Rotate the suction tube until the exhaust of the blower is pointed to the back of the bench. Screw through the inside of the suction tube into the 4 pieces of 2x4 attached to the bottom of the bench top.

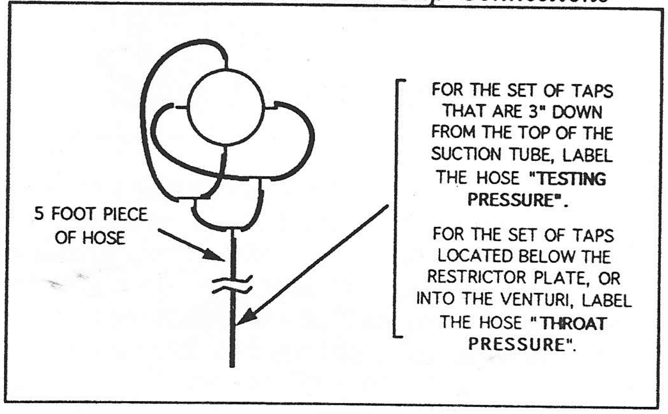
MOUNTING THE SUCTION FAN

If you are using the suction tube supplied with your leaf blower you just completed this task. If you are using a different suction fan you need to connect it to the suction tube. Since this connection occurs after the sensor it is quite insensitive to leaks and the type of connection you are using. However you should try to limit the number and severity of bends. Minimizing these factors will allow you to generate greater testing pressures. Use 4" PVC pipe, sheetmetal ducting, or whatever is required to connect the suction tube to the suction fan. Make sure whatever you end up fabricating is securely fastened and safe for operation.

PRESSURE TAP CONNECTIONS

Multiple taps are used to give us an average pressure reading. You will be joining both the "Testing Pressure" and "Throat Pressure" taps the same way. Use 1/8" vacuum hose to connect the taps as shown in diagram 39.

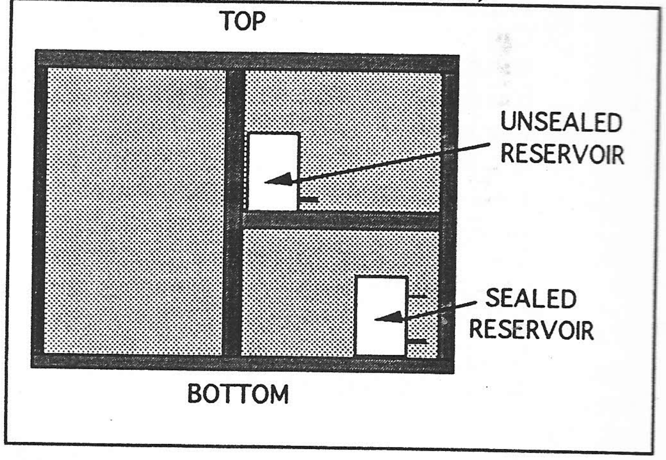
DIAGRAM 39: *Pressure Tap Connections*



MOUNTING THE RESERVOIRS

Place the reservoirs behind the backboard as shown in diagram 40.

DIAGRAM 40: *Mounting the Reservoirs (View from behind Backboard)*



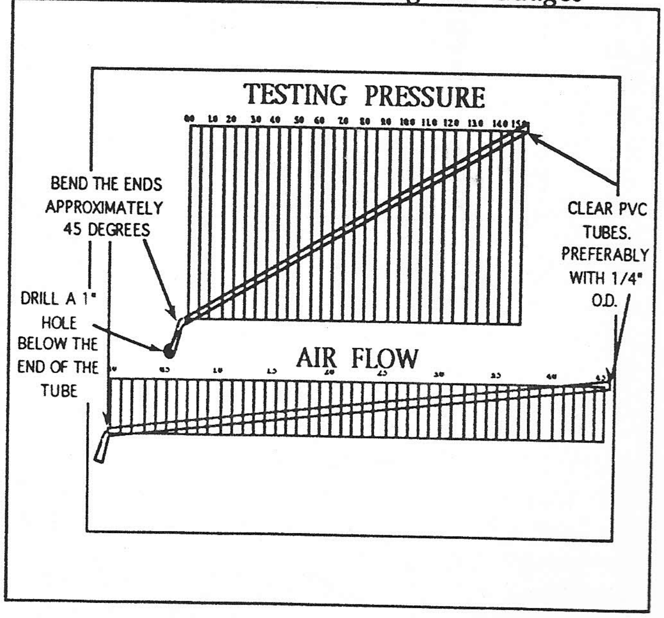
MOUNTING THE GAUGES

Cut two pieces of clear, rigid PVC 1/4" O.D. pipe to the following lengths.

