# BASIC PNEUMATIC PROPULSION CONTROL INSTALLATION INSTRUCTIONS FOR SHIPS

**Location and Mounting of Components**

It is important to first select the location for the control heads and to ensure that these units are installed in an area that is easily accessible. They should not interfere with any other moving projections or devices that could obstruct the accessibility of the control levers. The base for our controls must be smooth and flat. Details for cutout dimensions can be found on the product sheets.

The components on the engine must also be installed on solid brackets attached with bolts to the propulsion machinery. Badly designed bracketing can multiply basic engine vibration to a point where it can prematurely wear control devices installed on propulsion packages. Vibrations of this nature are visually apparent and the bracketing should be reinforced or altered to avoid this from happening. Linkages connecting our control components to the governor, clutch and C.P. propellor must provide the correct stroke.

Engine timing panels must be located in the engine room and should be easily accessible for installation of the tubing, and easy access for timing adjustments. It is understood that no components on a ship are absolutely vibration free, but timing panels again must be installed in such a way to avoid high frequency shaking and vibrations since this will prematurely damage the copper tubing. The timing panels must also be installed on a flat surface, and deformation of the panel or control box must be avoided.

**Installing the Air Lines**

The copper tubing connecting all the components must be kept clean and free from dirt during installation. It is extremely important that the tubing size is used as per Kobelt Manufacturing's specifications. Failing to select the tubing as per our drawing may result in poor control response of the system for which Kobelt Manufacturing will not assume responsibility.

Teflon tape should not be used on pipe fittings. A liquid pipe sealant, applied at the end of the fitting is preferable. Pipe fittings should not be over-torqued since the tapered thread can cause splitting of the control components. The table below indicates torque required for tightening tapered pipe fittings.

| | |
|---|---|
| 1/8" N.P.T. | 10 ft. lbs. |
| 1/4" N.P.T. | 20 ft. lbs. |
| 3/8" N.P.T. | 30 ft. lbs. |
| 1/2" N.P.T. | 40 ft. lbs. |

A section of rubber hose must also be installed at the end of the copper tubing connecting to throttle and gear actuator. This is to take up the vibration and to avoid the transmission of electrolysis to our control components. If a shipyard chooses to use hose for the complete installation on smaller ships, Kobelt Manufacturing has no objection to this providing that the inspection authorities will accept the hose material.

The tubing sizes specified by Kobelt Manufacturing always refer to the outside diameter (O.D.).

5/16" O.D. copper tubing must have a 1/4 " I.D.
3/8 " O.D. copper tubing must have a 5/16" I.D.
1/2 " O.D. copper tubing must have a 7/16" I.D.
3/4 " O.D. copper tubing must have a 5/8 " I.D.

All respective fittings used with the above tubing must have the same minimum I.D. flow capacity. This is to avoid flow restrictions. When tubing is properly installed and connected, the air supply lines must be flushed out with the available storage tank pressure at a minimum of 100 psi. The lubricator is best kept dry for this operation. The regulator should be adjusted as per specification. The filter must be kept clean and dry during the operation. The supply line to the control heads should be flushed out first for approximately 1 minute from the engine room to the control heads (with heads disconnected). The supply line(s) can then be reconnected to the control head(s), and the resulting lines at the control panel in the engine room must be disconnected. Each control head must be activated in the clutch mode first to flush clean the lines downstream for approximately 1 minute. After this is completed, the lines at the engine and gear should be disconnected and flushed from one station only. Any malfunction or leakage caused in Kobelt control valves by dirt will be repaired at customer's expense.

**The Air Treatment Unit**

After the air lines are properly cleaned, the lubricator should be filled with No.10 hydraulic oil. In some sparingly used systems, it may be advisable not to have a lubricator because very often lubricators get filled with the wrong fluid and are improperly adjusted resulting in either no lubrication or over-lubrication to the system. However, a properly maintained and calibrated lubricator will extend the life of the components. In most cases the basic control system will operate from 6 to 12 years with little need for maintenance. The air storage tank and air filter should be drained regularly to avoid water entering the control system. In sub-zero weather it is recommended to have an anti-freeze unit or special air drying equipment to prevent freezing in the pneumatic system.

**Multi-Station Controls**

On multi-station control systems the air supply is only available at one station at a time. The air pressure is transferred with Kobelt palm valve 3517 and pilot operated 3403 or 3405 transfer valve. Several methods of station transfer are available in order to comply with various inspection authorities.

The resulting lines from the control heads must be interconnected with two-way check valves (shuttle valve part no. 3009). It is important to remember that the shuttle valves must be installed horizontally in a location that will minimize tubing runs. Shuttle valves that are installed in boats for future additional stations must be left open to the atmosphere. Plugging the unused ports will cause failure of the control system.

**Quick Release Valve**

Quick release valves are required on long tubing runs to exhaust the control air rapidly. For this reason, the quick release valves must be placed in the control circuitry at locations where they serve their purpose best. For example, if a large cylinder with a reasonably long line leading to the control valve is too slow in dumping the air through the control valve, the quick release valve should be installed near the cylinder in order to dump the large volume of air in the cylinder to atmosphere almost instantly rather than returning the air part way up the control line. If the control system has a small volume device at the end of the control line and is dumping too slowly, the quick release valve should be installed approximately one third away from the control head. Since the quick release valve is primarily intended to dump air very quickly, it would handle approximately two thirds of the line and the control head would be dumping the other one third of the line, thus giving a very fast response.

