

# PONTIAC

## Cylinder Head Info

### Cylinder Head Interchange

All Pontiac V-8 cylinder heads from 1955 to 1976 are basically interchangeable. The block cylinder bore spacing, deck height and head bolt pattern has remained unchanged since 1955. With the exceptions noted below, the basic cylinder head design has remained unchanged since 1967, making interchange between 1967-76 very simple.

From a high performance standpoint, the only pre-1967 heads which would be used on a 1967-76 block would be the 1961-63 SD heads. The pushrods, rocker arms, intake manifold, rocker arm covers and pushrod cover for the exact head used must also be used. Any D-port exhaust manifold or header may be used with any 1961-63 SD head except casting number 9771980 which has a wider bolt pattern on the center two exhaust ports (stock D-port headers can be modified to fit).

Many pre-1967 blocks are desirable for racing use because of more preferable bore/stroke ratios or displacements. On blocks which provided for through-the-rocker stud oiling, the oil gallery to the head must be blocked with a tapered plug p/n 523091 if 1967+ or early SD heads are used. On blocks with final bore sizes less than 4.030", check for valve-to-bore interference. Use the same series pushrod, rocker arm, intake manifold, rocker arm covers and pushrod covers as the head to eliminate interchange incompatibility. On 389 GTO and 421 engines with stock pistons, the valve reliefs are in the wrong location for the 1967+ heads. However, with any 1967+ head but Ram Air IV adequate piston-to-valve clearance is available so long as 9779068 or milder cam and 1.50:1 rocker arms are used. If 400 or 428 pistons are used, there is no piston-to-valve clearance problem.

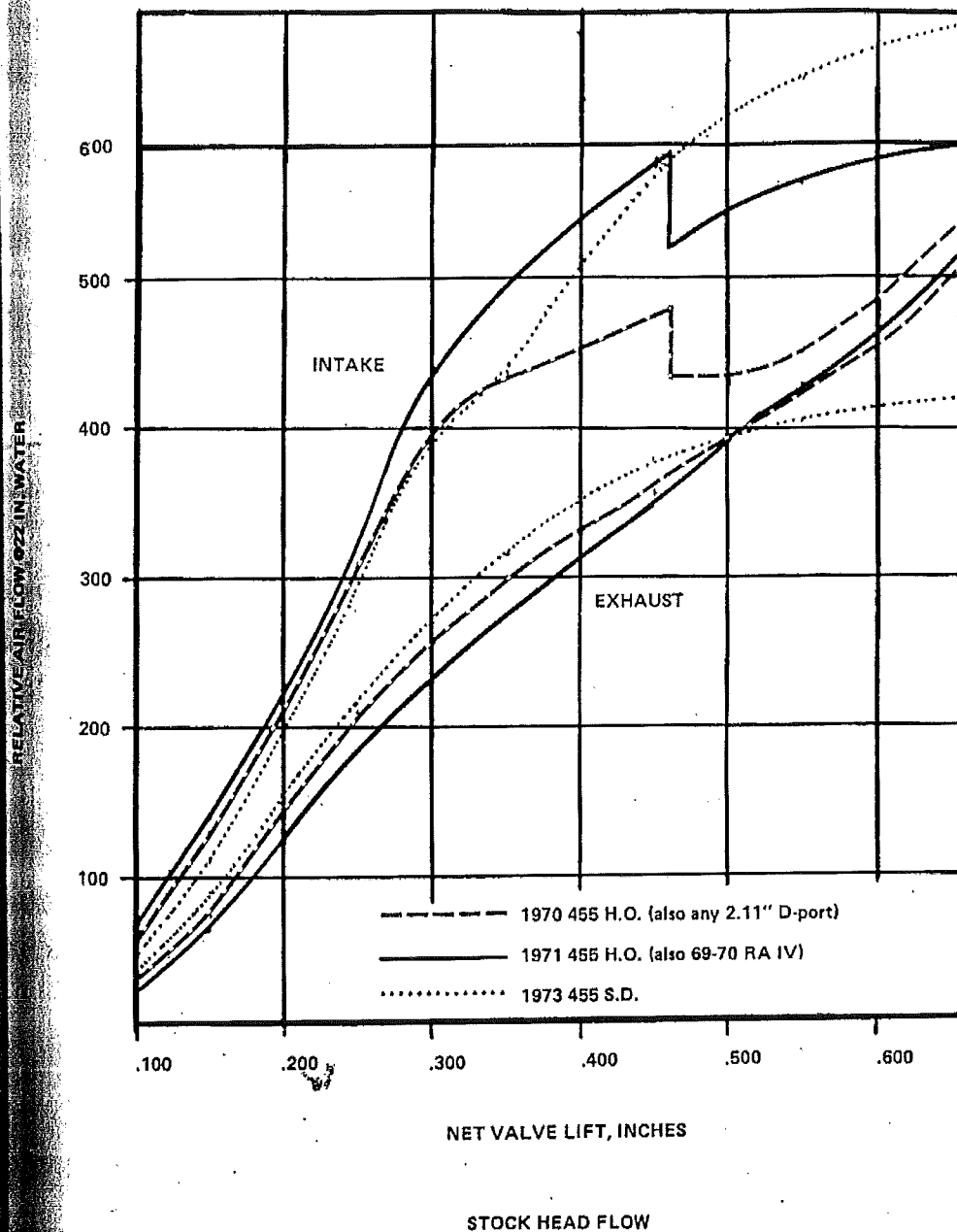
As noted above, all 1967-76 heads are basically the same. All 1967-76 pushrods (except 1969-70 Ram Air IV) are the same length. All 1967-76 rocker arms and covers are basically the same. The 1973-76 pushrod cover will work with all 1967-76 intake manifolds, but the 1968-72 cover will not work with 1973-76 intake manifolds because the cover lacks the deep recess in the center for the EGR provision. Although all 1965-76 intake manifold bolt patterns are identical, care must be taken when interchanging between 1965-71 and 1972-76 because of the difference in exhaust crossover port design. To prevent exhaust leaks at the crossover port: (1) use the same series intake manifold as head (1965-71 or 1972-76); (2) use 1972-76 intake gasket when using a 1972-76 manifold on a 1965-71 head; or (3) block or modify the exhaust crossover port when using 1965-71 manifold on 1972-76 heads.

### Comparison of Stock Head Air Flow

Figure 15 shows the comparative air flow of all late Pontiac high-performance heads described above. This data was obtained by H-O Racing Specialties, Inc. on our own flow bench and is corrected for temperature and pressure differences. The flow curves should be interpreted only as indicative because port-to-port variations are common on the same head. Notice the similarity in flow capacity between all heads of the open chamber design. There is sometimes more variation in port-to-port

flow on the same head than between all the open chamber heads shown. Therefore, you would probably be better off applying the scientific porting techniques described in the following sections to your present open-chamber heads than buying a new Ram Air head and running it stock.

FIGURE 15



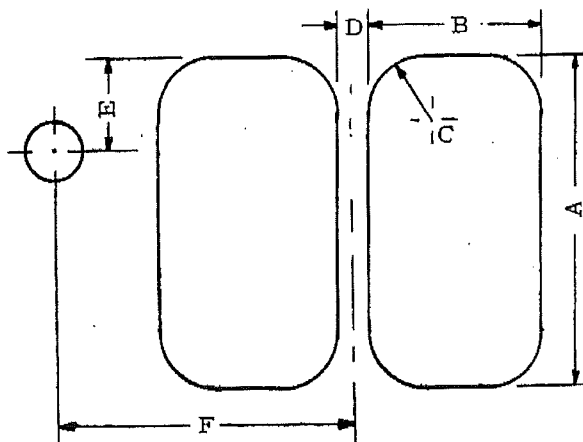
### Simple Head Modifications

The modifications described under this heading should be familiar to anyone experienced in competition valve jobs. These mods are all that are really required for a good street hop-up. The novice should limit himself to these changes because the additional changes described later require significantly more effort and if not done properly will be detrimental to performance, if not ruinous to the head. You will need a high-speed grinder for some of these modifications.

### Gasket Matching

The intake manifold-port interface is the most important to match. As a template, use the same brand gasket as you will use in service. Pontiac gaskets are recommended because they last longer. In any case, check your gasket dimensions against the intake port blueprints drawn. The gasket must be solidly located on the head surface, preferably by plastic retainers, P/N 543682. Use Dykem or machinest blue and a sharp scribe to mark the port. If you are going to use a Ram Air IV or 455 HO intake manifold on standard heads, you will note that this requires the port to be opened up an additional 0.130" at the top. Blend the top back at least 1" into the port (see item 4 under Intake Port modifications). The rest of the port can be blended 1/4" - 1/2" into the port.

FIGURE 16



"Blueprint" Port Dimensions

Dimension	Standard	RAIV	455 SD
A	2.05"	2.18"	2.22"
B	1.13	1.16	1.18
C	0.38	0.38	0.38
D	0.18	0.18	0.24
E	0.49	0.62	0.66
F	1.94	1.94	1.94
AREA	2.19 sq. in.	2.40 sq.in.	2.50 sq.in.

Match the intake manifold also. The best way to do this is to bolt the manifold to the head with the gasket in place (held by plastic retainers), and then spray paint the manifold flange and the gasket which sticks over the edges. Take the manifold and gasket off the head. The gasket can now be properly located on the manifold surface by noting the location of the paint over-spray. Proceed with matching as with the intake port.