- -If using the backboard shown in diagram 11A, cut them to 52" and 36".
- -If using the backboard shown in diagram 11B, cut them to 52" and 45".

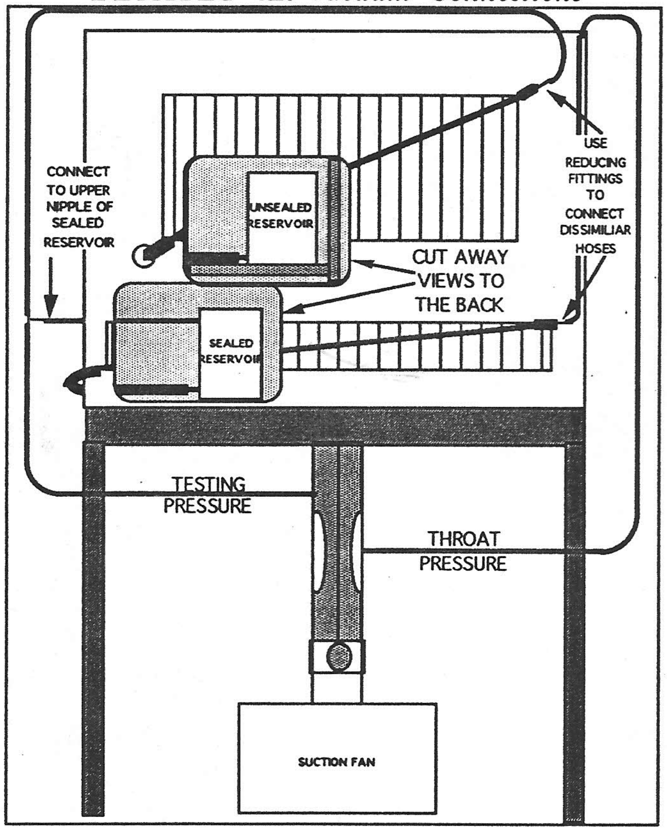
Next warm the ends of the pipe with a hairdryer. Bend the last inch approximately 45 degrees. Mount the tubes on the backboard as shown in diagram 41.

DIAGRAM 41: *Mounting the Gauges*



Slip a piece of 1/4" I.D. clear vinyl hose over the bottom end of the clear "airflow" PVC tube. Connect the other end of the hose to the lower nipple of the sealed water reservoir. Place a piece of 1/4" I.D. clear vinyl hose over the bottom end of the clear "testing pressure" PVC tube. Connect the other end of the hose to the lower nipple of the unsealed reservoir. Use hose clamps to secure the ends of the vinyl tubing. Route the "Testing Pressure" vinyl hose through the 1" hole cut in the backboard. Connect the vacuum hoses as shown in diagram 42.

DIAGRAM 42: *Vacuum Connections*



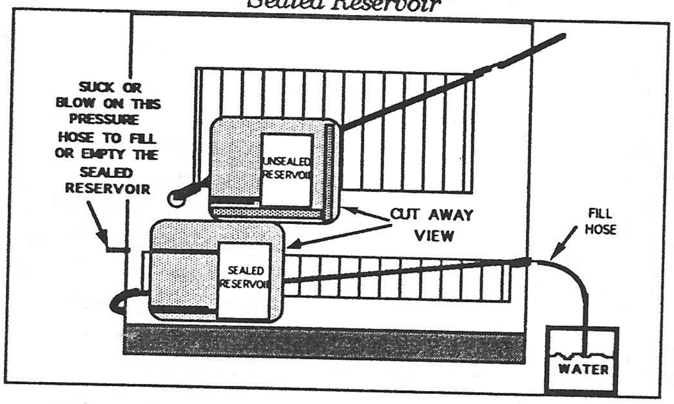
Make sure you route the vacuum hoses up and over the top of the backboard. This will help prevent the liquid from being "sucked" out of the reservoirs. This is particuliarly important when using a high powered fan.

BEFORE USING YOUR FLOWBENCH

First the horizontal gridlines need to be levelled. Using a level, check to see if the horizontal gridlines on the backboard are precisely horizontal. If not shim the bench until they are level.

Next the reservoirs need to be filled with water. I suggest you tint the water with food coloring. To add water to the unsealed reservoir pour the water directly into the can. Continue to add water until the water level in the clear rigid PVC tube is at the first vertical gridline. Make sure there are no trapped air bubbles between the reservoir and the clear PVC tube. To add water to the lower reservoir, you need to temporarily connect vacuum tubes as shown in diagram 43.

