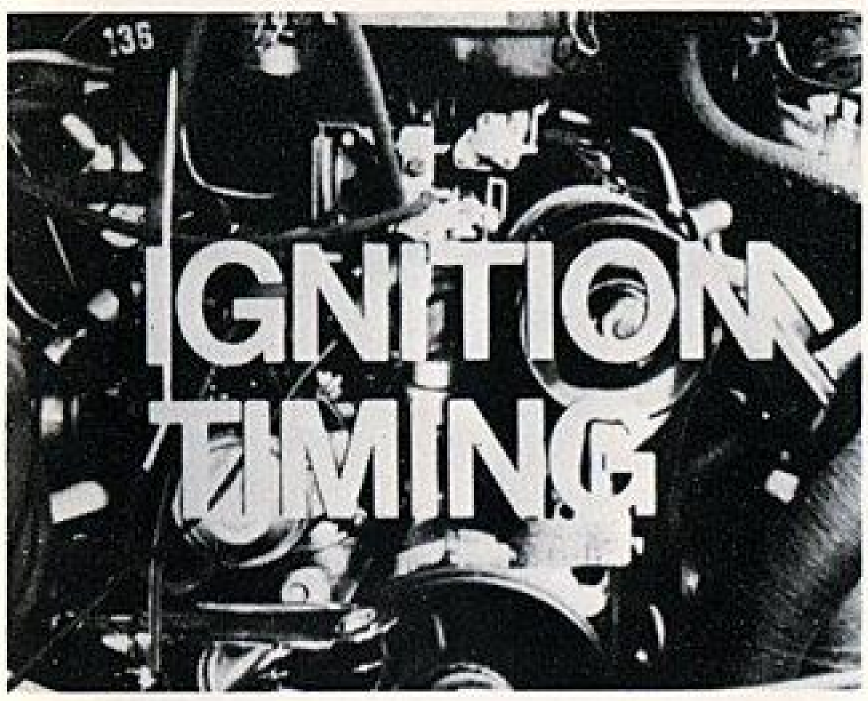
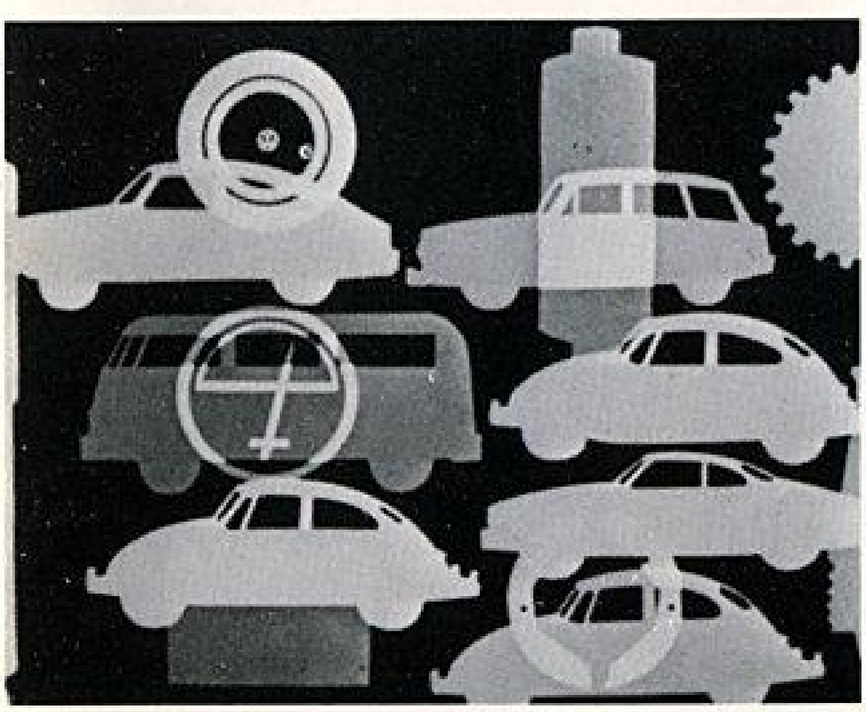
IGNITION TIMING

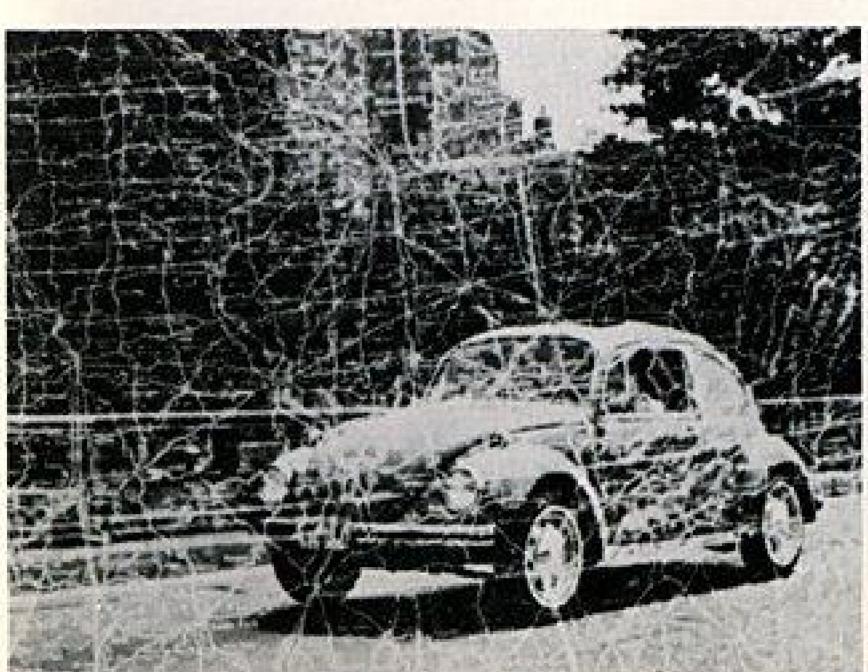
Dealer Level Training

Volkswagen of America, Inc.

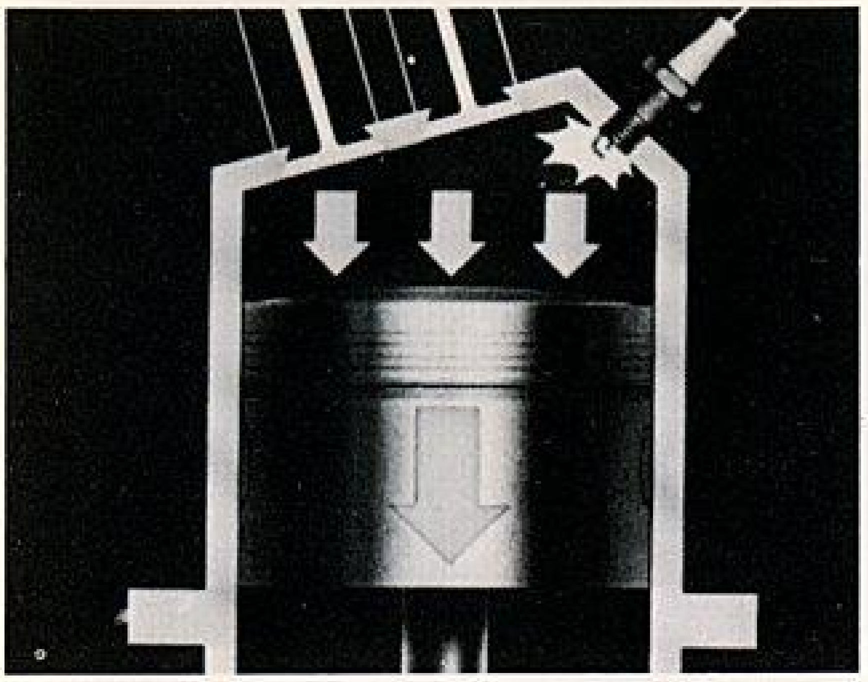




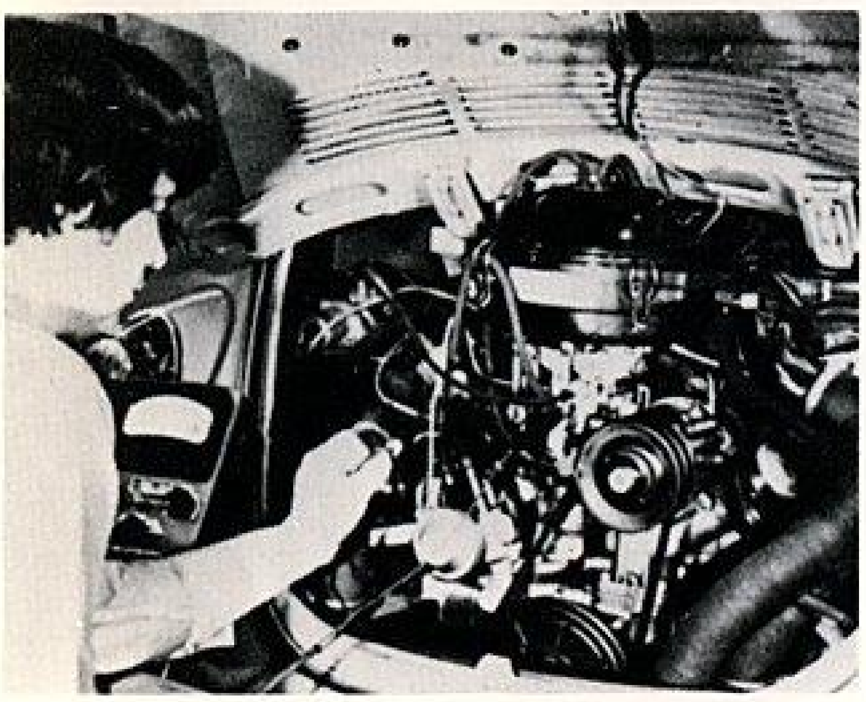
NARRATOR:
The automobile is a marvelous piece of machinery in many ways.



Consider a Volkswagen being driven from New York to Chicago. During that 16 hour trip, 12 million, 6 hundred thousand individual sparks will ignite a fuel-air mixture to drive the pistons.

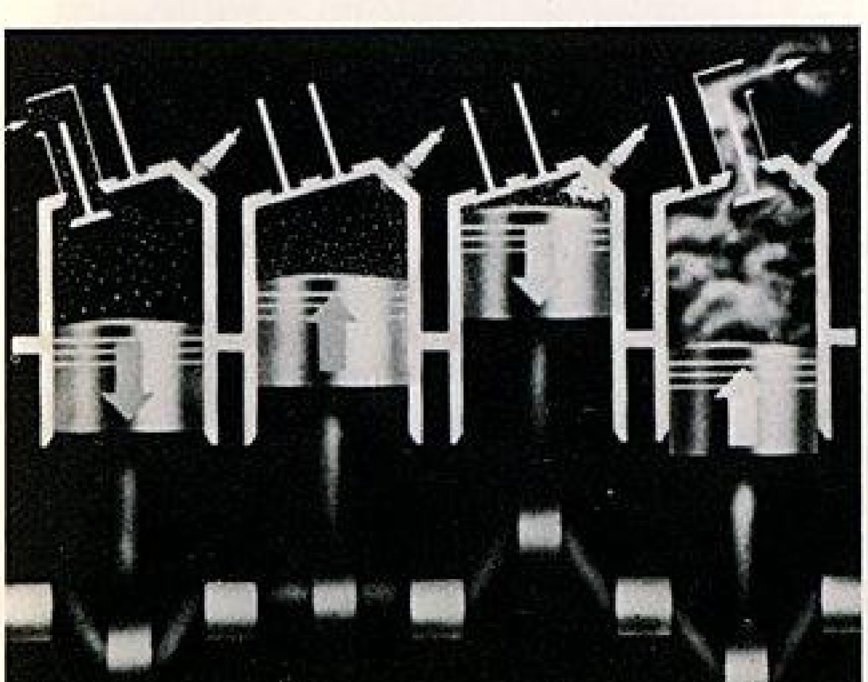


And each of these 12 million 6 hundred thousand sparks must occur at the exact instant it will do the most good.

