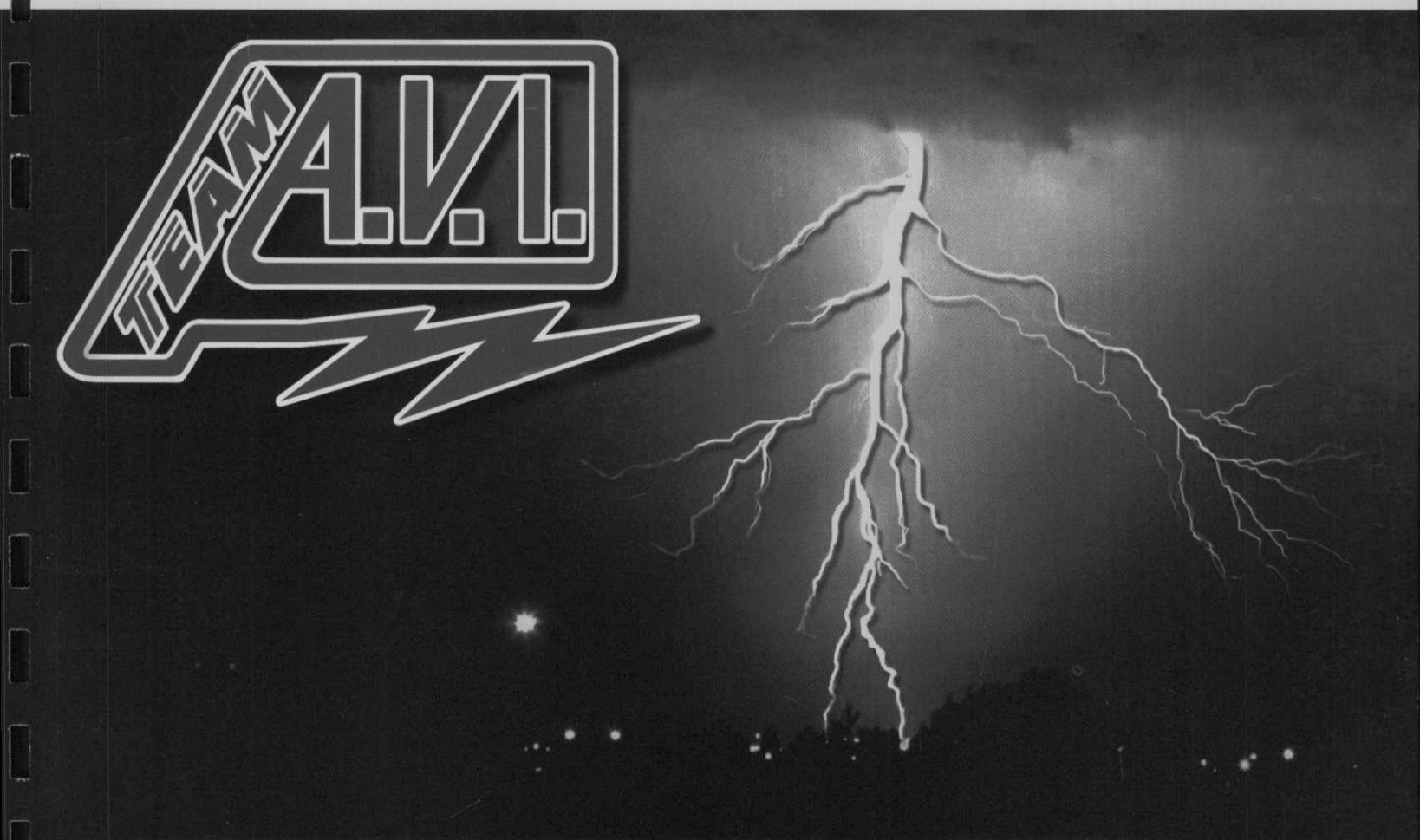
As Fast As Lightning Strikes . . .

Automotive Technology Changes . . .



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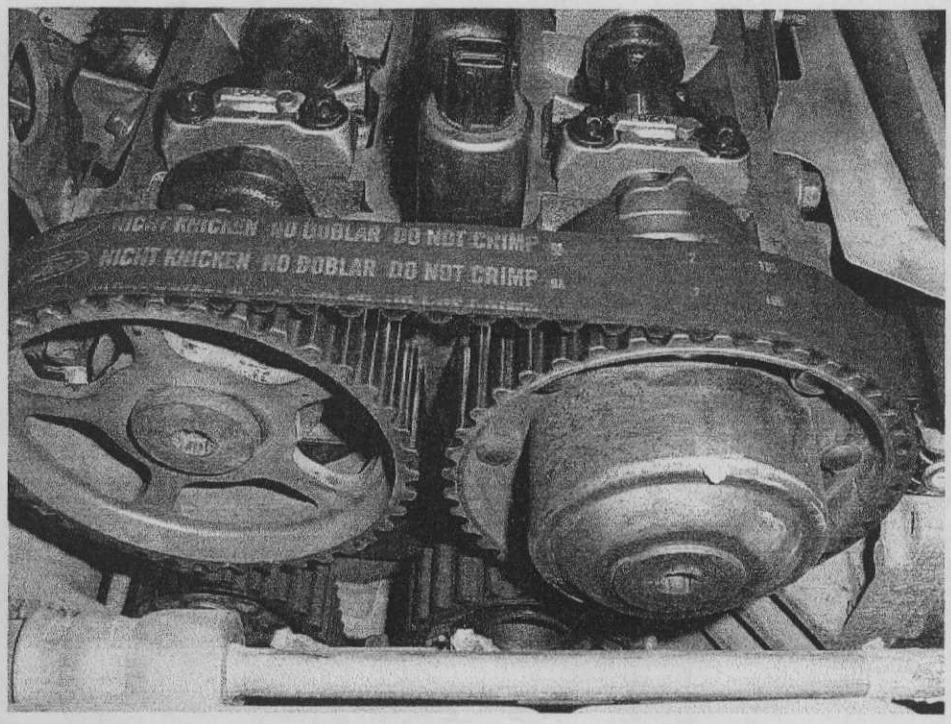
Ford Variable Cam Timing

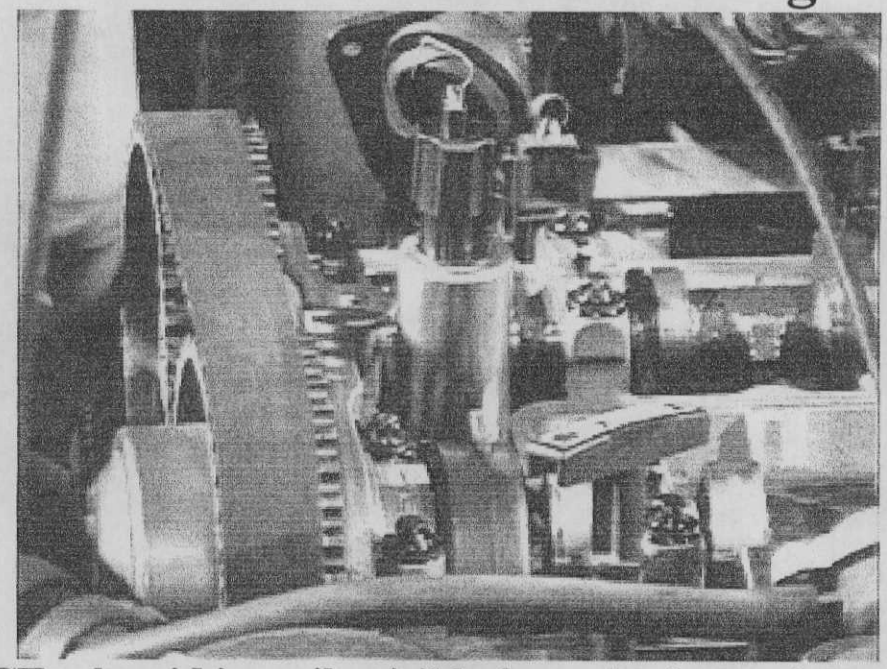
Written and presented by John Thornton

Ford Variable Camshaft Timing

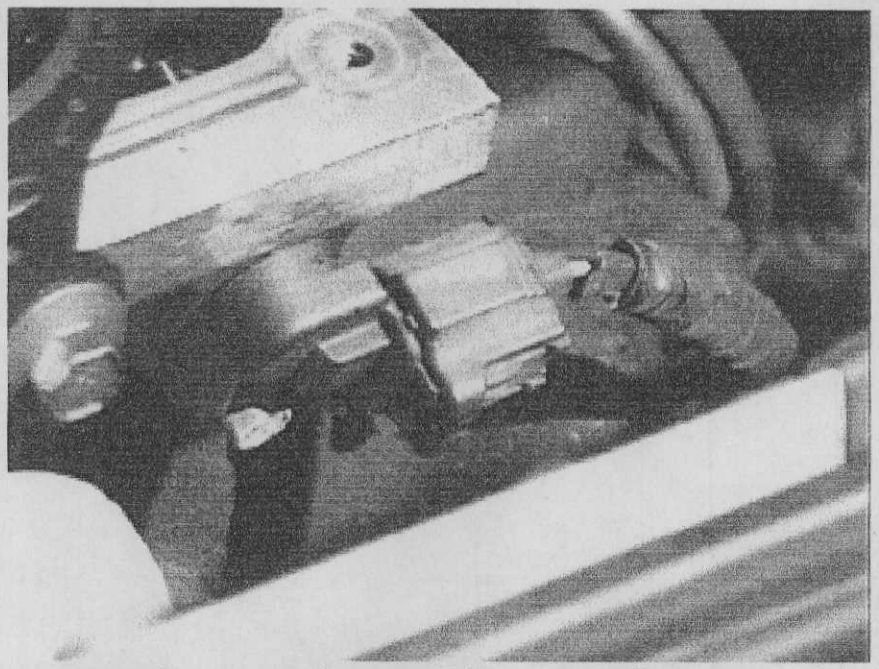


- Ford introduced VCT in 1998 on the Zetec 2.0L vin 3 DOHC engine
- only the exhaust cam timing is controlled; intake cam timing is fixed
- the exhaust cam is normally fully advanced
- the PCM can command up to 30° of exhaust cam retard (60° on the crank)
- the VCT engine has 5° of cam overlap when the exhaust cam is in its advanced state (default position)
- valve overlap can increase to 35° when the exhaust cam is retarded 30 cam degrees
- VCT has replaced the EGR valve

