You have now determined the flowrate of the intake port for valve openings of 1/8" to 1/2" while maintaining a testing pressure of 5" of water. Columns 7 and 8 are used if you would like to know how much air would have flowed at a different testing pressure. For example, how much air would have flowed if a testing pressure of 25" of water had been used? To find out you would do the following. First you must determine a conversion factor. To find the conversion factor use the Conversion Table in the appendix. To use this table look down the left hand side for the pressure you actually tested at (5"), then move across to the right until you run into the column of the desired test pressure(25"). In that box you find 2.236. This is our conversion factor. Place this conversion factor in column 7 of the chart below. Multiply the airflow figures of column 6 by the conversion factor of column 7. Place the results in column 8. Your table should look like 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	2.236	97.80CFM
1/4"	0.6000	5"	36.73%	200 CFM	73.46 CFM	2.236	164.26CFM
3/8"	1.1500	5"	50.80%	200 CFM	101.6 CFM	2.236	227.18CFM
1/2"	1.3000	5"	54.00%	200 CFM	108 CFM	2.236	241.49CFM

All the figures in column 8 are equal to the flowrates that would have been attained if a testing pressure of 25" had been used.

ALTERNATE TESTING PROCEDURES

Alternately you could have opened the valve from 1/8" to 1/2" while leaving the air bleed closed. If you had done this the airflow and pressure readings would have varied for each of the valve positions. These readings would be recorded just as above. Then a different conversion factor for each of the actual testing pressures would have been selected. Using this approach the completed table would look like the one shown below. The advantage of using this method is that you don't have to keep readjusting the bleed valve. The small differences in the final figures are due to rounding of the numbers that occurred in the appendix.

CHART

VALVE LIFT	AIRFLOW GAUGE READING	TESTING PRESSURE READING	% FLOW	SENSOR SIZE	INDICATED CFM	CONVERSION FACTOR	CONVERTED CFM
1/8"	0.425	10.1"	30.92%	200 CFM	61.84 CFM	1.573	97.29CFM
1/4"	1.075	8.9"	49.13%	200 CFM	98.26 CFM	1.676	164.68CFM
3/8"	1.9625	8.5"	66.29%	200 CFM	132.58CFM	1.715	227.37CFM
1/2"	2.8075	8"	68.35%	200 CFM	136.7 CFM	1.768	241.68CFM

To maximize resolution and sensitivity try to use the smallest sensor possible without having the airflow gauge reading go off the scale. In the above example it is apparent that the

100 CFM sensor could have been used for the first two readings. If this had been done the completed chart would look like the following.

CHART

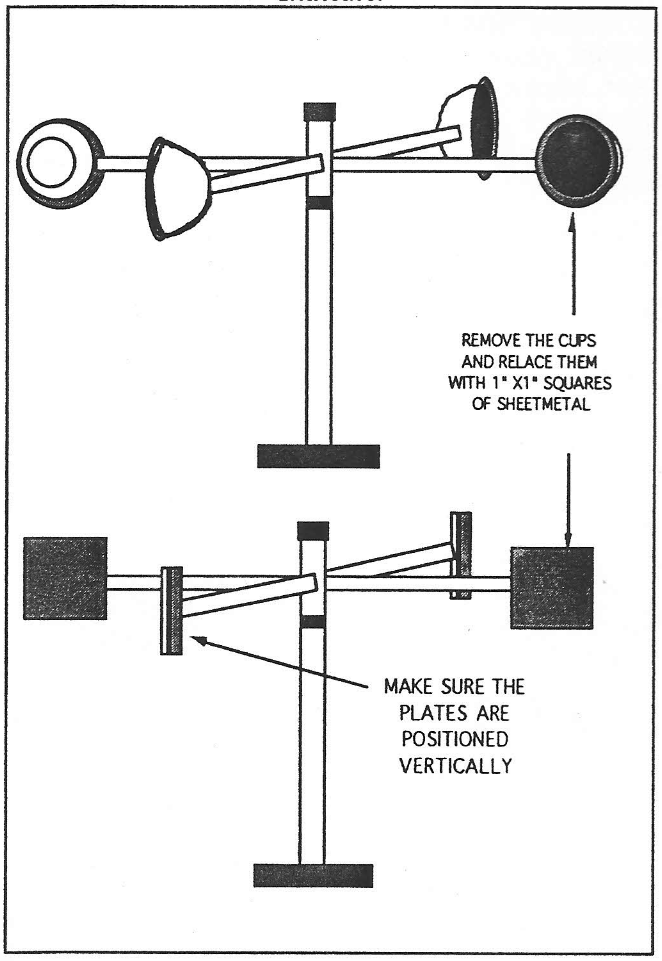
VALVE LIFT	AIRFLOW GAUGE READING	TESTING PRESSURE READING	% FLOW	SENSOR SIZE	INDICATED CFM	CONVERSION FACTOR	CONVERTED CFM
1/8"	1.7125	10.1"	61.95%	100 CFM	61.95 CFM	1.573	97.45CFM
1/4"	4.3375	8.9"	98.20%	100 CFM	98.2 CFM	1.676	164.58CFM
3/8"	1.9625	8.5"	66.29%	200 CFM	132.58CFM	1.715	227.37CFM
1/2"	2.8075	8"	68.35%	200 CFM	136.7 CFM	1.768	241.68CFM

