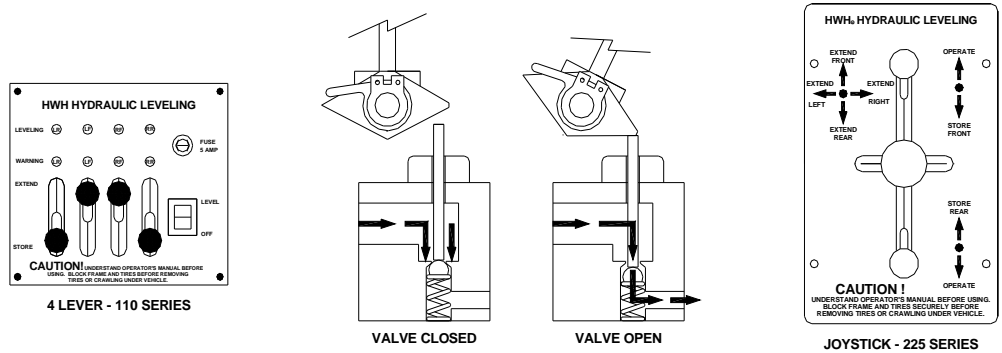


Figure 10

**4-2.1.2 ELECTRICALLY CONTROLLED SOLENOID VALVES** use 12 volts or 24 volts to energize a coil to operate the valve. All of the HWH solenoid valves are normally closed valves which means fluid cannot go by the valve when there is no power to the valve. When power is applied to the coil of the valve a magnetic field pulls a needle off a seat which allows fluid to move to or from a cylinder. When power is removed, a spring returns the needle to the seat and closes the valve. HWH has two solenoid valves, a large diameter valve and a small diameter valve. Both valves have a manual release nut to allow the valve to be opened in the event of an electrical failure. The large valve used to have a manual release t-handle. Both valves have two wires and are controlled by switching +12 (or +24). The large valve is presently used only for leveling systems but from 1995 until 2002 it was also used to operate room extensions. The small valve is used for leveling systems and is the only valve used to control room extensions at this time. Other than size, the main difference between the two valves is the orifice size in the seat. The small valves have a smaller orifice and flows a smaller volume of fluid. The small valve should only be used to replace another small valve. The present large valve with the valve release nut is used to replace any large round or hex shaped valve that HWH has produced except one. HWH made a large hex shaped valve from 1985 until 1993 that had a transistor on the exterior of the valve and was controlled by switching the ground for the valve. That valve has to be replaced with a like valve. To view all solenoid valves, refer to page MR55.2000 & MR55.2001 of the HWH parts manual.

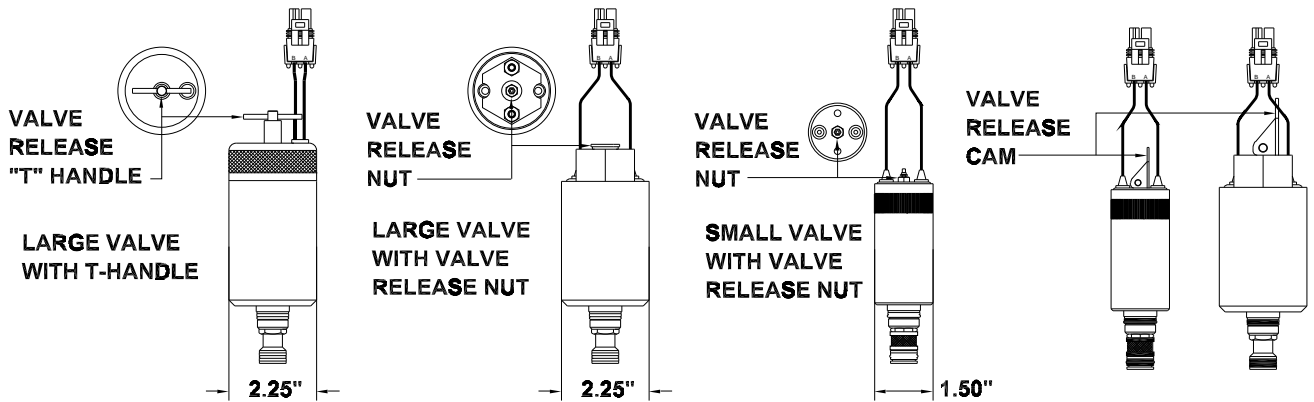


Figure 11

**Note:** As of May 2011 all large and small valves are equipped with the valve release cam lever.

It is important to note that all HWH valves, both lever and electrically controlled, are true zero leak valves. This means there should be no internal leakage of fluid past the seat of the valve.

**4-2.1.3 VALVES CONTROLLED WITH PRESSURE** that HWH uses have no mechanical or electrical controls. They are opened and closed with an increase or decrease in pressure. Some valves use a spring to move the valve as the pressure decreases. HWH uses two pressure controlled directional valves, a shuttle valve and check valves.

**4-2.1.3.1 The Shuttle Valve** is only used in electrically controlled leveling systems with solenoid valve manifolds. Although the shuttle valve is not used in room extension manifolds, the operation of the rooms that are used with a combination of a leveling manifold and room manifold power unit may be affected by a shuttle valve failure. The HWH pumps have two ports, a pressure port (fluid to the manifold) and a return port (fluid from the manifold back to the reservoir). The shuttle valve is used to block the return port from the leveling manifold. This allows the system to develop pressure so the leveling jacks can work properly. The shuttle valve also has to shift to allow fluid into the leveling manifold. Anytime the pump is running, the shuttle valve shifts. This allows fluid into the manifold and blocks the return port back to the pump. It takes approximately 800 psi of pressure to shift the shuttle valve. When the pump turns off, a spring arrangement in the shuttle valve shifts the shuttle valve back to the original position, pressure side blocked, and return side open.

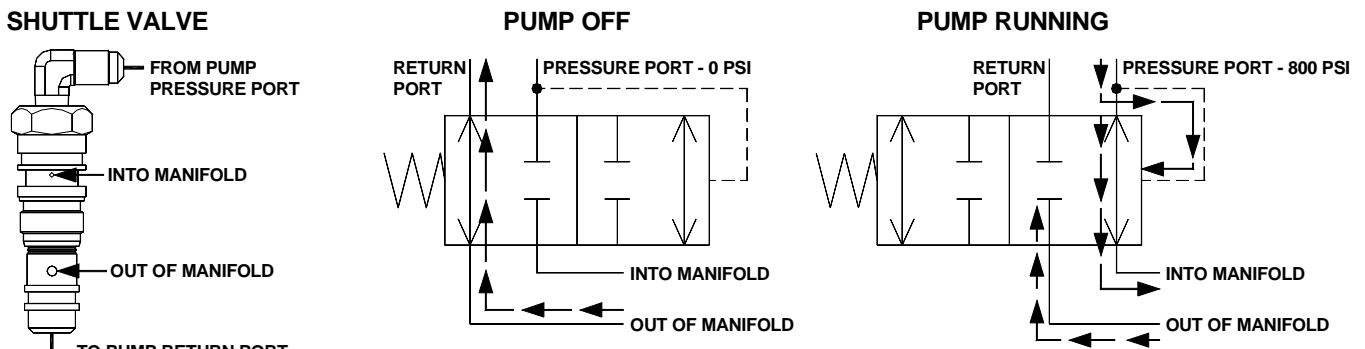
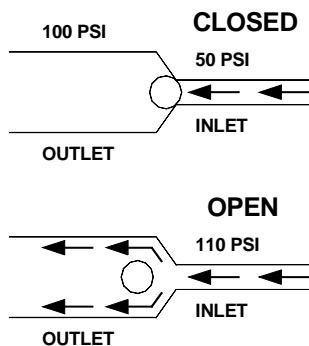


Figure 12

**4-2.1.3.2 Check Valves** are used in many different HWH components such as manifold assemblies, lever valve assemblies, kick-down jack actuators, room cylinder assemblies to name a few. A check valve allows the fluid to flow in one direction only. A check valve will open to allow fluid to flow by when the pressure on the inlet side of the check valve is greater than the pressure on the outlet side of the check valve. HWH uses two simple styles of check valves. One is a ball and the other is a poppet. Depending on the position of the check valve, some times a spring is used to help close the check valve. The original poppet style check valves used in hydraulic systems were a metal poppet with an o-ring. The present poppet check valves are made from a plastic type material with no o-ring. The new poppet can be used to replace the metal poppet.

**BALL TYPE CHECK VALVE**



**POPPET TYPE CHECK VALVE**

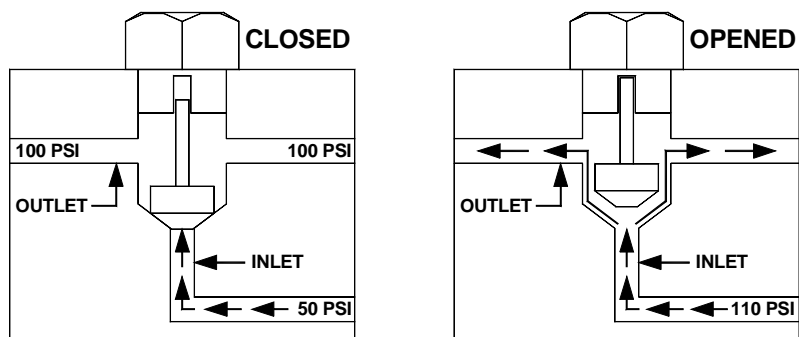
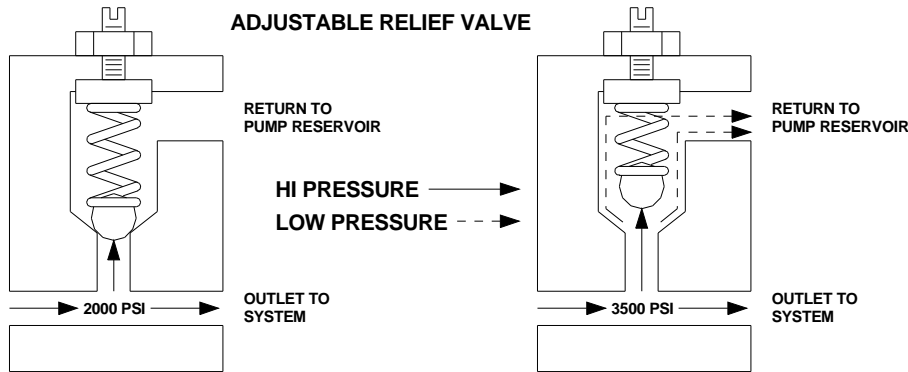


Figure 13

**4-2.2 PRESSURE CONTROL VALVES:** Pressure control valves are used to limit or reduce system pressure. Pressure control valves would include relief valves and pressure sequence valves. Pressure control valves can be adjustable or set at a specific pressure that cannot be changed.

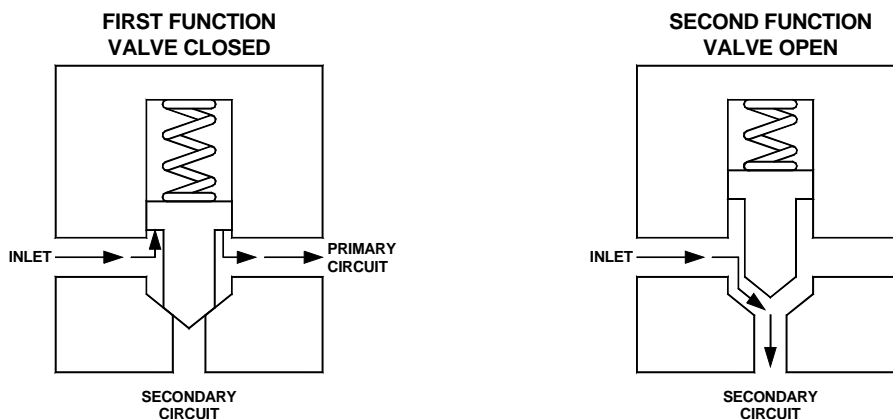
**4-2.2.1 RELIEF VALVES** are used to limit the amount of pressure in a hydraulic system. This is done to protect equipment from being damaged with too much pressure. The relief valve for HWH hydraulic systems is built into the pump. Most, but not all of the pumps used by HWH have an adjustable relief. Most, but not all pumps used by HWH have the relief valve set at 3500 psi. Some pump relief valves are set at 3000 psi and some are set at 2500 psi or lower. The relief valves are set at the pump manufacturer’s facility or at HWH and should not be changed in the field. If the pump pressure is low when checked and the pump is equipped with an adjustable relief valve, it may be possible to increase the pressure to the proper setting. HWH should always be consulted before adjusting a relief valve and the relief valve should never be adjusted unless a pressure gauge is available to check the pressure.



*Figure 14*

The relief valve stays closed until the system pressure increases enough to overcome the relief valve spring. At this point, the valve opens enough to allow a slight amount of fluid to return to the reservoir. This prevents any further rise in system pressure. As the pressure drops below the spring tension, the valve closes. When the pump is running under a full load, the relief valve opens and closes rapidly. This causes the harsh noise heard when the pump is running under full load.

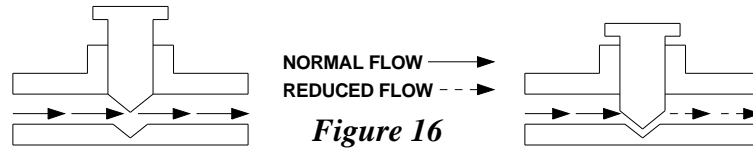
**4-2.2.2 PRESSURE SEQUENCE VALVES** are used to control the flow of fluid to a different branch of the circuit at a specific time. This is done so one function can be performed before another function takes place without using a separate control valve. HWH uses sequencing valves in kick-down jack actuators and room lifting mechanisms for level out style rooms. The HWH sequencing valves are not a replaceable valve. They are an internal part of the component it is used in. The sequence valve used in the jack actuators is a special valve and will be discussed later when actuators are addressed.