Variable Camshaft Timing

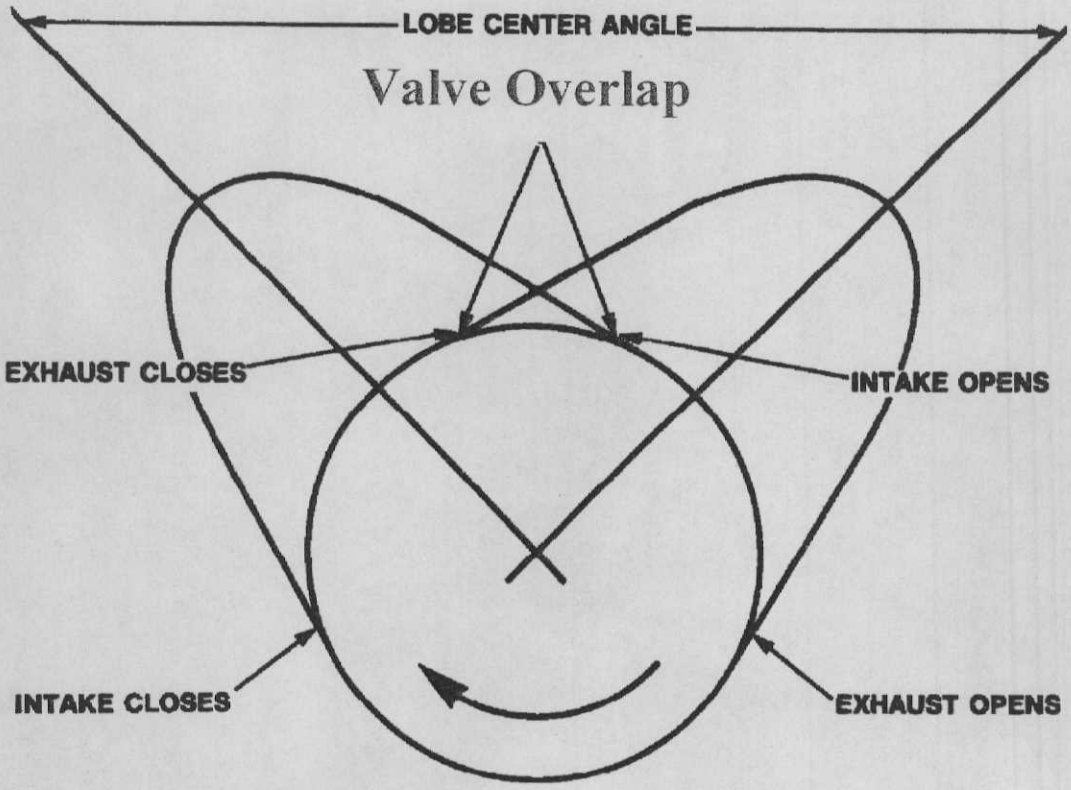


The VCT solenoid is easily visible from the front of the engine.



The cam sensor is now triggered from a reluctor on the back of the exhaust camshaft as opposed to the intake camshaft on previous 2.0L's.

Variable Camshaft Timing

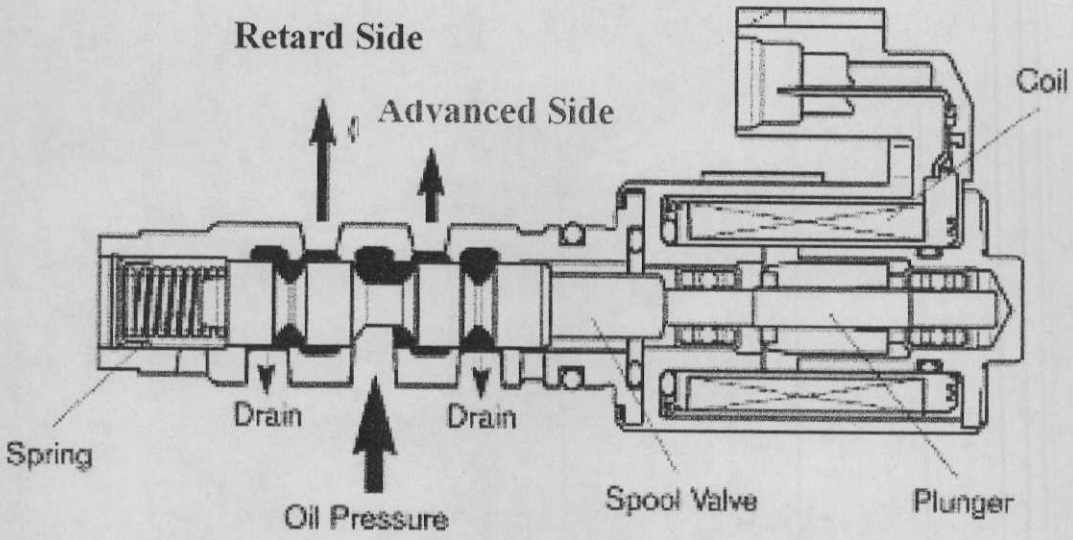


Valve overlap is defined as the amount of time that both the exhaust valve and the intake valve are open as the piston transitions from the exhaust stroke to the intake stroke.

Exhaust Cam Retards (30°)

- **the exhaust valves open _____ during the power stroke**
- **the exhaust valves close _____ during the intake stroke (this increases overlap)**
- **lift and duration remain unchanged**

Variable Camshaft Timing

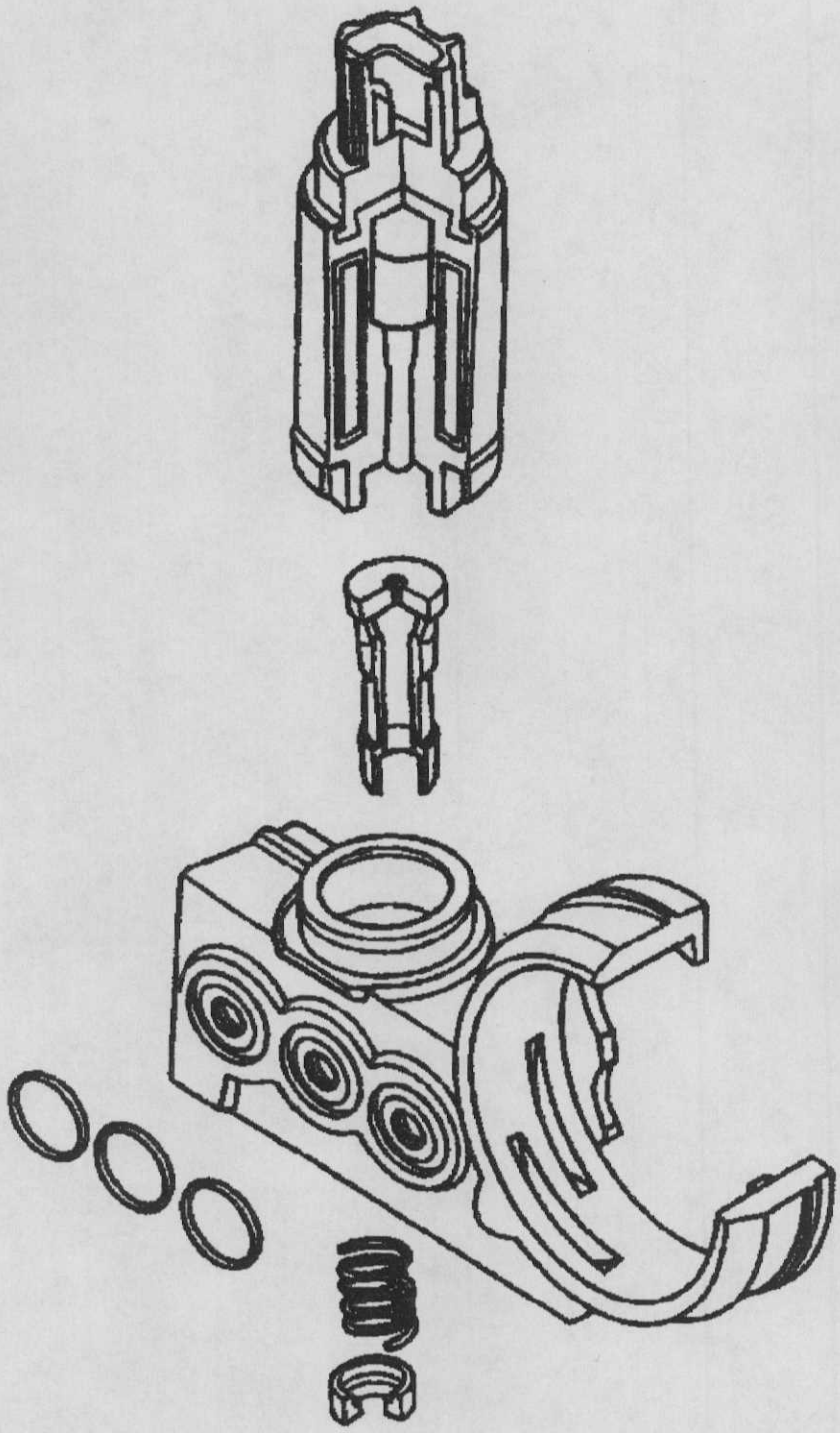


Engine oil pressure is supplied to the VCT solenoid. Depending on the PCM command, the VCT solenoid will direct oil to either the advanced side or the retarded side of the variable cam timing unit assembly (axially sliding piston).

