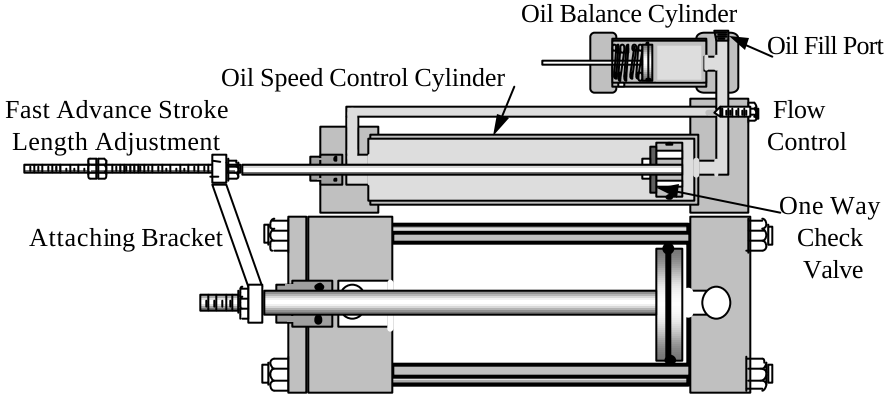
Air-Oil Cylinders, Tanks and Intensifiers

Air-Oil Systems



Hydraulically Controlled Air Cylinder for Fast Advance and Controlled Feed Stroke With Fast Retract

Fig. 17-1

Compressed air is suitable for low power systems, but air compressibility makes it difficult to control actuators smoothly and accurately. However, some low power systems need, smooth control, rigidity, or synchronization capabilities normally associated with oil hydraulics. All of these features are available to low power circuits by using compressed air as power and oil for control. Purchased or special built Air-Oil circuits give smooth control when power requirement is low.

Attached Oil Control Cylinders

Some manufacturers offer attached oil filled cylinders to control speed and/or position, **Fig. 17-1**. These units usually work in one direction of travel in a meter out circuit. They operate such things as drill feed or other actions that may try to pull the cylinder out. They can be used with hydraulic cylinders at higher forces also.

Most manufacturers offer units with valves in the oil line that can stop flow and/or bypass the speed control. The stop control allows an air cylinder to be stopped reasonably accurately with very good repeatability. The bypass control makes it possible to have fast and controlled speeds as the cylinder advances.

The cutaway in **Fig. 17-1** shows an air cylinder that advances rapidly with air flow controls until its **Attaching Bracket** comes in contact with the **Fast Advance Stroke Length Adjustment**. At this point air cylinder movement is retarded and controlled by the **Oil Speed Control Cylinder** as oil flows through a **Flow Control.** The air cylinder cannot move any faster than oil flow allows during this part of the cycle. A spring loaded **Oil Balance Cylinder** furnishes oil to makeup for the differential loss from rod to cap. The air cylinder is controlled by oil flow for the remainder of the cycle.

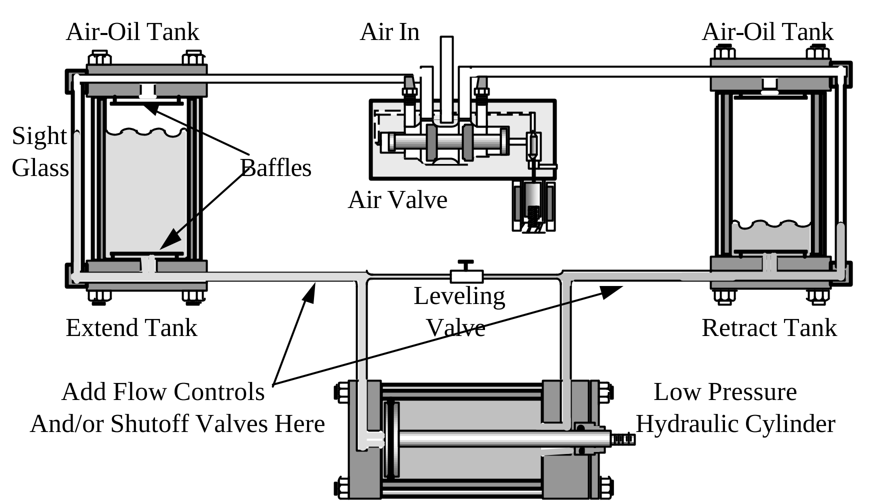
As the air cylinder retracts and the **Attaching Bracket** contacts the rod nut it pushes the **Oil Speed Control Cylinder** back to the start position. A flapper type **One Way Check Valve** on the piston with through holes allows fluid to transfer back to the rod end. Excess cap end fluid is stored in the spring loaded **Oil Balance Cylinder** during this part of the cycle.