If desired, the exhaust port flange can be matched to the exhaust gasket, although this is not too critical for the street. The paint overspray method is the best way to properly locate the gasket since there are no retainers used. Also, you can match the combustion chamber edge to the head gasket used and smooth the machined chamber contours. This will eliminate sharp edges which can cause ping and pre-detonation. It will also serve as a basis for later chamber work, if desired.

#### Deburring, Cleanup and Blending

In order to promote oil flow back to the crankcase, it is a good idea to remove the casting flash that partially blocks the oil return paths on the head. A lot of strong running, reliable Pontiac engines seem to get along fine with the casting flash intact, but it will not hurt to remove it.

If you are running in a class where it is within the rules, then a cleanup operation which is worth doing is to very carefully remove any casting flash in the intake and exhaust ports. Do not change the actual shape of the port at all! This work must be done prior to any valve seat grinding. Also, the valve under seat contour cuts may be carefully blended into the cast port wall. Again, do not disturb the basic shape of the port.

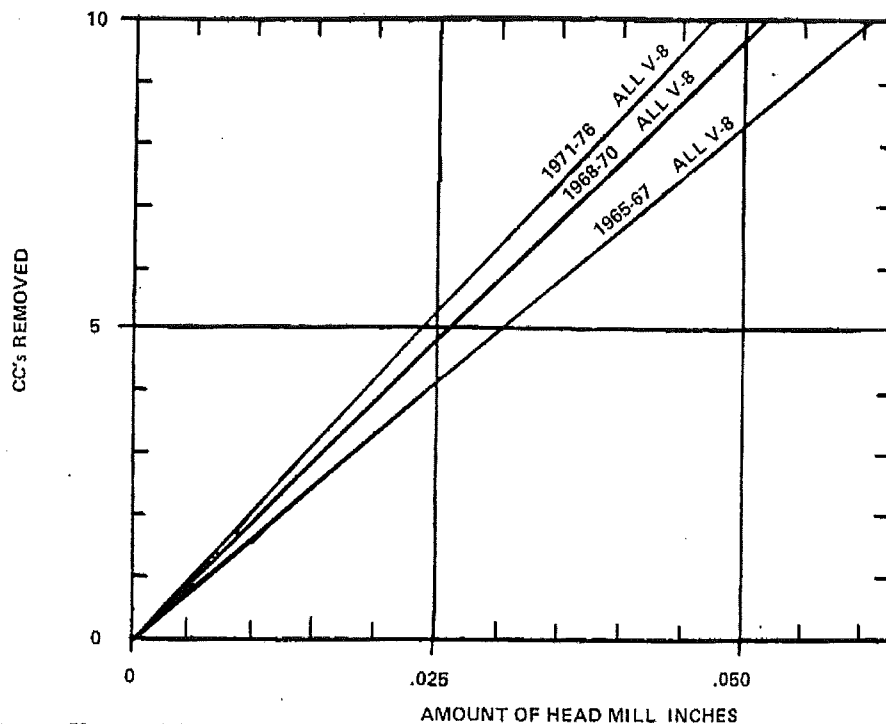
#### Milling for CC's

All Pontiac heads have fully machined combustion chambers. This provides extremely accurate volume control. If the measured depths from the floor to the head surface on any two chambers are within .003", then the chamber volumes will be equal to within 0.6 cc. This method of comparing volumes is also valid between heads of the same type. You will have to 'CC' one chamber to determine the actual volume, but this measurement technique will save you the chore of CC-ing every chamber.

Figure 17 shows how much must be milled off the head surface to reduce the chamber volume by a certain amount. Generally, each .005" milled off removes 1 cc on open chamber heads. Also, to prevent warpage you should not mill a head more than that maximum recommended in the figure. You must mill an equal amount off the intake surface to maintain proper manifold/port match.

FIGURE 17

## HEAD MILLING GUIDE

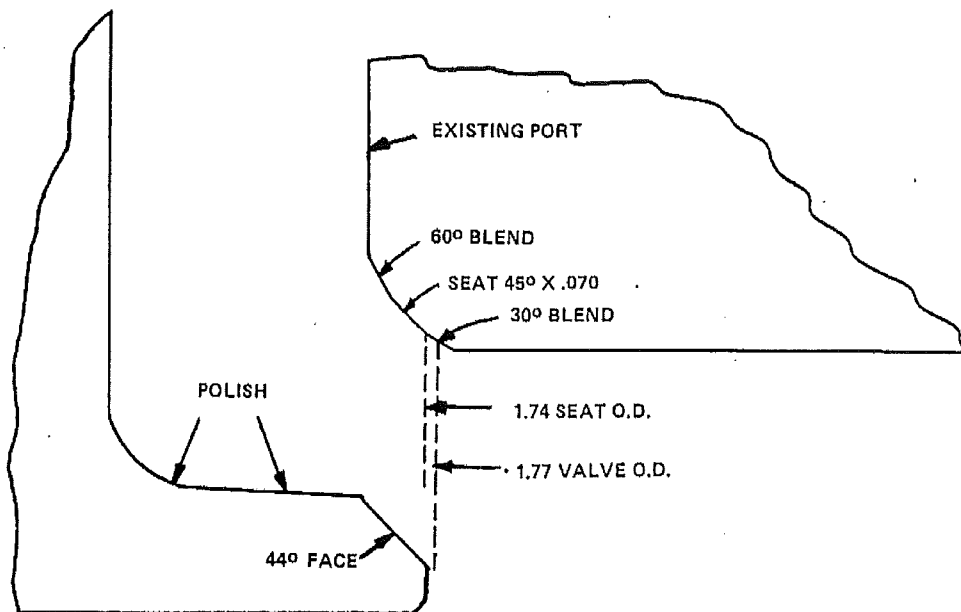
Street Valve Jobs

One of the most common "performance" mistakes made on Pontiac heads is to change the intake valve angle from  $30^{\circ}$  to  $45^{\circ}$ . This change is sometimes included in a 3-angle ( $30^{\circ}$ - $45^{\circ}$ - $60^{\circ}$ ) valve job. Do not do it! There are good reasons why a  $45^{\circ}$  intake seat works on Chevrolet or other makes and there is a good reason why it will not work on a Pontiac. There is a sensitive interrelationship between valve angle, seat width, chamber floor shape, wall contour, valve back angle and other factors. Pontiac knew what they were doing when they put a  $30^{\circ}$  seat on the intake because it works best with the Pontiac machined combustion chamber. We have proven on the flow bench and the strip that a  $45^{\circ}$  seat loses both air flow and horsepower compared to a  $30^{\circ}$  seat. This is basically because of the flat chamber floor.

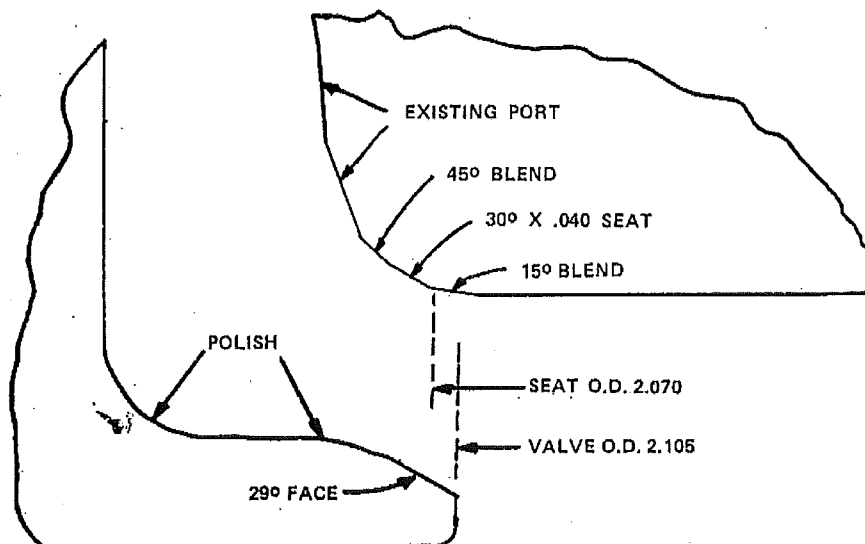
The valve and seat dimensions shown in figure 18 have proven to be the simplest and most beneficial valve and seat configuration for street use. On the intake valve, the  $45^{\circ}$  under-seat cut can be deleted if necessary, but if the  $15^{\circ}$  outer cut is deleted, there will be a performance loss. Notice that the exhaust valve transitions to a  $30^{\circ}$  cut. Seat runout should be held to .001" for either one.

FIGURE 18

STREET EXHAUST GRIND



STREET INTAKE GRIND



The valves illustrated are originally standard ones and will work better for street use than Ram Air IV or 1973 Super Duty valves because of the flat back angle. This angle is more compatible with the flat chamber floor at low and mid lift than the steeper valve angle of the RA IV/SD. The area from the stem to the first back cut should be polished by using cratex or very fine sandpaper while the valve is turned in a drill. This polishing will retard carbon build-up and eliminate sharp edges for better flow.

### Substitute Valves

If you are going to do a complete valve job on your used heads, then a new set of valves is the most trouble-free way to go. However, do not automatically order the same type valves that came with your heads. Since all 1967-up 4-bbl Pontiac valves have the same head and stem diameter, essentially any valve can be used.