There is an alternative way of detecting changes in airflow without using the airflow gauge. Although this method will detect small changes in airflow, it will not provide you with *any* absolute numbers. This method requires that you use the 6" X 6" calibration plate used in the *Initial Turn On* section. Each time before you start testing a part you will calibrate the bench. First turn on the machine. Center the calibration plate over the suction tube. Observe the testing pressure. Adjust the bleed valve until the "testing pressure" drops to the nearest whole number. Write this testing pressure down. This will be the testing pressure you recalibrate the bench to each day. Now you can test your part. Instead of observing changes in the airflow gauge, you will be observing the changes in the test pressure. For example, if you were to test the effects of a three angle valve job on an intake port with the intake valve opened 0.125", you would do the following: First turn on and calibrate the bench. Position the cylinder head model over the cylinder head adapter. Open the valve to 0.125". Observe the test pressure (for this example, 9.5"). Next make changes to the model to represent a three angle valve job. Once again turn on and recalibrate the machine. Test the modified model. With the three angle valve job, the testing pressure is now 9.2". This represents an improvement. As you improve the efficiency of the port, you will see a reduction in the "testing pressure" gauge. It is necessary to recalibrate the machine each time you use it. Otherwise changes in the weather could give you erroneous readings. If you do not require "hard" numbers there are quite a few advantages to this method. You do not have to build an airflow sensor, airflow gauge, or flow directors. Additionally, you do not need to use any tables, or math.