DIAGRAM 43: *Connections Needed to Fill the Sealed Reservoir*



Cut a separate piece of vacuum tubing for the fill hose. Do not reuse this hose unless it is completely dried out. One drop of water could create errors in the readings. Suck on the pressurizing hose. This will cause water to be sucked out of the pan and into the reservoir. Periodically pick up the fill hose out of the water and continue to suck until you hear the air bubbling in the sealed reservoir. Then wait and see where the water level settles. The water level should settle at the first vertical gridline. Add more water as necessary. If too much water is sucked in, blow into the pressurizing hose. This will force out water.

TESTING FOR AIR LEAKS

First you will check the "Testing Pressure" gauge. Suck on the vacuum hose which is attached to the upper end of the "Testing Pressure" PVC tube until the water level rises to the upper end of the scale. Quickly place your finger over the end of the vacuum hose. The water level should not recede. If it recedes, you have an air leak between the upper end of the tube and the vacuum hose. Take steps to remedy the problem,(i.e. add sealer...etc). Repeat the same test on the airflow gauge.

Next blow into the pressurizing vacuum hose (the upper hose of the sealed reservoir) until the water level is near the upper end of the scale. Quickly place your finger over the end of the pressurizing hose. Observe the water level. It should not be sinking. If it is, the pressurizing reservoir has an air leak in it. Find the leak and seal it.

Now use the "testing pressure" gauge as a leak tester for the rest of the system. Unhook one of the suction tube taps. Tape over the tap from the inside of the suction tube. Connect a 6' piece of vacuum hose to the upper end of the "testing pressure" PVC tube. Suck on the vacuum hose until the liquid in the "testing pressure" PVC tube is near the top of the scale. Quickly connect the vacuum hose to the suction tube tap. The water should not recede. If it does recede, you have a leak at the suction tube tap. Seal as necessary.

Repeat the above procedure for all eight of the suction tube taps. If you are using the venturi sensors test all of the throat taps on each of the sensors. Once complete, reconnect all the hoses to their original state as shown in diagram 42.

FLOWBENCH ACCCESSORIES

To fully use the capabilities of the flow bench you will need several accessories. Most of these are available commercially. However, for those of you who would rather build your own, follow the instructions given below.

BUILDING A CYLINDER HEAD ADAPTER

A cylinder head adapter will allow you to simulate the cylinder of an engine. This is important. The location of the valves relative to the cylinder walls can dramatically affect air flow. Diagram 44 shows you how to build a cylinder head adapter.

DIAGRAM 44: *Cylinder Head Adapter*

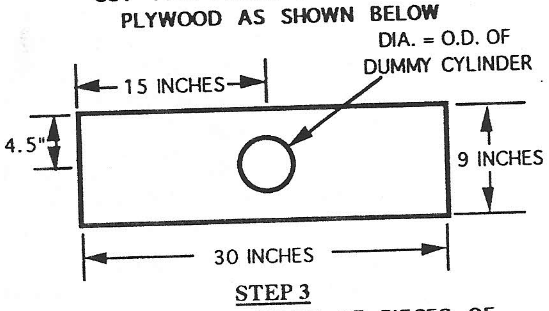
STEP 1

MAKE A 7" LONG DUMMY CYLINDER .

A DUMMY CYLINDER IS A PIECE OF TUBING WITH AN INSIDE DIAMETER EQUAL TO THE CYLINDER YOU ARE TRYING TO DUPLICATE. A GOOD CHOICE FOR AN ENGINE WITH A 4" BORE (CYLINDER DIAMETER) IS 4" PVC PIPE. INSTALL A COARSE SCREEN IN BOTTOM OF TUBE . THIS SCREEN IS A SAFETY DEVICE WHICH WILL BLOCK LARGE OBJECTS(VALVES, ETC) FROM FALLING INTO THE SUCTION FAN