When de-energized by the PCM, oil is supplied to the advanced side of the variable cam timing unit. This is the default position.

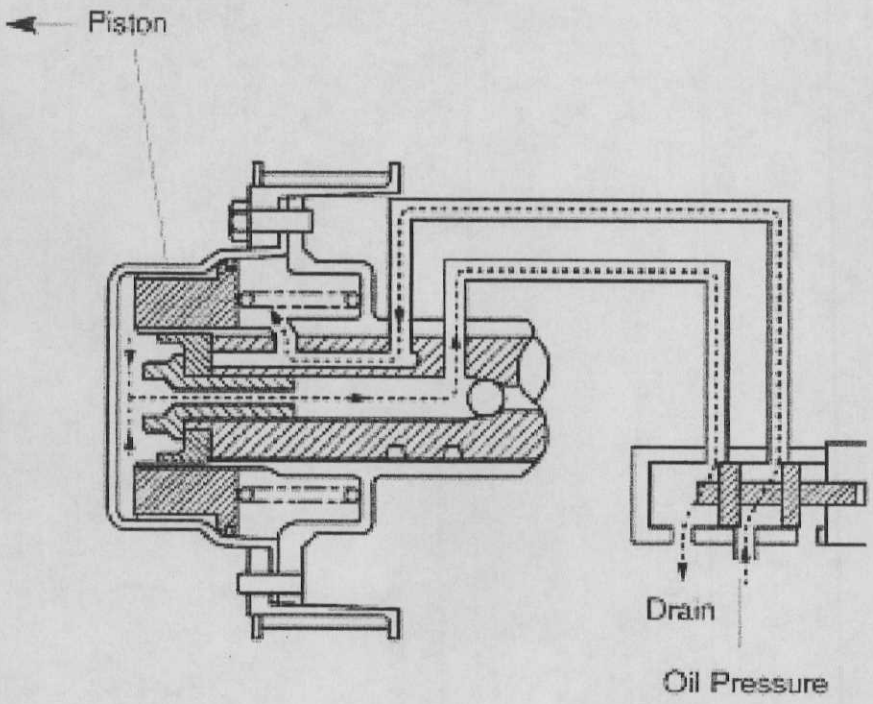
When energized by the PCM, oil will be supplied to the retarded side of the variable cam timing unit. Depending on the duty cycle command, the exhaust cam can retard up to 30 cam degrees.

Variable Camshaft Timing



This is an exploded view of the VCT solenoid and oil feed flange assembly.

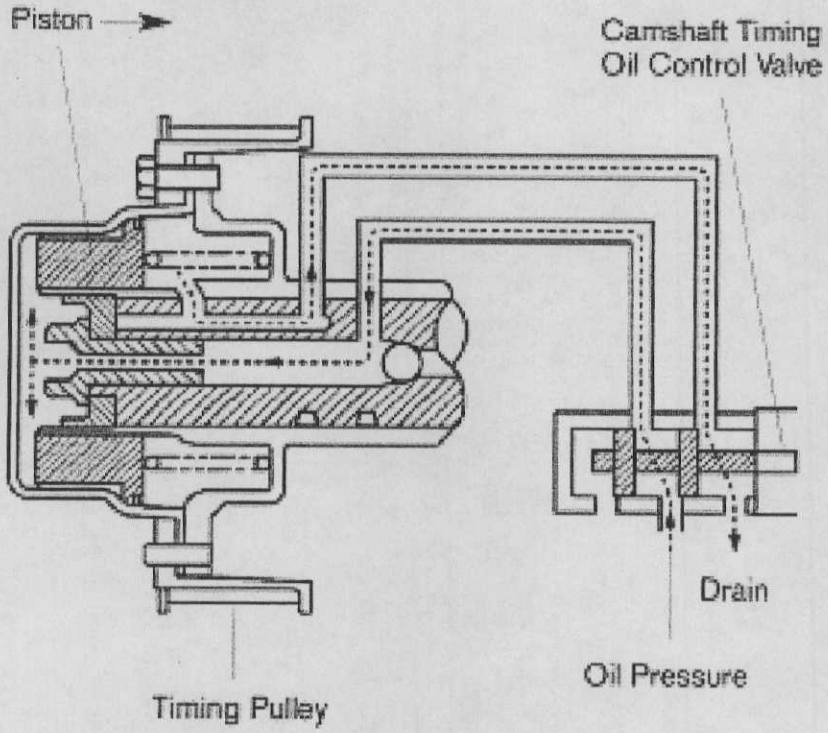
Variable Camshaft Timing



As the piston in the variable cam timing unit assembly is hydraulically pushed towards the front of the engine, the exhaust cam is in its advanced position.

Engine oil pressure is applied to the back side of the piston. This is the side towards the rear of the engine.

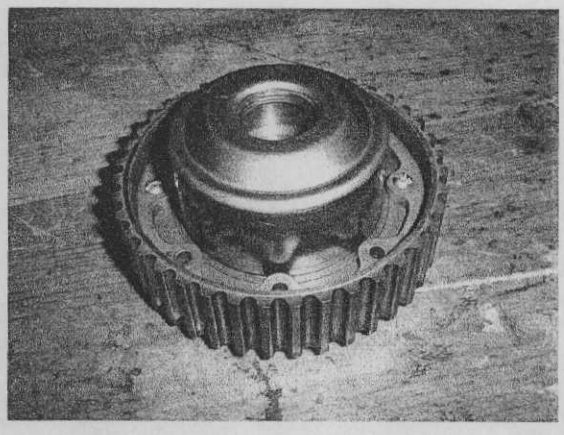
Variable Camshaft Timing

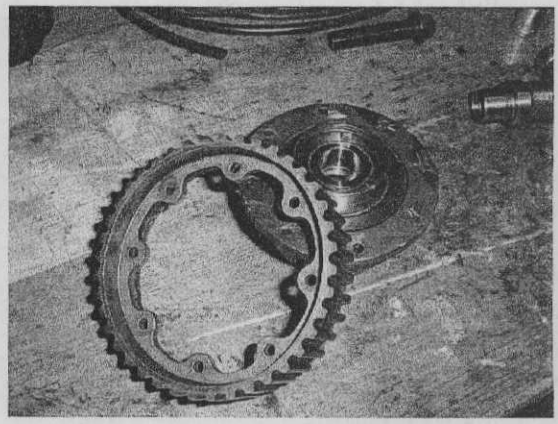


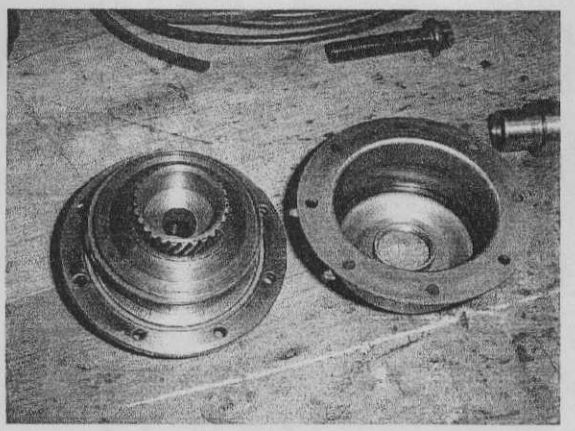
As the piston in the variable cam timing unit assembly is hydraulically pushed towards the rear of the engine, the exhaust cam is retarding its position from the timing belt sprocket.

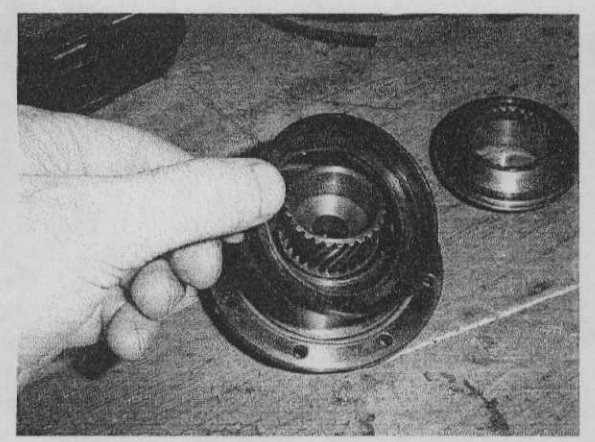
Engine oil pressure is applied to the front side of the piston. This is the side towards the front of the engine.

