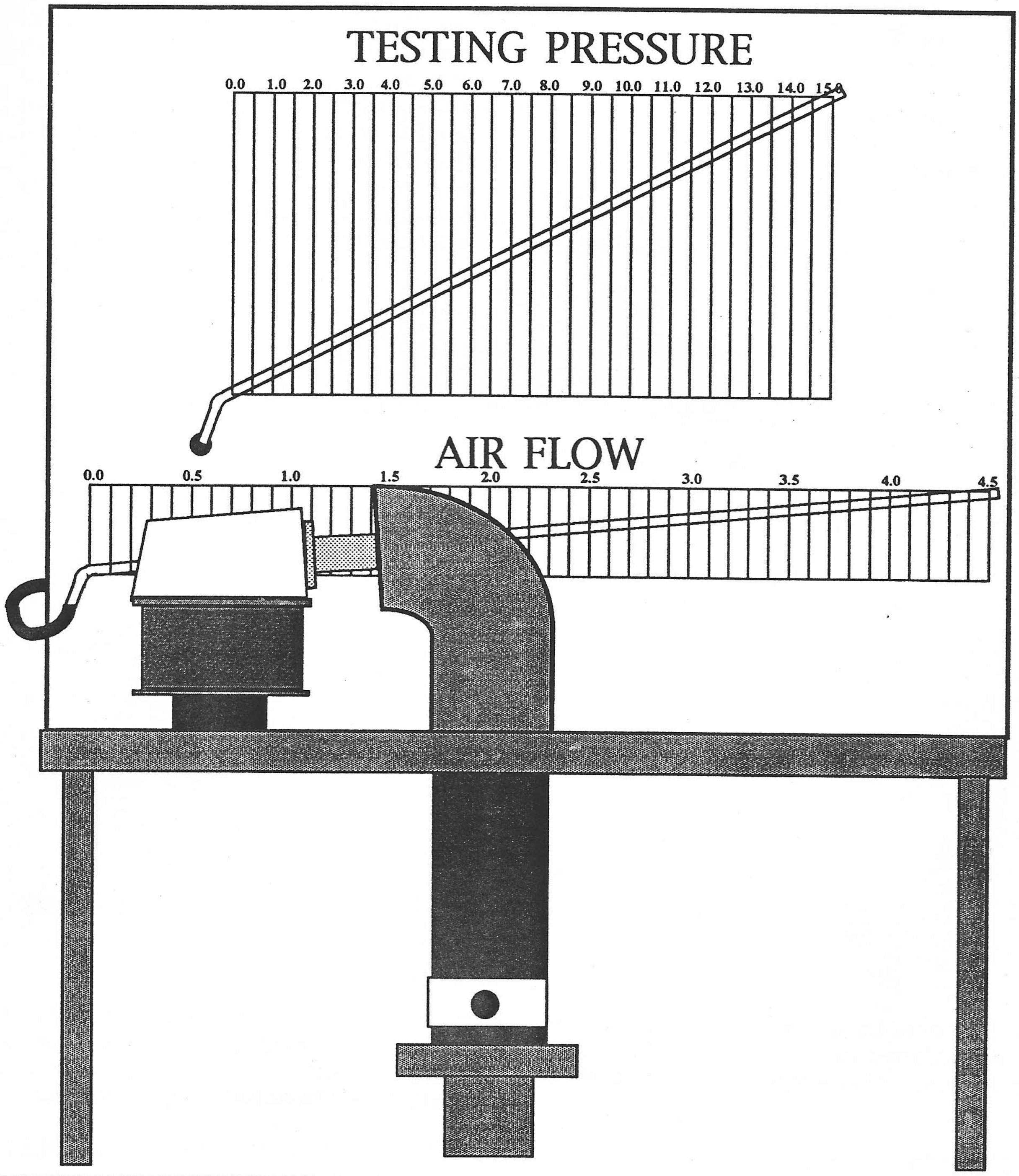
HYPERFLOW



P.O. Box 948 S.W. Harbor Maine 04679

HYPERFLOW
P.O. BOX 948 SOUTHWEST HARBOR ME. 04679 (207) 244-4373

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SAFETY PRECAUTIONS

⚠ Never allow the flowbench to ingest any flammable substances. These substances could be ignited by the suction fan. A resulting explosion could cause fatal injuries. Flammable substances include but are not limited to gasoline, alcohol, sawdust, and kerosene. Never test a carburetor on the flowbench. There are many small passages and airbleeds that could contain fuel even after the carburetor has been emptied.

