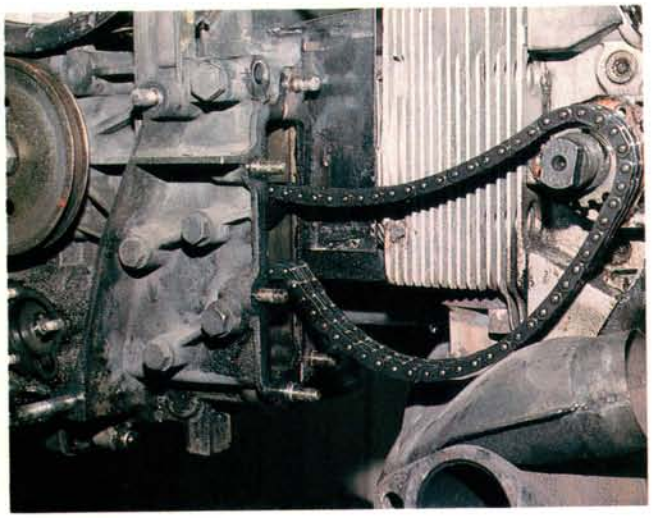
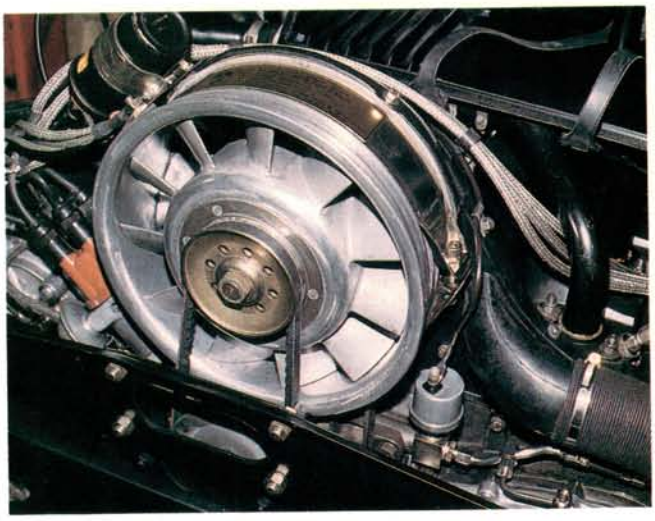
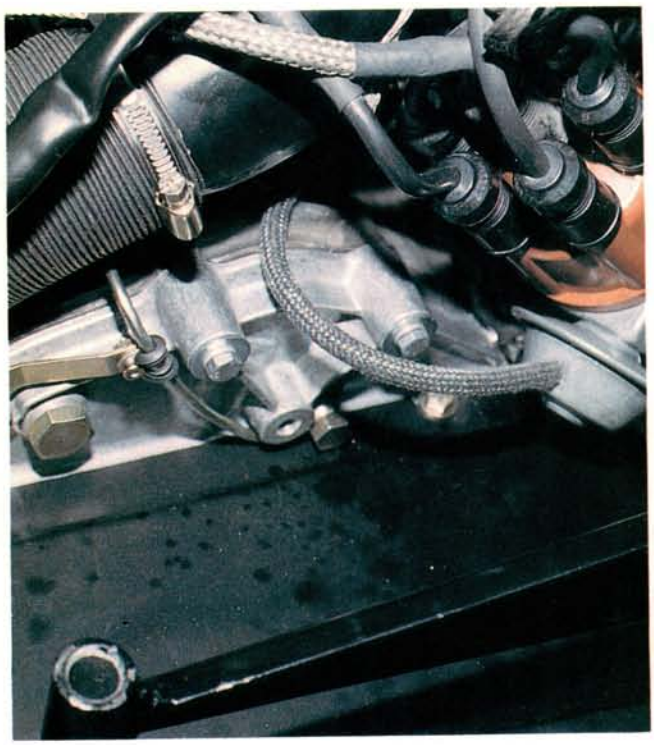
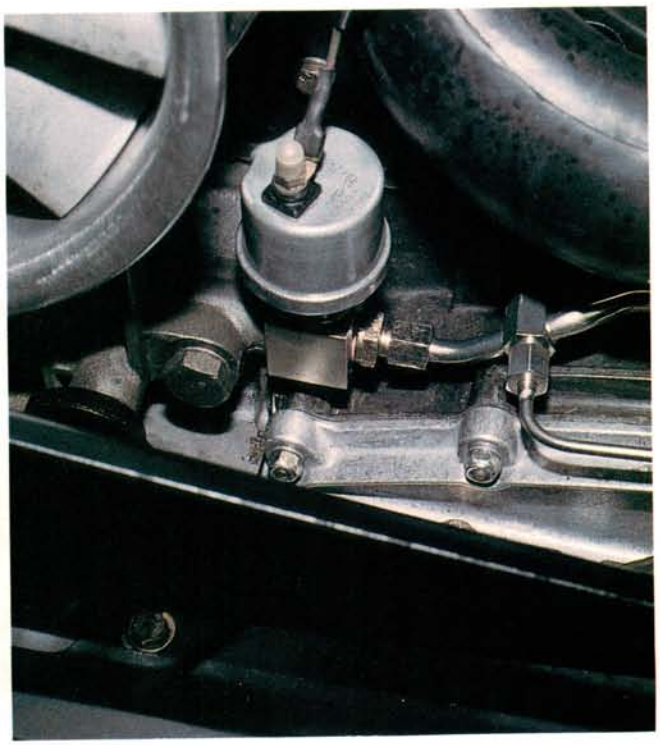




