

Pelican Technical Article: 911 Valve Adjustment Made Easy

Wayne R. Dempsey

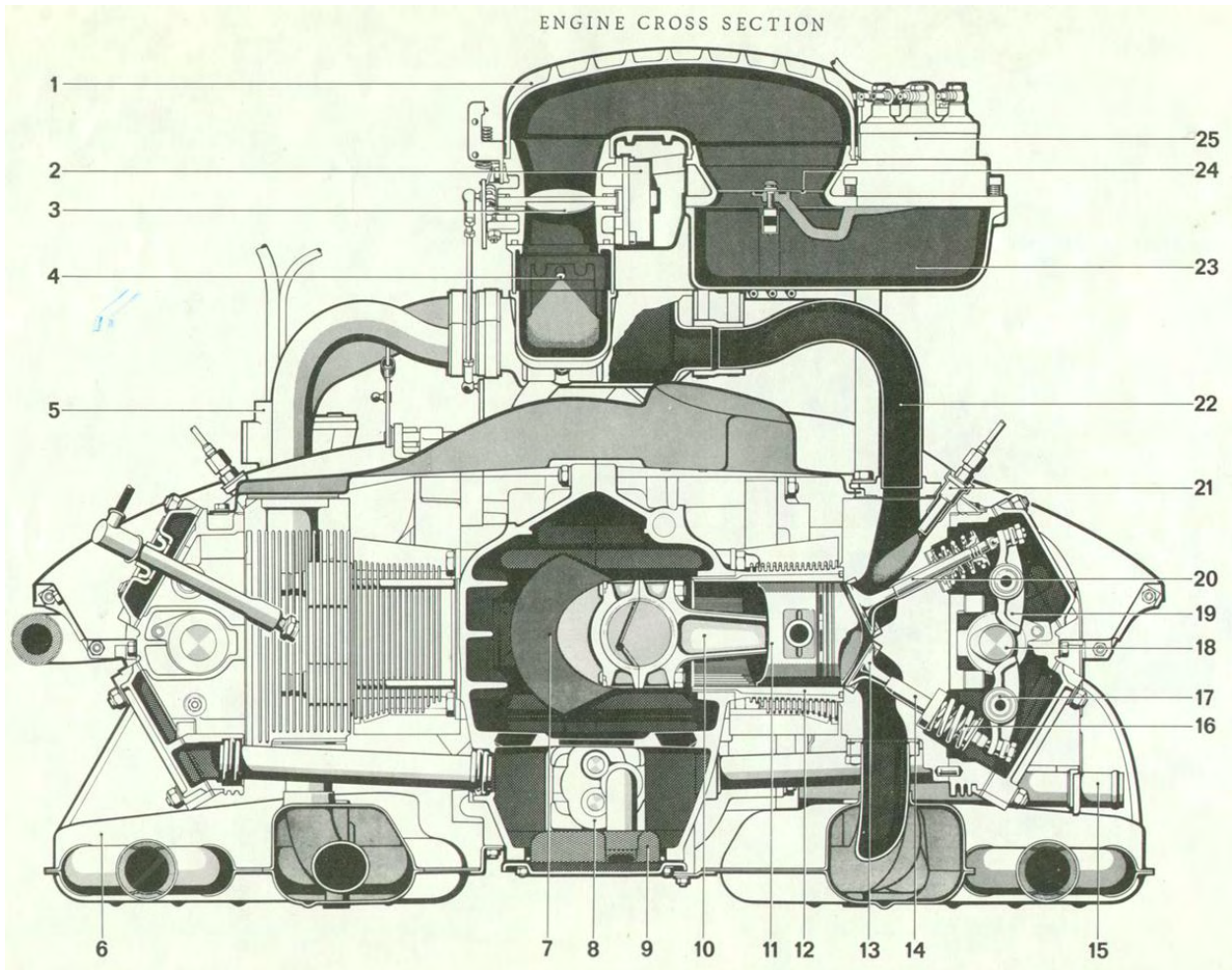
Difficulty Level 3

Difficulty scale:

Adding air to your tires is level one

Rebuilding a 911 Motor is level ten

Adjusting your valves is one of the routine tasks that need to be performed on your 911 in order to keep it running. While most people pay big bucks to take their cars to their local shops, the valve adjustment procedure can be easily performed at home with a little patience, a few tools and the right information, which I hope to provide here.