⚠ Each time before turning on the flowbench make sure all the components are securely in place and that no debris has fallen in the suction tube or suction fan.

⚠ Do not allow the flowbench to ingest any liquids, including water. Allowing fluid to be ingested could possibly lead to electrical shock, electrocution, or fire.

⚠ Never place any body parts into the suction fan or suction tube. Unplug the suction fan when examining or removing debris.

⚠ Do not allow the flowbench to ingest any objects. The objects can cause severe damage to the suction fan. Additionally if the object jammed the fan the unit could quickly overheat, and ignite.

WHAT DOES A FLOWBENCH DO?

A flowbench is an airflow measuring device. It applies suction to a part and measures the amount of air which passes through. As you make improvements to the part you will see an increase in airflow for a given amount of suction. Shown below is a basic drawing of a flow bench. Many of the components are identified in the drawing. Familiarize yourself with these terms as it will make it easier to follow the text.

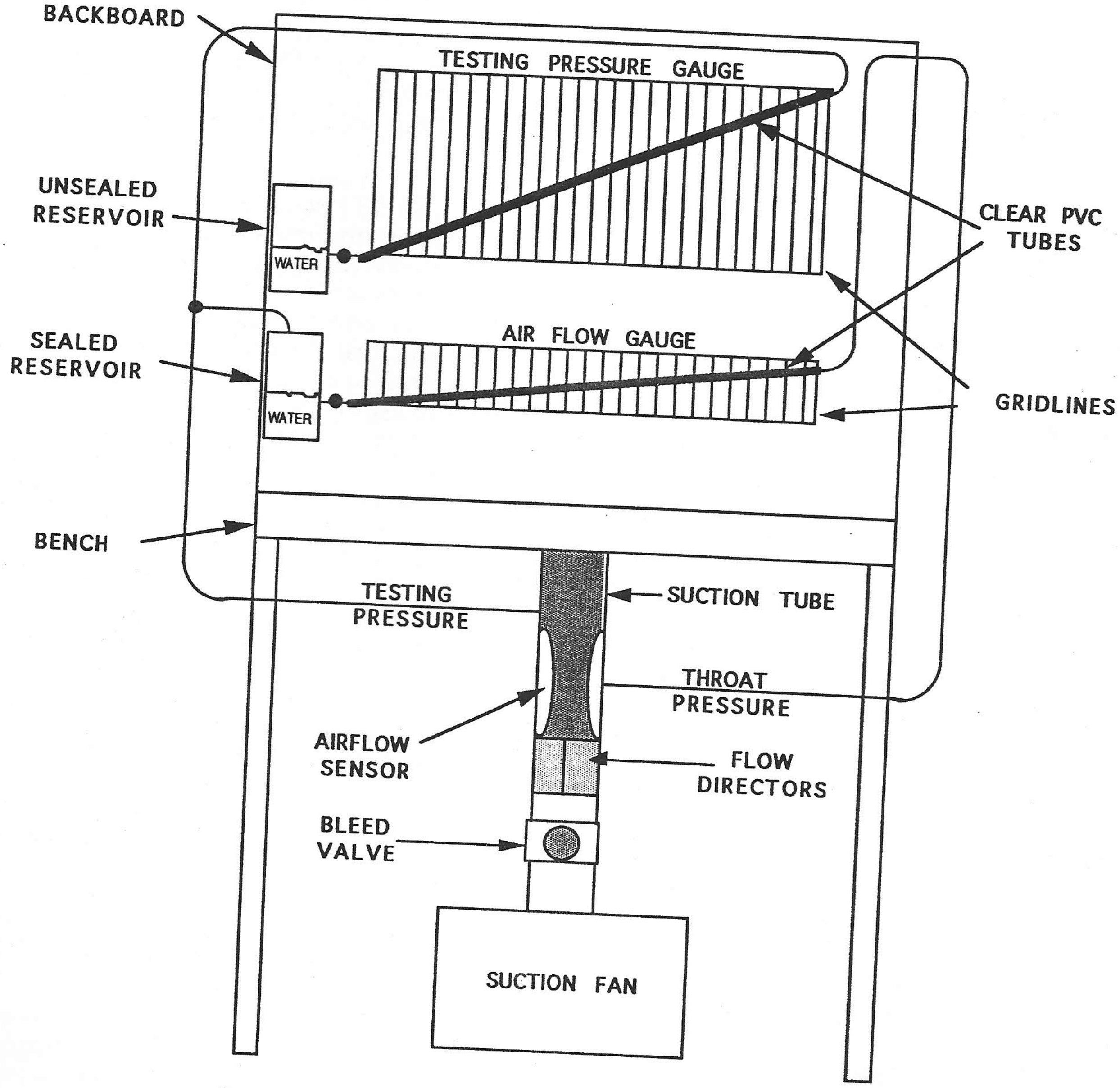


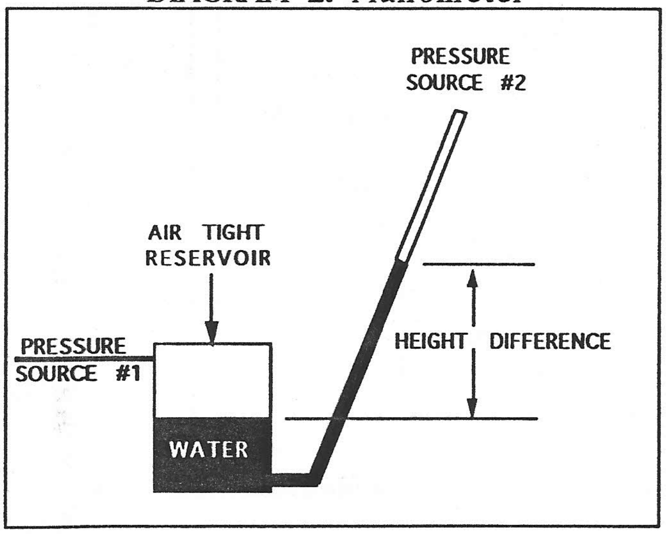
DIAGRAM 1: *Flowbench with components identified*

PRESSURE AND PRESSURE MEASUREMENT

It would be beneficial to discuss pressure measurement before starting on the details of building the airflow bench.

What is meant when a part is tested at 10 inches(") of water, or when the barometer reads 29.92 inches of mercury? Both of these are measurements of pressure, just like pounds per square inch(psi). If you were to take a tube with a cross sectional area of 1 square inch and a length of 27 3/4" and fill it with water, it would weigh 1 pound(lb). If you stood the tube upright on a table it would exert 1 lb of force over a 1 square inch area. If the tube had a crossectional area of 2 square inches, it would weigh 2 lbs. Therefore this tube would exert 2 lbs of force over a 2 square inch area. This is the same as 1lb/ 1 square inch (1 