Porsche 911 Timing Chains





And now for something completely different. Put those rubber timing belts out of your mind for a moment. Think about timing chains. Yes, two of them on the same engine.

Now think Porsche 911, and think even further about a flat-six engine that can expand and contact with temperature up to one full millimeter. The job done by the chain tensioners in such an engine is very important, since the swelling and shrinking of this incredible hulk require some means of keeping those two timing chains properly tensioned, regardless of engine temperature.

This article will look at 911 timing chain installation, camshaft timing adjustment, and modifications to the chain tensioner system. These modifications were designed to improve the efficiency of the timing chain tensioner system, and also increase chain life. This retrofit procedure has become standard equipment on 1984 and newer 911 engines.

Know the Specifications

If you decide to tackle one of these yourself, start with the repair manual. You can purchase pocket sized specification books from your Porsche dealer. Those of you old enough to remember the old Volkswagen "Without Guesswork" booklets will know what we're talking about. These booklets contain important information about camshaft timing, torque specifications and critical measurements. They are more than just helpful, they should be considered as a basic tool.

This is a lengthy procedure compared to more common rubber timing belt setups. This article does not replace the shop manual or the spec sheets. There isn't enough room. Instead, we'll show some highlights, and hope they supplement the repair manual.

Compare the engine number to the specifications chart for your engine. The engine specification list is long enough to give you a migraine. But failing to make some very critical adjustments with the CORRECT specifications for your engine, can leave you with the biggest headache of all—a damaged engine.

The price you pay for improperly adjusted valve timing will vary. Even minor misadjustment of valve timing will mean reduced engine performance. Major misadjustment can mean major damage to the engine. When things get too far out of sync. and the pistons and valves go head to head in the darkness, it's an expensive, embarrassing situation.

But there's no reason to be bullied around by the hulk, once you get the hang of things. Here are some key points to keep in mind as we go along:

• **Camshafts, like coffee, come in a lot of different grinds.** And the 911 engine is the rule, not the exception. In addition to a lengthy list of factory cams, there are many aftermarket cams available. Checking valve lift before teardown is the best starting point. It will tell you what was going on before you started the repair.

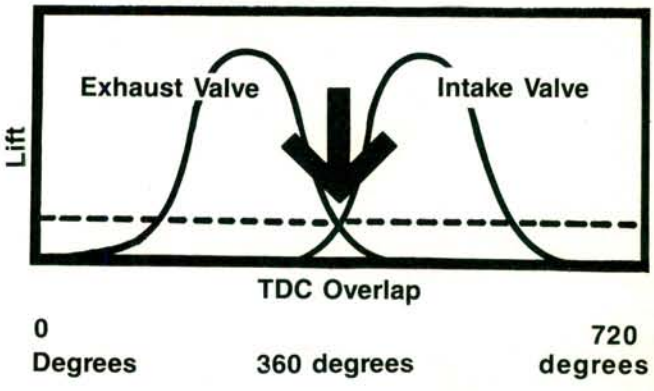
Camshafts have numbers stamped on the ends for proper identification, and most engines will have Porsche cams. If the engine has been modified, you need to know which camshafts were used. Some rebuilders like to make camshaft substitutions, usually installing cams from other Porsche engines, so be careful. Usually, only the very large carbureted engines will use Garretson, or other camshafts.