If you have a standard 400/428 head, then consider ordering either the late 67 or early 68 Ram Air valves. They come swirl-polished from the factory and can save you a lot of work on the backside of your standard valves if you are modifying them as previously described. They are of about normal length (not extra long like the Ram Air IV valves), so they can be directly substituted. You will probably have to wait out a factory delivery (7-10 days), so order them early.

Most Pontiac valves are also available in oversize (+.001", +.003", +.005") stem sizes. If your heads have some miles on them and you have to order new valves anyway, then oversize stems may save you a guide knurl job. A factory delivery may be applicable here too.

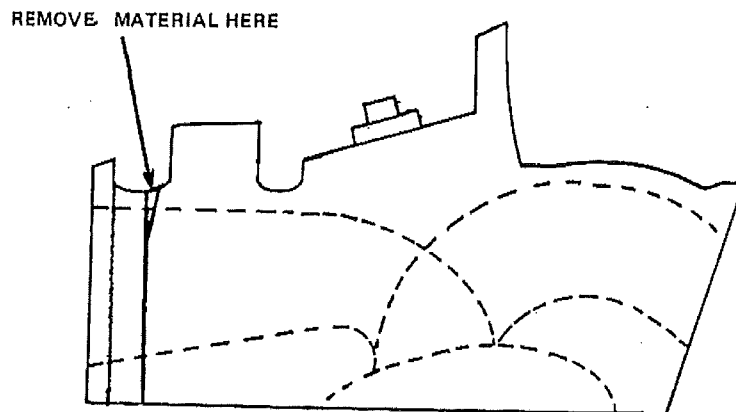
Except for Ram Air IV valves, all valves come in various overall lengths depending on original application. This fact can be useful to correct valve train geometry and/or spring installed height for head milling and valve seat grinding. The H-O Racing Specialties, Inc. Pontiac HEAVY DUTY PARTS AND SPECIFICATIONS book has a complete listing of all 67-up valve lengths, oversize stem diameters and part numbers.

### Pushrod Guidehole Enlargement

A modification worth doing to non-Ram Air IV/455 SD heads while they are being worked on is to enlarge the pushrod guidehole at the top towards the rocker stud hole. As shown in Figure 19, enlarge the top about 1/8", tapering to the original hole diameter about 1/2" down. Then in the future if you want to use 11/32" pushrods, 1.65:1 rocker arms and/or a high lift (greater than .420") cam, you will have no pushrod-to-guide hole clearance problems. However, most heads will accept either 11/32" pushrods or 1.65:1 rocker arms alone without modification so long as the valve lift is less than about .460".

FIGURE 19

PUSHROD HOLE ELONGATION



### Porting

A properly ported Pontiac head results from intelligently and judiciously applying a high-speed grinder to the proper places. It requires a great amount of work (50+ manhours), but it also pays great benefits. If you follow the instructions and discussions in this section, there is a free horsepower gain to be had.

All information in this section is strictly a result of research and development by H-O Racing Specialties, Inc. on our own air flow bench and proven to our satisfaction by actual head modification and track and street testing.

### Exhaust Port

All Pontiac factory cams have more exhaust duration than intake duration. The reason is that, at the valve lifts used by the factory, the exhaust port has deficient flow in relation to the intake port. On the flow bench, an optimally flow balanced head would have an intake/exhaust flow ratio of 1.38:1 averaged over the range of valve lifts of interest. An average intake/exhaust flow ratio of greater than 1.38:1 indicates a deficient exhaust port flow. As an example, consider a stock 1968-70 Ram Air III head with a 9779068 Pontiac cam;

Valve Lift	Intake Flow	Exhaust Flow	Flow Ratio	% Duration @ Lift (068)	Flow ratio times % Dur.
.100	65	35	1.86	.13	.24
.150	130	75	1.73	.08	.14
.200	210	145	1.45	.09	.13
.250	310	210	1.48	.10	.15
.300	395	255	1.55	.13	.20
.350	435	300	1.45	.16	.23
.400	440	330	1.33	.31	.41
.450	475	365	1.30	0	0
.500	435	390	1.12	0	0
.550	450	425	1.06	0	0
.600	480	465	1.03	0	0
.650	550	510	1.08	0	0
Average flow ratio:					1.50

After the ratio of the intake to exhaust duration is accounted for by multiplying the average flow ratio of 1.50:1 by 211/225 (9779068 cam duration at .050" tappet lift), the resultant flow ratio with this particular combination would be a more desirable 1.41:1. Generally speaking, the intake/exhaust flow ratio of most Pontiac heads indicates a deficient exhaust flow which should be corrected by properly modifying the ports and valve seat.

Figure 20A is a cross section through the center of 1967-74 1.77" stock exhaust ports. The exhaust flow has to turn through a total angle of about 150° before it arrives at the manifold flange (1966 and prior heads had a 156° turning angle). The port is very constrictive at section C-C, but for a reason. The general philosophy of flow direction in the stock port is to deflect the flow and not uniformly turn it. This works fine at low flow rates, but chokes up at high ones. Part of the reason this design philosophy was necessary is because the large valve guide boss for adequate valve support on a production line basis. Also, the inside of the throat could not be opened up and still provide adequate valve seat cooling (note the proximity of the water jacket). Both of these areas can be corrected and the section C-C constriction removed by porting.

The general philosophy of the following modifications is to make the exhaust flow turn uniformly through the port, the exact modifications depending on use.

1. High Performance Street. Not much material is actually removed since flow velocity must remain high for good scavenging at street rpm. The major increase in flow is gained with combining a smoother short turn radius with a more efficient valve seat.

For 1967-72 D-port 1.77" exhausts, copy the contour outlined in figure 20B. The roof and end of the port do not need to be opened up, but any dimples or bumps can be smoothed (removal is not necessary).

For 1968 1/2-71 Round-port, only the deficiencies inherent in machining and casting operations are corrected. The area directly under the seat is smoothed and the front part of the casting bump at the inner port radius is removed. The area around the guide boss must also be reduced to allow a more uniform turning path.

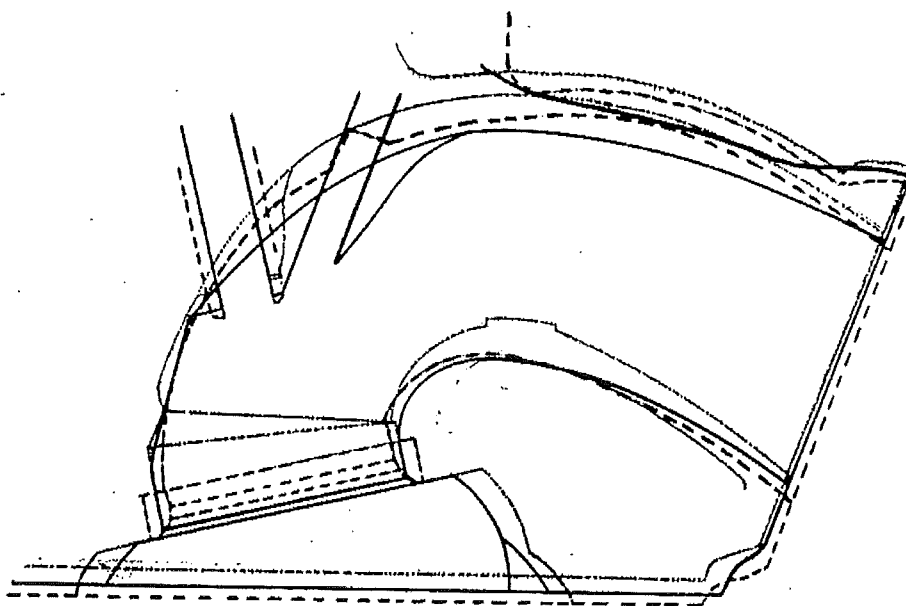
For 1972 455 HO (not shown), much more material must be removed to achieve the above configuration. Otherwise, the resultant contour is the same as 1971 455 HO.

For 1973-74 455 Super Duty, the port is left as produced. Only the transition from the inserted seat to the port is generously radiused and smoothed.

2. Competition Only. Except for 1973-74 455 SD, much more material is removed to allow for greater cross-sectional area and a straighter flow path consistent with the attendant high valve lift of competition cams. Follow the contours shown in figure 20C. In addition, the width of the port must be increased to provide a straight transition to the exhaust manifold/header. Remove as much material as necessary (but never more than .135" anywhere) to achieve a smoothly radiused and contoured port.