Quick release valves are not recommended in control systems with variable pressure outputs and require a high degree of repeatability or accuracy as these quick release valves generate hysteresis. The quick release valve should always be installed with the exhaust port facing down to avoid dirt entering the valve. The ports on our quick release valves are clearly marked for all the necessary connections. If only one air outlet is required, the other port must be plugged. It is important that the exhaust port must not be plugged since this will make the valve inoperative.

**INSTALLING ACTUATORS ON PROPULSION ENGINES AND GEARS**

In most cases brackets must be made to adapt our actuators to the propulsion machinery. Under no circumstances should these brackets be welded on the machinery. Existing bolts as provided by the manufacturer can be used. Care must be taken that the installation of our actuators and brackets does not interfere with the accessibility of the engine and gear for regular maintenance. It is recommended that a section of rubber hose be used to connect our actuators to the copper tubing for flexibility and maintainability. Two different clutch actuators, model 4304 and model 4307 are available from Kobelt Manufacturing.

**Model 4204**

The model 4204 provides one inch of stroke in either direction. If this cylinder is attached to the control valve lever, care must be taken that the output rod is at 90 degrees to the control valve lever in the neutral position. The hole in the control valve lever must be selected to provide full engagement in both directions without overtravelling the maximum available movement of the control valve. A little free play at either extreme position is essential. The cylinder must be arranged to provide free motion throughout the whole angular operation of the valve lever without side binding. The lever to be actuated should not have a resistance of more than 40 lbs. in order to stay well within the safety limits of the cylinder forces.

**Model 4207**

The model 4207 is designed with an output lever which provides seven different possibilities of stroking the gear control valve. By reversing the output lever, an additional seven positions can be obtained (see product sheet). The output lever housing can be rotated at 45 degree increments. A connecting link must be provided between the output lever of the 4207 and the control valve lever. It is important that these two levers are parallel and that the connecting link is at 90 degrees to both levers in the neutral position. The linkage must be arranged so that when the cylinder is in neutral position, the gear control valve is also in neutral position. Furthermore, the linkage must be attached on the 4207 output lever to provide full gear engagement without overstroking the valve. A little clearance on either end is essential. The connecting link between the two levers should be made out of 5/16" diameter steel rod and should not exceed 18" in length. The rod end fittings should be of good quality that will provide years of trouble free service. Also, a locking nut should be provided on either end of the connecting link against the rod end fitting. These nuts should be secured to avoid wear. The rod end fitting must be installed to permit free movement without binding. Care must be taken to prevent torsional loading between the rod ends. At the longest lever position (2-3/8" stroke in either direction) the lever to be actuated should not have a resistance of more than 20 lbs. At mid lever position (1-5/8" stroke in either direction) the lever to be actuated should not have a resistance of more than 32 lb.. At the shortest lever position (1-1/16" stroke in either direction) the lever to be actuated should not have a resistance of more than 45 lbs..

**Throttle Actuators 4106 - 4107 - 4108**

Three throttle actuators are available from Kobelt. Model 4106 is designed for light duty throttles when little force is required to accelerate or deaccelerate engines. It is important that these actuators match the operating pressure of the control head.

Model 4107 is a medium duty speed setting device and model 4108 is used to control engines with a stiff governor. It is very important that the actuator is capable of moving the throttle from the idling position to the full open position smoothly. The linkage should be substantial enough to withstand the vibration and the mechanical loads.

It is recommended that periodic inspections are made of all control equipment installed on engines and gears. Due to the high frequency vibration of such machinery, wear can sometimes result prematurely on actuators as described above. It is important that the control tubing leading to the engine does not transmit electrolysis through our actuators.

**Shaft Brake Installation**

The basic propellor shaft brake installation, if it is a part of the drive line, must be installed to conform with the local marine inspection authorities. If the disc forms an indirect part of the drive line (attached to the shaft with its own coupling) it will, in most cases, not come under the inspection authorities and therefore no fitted bolts are required. Grade 5 bolts or better must be used to attach the disc to the drive hub, properly torqued and locked.

The foundation plate for the brake caliper must be designed to withstand the brake torques and must be smooth and flat. The brake caliper should be installed so that the whole brake pad is making contact with the disc when the brake is applied. The clearance between the brake shoe and disc should be approximately equal on both sides. The rugged design of Kobelt disc brakes will permit a 1/16" deviation from side to side and top to bottom. The shoes will readily adapt themselves to the disc and will tolerate some inaccuracy.

The bolts used for fastening the caliper to the foundation must be of Grade 5 or better. Lock washers should be installed under the nut and the bolt should be long enough to come through the nut completely. It is also important to ensure

# TROUBLE SHOOTING GUIDE FOR BASIC PNEUMATIC CONTROL SYSTEMS NOT INCLUDING THE TIME DELAY SYSTEMS

The most important factor during the installation of a pneumatic control system is to avoid dirt entering the tubing and control components. This could cause valves to leak or stick.