Some manufacturers offer attached units that are capable of control in both directions of travel.

There are also self contained air powered cylinders, with built in oil cylinders and reservoirs. Air gives thrust while oil controls speed and/or mid stroke stop and hold. Some units also have two speed capabilities. These units look like a standard cylinder with an over size rod.

Air-Oil Tank Systems

Another common air oil system uses **Low Pressure Hydraulic Cylinders** coupled with **Air-Oil**



Typical Air-Oil Tank System

Fig. 17-2

Tanks, **Fig. 17-2**. These tanks hold more than enough oil to stroke the cylinder one way. An **Air Valve** piped to the **Air-Oil Tanks**, forces oil from the tanks into the cylinder. **Add Flow Controls and Shutoff Valves** to the oil lines to give smooth accurate cylinder control.

When control is only necessary in one direction the tank on the uncontrolled side can be left off. This type circuit requires very good cylinder seals to stop air or oil transfer.

Air over oil tanks give no intensification to the oil, no matter the tank diameter or length. The amount of air pressure supplied is the highest possible oil pressure available.

Several cylinder suppliers offer air-oil tanks that are made of a cylinder tube with two cylinder cap ends held on the tube with tie-rods. The sight glass can be as simple as plastic tubing and air line fittings attached opposite the air ports. A **Baffle** at the air port keeps oil from being aerated as air blasts in from the valve. A **Baffle** at the oil port keeps any vortex formed from sending air to the cylinder and keeps returning fluid from blowing into the air port.

<u>Air-Oil Tandem Cylinders</u>

Tandem cylinders are another way of having oil control and air power, **Fig. 17-3**. The **Single Rod Cylinder** of the tandem runs on air, while the **Double Rod Cylinder** is full of oil. Since volume is equal in both ends of the **Double Rod Cylinder**, oil flows from end to end through a **Flow Control** and/or **Shut Off** or **Skip Valves** for accurate speed and stop control.

Two flow controls in opposite directions gives variable speed in both directions. A bypass flow control around the **Stop Valve** would allow for two speed operation in one direction. The second speed must be the slowest.

The **Skip Valve** option allows a fast approach and slow down before work contact. Slow down would be signaled from a limit switch or limit valve.

Fig. 17-4 shows tandem cylinders in a synchronizing circuit in a schematic drawing. This is a practical way to make two or more air powered cylinders move in unison. The only other fluid power way is to use flow controls which is not at all accurate.

When the air valve shifts to extend the air cylinders they must move at the same time. This is because the trapped hydraulic oil in the hydraulic cylinders must transfer from the top side of one cylinder to the bottom side of the other one. If one cylinder stops they both must stop at the same time.

It should also be noted that the maximum load capability is equal to the capacity of both cylinders thrust. With the load placed as shown the left cylinder transfers energy to the right cylinder through the oil and gives the right cylinder up to twice as .much thrust.

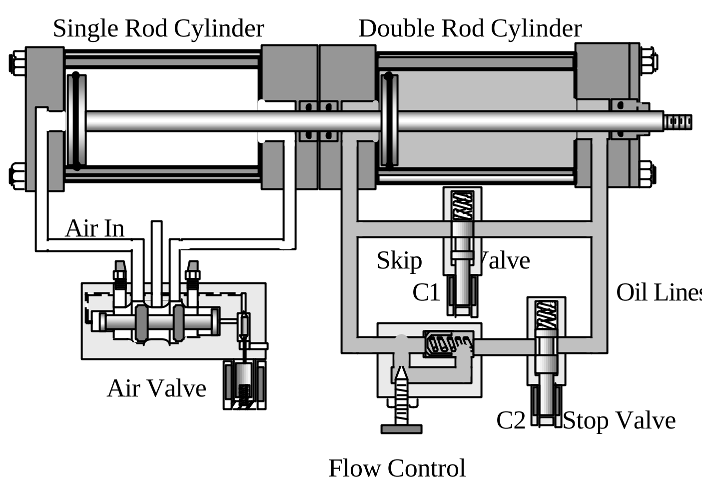
A small **Makeup Tank** and **Check Valves** replenish leakage in the plumbing or at the rod seal. If the unit is subject to heating a small relief valve may be required to keep thermal expansion from over pressuring the oil filled chambers.