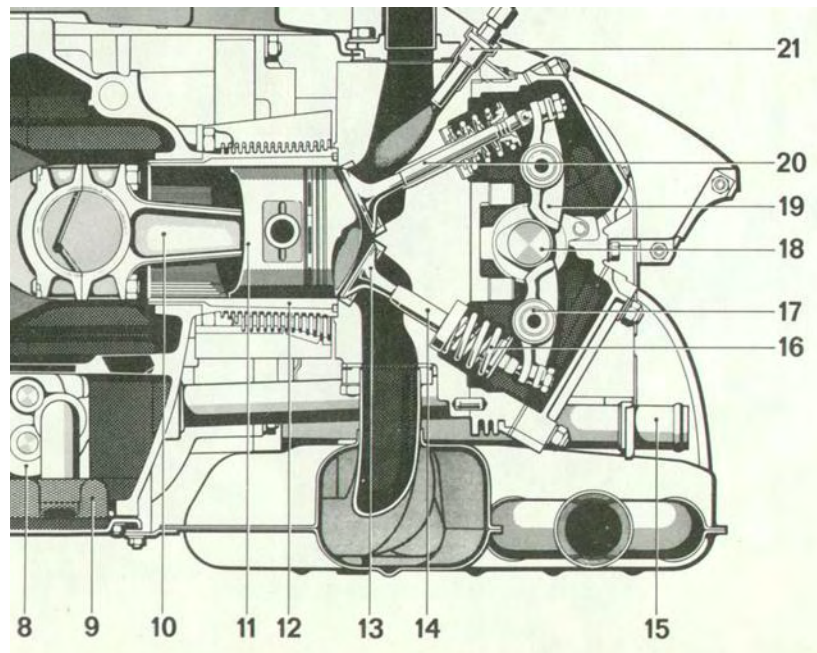


## Background

This has perhaps been the most requested technical article of all time here at Pelican Parts. With this in mind, I've decided to throw in a little background into why you would want your valves properly adjusted. See above for a complete side view of the 911 engine to refer to. The valves control the volume and timing of the fuel-air mixture that is injected and exhausted from the cylinder head.

**Figure 1** shows a cut-away view of the valve train.

- On the first stroke of the piston (#11), the intake valve (#20) opens to allow the air fuel mixture into the combustion chamber.
- As the piston retreats from the surface of the heads, (travels to the left in **Figure 1**) the resulting vacuum sucks in the air-fuel mixture that was provided by the fuel injector (#21).
- When the piston reaches the end of its travel to the right, the valve is closed, and then the piston begins its compression cycle. The piston travels all the way to the right (in **Figure 1**) and compresses the air-fuel mixture.
- When the piston has almost reached the end of its travel, the spark plug (not visible in **Figure 1**) ignites the mixture, and the resulting ignition exerts a force on the piston, pushing it back to the left.
- When the piston returns to the right, it pushes out the remnants of the explosion (exhaust gasses) through the exhaust valve (#13) which is now open. Then the cycle repeats itself.



**Figure 1:**  
**Side View of Valve Train**

The entire cycle requires precise coordination of all the components involved. In the 911 motor, the crankshaft, which controls the motions of the pistons, is tightly integrated with the valve motion through the timing chain.

The timing chain runs around the crankshaft and controls the motions of the camshafts (#18) which control the motions of the valves.

The exhaust and intake valves are both actuated by a set of rockers (#17 & #19) which open the valves by riding on the camshaft.

In their normal position, the valves are sprung closed by the valve springs (#16). When closed, they make a tight air seal with the valve seats that are pressed into the heads.

The timing of the motor refers to the moment in the piston stroke cycle when the air-fuel mixture is ignited. When someone says that they have advanced their timing, they generally mean that they have set the spark to ignite way before the piston has completed its stroke (travel to the right under compression). The reason that you set the timing in advance is because the air-fuel mixture takes a certain amount of time to ignite before it begins to exert a force on the piston.

In general, the amount of time it takes to ignite the fuel is the same when running at different RPMs. As a side note, the octane of the fuel directly affects the time it takes to burn the fuel. The higher the octane, the slower the fuel takes to burn. The term octane (I'm stretching my knowledge of chemistry here) refers to the amount of oxygenation within the fuel. From what I hear, the oxygenation slows down the rate of burn. In general, the slower the fuel burn, the lower the burn temperature of the fuel within the heads. The term 'knocking' refers to times when the fuel ignites so fast, that it starts to exert a force on the piston before it has finished its travel to the right. This force, exerted on the piston as it is finishing its travel, creates the knocking sound, which in general is bad for the engine.

Bill Calcagno (calcagno@erols.com) had this to add as well:

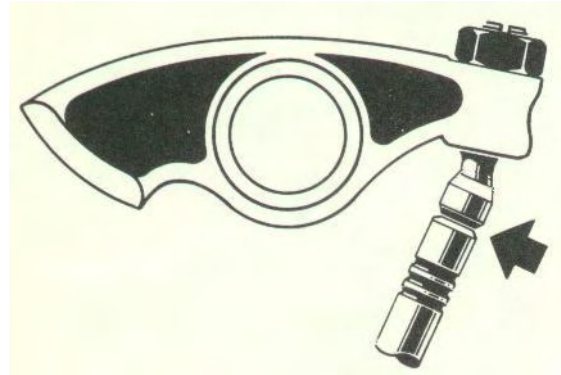
"As you correctly pointed out, octane rating indicates how fast the fuel will burn, with higher ratings burning slower. The octane rating originally referred to the percentage of the chemical octane in the gasoline (back in the days when gasoline was only about 40 Octane, around the turn of the century). Nowadays, it refers to a burn rate equivalent to fuel consisting of that percentage of octane. Obviously, the gas companies are using different chemicals and compositions than in the past, especially to get ratings over 100, but "Octane" has remained the standard method of indicating gasoline performance.