The first thing to check if control failure occurs is the air preparation unit and source of supply (filter, regulator, lubricator). It is important that the filter is kept drained and clean. The regulator should be set at a minimum of 90 PSI (higher pressures are required in some cases). The lubricator should be filled with #10 hydraulic oil. At the end of the air preparation unit, a good flow of air should be available and an additional test gauge might be necessary to confirm the pressure regulator setting.

In order to trouble shoot the system, it is best to have full bottle(s) of compressed air available, shut down all running engines to obtain a silent ship. Place control head into forward idling position and listen for air rushing through control head downstream to actuator. Then follow control lines to the engine room and check for leaks right to the actuator. When the control head is returned to its neutral position, listen for the air exhausting through exhaust ports. Repeat same procedure for reverse direction and for engine speed section.

When the control head is placed in forward position and air leaks through the reverse side of the clutch valve, (or vice versa ) the clutch actuator is leaking. Check and replace seals as necessary. On a multi-station system, if the air leaks through the head actuated, the problem lies in that same head. If the air leaks through another head, (not in use) the problem lies in the shuttle valve system. This can be easily traced from either head. Once the shuttle valve is found, remove dirt or replace seals.

If no movement takes place in either clutch or throttle actuator, remove the air lines connected to same. Actuate control head to see if air pressure is available. If air pressure is available, remove and dismantle actuator to find worn or damaged seals, or dirt in the system. Repair as necessary. If rolling diaphragm needs replacing, ensure correct installation (Fabric side of diaphragm is piston side, rubber side of diaphragm is pressure side.) When re-assembling, also ensure good lubrication of all seals and moving parts with oil or very light grease. Cleanliness during re-assembly is very important.

If the air pressure does not reach the end of line attached to the actuator, the fault must be in the control head, or possible clogged shuttle valves or damaged tubing. Check all outgoing ports from the control head to ensure that full line pressure for the clutch actuation and variable air pressure at the throttle ports are available. Check that there are no plugs in the exhaust ports.

If no air flow for the clutch is available, check needle valve on 2540 series heads for position. The needle valve should be open approximately two to three turns. Also check adjustment screws operating valve spool so that half the mechanical movement of the cam is closing the valve and the remaining half is opening the valve.

If these screws are not properly adjusted, the valve could have very little supply capabilities and lots of exhaust volume. This would cause the clutch to engage very slowly or not at all. Turn screw down to correct problem. If the screw is turned down too far, plenty of supply air is available but the air will exhaust very slowly or not at all. Turn screw up. If no air passes through the valve, remove same and repair. If the valve poppet shows a small amount of damage, use a piece of sandpaper or emery cloth, place same on the flat surface to smoothen the seal. Replace "O" rings if necessary.

If the throttle valve is not performing to original setting, it can be adjusted with the upper or lower adjusting screw. Please see our sheet on General Installation and Adjustment Instruction for Variable Control Heads. Dirt will cause this valve to either leak or stick, dismantle, clean and install new parts as needed. When replacing diaphragm, make sure piston side of diaphragm is facing piston.

It is also possible that a lack of supply air is caused by the station transfer system. If the control stations are far apart, it is important that the palm valve 3517 is depressed long enough to ensure a complete shift of the 3403 or 3405 station transfer valve. Improper adjustment of the screws operating the valve spool could again cause either a slow charge or discharge of the control system during station transfer. Check that half the travel is available for the charge of the control system and half for the exhaust. Again the poppets in this valve can be cleaned with sandpaper or emery cloth. Replace "O" rings if needed.

Very often linkages between our actuator and gear control valve lever and governor lever are improperly installed or matched. It is very important that a gear control valve is moved to the full gear engaged position and not beyond. It is also important that the linkage provides alignment in neutral position. The linkage must be at 90 degrees to the levers in the neutral position. The axis of rotation must be on the same plane. The actuator controlling the engine governor must have the same pressure range as the control head. Again the linkage must be installed to provide complete movement of the actuator from idle to maximum RPM without bottoming the governor lever in either direction. If the pressure range or actuator stroke are not matched to the engine speed setting device, engine speed control can be very irradical.

## BASIC OPERATING PRINCIPLES OF KOBELT PNEUMATIC COMPONENTS

The purpose of this section is to remove the mystery of how pneumatic components function. We feel that this will be of great benefit to all personnel involved with Kobelt pneumatic control components. All the illustrations show only the most essential parts in order to provide a better and clearer view of the basic operating principles.

The color scheme chosen was purposely shown in blue only. The darker the blue the higher the pressure and the lighter the blue the lower the pressure.

Some control systems and machinery packages can be very complex in their design. However, if the basic principles of operation for each component are understood, any person with some mechanical aptitude should be able to work their way through the system and provide a clear overview for troubleshooting and maintenance. In many instances a failure in control response could be due to a malfunction in associated equipment and a good service technician can then point out to the customer precisely where the problem lies.