FIGURE 20 A

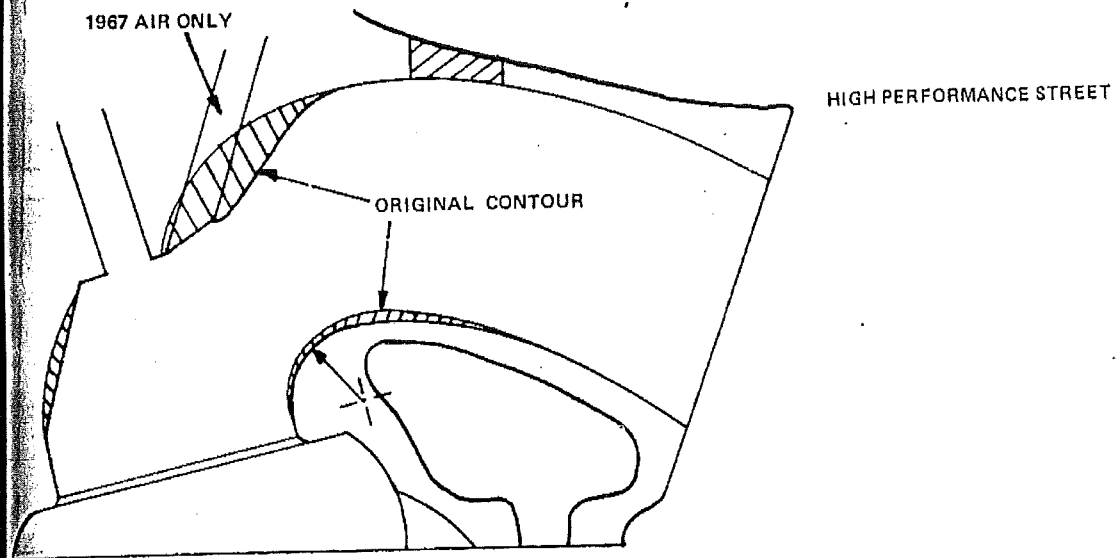
STOCK EXHAUST PORTS



———	1967-72 STANDARD 1.77" D-PORT		
.....	1968 1/2 RAM AIR II	1969-70 RAM AIR IV	1971 455 H.O.
----	1973-74 455 S.D.		

FIGURE 20 B

1967-72 STANDARD EXHAUST PORT



COMPETITION ONLY

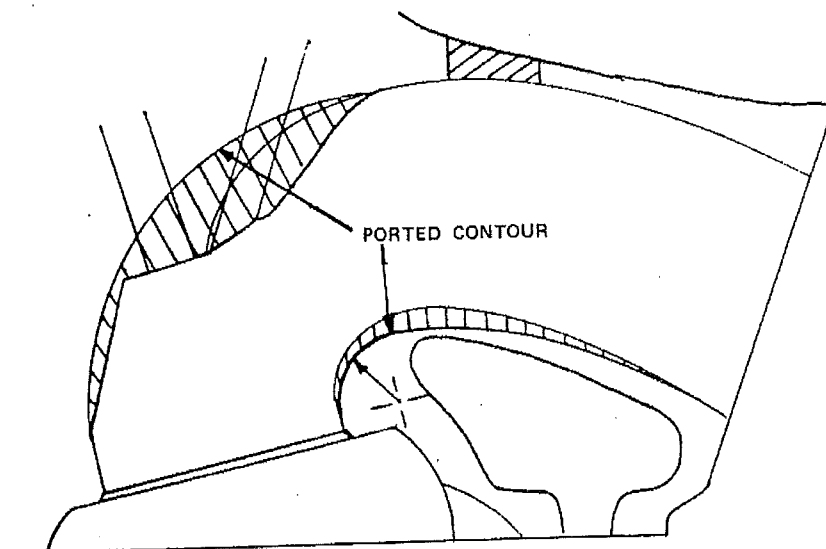
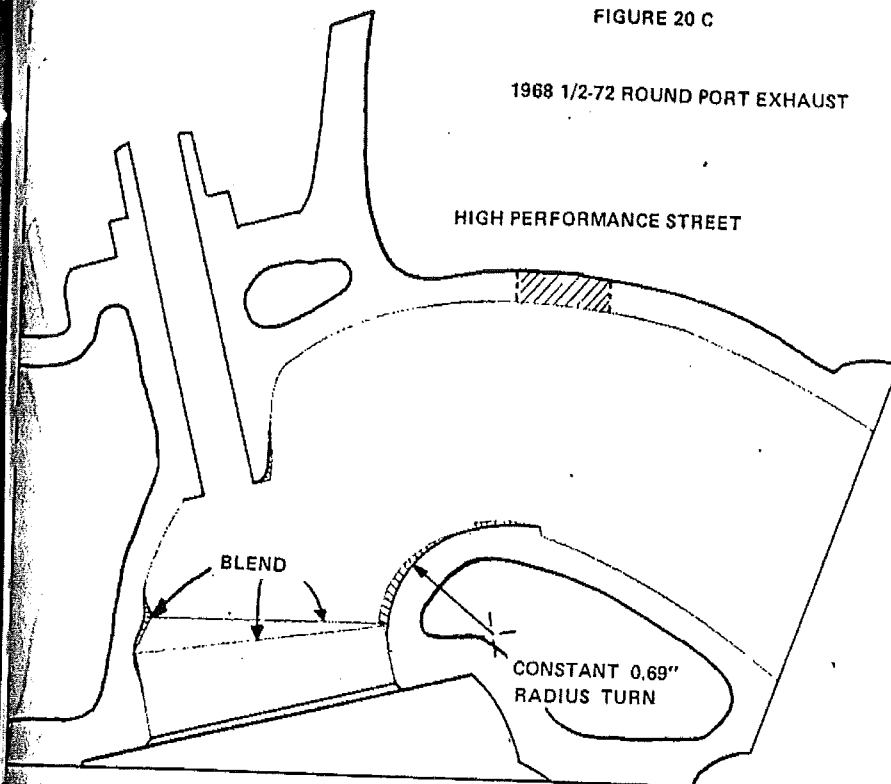