psi). This means for every 27 3/4" of water you have in a tube you would have 1lb/ 1 square inch (1psi) at the bottom of the tube regardless of its diameter. If we substitute mercury, a much denser liquid, it would take approximately 2 inches to equal 1 lb/square inch. Shown below is a simple device to measure pressure difference.

DIAGRAM 2: *Manometer*



If the pressure source #1 is 1 psi greater than that of pressure source #2, the water will rise in the glass tube until it is 27 3/4" higher than the level in the reservoir. Therefore each inch rise in water equals $1/(27.75)^{th}$ of a psi or 0.036 psi. This is a simple and accurate way of measuring pressure differences. This device is referred to as a manometer. The flowbench gauges are built using this principle.

When you test a part with the flowbench you will reduce the pressure in the suction tube and measure the amount of air that flows through the part. The difference in pressure between the atmosphere and the pressure in the suction tube is what we will call our "testing pressure". The "testing pressure" is expressed in inches of water. Using the above manometer to measure the "testing pressure" you would connect pressure source #2 to the suction tube and expose the reservoir to the atmosphere. The difference in height between the water level in the tube and that in the reservoir is equal to the "testing pressure".

A barometer is a device which measures air pressure. It makes a comparison between the air pressure surrounding us and a perfect vacuum. The difference in pressure is expressed in inches of mercury. To use the manometer above as a barometer, you would first replace the water with mercury. Then you would connect pressure source #2 to a perfect vacuum and expose pressure source #1 to the atmosphere. On a day when the barometric pressure is 30.00", the mercury level in the tube would rise 30.00" above the level in the reservoir.

BASIC ELEMENTS OF A FLOWBENCH

Refer back to DIAGRAM 1 to see the identified components.