A **Shutoff Valve** connecting the transfer lines allows the cylinders to be re-synchronized when piston seals bypass and the **Platen** gets out of level. This can be handled automatically with a 2-Way normally closed spool valve and limit switches.

For other Air-Oil circuits see the authors book "Fluid Power Circuits Explained".

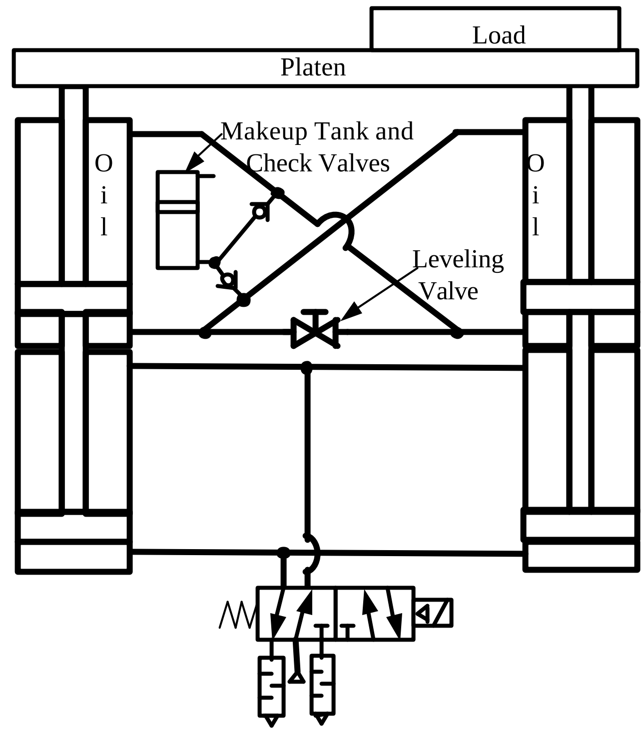
Some Precautions when designing and setting up Air-Oil circuits.

- Most air-oil circuits operate at 100 PSI or less, so any pressure drop in the circuit can cut force drastically. If oil lines are undersized, cylinder movement will be very slow. Size most air-oil circuit oil lines for about two to four feet per second velocity. This low speed requires large lines and valves but is necessary if average travel speed, with maximum force is important.
- Another common problem with air-oil circuits is bleeding of air from the oil chambers. Any trapped air in the oil makes the cylinder spongy. This compressibility makes accurate mid stroke



Typical Air-Oil Tandem Cylinder Circuit

Fig. 17-3



Air-Oil Tandem Cylinder Synchronizing Circuit

Fig. 17-4

stopping and smooth speed control hard to attain. When using an air-oil tank system, it is best to mount the tanks higher than the cylinder they feed. All lines between the cylinder and the tanks should slope up to the tanks. Also, if possible, let the cylinders make full strokes to purge the air.

- With dual oil tank systems, incorporate a means for equalizing tank level in the design.
- The cylinder seals must be as leak free and low friction as possible. Any leakage past the seals can cause tank overflow, oil misting, and loss of control.

Air to Air, Air-Oil and Hydraulic-Hydraulic Intensifiers (Booster)

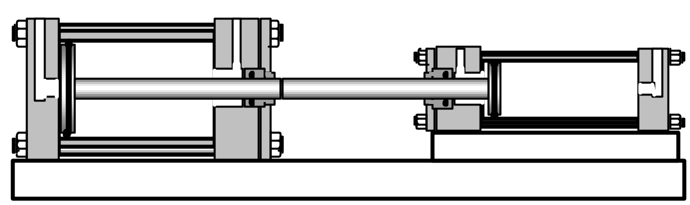
In some of the foregoing Air-Oil circuits 80-100 PSI pressure may not be adequate for some operations. This does not mean a hydraulic pump and all the items related to it must be used. Several manufacturers make Air-Oil Intensifiers that convert 80-100 PSI shop air into 500-40,000 PSI hydraulic pressure in minor to small volumes.