Some 911 engines, even from the factory will have dissimilar timing overlaps. That doesn't mean the cams are different. It means that they aren't synchronized as closely as they should be.

• **Valve lash is very critical.** Some techs may be tempted to use a feeler gauge to adjust valves. But the use of a feeler gauge to check lash depends on the skill of the technician, and even then, may not be close enough. The use of a metric dial indicator will tell you the difference between a valve lash of 0.09 mm and 0.11 mm. Valve lash must be right on the money before you measure lift. Adjust all valves with the engine dead cold.

• **What are we measuring when we measure camshaft timing?** Maybe this illustration will help. What we measure is the TDC valve overlap. Our illustration shows sample intake and exhaust profiles.

The illustration shows the valve overlap, which is what we measure with the dial indicator. Valve clearance must be exactly 0.10 mm, and the dial indicator should have a preload of 1.0 mm.



The arrow shows the overlap being measured. If the reading at TDC overlap is too high, the camshaft is advanced. If it is too low, the camshaft is retarded. This advance/retard information is useful, especially if the car has a special use such as auto-crossing or time trials. If the cams are slightly advanced, the bottom end performance will improve. If they are slightly retarded, top end performance will improve. This information is especially important to large 911 engines and 911 turbo engines.

• **Write down your valve lift measurements so you don't forget them.** It's a good idea to check valve lift on both sides of the engine to see if readings are even, side to side. Compare the readings to the specifications for the factory camshaft for this particular engine number. If the cam or cams is out of time, or if a custom cam has been installed, simply resetting the cam timing to your pre-teardown measurements won't do you much good.

Cams should be timed within 0.10 mm side to side, although it is possible to get them closer.

• **Unlike most timing chain or timing belt replacements where you simply line up a pair of timing marks, the cams on the 911 are individually adjustable. Each cam sprocket can be degreed to its camshaft.** There are two sprockets on each camshaft. The inner sprocket is keyed to the camshaft snout, and has a ring of teeth like a bicycle chain sprocket. The larger diameter outer sprocket is the one driven by the timing chain. The larger sprocket also has a smaller ring of holes that are the same diameter as the sprocket teeth on the inner sprocket. The hole pattern is slightly different from the pattern on the inner sprocket teeth, however. Only one of the holes in an outer sprocket, and one of notches between the sprocket teeth on its mating inner sprocket will align at any one time.

When the cam is properly timed, a pin is installed that locates the two sprockets before final tightening of the sprocket retaining nut (or bolt).

• **Special tools are also an important consideration on this engine.** Our host shop has seen the unmistakable marks left by a pipe wrench on several cam nuts. You'll also need a good quality, properly mounted dial indicator for checking and adjusting valve timing, and a depth gauge for checking and adjusting sprocket alignment. Save yourself the hassle of converting from inches to millimeters by using only metric measuring tools. This not only saves time, it eliminates the possibility of making a conversion error. One inexpensive tool (and we mean inexpensive!) can probably be found on your workbench. An old Bosch spark plug makes a great tool for removing and installing the locator pin between the sprockets. It screws right into the pin, and the price is certainly right.

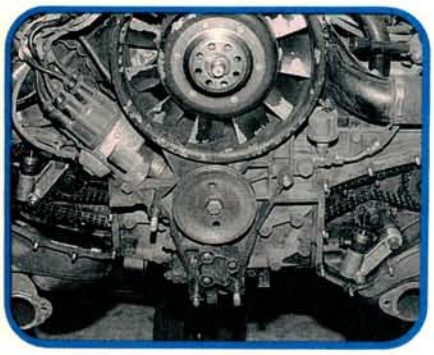
• **One final note. Some of the photos were taken with other components removed, only so you could see better.** For instance, you don't have to remove the camshaft housings to install a new chain. We had the housings off to seal oil leaks. It's a little tougher to install the chain with the housing installed, but it can be done.

You eagle eyes will also note one or two photos showing sprockets with no chains installed. Once again, it was just easier to see without the chains.

Our thanks to Eric Steinel of Steinel's Autowerks in Twinsburg, Ohio, and Marvin Besmer of Sportwagens in Reno, Nevada for their assistance in the preparation of this article.