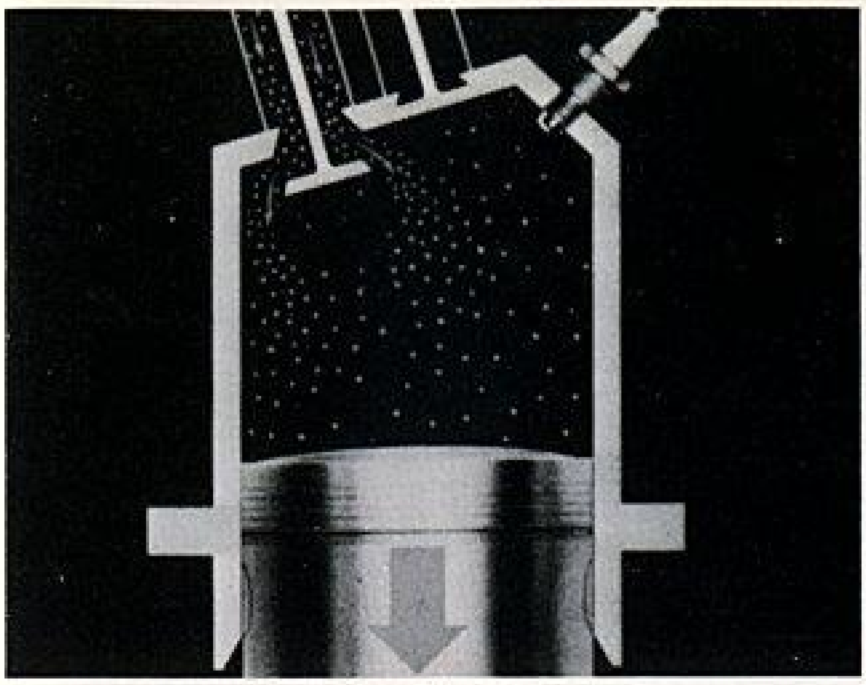


Making sure the firing happens at the precise right time is one of the jobs of the Volkswagen mechanic and the subject of this filmstrip.

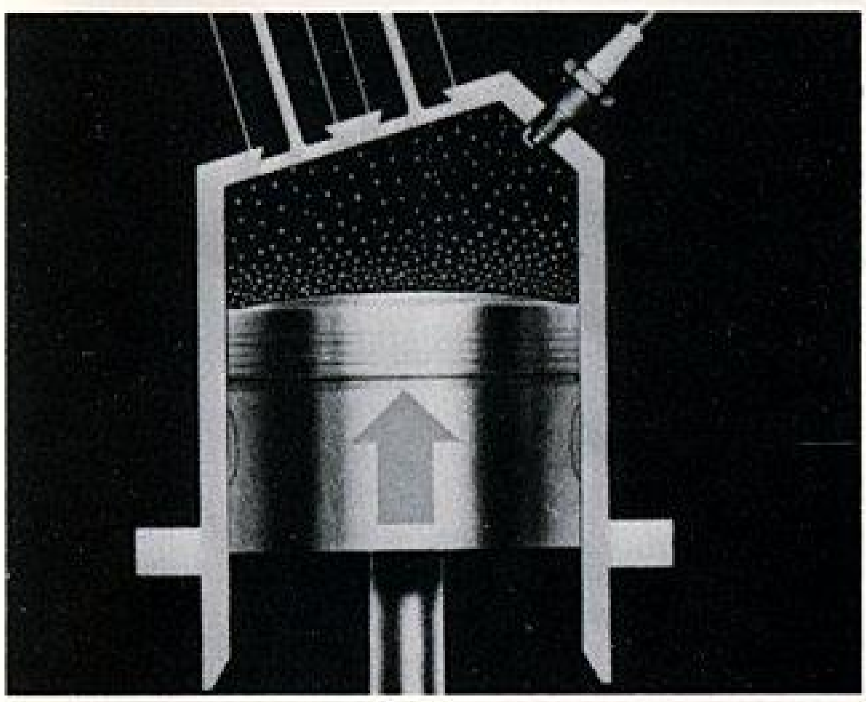
Ignition failures and poor ignition performance are the most common and costly source of automobile trouble. Therefore, it will be worthwhile to spend a few minutes to review some of the basic principles of the ignition system.



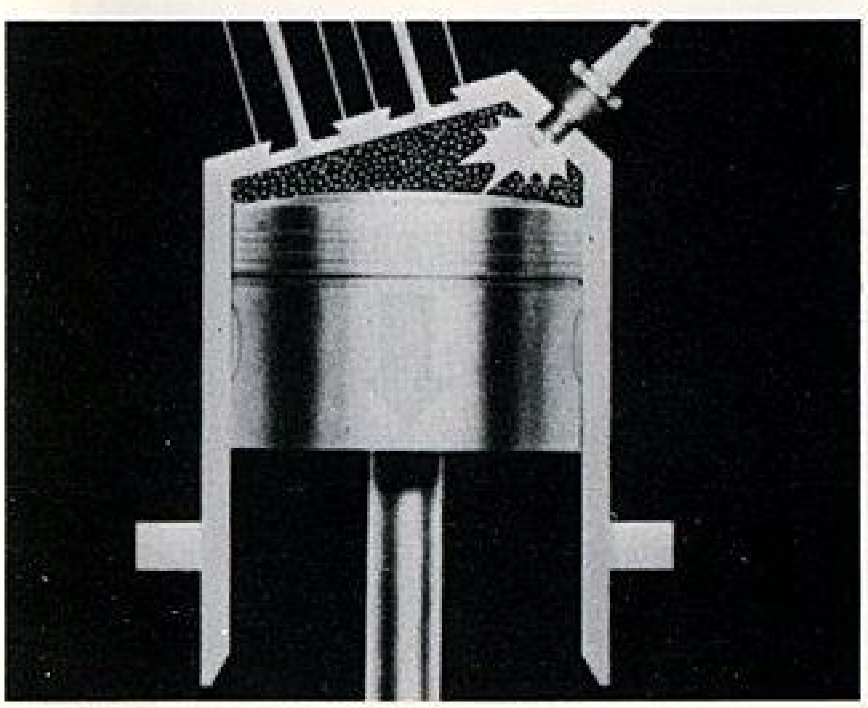
As we know, in the 4 stroke cycle engine, each cylinder fires every second revolution of the crankshaft.



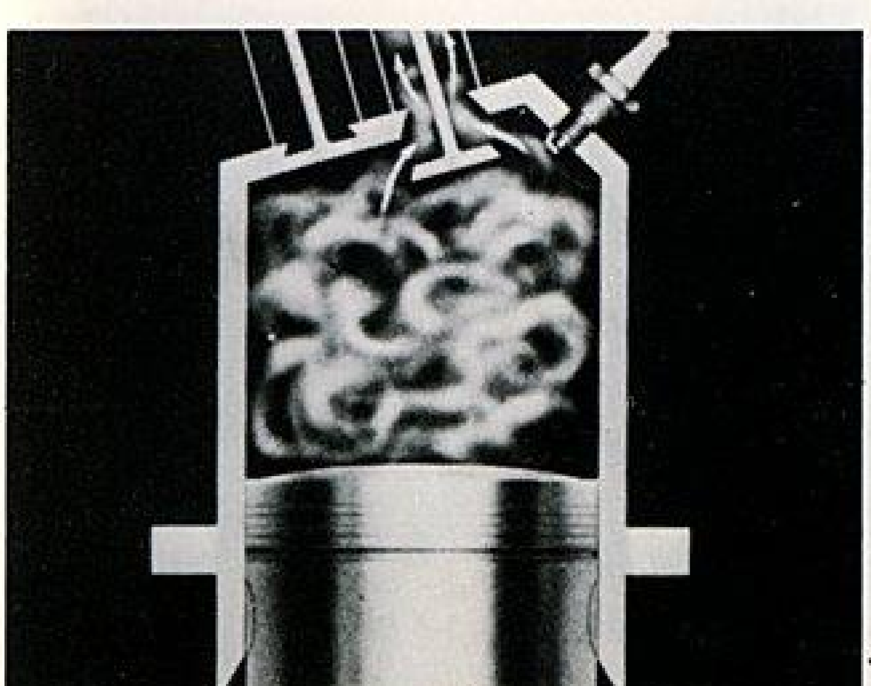
On the intake stroke, the piston goes down and draws in the fuel-air mixture.



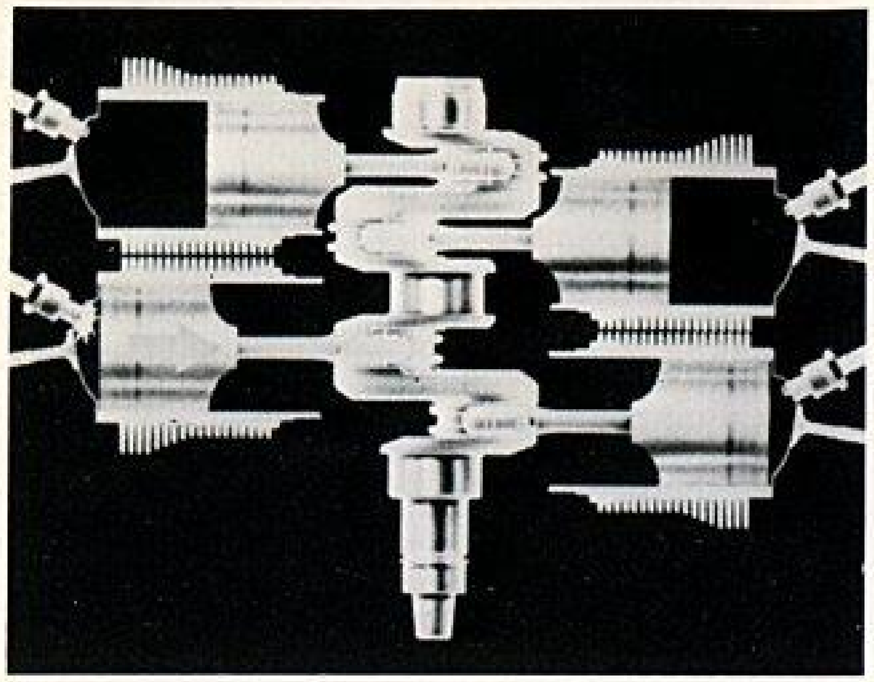
On the compression stroke, the piston goes up with both valves closed, and the fuel mixture is compressed.



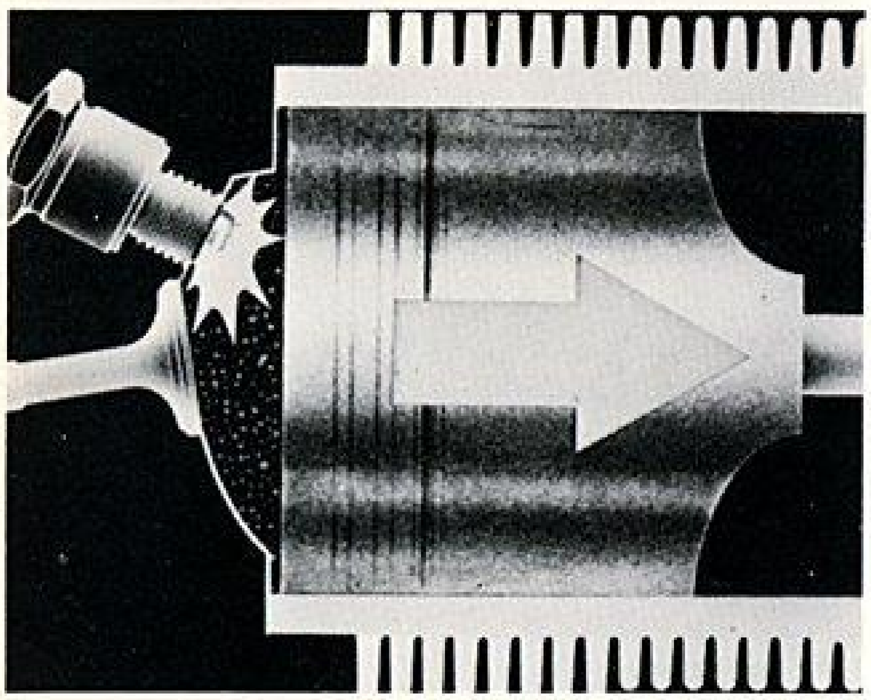
Then comes the spark and the power stroke as the expanding gases of the burning fuel force the piston down.