Also, higher octane rating gasoline is really not used to reduce combustion temperature. It is used to prevent self-ignition in high-compression engines (car engines prior to WWII, when there was only low octane gas, generally only had 4-to-1 or 5-to-1 compression ratios). Combustion temperatures are reduced by adding a non-combustible component to the air-fuel mixture, usually with an Exhaust Gas Recirculation (EGR) system (but sometimes with water or alcohol injection)."

Since the time it takes to ignite the fuel basically remains the same regardless of the RPM of the motor, the motor must adjust to account for the fact that at higher RPMs, the piston is travelling to the right much faster than at idle. In general, as the motor RPMs increase, the timing must advance in order to sync the burning of the fuel with the motion of the piston to the right. On Porsches, there are a few types of timing advances. The most common is the centrifugal advance. Built-in to most distributors is a set of weights that spin around with the distributor rotor. As these weights spin faster and faster (as RPMs increase),

they cause a small plate in the distributor to move the points (the small switches that control the firing of the spark) to a more advanced position. In a similar manner, vacuum advance units on distributors cause a small plate to advance the points based on the amount of vacuum generated by the engine. In most cases, the amount of vacuum generated is somewhat related to the RPM of the engine.

**Figure 2:  
Valve Clearance**



Now, back to the valves, and the valve clearances, and why they are so important. **Figure 2** shows a close-up of a valve and rocker.

The clearance that needs to be adjusted is located between the valve tip and the rocker arm adjusting screw. This screw has a little swivel foot that rotates to meet the valve stem flat. This prevents wear on the tip of the valve.

- If the clearances of valves are too tight (not enough space), then you can have valves that don't completely close. This can cause leaks through the valves during the motor's compression and/or power stroke, which results in significant power loss, and in some cases can cause engine damage.
- If the valve clearances are too loose, then you might have a situation where not enough fuel is getting into the cylinder head, or the piston is working extra hard to push out exhaust gases through the narrow opening of the improperly adjusted exhaust valve. Also, valves that are loose are notoriously noisy.

Another good point to remember, and one that is often very confusing, is that a full-stroke of the engine requires two full turns of the crankshaft. The first stroke is the power stroke, combined with the expulsion of the exhaust gases. Then the chamber sucks in air-fuel mixture, and then compresses and ignites it on the second stroke. This is why the distributor rotates at half the RPM of the engine. It takes the engine two complete turns of the crankshaft to complete one ignition cycle. While the engine rotates 720 degrees, the distributor only rotates 360 degrees.

## Procedure

1. The first thing that you need to do is to prep the car for the adjustment.
  - Raise the rear of the car off of the ground in order to gain access to the lower valve covers. I recommend using jack stands or drive-up ramps to support the car. Do not simply rely on the strength of your hydraulic jack to support the car. This is both foolish and dangerous.
  - Another important point to make here is that the valves need to be adjusted when the car is stone cold. This means that the car cannot be run for at least four hours prior to you beginning the adjustment. Keep this in mind if you need to drive your car up the drive-up ramps to raise it into the air. I usually let my cars sit overnight before I adjust the valves. I make sure that I jack them up in advance.
  - There are a few special tools and parts that you will need:

Firstly, you will need a valve adjustment tool. This is nothing more than a small feeler gauge placed on the end of a handle. It's a simple tool, but one that is absolutely necessary for getting into the small spots in the rear of the engine. This tool is shown in **Figure 3**. It is also advised that you get some extra blades for this tool, as they have a tendency to break, and you don't want to get half way through the job, only to find that you need some more. A normal feeler gauge will not do the job well.

You will also need a 13mm socket wrench with a couple of extensions that you will need to be creative about getting the socket into tight places.

As for parts, you will need

a valve cover gasket kit, and at this time you might want to consider upgrading to the 911 Turbo Valve covers. For more information on this upgrade, please see our Pelican Technical Article, "911 Turbo Valve Covers Upgrade". For ordering information on the covers and the valve cover gasket set, please see our extensive "911 On-line Catalog".