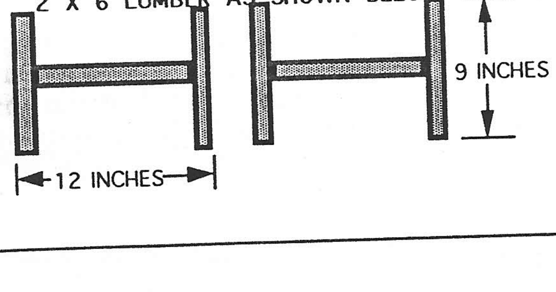
STEP 2

CUT TWO PIECES OF 3/4" THICK PLYWOOD AS SHOWN BELOW



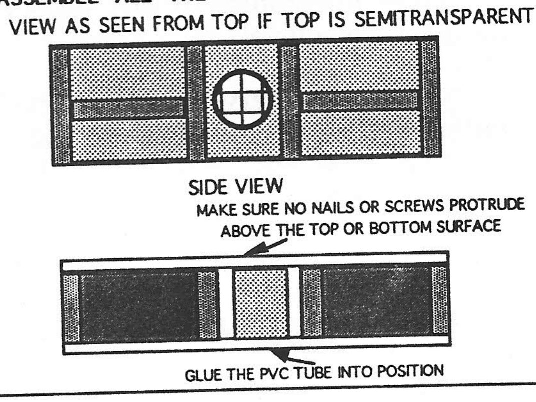
STEP 3

CUT AND NAIL TOGETHER 9" PIECES OF 2 X 6 LUMBER AS SHOWN BELOW



STEP 4

ASSEMBLE ALL THE PIECES AS SHOWN BELOW



Smear a thin coat of silicone around the top and bottom of the dummy cylinder. Allow the silicone to dry. The silicone will act as a thin o-ring to prevent air from leaking between the bench and the cylinder head adapter. When using the adapter it will be positioned so the dummy cylinder is centered over the flowbench's suction tube. Then you will place the cylinder head on top of the adapter. Align one of the cylinder head's combustion chambers so that it is directly over the dummy cylinder. Repeat this procedure to test other sets of ports.

To save time readjusting the setup each time you test a different set of ports you can do the following. Once the adapter is centered over the suction tube drill two 1/2" holes through the adapter and into the benchtop. Use 1/2" bolts to "pin" the adapter in place. Position one of the combustion chambers over the dummy cylinder. Drill through two of the cylinder head bolt holes into the adapter. Repeat this process for the remaining combustion chambers. Use 1/2" bolts to "pin" the cylinder head into the desired position.

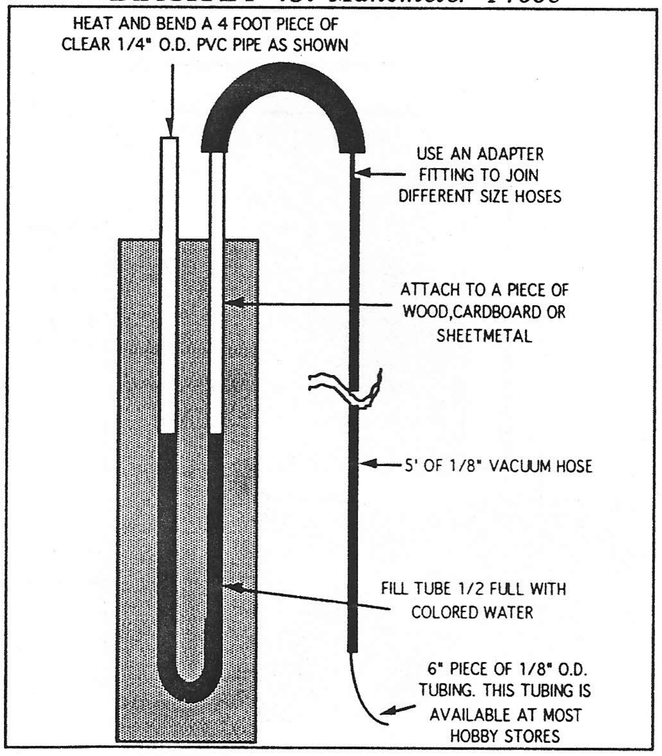
If you are using a dummy cylinder which

is significantly smaller than the suction tube diameter you should build a transition spacer. A transition spacer is a cylinder head adapter which uses a dummy cylinder with an I.D. equal to that of the suction tube. The spacer should be placed between the flowbench table top and the cylinder head adapter. The spacer acts as an extension of the suction tube. This gives the air more time to diffuse uniformly across the entire diameter of the suction tube. If there isn't sufficient time for the air to diffuse it is possible in extreme cases to obtain negative airflow readings, and have the restrictor plate float up in the air. Usually a 6" spacer is more than sufficient.

BUILDING A MANOMETER PROBE

This probe will enable you to determine where most of the air is flowing. Diagram 45 shows how to build this probe. When using the probe, do not be concerned about exact values of water displacement, instead look for general trends. As the water level is raised you are in a high flow region. If the level jumps erratically then the flow has become unattached and turbulent.