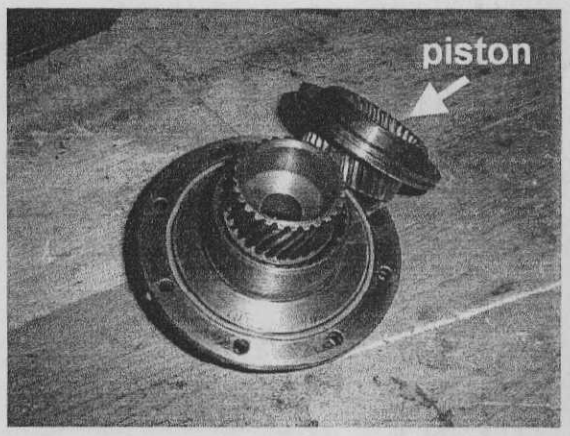
Variable Camshaft Timing





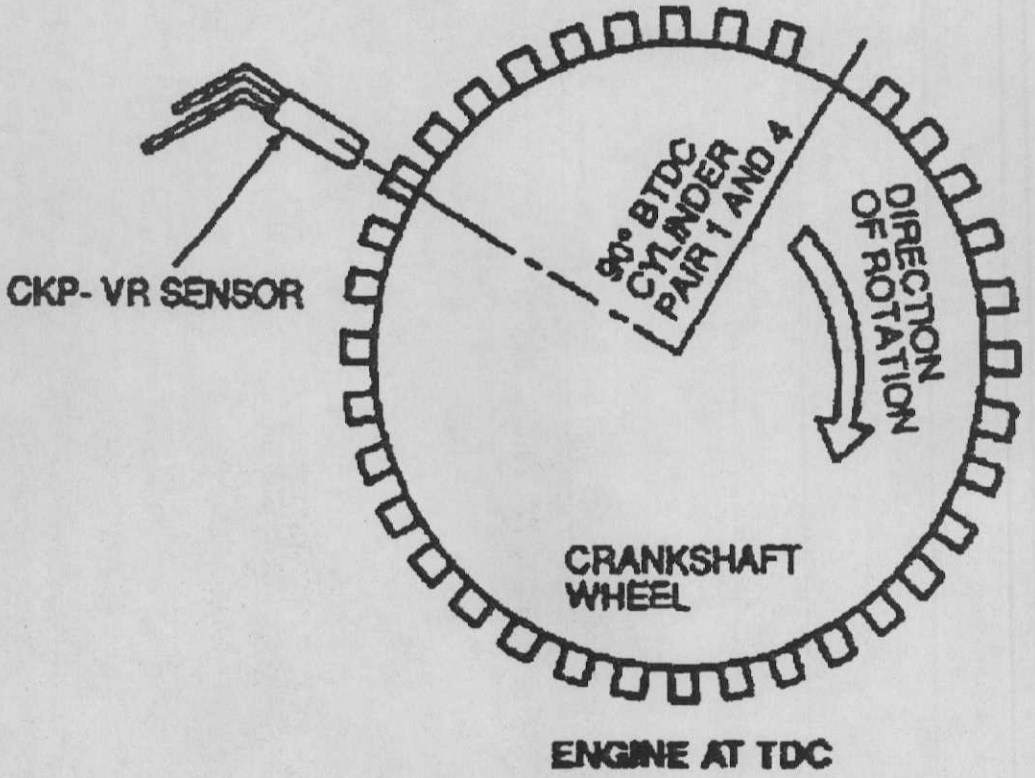






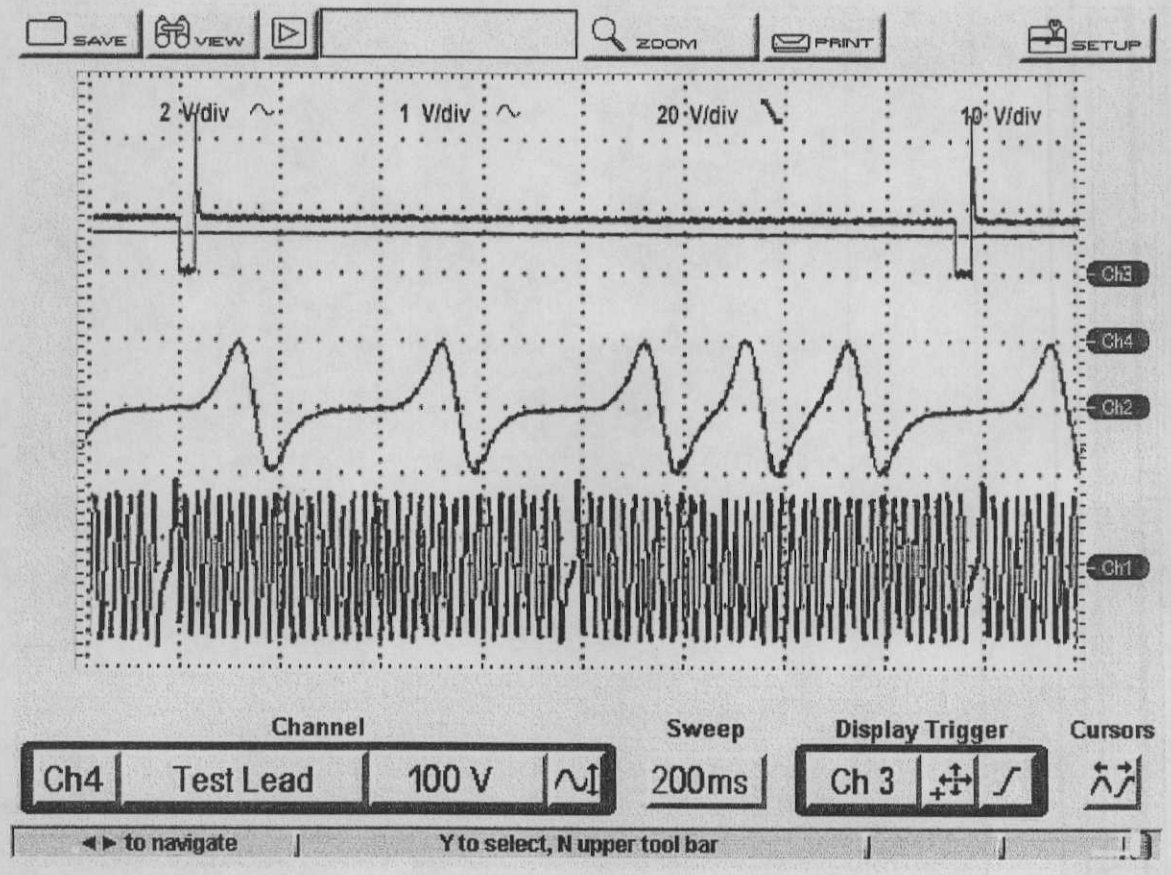
The helically splined piston connects the camshaft to the camshaft sprocket.

Variable Camshaft Timing



The crank synch pulse on the 36 – 1 tooth reluctor occurs 90° BTDC on the compression stroke of cylinder #1 in a 4-cylinder engine.

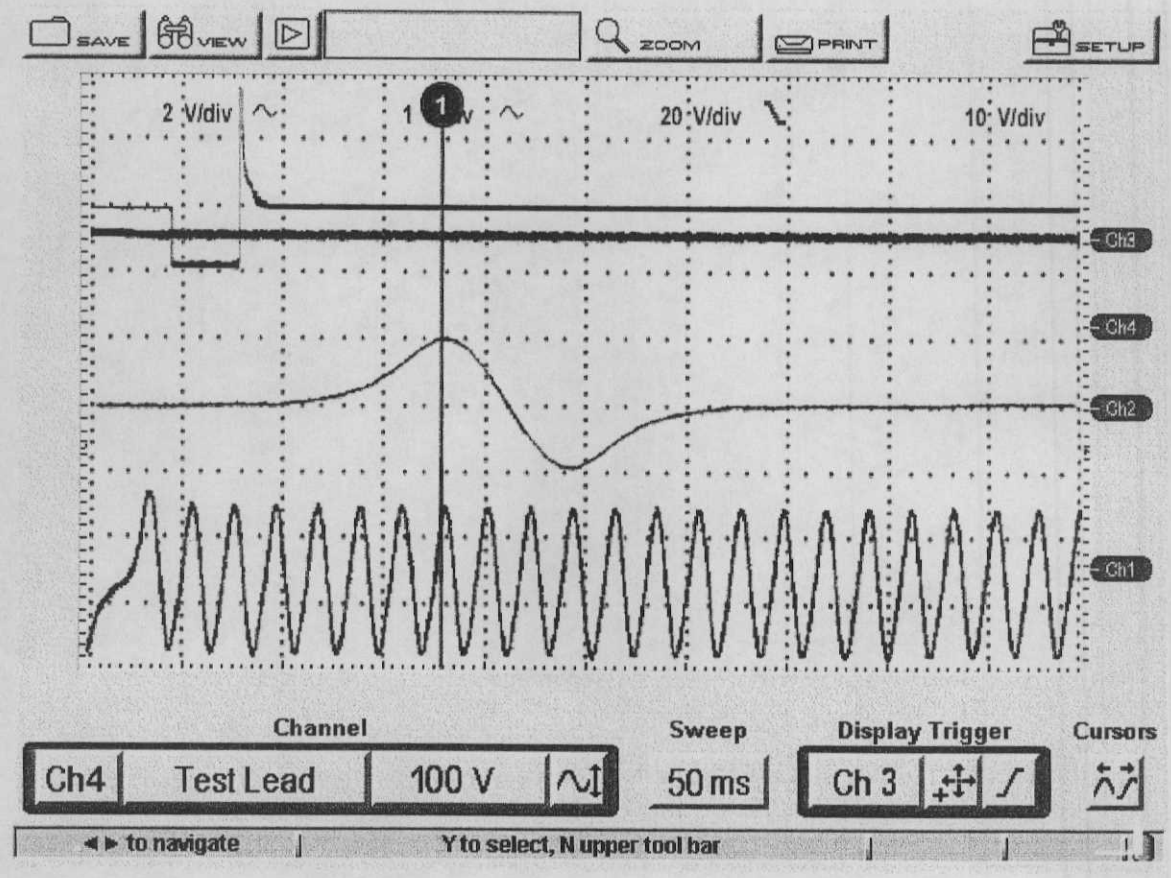
Variable Camshaft Timing



Channel 1 is on the "36 – 1" tooth crank sensor.
Channel 2 is on the "4 + 1" cam sensor.
Channel 3 is on the #1 fuel injector. This is the trigger source.
Channel 4 is connected to the control line of the VCT solenoid.