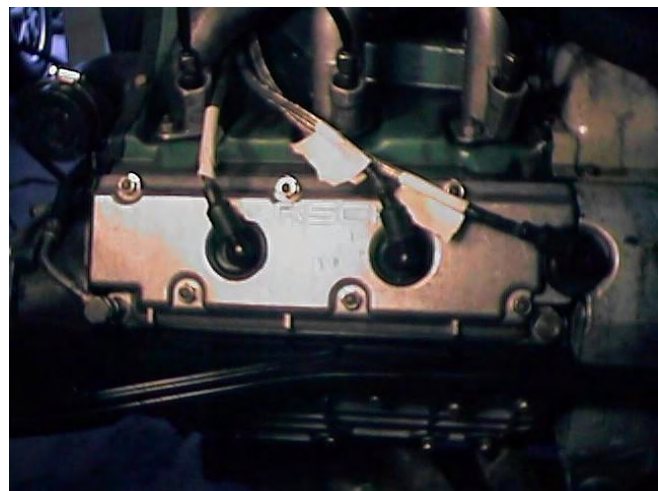


**Figure 3:**  
**911 Valve Adjustment Tool**

2. Depending upon which car you have (this article is applicable for all air-cooled 911s up to 1989), you may have to remove some equipment from the top of the engine to gain access.
  - If you have an early car with carburetors or mechanical fuel injection (1965-73), then remove the air cleaners to give you some more breathing room in the engine compartment.
  - If you have CIS or Motronic (1973-1989), then remove the large air cleaner on top of the engine.
  - If your car has air conditioning, you may need to disconnect the a/c belt and the a/c compressor clutch electrical connector, and slide the compressor out of the way. This is an easy and common procedure. Be sure to wrap the compressor in a blanket to avoid having it damage other items located in the engine compartment.
  - On some cars, there may be some plastic ducting located on the left side, near the blower motor. This may have to be removed as well. Basically, you need to get access to remove the upper valve covers.
  - There have been some rumors that you should remove the spark plugs when adjusting the valves, as this will make the engine turn easier. **Although the engine will turn easier, there is a risk involved with removing the plugs.** Very often, carbon deposits that have built up on the plugs and in the combustion chamber can become loose, and subsequently lodged in the valves between the head and the seat while you are trying to adjust them. This would result in an inaccurate adjustment of the valves, and the subsequent poor running of the engine. Wait until after you have finished adjusting your valves to remove the plugs. You can still turn the engine with the plugs installed - it will just resist you a little more.
3. I also recommend draining and changing the oil. If you are adjusting your valves and performing a major maintenance on the car, it makes sense to replace your oil and filter. Besides, there is a large chance that oil in the bottom sump of your engine will leak out when you remove the lower valve covers.
4. After the oil has been drained, and the all of the items that would get in the way are removed, the valve covers can be removed.

Begin by unplugging the plug wires, shown in **Figure 4**, that feed through the valve covers. You may want to label the plug wires if you think that you might get them mixed up later on.

**Figure 4:  
Spark Plug Wires Feeding  
Through Valve Covers**



You should also remove the distributor cap from the top of the distributor. You don't need to unplug the wires from the cap.

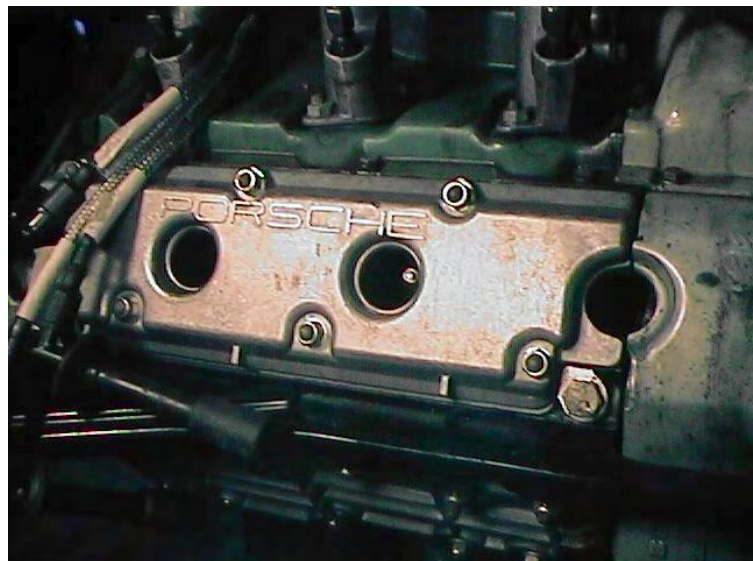
Now, remove the nuts on the valve covers, as shown in **Figure 5**. The upper cover is shown in **Figure 6**, and the lower valve cover (Turbo style) is shown in **Figure 7**.

(For clarity, all of the photos used in this article were taken on a motor that was removed from the car. Without a doubt, it is much easier to adjust the valves when the engine is out of the car.)