SWIRL

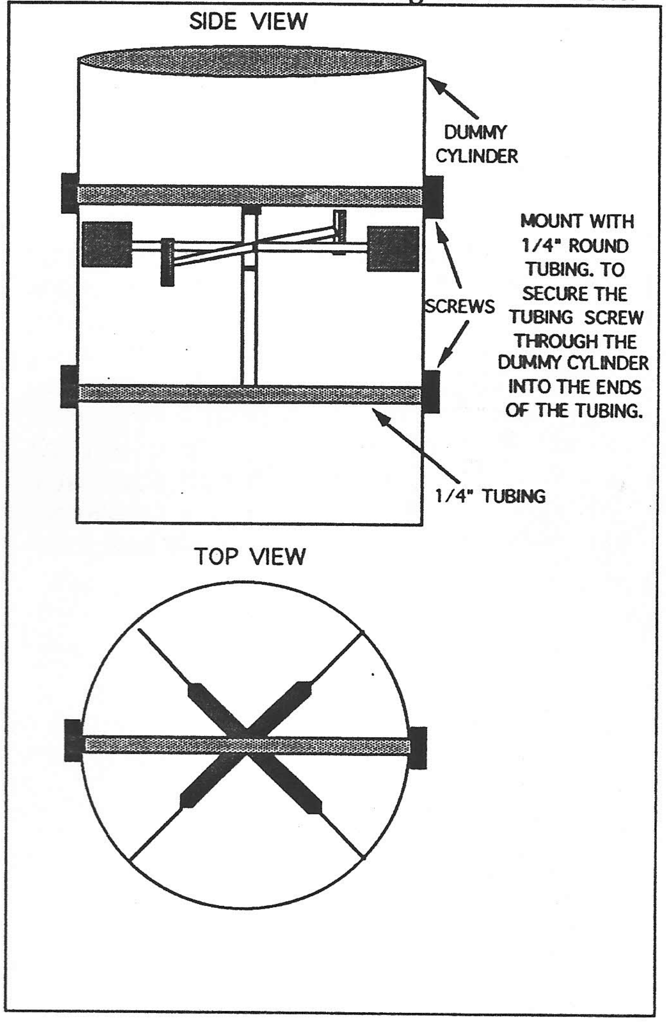
If you are interested in measuring swirl, here is a way of doing so. The cylinder head adapter can be modified to house a swirl meter. This swirl meter is a modified wind speed indicator. The windspeed indicator that will be modified needs to meet the following criteria. The meter must be able to give a reading when the cups are rotated in either direction. It is not normal for the cups to be rotated in both directions and some of the more expensive digital type meters will ignore the sensor if this occurs. Check before you buy your wind speed indicator. The cups need to be cutoff of the sensor. Pieces of 1"X1" sheet metal are to be glued in place of the cups. See diagram 49.

DIAGRAM 49: *Modifying the Wind Speed Indicator*



Make sure the pieces of sheetmetal are in line with the axis of the windspeed meter. Mount the windspeed indicator in the cylinder head adapter as shown in the diagram 50.

DIAGRAM 50: *Mounting the Swirl Meter*



To determine if the fins are correctly aligned, perform the following test. Turn on the machine with the cylinder head adapter in place. Do not attach the cylinder head to the adapter. The windspeed indicator should read 0 MPH. If necessary bend the fins so that the windspeed reads 0 MPH.

The windspeed indicator will provide information as to the amount of swirl present. The "swirl factor" will be defined as the indicated wind speed divided by the CFM of air passing through. The "swirl factor" is affected by atmospheric changes. Therefore atmospheric compensation needs to be made.

Below is an example of how to use the swirl meter. Assume you set a cylinder head on the bench and find 100 CFM are being passed with a test pressure of 7" of water. If the swirl meter were to read 20 MPH, you would have a swirl factor of 0.20 (20 MPH/100CFM=0.20). If the barometric pressure during the test was 29.92" and the temperature was 70 degrees Fahrenheit (standard conditions), the swirl factor would stand as is. However under nonstandard conditions a correction will need to be made. Use the Swirl Correction Table found in the appendix to find the amount of correction required. Using the actual barometric pressure and temperature that existed during the test, find the appropriate correction factor. For example if the test conditions were 31.00" Hg and 50 degrees, you would find the correction factor 1.038. The corrected swirl factor would be .208 (.20 X 1.038 = .208).

TIPS ON PORTING

There are very few rules that can be applied universally when it comes to porting. However there are a few things to keep in mind. Sudden changes in crossectional area will usually reduce airflow. Sudden changes in direction should be avoided. Smoothing factory machining in the bowl will usually help. Narrowing and smoothing the valve guide boss will often aid airflow. "Hemi" heads usually will benefit from "tulip" type valves. "Wedge" heads will often benefit from reduced diameter valve stems. Each situation is different. The best approach is through trial and error with your plaster model. Often it takes a combination of modifications to see improvements. There are many good sources of information concerning porting. Practical Gas Flow, published by MRP is an excellent book covering many practical approaches to improve airflow. There are so many factors that can alter each situation it would take several books to cover them all. For more detailed information about specific cylinder heads I suggest you look at the books listed below.