The cam sensor has been modified for the VCT engine. It now senses the exhaust cam position versus the intake cam position. The PCM can more accurately measure the exhaust cam's position relative to the crank.

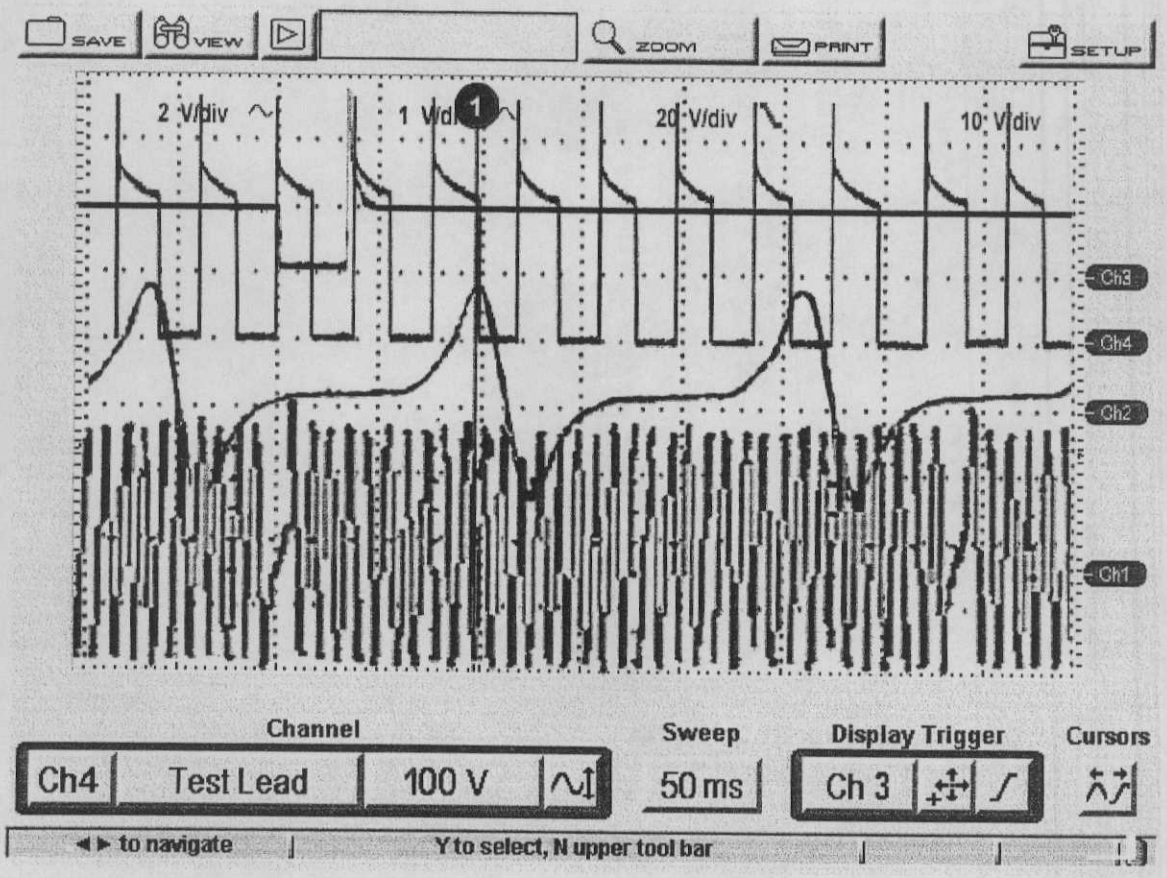
Variable Camshaft Timing



Channel 1 is on the "36 – 1" tooth crank sensor.
Channel 2 is on the "4 + 1" cam sensor.
Channel 3 is on the #1 fuel injector. This is the trigger source.
Channel 4 is connected to the control line of the VCT solenoid.

With the VCT solenoid turned off, the cam should be in its advanced position. Note the cam's position relative to the crank synch pulse. With no exhaust cam retard, the 2 pulses are about 8 teeth (80° crank) away from each other. Also, since each crank sensor "tooth" equals 10°, notice that the cursor lines up the cam peak at about 15° BTDC.

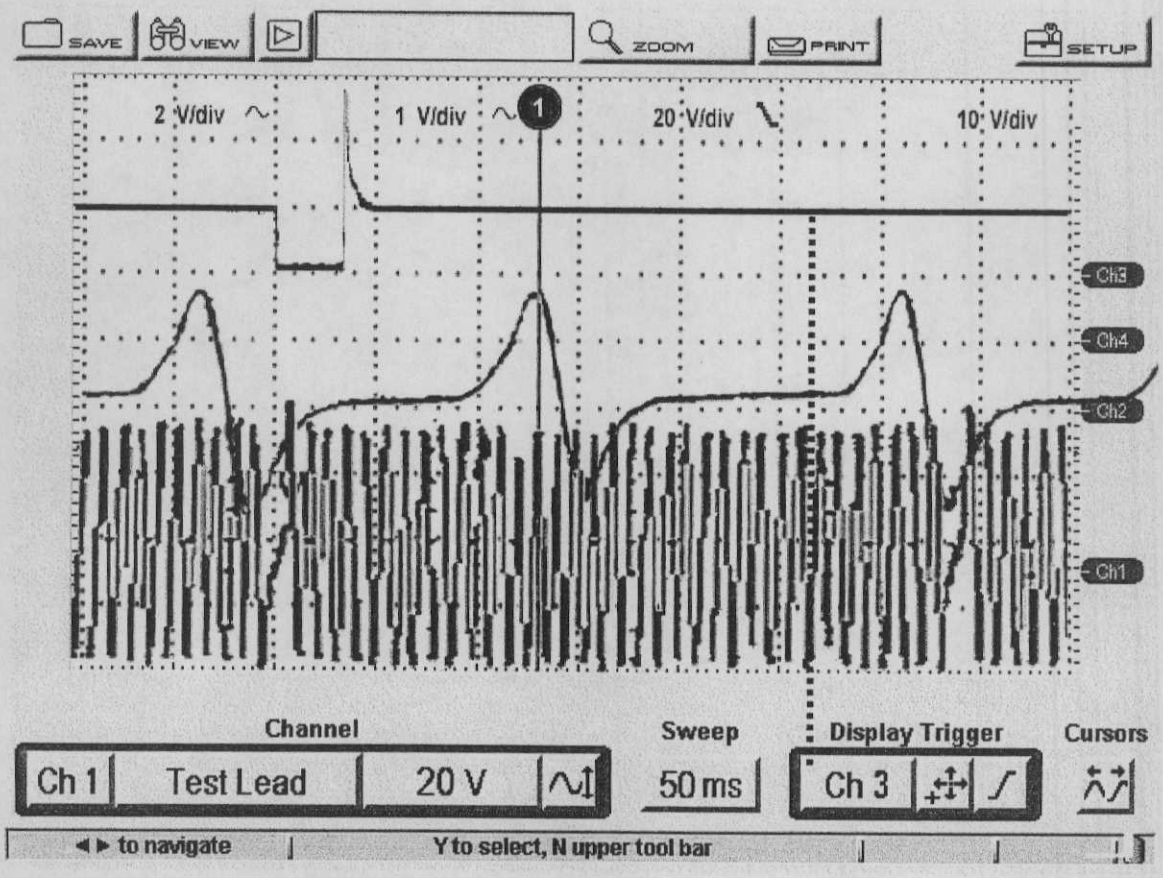
Variable Camshaft Timing



Channel 1 is on the "36 – 1" tooth crank sensor.
Channel 2 is on the "4 + 1" cam sensor.
Channel 3 is on the #1 fuel injector. This is the trigger source.
Channel 4 is connected to the control line of the VCT solenoid.

When the VCT solenoid is commanded with a 45% duty cycle, the 2 pulses are about 10 teeth (100° crank) away from each other.