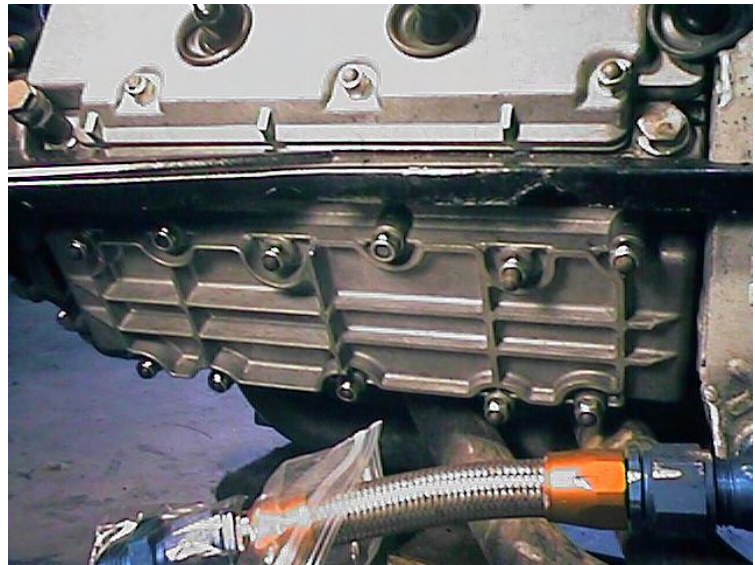
**Figure 5:**  
Valve Cover Nut



**Figure 6:**  
Upper Valve Covers

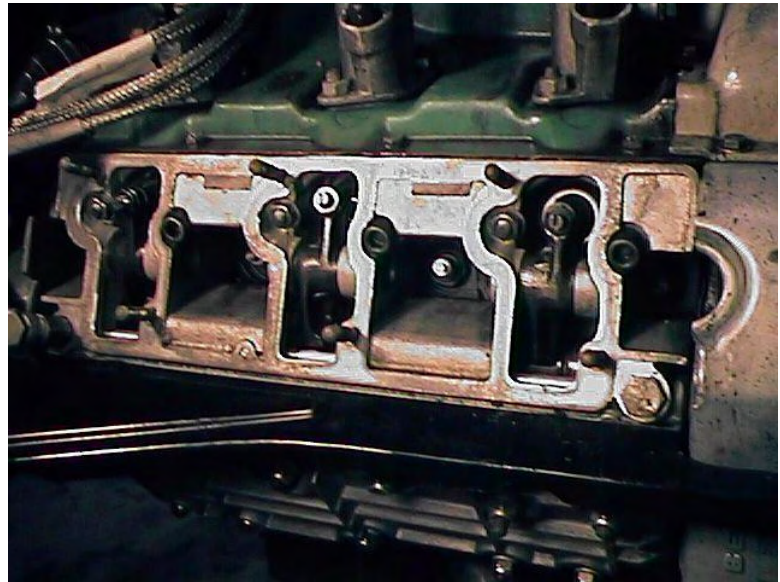


**Figure 7:  
Lower Valve Covers**

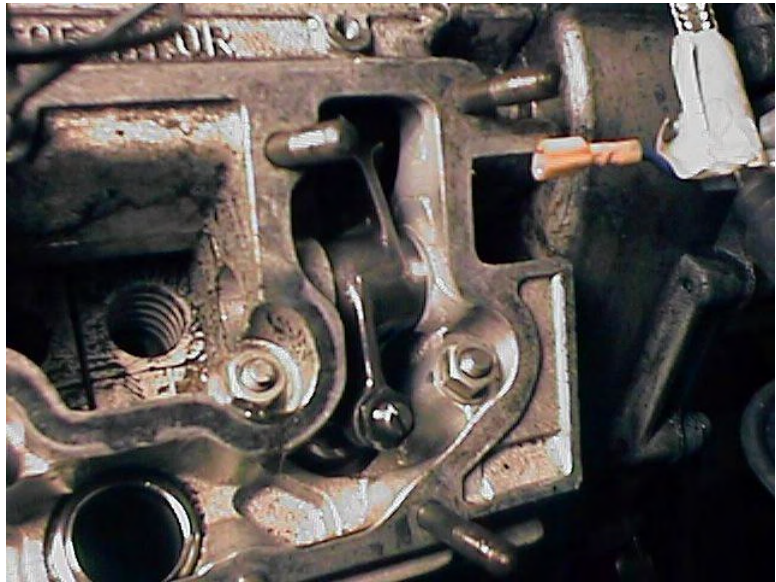


The upper valve covers need to be removed from within the engine compartment, and the lower ones need to be removed from underneath the car. Access to both upper and lower valve covers is normally tight, but you should be able to reach in there with a 13mm socket and remove all of the nuts. **Figure 8** shows the cam towers with the upper valve covers removed, and **Figure 9** shows the lower valve cover removed.

**Figure 8:  
Upper Valve Covers Removed**



**Figure 9:  
Lower Exhaust Valves**

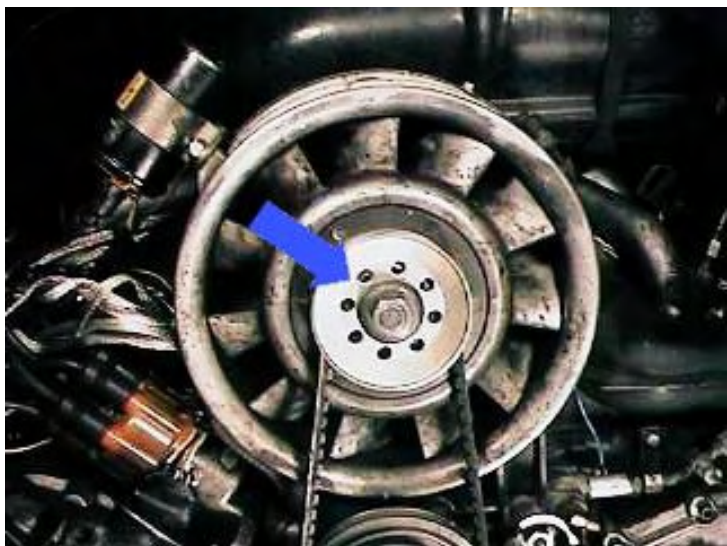


5. Now you need to place the engine in Top-Dead-Center (TDC) position for cylinder one. This corresponds to piston number one being all the way near the cylinder head, and just about to begin the power stroke where it is pushed back towards the crankshaft.