# 3-WAY AND 4-WAY VALVES

Kobelt control valves and pneumatic devices are all designed around the poppet valve principle. The poppet valve is the least sensitive to dirt, leakage and sticking. Since our first aim is to provide a trouble free system, we have chosen this type of valve.

The 3-way valve illustrated in Figure 1 is shown in the closed position with the control stem outward. The air entering the "IN" port is trapped behind the seat and the poppet and has no way of going past these two parts. Any accumulated air in the "OUT" line is allowed to exhaust via the hollow stem through the "EXHAUST" port to atmosphere.

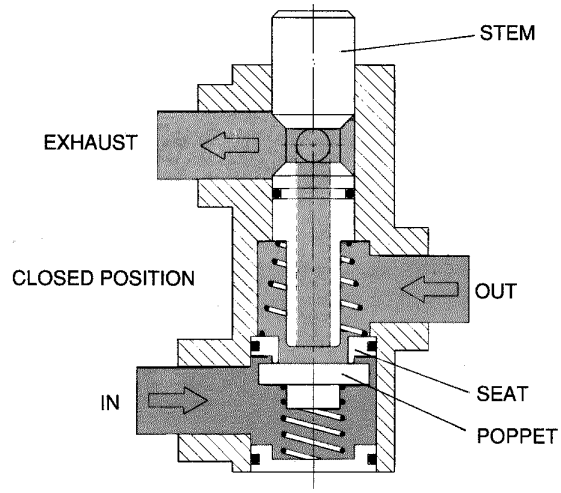


FIGURE 1

The 3-way valve illustrated in Figure 2 is shown with the stem moved inward to an open position and permits air flow from the "IN" port to the "OUT" port therefore energizing the actuator attached to this valve. The hollow stem is seated against the inner portion of the poppet and does not permit exhaust of air to atmosphere while the valve is in this position.

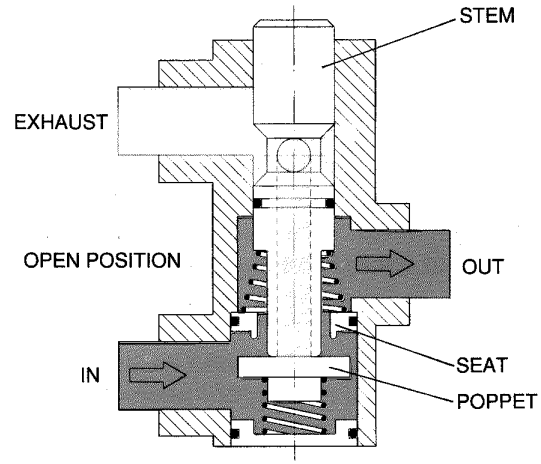


FIGURE 2

The Kobelt 4-way valve consists of two 3-way valves combined into one housing with a common supply. These valves are not pressure compensating but, are intended strictly for on/off use.

The poppets in this type of valve should provide a minimum of 10-15 years of trouble free service. The "O" Ring on the stem should last a minimum of 6-10 years. After dismantling this valve be sure to re-install all components properly (check product sheet). **It is important that no foreign matter enters the system or the valve.**

# SHUTTLE VALVES

The purpose of the Shuttle Valve is to provide a common resulting line from two different sources of supply. If for example two 3-way valves are used to control a common cylinder and these two units are inter-connected with an ordinary "T" fitting, the control air pressure from one control would exhaust out from the exhaust port of the second control. Consequently a device such as a 2-way check valve or Shuttle Valve is required to prevent this from happening.

Figure 1 shows the control air pressure coming in from "LINE 1" and going out the "RESULTING LINE". The air pressure causes the shuttle to slide towards "LINE 2" and seal against the "RUBBER WASHER" thus preventing air from leaking out through the device attached at the end of line two.

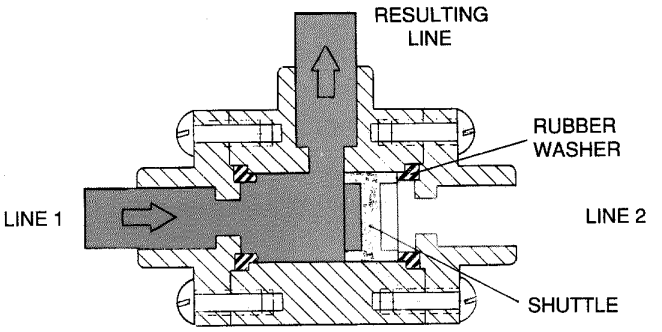


FIGURE 1

Figure 2 shows the Shuttle Valve with full line pressure entering "LINE 2" and partial line pressure in "LINE 1". The higher air pressure in "LINE 2" is capable of moving the shuttle against the "RUBBER WASHER" thus preventing air from leaking past this seal into "LINE 1".