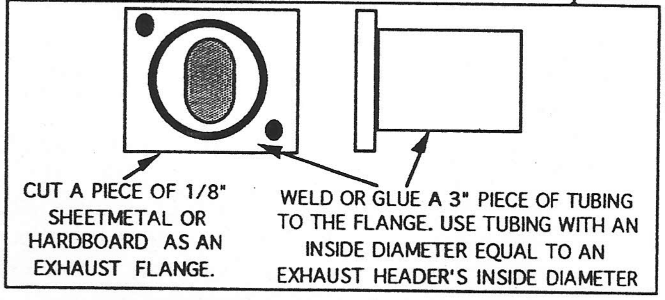
DIAGRAM 45: *Manometer Probe*



TESTING AN EXHAUST PORT

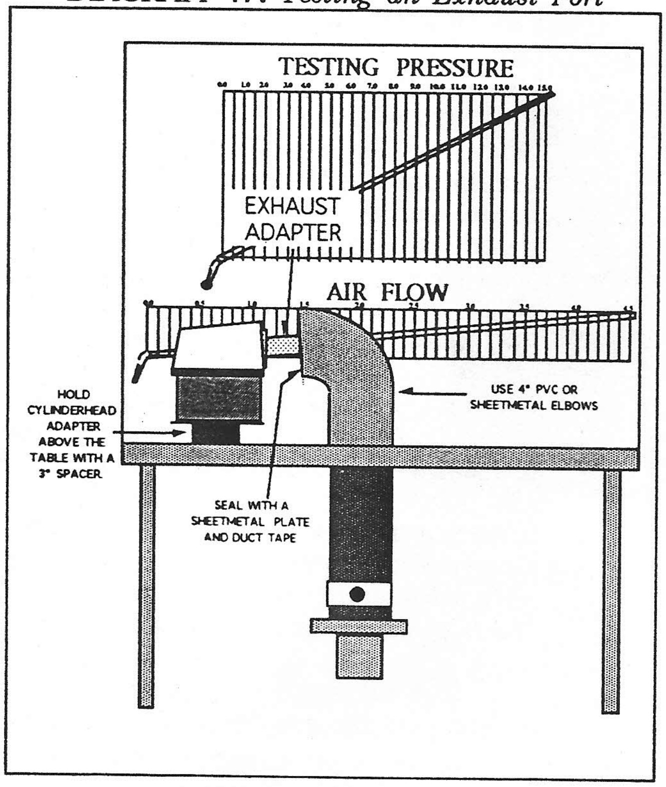
To test an exhaust port you need to build an adapter. This adapter will bolt onto the cylinder head's exhaust port. Use ducting to connect the adapter to the suction tube. If you have an old exhaust header an adapter can be made by cutting off the first 3" of the header (including exhaust flange). If you don't have an old header you can make an adapter as shown in diagram 46.

DIAGRAM 46: *Exhaust Port Adapter*



Using the exhaust adapter, the cylinder head adapter, and two 3" blocks, assemble as shown in diagram 47.

DIAGRAM 47: *Testing an Exhaust Port*



INITIAL TURN ON

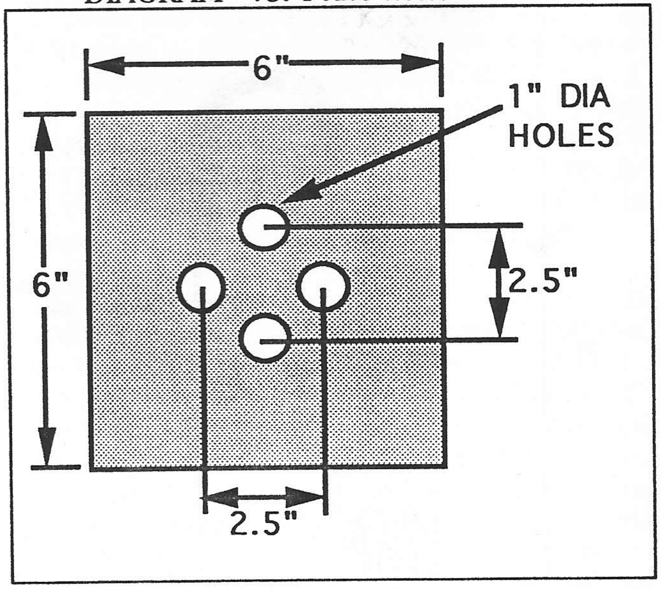
If you are using restrictor plate sensors, use the permanently mounted 300 CFM sensor for the following tests. If you are using the venturi sensors, install the 300 CFM sensor. Before you start the machine make sure no objects have fallen down into the suction tube. *Do this every time before you start the fan.* Once you are sure no debris has fallen, and all of the components are securely in place, you can start the machine.