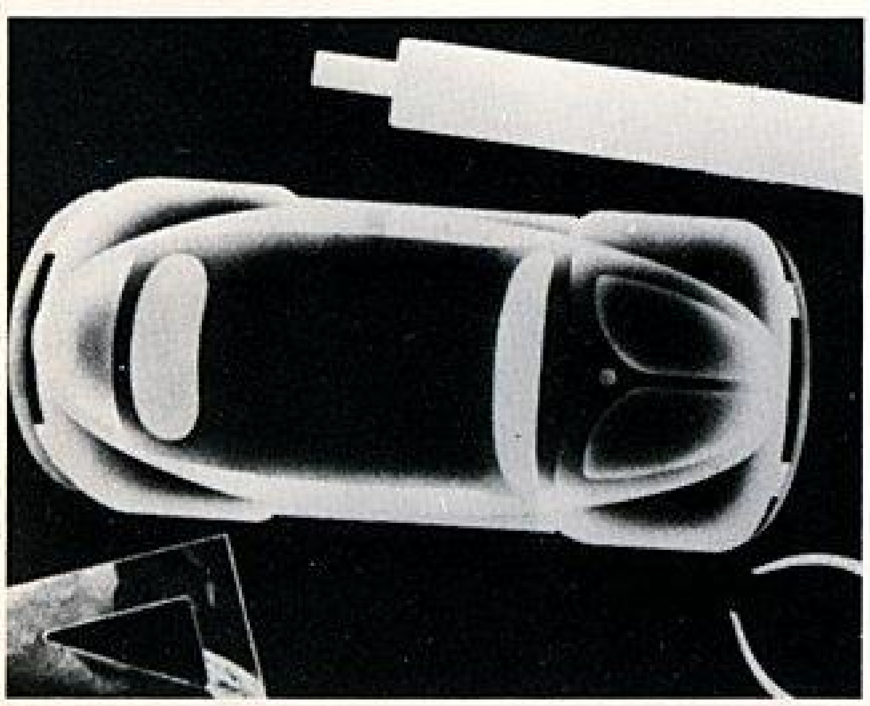
After the fuel is burned, the piston goes up again in the exhaust stroke forcing the combustion by-products out of the now open exhaust valve.



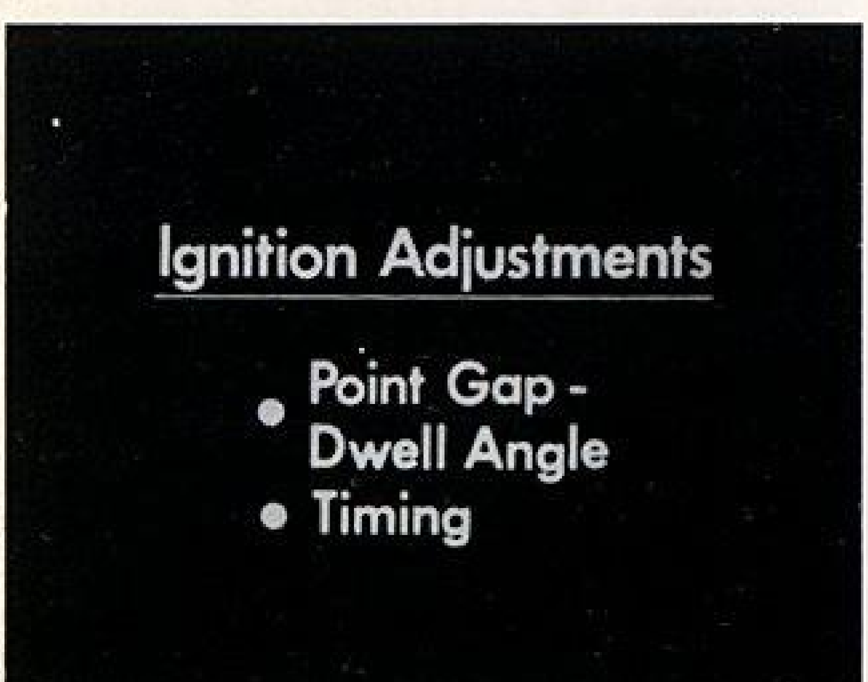
Thus, in a Volkswagen, 2 cylinders fire for every crankshaft revolution, and all four cylinders fire every two revolutions.



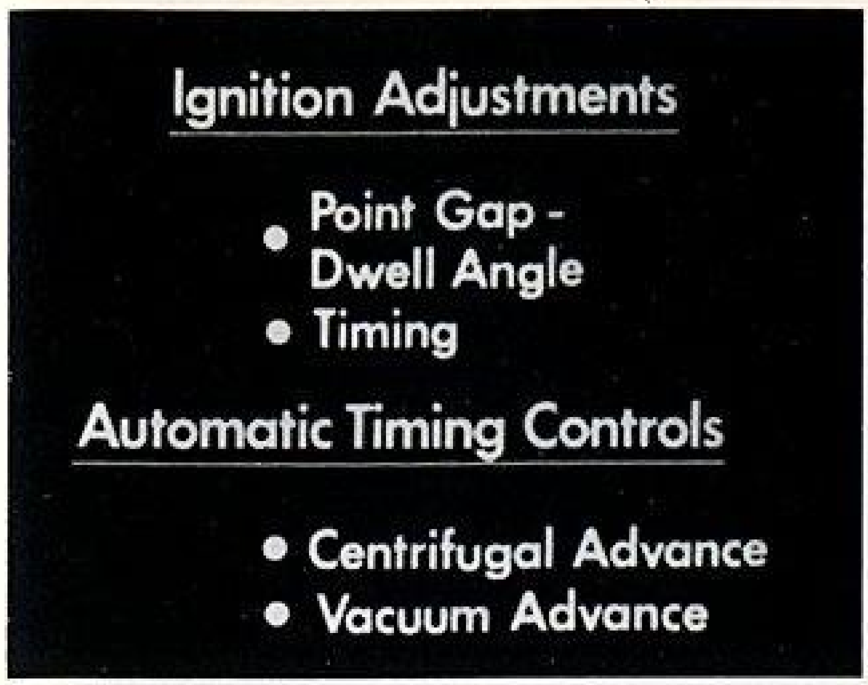
The job of the ignition system is to assure that sufficient voltage is delivered to the spark plug of the correct cylinder at the exact instant that the piston is in position to make the most efficient use of the burning fuel-air mixture.



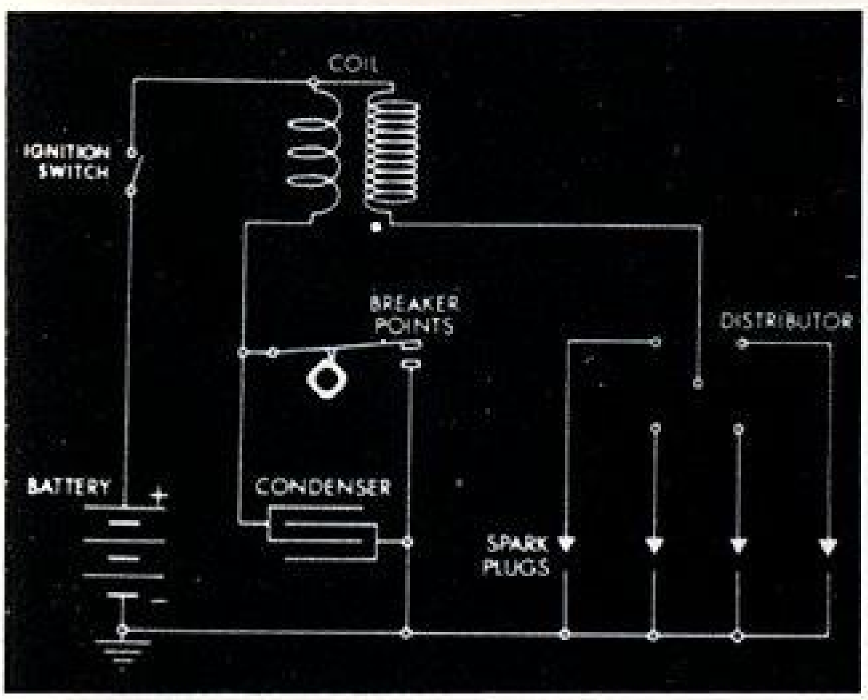
Naturally, this doesn't just happen. First come years of research, design and testing by the manufacturer.



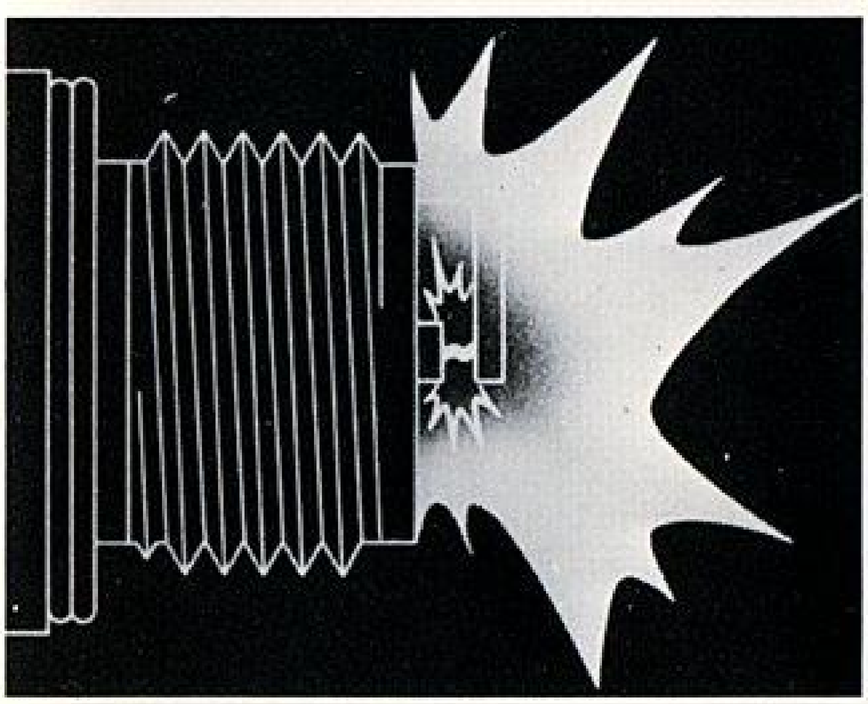
Then, it is the responsibility of the mechanic to follow certain guidelines in making basic adjustments.



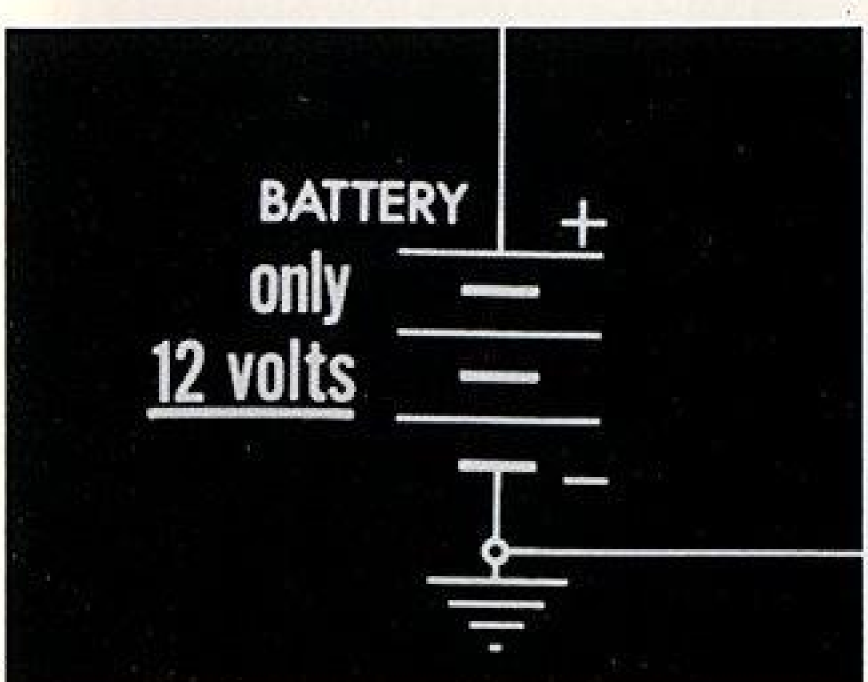
Then, there are certain automatic controls designed into the system but also checked by the mechanic. These controls change the instant of ignition to meet varying requirements of speed and engine load. We will go into these adjustments and controls in a moment. But first, let's look at the basic ignition system.