*Figure 15*



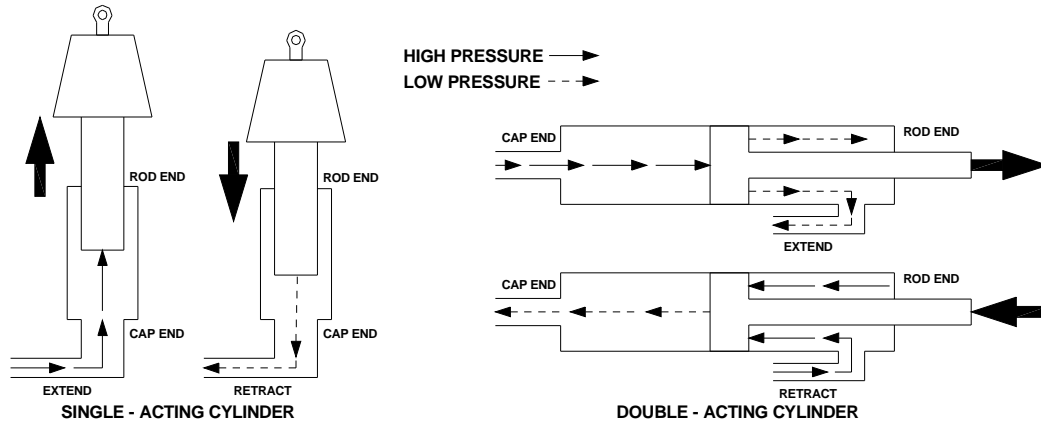
**4-2.3 FLOW (VOLUME) CONTROL VALVES** are used to regulate the flow of the fluid. By changing the flow, the speed a component moves can be controlled. In most cases, HWH reduces the flow to slow the movement down. We use fixed flow control, adjustable flow control and a variable flow control valve. The variable flow valve is called the velocity valve and is used in leveling systems to slow the retraction of the jacks when they are under a load. As the load decreases, the valve opens to allow a more natural flow of fluid back to the tank. This makes it so the vehicle will not drop so fast when the valves are first opened to retract the jacks. Adjustable flow valves are used to slow down room movement and fixed flow valves are used on step cover cylinders and the 500/510 computerized leveling system when stabilizing the vehicle.



*Figure 16*

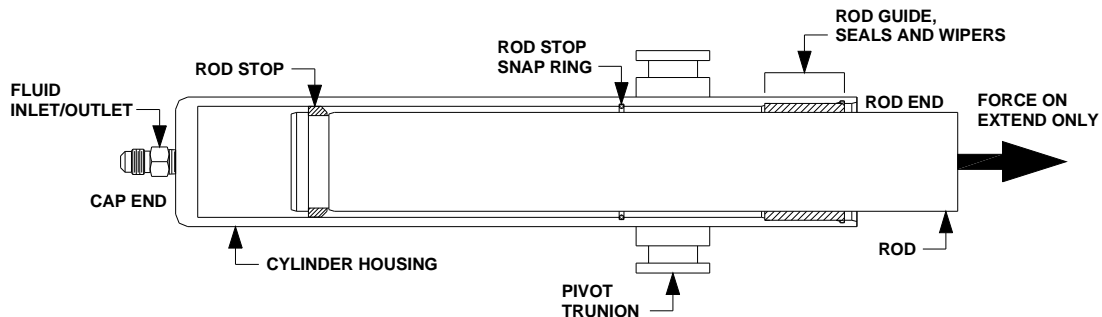
### 4-3 CYLINDERS

**(INCLUDES JACKS AND KICK-DOWN JACK ACTUATORS; ROOM EXTENSION AND SYNCHRONIZING CYLINDERS):** The cylinders convert hydraulic power into mechanical power to level a vehicle or move a room or other component. There are two basic types of cylinders, single-acting (one way) and double-acting (two way) cylinders. When discussing either the single-acting or double-acting cylinder, we will refer to the ends of the cylinder as the *cap end* or *rod end* of the cylinder. The rod end is the end the rod extends from and the opposite end is the cap end.



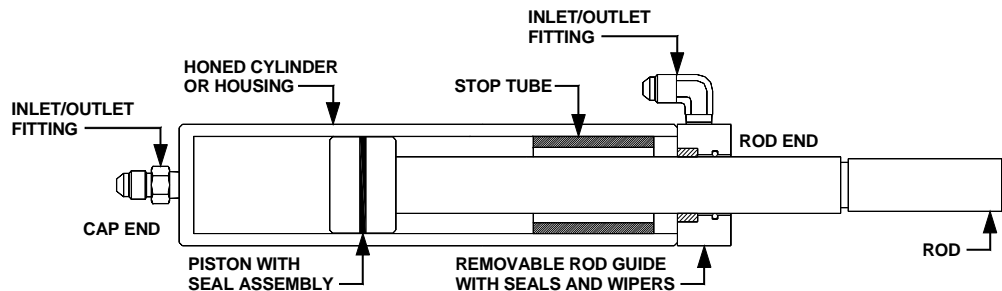
*Figure 17*

**4-3.1 SINGLE-ACTING CYLINDERS** for the most part are only used for leveling system jacks. Although no cylinders used to extend and retract rooms are single-acting cylinders, some HWH room lifting mechanisms are single-acting cylinders. Single-acting cylinders provide force in only in one direction, when the rod is extending. There is only one inlet fitting for fluid. It is at the cap end of the cylinder. When the rod is retracted, fluid is pushed out of the cylinder through the same fitting. The hydraulic pump in the system only runs when the rod is extending. A force such as gravity or the use of a spring is used to retract the rod. Single-acting cylinders are easier and less expensive to build and maintain. In most cases, it is easier to retract a single-acting cylinder than a double-acting cylinder in the case of an electrical or hydraulic failure.



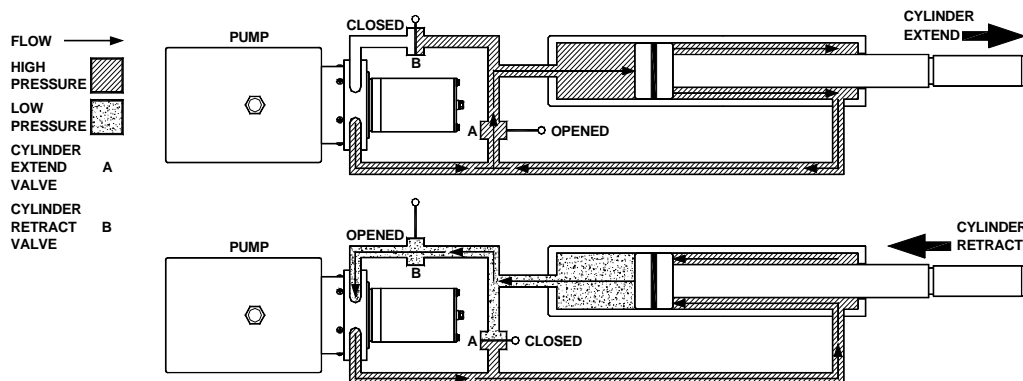
*Figure 18*

**4-3.2 DOUBLE-ACTING CYLINDERS** are used mainly for room extension and locking cylinders. In 2007 HWH started using double-acting cylinders for landing gear on fifth wheel type trailers. Double-acting cylinders provide force both when extending and retracting. There is an inlet/outlet fitting at the cap end and rod end of the cylinder. The rod is equipped with a sealed piston that isolates the cap end from the rod end of the cylinder. To extend the cylinder, system valving directs fluid under pressure into the cap end of the cylinder and releases fluid from the rod end of the cylinder returning the fluid to the reservoir. To retract the cylinder, system valving directs fluid under pressure into the rod end of the cylinder and releases fluid from the cap end of the cylinder returning the fluid to the reservoir. The double-acting cylinder is also used when a regenerative hydraulic circuit is used. The regenerative cylinder operates differently when extending and is discussed in the next segment. The double-acting cylinder is more complicated and expensive to produce. The cylinder bore must be precisely honed to maintain a good piston seal between the cap and rod end. Leakage by the piston seal in a double-acting cylinder will cause a cylinder to become “weak” and may cause cylinders to creep out. The sizing of the rod and piston may need to be larger to maintain the proper lifting capacity yet give adequate side load capabilities. It takes more or different valving to operate the double-acting cylinder. It also requires two hoses to each cylinder instead of the one required for a single-acting cylinder. The use of a double-acting cylinder does eliminate the need for a return spring arrangement.



**Figure 19**

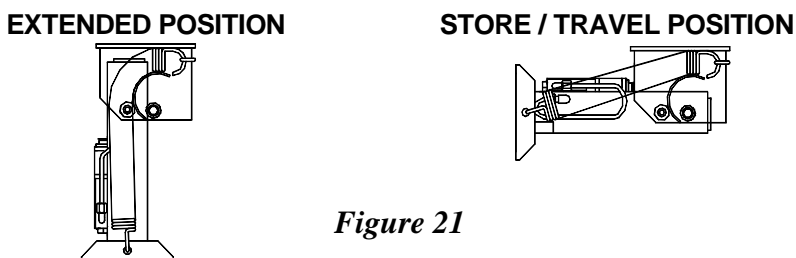
**4-3.2.1 Regenerative cylinder (room extension cylinders):** The difference between a normal double-acting cylinder and a regenerative cylinder is when extending, the system valving applies the same pressure to both the cap and rod ends of the cylinder. The reason the rod can extend is due to the fact that the surface area of the piston on the cap side is greater than the surface area of the piston on the rod side. When the formula  $F=PA$ , which was discussed earlier, is applied, it tells us there is more force on the cap side of the piston than on the rod side of the piston. A greater force will always move a lesser force. Thus, the piston and rod assembly extends. The force and speed the rod moves at can be changed according to the needs of the system by changing the ratio between the size of the piston and the size of the rod. The smaller the rod, the less the force developed would be, but the faster the rod would move. The larger the rod, the more the force developed would be, but the speed the rod moved would slow down. HWH room extension cylinders are built with a close to 2:1 ratio, piston to rod. This develops the same force and speed both when extending and retracting a cylinder. For a detailed study of the regenerative cylinder, review manual ML37939, “HWH Regenerative Hydraulic Circuit” in the “Educational Manuals” section of the HWH web site.



**Figure 20**

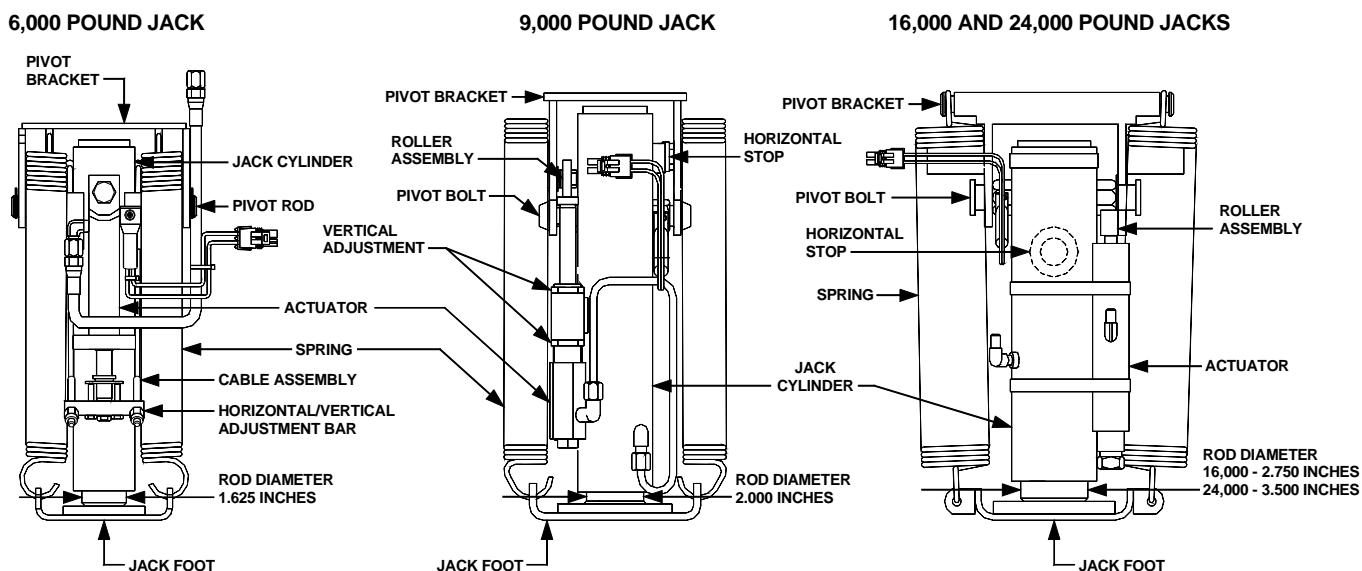
**4-3.3 JACKS** are used to lift, level and/or stabilize vehicles. They are used on motorized and towable vehicles. HWH provides leveling and landing gear systems for motor homes, travel trailers and fifth wheels, auto and horse trailers, specialty vehicles for medical, civil and military purposes, broadcast vehicles and many other uses. Jacks are split into three basic categories, kick-down jacks, fixed jacks and pivot style straight-acting jacks.

**4-3.3.1 Kick-down jacks** store to a horizontal position for moving the vehicle. When needed, the jacks fold down to a vertical position. All kick-down jacks are designed to allow the vehicle to move forward or backward off the jacks without damaging the jacks. The kick-down jacks have to be mounted so they swing up to the rear of the vehicle. If the hydraulic hoses and wiring harnesses are not routed properly, they can be damaged when the jacks are used or if the vehicle rolls off the jacks. Kick-down jacks should not be used on non-motorized vehicles. Vehicles with kick-down jacks depend on the vehicle's parking brake to keep the vehicle from rolling off the jacks. The vehicle should always be parked with the rear of the vehicle low if the jacks are to be used. Lifting the rear of the vehicle too high will allow the vehicle to roll off the jacks.