Single Stroke Intensifiers

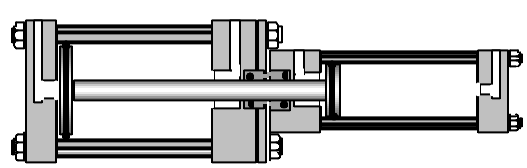
The simplest intensifier is a single rod end cylinder with a large piston rod. As seen in Chapter 15 page 15-12 a cylinder with a 2:1 area ratio rod can have pressure up to twice system pressure in the rod end. This type intensifier is only available in ratios up to 2:1 unless special over size rods are specified.

Another simple intensifier can be made by coupling the rod of a large bore cylinder to that of one with a smaller bore and the same stroke, **Fig. 17-5**. Supplying the large bore cylinder with air or hydraulic fluid forces hydraulic fluid out of the smaller bore.

The upper cutaway is two cylinders assembled in the users plant from stock air and/or hydraulic cylinders. The lower cutaway is a purchased assembly that takes less space and eliminates mounting and alignment problems. The purchased unit is limited to piston ratios that can have the same size rod in both cylinders.



Assembled Differential Cylinder Intensifier



Purchased Differential Cylinder Intensifier

5? Bore Driving a 2 ½? Bore 10? Stroke.

5? Bore= 19.635?²
2 ½? Bore= 4,909?²
Area Ratio= 4:1

Output Volume= 4.909?² X 10? Stroke= 49.1?³

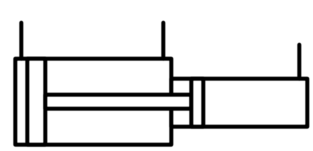
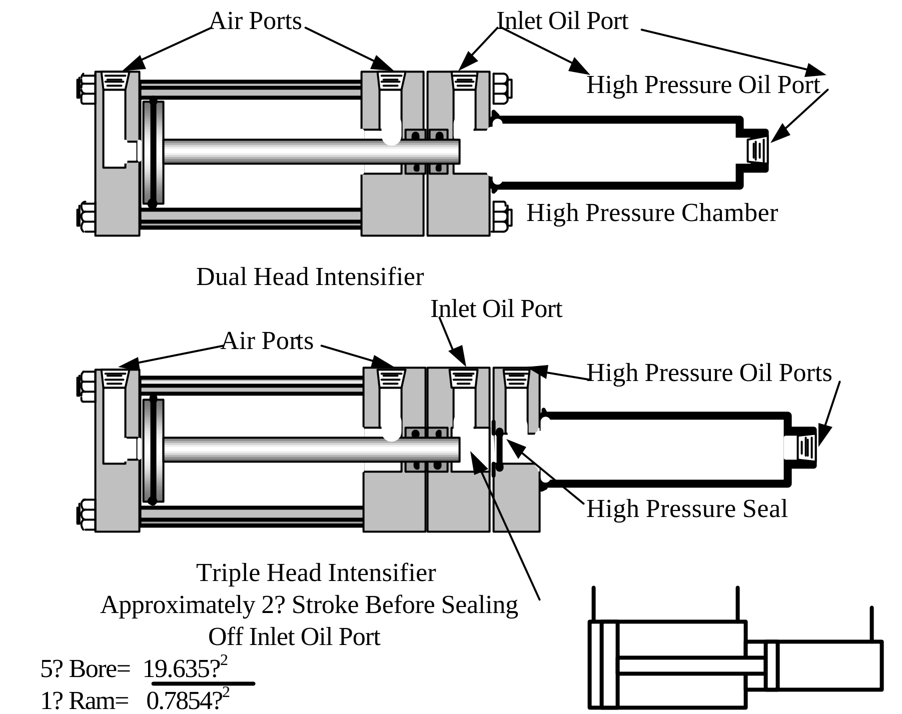


Fig.17-5 Symbol



5? Bore= 19.635?^{2}
1? Ram= 0.7854?^{2}
Area Ratio= 25:1

Output Volume= 0.7854?^{2} X 10? Stroke= 7.85?^{3} Dual Head Intensifier

Output Volume= 0.7854?^{2} X 8? Stroke= 6.28?^{3} Triple Head Intensifier

Ram Type Single Stroke Intensifiers

Fig.17-6

Usually these intensifiers are hydraulic to hydraulic and under a 5:1 ratio. Later there is a similar design for air to air intensifiers up to 4 or 5:1 ratios.

Never operate these types of intensifier above rated cylinder pressure.