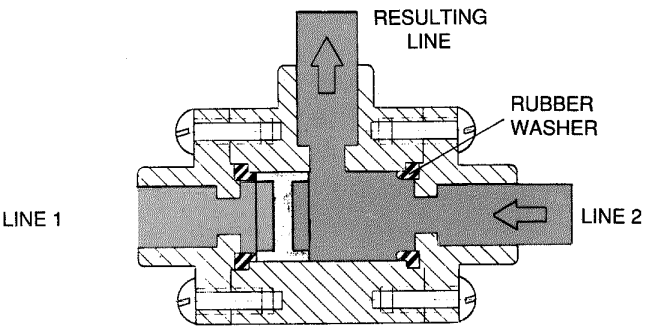


FIGURE 2

Figure 3 shows an equal air pressure coming from two sources of supply and also going downstream via a "RESULTING LINE". Please note that the cylindrical bore for the resulting line is opened up to allow air passage with the shuttle sitting in mid position (Model 3010). A regular Shuttle Valve such as a model 3009 (without the internal relief on either side) would seal the port of the resulting line and would result in no air flow to the controlled device.

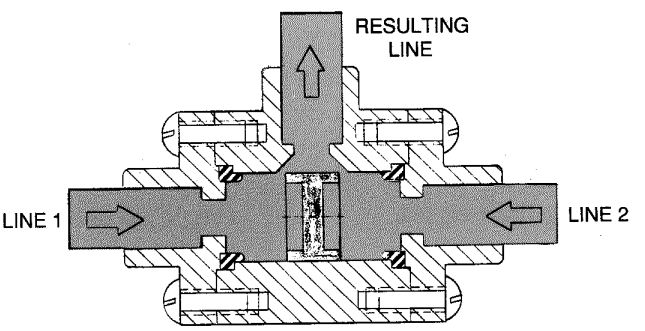


FIGURE 3

An important factor to remember is that **the supply line to a shuttle valve should never be plugged**. Plugging of a supply line (line 1 or 2) will result in a gradual accumulation of pressure which will eventually reach maximum line pressure. This will render the Shuttle Valve inoperative and cause loss of control.

The Shuttle Valve **should always be installed with the cylindrical bore in a horizontal position**. The rubber seals are the only parts that require replacement after approximately 6-10 years of use. If the system is kept clean no metal parts should ever be required.

# QUICK RELEASE VALVES

The Quick Release Valve serves as a device in a control circuit for exhausting air without returning it to the original source of supply. The name itself defines its function very clearly. Its main purpose is to dump air quickly.

In Figure 1 the valve is illustrated with high pressure coming from the control device to the "IN" port. This is causing the outer rim of the diaphragm to deflect downward, pushing the spring and retainer plate down in the same direction, which will permit air flow to the "OUT" ports.

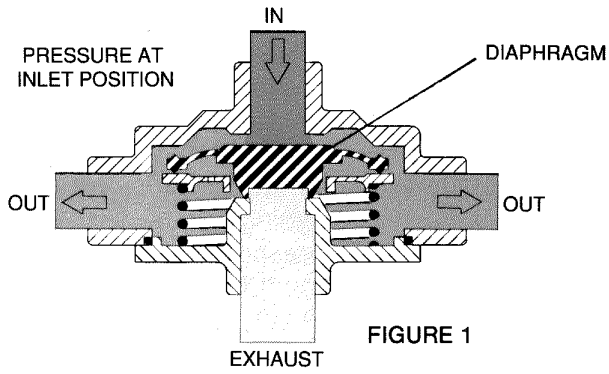


FIGURE 1

In the equilibrium position shown in Figure 2 the outgoing pressure is now equal to the supply pressure. The diaphragm is returned to its original position sealing against both the "EXHAUST" and the "SUPPLY" seat.

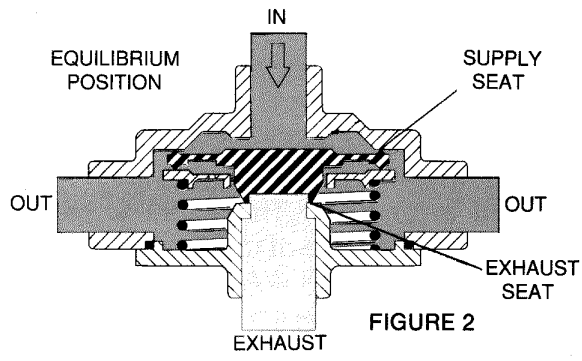


FIGURE 2

In Figure 3 the Quick Release Valve is shown with the supply pressure vented to atmosphere. The accumulated air in the system now forces the diaphragm against the "INNER SEAT" of the "IN" port, which permits venting of the system to atmosphere via the "EXHAUST" port of the Quick Release Valve.

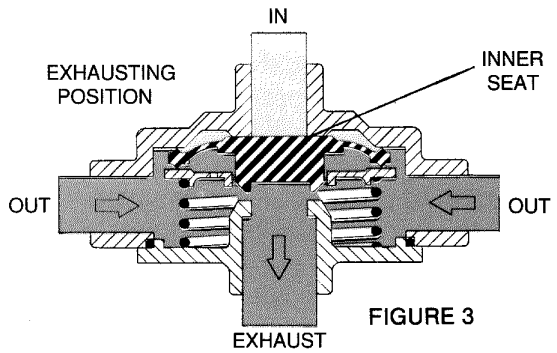


FIGURE 3

The Quick Release Valve as illustrated in Figure 2 shows its natural position. In this position the rubber diaphragm must make contact at the upper edges of the supply cavity and at the exhaust seat without deflecting the diaphragm in an upward position. There should be no clearance between the exhaust portion of the diaphragm and the Quick Release housing cap.