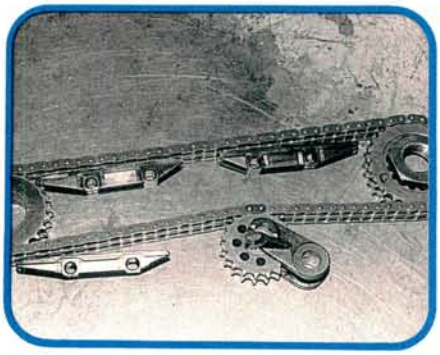
—By Ralph Birnbaum

Eurometrix Valve Lash Tool Compliments of Automotion
Circle No. 200



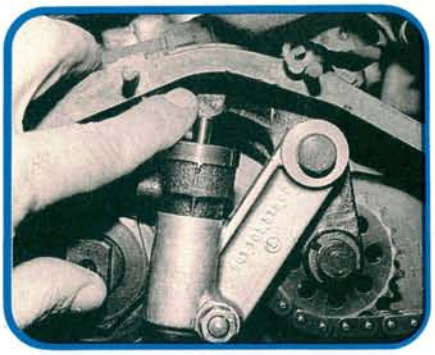
1

This job can be done in the car. You'll need to remove the rear engine hanger, sheet metal cover, and muffler. On A/C equipped cars, remove, but don't disconnect the compressor. Lay it off to the side. Then remove the timing chain covers and do a quick visual check for cracked or worn chain guides.



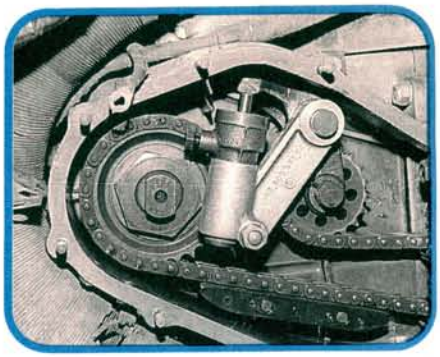
2

Remember there are 5 black chain guides and one brown one. The single brown guide is installed on the lower right side. Don't drop it in the engine. It's not magnetic and fishing it out can be a nightmare. The long end of each ramp points toward its nearest gear.



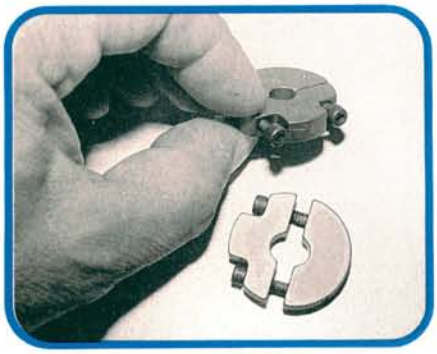
3

Check the old tensioners for full extension as a sign that the chains are so badly worn that they must be replaced. These are Harley-heavy chains, however, and our host shop doesn't always need to replace them. Often new tensioners and guides put things back in good running order.



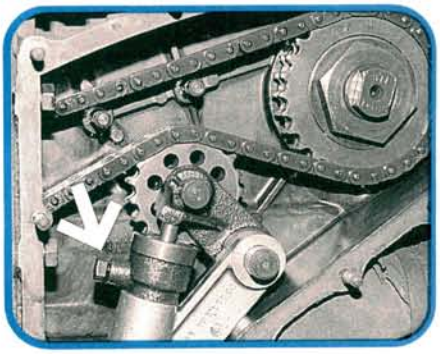
4

Old style chain tensioners were sealed like small shock absorbers, and like shock absorbers, they lost their charge over time. Good tensioners should keep the chains tight on a cold engine, but relieve some of the chain tension as the engine warms and expands.



5

These are chain tensioner guards. If you aren't installing the 1984 and newer pressure fed chain tensioner system, at least install these guards. They clamp around the tensioner shaft, and limit downward travel to keep a chain from jumping if an old style tensioner completely collapses. Cheap insurance.



6

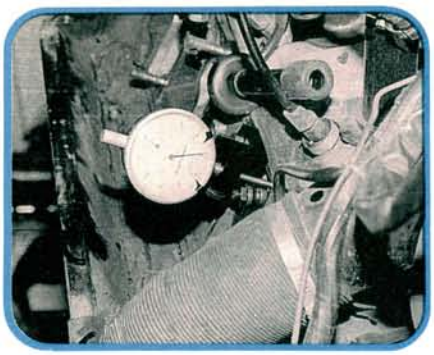
Some "dead" tensioners were converted to mechanical ones by threading a bolt into the tensioner housing until it pinched the tensioner shaft and held it tight. These fixed-length tensioners can't compensate for engine expansion. We'll talk about proper tensioner modification in a moment.