For all intensifier designs, output pressure is directly related to the Area Ratio between the driving piston and the driven piston or ram.

The cutaway in **Fig. 17-6** shows typical construction of a **25-1** Air-Oil **Intensifier**. It consists of a **5? Bore Air Cylinder** with a **1? Rod** displacing oil from a **High Pressure Oil Chamber**. The upper cutaway is a **Dual Head Intensifier** that requires some sort of blocking valve to isolate **Inlet** oil from **Outlet** oil. This is usually done with a pilot operated check valve so flow can return when the actuator reverses.

The lower cutaway is for a **Triple Head Intensifier** that has a built in **High Pressure Seal** that isolates **Inlet** oil from **High Pressure Oil** after the rod moves approximately 2?. There is no need of external isolation since oil can flow freely either way anytime the ram is retracted.

As indicated by the math in the **Fig. 17-6** this combination of driving piston and ram gives a 25:1 intensification and approximately 0.785 cubic inches of oil per inch of stroke.

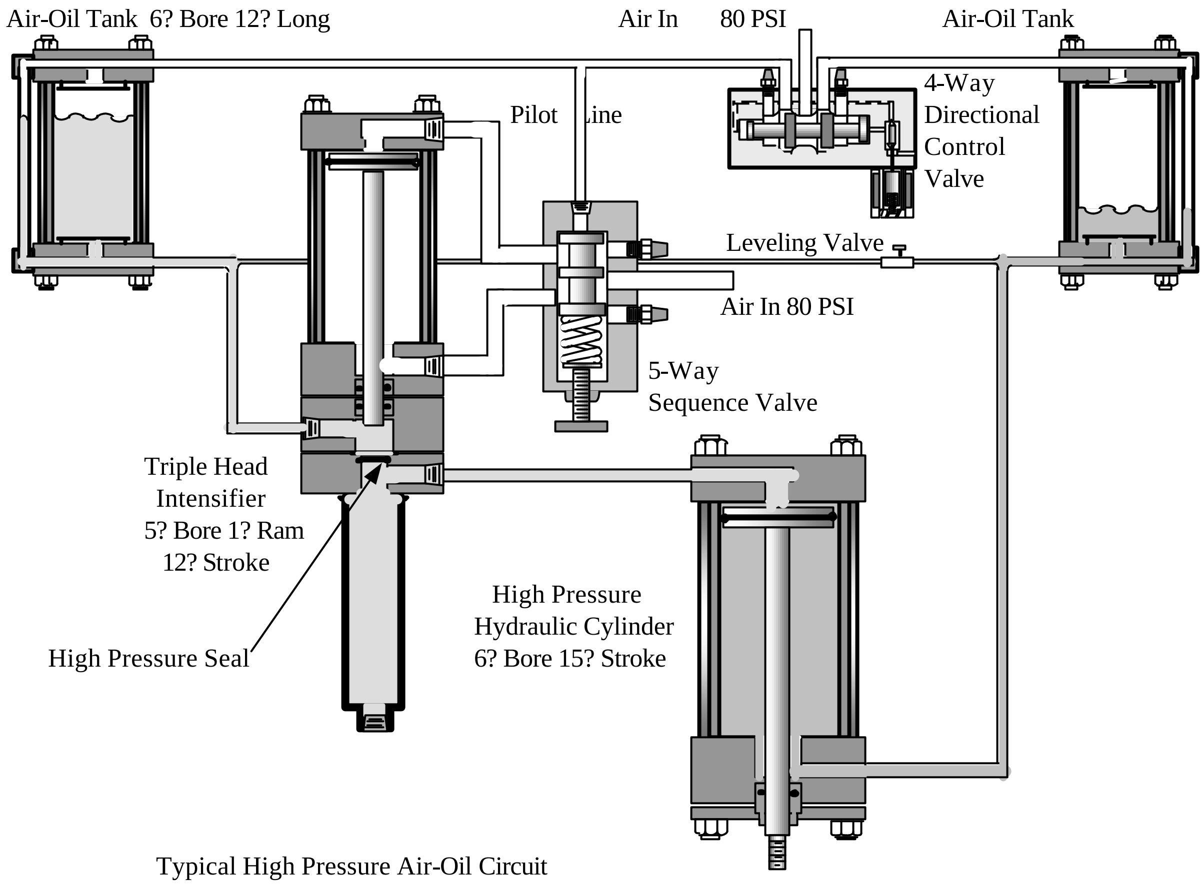
A single stroke intensifier must be sized to supply enough oil to make the working cylinder perform its work before the air piston hits bottom. It is good practice to size for 10-15% more fluid than required. Avoid long lines and hose if possible since oil compressibility and hose stretch can use up the small volume output quickly.