The water level in the testing pressure gauge should be very low. The water level in the airflow gauge should be nearly at the top of the scale. If you are using a high power fan you may actually be off the scale. Open the bleed valve to its maximum setting (fully expose the holes). Place an obstruction over the suction tube inlet. *NOTE: make sure you use a large rigid object that cannot be sucked into the suction tube, i.e. a large hard cover book.* The air flow gauge should drop to nearly zero (approximately 0.0-0.1). Slowly close the bleed valve while watching the "testing pressure" gauge. *If you are using a high power fan, stop closing the bleed valve when the "testing pressure" gauge rises to its maximum reading. Note the position of the bleed valve. Upon start up make sure the bleed valve is set at this position. The reason for this is that if you are testing a part which offers little flow and the bleed valve is not open sufficiently, you will suck all the water out of the testing pressure reservoir. If this occurs you will need to refill the reservoir and thoroughly dry out the vacuum lines. If you are using a leafblower for a suction fan you shouldn't have this problem. The blower has internal leakage which limits the testing pressure to approximately 13" of water. This will eliminate accidently depleting the "testing pressure" reservoir.*

If your unit responded as described above you can proceed. If not double check the vacuum hose routing (the most common problem), and check for air leaks .

In a 6"x 6" piece of sheetmetal drill four 1" holes as shown in diagram 48. Install the cylinder head adapter. Center this piece of sheetmetal over the cylinder head adapter. Open the bleed valve to the maximum bleed setting. Turn on the machine. Adjust the bleed valve until the testing pressure is 5" of water. The airflow gauge should read approximately 1.6" of water. If you are using a high power suction fan you may find that the bleed valve will not let you drop the testing pressure down to 5" of water. If you cannot lower the testing pressure to 5" of water set the testing pressure to 25" of water. The airflow gauge should read approximately 3.8" of water. If your readings are close to this, you have completed building the flowbench. If not recheck all the connections and make sure the vacuum hoses have no liquid in them.

DIAGRAM 48: *Plate holes*



MODELING CYLINDER HEADS

Don't start making modifications directly on your cylinder heads. You should first test your ideas on a replica of your cylinder heads. Otherwise you will be taking a "shot in the dark", and if material is removed incorrectly it is difficult if not impossible to replace. To make a replica you will need the following.

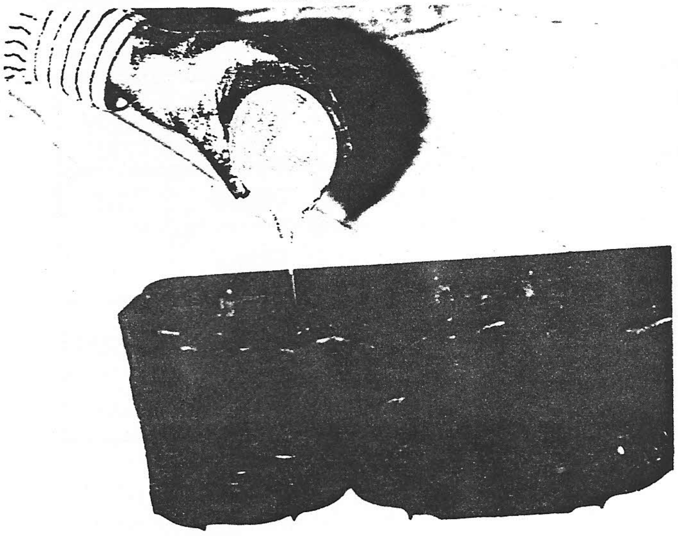
These first three products are available through Circle K Products®
Torrance, CA 90502
(301) 320-4218

- *RTV silicone Moldmaking Rubber*
- *RTV Activator*
- *Silicone Mold Release*

- *Plaster of Paris*

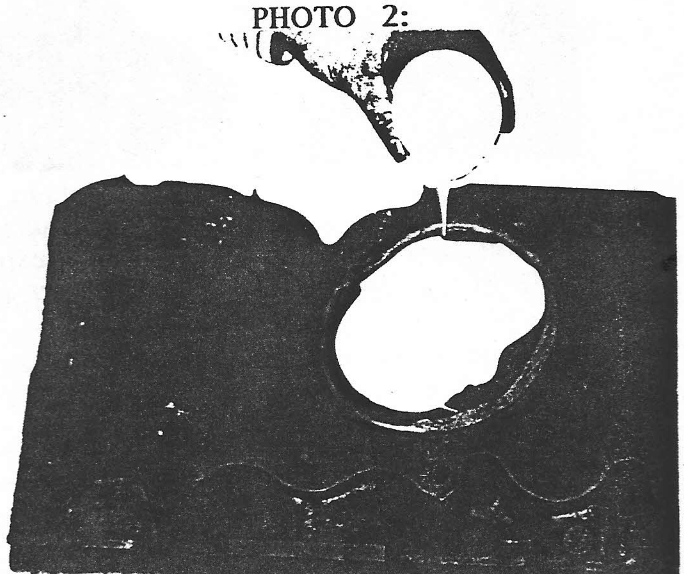
Apply mold release over the entire intake port and intake valve. Put the intake valve in the cylinder head and use the valve spring and retainer/keepers to close the valve. Mix up enough silicone rubber to fill the intake port approximately 1/3 full. Pour the silicone mixture into the intake port as shown in photo 1.