7

Before checking valve lift, check valve lash. This Eurometrix dial indicator setup is more accurate for checking lash than feeler gauges. Incorrect valve lash will give us incorrect cam lift readings. Correct lash on all valves to 0.10 mm with the engine colder than a well digger's belt buckle.

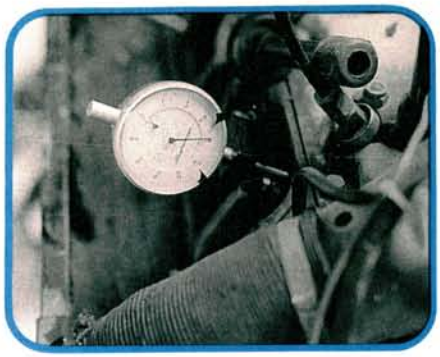
8

There are three, 120 degree marks on the crank pulley. Z1 is TDC on numbers 1 or 4. If the valves on number 4 are lapping with Z1 coming to 12 o'clock, number 1 is "up" and vice verse. The mark for cylinders 3 or 6 is at 4 o'clock. The mark for cylinders 2 or 5 is at 8 o'clock.



9

Valves adjusted? Check valve lift as shown. Attach a dial indicator holder to the cylinder head. The point of the indicator should rest on the upper valve spring retainer. Set the engine at TDC on number one. Preload the gauge for about 4 mm. Turn the engine 360 degrees in the direction of normal rotation.

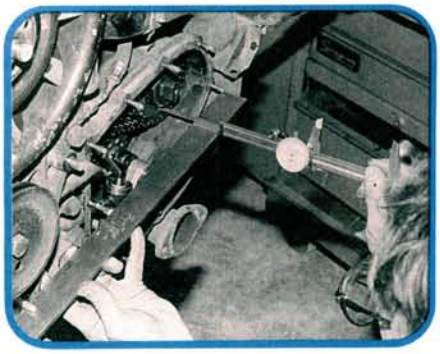


10

Take the highest reading and compare it to a factory camshaft spec sheet. There were a number of cams used on these engines depending on horsepower ratings and emissions. Some very mild cams will give you a gauge reading of less than one millimeter—some will go as high as 4-5 mm.

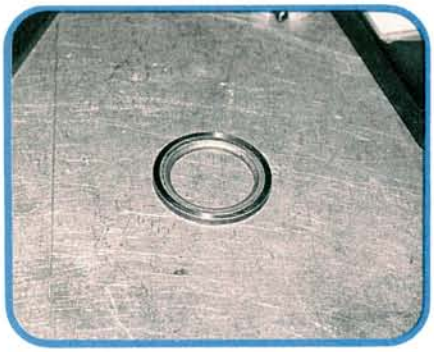
11

Before we remove the chains and sprockets, we need to make sure the faces of the intermediate shaft sprockets and cam sprockets are parallel. Remove the intermediate shaft cover. Measure from the casting face to the face of the intermediate shaft sprocket. Don't let the gauge hit the snap ring on the sprocket.



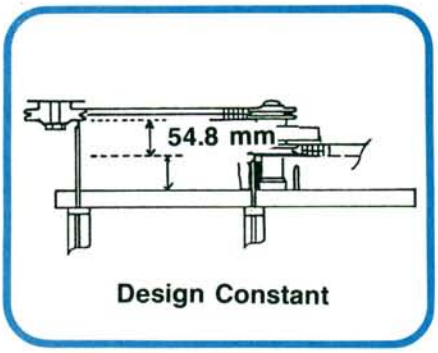
12

Leave the intermediate shaft cover off. Lay a long machinist's straight edge across the same casting face. Measure to the face of the right cam sprocket (less the width of the straight edge). The measurements to the sprocket faces should be within 0.25 mm of one another.