Using a large socket on the fan pulley nut, turn the engine fan clockwise. The fan pulley nut is shown in **Figure 10**. You can also use the pulley holding tool that is normally found in all the 911 toolkits to turn the fan, if your car still has it. The engine crankshaft (attached to the engine fan pulley by the fan belt) should turn easily. If the fan belt slips, then you need to tighten it.

**Note:** it is important that you remember to only rotate the engine clockwise. Failure to do so may cause damage to your timing chains.

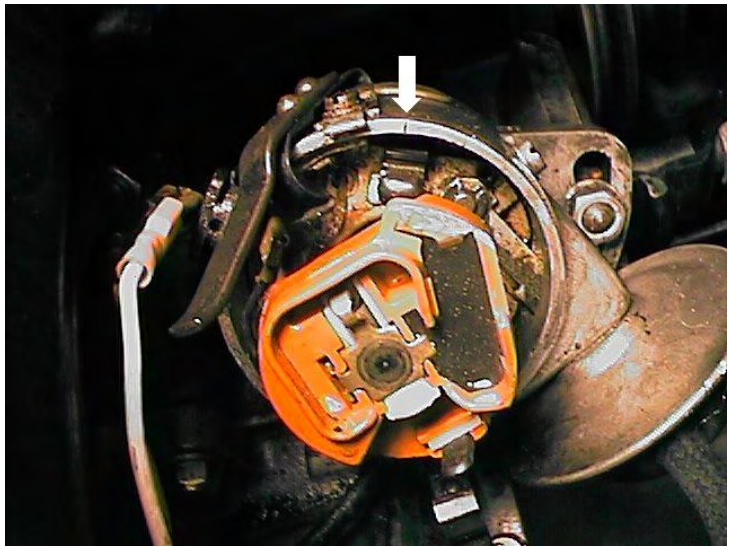
**Figure 10:  
Fan Pulley Nut**



Continue rotating the engine until the distributor rotor is pointing to the little notch that indicates TDC for piston #1. This is shown in **Figure 11**. Once the rotor is near that point, look carefully at the crankshaft pulley for the marking 'Z1' When the mark 'Z1' lines up with the center line of the case, the motor is at TDC for piston #1. This is shown in **Figure 12**. When the crankshaft is in this position, the following three things should confirm that you are doing everything correct:

- The crankshaft pulley is showing 'Z1' lined up with the case centerline
- The distributor rotor is pointing at the notch in the distributor housing
- The intake and exhaust valves for piston #1 should be loose and able to be slightly rocked back and forth.

**Figure 11:  
Distributor Pointing at TDC  
Notch**



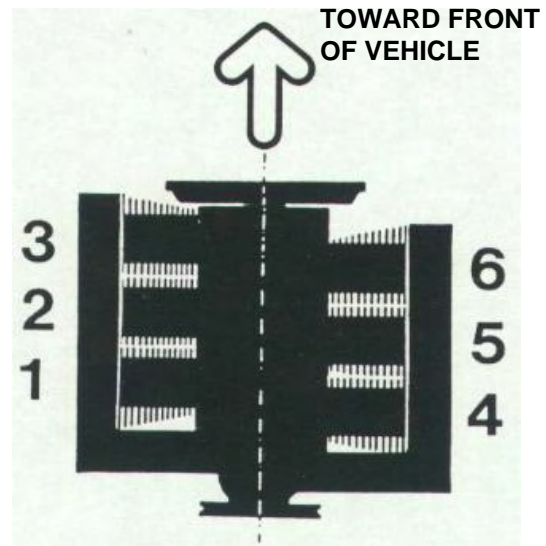
**Figure 12:  
TDC 'Z1' Mark Aligned with  
Case Centerline**



**Figure 13** shows the arrangement of the pistons and cylinders in the 911.

Piston #1 is located on the driver side towards the rear of the car. You should be able to 'wobble' both the intake and exhaust valves, because there will be a clearance there, and the valves will be closed. This is of course, assuming that the motor was running ok before you started to adjust the valves. If the valve clearances are really tight, then there may not be any noticeable wiggle in the valves.

**Figure 13:  
Piston/Engine Layout**



6. At this point, you are ready to adjust the valves on cylinder #1. For all 911 and 914-6 engines from 1965 the valve adjustment clearances should be:

**Intake: 0.1mm (.0039")**

**Exhaust: 0.1mm (.0039")**

**Figure 14** shows the intake rocker arm for cylinder #1. Take the feeler gauge and check the clearance on both the intake and the exhaust, as shown in **Figure 15**.