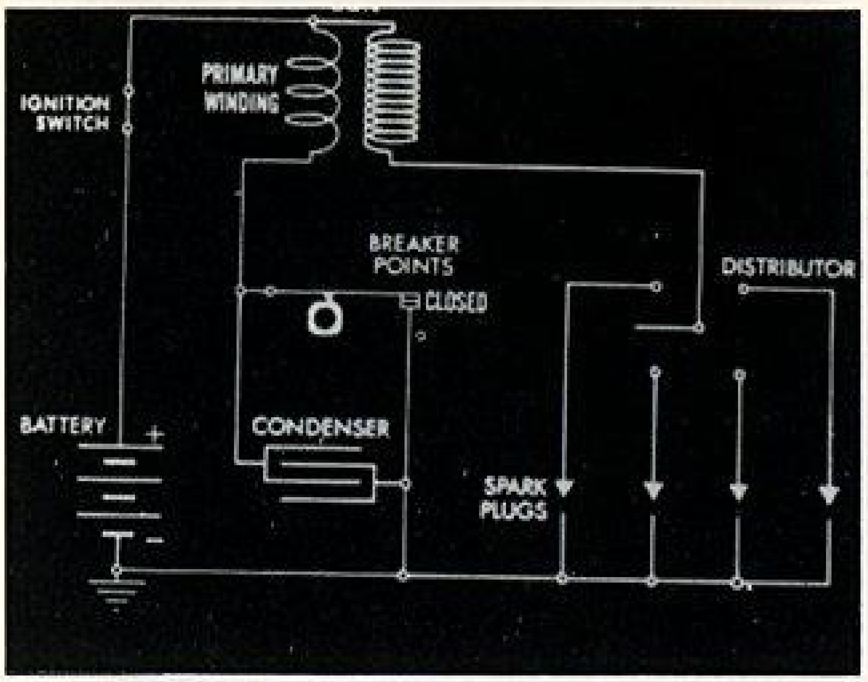
Here is an ignition circuit with the parts indicated. They are: the battery, ignition switch, ignition coil, breaker points, condenser, distributor and spark plugs.



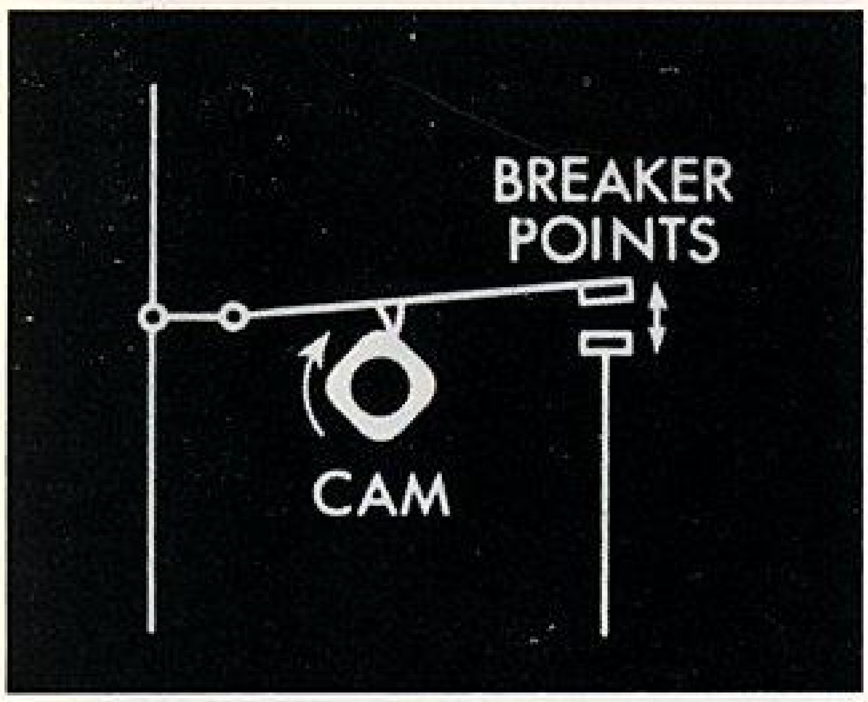
The object of the system is to get the battery to furnish enough voltage to make a spark jump across the gap of the spark plug electrodes.



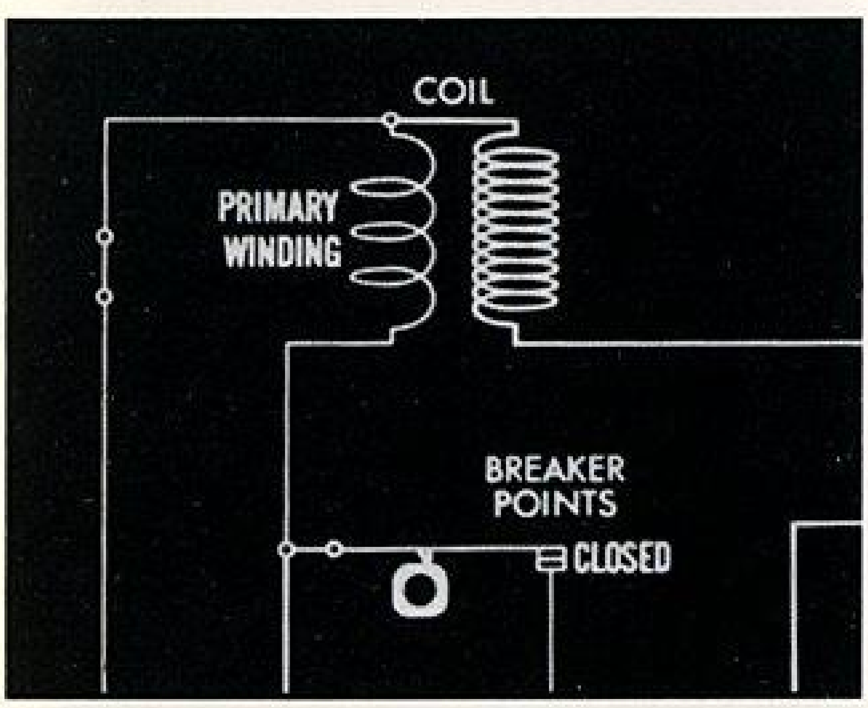
But a modern automobile battery puts out only 12 volts, far too little to cause this to happen, so we have to find a way to increase the voltage many times.



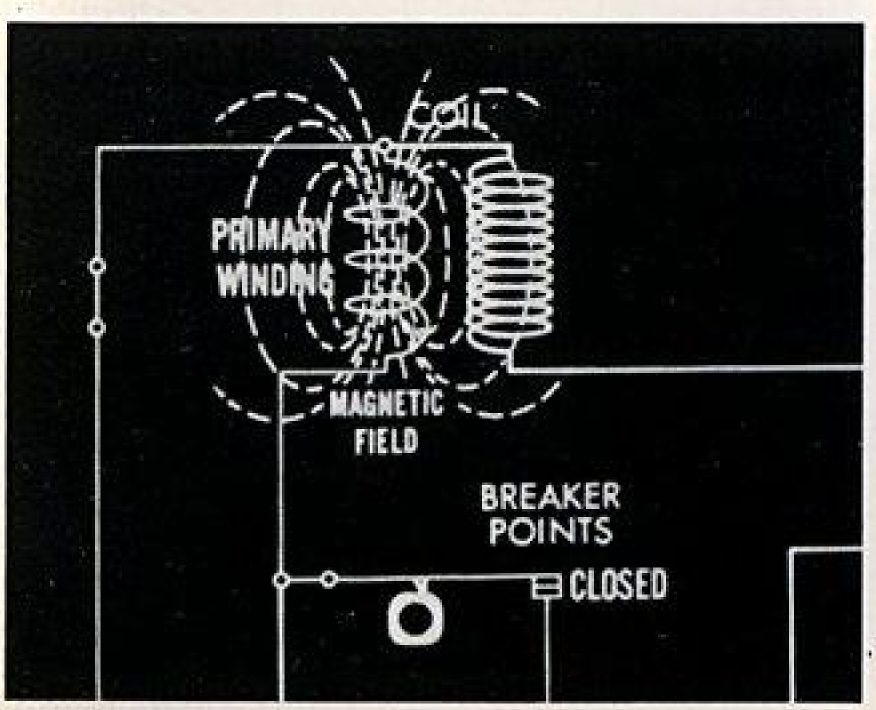
The voltage is increased by the coil working with the breaker points. As the ignition switch is turned on, current flows from the battery, through the primary winding of the coil, and through the breaker points when they are closed.



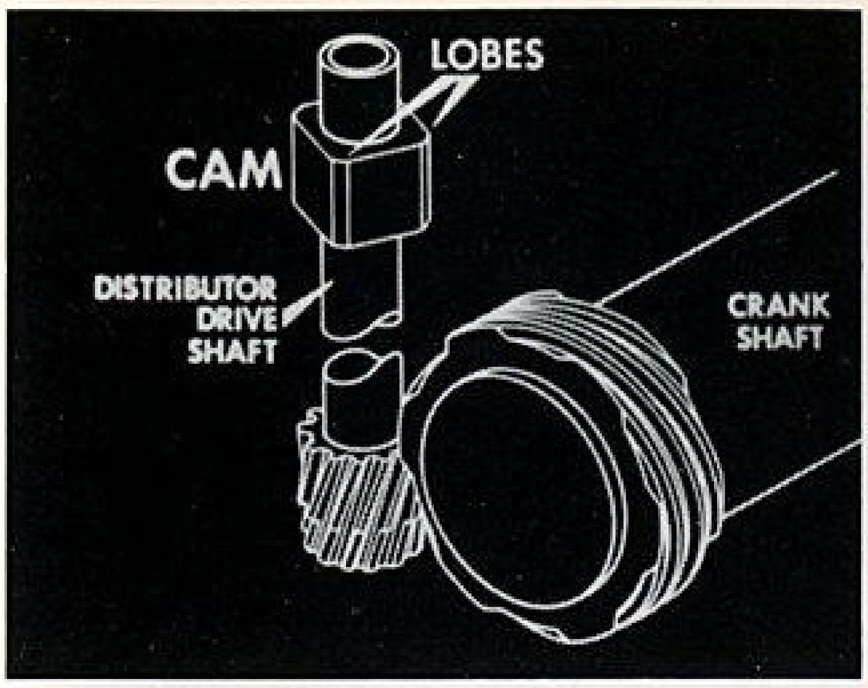
The points are opened and closed by a cam which revolves at half crankshaft speed as the engine is turned over.