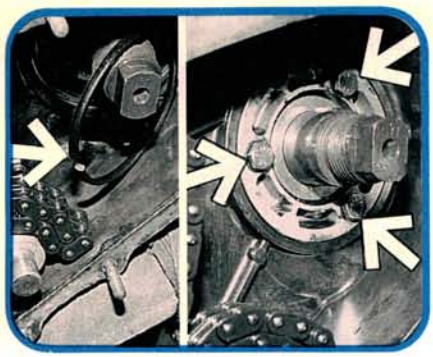
13

If the sprockets are out of parallel by more than 0.25 mm, you'll need to adjust the cam sprocket in or out with 0.5 mm shims. The shims go between the inner cam sprocket and a thrust shim on the end of the cam. The thrust shim is always installed with the chamfered inner hole facing the radius on the camshaft.



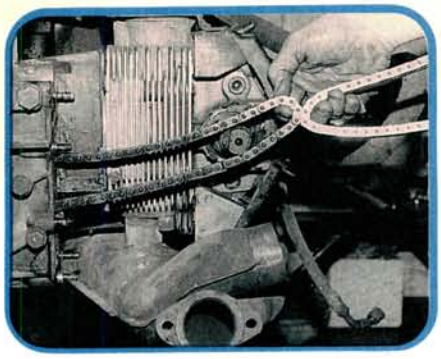
14

The left side of the engine presents a different problem. You can't get at the face of the inner sprocket to measure depth. Use the measurement taken in step 21 and add the design constant of 54.8 mm. Then use your straight edge and depth gauge to measure the left sprocket dimension.



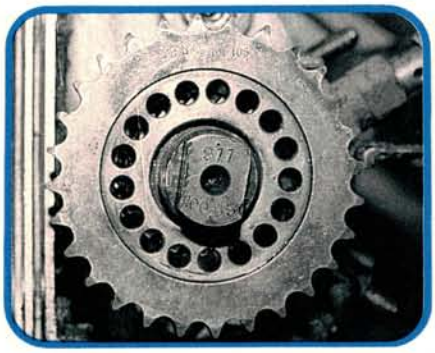
15

We also have some oil leaks to fix on this engine, so we'll remove the cam sprockets, and the three bolts in the camshaft retainer ring. With the retainer removed we found the o-ring behind the collar broken as shown. There's also a flat gasket between the retainer and camcase.



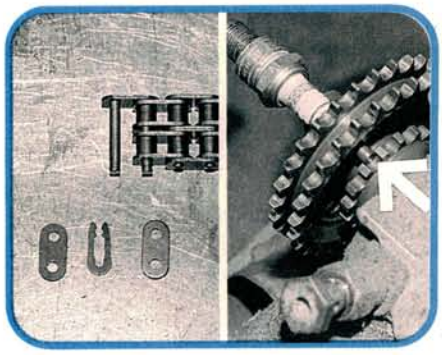
16

Separate the old chain by grinding the head off a link pin in the old chain. Hook the new chain to the old one. Turn the crankshaft to pull the new chain onto the intermediate gear. At the same time, have an assistant rotate the cams at half crank speed. Make sure the chain engages both rows of teeth on the gear.



17

Repeat this process for both chains. Be VERY careful to proceed with GREAT caution as you turn crank and cams. We don't want to bend any valves. Each cam has a dot stamped on its nose. With the crank at Z1, and both dots facing upward, the engine is in its initial position to be timed.

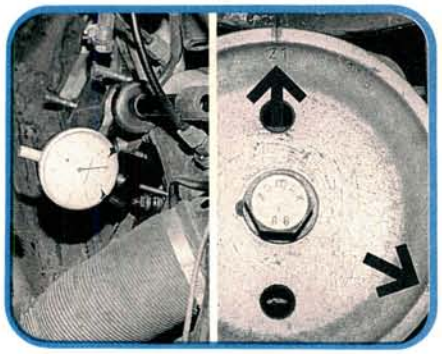


18

Install the chains and sprockets. Install the closed end of the timing chain master link facing toward the direction of normal chain travel. Install the sprockets and find the hole in the outer sprocket that aligns with the slot between the inner sprocket teeth.

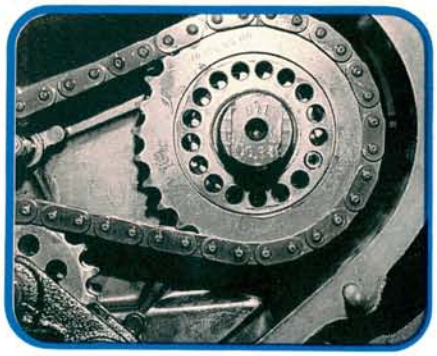
19

With the timing chain guides and tensioners reinstalled, repeat the cam lift measurement sequence. If the original cam timing was correct, we should be able to reset our cam timing using the pre-teardown cam lift measurements.