*Figure 21*

Kick-down jacks do not mount directly to the vehicle frame. Some type of mounting bracket must be used. The jack has a pivot bracket which mounts to the frame mounting bracket. The jack cylinder mounts to the pivot bracket with a pivot bolt assembly or a pivot rod. A hydraulic actuator which is mounted to the jack cylinder is used to “kick” the jack down to the vertical position. The actuator pushes against a roller or a cable assembly to swing the jack vertical. A pair of springs retract the jack to the horizontal position. The springs attach to the pivot bracket and the jack foot. The jack feet are fixed and welded to the rod. Early jacks up until 1987 used a mechanical linkage to “kick” the jack down. This mechanism will NOT be discussed as there are no repair parts available nor can the jack be repaired at HWH. Sometimes a lot of elbow grease and several cans of WD-40 can bring this jack back to life. Refer to ML9547, “Maintenance for the AP1206 Mechanical Kick-down Jack” repair sheet found in the “Information Bulletins” section of the HWH web site. This jack is replaced with the AP7001, 9000 pound capacity kick-down jack. Kick-down jacks are available in four weight capacities, 6000 pounds, 9000 pounds, 16000 pounds and 24000 pounds.

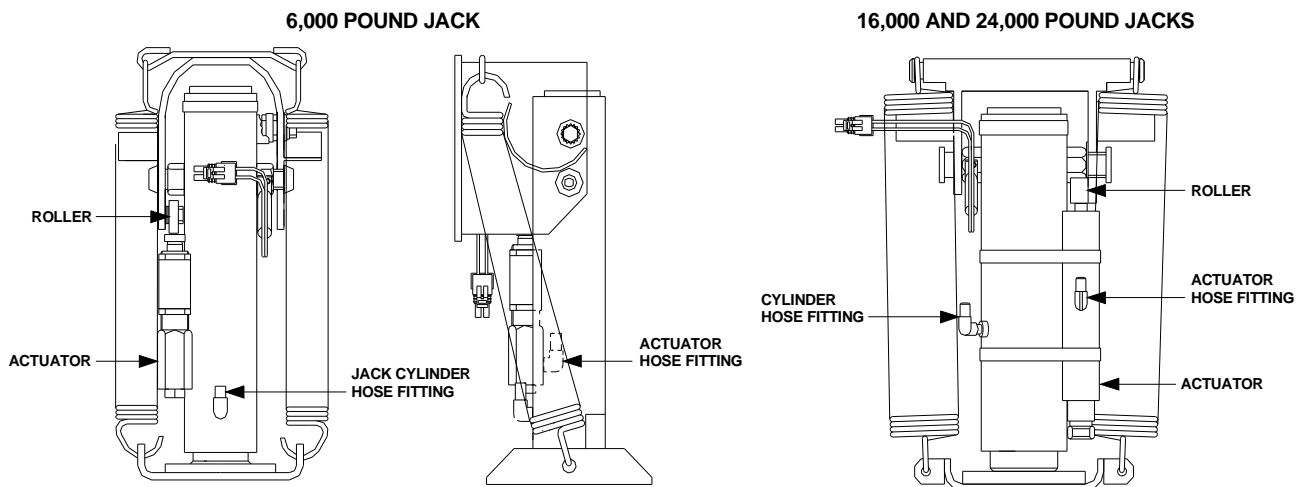


*Figure 22*

All kick-down jacks have two adjustments that need to be checked and made, if necessary, either after the initial installation or replacement of a jack during a repair; the horizontal and vertical position. When the jack is in the **horizontal position**, it needs to have a little downward tilt. This allows the actuator to work properly. Also, the foot of the jack should be able to fully extend while in the horizontal position, without contacting any part of the vehicle, including holding tanks, shields and suspension components. Remember, these jacks can produce from 6000 to 24000 pounds of force, depending on the jack, and can do a lot of damage, just imagine a black water tank, if they extend without swinging down. This failure is possible if there is an actuator malfunction. When the jack is in the **vertical position**, it should be as straight up and down as possible. This is important for visual appearances and if the jack is at too much of an angle, the jacks may push the vehicle off of the jacks as they extend. Refer to MI95.62 “Information Bulletin- Horizontal and Vertical Adjustments for Kick-down Jacks” in the “Information Bulletins” section on the HWH web site under “Hydraulic Jack Information”. When a kick-down jack cylinder needs to be replaced, the complete jack should be replaced. If an actuator needs to be replaced, only the actuator should be replaced.

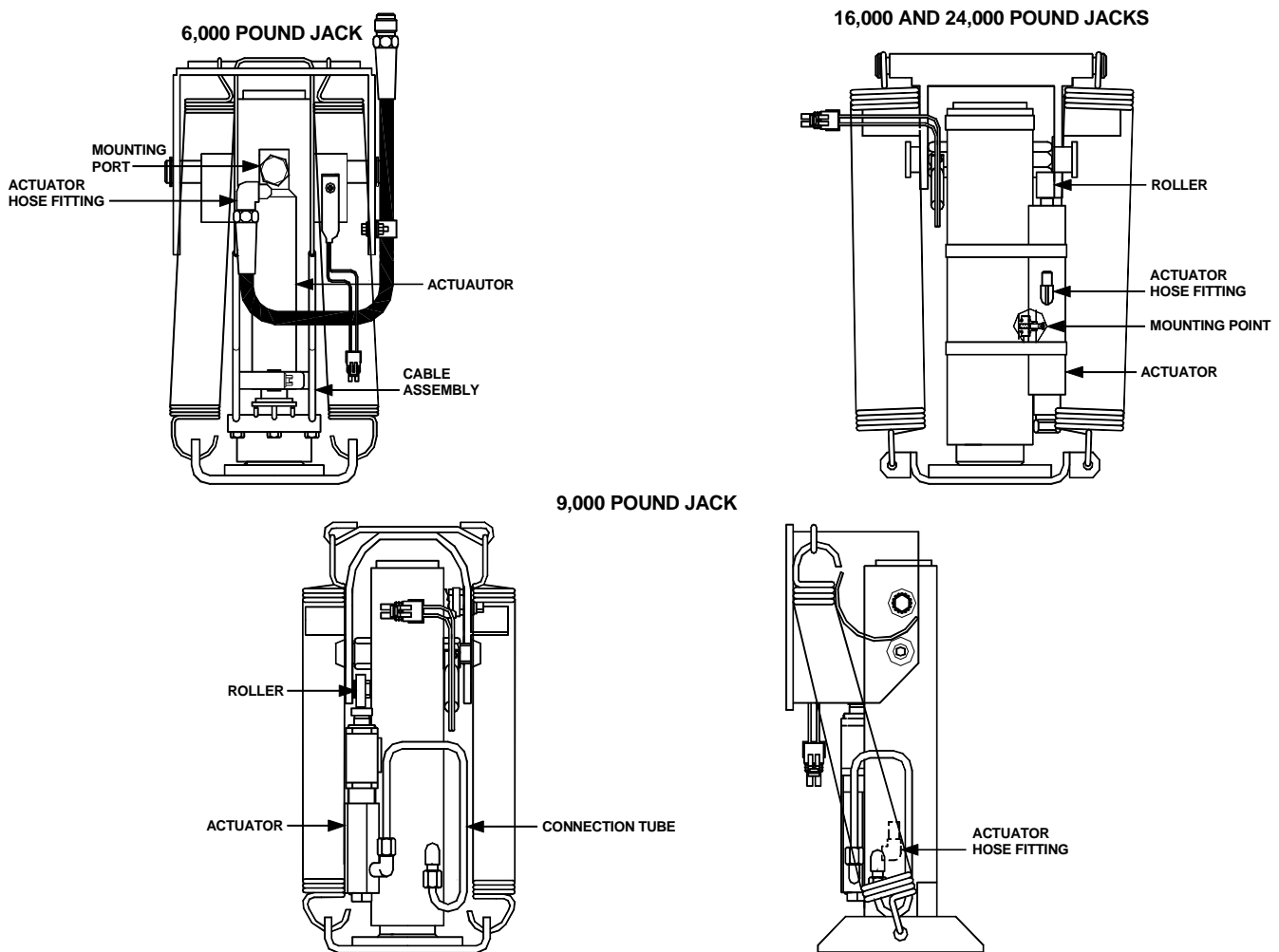
**4-3.3.2 Kick-down Jack Actuators** are a single-acting cylinder that is used to move a kick-down style jack to the vertical position. Each different capacity jack has a different style actuator. The early 400 and 500/510 automatic (computerized) leveling systems used two hoses to each jack, one for the actuator and the other for the jack cylinder. All manually controlled (lever or push button) leveling systems and all newer automatic leveling systems since the 500/510 system only use one hose to each jack. The single hose supplies fluid to the actuator and then through the actuator into the jack cylinder. These actuators are not interchangeable. The correct actuator must be used to make the system function properly.

**4-3.3.2.1 The two hose jack actuators** are very simple single acting cylinders. Only the 9000, 16000 and the 24000 pound jacks use these types of actuators. The 6000 pound jack was never used on the older automatic leveling systems. The actuator rods for these jacks push against a roller assembly. When the actuator control valve is open and the pump is running, fluid is directed to the actuator. When sufficient pressure builds up, the actuator rod extends, pushing against the roller assembly. This forces the jack to the vertical position. When the actuator control valve is open and the pump is not running, the jack springs force the actuator rod to retract as the jack foot is pulled up and the jack swings back to the horizontal position. There is only one valve for all actuators in these systems. The jacks will randomly swing to the vertical position. **It is important to note that due to the design of the 16000 and 24000 pound jack actuators, if the foot of the jack is not on the ground when the jack cylinder reaches full extension, the jack will swing back to the horizontal position.**



**Figure 23**

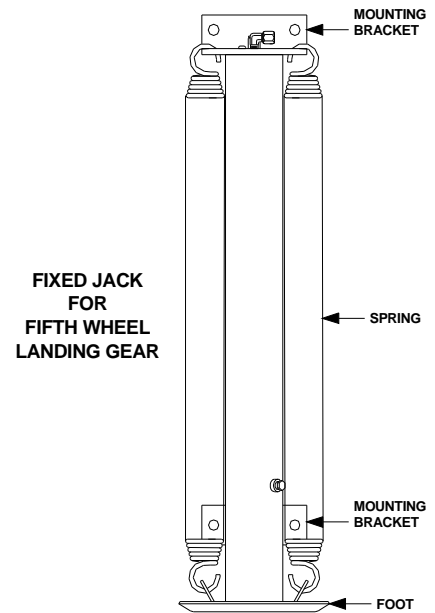
**4-3.3.2.2** The *single hose jack actuator* is more complicated than the two hose jack actuator. The single hose jack actuator, like the two hose jack actuator, is a single acting cylinder. The difference is the single hose jack actuator has a special sequencing valve built into it. This valving allows the jack to swing to the vertical position before fluid is directed through the actuator to the jack cylinder. This enables us to rout only one hose to the jack instead of two. On a 9000 pound jack, the actuator is hydraulically connected to the jack cylinder through a steel tube. On 6000, 16000 and 24000 pound jacks, the actuator is hydraulically connected to the jack cylinder directly through an open mounting port. When pressure to the actuator reaches somewhere between 500psi and 900psi, the actuator rod will produce enough force to kick the jack vertical. The actuator rod must be fully extended before the sequencing valve can open. Depending on the style of actuator, the sequencing valve will start to let fluid into the jack cylinder between 1050psi and 1500psi. The jack will start to extend and lift the vehicle. As the pressure approaches 2000psi, the sequencing valve will open completely allowing full pressure and flow into the jack cylinder. This is why sometimes you will notice a “bump” as a jack gets closer to full extension. When operating two jacks at once as with our Bi-axis style leveling systems, because of tolerances used when building actuators, it is possible for one jack to kick vertical and start to extend before the other jack kicks vertical. This is permissible as long as the first jack does not lift the vehicle more than an inch or less before the other jack kicks down and catches up.



**Figure 24**

The above section explains how the actuators work. When diagnosing actuator problems, the pressure amounts given above should not be used. They are approximate values and will cause you problems if you try to use them for diagnostics. When diagnosing actuator problems, the most important thing to remember is; ***“If the system is static, no cylinders moving, the pressure to all parts of the system that are hydraulically connected is the same and if a cylinder is moving, the fluid has got to be coming from somewhere.”***

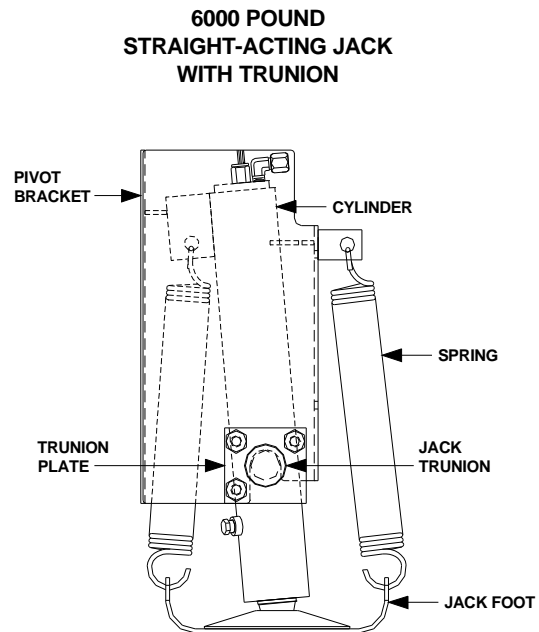
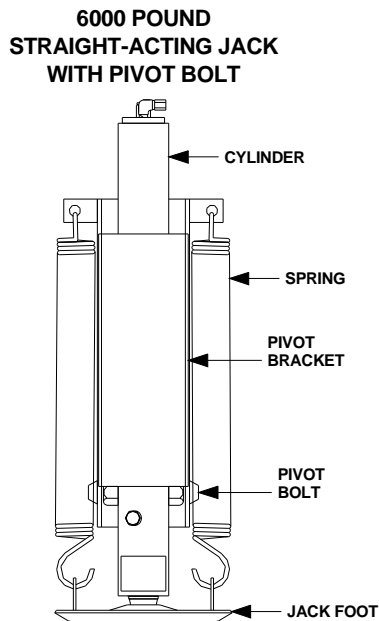
**4-3.3.3 Straight-Acting jacks (Fixed jacks)** are jacks that have no pivoting capabilities at the mounting point of the jack. Most jacks will have a pivoting foot but in some cases the foot of the jack is welded to the jack rod. Fixed jacks are available in single acting cylinder and double acting cylinder versions. The most common version at the time of this paper is the single acting cylinder. The most common use for fixed jacks is landing gear and jacks for fifth wheel trailers and travel trailers. Fixed jacks have also been used with 3 jack systems and specialty systems on motorized vehicles. The fixed jacks are available in sizes ranging from 6000 to 24000 pound capacities. Because fixed jacks are used as landing gear for trailers, the rod size for different capacities is not the same as the rod size for kick-down and pivoting style straight-acting/pivoting jacks with the same capacities. Refer to the HWH parts catalog for rod size information on fixed jacks. The mounting brackets for fixed jacks are part of the jack cylinder. When replacing a fixed jack, the complete jack must be replaced. Double acting fixed style jacks will not have springs.