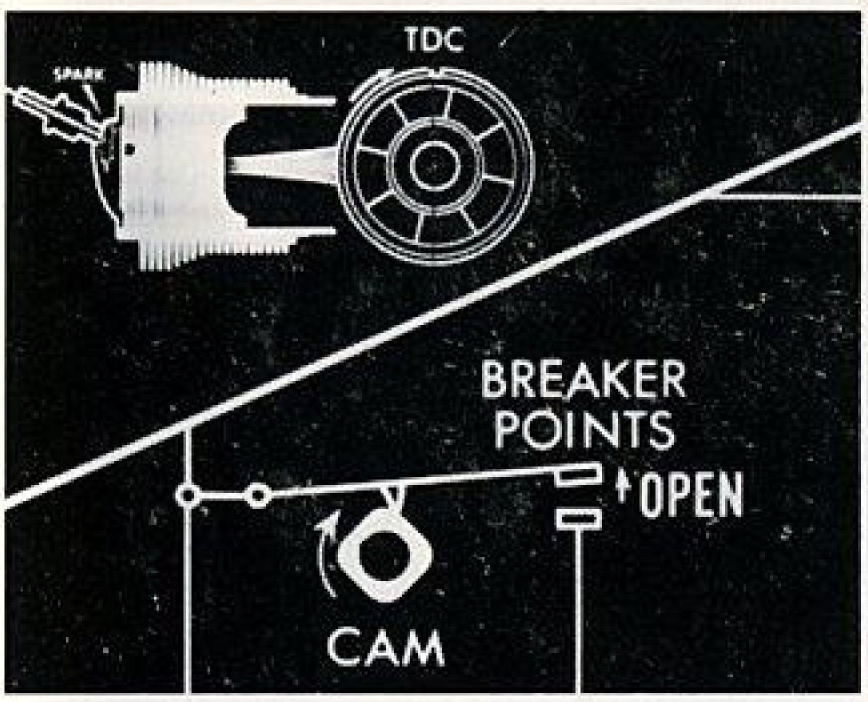
With the points closed, the ignition circuit is completed and a . . .



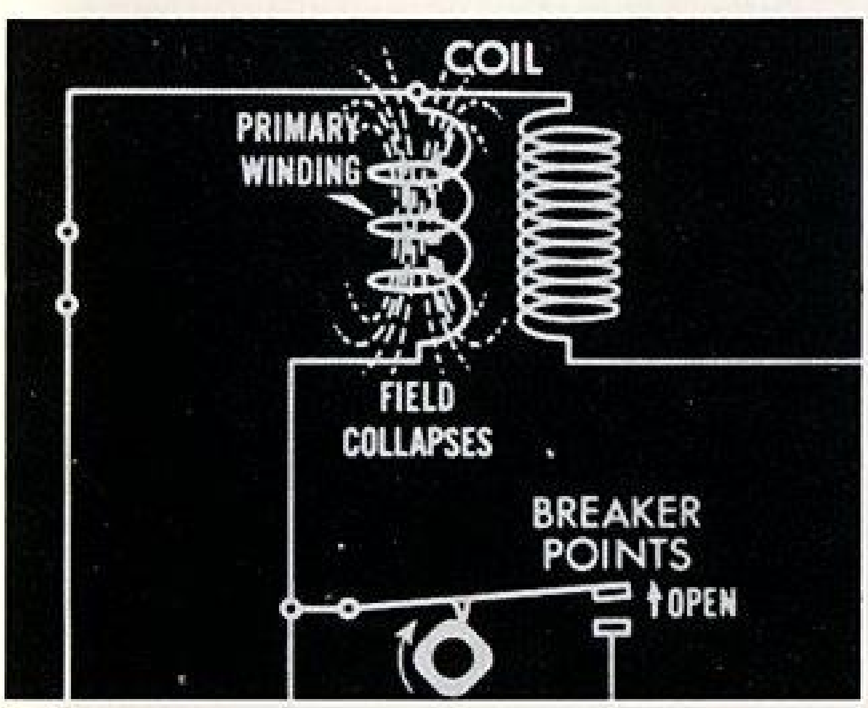
. . . magnetic field is set up in the primary winding of the coil. Any change in this field will induce a high voltage current in the secondary winding, because it has many more turns than the primary.



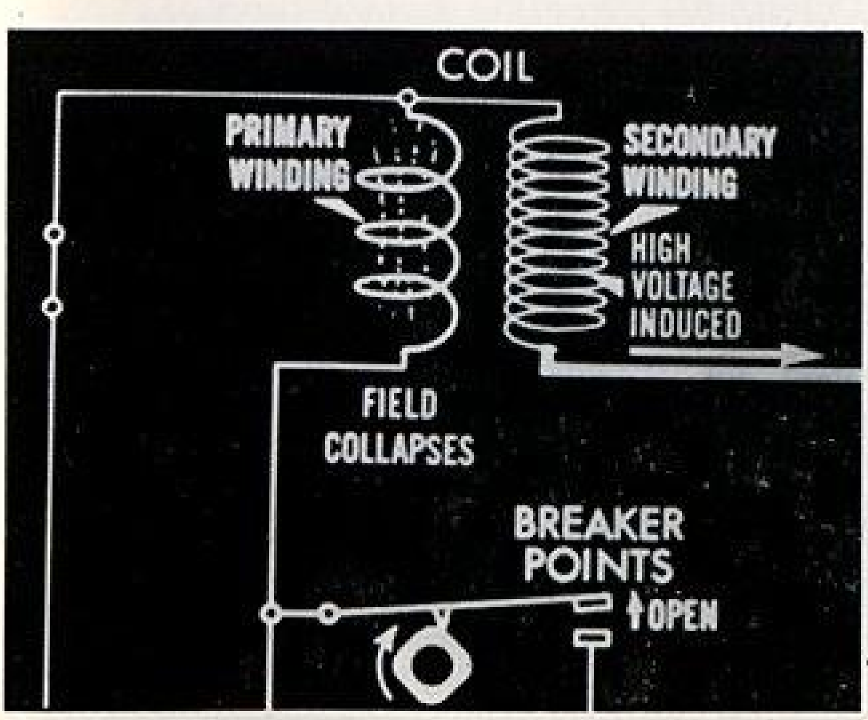
The cam has 4 lobes, one for each cylinder. It is at the end of the distributor drive shaft which in turn is driven by the engine crankshaft.



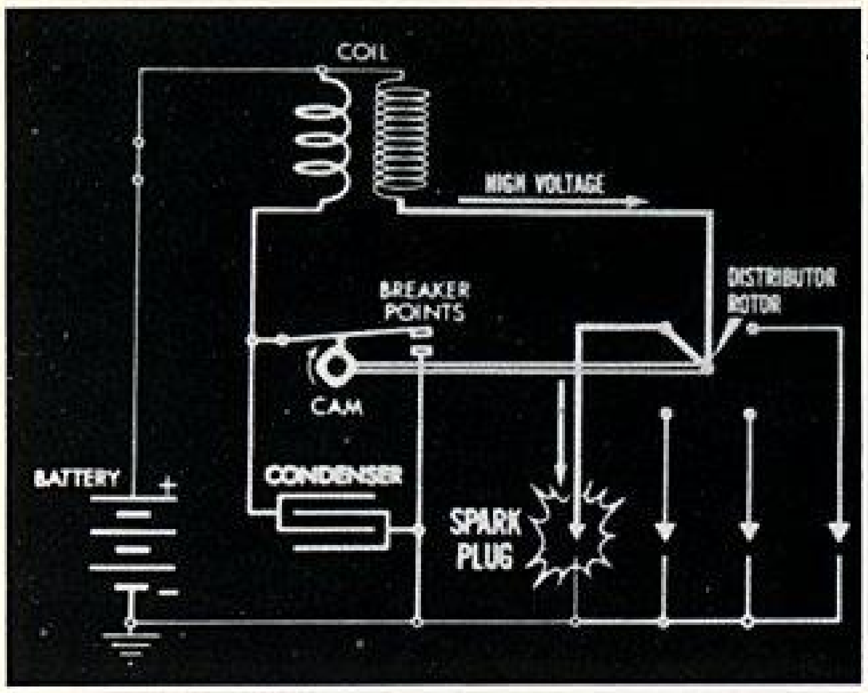
It is so linked with the crankshaft that each time a piston reaches approximately Top Dead Center of the compression stroke, one of the cam lobes opens the ignition points.



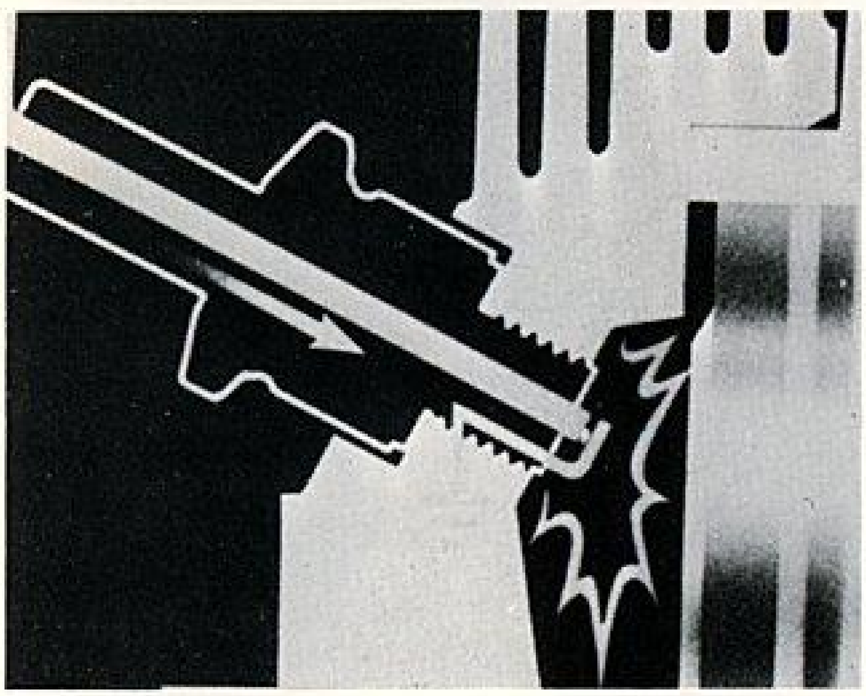
When the points open, current stops flowing through the primary winding, and the magnetic field suddenly collapses.



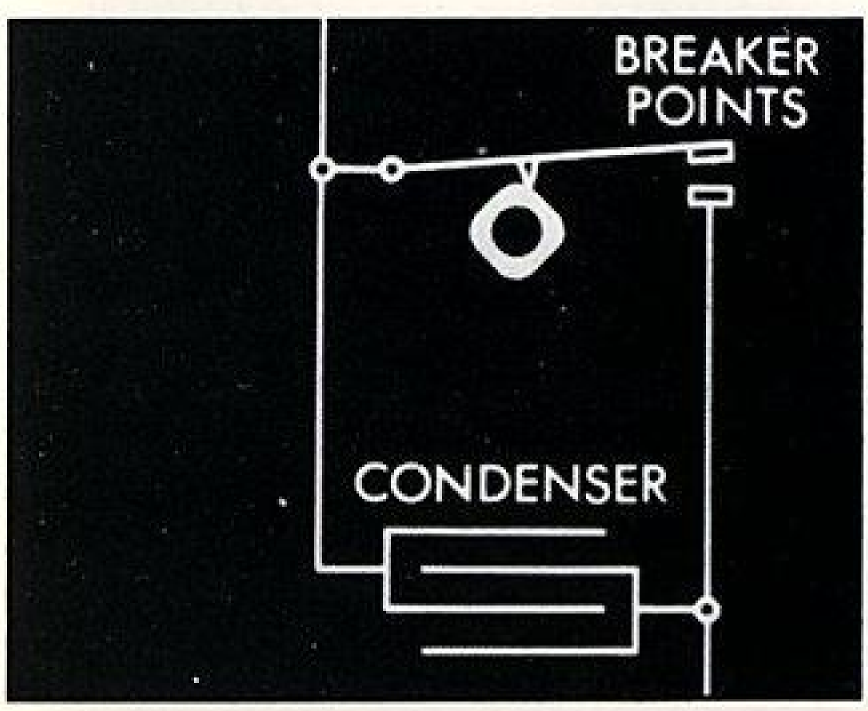
The magnetic field collapses inwards; as it collapses, it induces a high voltage current in the secondary windings, because there are many more turns in the secondary.