HP BOOKS®

- How To Hot Rod Your Big Block Chevy
- How to Hot Rod Your Small Block Chevrolet
- How To Hot Rod Your 2000CC OHC Ford

SA DESIGN®

- How To Build Horsepower
- Smokey Yunicks Power Secrets

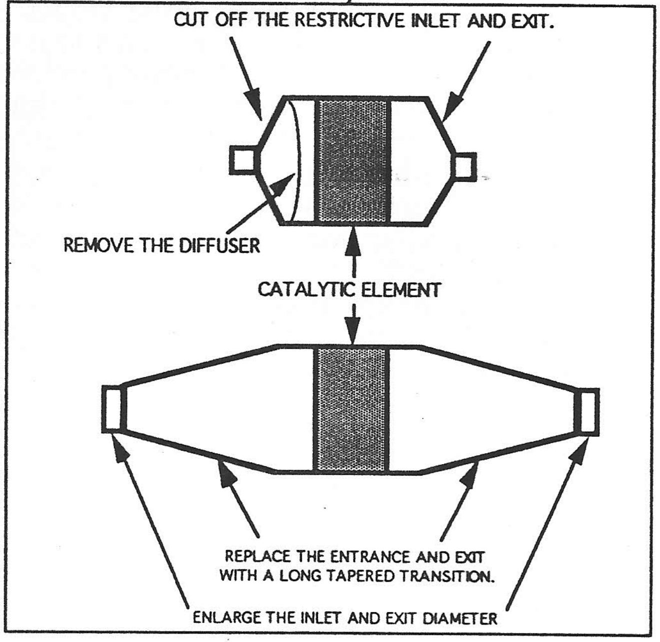
These book contain useful information concerning specific combinations. Before you start changing things, use the manometer probe you built and explore all the areas in your model. Write down your findings accompanied by a sketch. Then make one change at a time. After each change reprobe the port and record your findings. The more you experiment the more you will learn. Recording the data will allow you to quickly go back and see what helps and what does not.

EXHAUST SYSTEM IMPROVEMENTS

WARNING- *Before altering any emission control equipment make sure the changes you make will be in compliance with local, state, and federal regulations. Violating emission laws may subject you to penalty.*

Much can be done to improve the flow of your exhaust system. Start with the exhaust manifold. Most manifolds are very restrictive, if you can replace them with tube headers do it. No amount of work will let cast iron manifolds flow as well or be able to use the exhaust pulses to aid flow. If you are in a racing class that requires cast iron production manifolds try to find one with a center outlet. These "ram's horn" type will flow considerably better. Modifications to cast iron manifolds are primarily limited to enlarging the outlet and port matching. Actually I should say port mismatching. If you enlarge the exhaust manifolds ports larger than cylinder heads exhaust you will create a mismatch which will restrict the amount of exhaust gas flowing back into the engine. This mismatch should be about 3/32" wide. Don't apply the mismatch to the roof of the exhaust port, otherwise you may loose more in forward flow than you gain with the antireversionary effects. If you are allowed to replace the exhaust tubing with larger diameter mandrel bent tubing, do so. The factory bends wrinkle the tubing and restrict airflow. If you are allowed to replace pellet type catalytic converter with a monolithic converter, do so. The monolithic type converters flow much better than the pellet type. In many cases the most restrictive part of a monolithic converter is the entry and exit. The factory type ones often come with a cheap diffuser to force the exhaust gases throughout the converter. However if the emission laws in your area permit you to alter the entrance and exit as shown in diagram 51, you can increase the flow in some cases by 200%.

DIAGRAM 51: *Catalytic Converter Modifications*



Many mufflers claim to be high flow. You can use your bench to find out which ones are high performance and which ones are hype. Flow rates vary considerably, so find an understanding parts man and test them before you buy.