Variable Camshaft Timing

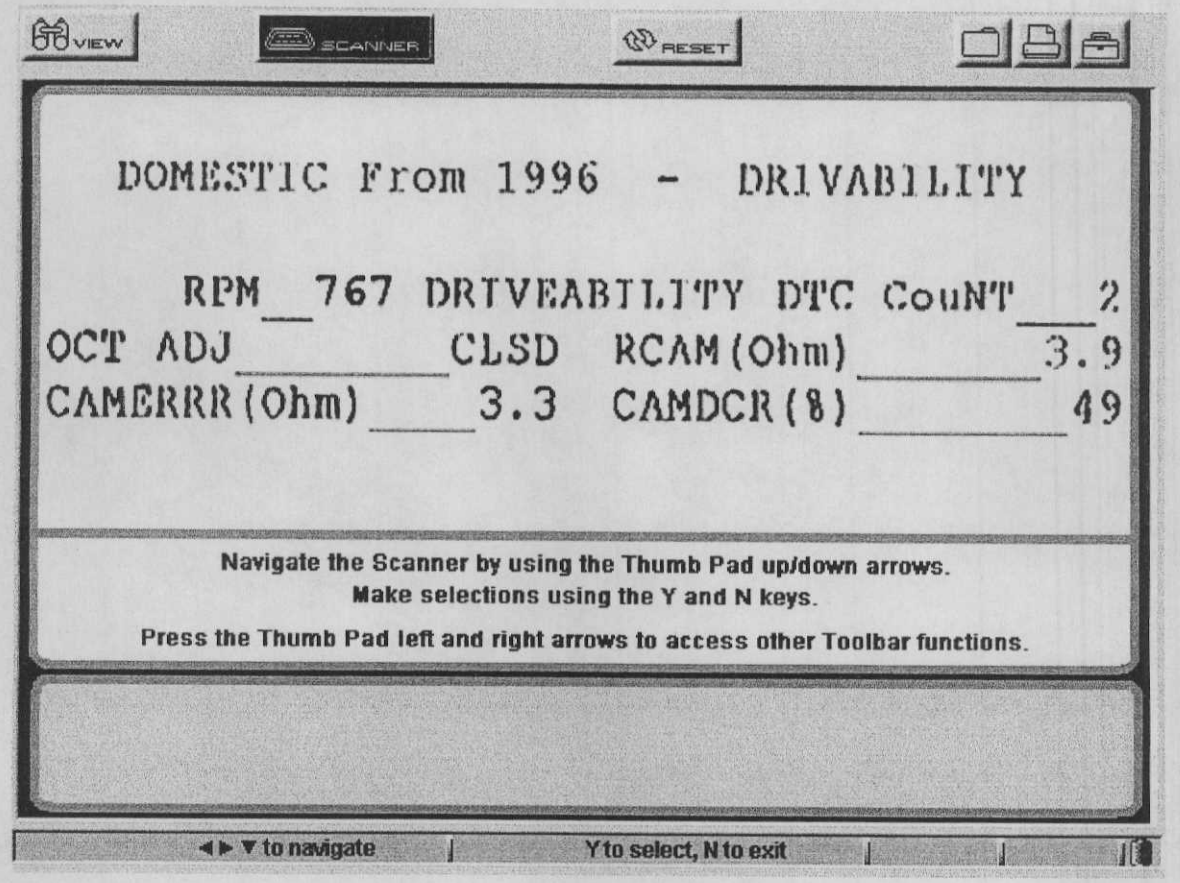


Channel 1 is on the "36 – 1" tooth crank sensor.
Channel 2 is on the "4 + 1" cam sensor.
Channel 3 is on the #1 fuel injector. This is the trigger source.
Channel 4 is connected to the control line of the VCT solenoid.

When the VCT solenoid is commanded with a 100% duty cycle, the 2 pulses are about 14 teeth (140° crank) away from each other.

14 teeth (currently) minus 8 teeth (initially) equal 6 crank teeth. 6 crank teeth equal 60° crank or 30° cam.

Variable Camshaft Timing



1. **VCT Sol Out – Right Bank (NGS pid: CAMDCR)**
   This pid is the PCM's duty cycle command to the VCT solenoid. The pid shown above must be multiplied by 100. So, 0.5 times 100 equals a 50% duty cycle command.

2. **VCT Right Cam Act Pos (NGS pid: RCAM)**
   This pid represents the actual position of the exhaust cam relative to the crank. This is normally about a negative 15 crank degrees. At a 100% duty cycle command, this would show an additional 60° crank (30° cam) for a reading of about a positive 45°.

3. **Actual Camshaft Position (NGS pid: CAMERR)**
   This pid indicates how many cam degrees the exhaust cam is away from its commanded position. This will show 0 to +/- 30°. This pid provides feedback to the PCM regarding its duty cycle command.

Variable Camshaft Timing Trouble Codes

1. P1380: VCT Solenoid Malfunction
   - **this is an electrical performance code**
   - **there is a problem with circuit continuity, high resistance or low resistance**

2. P1381: VCT Exhaust Cam Over-Advanced
   - **the PCM did not see the exhaust cam retard when it commanded the VCT solenoid on**
   - **this code could be caused by problems with the solenoid, cam gear assembly or engine oil quality (see TSB # 99-13-8)**

3. P1383: VCT Exhaust Cam Over-Retarded
   - **the PCM does not see the exhaust cam in its normal at rest position (no retard)**
   - **this code could be caused by an incorrectly installed timing belt**

Variable Camshaft Timing
Interpreting the PIDs

CAMDCR: PCM's duty cycle command to the VCT
RCAM: actual exh. cam position relative to the crank
CAMERR: how many cam degrees the exhaust cam is away from its commanded position

CAMDCR = 0%
RCAM = -15°
CAMERR = 0°

_____

_____

CAMDCR = 100%
RCAM = -15°
CAMERR = +30°

_____

_____

CAMDCR = 0%
RCAM = +45°
CAMERR = -30°

_____

_____

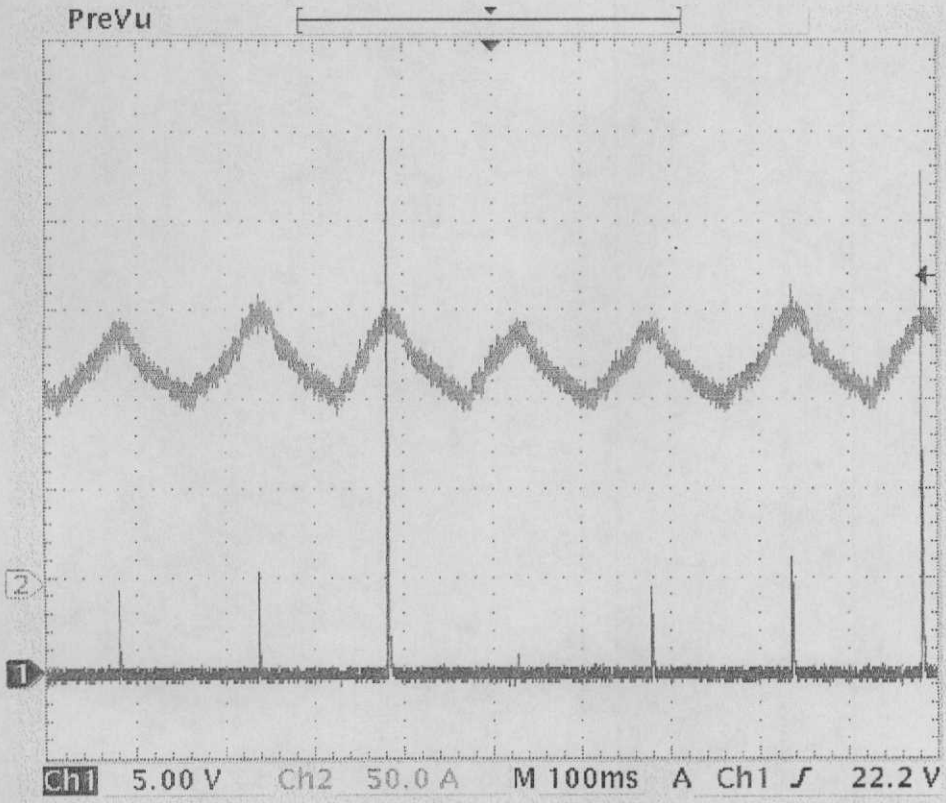
CAMDCR = 50%
RCAM = +30°
CAMERR = 0°

_____

_____

No Start Case Study

Vehicle: 1998 Ford Contour 2.0L vin 3 DOHC 75,000 miles
Concern: engine cranks strong, but will not start; there are no codes

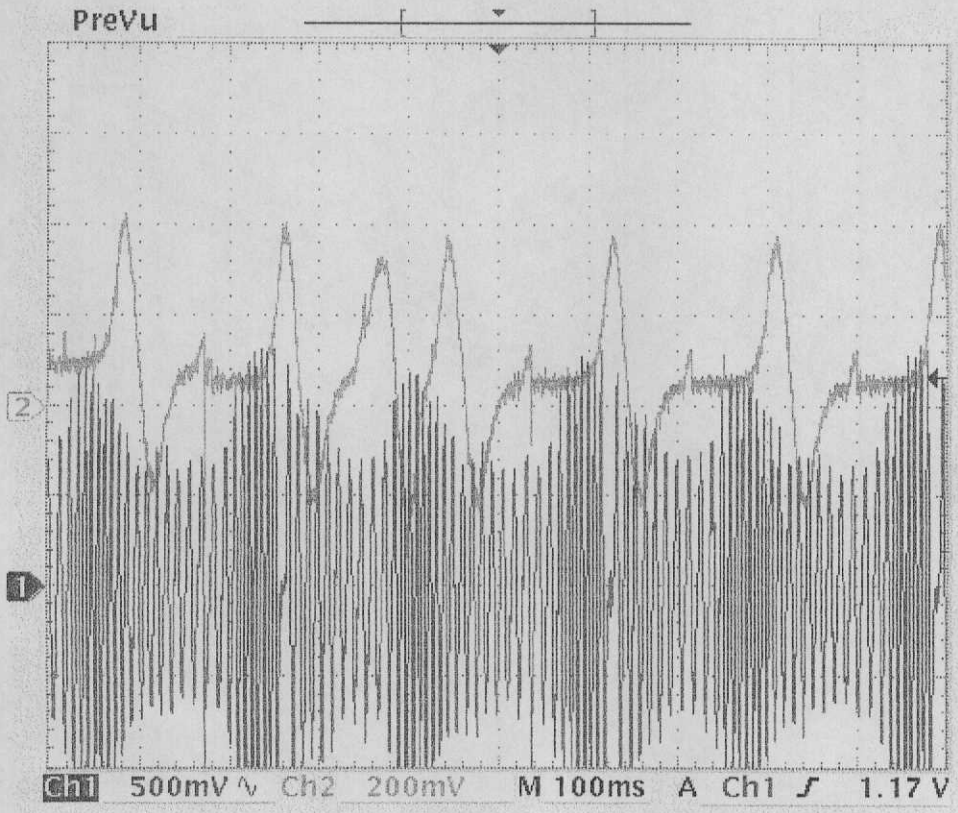


Channel 1 is connected to a synch probe clamped around the #1 plug wire, and Channel 2 is connected to a high amp current probe clamped around the battery cable. Fuel is disabled and the engine is cranking.