The Quick Release Valve should always be **installed with the exhaust port facing down** to avoid dirt entering the valve. The only replacement parts required in this valve is the diaphragm, which normally provides 6-10 years of trouble free service.

# RELAY VALVES

The basic purpose of a Relay Valve in pneumatic control circuitry is to provide interlocks and delays of various pneumatic actions. The pilot line, which is the control element of the relay, overcomes the adjustable spring setting to either open or close. **It is important that the spring setting conforms with the requirements of the control system.** Setting a normally open relay valve spring too low will result in the valve remaining closed at all times. At the same time, setting a normally closed relay valve spring above the available air pressure will result in the valve not opening. A flow control valve used in conjunction with an accumulator tank will further assist the timing range of these adjustable relays.

It is recommended that the valve be mounted with the adjusting means at the top and the supply and outlet ports at the bottom.

The Relay Valve illustrated on this page is a normally open type. It is basically the same as a mechanically operated 3-way valve with its in, out and exhaust ports (as illustrated on page 6).

In Figure 1 the valve is shown in its open position with the spring forcing the stem down. This permits flow of air from the "IN" port to the "OUT" port. Air cannot escape out of the "EXHAUST" port since the lower part of the stem is sealed against the poppet.

Figure 2 illustrates the valve in its closed position. The pilot air pressure is accumulated under the diaphragm which causes the spring to compress and in turn retract the stem which causes the poppet to seat. This stops the flow of air from the supply to the valve. At the same time any accumulated air in the "OUT" line and attached components is permitted to enter the hollow stem and exhaust to atmosphere via the "EXHAUST" port.

It is important to remember that **the vent port must not be plugged**, in order to allow the diaphragm to move without back pressure. The pressure setting screw on top of the valve will permit in-field fine adjustment of the valve pressure setting point. Several springs are available which will provide a complete range of pressure settings from 15 to 140 psi.

The synthetic rubber parts in all Kobelt Relay Valves should provide 6-10 years of trouble free service. When dismantling valves of this nature **it is important to avoid dirt and foreign matter entering the control system and the valve.**

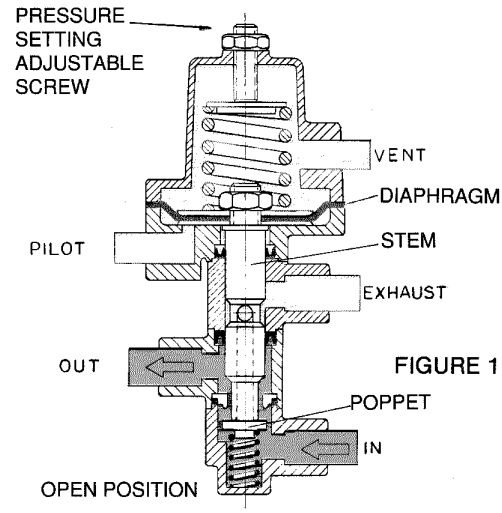


FIGURE 1

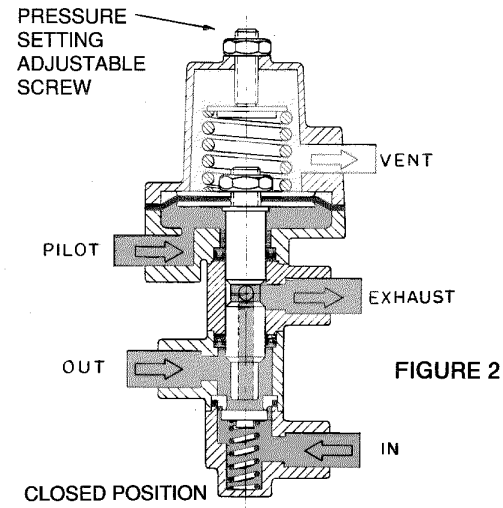


FIGURE 2

# RELAY VALVES

The valve illustrated on this page is normally closed. It is basically the same as the valve shown on page 9 but the function of the valve is reversed.

Figure 1 shows the valve in its normally closed position with the spring pulling the diaphragm stem up which allows the valve stem to follow. This stops the flow of air through the valve and will permit all accumulated air in the "OUT" line to exhaust via the "EXHAUST" port.

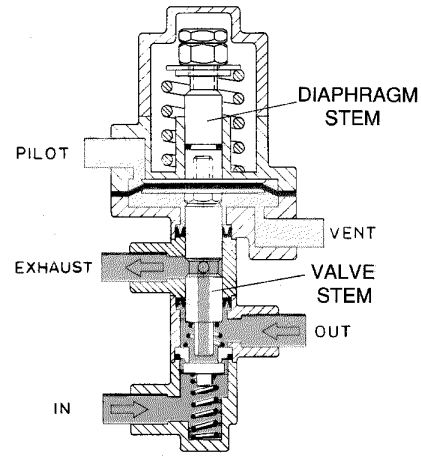


FIGURE 1

Figure 2 shows the valve with sufficient pilot pressure entering the diaphragm cavity to overcome the spring thus depressing the valve stem downward and permitting flow of air from the "IN" port to the "OUT" port. The "EXHAUST" port at this point is sealed.