FIGURE 20 C

1968 1/2-72 ROUND PORT EXHAUST

HIGH PERFORMANCE STREET



COMPETITION ONLY

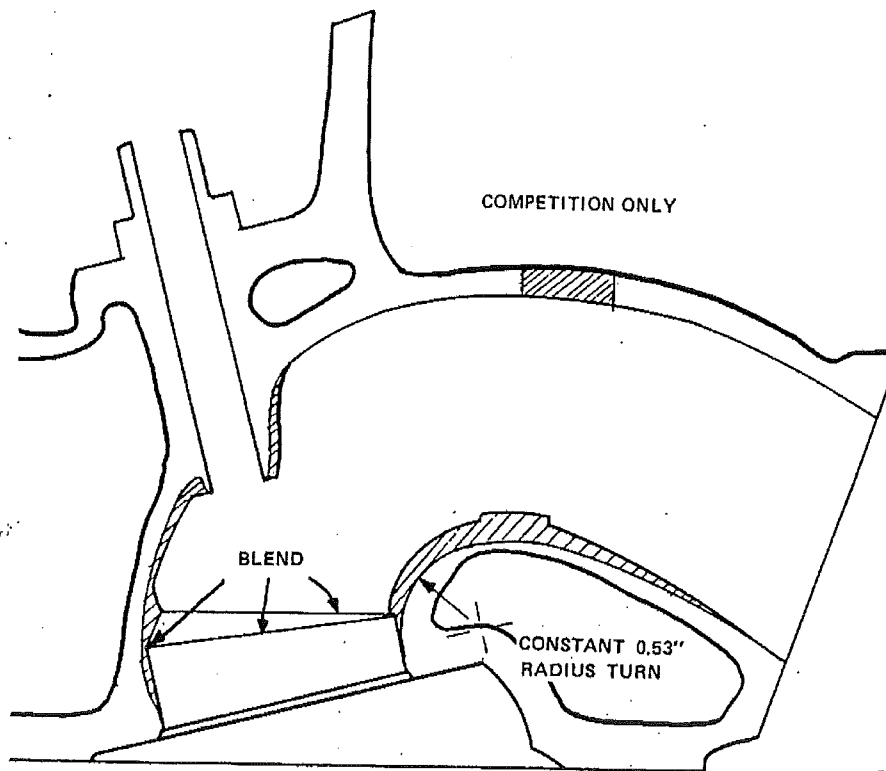


FIGURE 20 D

1973-74 455 S.D. EXHAUST PORT

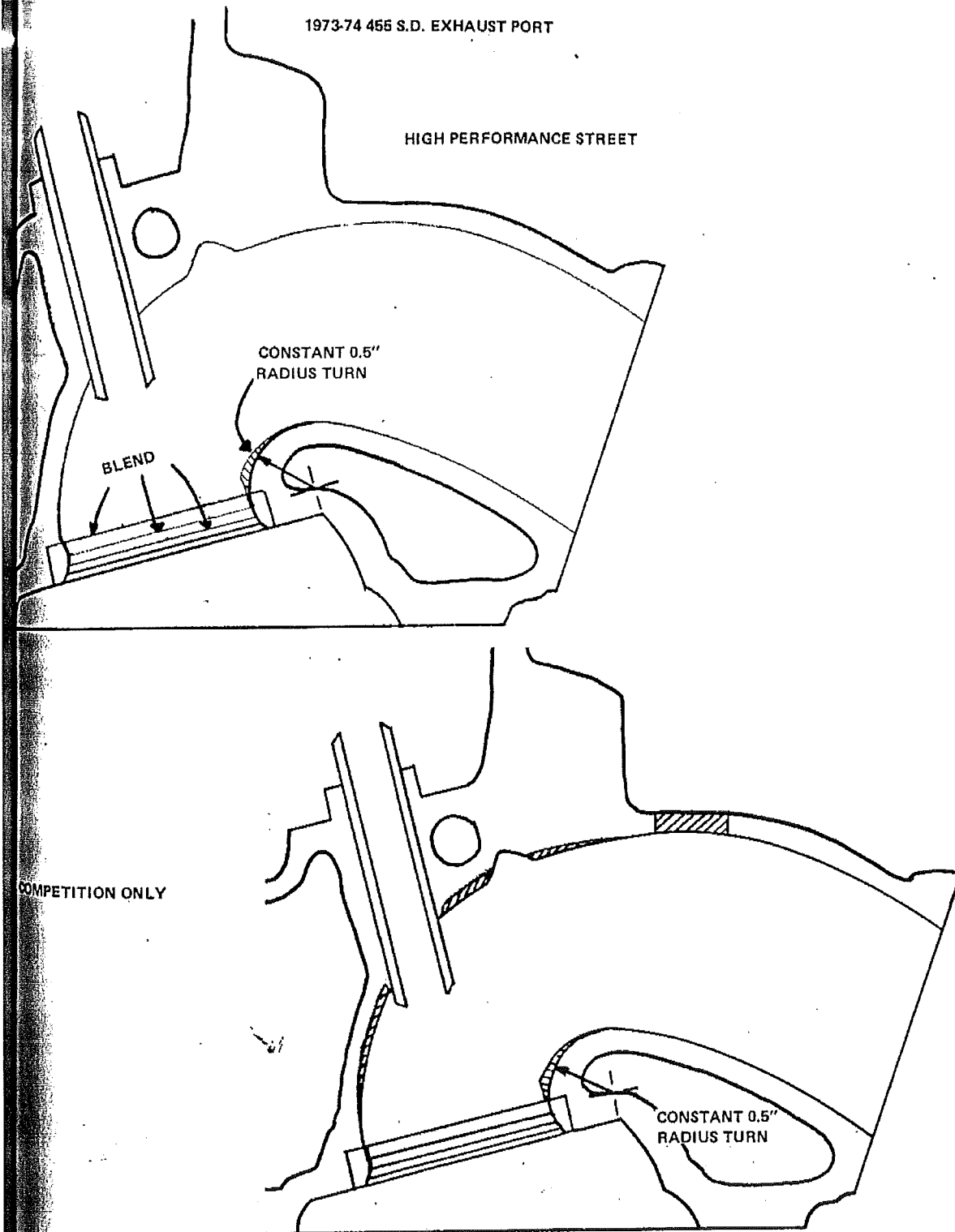
HIGH PERFORMANCE STREET

CONSTANT 0.5"  
RADIUS TURN

BLEND

COMPETITION ONLY

CONSTANT 0.5"  
RADIUS TURN



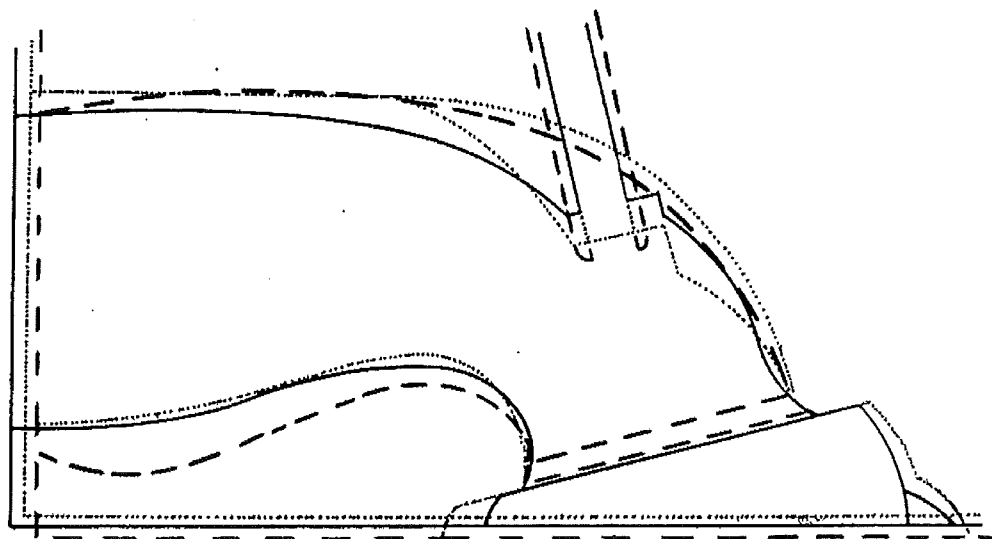
## Intake Port

The stock Pontiac intake port on 1967-up heads is already very close to an optimum venturi port shape. Compromises in the port design have been made to allow placement of the pushrod guide-hole and the valve guide boss. The  $14^{\circ}$  valve-to-bore centerline angle assures minimum cylinder wall shrouding for the bore size used, although port turning angle is increased somewhat. The modifications described in this section are simple and designed to return the port to its optimum shape.

Figure 21A is an intake port cross-section of the 1967-75 standard port, the 1969-72 high port and 1973-74 455 SD port. Notice that it is not possible to open-up standard port heads to exactly high port shape because of the lower port roof. Besides the blending and matching operations described previously, the following modifications are required:

FIGURE 21 A

### STOCK INTAKE PORTS



- 1967-76 STANDARD PORTS
- ..... 1969-70 RAM AIR IV    1971-72 455 H.O.
- 1973-74 455 S.D.

FIGURE 21 B

1967-76 STANDARD INTAKE PORTS

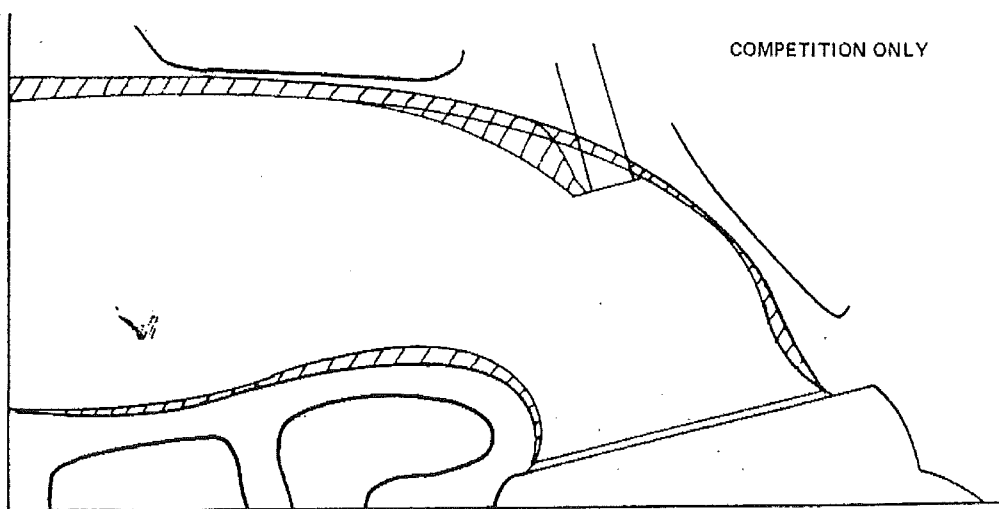
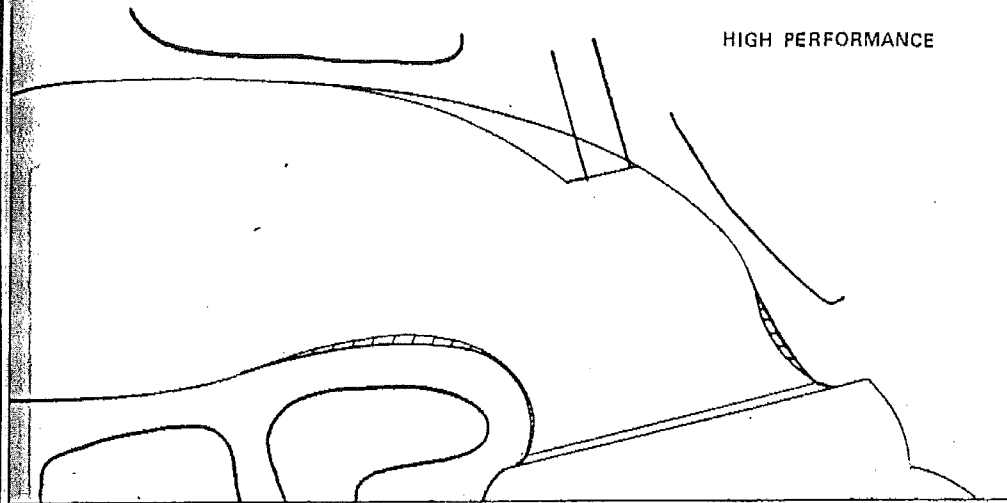


FIGURE 21 C

1969-70 RAM AIR IV AND 1971-72 455 H.O.