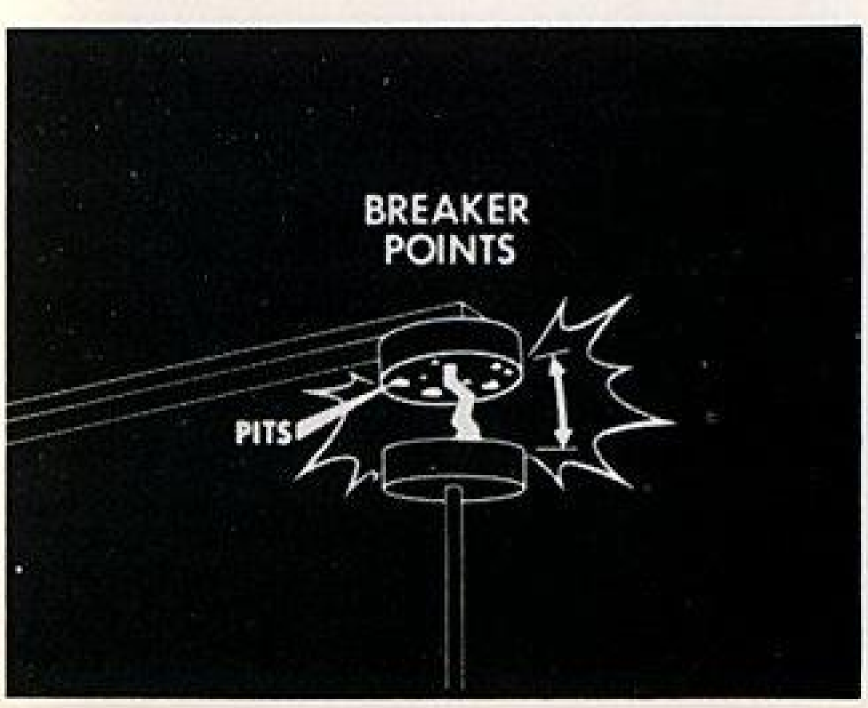
The high voltage, as much as 23,000 volts, now goes to the distributor rotor which is keyed to the breaker cam so that they operate in synchronization. At the same time the breaker points are open, the rotor is in contact with one of the four terminals connected to a spark plug.



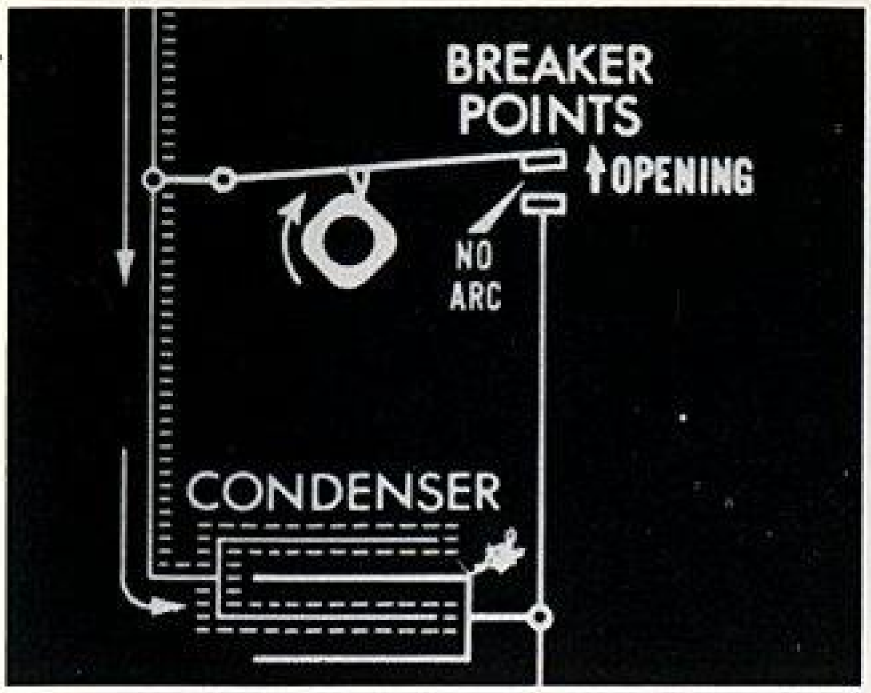
The current then flows down the center of the plug, jumps the gap between the electrodes to produce a hot spark and is grounded to the engine block.



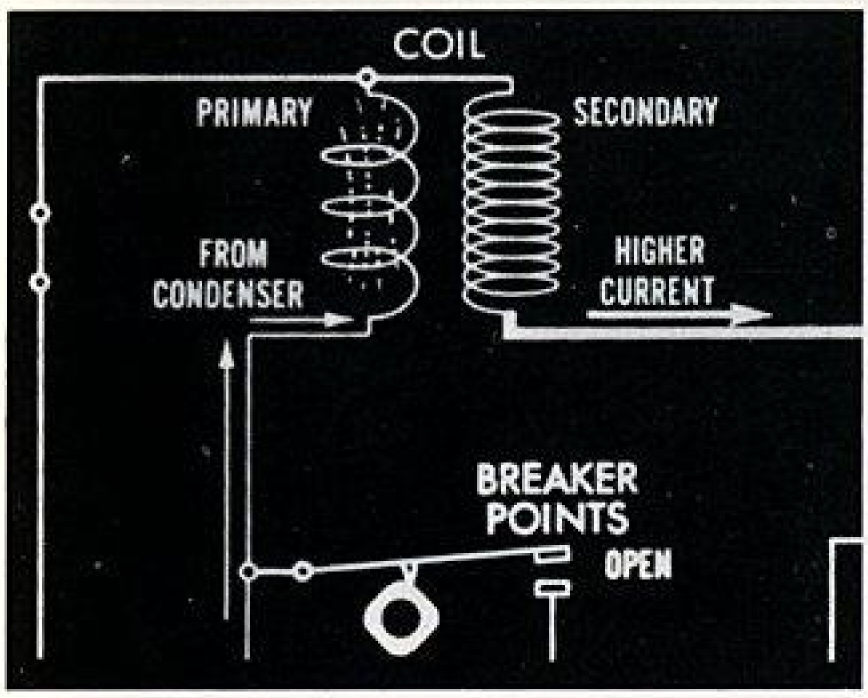
One very important component in creating the high voltage current which fires the fuel-air mixture is the condenser. The condenser is connected across the ignition breaker points. It has two functions.



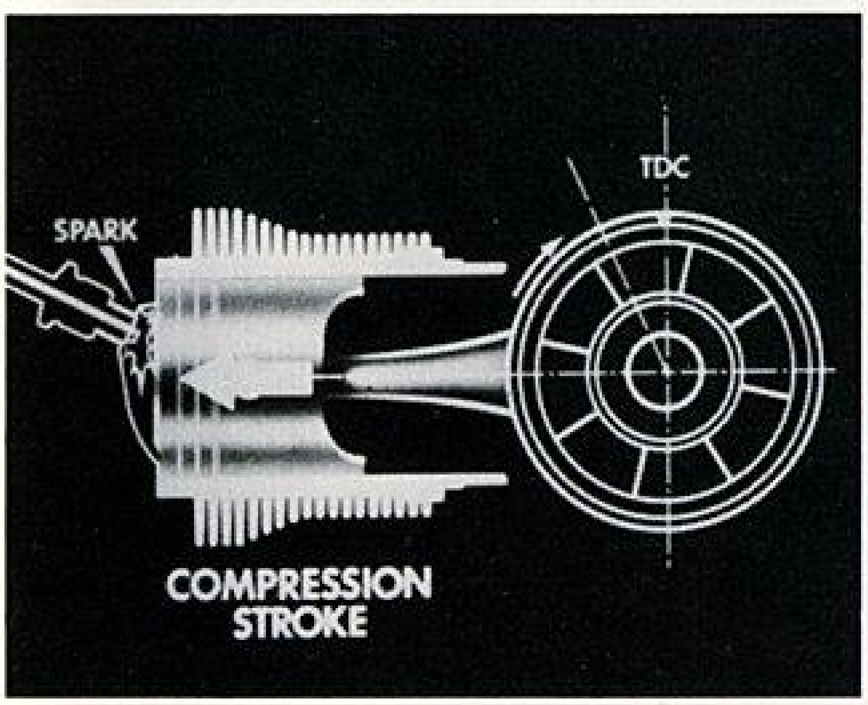
First, as the breaker points open, they tend to arc. This may cause the breaker points to pit or burn.



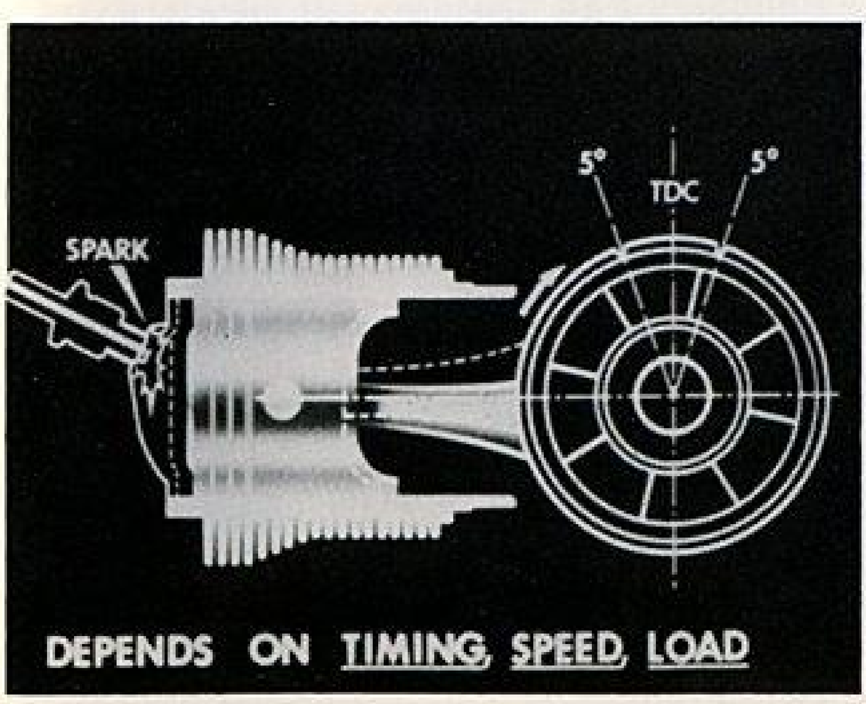
The condenser provides a place for the current to go during the first instant that the breaker points separate, so that it doesn't arc across the opening points.



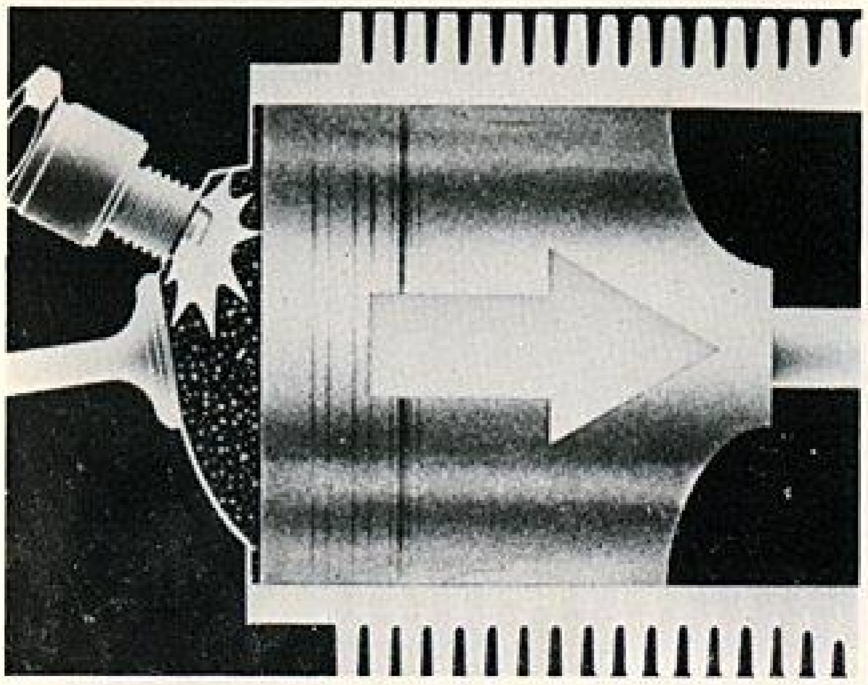
Second. After the points have separated and there is no longer any danger of an arc, the current that has been stored in the condenser flows back into the coil, opposing the primary magnetic field which is already collapsing. The faster the field changes, the higher will be the current induced in the secondary.