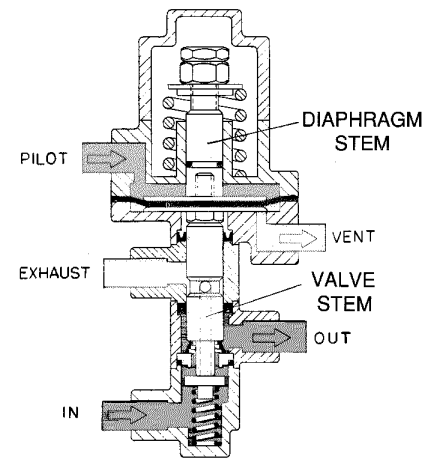


FIGURE 2

Figure 3 illustrates a normally open relay valve with two diaphragms. These relay valves are used for dual piloting and can be extremely useful in interlocking circuits. The reason for the two diaphragms is to avoid double deflection of the diaphragm which results in premature failure. Also, in case of diaphragm failure, the pilot pressure cannot be cross-fed back into the system, since the spacer piece provides for venting to atmosphere.

The basic operating principles of this valve are the same as the foregoing valves. It is also available in a normally closed version.

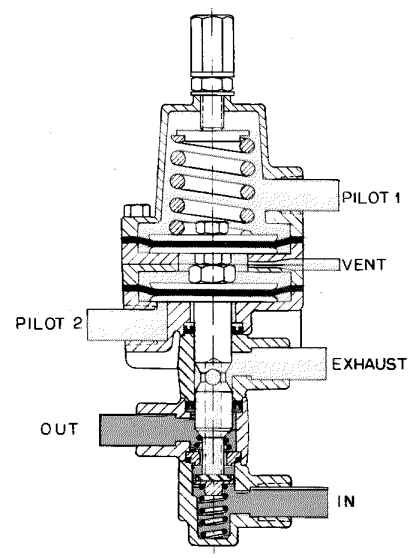


FIGURE 3

# PRESSURE COMPENSATING REGULATOR VALVES

The purpose of the pressure compensating regulator is to provide an infinitely variable output pressure signal. There is a direct relation between the mechanical input stem position and the amount of accumulated air in the control system. The balance is obtained with air pressure against a reactor spring. The rolling diaphragm makes these valves very accurate due to the low friction. The air pressure entering the "IN" port is held in check until the "STEM" is depressed downward (see Figure 1). This downward movement will create an opening between the supply ball and the seat thus allowing air to flow to the "OUT" port (see Figure 2). Air pressure going to the "OUT" port and via the orifice to the piston chamber, then compresses the reactor spring at the bottom of the valve until such a point that both valve balls (supply and exhaust) are seated into their respective seats. This will cause an equilibrium point whereby no air flow will take place. Allowing the "STEM" to move upwards will cause the exhaust ball to lift itself from its respective seat and permit exhaust of air to atmosphere. This will allow the main reactor spring to push the seat upwards until the valve is in a balanced position again.

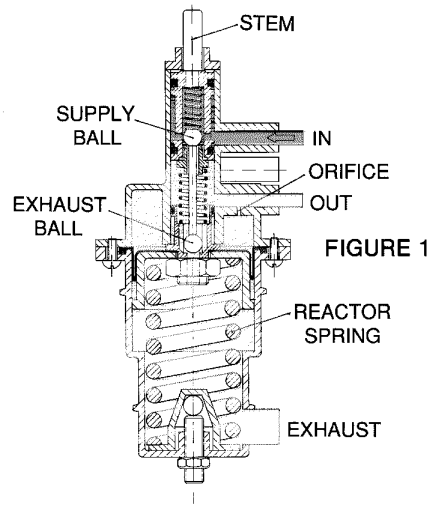

FIGURE 1

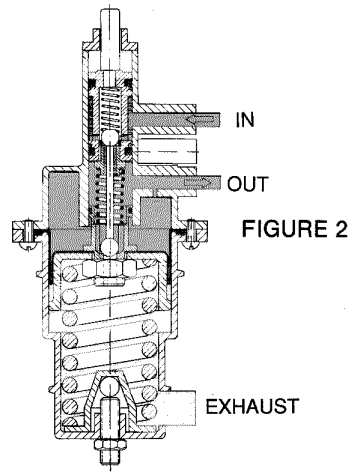

FIGURE 2

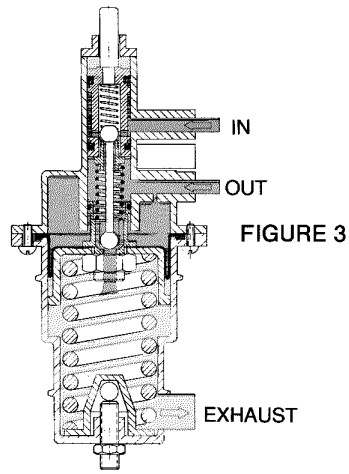

FIGURE 3

These valves are manufactured in three different pipe sizes, 1/8", 1/4" and 1/2" N.P.T. **It is important to keep these valves free from dirt and foreign matter since the valve seat and the valve ball are quite sensitive to dirt. Caution should be taken to avoid dirt entering the pneumatic control system during installation and operation.**
**A filter in the supply line is essential. Steel and iron tubing are not recommended.** This valve should operate for 6-10 years without problems. Only synthetic rubber parts and diaphragms will be required for overhaul.