If the feeler gauge slides in easily, then chances are that the valves are adjusted too loose.

Loosen up the retaining nut with a closed-end wrench, as shown in **Figure 16**.

Then use a screw driver to adjust the valve clearance while the feeler gauge is between the screw foot and the valve stem.

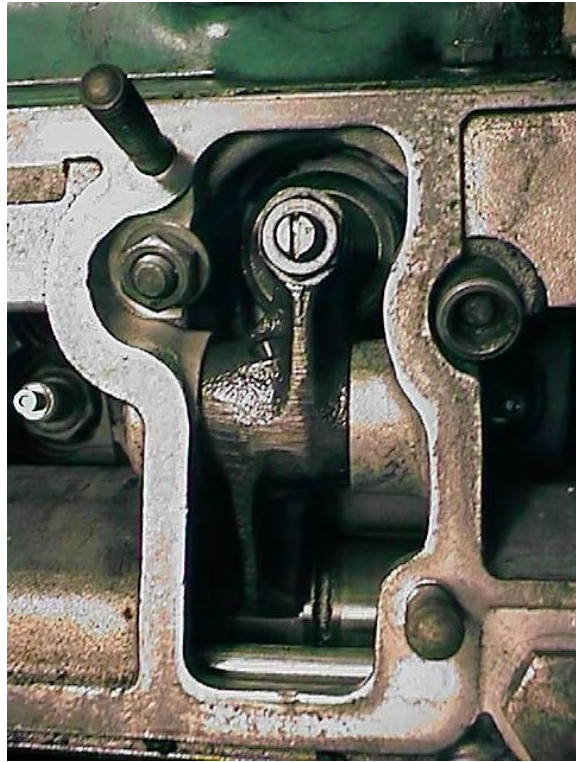
Tighten up the screw until you feel a somewhat mild resistance on the feeler gauge, as shown in **Figure 17**. Make sure that you can still move the feeler gauge.

Leaving the feeler gauge placed in-between the valve stem and the screw foot, tighten down the retaining nut.

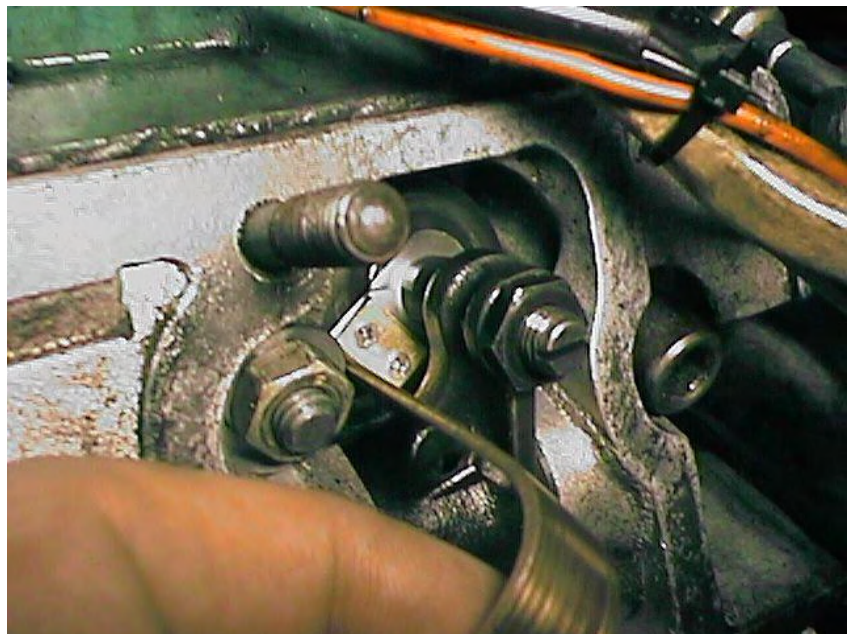
Remove the feeler gauge, and recheck the clearance. Again, there should be mild resistance on the feeler gauge. Sometimes the retaining nut turns the adjustment screw and makes the valve clearance tighter than it should be. If this is the case, then loosen up the retaining screw, and readjust as needed.

Do this for both the intake (upper, shown in **Figure 14**) and exhaust (lower, shown in **Figure 9**) valves on piston #1.