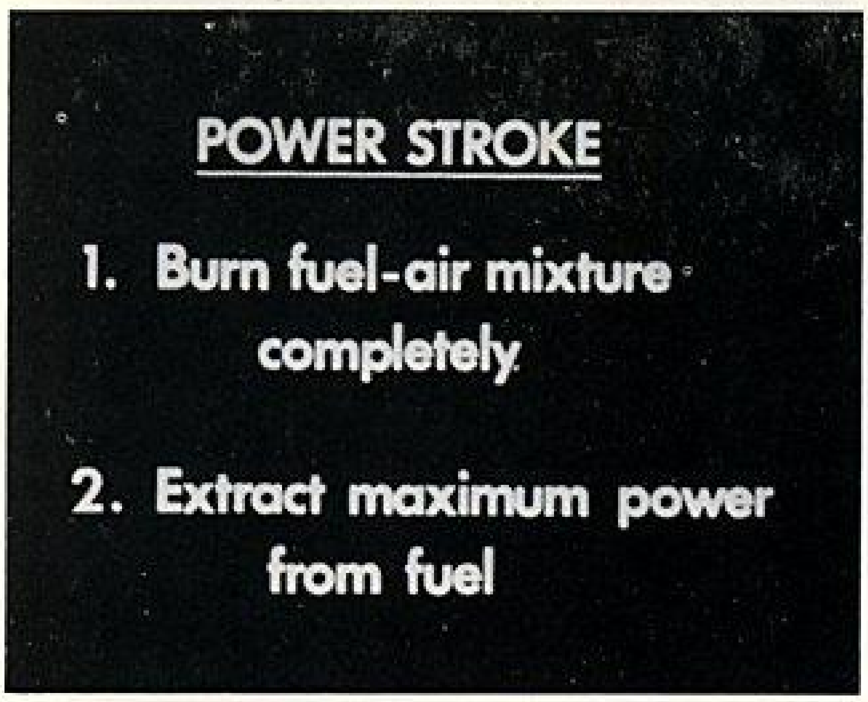
The spark should jump the gap between spark plug electrodes when the appropriate piston is at its firing point in the compression stroke.



Where the piston is in relation to Top Dead Center when the spark occurs, depends on how the timing is set and how the automatic advance-retard controls work in response to engine speed and load.

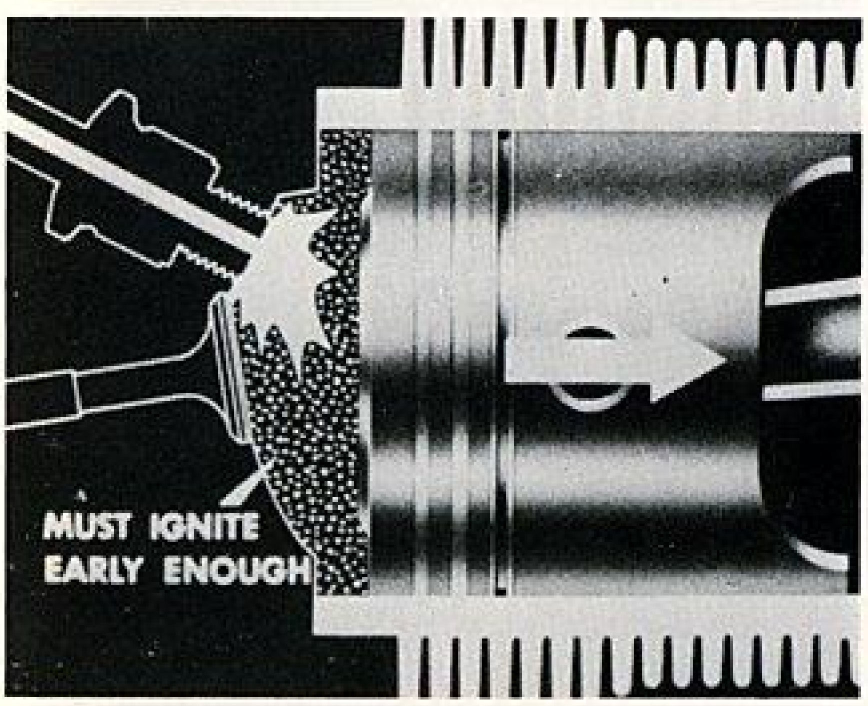


It is obvious that the spark should occur at exactly the right time to ignite the fuel-air mixture so that it burns as efficiently as possible. But why should this timing vary?

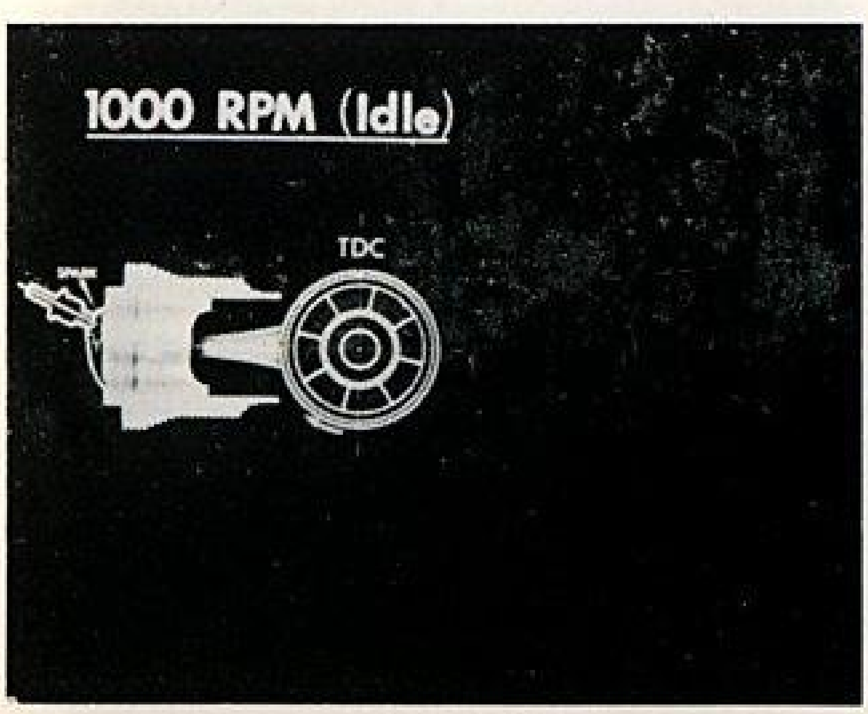


Let's examine what goes on within a cylinder on its power stroke. Well basically, we're attempting to do two things:

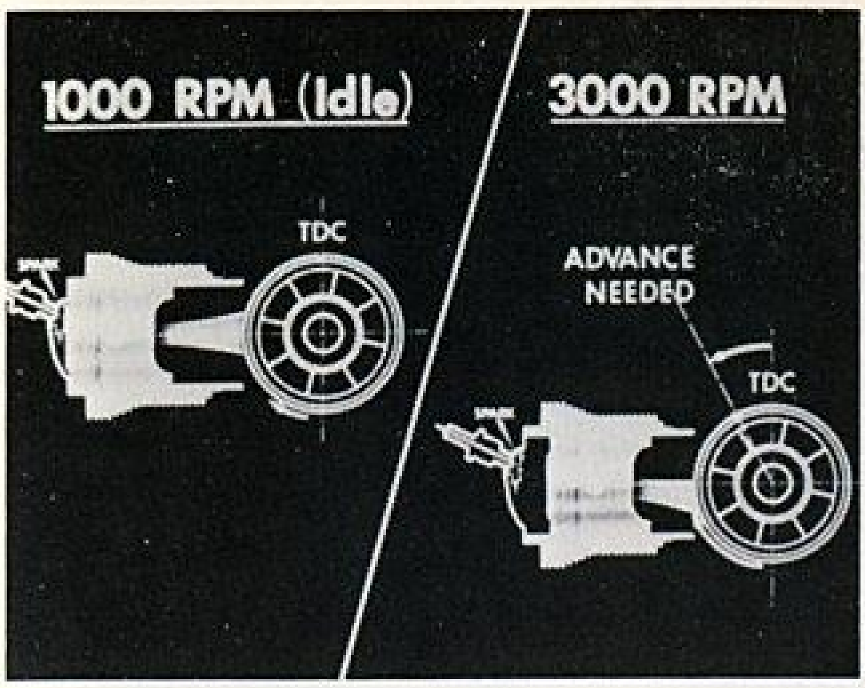
1. Completely burn the fuel-air mixture inside the cylinder for clean emissions.
2. Extract the maximum amount of power from the charge in the cylinder.



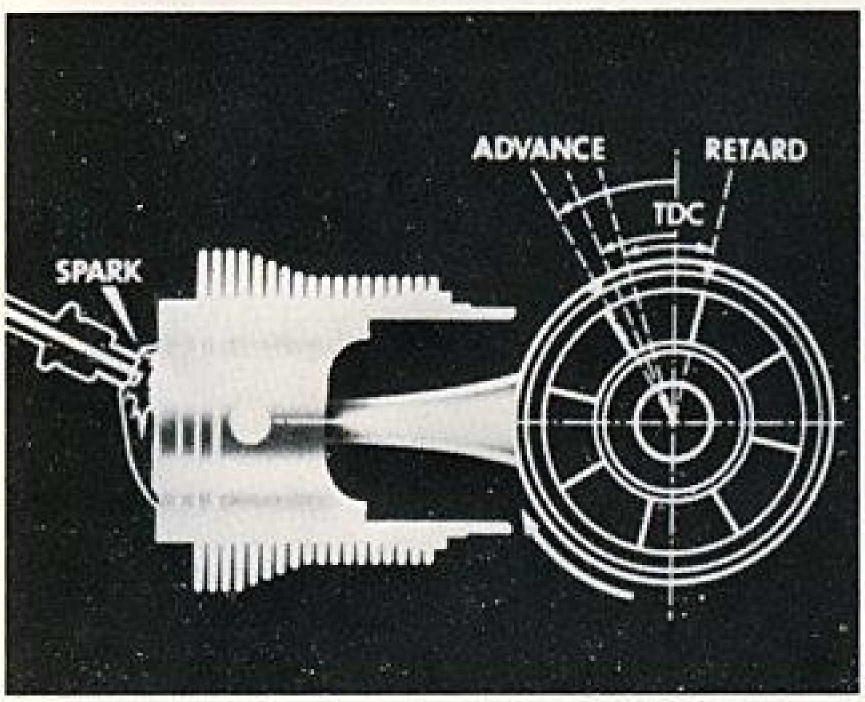
The time taken to develop maximum pressure from a specific fuel-air charge remains constant. So, we must ignite the mixture early enough to assure that as it burns and expands, it develops its maximum pressure at the point in its down stroke where the designer calculates its maximum efficiency to be.