TIPS FOR USING AND SETTING UP YOUR FLOWBENCH

ATMOSPHERIC COMPENSATION

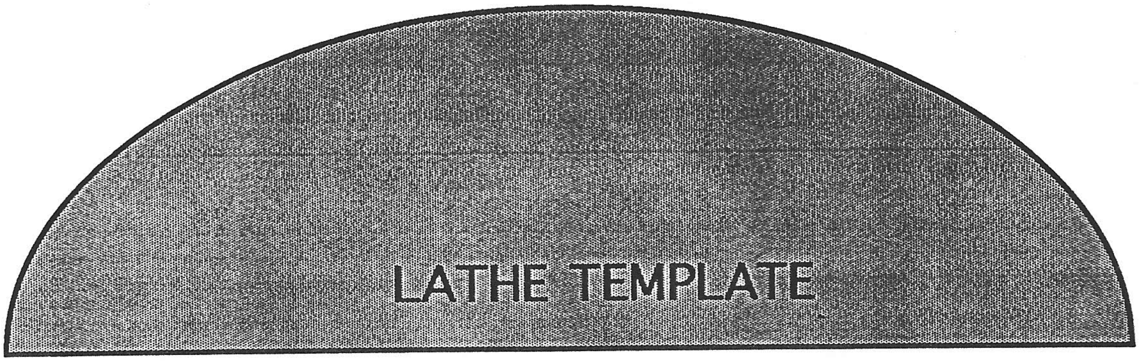
Why is it necessary to compensate for atmospheric changes when measuring swirl and not when you measure airflow? The answer is that the different sensors used are affected by changes is air density differently. Air density is affected when air pressure and/or temperature varies. As air pressure rises air density increases. As temperature falls air density will increase. Both the airflow gauge and the part you are testing are affected by changes in air density. It is possible to build an airflow sensor that isn't affected by density changes. An air turbine airflow sensor is one type of sensor that isn't affected by density changes. At first it might appear that you would want to use this "perfect" airflow sensor. However the part you are testing is also affected by air density changes. As air density decreases (the air becomes thinner) the air will more easily pass through the restrictions. If you were to use a perfect airflow sensor to measure the part you would find that during conditions of low air density a greater volume of air would pass though the part. Although you haven't changed the shape or size of the part a greater volume of low density air will pass through it with the same amount of suction "testing pressure" being applied to it. If you used a "perfect" flow sensor you would have to mathematically compensate for the parts behavior during atmospheric changes. This isn't what you want. What you want to measure are the improvement's in the aerodynamic shape of the part. If a sensor was used that was affected in an equal an opposite manner that the part was the effects of the atmosphere could be ignored. Both the restrictor plate and the venturi sensor meet this criteria. Low density air will cause the sensors to give a lower reading than normal for the same volume of air passing through it. This lower reading will equally offset the fact that the part is passing a greater volume of low density air. This is just what you want. If you do not change the shape or size of the port, and you maintain the same testing pressure you will get the same reading from the airflow manometer. It could be said that the airflow bench is actually an efficiency meter. It will only show a change when the part's shape or size has improved. The airflow values in the appendix correspond to a standard day (29.92" Hg and 70 degrees F). To reiterate on low density days the part will actually be allowing a greater volume of air to pass and on high density days the airflow volume will be reduced, however if nothing else has change the reading on the airflow manometer will remain the same and will be indicating the volume of air that would have passed on a standard day.

The swirl meter is a variety of a turbine flow sensor. It is an axial turbine flow sensor. This sensor isn't affected by air density changes. As discussed before the part you are testing is affected by the density changes therefore the sensor needs to be mathematically corrupted to offset these effects. This is why there is a swirl correction table in the appendix.