**Figure 25**

**4-3.3.4 Straight-Acting/pivoting jacks (Pivot style)** are the most common jacks now used. At this time, straight-acting/pivoting jacks are only available with a single acting (one way) cylinder. These jacks offer greater stability than the kick-down jacks. They also have a pivoting foot that will be considerably larger than the foot on a kick-down jack. Until 2006, the jack foot was held onto the cylinder with the return springs. Starting in 2006, some straight-acting cylinders have the jack foot bolted onto the rod. The foot still pivots. This was started with the 24000 pound jack but eventually all straight-acting jacks will have the foot bolted on. Replacement cylinders will have an adaptor ball included when used to replace an older cylinder that does not have a bolted on foot. A vehicle with the straight-acting/pivoting jacks can be leveled from any parking position. The vehicle cannot roll off the jacks. That is also the only real disadvantage to the straight-acting/pivoting jacks. If the vehicle is moved with a straight-acting/pivoting jack on the ground, the jack and/or vehicle can be damaged. The straight-acting/pivoting jack allows the cylinder to move as the vehicle moves. This reduces stress on the vehicle frame and the jack itself. That is why the straight-acting/pivoting jack is preferable over the fixed style jack. Double-acting pivoting jacks may be available sometime. They will not have springs.

With a straight-acting/pivoting jack, the cylinder actually pivots in a bracket that mounts to the frame of the vehicle. This is referred to as the pivot bracket. The amount of pivot ranges from about 3° to 7° on various jacks. This is why you will note that the straight-acting/pivoting jack extends at a slight outward angle instead of straight up and down. The amount of pivot the jack is capable of depends on the bracket style and cylinder used. Early straight-acting/pivoting jacks were mounted to the pivot bracket with a pivot bolt assembly. The only jack that still employs the pivot bolt is the 24000 pound capacity jack. Most other straight-acting/pivoting jacks now have a trunnion welded to the cylinder and a trunnion plate bolts to the pivot bracket to hold the cylinder in place. There are many different straight-acting/pivoting jacks available. Many pivot brackets are designed for a specific vehicle with a specific chassis. Straight-acting/pivoting jacks are available in 3000, 4000, 6000, 9000, 12000, 16000 and 24000 pound capacities. The 3000 and 4000 pound capacity jacks are specially designed for use on smaller vehicles with minimal mounting space and ground clearance available. The 3000 pound jack uses a cable assembly to hold the cylinder into the pivot bracket and to give the jack ample stroke with a shorter mounting capability. The 4000 pound jack uses a telescoping rod to give the jack ample stroke with a shorter mounting capability. When a straight-acting/pivoting jack cylinder has a problem such as a leak, only the cylinder should be replaced. The only time a pivot bracket should be replaced is if the bracket is damaged.

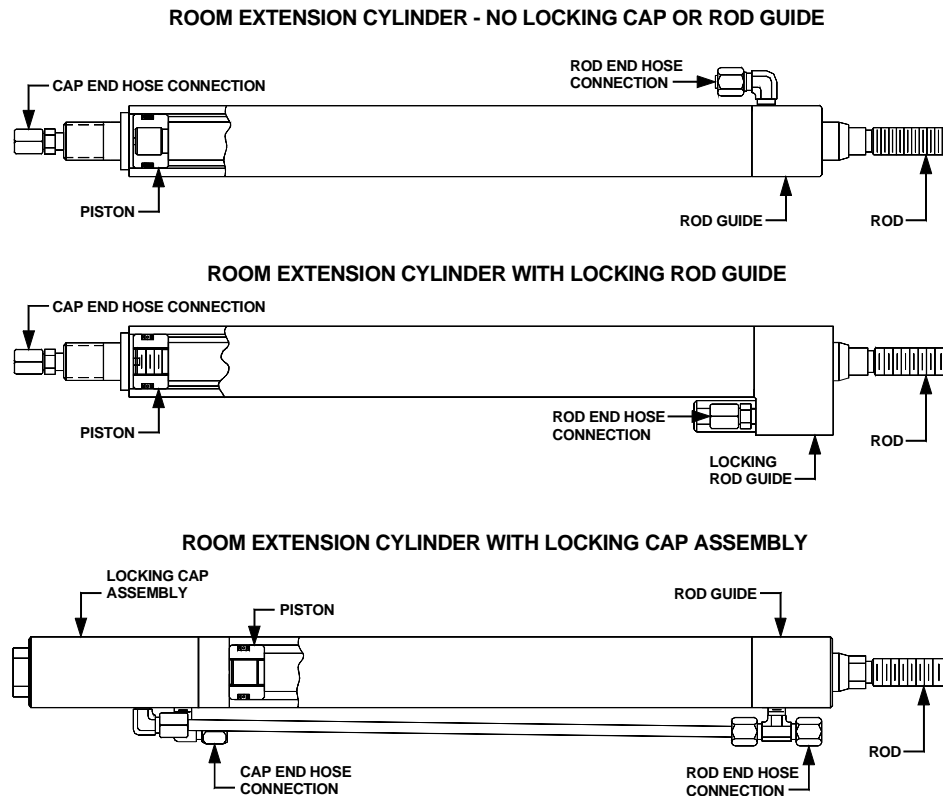


*Figure 26*

**4-3.3.5 JACKS WITH DOUBLE-ACTING CYLINDERS.** At the time of the original publishing of this lesson, the use of double-acting cylinders for leveling system jacks was not common. HWH now is using double-acting jacks more often, especially with trailer systems and for specialty vehicles. Double-acting jacks like room extension cylinders are operated as a “**regenerative**” cylinder. Double-acting jacks are available as fixed, straight-acting jacks or as straight-acting/pivoting jacks. Jacks with double-acting cylinders **WILL NOT** have return springs. Like other jacks, double-acting jacks are available in a variety of sizes and different strokes.

**4-3.4 ROOM EXTENSION CYLINDERS** are always a double acting cylinder. “Room extension” cylinders are obviously used in room extension mechanisms but are also used in generator slides, step covers, door and bed lifts and many other mechanisms. Most room cylinders are used with a regenerative hydraulic circuit. See “**Regenerative cylinder**” in this section. Sometimes, if a vehicle has only one HWH extension device and no hydraulic leveling system, a reversible pump with no solenoid valves is used. Room extension cylinders are available in three different sizes at this time. There is a cylinder with a  $\frac{9}{16}$  inch rod and a  $\frac{3}{4}$  inch piston, a cylinder with a  $\frac{7}{8}$  inch rod and a  $1\frac{1}{4}$  inch piston and a cylinder with a 1 inch rod and a  $1\frac{1}{2}$  inch piston. The cylinder which is needed is determined by the mechanism it is used in and/or the force needed to move the room or other type of equipment. The number of different room cylinders available would seem to be virtually unlimited. The design of our room mechanisms uses the complete stroke of the cylinder to determine how far the mechanism can move when the cylinder is extending. Thus, the cylinders always extend as far as physically possible. The same basic cylinder can be used for many different stroke lengths. The actual stroke the cylinder will produce is determined by a stop tube inside the cylinder. This is not something that should be changed in the field. It is very important the correct cylinder is obtained when replacing a cylinder because two cylinders that look exactly the same may not have the same stroke.

Some room cylinders are equipped with an internal locking device which prevents the room (not cylinder) from extending in the event of some type of hose failure that would cause the loss of pressure and fluid to the room cylinder. The “lock” is actually a relief valve that opens at about 1000psi to allow the fluid to move from the rod or cap end of the cylinder as necessary under normal operation. Some cylinders have the lock on the rod end and some on the cap end. If extending the cylinder extends the room, the lock is on the rod end of the cylinder. If retracting the cylinder extends the room, the lock is on the cap end of the cylinder. In either case, the 1000psi must be on the rod side of the hydraulic circuit for the lock to operate. If the locking valve is in the rod guide, the pressure is applied directly at the rod guide. If the lock is at the cap end, the fluid supply for the rod end goes into a tee at the rod guide and is then directed to the cap end lock. This does not directly affect the cap end pressure or flow. The rod end pressure is completely isolated from the cap end fluid supply. ***If the cylinder has a locking rod guide, the cylinder cannot be extended without pressure to the rod guide fitting. If the cylinder has a locking cap, the cylinder cannot be retracted without pressure to the rod guide fitting.*** This is an important thing to remember if you are working on a room mechanism or replacing a room cylinder. If there is a failure with a cap end lock, it may be necessary to actually cut the extended cylinder rod.



*Figure 27*

**4-3.5 SYNCHRONIZING CYLINDERS** are used to make multiple cylinders move together. Synchronizing cylinders are commonly referred to as the “sync cylinder”. A sync cylinder is used anywhere it is necessary to have two or more cylinders move at the same speed. They are used for room extensions, floor lift cylinders, door lifting mechanisms, generator slides and many specialty mechanisms. For a detailed review of the sync cylinder see: ML37955 “HWH Synchronizing Cylinder” in the “Educational Manuals” section of the HWH web site. The sync cylinder has one piston for each operating cylinder in the hydraulic circuit. For example, if there are two room extension cylinders for one room, the sync cylinder for that circuit will have two pistons. The principle is simple; ***if the same amount of fluid is directed at the same time, to or from two (or more) cylinders that are the same size, both cylinders will move the same distance at the same speed.***



The sync cylinder is like two double acting cylinders of the exact same size hooked end to end. The two pistons are physically tied together with a rod or hollow tube. When one piston moves, the other piston has to move the same speed and distance. Thus, the same amount of fluid at the same speed is moved two or from the room cylinders. The sync cylinder is designed to allow fluid to flow through or by the pistons when the sync cylinder is fully extended or retracted. In essence, this turns the sync cylinder into a tee fitting. This allows one room cylinder to move even through the other room cylinder cannot move (the cylinder fully extended or retracted) and resynchronizes the room or lets the room seal properly at both ends of the room. The sync cylinder makes up for manufacturing tolerances in the room extension mechanism or the room itself and other operating issues such as the weight of the room, room seals and awnings.

There are two types of sync cylinders. The original sync cylinder has a visible rod which extends and retracts when the sync cylinder is in use. This sync cylinder tube is the same size the full length of the cylinder. The new style sync cylinder has no visible rod. This sync cylinder has two different diameter tubes. This is because one piston has to be larger than the other piston to make up for the volume of the rod that is not there anymore. Both styles of sync cylinders do the same thing, they just accomplish the job with slightly different internal equipment. Neither style sync cylinder is serviceable in the field.

It is important that the sync cylinder is properly sized for the stroke of the room. How wide the room is does not matter. To allow the room to synchronize itself properly, the synchronizing valves in the pistons need to open slightly before the room is fully extended or retracted. We like to make this about one inch before the room is fully extended or retracted. If the stroke of the sync cylinder is too short, the synchronizing valves will open too soon, the room will run in an unsynchronized manner for too much of the stroke which may allow the room to rack. If the stroke of the sync cylinder is too long, the synchronizing valves will never open and the room cannot resynchronize. One end of the room may not extend or retract all the way and seal properly. Also, the sync cylinder is a larger diameter than the room cylinders. This means the stroke of the sync cylinder is not a 1 to 1 ratio with the stroke of the room cylinders (the sync cylinder rod does not move the same distance as the room cylinder rod). When replacing sync cylinders, the correct sync cylinder must be used. If there is any doubt, HWH should be contacted to get the correct information.