BENCH The table that supports all the equipment will be referred to as the bench. This is the skeleton of the flowbench. It is not necessary to build a bench from scratch. You can modify an existing bench or use an old table you may have as long as it is sturdy enough to handle the parts that you want to test.

BACKBOARD The backboard and gridlines support the manometers and make it easy to read the water level.

SUCTION FAN The suction fan is the heart of the system. It creates the required suction. Many suitable choices exist for this application. It should have a relatively powerful suction when fully blocked off (approximately 10" of water) and be capable of moving a large amount of air, approximately 200 cubic feet per minute (CFM). A suitable low cost suction fan is available at most department stores. The fan is a Weedeater® Model #2560 leafblower. Prices vary from $45 to $80 depending on where you shop. You do not have to use this particular fan. The following text gives sufficient information to use almost any suction fan you desire. However in this manual this fan is used as an example in many instances. Consequently some of the required templates and information extracted from the appendix have been explicitly worked out for this particular model.

When testing a cylinder head with the valve fully open this fan will pull approximately 7 inches of water. This may not seem like a lot, but for most applications this is more than enough. If you are interested in comparing results with those printed in a magazine you can easily convert the figures you obtained at 7 inches of water to those of any other testing pressure. Conversions from one test pressure to another will be explained later. However you should not worry about what you read somewhere else. Concentrate on making steady improvements in the figures you are finding. Comparing flow figures with other sources can be in many situations like comparing apples and oranges. Many little differences in the test setups can completely alter the comparison.

If you insist on testing at a higher pressure you can look through the yellow pages for industrial companies which sell fans that will meet your demands.

TIP: One low cost "do it yourself" method would be to use a blower from a 6-71 diesel. This might seem expensive and exotic at first until you consider that these "cores" can be purchased for approximately $100 at industrial salvage yards. The reason they are expensive for automotive use is that they require expensive "blueprinting". For our application. they are ideally suited as is. If the blower will turn over by hand without binding, chances are it will work perfectly for our application. Simply hook a 5HP compressor-duty electric motor to the blower through a pulley so that the blower is turning approximately 1300 RPM. This setup will move approximately 300 CFM of air and can easily pull 30" of water when restricted.

SUCTION TUBE The suction tube acts as the pathway between the suction fan and the part being tested. Additionally the tube supports the airflow sensor. If you are using the leafblower, you can use the provided suction tube. For other suction fans, you can use 4" PVC pipe.

BLEED VALVE The bleed valve is used to bleed off excess vacuum. Lets say you wanted to use a "testing pressure" of 7" of water. If you tested a cylinder head with a valve opened 0.5", you could adjust the bleed valve until you have a testing pressure of 7" of water. You would then read the airflow gauge. When you close the exhaust valve to 0.10" lift, the testing pressure might jump to 11" of water. Consequently you would readjust the bleed valve until the testing pressure dropped back to 7" of water. Although this might seem like a necessary step, it is actually not needed. You could have recorded both airflow readings at the different testing pressures. These readings could then be converted to some other testing pressure, for example 25" of water. This is easy to do and is actually what we suggest you do. The reasons for this are twofold. First you don't have to keep adjusting the valve. Second you don't bleed away any of the available power of the suction fan.

FLOW DIRECTORS If you are using a centrifugal type suction fan such as the leafblower, you will need a flow director. This will prevent the air from rotating wildly in the suction tube at low flow rates. The centrifugal force from rotating air could cause significant errors. The flow director will minimize this problem.

AIRFLOW SENSOR The airflow sensor measures the amount of air passing through the suction tube. In the construction section you will see that two different types, and three ways of constructing a flow sensor are provided. You will be constructing four (4) different size sensors for your bench. Each size will allow your bench to measure flow over a different range of values; 0-50 CFM, 0-100 CFM, 0-200 CFM, and 0-300 CFM. You may ask why not use the 0-300 CFM sensor for all your tests? The answer is resolution. By using a smaller sensor you can more easily detect small improvements in airflow. For example an 8% improvement in a part which flowed 38 CFM would be represented by an 1/8th inch movement in the airflow gauge if the 300 CFM sensor was used. If the 50 CFM sensor was used the airflow gauge would have moved 5 3/4". Obviously it is much easier to detect changes in airflow with the smaller sensor. Later you will see that it is very easy and quick to change sensor sizes. It is best to use the smallest sensor possible without having the airflow readings go "off the scale". However, it is possible to build a useful flowbench without a flow sensor. At first this might seem like a ridiculous concept, but it does have strong merit. As with most things there are trade-offs to consider. Listed below is a brief description of each type with some of the advantages and disadvantages outlined.