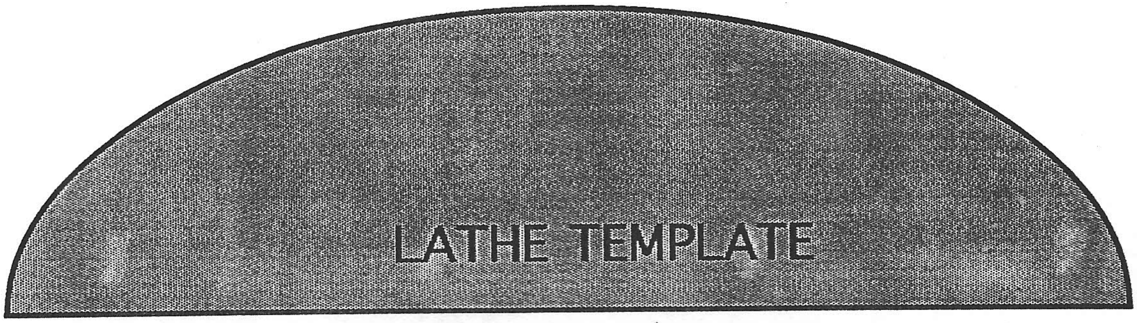
RESTRICTOR PLATE FINE TUNING

The restrictor plate flow characteristics are quite sensitive to the shape of the edges at the throat. Consequently assigning flow ratings to the plates can be a little unpredictable. As I stated earlier measuring change is what's really important. As long as you are consistent in using the same plates when testing a part the bench will give reliable and repeatable readings. The following procedure is optional for those who wish to improve consistency between the different plates. Set up the flowbench with the cylinder head adapter and a cylinder head. Install the 50 CFM plate. Turn on the flowbench, and open one of the valves until 100% is indicated by the airflow gauge.

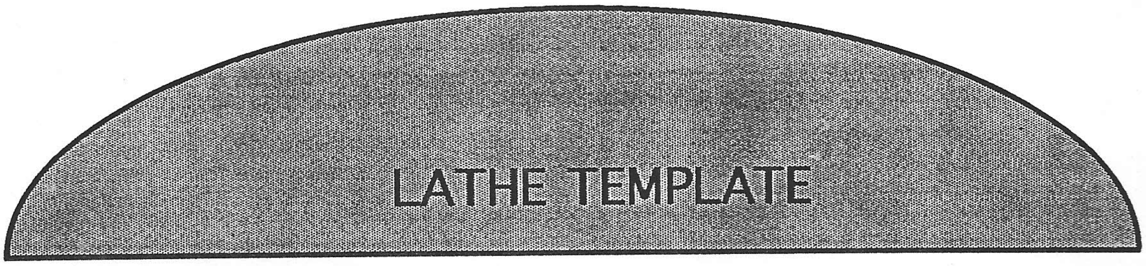
Record the testing pressure. Turn off the machine and install the 100 CFM plate. With the valve in the same position as before, adjust the bleedvalve until the same testing pressure is obtained. The airflow gauge should read 50%. If it does not, adjust the size of the throat until it does. Increase the opening of the valve until an airflow gauge reading of 100% is obtained. Note the test pressure. Install the 200 CFM plate. Adjust the bleed valve until the same testing pressure is obtained. The airflow gauge should be indicating 50% airflow. If it doesn't adjust the throat size of the 200 CFM plate until it does. Increase the valve opening until a reading of 100% is obtained. It may be necessary to open both the intake and the exhaust valve. Record the testing pressure. Install the 300 CFM plate. Readjust the testing pressure to that you just recorded. The airflow gauge should read 66%. Adjust the 300 CFM plates' throat size until it does.