The circuit in **Fig. 17-7** shows a typical High Pressure Air-Oil circuit using the equipment discussed so far. This could be a press operation that requires a 10? total stroke and a 0.250 high pressure stroke of 25 tons. Based on a maximum pressure of 2,000 PSI this amount of force requires a cylinder with a 6? bore. Since a 6? bore cylinder has 28.274?^{2} the 0.250? work stroke requires 0.250 X 28.274= 7.07?^{3} of high pressure oil. Using a standard 5? intensifier with a 1? ram this requires 7.07 X 110% / 0.7854= 9.9? stroke plus 2? for passing the **High Pressure** seal for a total of 12?.

The 6? Bore X 10? Stroke **High Pressure Hydraulic Cylinder** has 28.275?^{2} Area X 10? Stroke= 283?^{3} of volume so the **Air-Oil Tanks** should be 6? Bore X 12? Long

The cycle starts when the solenoid on the **4-Way Directional Control Valve** is energized and sends air to the left **Air-Oil Tank** and exhausts air from the right **Air-Oil Tank**. Oil at air pressure is pushed through the **Triple Head Intensifier** and to the **High Pressure Hydraulic Cylinder**. The cylinder fast advances at low force until it contacts the work.

At work contact pressure builds in the left **Air-Oil Tank** and in the **Pilot Line** to the **4-Way Sequence Valve**. With inlet air pressure at 80 PSI and the **4-Way Sequence Valve** set at 65-75 PSI it shifts and cycles the intensifier. As the intensifier extends it travels approximately 2? and passes through the **High Pressure Seal** to block low pressure oil and force high pressure oil to the cylinder. Pressure in the work cylinder can now go as high as 2,000 PSI to give up to 25 Tons of force.



Typical High Pressure Air-Oil Circuit

Fig. 17-7

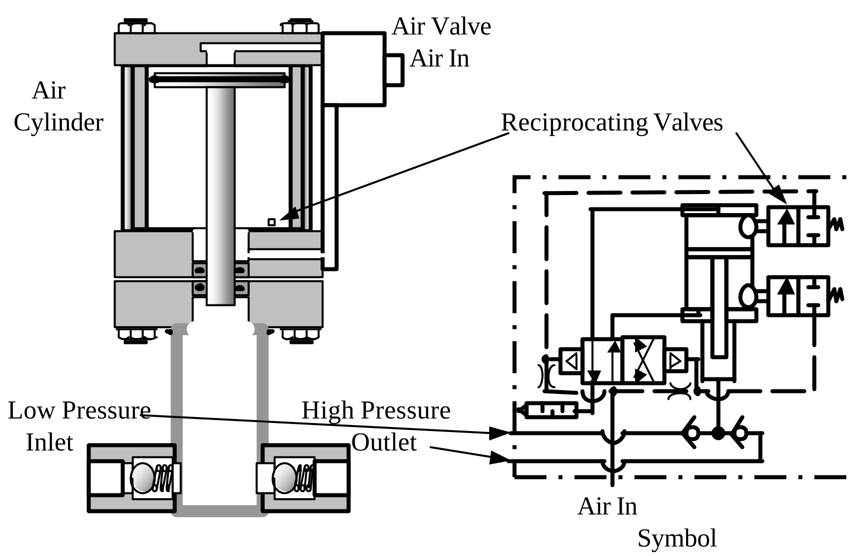
When the solenoid on the **4-Way Directional Control Valve** de-energizes, air exhausts from the left **Air-Oil Tank** and from the **4-Way Sequence Valve Pilot**. The **4-Way Sequence Valve** shifts to its original position and the **Triple Head Intensifier** retracts. Air is also directed to the right **Air-Oil Tank** and pressurizes it for the retract stroke of the **High Pressure Hydraulic Cylinder**. After the intensifier retracts past the **High Pressure Seal** the work cylinder can retract fast to end the cycle. *Note: Retract force is only 80 PSI on the area of the work cylinder. There was up to 25 Tons of force to extend for a short stroke but only 1,869 pounds to retract.*

The intensifier could be cycled by other means such as a limit switch or pressure switch and a solenoid valve. It could even be manual or any way to meet the needs of the operation.