RESTRICTOR PLATE This sensor is extremely easy to build, and is the easiest type of sensor to change sizes with. However, this method lacks "absolute" accuracy. Absolute accuracy means that the flow numbers determined with this method could be considerably off from what actually is happening. However it has good relative accuracy. Lets say a part actually flows 90 CFM with a "testing pressure" of 10" of water. If you used the restrictor plate sensor to test it, you may determine it flowed 100 CFM with a "testing pressure" of 10" of water. This would represent an error of 10%. However if you make a 10% improvement to the part, and retested it, the sensor would indicate that the part is flowing 110 CFM. Although the restricter plate sensor readings were in error, the sensor accurately detected the improvements. Measuring improvements is what is important, and as I mentioned earlier trying to compare exact figures with those of another source can be very misleading. There is another downside to this method; it will waste a small amount of the suction fan's power.

VENTURI METHOD This method will give better absolute numbers and provide excellent relative numbers. Additionally this sensor will waste very little of the available suction power. In the construction section two ways of making this sensor are given.

Both of these sensors work using the same principle. As the air moves through a restriction, the speed of the air will increase while the pressure drops. You will measure the pressure difference. From this you can determine the amount of air passing through.

NO AIRFLOW SENSOR Deleting the sensor greatly simplifies construction. You don't have to build the flow sensor, sealed reservoir, airflow gauge, or the flow directors. Additionally you don't have to use any tables or charts. The method of operating the flowbench without the flow sensor is discussed in the *Alternative Test Procedures section*. Although this method yields no absolute numbers it does produce good relative figures.

GAUGES Both of the gauges you will be building are based on the manometer principle. A schematic of these manometers are shown in diagrams 3 and 4.

DIAGRAM 3: *Airflow Manometer*

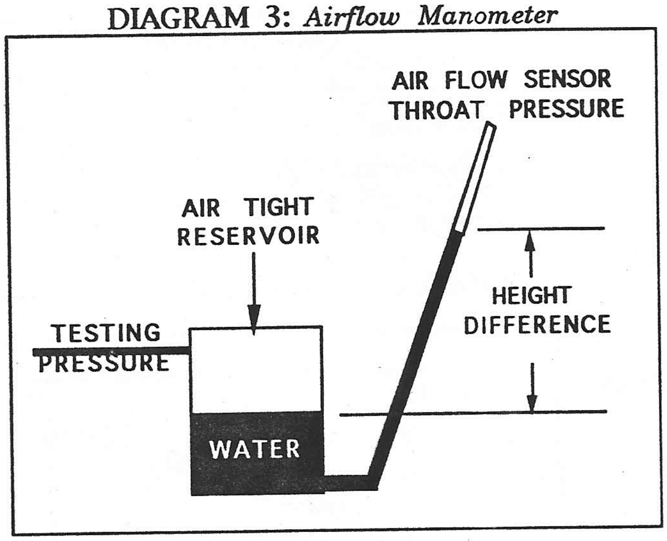
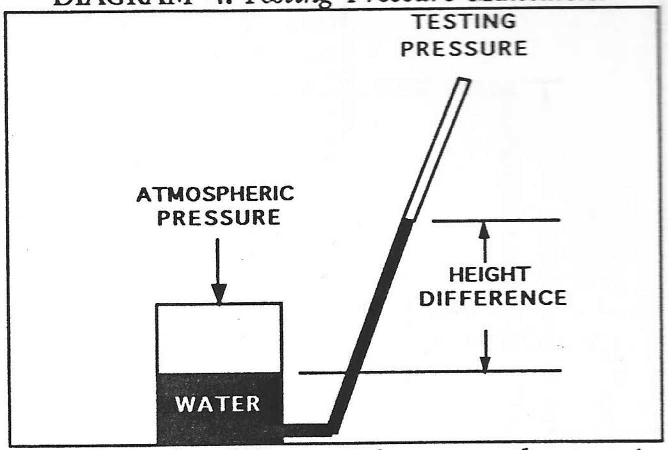


DIAGRAM 4: *Testing Pressure Manometer*



The only difference between the two is that the airflow manometer's fluid reservoir has to be air tight. The "testing pressure" manometer measures suction relative to the atmospheric pressure. Thus this reservoir should be exposed to atmospheric pressure. The diameter of the tube should be kept reasonably small (between 1/8" and 1/4" I.D.). If you use small diameter tubing you can ignore small water level changes in the reservoir, and simply compare the water level in the tubing against gridlines.