PHOTO 1:



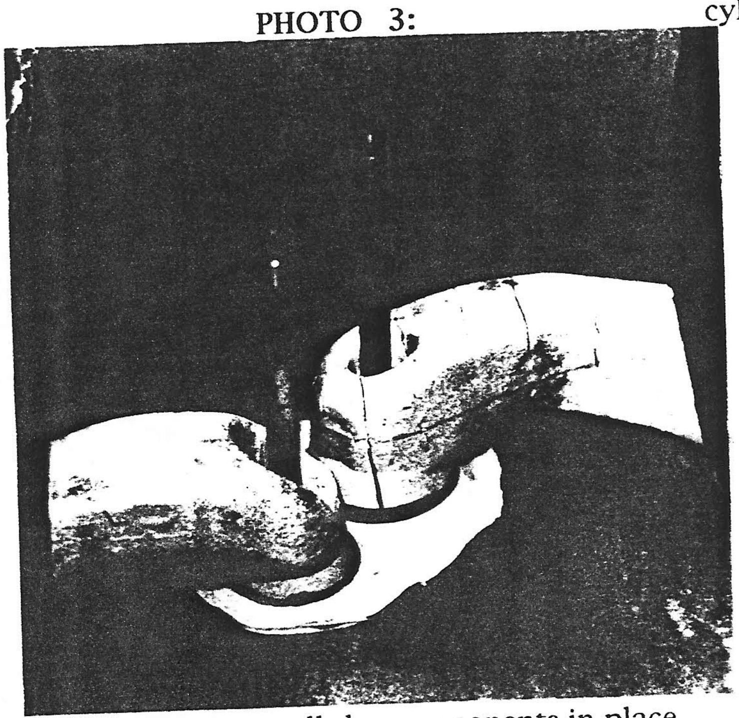
Allow the silicone to cure. Apply mold release to the exposed rubber. Pour in more silicone until the port is about 2/3 full (approximately where the port is constricted due to the pushrod passing through). Allow the silicone to cure. Apply mold release to the exposed rubber. Pour in more silicone until the port is filled. When cured repeat all of the above steps to the exhaust port. Once cured place the cylinder head upside down. Use modeling clay can be used to plug the spark plug hole. Additionally use the clay to form a "fence" around the combustion chamber. Mix enough silicone to fill the combustion chamber. Fill the combustion chamber as shown in photo 2.

PHOTO 2:



Once cured, remove the silicone from the combustion chamber. Remove the valves. Remove the silicone from the intake and exhaust ports (easier said than done). Once removed cut each third into three pieces. Use tape or toothpicks to reassemble the pieces of intake and exhaust port to there original shape. Don't overdo the reassembly as this will soon have to be removed from our plaster cylinder head. Position the intake and exhaust valves into the silicone ports. Now reassemble all the parts as they would go together in the actual cylinder head. Tape together a cardboard box to surround the assembled parts. See photo 3.

PHOTO 3:



Tape or pin all the components in place so they don't float away when you pour in the Plaster of Paris. Mix up enough Plaster of Paris to completely cover the rubber parts.

Pour the Plaster of Paris into the box. Once dry disassemble the box and remove the valves and silicone parts. Clean up any irregularities in the casting. Use this Plaster of Paris cylinder head to experiment with. Once you are satisfied with the results transfer all the modifications to the actual cylinder head.