**Figure 14:**  
intake rocker arm for  
cylinder #1



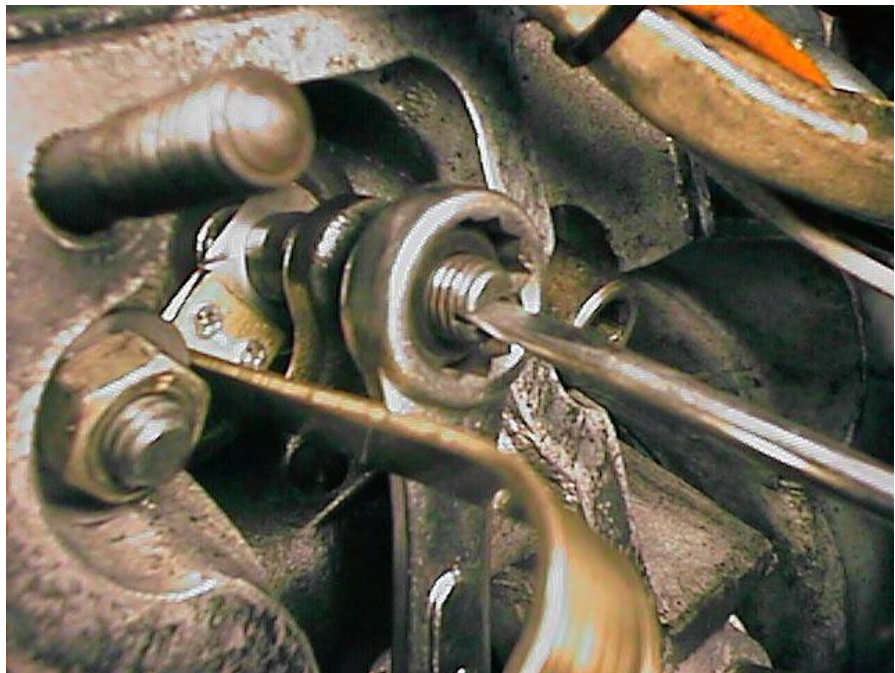
**Figure 15:**  
Checking Clearances



**Figure 16:  
Tightening / Loosening  
Retaining Nut**



**Figure 17:  
Adjusting Intake Valve  
with Feeler Gauge**



7. After piston #1 has been adjusted, you need to rotate the crank to adjust the next set of valves.

Using the socket driver on the fan belt pulley nut, rotate the fan clockwise until the crankshaft moves exactly 120 degrees. There is a marking on the crankshaft pulley that will tell you exactly where 120 degrees is located. This is shown in **Figure 18**.

**Figure 18:  
120° Mark on Crankshaft  
Pulley**



Don't over rotate; 120 degrees is the same amount of rotation that there is between the 12 and the 4 on a clock.

Now you can adjust the valves for piston #6. Refer to **Figure 13** for the location of piston #6; it is located on the passenger side all the way towards the front of the car. Check to see if the valves are slightly loose; they should be. If they are not, they may have tightened up, or you may be on the wrong piston.

Repeat the procedure explained above. This time you might have to do it blindly, as it is really difficult to see into the front section of the engine compartment. An inspection mirror might come in handy for the cylinders located all the way in the front of the engine compartment.

8. After you have adjusted #6, then rotate the fan clockwise another 120 degrees. There should be another notch on the crankshaft pulley.

Now adjust the valves for piston #2. Number two is on the driver side in the middle.

9. When complete, rotate another 120 degrees. You should be back at the 'Z1' marking, and the distributor should be pointing away from the notch on the housing. Now, adjust #4.
10. Repeat the entire procedure above: Rotate 120 degrees and adjust #3
11. Repeat the entire procedure above: Rotate 120 degrees and adjust #5

12. After you adjust #5, you can rotate another 120 degrees, and you should be back at TDC for piston number one, and the 'Z1' mark should line up with the case center line again.
  13. Well, your valves should be fully adjusted by now. I usually go back through the motions and just simply check them again to make sure that the clearances didn't tighten up for some reason, or to make sure that I didn't make a mistake somewhere.
  14. When you are finished, you need to replace your valve covers. When you re-install the valve covers, make sure that you use a new set of valve cover gaskets, nuts and washers. **Figure 19** shows the valve cover gaskets, and **Figure 20** shows the complete kit with all the nuts, washers and gaskets.
- It is important not to overtorque the nuts on the valve covers. I was not able to locate a torque specification in the factory manuals, but Richard Lebens found one in the Carrera manuals that says to torque it to 6 ft-lbs.
- Make sure that you torque them down in a diagonal pattern, and it is advised to start at 4 ft-lbs, and then after all of them are tight, re-torque to 6 ft-lbs.
15. Make sure that you replace everything that you disconnected, and that you **refill the motor with oil**. Adjusting your own valves gives you more of a sense of ownership of the car, and also helps to cut down on those expensive maintenance bills that are typical of Porsche ownership.

**Figure 19:**  
Valve Cover Gaskets



**Figure 20:**  
Valve Cover  
Gasket Kit



After you have done this a few times you will recognize that there are a few tips and tricks to adjusting the valves. Firstly, instead of turning the crank 120 degrees, you can turn it 240 each time, and adjust each set of valves on the same side. You will eventually have to turn it 120 degrees to get it started on the other bank of cylinders. Also, after a while, you will be able to adjust the valves just by looking at when they both close. This is known as adjusting 'by feel' and is quite easy once you get the procedure down the first time.

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Well, that's about all there is to it. It's really not that difficult if you follow the steps carefully, and make sure that you double-check your work. This technical article, and the others like it on this site are made possible not by a grant from the Public Television Foundation, but by your purchases of parts and accessories through **Pelican Parts** ([www.pelicanparts.com](http://www.pelicanparts.com)).

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