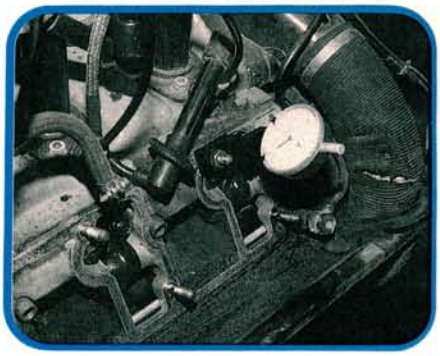
20

If the cams were in time to begin with, and the dial indicator readings are different now, the cams are out of time. If the gauge peaks at the original readings and falls off before you reach Z1 on a 360 degree rotation, the cam is advanced. If the indicator reading never gets that high, the cam is retarded.



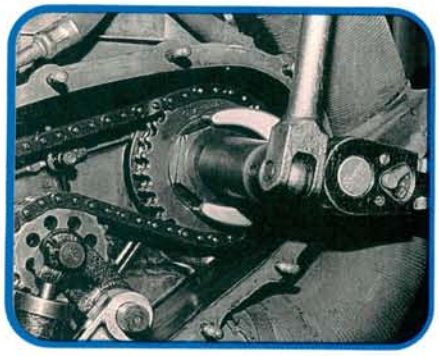
21

If the cam timing is way off, you'll have to loosen the retaining nut (or bolt), remove the lock pin, and turn the outer sprocket one full hole. If the reading is off only a tiny bit, there may be enough play between the sprockets and lock pin to loosen the nut and tweak the adjustment until it's in time.



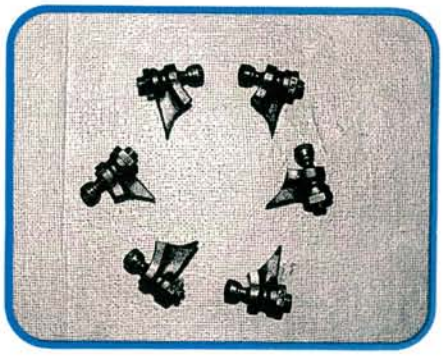
22

Repeat the process for the other cam. Use the same Z1 mark on the crankshaft pulley. But this time, make sure the valves on number one are the ones lapping as you make your lift measurement. The difference between readings from side to side should be a maximum of 0.10 mm (or closer).



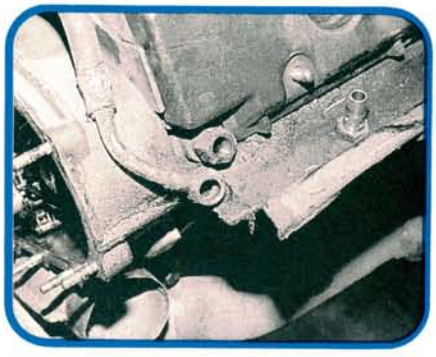
23

Be very careful when final torquing the camshaft nuts. Simple tightening of the nut can turn the sprocket enough to throw off your adjustment. As we said, there is play between the locator pin and sprocket holes. Always double check final valve lift after tightening the nuts.



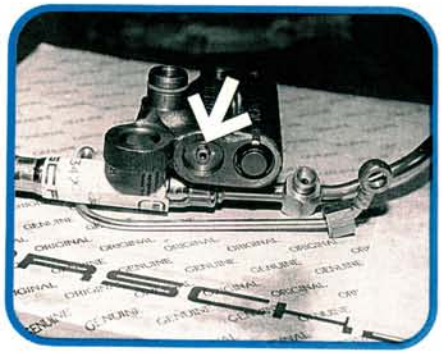
24

This photo should be worth a thousand words when we emphasize the importance of valve timing. These are the heads of decapitated rocker arms. Pistons, valves, rocker arms, and cam lobes all tried to grab the last parking space when a broken chain guide launched a timing chain. Ouch.



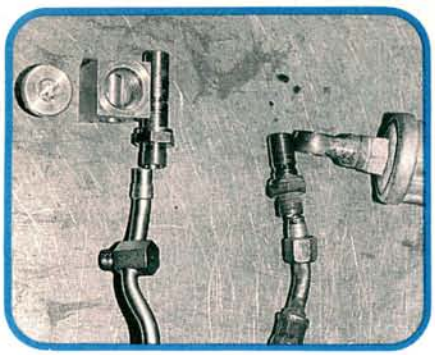
25

Finally, lets look at the chain tensioner modification. It's a long way between the centerlines of the crank and intermediate shafts. Since the 911 engine isn't a solid block design, camshaft oil is piped through external lines to the camshaft oiling trees. Early cams were center drilled.