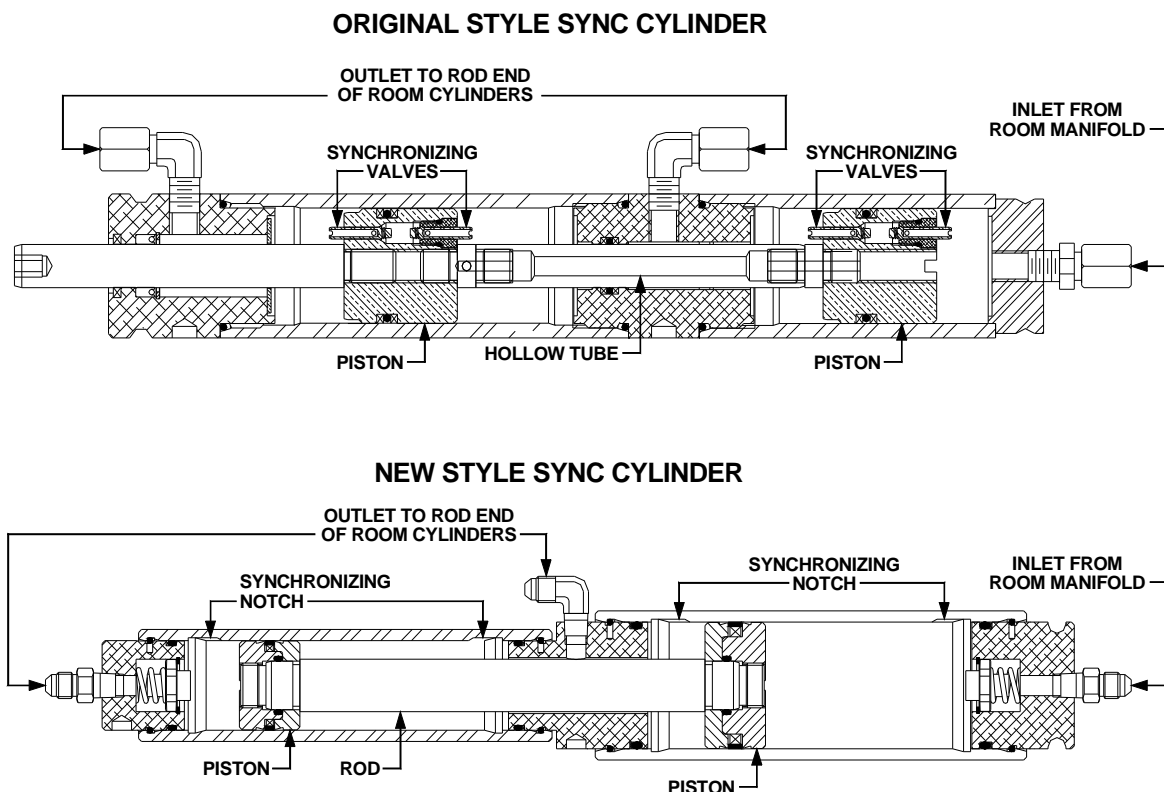
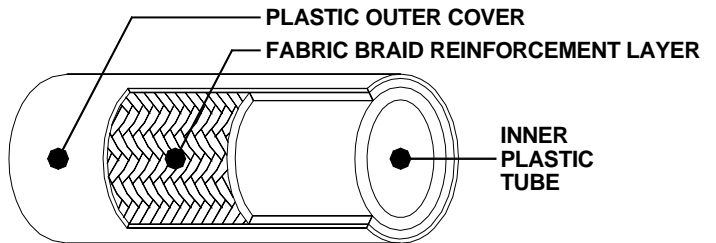


Figure 28

**4-4 HOSES:** Hoses are used to transfer fluid through the system. In lever controlled systems, from the pump to the valves then to the cylinders. In button or switch controlled systems, the valves and pump are one unit called the power unit. The hoses transfer the fluid between the power unit and the cylinders in the system. Although short pieces of steel tubing are used for some applications, HWH uses several different sizes and ratings of flexible hose depending on the flow and pressure requirements of the system. In some cases a smaller, more flexible hose or steel tube may be used because of space limitations or bending requirements of a mechanism.

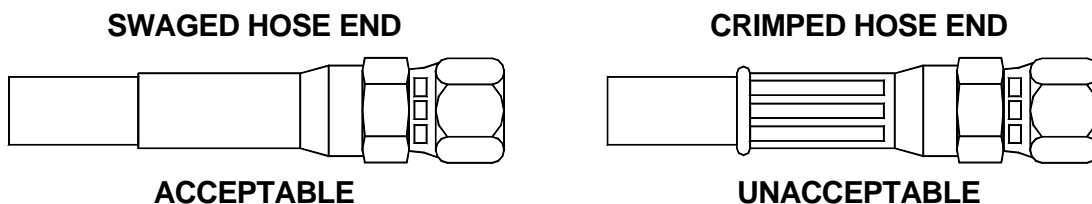
**4-4.1** The hose HWH uses is composed of three basic layers; an inner tube, the reinforcement layer and the outer cover. The inner tube is a plastic material. The reinforcement layer is a fabric braid. The outer cover is a plastic cover that will resist some heat splatter such as from welding. HWH hose has a heat tolerance of about 180° Fahrenheit. Constant temperatures exceeding this can damage the hose and create leaks especially at the hose ends. Bubbling of the outer cover is usually an indication of a heat issue. Engine or exhaust heat and even engine cooling systems (the engine radiator) can cause heat issues.



*Figure 29*

**4-4.2** For warranty purposes, HWH requires that the hose, hose ends and swaging equipment are supplied by HWH. When the system is out of warranty HWH highly recommends the use of hose and equipment supplied by HWH. There are two main reasons HWH requires or recommends this. The hose HWH uses has the capability to expand slightly under pressure. Solid tubing or steel braided lines will not do this. The expanding of the hose acts like an accumulator in the system. Example: A jack cylinder is extended as far as it is capable. The jack was extended when the temperature was 40°. Later in the day the temperature rose to 70° (this vehicle must be parked in Iowa). Remember, an increase in temperature will increase the volume of fluid in the system and fluid cannot be compressed (at least not very much). The increase in the volume of fluid in the hose between the jack and its valve has to go somewhere. Without the expandability of the hose, the increase in volume will increase the pressure in the hose. This could cause a seal or valve to leak which is unacceptable. The use of a short piece of steel tube in the system is acceptable as long as it is combined with a piece of HWH hose at least 6' in length. The second reason is the construction of hose assemblies. The HWH hose is easily cut with a scissors type tube or hose cutter. Steel braided hose is usually cut with some type of hacksaw or abrasive cutoff tool. This creates debris that can end up in the hose. This debris can get into valves causing damage to the seat and create an internal leak. This will allow jacks to retract or rooms to creep in or out when the movement is not wanted.

**4-4.3** HWH requires the hose ends to be swaged on instead of crimping the ends on. The crimping of ends onto a hose seems to be a more common practice than swaging, but HWH feels the swaged end is a more reliable end for the type of hose HWH uses and the pressures the hose assemblies have to function at. Please do not compare what HWH does with other systems. Where appropriate, crimping would be perfectly acceptable, just not on HWH systems.

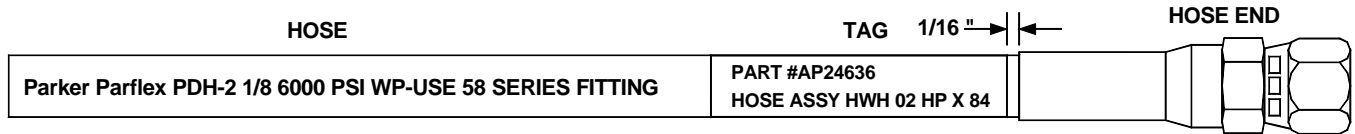


*Figure 30*

**4-4.4** HWH hose is easily identified by the printing on the outer cover of the hose. Also, hose assemblies made at HWH will have a part tag with the part number, size and length of the hose assembly. This part tag should be within  $\frac{1}{16}$  of an inch of the hose end. If the tag is further away from the hose end, the hose should not be installed. Refer to ML24976 “HWH CORPORATION-HYDRAULIC HOSE/FITTING/SWAGING GUIDE” for a complete guide to identify HWH hose and to obtain the correct hose ends and swaging equipment for repair of hoses. If the correct hose ends or equipment is not available, do not attempt to repair a HWH hose, replace the complete hose assembly.

Example: **HOSE: M50022P 1/8” High Pressure (Currently Used)**

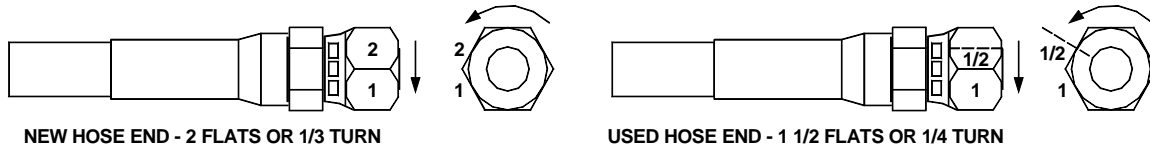
**Print on Hose: “Parker Parflex PDH-2 1/8 6000 PSI WP-USE 58 SERIES FITTING”**



**THIS IS A 1/8 INCH HIGH PRESSURE PARKER HOSE ASSEMBLY THAT IS 84 INCHES LONG**

*Figure 31*

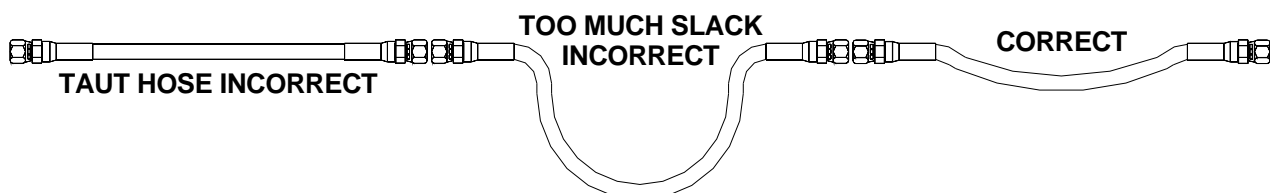
**4-4.5** The tightening of the hose end onto a fitting is probably the most common mistake made when installing a hose. If the hose end is new and has never been tightened onto a fitting, first make sure the threads of the hose end and fitting are clean and undamaged. Dirt or damaged threads may hinder the proper tightening of the hose end. Then, thread the swivel end of the hose end onto the fitting until the flares of the fitting and the hose end make contact, finger tight or snug. Finally, using backup wrenches as necessary to keep the hose from twisting or the fitting from moving, tighten the hose swivel 2 flats or  $\frac{1}{3}$  of a turn. Any more can damage the flare of the hose end and/or fitting causing a leak. If this happens, retightening will not stop the leak. The hose end and fitting should both be replaced. If the hose end being tightened has been used, follow the above instructions except only tighten the swivel 1 to 1 1/2 flats or approximately  $\frac{1}{4}$  of a turn. In no case should teflon tape or any thread sealant be used on hose ends.



*Figure 32*

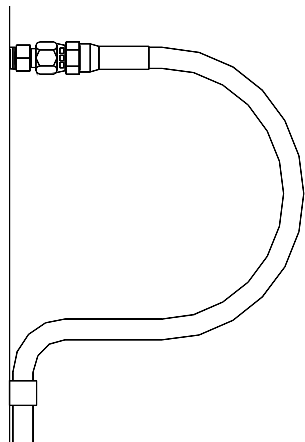
**4-4.6 Routing hoses:** The major cause of hose failure is due to improper hose routing. The following are 6 basic rules to follow when installing or replacing a hose:

**1. Do not pull hoses taut.** Always allow some slack when installing a hose. Consider the moving capability of the jack or room mechanism the hose is attaching to. Leave enough hose slack to accommodate this movement. Kick-down jacks require special hose routing. Straight-acting jacks can pivot slightly when lifting the vehicle. If the hose is too taut or clamped too close to a jack in the retracted position, the hose or fitting in the jack or actuator can be damaged as the jack kicks vertical or as a straight-acting jack moves while lifting the vehicle. A hose routed too tight to a kick-down jack may interfere with the jack moving to the vertical position. A tight hose between two no-moving points can create a strain on the hose or hose connection causing premature failure. The opposite is also true; **do not leave too much slack in a hose.** A dangling hose can create a hazard or cause serious damage if it catches while the vehicle is moving.



*Figure 33*

2. **Avoid loops or coiling extra hose.** Use hoses made to the correct length whenever possible. Use angle fittings where possible. If the equipment is available, cutting hoses to the correct length is preferred. Leaving extra hose in the circuit when not necessary will create more flow restriction due to the friction resulting from the longer hose. Using the correct length hose will also result in a neater looking installation.



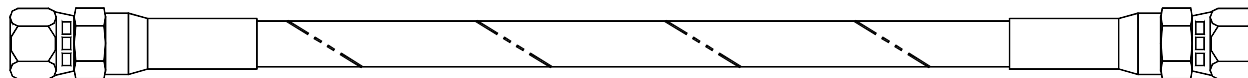
**INCORRECT**

*Figure 34*

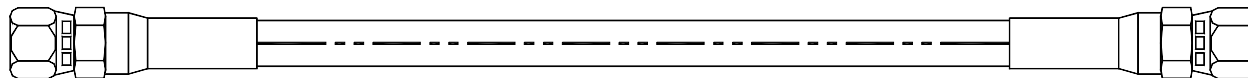


**CORRECT**

3. **Avoid twisting the hose:** Having a twist in a hose, especially a shorter hose, can damage the hose and/or loosen a connection. Use backup wrenches on hose ends and fittings when necessary to avoid twisting.



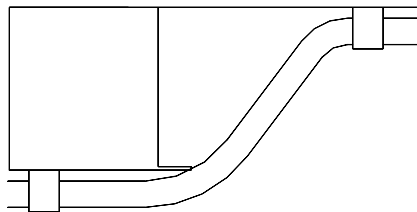
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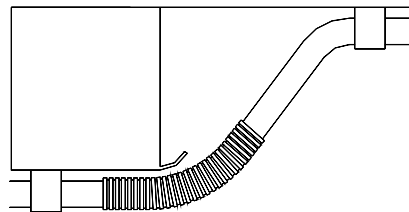
**CORRECT**

*Figure 35*

4. **Do not allow hoses to rub:** Make sure hoses will not come in contact with moving parts such as suspension components by using an adequate number of clamping devices; hose clamps, wire ties, etc. Avoid sharp edges when routing hoses. Dull the edge if possible and protect the hose with a hose guard such as split loom.