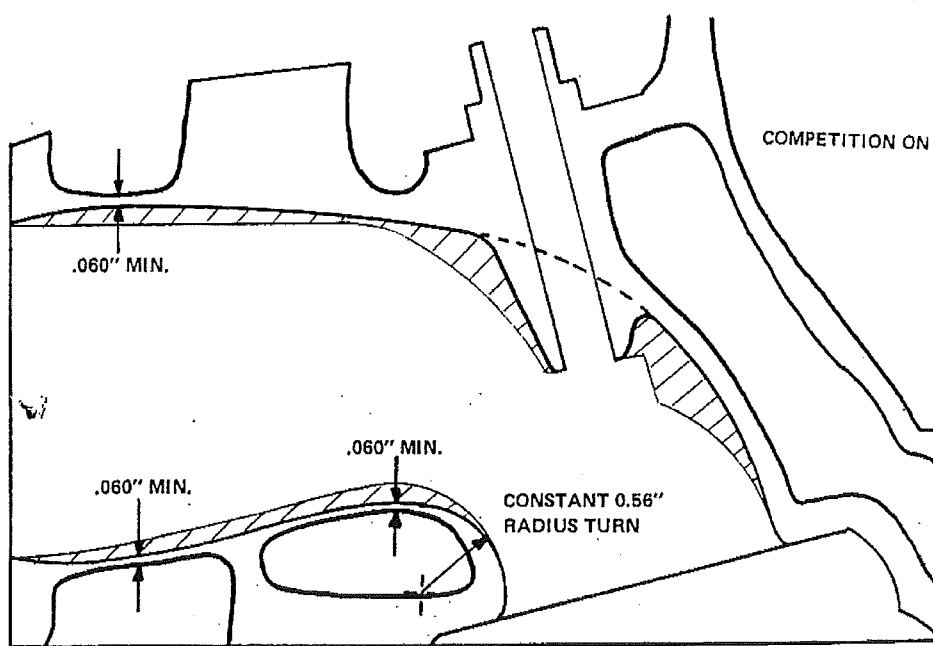
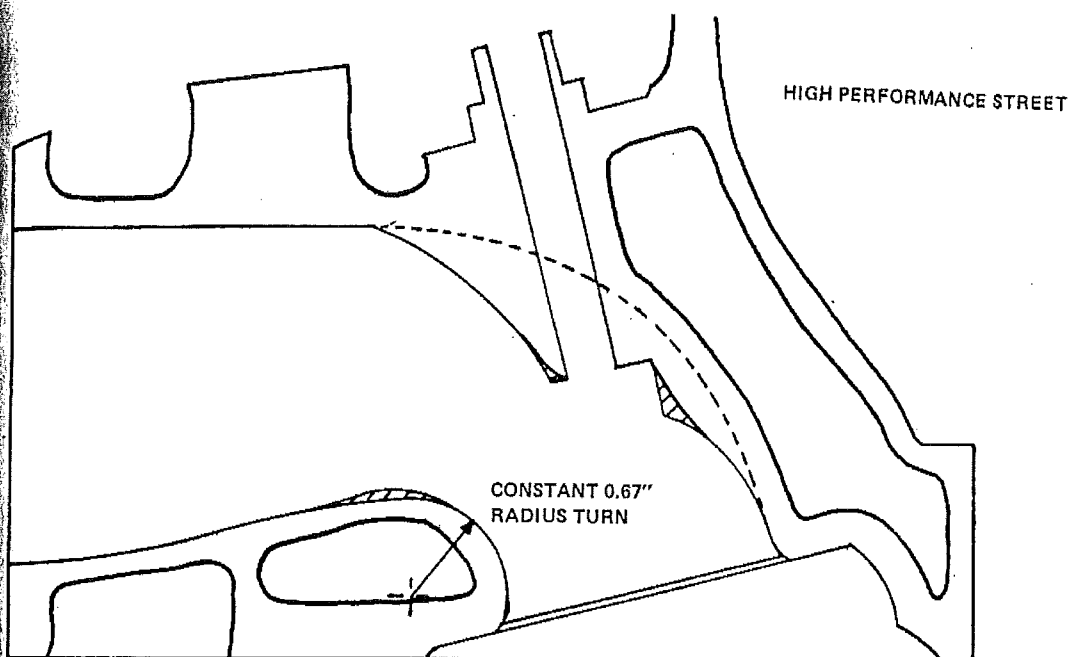
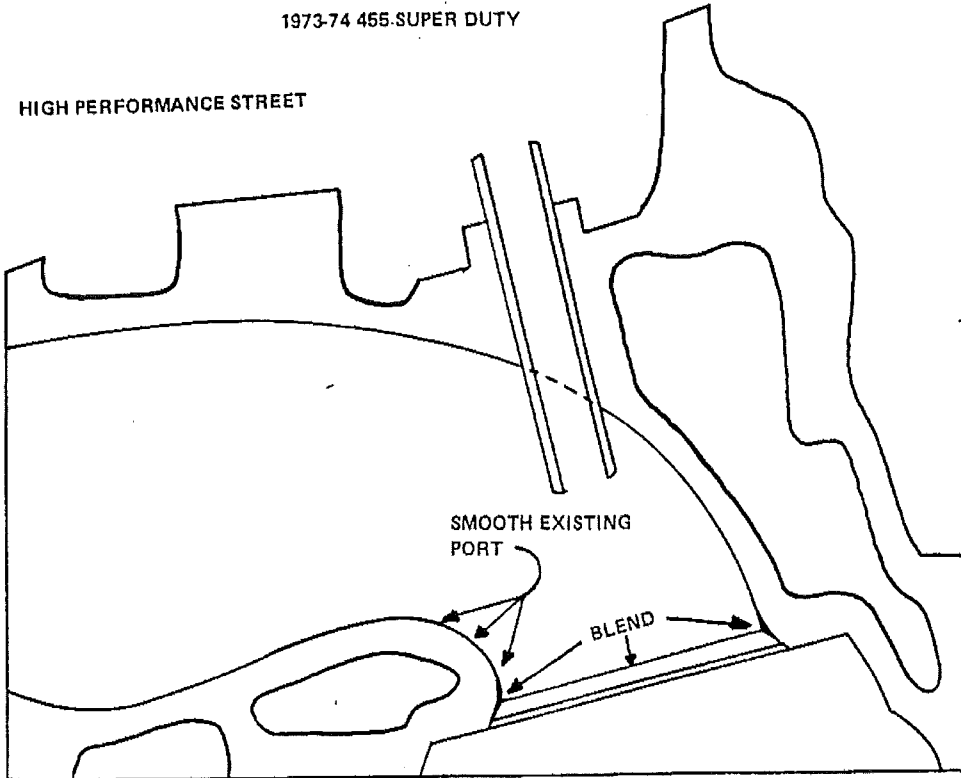


FIGURE 21D

1973-74 455.SUPER DUTY

HIGH PERFORMANCE STREET



COMPETITION ONLY

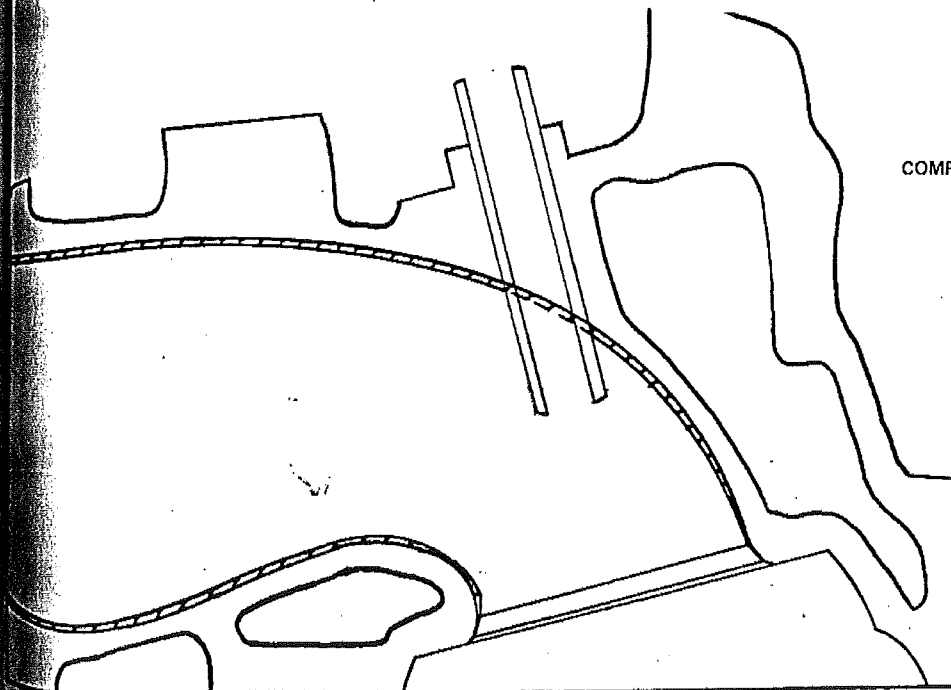
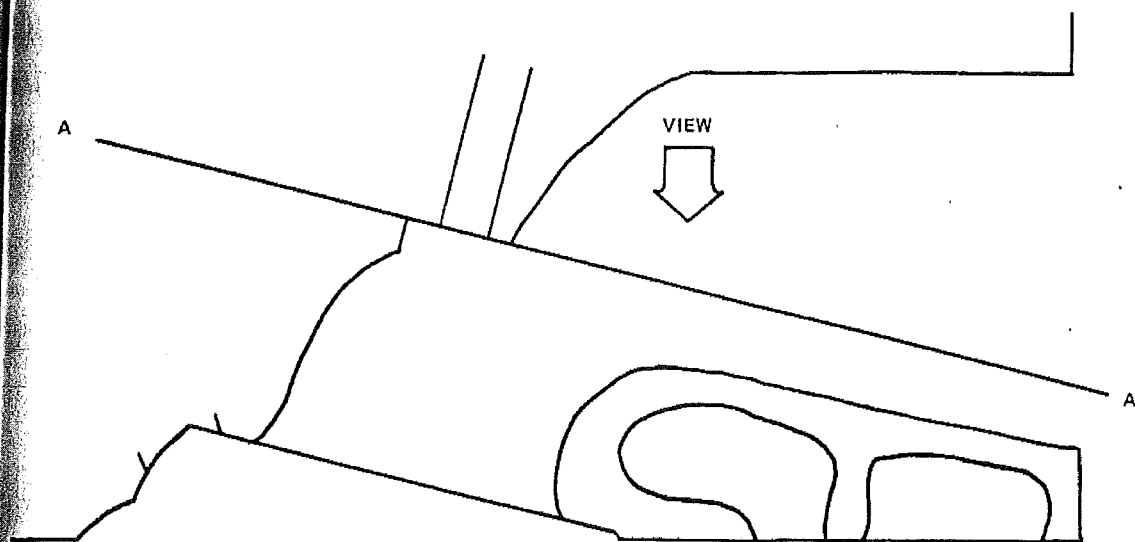
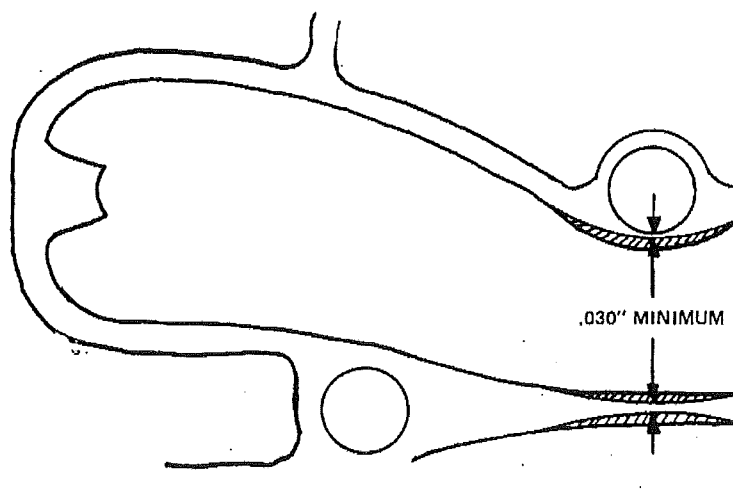