Any of the above units could be cycled with hydraulic oil as the driving force. Usually hydraulic intensifiers are only 2-5:1 since the input pressure can be much higher than air.

Reciprocating Intensifiers

For higher volumes of intensified fluid several manufacturers make Reciprocating units. The cutaway



Reciprocating Air to Hydraulic Intensifier

Fig. 17-8

and symbol in **Fig. 17-8** show a typical single ram intensifier that uses air as the power and pumps oil in the high pressure side. They are often supplied in a ready to run unit as pictured. They may cycle as soon as air is supplied or they may require an external signal to start.

Most reciprocating units supply less that 3 GPM maximum at low pressure and slow to a stop at maximum pressure.

For higher pressures some units use more than one **Air Cylinder** in series to raise intensification ratios. These units also come with pressure chambers and rams on both ends for higher oil volume

Some manufacturers make reciprocating hydraulic to hydraulic intensifiers with ratios up to 20:1 and pressures up to 12,000 PSI. They are used to supply a small volume of high pressure oil from low to high pressure input.

Special Air-Oil Units

Several companies make special self contained air hydraulic cylinders that have built in tanks and intensifiers that give low pressure advance, high pressure work and low pressure retract strokes. They appear to be over length air cylinders but have output forces up to 150 Tons.

Air to Air Intensifiers

When a small amount of high pressure air is required try an Air to Air Intensifier in place of a high pressure compressor. The cutaway and symbol in **Fig. 17-9** shows the makeup of a 2:1 intensifier that almost doubles output pressure.

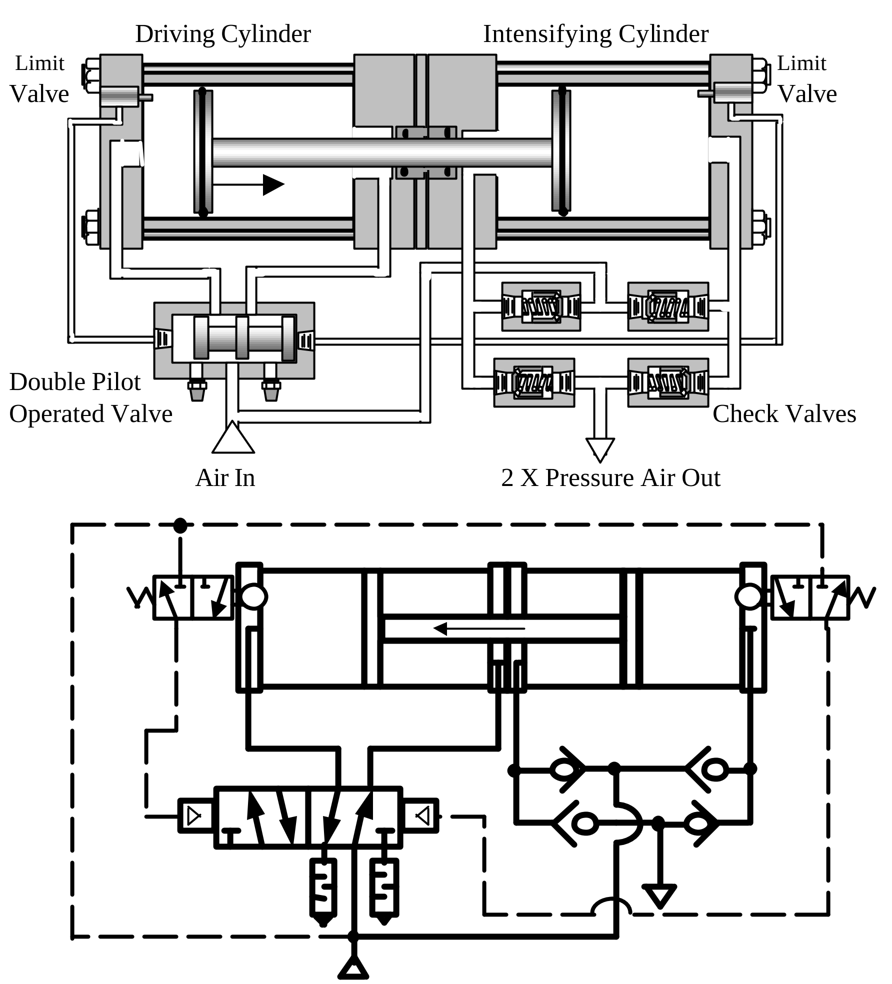
Inlet air is fed to the **Driving Cylinder** by a **Double Pilot Operated Valve** and to the **Intensifying Cylinder** through **Check Valves**. As the two pistons move right the full area of the left piston and the annulus area of the right piston are pushing the right pistons full area at almost double force. So air coming out of the right piston is up to twice input pressure. Discharge air goes through a **Check Valve** and on to the high pressure circuit.