**INCORRECT**



**CORRECT**

*Figure 36*

5. **Stay away from heat sources:** Always rout hoses away from heat sources as far as possible. Even radiant heat can damage hoses. Use heat shields when necessary and when needed make sure the shield is large enough and installed in a manner that will protect the hose. An improperly installed heat shield can become a heat sink and cause more damage than if it had not been installed. HWH uses a simple rule; *there should be no direct line of sight from any HWH component to a heat source.* With heat issues, the most vulnerable part of a hose assembly is where the hose and hose end are swaged together. HWH hoses will withstand constant temperatures up to about 180° Fahrenheit. Remember, areas around radiators and cooling lines, turbocharging equipment and any exhaust equipment can and usually will exceed 180°. Even compartments isolated from heat sources can exceed this temperature if the heat source is very close to the compartment wall and there is no air movement through the compartment. It should also be noted, areas that don't exceed this temperature under normal driving conditions can exceed this temperature when the vehicle is working under a heavier than normal load such as pulling a heavy trailer or constant driving through mountainous areas. Stickers are available that can be put on a hose or hose end to check for a temperature issue.

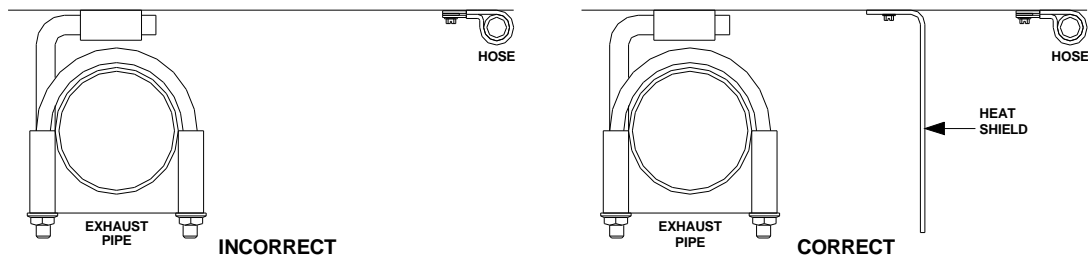


Figure 37

6. **Avoid sharp bends:** Different types of hose can accommodate different bend radii. The 1/8 inch high pressure hose that HWH uses can accommodate a much tighter radius than the standard 1/4 inch hose. Kinking a hose not only restricts the flow of fluid but can weaken or damage the hose. It is possible for a hose to kink after installation if the initial bend was too much. Too tight a bend can also put an excessive strain on hose ends, connections and fittings. Remember, the more sharp bends there are, the more restriction there will be to the flow of fluid in the system.

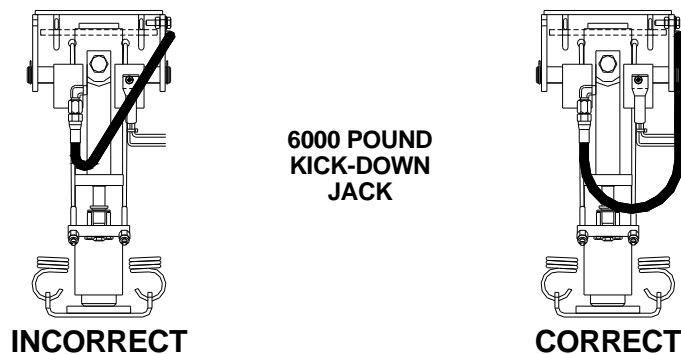


Figure 38

**4-5 FLUIDS:** The fluid discussion is a relatively simple discussion. HWH recommends using only “HWH Hydraulic Jack Oil”. Multi-purpose transmission fluid or the “Dexron” transmission fluids have been used and are compatible with the HWH hydraulic jack oil. The advantage of the HWH oil is it is clear. This will make clean-up from an oil leak easier. There is no dye to ruin carpet or other fabrics. All of these fluids will mix with each other, but it is not recommended to add a red fluid to the clear HWH oil. DO NOT use bottle jack oil, brake fluid or power steering fluid. Synthetic oils may or may not be compatible so do not use these oils without checking compatibility.

The two main things to remember about oil are; 1. Only clean, compatible oil should be added to a system and 2. The oils mentioned above are flammable. This is why it is critical to protect hoses and equipment from extreme heat sources.

**4-5.1** Before we start into the next section, which will be about schematics, it is time for a warning.

**WARNING: NEVER PLACE HANDS OR OTHER PARTS OF THE BODY NEAR HYDRAULIC LEAKS. OIL MAY PENETRATE SKIN CAUSING INJURY OR DEATH.**

This does not mean you shouldn't handle a valve or cylinder that has been leaking, although the oil should not be allowed to get into an open cut. What this warning means is **STAY AWAY FROM HIGH PRESSURE LEAKS**. Your finger is just that, a finger, not a pressures gauge. **DO NOT** try to find leaks by running your hand around a cylinder or along a hose. Oil under high pressure, especially from a pinhole leak can penetrate the skin like a knife. The oil is toxic and has to be removed or it can cause death.

## 5. SCHEMATICS

**5-1 Function/use/reading:** Schematics are used when designing components or systems to make sure they will function as needed. The information included in schematics varies, usually depending on who is drawing the schematic. The symbols used in schematics are usually a standard symbol, but there may be slight differences from company to company, even between two different reference books. We will supply you with a glossary of symbols that HWH uses in our schematics.

Schematics can be very useful in the diagnostics of basic hydraulic problems. If nothing else, once the symptom is known, a schematic will help you decide which parts in the system are needed to perform the intended function. This will allow you to concentrate on a narrow part of the system and eliminate parts that could not cause the symptom.

Reading schematics is really very simple. You just need a little imagination and have the ability to trace lines. That is taking it for granted that you know what the symbols mean. One of the most common mistakes I see when helping people use schematics is moving through the schematic to rapidly and jumping lines or missing parts. One tool that can be very useful is a set of different colored highlighters. This will help you eliminate the possibility of jumping lines. The highlighter lets you see the traced path. It usually doesn't hurt to have several extra copies of the schematic.

**It is important to note schematics do not show parts such as hose ends and fitting. These parts also need to be considered when diagnosing hydraulic problems.**

Schematics are drawn in the normally off position, as if the system is not being used. In a HWH hydraulic schematic that would be with the pump off, no power to electrically controlled valves or if the system has lever controlled valves, the valves would be drawn in the closed position. It may sometimes be helpful to redraw the schematic showing the valves in an on or open position. This can be time consuming so in most cases marking up several different copies of the schematic is probably easier and quicker. The best thing to do is study schematics and practice a little by giving yourself a symptom and using the schematic to tract down the problem. We'll show you how to do that after we give you the glossary of symbols.

HWH also uses flow diagrams, especially for room extensions. In fact, HWH has very few schematics for room extension systems. It is more common to find a flow diagram for room extensions. Flow diagrams used by HWH are a cutaway view of the parts in the system. The pump is not shown in these diagrams. We will show you some examples of flow diagrams and how we use them after concluding our schematic exercises.

## 5-2 GLOSSARY OF HYDRAULIC SCHEMATIC SYMBOLS

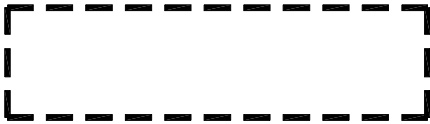
It is important to remember that schematics are used to show how the system works **NOT** how the system or parts are physically arranged. Schematics are drawn in a manner that makes it easier to follow the flow of the system. This does not mean the components of the system are assembled the same way the schematic is drawn. Do not use schematics to figure out how to disassemble or assemble components. System and connection diagrams or component drawings are available when needed for repair information.



A solid line designates a fluid path such as a hose, tube or fluid path in a manifold block.



A line of dashes can be a fluid path, usually a secondary path, like for a relief valve or the shuttle valve.

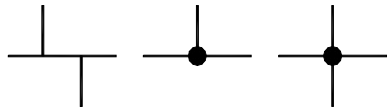


A box made of lines composed of dashes is used to show an assembly or to show a part of an assembly that is a separate component.

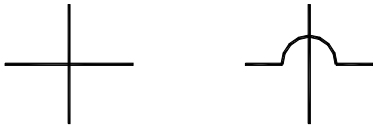


A box made of broken lines designates a component that is part of an assembly.

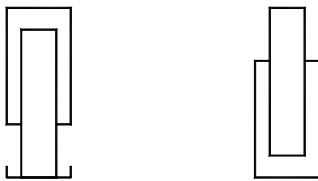
**Note: Because there is a box of dashes or broken lines around a symbol, it does not mean that component can be replaced. The lack of a box around a symbol does not mean that component cannot be replaced**



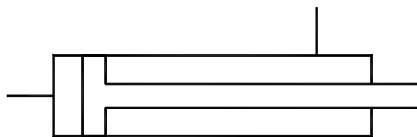
These lines show several ways fluid paths that intersect or join together are drawn.



These lines show several ways fluid paths that **DO NOT** intersect or join together are drawn.

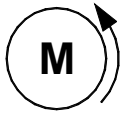


These are symbols for a single-acting cylinder.

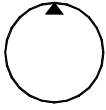


This is the symbol for a double-acting cylinder.

## Glossary of Symbols Continued



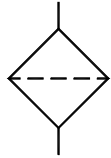
This is the symbol for a pump motor.



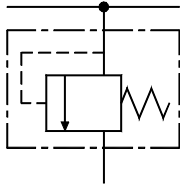
This is the symbol for a pump.



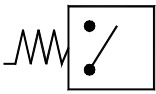
This is the symbol for the reservoir (tank).



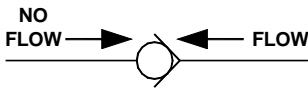
This is the symbol for a filter, strainer or screen (this is in the tank).



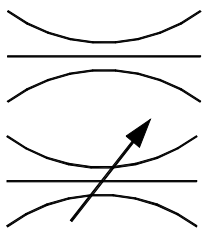
This is the symbol for a relief valve. The arrow in the relief valve will indicate the fluid flowing towards the reservoir (tank).



This is the symbol for a pressure switch with normally open electrical contacts. The switch contacts will close when the pressure at the switch reaches the switch setting. The pressure value for these switches is normally given on the schematic. Jack pressure switch values are not given because these switches are adjustable and the switch value changes from jack to jack.

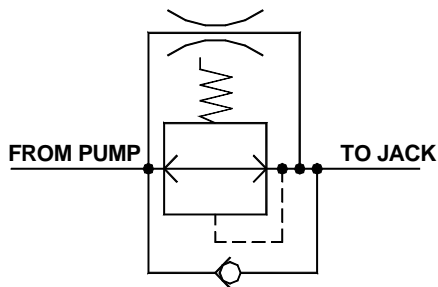


This is the symbol for a check valve. The arrows in this drawing show the direction the fluid can flow or not flow and are not shown in actual schematic drawings.



This symbol shows a fixed flow control.

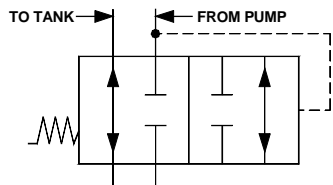
This symbol shows an adjustable flow control.



This is the symbol for the velocity valve. The “pump and jack” designations will not be on the schematic.



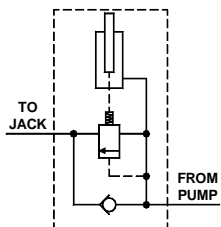
## Glossary of Symbols Continued



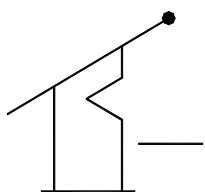
This is the symbol for the shuttle valve. The older shuttle valves will have a symbol that is drawn slightly different but they perform the same basic function. The shuttle valve will shift with approximately 800 psi from the pump.



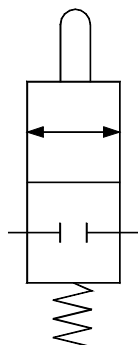
This symbol indicates a spring is used to move a valve or switch. For a relief valve, shuttle valve or pressure switch, it takes a set amount of pressure to get the valve/switch to move. With a lever valve or solenoid valve the spring moves the valve back to its normally "off" position.



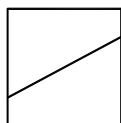
This is the symbol for a jack actuator. The rod of the actuator has to be fully extended before the sequence valve in the actuator can open. The "pump and jack" labeling is not on the schematic.



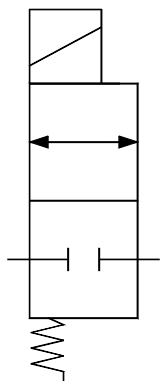
This symbol indicates a lever control with a detent. This would be for the "Store" levers on a Joystick valve or the control levers on a 4 lever 100/110 system valve.



This is the symbol for a manual lever controlled valve. This shows the valve is normally closed when the lever is in the relaxed position. Fluid cannot flow through the valve.



This symbol indicates the electric coil that is used to activate a solenoid valve.



This is the symbol for an electric solenoid valve. This shows the valve is normally closed when the power is off. Fluid cannot flow through the valve.

## 5-3 SCHEMATIC READING EXERCISES

For the following exercises we will work with actual schematics that are available in owner's manuals, repair manuals and are also in a section of the HWH web site dedicated specifically to schematics; hydraulic, air and electrical. This section is simply called "Schematics and Flow Diagrams" and is in the "Technical Information" section of the HWH web site.

For these exercises, we will state a specific symptom. Then we will first use the appropriate schematic and highlight the flow or pressurized areas for the correct operation of the function. Then we will use the same schematic and highlight what would be happening to cause the symptom. In both schematics we will redraw the components showing the symbols changed to show the operation of the components, correct or incorrect.

Note: These schematics are drawn slightly different than the actual schematics to allow them to fit on the page.

The two schematics we will be working with are first, "HYDRAULIC SCHEMATIC DIAGRAM—BI-AXIS LEVELING WITH STRAIGHT-ACTING JACKS—625 SERIES" page number MP65.306C and second, "HYDRAULIC SCHEMATIC DIAGRAM—200/210/225 SERIES JOY STICK BI-AXIS LEVELING SYSTEM—WITH KICK-DOWN JACKS" page number MP65.601C.