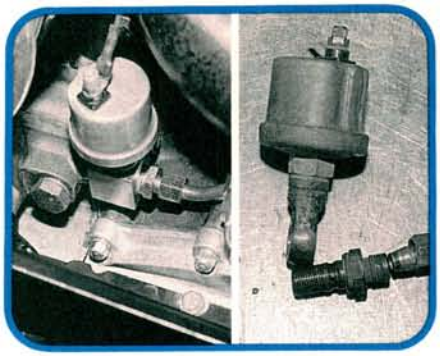
26

The new, improved tensioner system plumbs into these external oil lines. The same oil pressure from the main galleys that oils the cams, is used to keep the new oil-fed tensioners pumped up. Each tensioner has a bleed valve to vent any excess pressure.



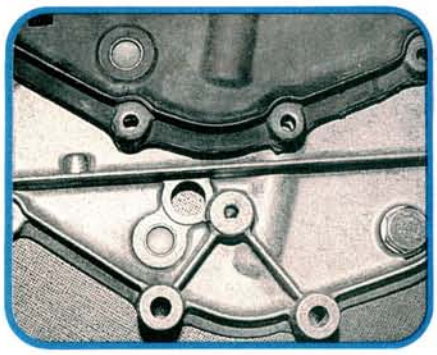
27

One caution: Starting in 1974, there was a modification made where the oil sending unit connects to the crankcase. A square junction block was installed with a threaded hole for the oil sending unit. On cars without a gauge, a threaded plug was installed in the junction block.



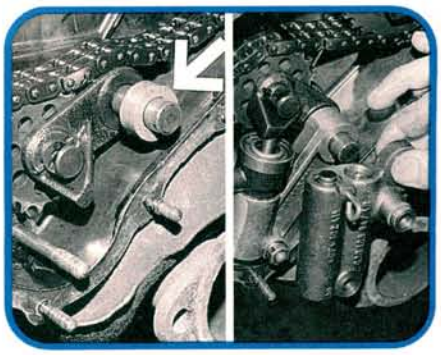
28

If you're installing the modified tensioners, replace the narrow, old style banjo fitting with the wider, square block. The new feed line is just a bit too short to reach the thinner, old style fitting. The line doesn't tighten properly, vibrates loose in a few thousand mile (or less), and leaks.



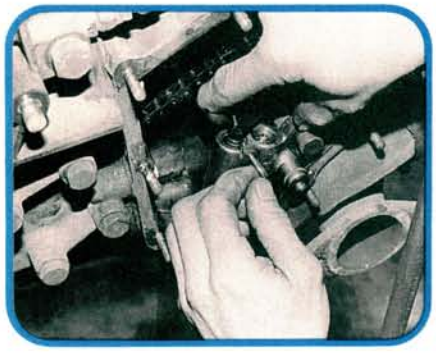
29

More plumbing. The new oil feed line to the camshafts has a tap-in point for the smaller, hydraulic-tensioner feed line. The new timing chain covers are already modified, strengthened, and drilled for the oil fitting that feeds the new tensioner. An o-ring seals the tensioner oil inlet in the cover.



30

Old and new. We held the new tensioner up to the old one so you could see the difference. Note the part of the new tensioner held between thumb and forefinger in our photo. It is narrower here than the old tensioner was. It comes with its own spacer to make up the difference (arrow).



31

The new tensioner is shipped with a "grenade" pin inserted to keep the hydraulic piston in place. After installing the new tensioner, remove and discard the pin. We hope these highlights will supplement the factory manual if you choose to tackle timing chains and tensioners on the incredible hulk.

Tensioner Modification Application Chart

911	YES	NO	YES	NO	COMMENTS
1965-66		X			Cannot be done.
1967	X		X		Machine Chain Covers.
1968	X		X		Circumvent Smog Pump.
1969-79	X			X	No Modifications Required. Easy Installation Of Update Kit.
1980-83	X		X		Machine Right Side for 02/Heat Sensor. Additional Chain Wheel Spacers Needed or New Chain Wheel Supports.