FIGURE 22

STRAIGHTENING THE PORT



VIEW THRU SECTION A-A



- 1. Modify the port just past the intake manifold interface as shown in figure 22. The criteria for how straight the port can be made is determined by a .030" minimum wall thickness where indicated. The port can be opened up until the guide hole is exposed if a guide tube such as the 1973-74 455 SD tube 485404 is pressed in to seal off the port. See figure 19 for machining dimensions. This is really not necessary however except for all-out competition, since the opposite port wall and the adjacent port floor can be opened up to achieve a more constant cross-sectional area. It is important to note that 1969-70 Ram Air IV intake ports cannot be widened as far as the standard (and 1971-72 455 HO) port because of the larger diameter pushrod guide hole used. This is not too important if the bulge is smoothly radiused and the floor and roof is opened up correspondingly.

2. High Performance Street. As with the exhaust port, not much material is removed. The original contour is retained near the valve to keep port velocity high for good torque. The 1967-75 port is raised near the intake manifold surface to meet the Ram Air IV/455 HO/SD-type gasket. Note however, that the raised roof can only be blended in about 2" from the manifold surface because of the thin stock roof. See figure 21B.

3. Competition Only. The port cross-sectional area is increased approximately 30%. This increases high rpm volumetric efficiency and the resultant horsepower. The short turn radius is very critical since it is decreased to provide a wider high valve-lift "window" to the flow path. The wrong short turn radius will result in flow separation (turbulence) at about .500" valve lift and a significant flow reduction. See figure 21C.

The 1973-74 455 Super Duty already has a configuration very similar to the competition-only port. Again, the critical area is the transition from the port to the seat. This should be generously radiused and smoothed as shown.

#### Combustion Chamber

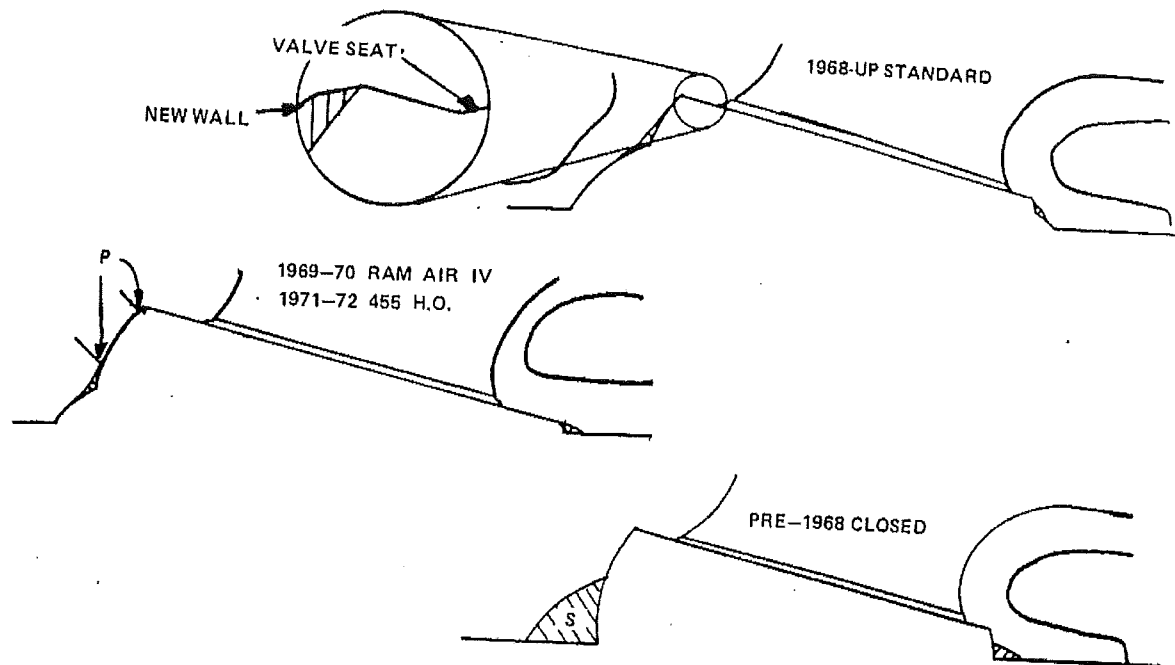
The combustion chamber is included in the porting modifications because as the valves open, the chamber becomes an extension of the port. Modifications to the chamber can both improve port flow and flame propagation. Unfortunately, it is very difficult to improve port flow by modifications to the existing combustion chamber because the chambers are fully machined. The chamber floor is flat which is the most significant theoretical limitation to flow improvement.

1. (1968-up non-Ram Air heads only) Remove the wall material indicated by the cross-hatch section in Figure 23. This modification will approximate the Ram Air chamber shape with one important difference. As shown in the enlarged view, the modified wall must meet the floor at its original point and at a 20° angle. This is critical to flow and must be done carefully. Blend and unshroud the spark plug hole similar to 2 below.

2. (Ram Air and 455 HO/SD heads only) Blend and unshroud the spark plug and valves at the areas marked P in Figure 23.

FIGURE 23

## COMBUSTION CHAMBER MODIFICATIONS



3. (Pre-1968 closed chamber heads only) These heads may safely be converted to semi-open chamber configuration by removing the wall section as indicated by S in Figure 23. Any further grinding risks hitting a water jacket. Air flow will be reduced somewhat at low lift but improved flame travel will more than make up for it.

#### Cylinder Bore Intake Valve Chamfers

The intake valve chamfers on 4.0625" bores or larger are there strictly for valve unshrouding (air flow) purposes; there is no valve-to-cylinder wall interference with 1967-up heads and bores at least this large. It is worthwhile to make sure the chamfers are in the right place and large enough.

Prior to 1968, the valve chamfers were placed more towards the outside edge of the block, which was the appropriate location for the pre-1968 (closed chamber) heads. If you are using a 1967 or earlier block and 1968 or later heads, then valve chamfers should be added at the correct location. In addition, some of the later low-performance blocks either had no chamfers or they were too small.

Use the appropriate head gasket for a template to determine where the edge of the chamfer needs to be. The chamfer should be machined at an angle of  $35^\circ$  with respect to the block deck plane. It is mandatory that it first be determined that the chamfer will not uncover any part of the top piston ring; if so, use smaller chamfers or angles less than  $35^\circ$ .

### Competiton Valve Job

The valve usage and modifications specified in this section are designed to complement the porting mods already done in order to increase mid- and high-lift (up to .700") flow. If you have ported your heads, but want to use them in a street engine, then use the valve seats and valves specified under the previous Street Valve Job section.

The intake valve seat modifications shown in Figure 24 will partly compensate for the flat chamber floor limitation discussed previously. Five angles are required to approximate a "venturi seat." It may take some convincing of your machinist to have him grind the 10° and 20° cuts. These are angles which are not normally used in standard valve jobs. However, it is critical that these two cuts be applied as illustrated, even if you have to foot the bill for a separate grinding stone for the low angle cuts. The 10° cut outside diameter (O.D.) is limited by the proximity of the O.D. of the 45° exhaust seat. There is only .088" between stock intake and exhaust valve seats so this is the O.D. limit of the 10° cut. The inside diameter (I.D.) of the 20° cut sets the O.D. of the 30° valve seat. A 2.060" valve seat O.D. is recommended. The 45° cut sets the I.D. of the 30° valve seat; a .035" seat width is recommended. Lesser widths do not seem to help flow. The 60° cut establishes the transition to the stock 70° throat cut and should be about the same width as the 45° cut. A .001" seat runout is specified. The five angle modification will sink the intake valve .020" and add 1.2 cc to the chamber volume.