### 5-3.1 EXERCISE NO. 1

We are working on a 625 computerized leveling system. The system is being operated with the manual up and down arrows on the touch panel. Three of the jacks will extend to the ground and lift the vehicle. The right front jack will not move at all when the front or right side up arrow is pushed. While pushing the front up arrow, the pump runs but seems to run under a load, the left front jack is fully extended and the right front jack will not move.

If the system was working properly, the schematic could be drawn like this:

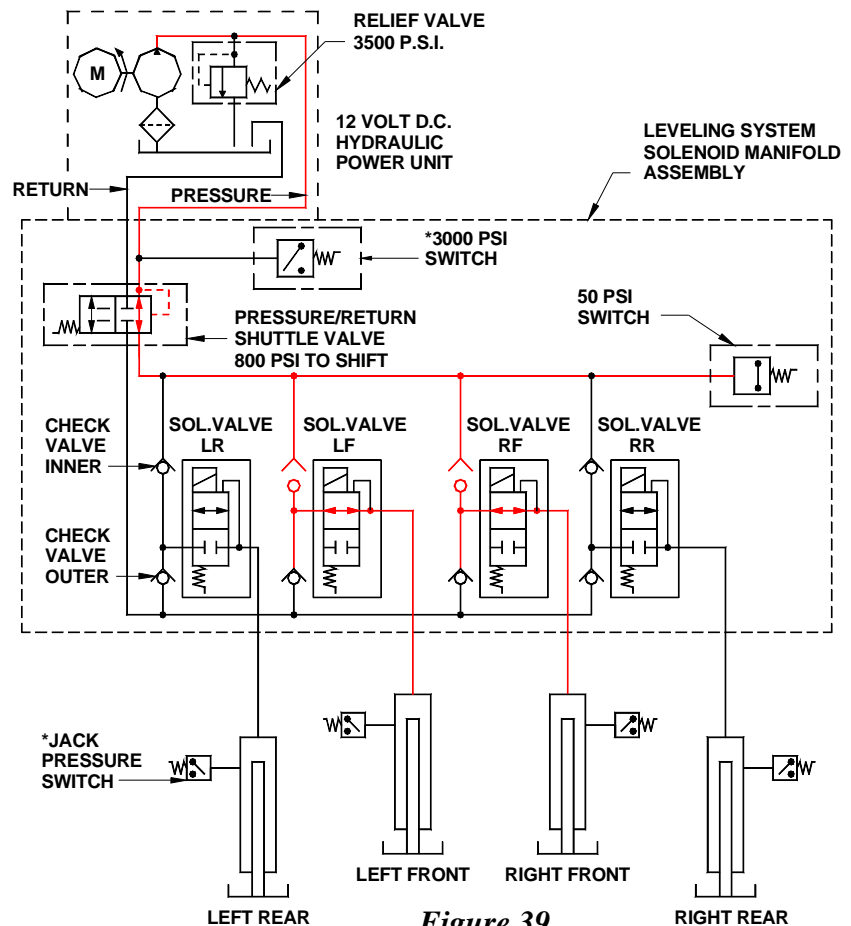


Figure 39

As you can see the parts needed to make the system work correctly when the front up arrow is pushed are the pump, the shuttle valve, the inner check valves, the right front and left front solenoid valves, the hoses and the jacks themselves. The hoses would also include the hose ends and the fittings in the manifold or jack cylinder.

By using the schematics you can see the pump and shuttle valve are common to all the jacks so if the left front will extend, the pump and shuttle valve are functioning at least good enough that the right front jack should be able to extend also. The components that have to be considered are the right front inner check valve, the right front solenoid valve, the hose and fittings to the right front jack and the right front jack itself. I have circled these parts.

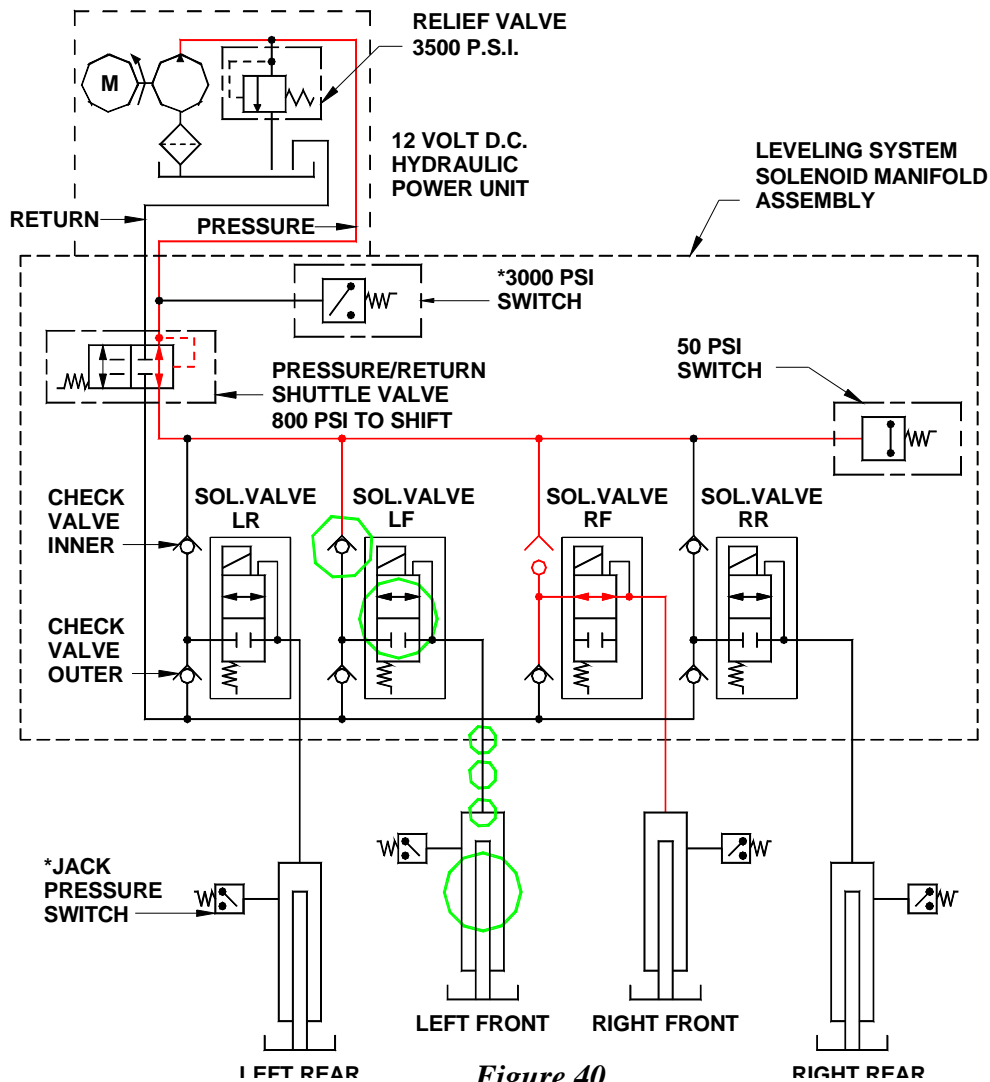


Figure 40

The diagnostics is fairly simple. The idea is to eliminate as many possibilities as you can as easily as you can. The easiest test to do first would be to open the right front valve manually with the manual release t-handle or nut and try to extend the front jacks. **It is important to make sure the manual release t-handle or nut is opened the appropriate number of turns to assure the valve should actually be open.** If the right front jack extends, this eliminates the inner check valve, hose and fittings, the jack and the mechanical operation of the solenoid valve. The problem is an electrical issue with the valve or the control circuit for the valve. (We will discuss electrical diagnostics in BASIC ELECTRICAL.) If the jack does not extend, we haven't really eliminated anything and will need to continue with more tests. Swapping the hoses for the right and left front jacks at the manifold will test the hose and jack. We know the left front works properly so if the hoses are swapped and the right front jack now extends, we know the hose and jack are ok. The problem is going to be the inner check valve or solenoid valve. If the jack does not extend, leave the hoses swapped and remove the hose from the jack. Run the pump (put the hose in some type of container so you don't create a large mess). If fluid flows from the hose, the jack or jack fitting is the problem. If no fluid flows from the hose, the hose has some type of blockage such as a kink. **Remember, no matter the outcome of this test, swap the hoses back to their original position when the tests are complete.**

If the jack extended with the hoses swapped, pointing to the inner check valve or solenoid valve, the most likely problem is the solenoid valve. The only test for the check valve would be to remove the solenoid valve, cover the solenoid valve port with a rag and very briefly run the pump. The check valve should pop out into the solenoid valve port. If the check valve does not pop out, it is jammed. The manifold may need to be replaced. HWH should be contacted if this is the problem. If the check valve pops out, the manifold fitting should be checked to make sure it is not plugged. Make sure the check valve is located before continuing. On a new system, it has happened that a fitting, especially an angle fitting is not drilled through. If the check valve is not jammed and the manifold fitting is not plugged, the solenoid valve is at fault and will need to be replaced. **The important thing to remember is *never assume something is ok just because it may be a rare problem.***

### 5-3.2 EXERCISE NO. 2

We are again working on a 625 computerized leveling system. This time the problem is with the left rear jack. This is a 12000 pound capacity, straight-acting jack. The temperature is above 70° Fahrenheit at night and warmer during the daytime. When storing the jacks, this jack consistently takes over 8 minutes to store when timed with a watch. The other 3 jacks are completely retracted in less than 1 minute every time. Only the left rear is ever slow. The jacks all have the new tapered springs. The jacks are clean and the springs have good tension when completely retracted. The jack manifold does not have velocity valves.

If the system is working properly, the schematic could be drawn like this. Possible issues are circled.

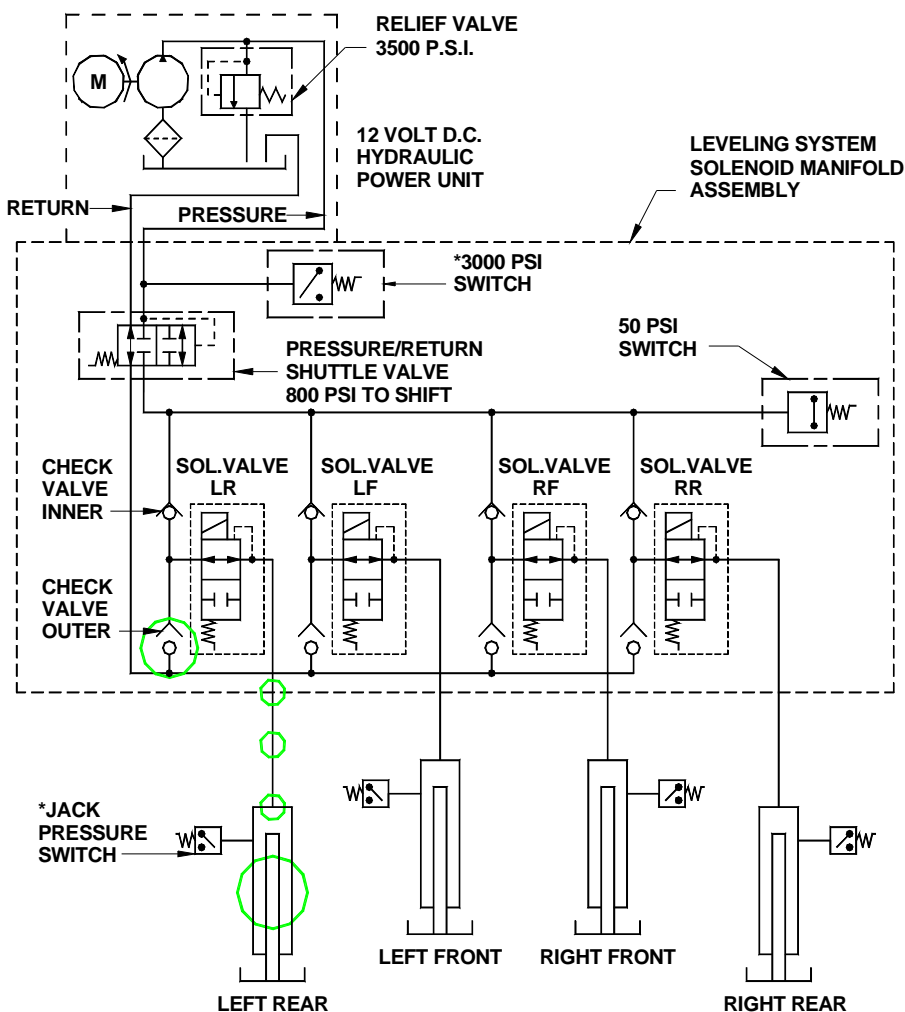


Figure 41

The parts involved with jacks retracting are the jacks themselves (this includes the springs), hoses and fittings, the solenoid valves, the outer check valves, the shuttle valve and the reservoir which includes the breather cap. You will note I listed the parts in order starting from one end of the system. In this case, redrawing the schematic would not be of much help because none of the parts are totally jammed, closed or blocked. The idea of using a schematic for this problem is that it shows us exactly which parts could cause the problem. Remember, the jack does retract; it just does it very slowly. If the jack is retracting, the fluid has to be going somewhere. This is the type of problem that if you do not pay attention to all the parts, you can really chase your tail if a less obvious problem is the cause.

As in exercise no. 1, eliminate the easiest things first. The shuttle valve is common to all the jacks so if the shuttle valve was causing the restriction, the return flow to the tank would be restricted for all the jacks and they would all be slow to retract. The reservoir and breather cap are also common to all the jacks. If the breather cap is plugged completely or partially, as the fluid returns to the tank a back pressure will build up and cause the retraction of the jacks to slow down. Remember, air can be compressed. In this case some jacks may still retract at a normal speed. While it would be odd for the same jack to be continually the slowest jack to retract, due to all the factors including hose routings, hose lengths and the manufacturing of the jacks, the left rear jack may always be the slowest, even with no problems. The diagnostics of the breather cap is simple, remove the breather cap while the jacks are retracting and if the left rear jack now retracts at a normal speed, replace the breather cap.