When the pistons stroke all the way the one on the right contacts a small built in **Limit Valve** that sends a signal to the **Double Pilot Operated Valve** and shifts it to stroke the pistons left. The same areas and forces push this way but are working against a smaller intensifying area. The intensifier will continue cycling until pressure at the **2 X Pressure Air Out** port is at full pressure. At that time the pistons stall and hold pressure until pressure downstream drops.

These intensifiers will slow considerably at about 80% of their maximum pressure so it is best if the output air is at least 20% above what is required. A regulator at the working machine can set actual working pressure so less air is wasted.

Higher intensification ratios and different output volumes are the function of piston ratios, bore size and stroke length. Outputs up to 250 PSI are standard with most manufacturers and higher pressures are offered by some.

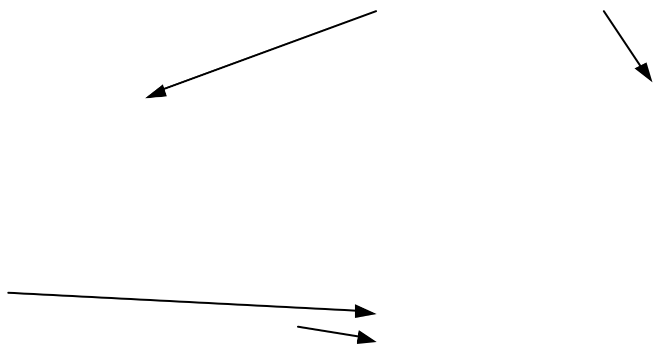
Very high pressure units use hydraulic cylinders to drive gas cylinders to reach pressures up to 45,000 PSI.



2:1 Air to Air Intensifier

Fig. 17-9

For more Air-Oil and Intensifier circuit designs see the authors book "Fluid Power Circuits Explained "



Quiz On Information Learned From Chapter 17

1. Air-Oil systems use_______as power and_______as the controlling medium.:
   - A. oil, air
   - B. water, oil
   - C. air, oil

2. Attached oil control units can control cylinder action:
   - A. both ways.
   - B. extend only.
   - C. retract only.

3. Large diameter Air-Oil tanks:
   - A. increase pressure at the outlet.
   - B. decrease pressure at the outlet.
   - C. have no effect on pressure at the outlet.

4. Size oil flow lines in an Air-Oil circuit for:
   - A. 2-4 FPS velocity.
   - B. 4-8 FPS velocity.
   - C. 10-15 FPS velocity.

5. Tandem cylinders can be used in:
   - A. synchronizing circuits.
   - B. mid stroke stop circuits.
   - C. two speed circuits
   - D. all of the above.

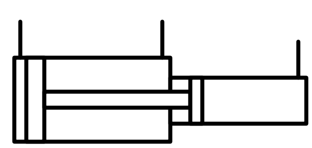
6. Air to oil intensifier oil output volume is equal to:
   - A. air input volume.
   - B. a large portion of air input volume.
   - C. a small portion of air input volume.

7. Air to oil intensifier output pressure is controlled by.
   - A. the area ratio of the pistons and/or rams involved.
   - B. the length of stroke.
   - C. what size the outlet port is.

8. Air to air intensifiers:
   - A. run continuously regardless of output pressure.
   - B. stall when output pressure on the intensifier piston reaches input pressure.
   - C. stall when output pressure on the intensifier piston tries to go higher that input pressure times area ratio.

9. Air to air intensifiers are good for:
   - A. high volumes of air at increased pressure.
   - B. medium volumes of air at increased pressure.
   - C. low volumes of air at increased pressure.

10. This symbol is for a/an:
    - A. double rod cylinder.
    - B. intensifier.
    - C. Hi-Lo pump.



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