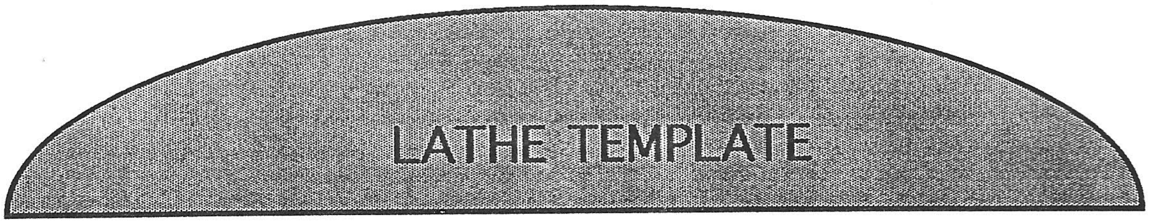
50 CFM VENTURI TEMPLATE FOR
WEEDEATER® SUCTION TUBE



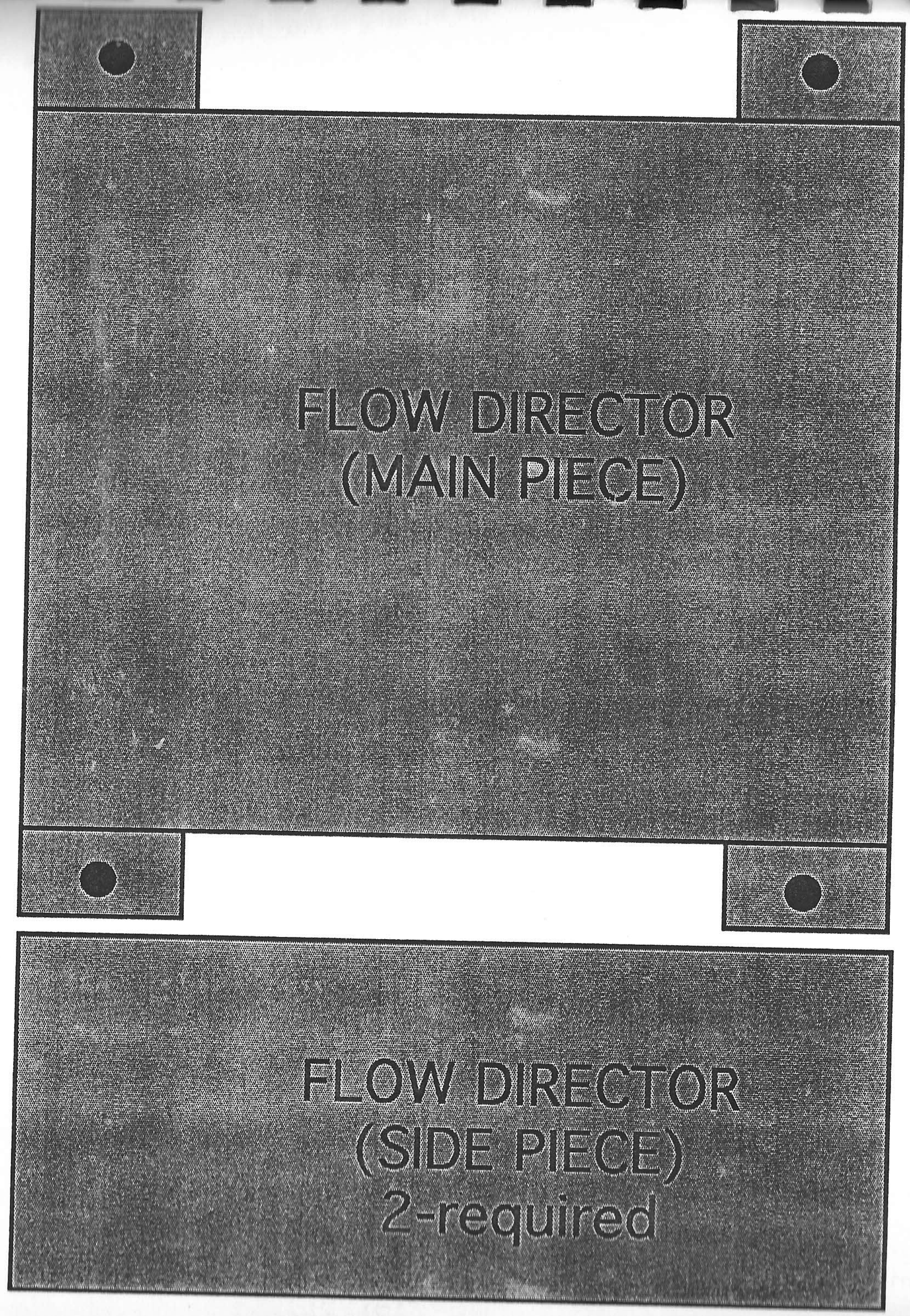
100 CFM VENTURI TEMPLATE FOR
WEEDEATER® SUCTION TUBE



200 CFM VENTURI TEMPLATE FOR
WEEDEATER® SUCTION TUBE



300 CFM VENTURI TEMPLATE FOR
WEEDEATER® SUCTION TUBE


FLOW DIRECTOR
(MAIN PIECE)
FLOW DIRECTOR
(SIDE PIECE)
2-required