The rest of the diagnostics are a matter of simple tests to eliminate possible problems. Several of the following tests will make quite a mess so be prepared for some clean up. Start at the jack. Remove the hose from the jack. If the jack retracts at a normal speed, the jack is not the problem. Reattach the hose, extend the jack and remove the hose at the manifold. Again, if the jack retracts at a normal speed, the hose is not restricted. Reattach the hose and extend the jack again. The only two things left are the solenoid valve and the outer check valve. The outer check valves are easily removed by removing the 5/8 inch cap on top of the leveling manifold. There is one for each solenoid valve. Make sure the solenoid valve is closed before removing the check valve cap. Take the cap off, remove the check valve and replace the cap. If the jack now retracts at a normal speed, the check valve is the problem. If the jack is still slow, the solenoid valve is the issue.

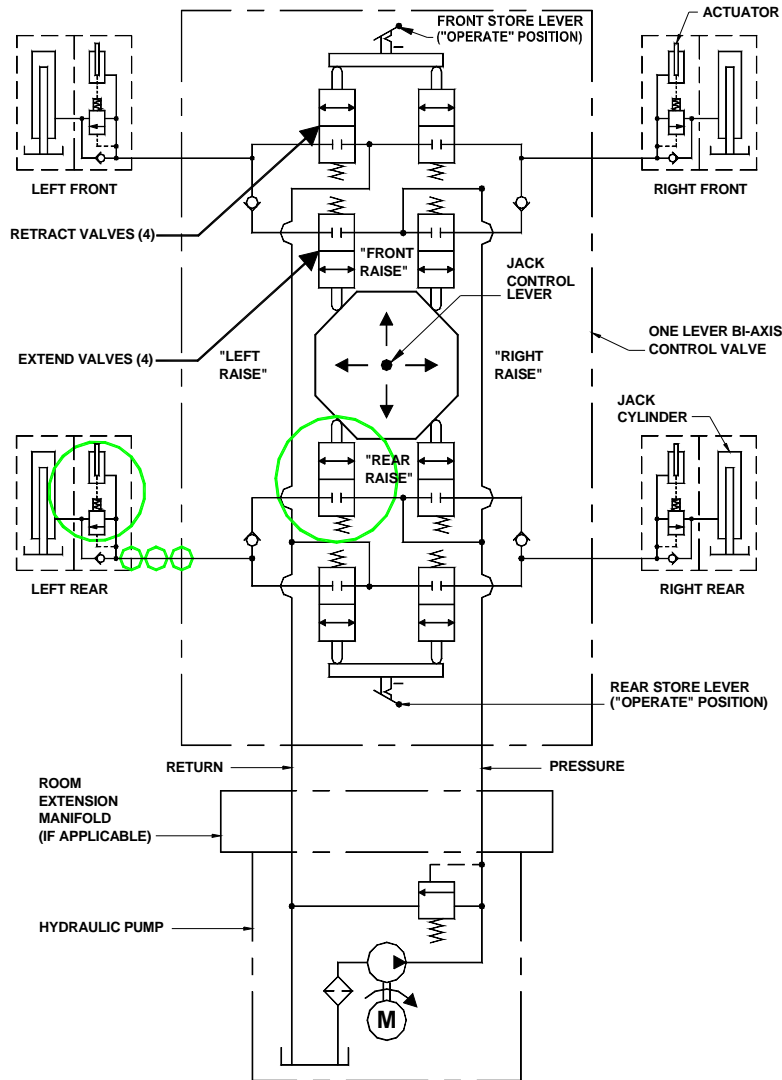
### **5-3.3 EXERCISE NO. 3**

This problem is on a Joystick leveling system (200/210/225 series) with 6000 pound kick-down jacks at the front and 9000 pound kick-down jacks at the rear of the vehicle. The left rear jack will not kick down to the vertical position. The other three jacks will kick down, extend to the ground and lift the vehicle.

The proper way to operate the joystick system when putting the jacks in the vertical position is to move the jack control lever to either the front position to kick the front two jacks down or the rear position to kick the rear jacks down. Which is done first does not matter. It is possible that one jack can kick vertical and extend to the ground before the other jack kicks vertical. This is due to any number of things such as manufacturing tolerances, the jack springs, hose lengths, but most likely the actuators are slightly different. This is not considered a problem unless the jack that has kicked down continues to lift the vehicle without the other jack kicking vertical.

The schematic only shows the hydraulic parts of the system, not the mechanical. As before, the schematic will help you isolate the problem. It may be necessary to inspect the mechanical features of the system to perform a complete diagnostics. In this system, the rear jacks are 9000 pound jacks. The actuator rod pushes against a roller bearing. There is a mechanical stop to keep the jack from swinging up to far. The jack should be free to pivot on the pivot bolt assembly. Hose routing could be an issue especially on a new installation.

The following schematic is drawn showing the position of parts if the system was working properly. Possible issues are circled.



**Figure 42**

The schematic shows us the fluid level, left rear extend (raise) valve, the left rear check valve, the hose and fitting connections and the left rear actuator could be an issue. The other components that are needed to make the jack function are the pump and the left rear retract valve. The pump is common to all the jacks and would cause a problem with the other jacks if it was not functioning properly. The schematic shows us a leaky left rear retract valve could allow fluid to bleed back to the pump. This would cause low pressure and could effect the left rear jack but the low pressure would also effect the right rear jack. So we can eliminate the left rear retract valve because the right rear jack is functioning properly. Low fluid could be an issue, but this would probably see different jacks not function properly at different times. Even so, never assume the unlikely problems are ok. Check the fluid level, it only takes a minute.

That leaves us with the extend valve or check valve, the hose or fittings and the actuator. Remember, the schematic does not show us the mechanical parts of the jack, so check them first. This will be the easiest because it is just a visual check of the jack. It is also the least messy and is very often the problem. Check the roller bearing. If it is frozen and will not turn, this will keep the jack from kicking vertical. Pull the jack to the vertical position to make sure the pivot assembly is not binding or frozen up. **Be very careful when you release the jack, it will swing up very quickly.** Make sure the jack stop is in place and that the jack has a slight downward tilt. If the jack has no tilt or is tilted upwards, the actuator will not be able to kick the jack vertical. In fact, the actuator rod may be jammed on top of the roller bearing if the jack has an upward tilt.

If the mechanical parts are ok, it's time to check the hydraulics. This can be the messy part. Remove the hose from the valve fitting. Pull the jack control lever to the rear position. If no fluid comes from the fitting or the flow is very restricted, the extend or check valve is the problem. The nice thing here is we don't replace just a check valve or an extend valve on a Joystick assembly. When there is a problem inside a joystick valve, the complete assembly is replaced. So it doesn't matter which is the problem, replace the complete assembly. Although the static theory of fluid would say the jack should kick down if fluid is getting to the actuator because the pressure should be there; if the right front jack is moving, there might not be enough pressure to kick the jack vertical until the right front jack stops moving. Anyway, with the hose removed from the fitting, there should be a healthy stream of fluid coming from the fitting when the pump is running and the left rear extend valve is open. If there is a healthy flow of fluid from the fitting, the check valve and the extend valve are ok. Reattach the hose to the valve fitting and remove the hose from the actuator fitting. Pull the jack control lever to the rear position. If fluid does not flow or is very restricted, the problem is the hose. If there is a healthy flow of fluid from the hose, the problem is the actuator.

These three exercises should hopefully show you how to use a schematic to help diagnose problems. The only way to really become proficient with schematics is to practice. I will list some more problems that are commonly dealt with at HWH technical service. They are problems that can be diagnosed completely with the use of the schematics, at least isolating the problem to a particular component. Here are some good rules to follow when reading schematics.

1. Mechanical parts such as springs, rollers and stops are not shown in the schematic.
2. The actual hose ends and fitting connections are not shown in the schematic.
3. Take your time and follow lines carefully. The use of high lighters is helpful.
4. Refer to the glossary of symbols when necessary, don't guess.
5. Schematics are drawn with parts in the normally off, not in use, position.
6. List ALL the possible problem parts in order. Start from one end or the other.
7. If a path separates into two or more paths, list an order of parts for each path.
8. When you start to eliminate things, start from one end of the list never the middle of the list.
9. Eliminate least likely or easiest to diagnose parts first.
10. Never assume unlikely problems are ok.

The following problems are covered with the same schematics used for the above three exercises. Use schematics MP65.306C (Joystick system) and MP65.601C (625 system) to list as many problem parts as you can and how you might diagnose the problem. Download the [test](#) and put your answers for problems 1, 2 and 3 at the end of the test. Send your work to [school@hwh.com](mailto:school@hwh.com). Your papers will be reviewed and any corrections or suggestions will be added and returned to you. On the "Subject" line for your email, note that this is Test for Lesson 8 from the HWH online school.

**Problem 1:** This is a 625 leveling system with straight-acting jacks and no rooms. When manual up arrow buttons (jack extend buttons) are pushed, the pump runs, but the jacks extend slowly and will not lift the vehicle. This happens no matter what up arrow button is pushed. The correct jacks are extending when the buttons are pushed.

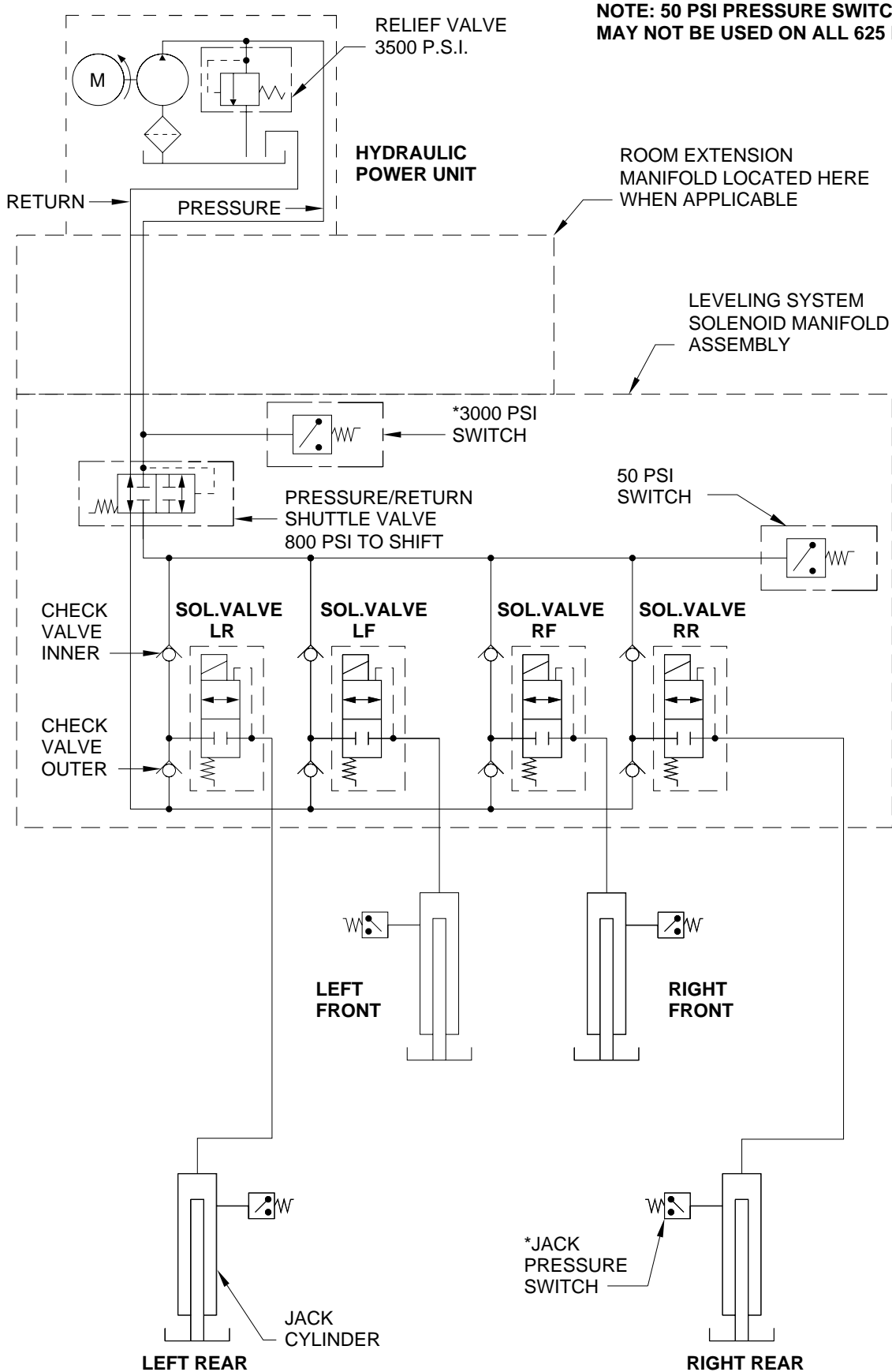
**Problem 2:** This is a Joystick leveling system with kick-down jacks and no rooms. When the jack control lever is moved to "FRONT RAISE", neither jack will kick vertical. The pump seems to be freewheeling. When the lever is moved to "REAR RAISE", the rear jacks kick down normally and the pump sounds normal.

**Problem 3:** This is a 625 leveling system with straight-acting jacks and no rooms. The jacks are extended to the ground, lifting the vehicle. None of the jacks will retract either with the manual down arrow buttons (jack retract button) or the "STORE" button.

# HYDRAULIC SCHEMATIC DIAGRAM

## BI-AXIS LEVELING WITH STRAIGHT-ACTING JACKS

### 625 OR 625S SERIES



\* USED ON AUTOMATIC SYSTEMS ONLY

MP65.601C  
08SEP09



# HYDRAULIC SCHEMATIC DIAGRAM

## 200/210/225 SERIES JOY STICK BI-AXIS LEVELING SYSTEM

### WITH KICK-DOWN JACKS