The exhaust valve seat modification consists of a 4-angle cut. Because the exhaust port wall directly under the seat is bored parallel to the valve centerline, the I.D. of the inner cut will be constant no matter how much it is ground. The technique for establishing the various seat cuts is the same as described above. The exhaust valve will be sunk by the same .020" that the intake valve was, resulting in an increase in chamber volume by an additional 0.75 cc. See figure 25.

The full radius intake and exhaust valve seat is very simple to grind once the corresponding special stone has been ground. Not all head shops can provide you with a full-radius valve seat stone, but it is definitely worth the trouble to have one made to the specified dimensions in figure 24 and 25. We have had absolutely no problems with valve seat wear or deterioration with the full-radius valve seat, even on street driven engines.

### Modified Head Air Flow

Figure 26 shows the comparative air flow of a stock 1970 455 HO and 1971 455 HO (standard/D-port and High-port/Round-port) heads and the resultant air flow of the heads in High performance Street configuration. As can be seen from the figures, the intake flow is increased 47% (at .470" net valve lift) for the high-port head and 29% for the standard head. The exhaust flow is increased 35% for the round-port head and 48% for the D-port head. The resultant flow ratios are 1.6:1 for the high-port/round-port head and 1.1 for the standard-port/D-port head. A single pattern cam can be used with either head, although the standard-port head demands a high performance intake manifold (such as the Edelbrock Torker).

FIGURE 24

COMPETITION INTAKE VALVE AND SEAT

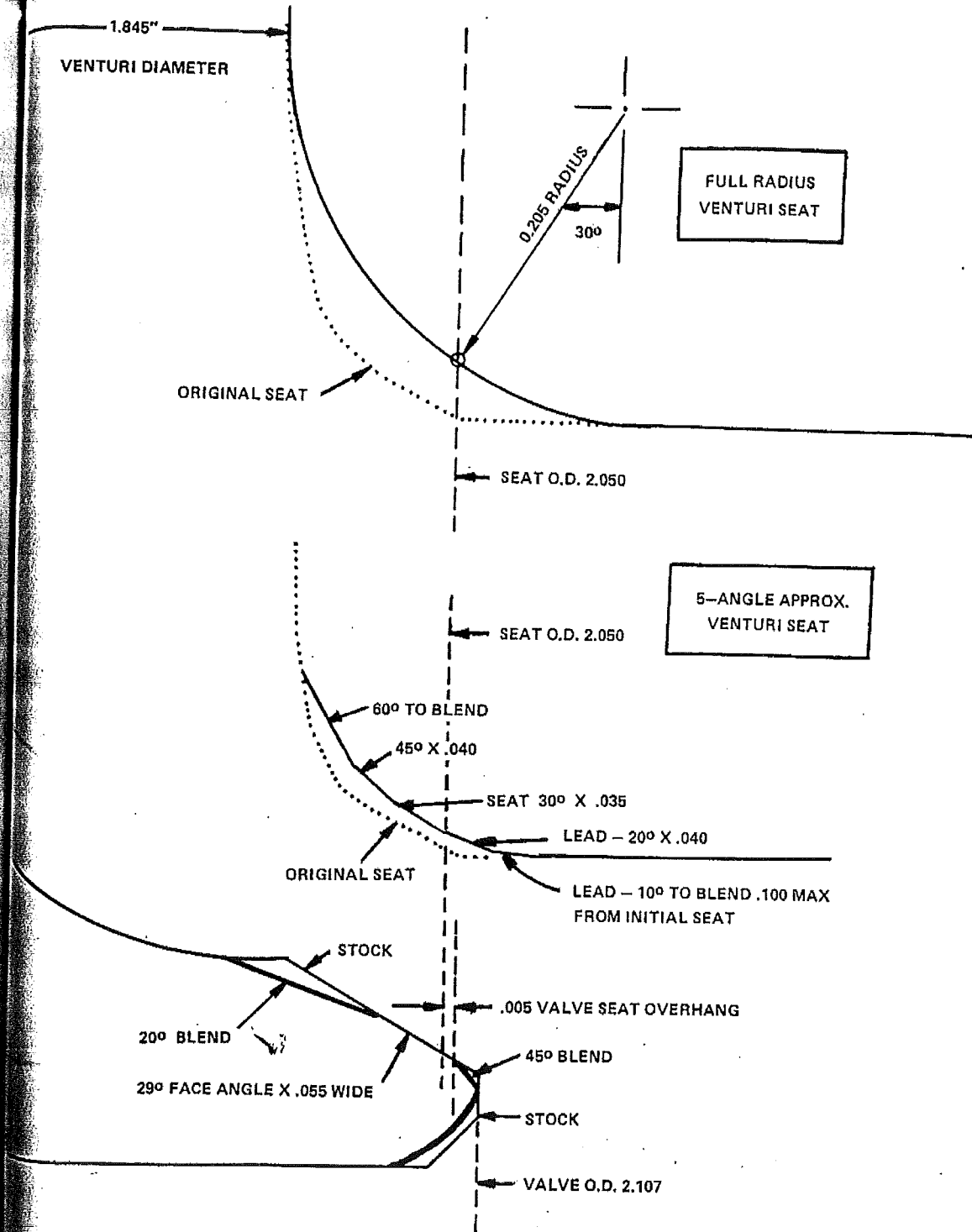


FIGURE 25

COMPETITION EXHAUST VALVE AND SEAT

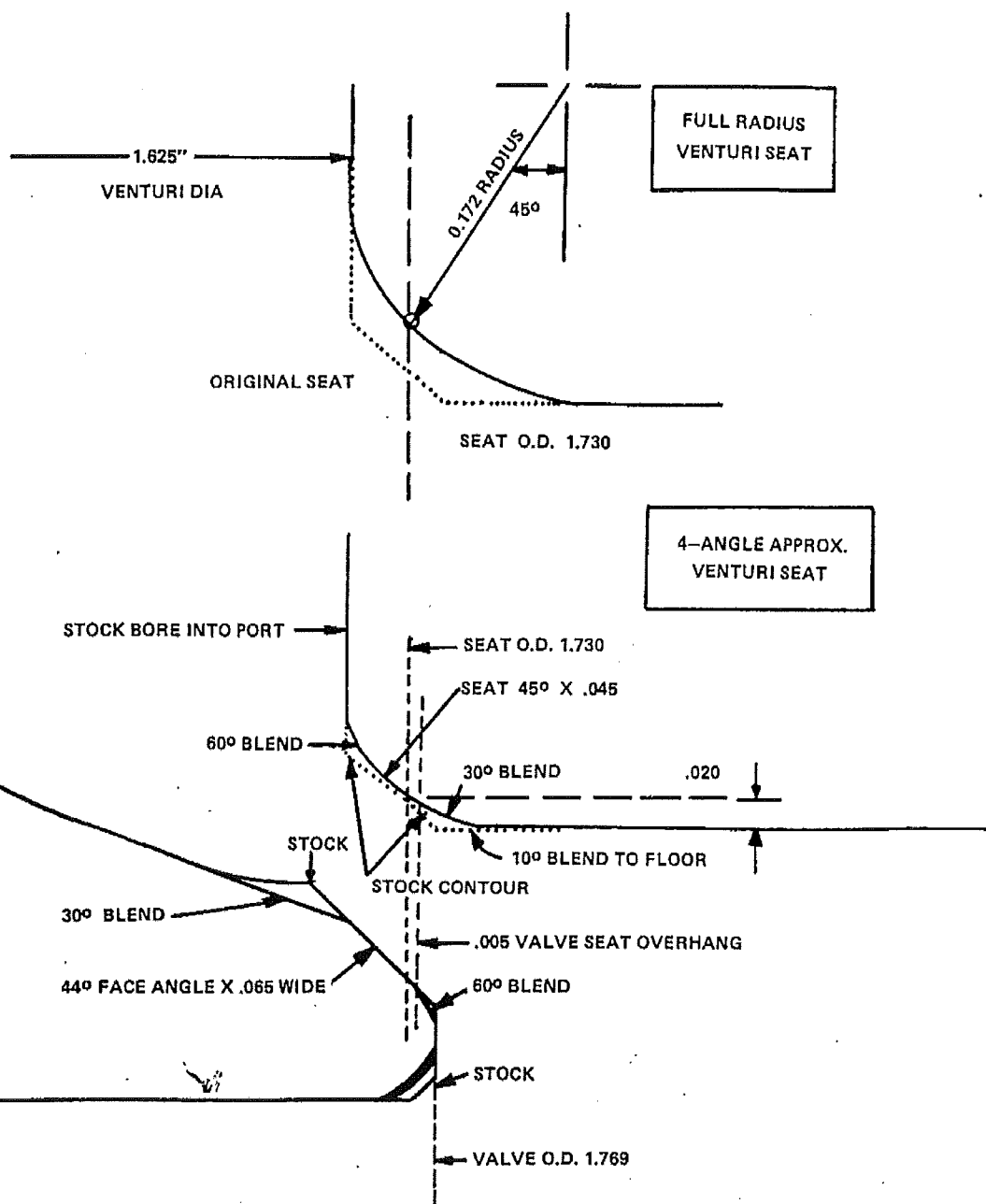


FIGURE 26