For those that would rather purchase manometers than build them, contact a company such as:

DWYERS Instrumentation
P.O. Box 373
Michigan City, Indiana 46360
1-312-733-7883

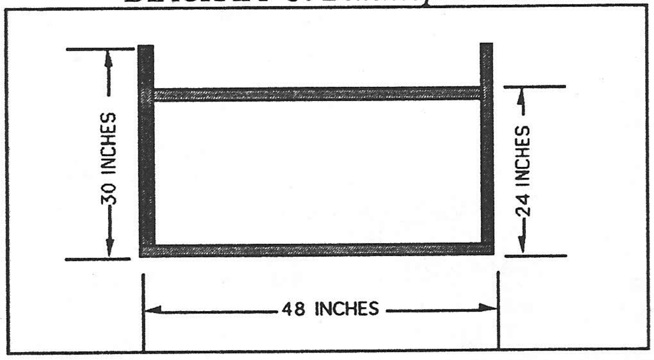
You will need one manometer which reads between 0 and 4.5" of water; and a second which reads between 0 and the maximum testing pressure you will use (typically 10" or 28" of water).

CONSTRUCTING THE FLOWBENCH

THE BENCH

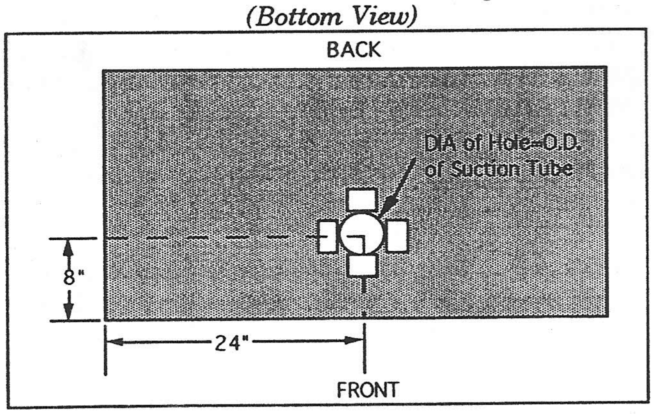
Using 2X4 lumber nail together a bench frame as shown in diagram 5.

DIAGRAM 5: *Benchtop Frame*



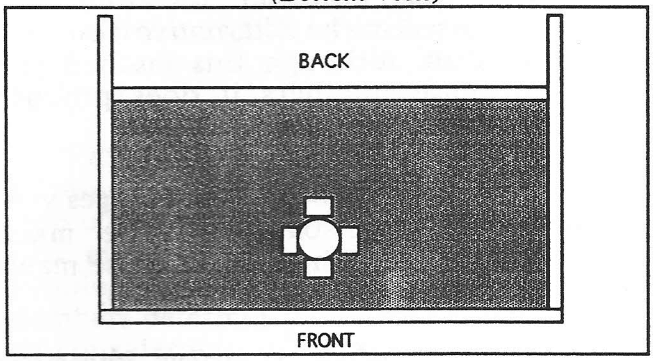
Cut a piece of 3/4" thick plywood 2 feet by 4 feet. Cut a hole in the plywood top. The diameter of the hole should equal the outside diameter of the suction tube you are using. Screw four three inch pieces of 2x4 adjacent to the hole. Screw through the top and into the blocks (as opposed to through the blocks and into the top). See diagram 6.

DIAGRAM 6: *Bench Top (Bottom View)*



Next screw the plywood top onto the 2X4 frame. The frame should be on the same side as the 3" pieces of 2 X 4. See diagram 7.

DIAGRAM 7: *Bench Top With Frame (Bottom View)*



Countersink all the screw so the heads do not protrude above the surface. Use 4 pieces of 2 X 4 lumber cut to 35" for legs. Bolt the legs into each corner of the frame. Stand the table upright and brace it with 1X3 spruce strapping. See diagram 8.

DIAGRAM 8: *Bench With Legs and Strapping Attached*