Cranking Compression = _____ psi

No Start Case Study

Vehicle: 1998 Ford Contour 2.0L vin 3 DOHC 75,000 miles

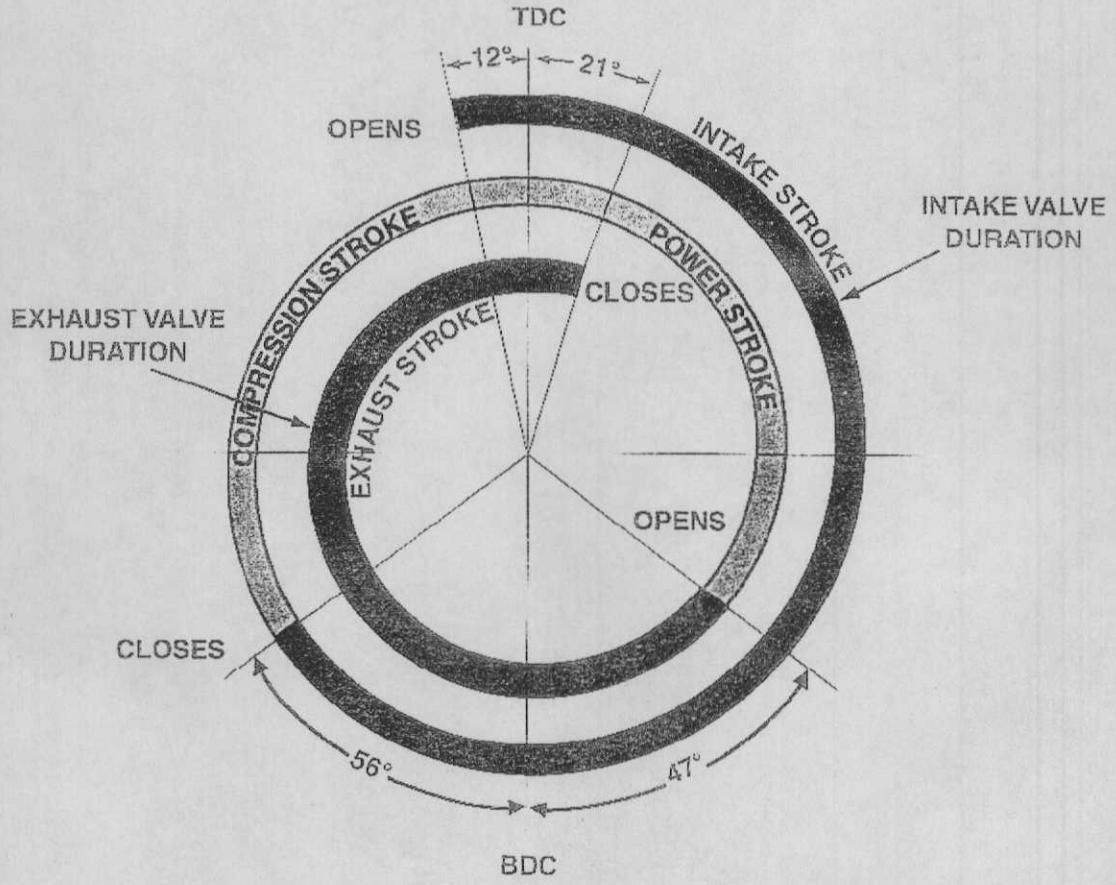


Channel is connected to the crank sensor, and Channel 2 is connected to the cam sensor. The engine is cranking. What can be said about cam timing relative to crank timing?

_____

_____

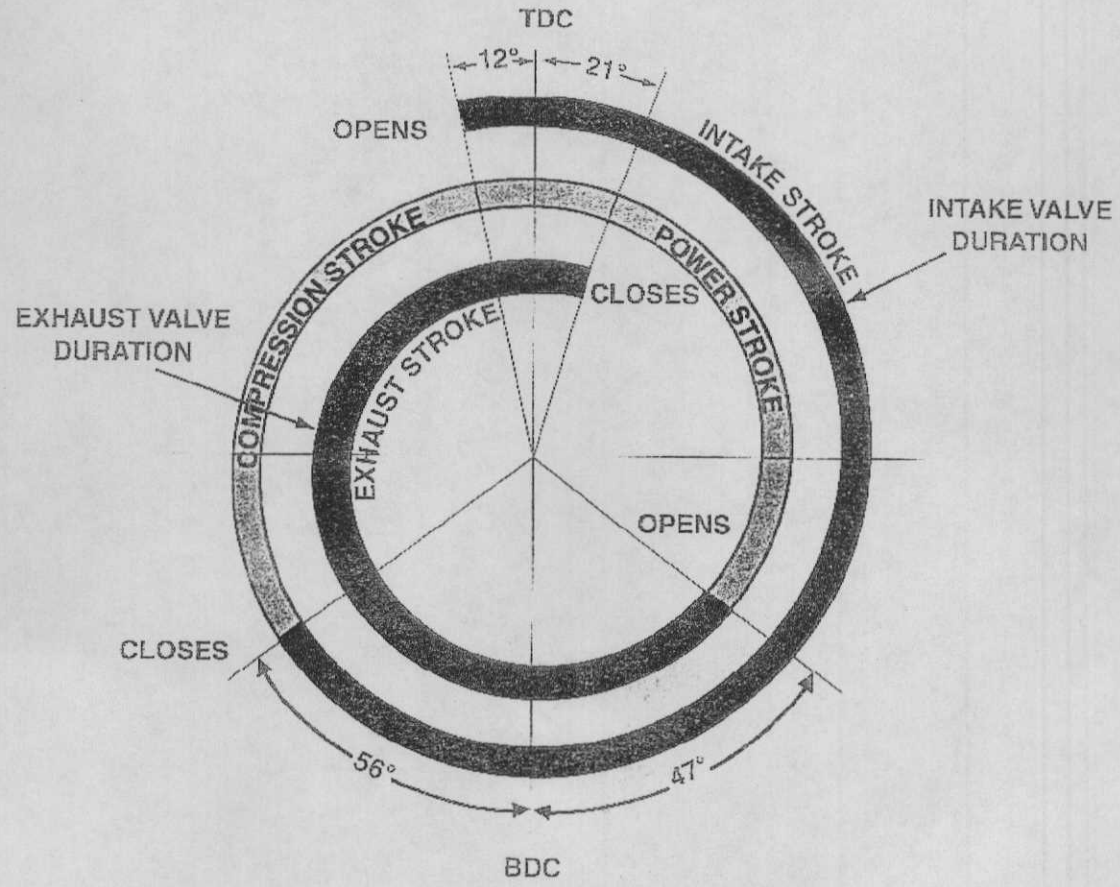
DOHC Valve/Cam Timing



Cam Advanced (valve events occur earlier)

- **intake valve opens sooner in the exhaust stroke (increases valve overlap)**
- **intake valve closes earlier in the compression stroke (this increases the effective compression ratio)**
- **exhaust valve opens sooner in the power stroke**
- **exhaust valve closes earlier in the intake stroke (reduces valve overlap)**

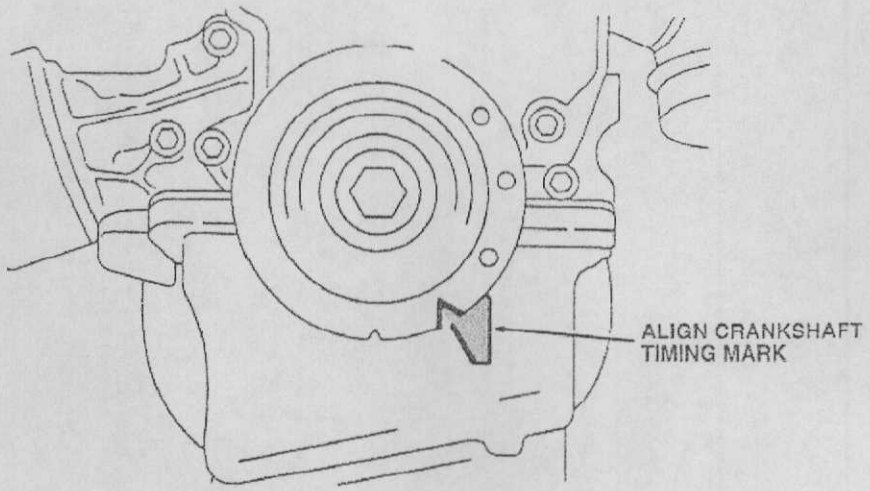
DOHC Valve/Cam Timing



Cam Retarded (valve events occur later)