USING YOUR FLOWBENCH

First we should discuss how to read the gauges. When you read a gauge you are comparing the water level in the clear PVC tube with the gridlines on the backboard. When do you consider the water level to have reached a particular value? Is it when the water level first reaches the gridline, or is it when the water level completely covers the gridline? The answer is - it doesn't really matter. What is important is consistency. If at rest the water level is barely at the zero mark, then the water level is considered to have reached the 1.0" mark when the water level is barely touching the 1.0" gridline. If at rest the water level completely covers the zero mark then the water level is considered to have reached the 1.0" mark when the water level completely covers the 1.0" gridline. Consistency, patience, and attention to detail are the keys to detecting small differences. When you make a change to the part you are testing or when you adjust the bleed valve wait for about one minute before recording your readings. Make sure the water has completely settled to its new level. If the water level is part way between gridline use a pencil to mark its position on the grid. Once you are done testing, use a ruler to determine its exact position. For example, while testing a part you marked the water level on the airflow gauge to be nearly 0.9" on the grid. Using a ruler you determined your mark was 3/4" from the 0.8" gridline. Since each gridline is separated by one inch your mark was three quarters (75%) of the way toward the 0.9" gridline. Therefore your reading was 0.875". If the mark had been 1/2" away from the 0.8" gridline your reading would have been 0.85.

The following example will illustrate how to use your flowbench. In this example you will be testing an intake port of a cylinder head. Start by fastening your cylinder head adapter to the flowbench. Position the cylinder head over the adapter. Tape shut the exhaust port and sparkplug hole. You will be using a testing pressure of 5" of water. The intake valve's lift will be varied between 1/8" to 1/2" in 1/8" increments. In this example the 200 CFM restrictor plate or venturi will be used. To record the information make a chart like the one shown below.

VALVE LIFT	AIRFLOW GAUGE READING	TESTING PRESSURE READING	% FLOW	SENSOR SIZE	INDICATED CFM	CONVERSION FACTOR	CONVERTED CFM
1/8"							
1/4"							
3/8"							
1/2"							

Open the bleed valve to its maximum position. Open the valve to its lowest lift (in this example 1/8") Turn on the flowbench. Adjust the bleed valve until a testing pressure of 5.0" is indicated on the "testing pressure" gauge. Read the "air flow" gauge. For this example, lets assume the gauge reads 0.2125"of water (1/8" past the second gridline). Write in 0.2125" of water in the second column of the chart. Write in 5" of water in the third column. Now open the intake valve to the next position (1/4" in our example). Readjust the bleed valve until a testing pressure of 5" is reestablished. Read the airflow gauge. Assume you found a reading of 0.6" (exactly on the 6th gridline). Write 0.6" on the second row/second column of the chart. Repeat the same steps at valve openings of 3/8" and 1/2". For this example assume you found airflow readings of 1.15" and 1.3" respectively. Your chart should now look like the following chart.

CHART

VALVE LIFT	AIRFLOW GAUGE READING	TESTING PRESSURE READING	% FLOW	SENSOR SIZE	INDICATED CFM	CONVERSION FACTOR	CONVERTED CFM
1/8"	0.2125	5"					
1/4"	0.6000	5"					
3/8"	1.1500	5"					
1/2"	1.3000	5"					

In the fourth column write in the percentage of flow which corresponds to the airflow gauge readings. To find the percentage of flow use the Airflow % Table in the appendix. Look up the number of inches you recorded from the airflow gauge. The number to the right will equal the percentage flow. In this example the first reading was 0.2125" of water. According to the Airflow % Table this equals 21.87%. Write 21.87% in column 4, row 1. The next reading you recorded was 0.6000". This corresponds to 36.73%. Write this down in column 4, row 2. Continue for the next two rows. In the fifth column write in the sensor size being used (in this example write in 200 CFM). Your chart should be as shown below.

CHART

VALVE LIFT	AIRFLOW GAUGE READING	TESTING PRESSURE READING	% FLOW	SENSOR SIZE	INDICATED CFM	CONVERSION FACTOR	CONVERTED CFM
1/8"	0.2125	5"	21.87%	200 CFM			
1/4"	0.6000	5"	36.73%	200 CFM			
3/8"	1.1500	5"	50.80%	200 CFM			
1/2"	1.3000	5"	54.00%	200 CFM			

The indicated CFM is determined by multiplying the plate size by the % flow. For example the indicated CFM for a valve opening of 1/8" equals 43.74 CFM (200 CFM *21.87%= 43.74 CFM). After the completing the multiplication for all four rows, the chart should look the following.

CHART

VALVE LIFT	AIRFLOW GAUGE READING	TESTING PRESSURE READING	% FLOW	SENSOR SIZE	INDICATED CFM	CONVERSION FACTOR	CONVERTED CFM
1/8"	0.2125	5"	21.87%	200 CFM	43.74 CFM		
1/4"	0.6000	5"	36.73%	200 CFM	73.46 CFM		
3/8"	1.1500	5"	50.80%	200 CFM	101.6 CFM		
1/2"	1.3000	5"	54.00%	200 CFM	108 CFM		