# PNEUMATIC POSITIONERS

Single direction positioning units (Figures 1and 2) are required for the control of engine speed, etc. Two direction control devices (Figures 3 and 4) are used for such applications as variable delivery hydraulic pumps,controllable pitch propellors and many other applications where two direction positioning is required.

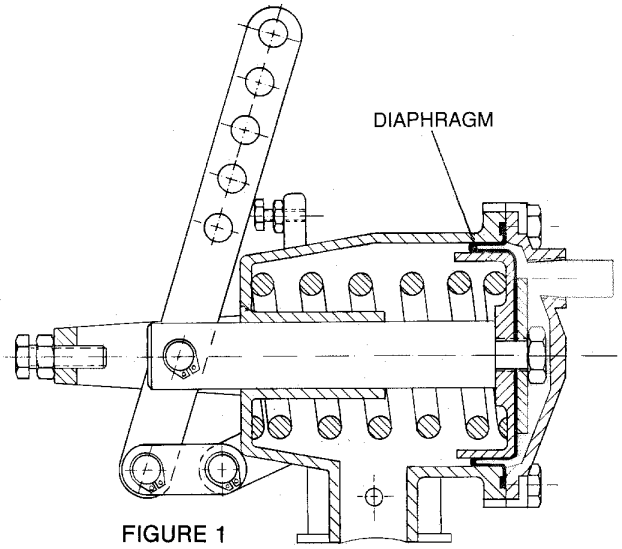


FIGURE 1

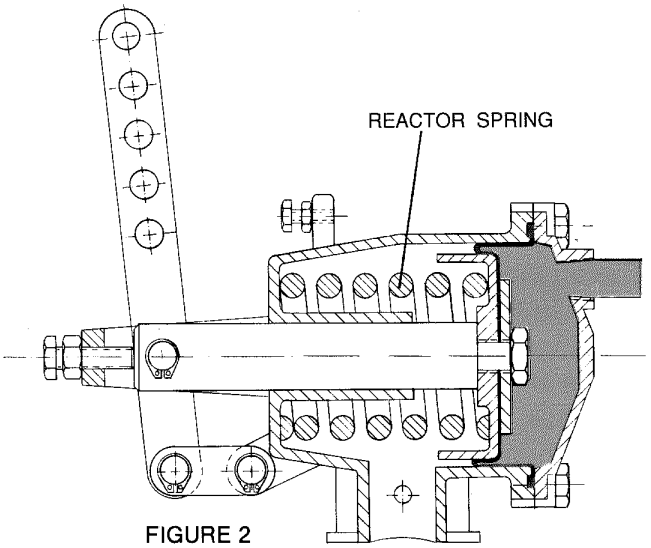


FIGURE 2

Figure 1 shows atmospheric pressure behind the spring and diaphragm assembly. The piston rod and output linkage are in their most retracted position.

In figure 2, increasing the air pressure will cause a proportional compression of the reactor spring, which in turn causes the piston rod and linkage to move outward proportionally to the input pressure.

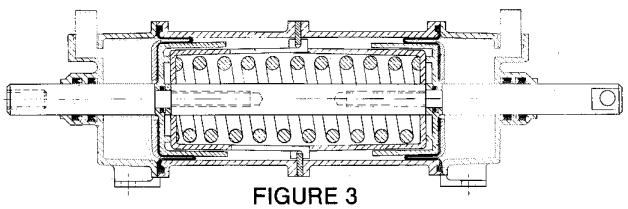

FIGURE 3

Figure 3 shows a positioning device in its neutral and relaxed position with atmospheric pressure entering the cylinder at both ends.

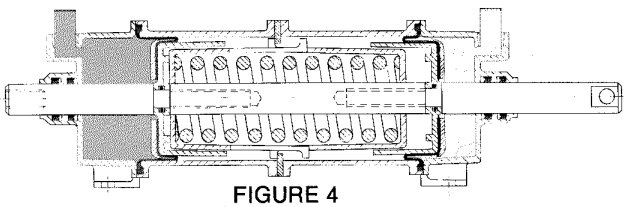

FIGURE 4

Figure 4 shows the cylinder with air pressure accumulated at the left hand side behind the diaphragm and piston assembly. This causes the piston rod to move to the right. The spring is retained by a spring housing which is caged behind a center ring. Again a rolling diaphragm and spring permits infinite positioning in both directions. In order to prevent premature damage to the diaphragm, it is recommended to maintain a 2-3 psi pressure at all times at both ends of the cylinder.