- **intake valve opens later in the exhaust stroke (reduces valve overlap)**
- **intake valve closes later in the compression stroke (this reduces the effective compression ratio)**
- **exhaust valve opens later in the power stroke**
- **exhaust valve closes later in the intake stroke (increases valve overlap)**

Variable Camshaft Timing
Checking Cam Timing

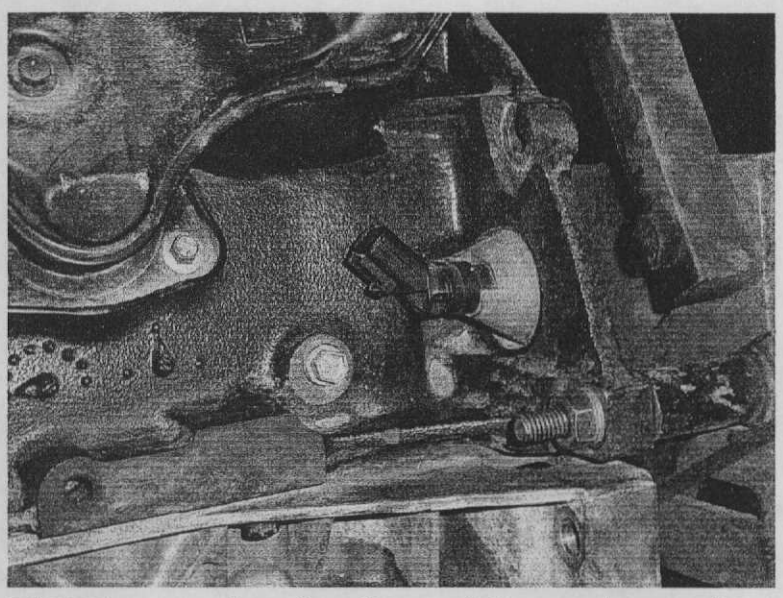


The first step in checking cam timing is to find TDC on compression for cylinder #1. There are marks on the harmonic balancer and aluminum bedplate.

Turn the crank CW until the 2nd, larger notch (hard to see) aligns with the trailing (to your left) edge of the raised aluminum boss on the bedplate.

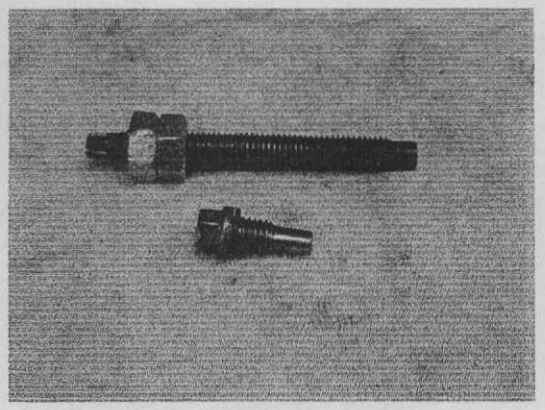
Cylinder #1 exhaust cam lobes will be pointing out towards the exhaust manifold. Cylinder #1 intake cam lobes will be pointing out towards the intake manifold.

Variable Camshaft Timing
Checking Cam Timing

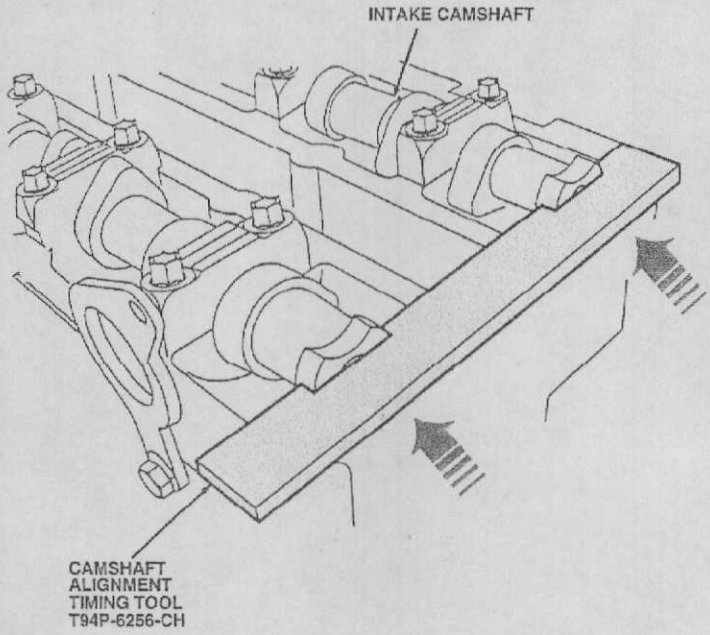


TDC can also be found by using what Ford calls a timing peg.

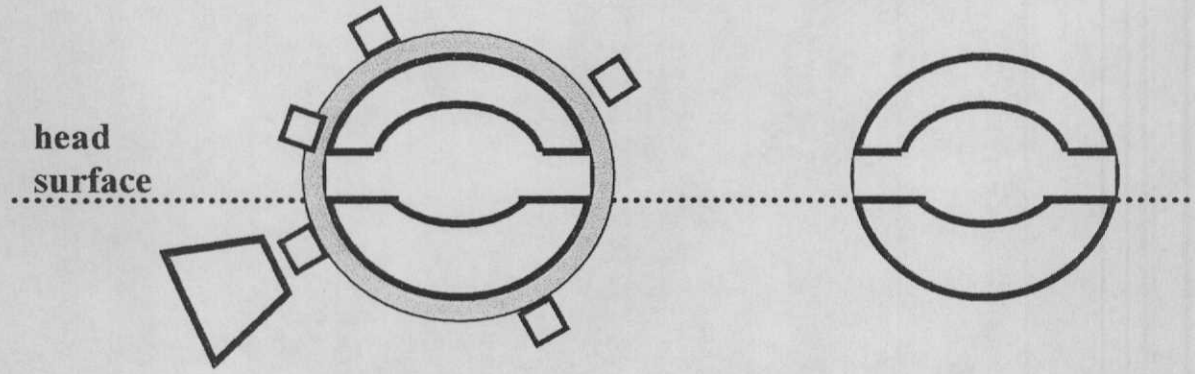
There is a bolt (10 mm head) on rear of the block about 2 inches in front of the crank sensor. Remove this bolt and install the timing peg (T97P-6000-A or 303-574; 1-800-ROTUNDA). This peg is used to locate the crank and keep it from moving. A 10 x 1.5 mm bolt which is 63.5 mm (2.5 inches) long could be used.



Variable Camshaft Timing
Checking Cam Timing

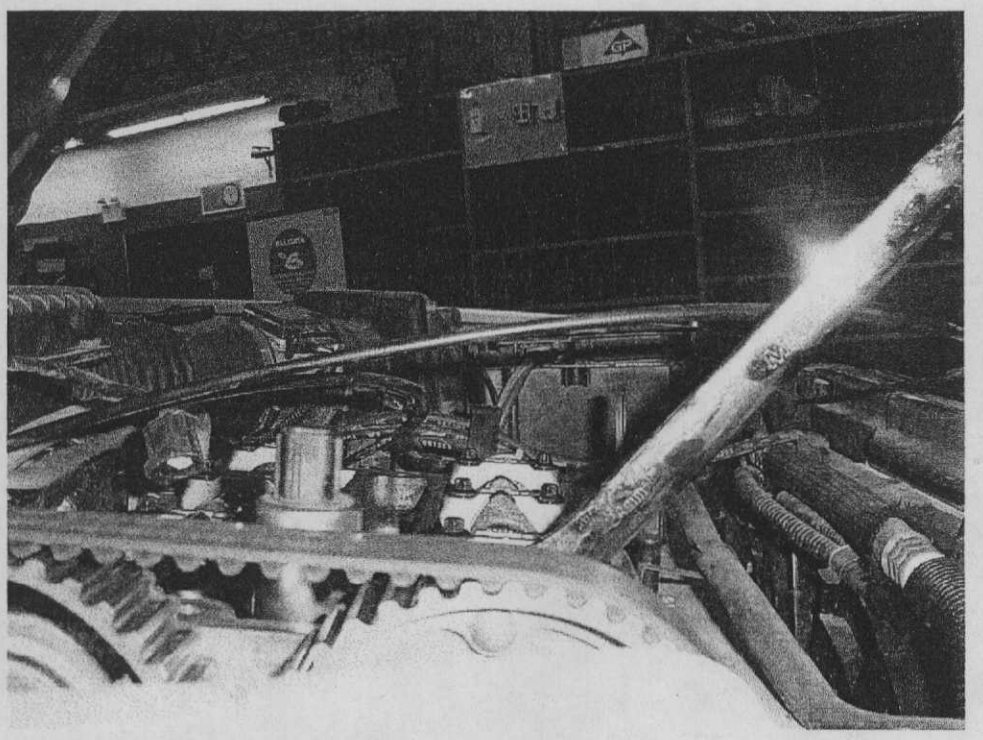


Once the crank is properly located, cam timing can be checked. An alignment tool should slide into the offset notches on the back side of both cams. A bar stock that is ¼ inch thick by 9 – 9 ½ inches long by ¾ - 1 inch wide will do the job.



Cam Sensor

Variable Camshaft Timing
Checking Cam Timing



With the timing belt properly installed and the cam sprockets torqued, the exhaust cam can be rotated about 30°. This is normal.

Put a 24 mm open end wrench on the hex just behind the 2nd exhaust cam lobe on the exhaust cam. Pull the wrench towards the radiator. The cam is now in the fully advanced position. Now the cam "aligning tool" can be used to check cam timing.

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