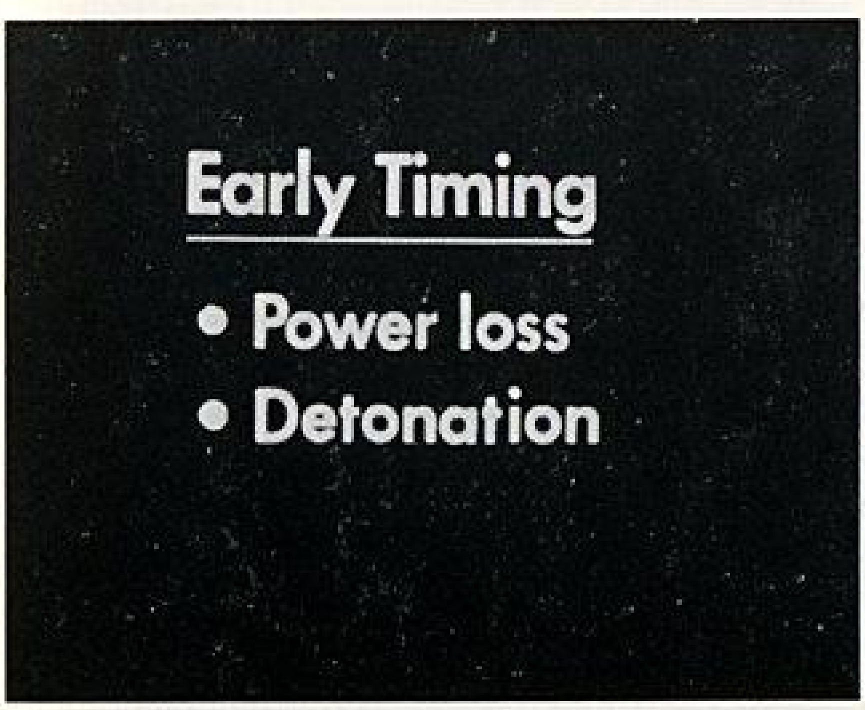
At 1,000 RPM, there is enough time during the power stroke to burn the fuel completely.



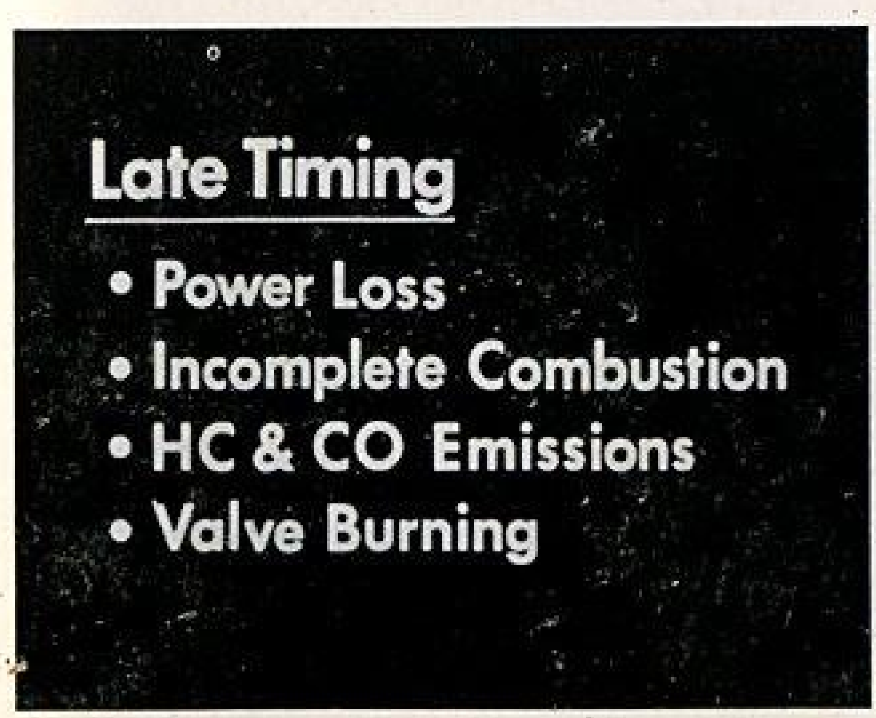
But the time available from Top Dead Center at, say, 3,000 RPM is two-thirds less than at 1,000 RPM. Therefore, in order to have maximum pressure at the correct time at higher RPM, it's necessary to "light the fire" earlier – or advance the ignition timing.



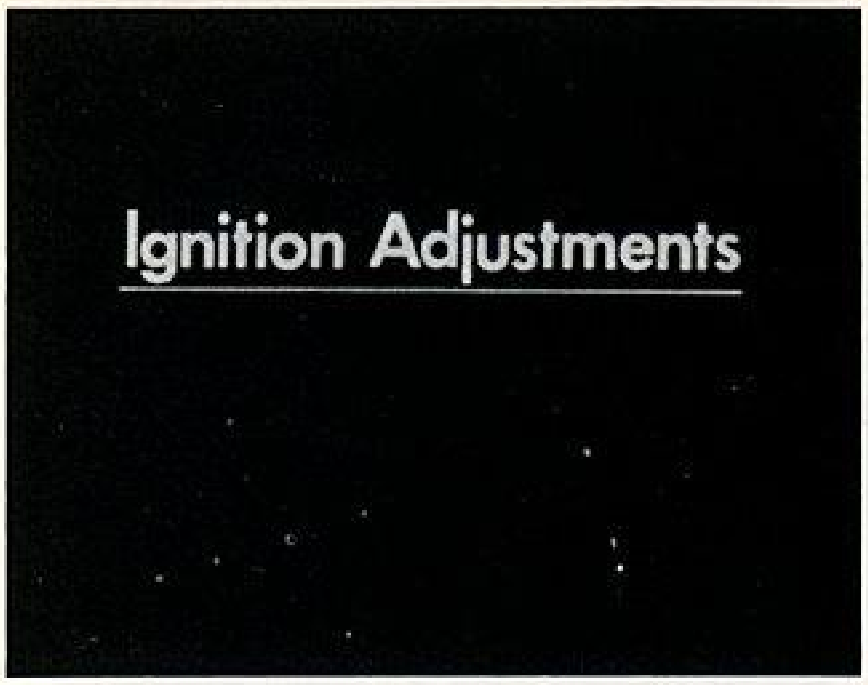
Other combinations of load and speed require different ignition advance settings, and the engine must be capable of adapting to these requirements.



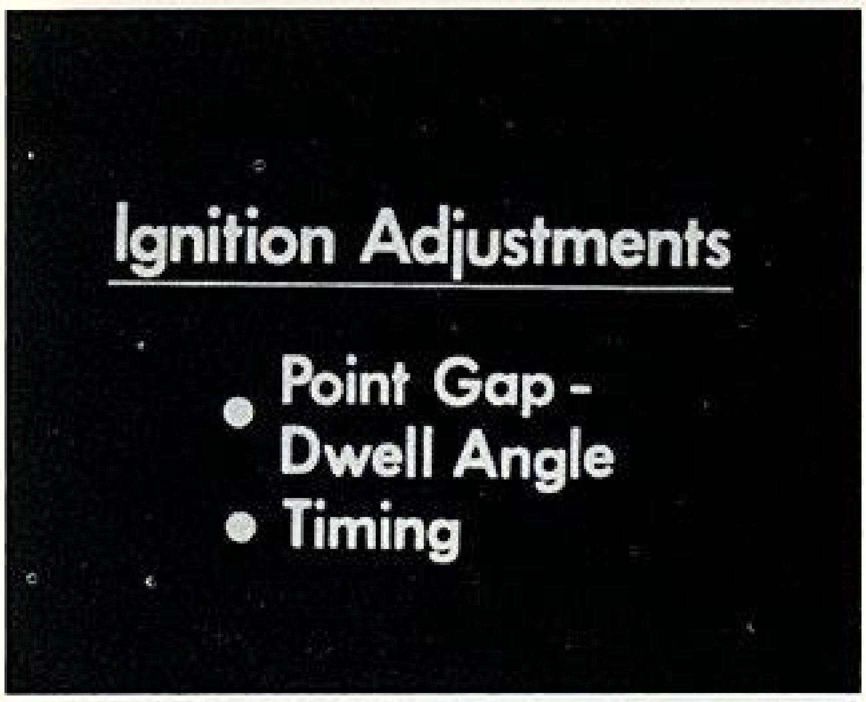
We can summarize incorrect timing in two broad categories. Early timing will mean loss of power and/or detonation, because the engine is fighting itself.



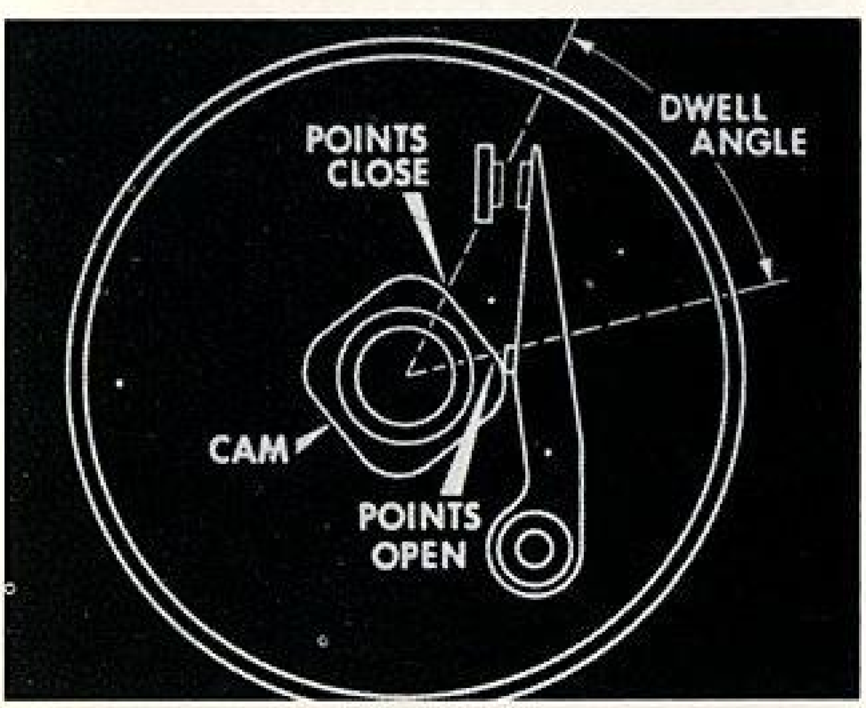
Late timing also means loss of power because of incomplete combustion which in turn means emissions of unburned fuel and carbon monoxide. Also, the exhaust valve will open earlier in the combustion cycle, so the gases passed into the manifold will be hotter and will cause valve burning.



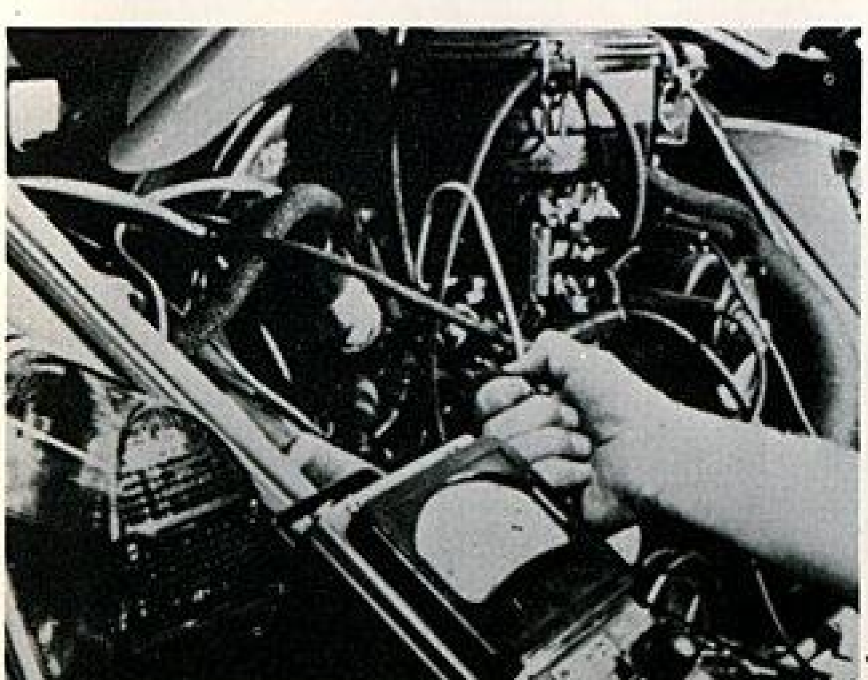
We'll go into advance-retard systems more in detail later, but right now, let's talk about basic ignition adjustments.



As stated before, although there are a lot of steps to take in properly servicing an ignition system, there are basically two main categories. Setting the breaker point gap, or dwell angle, and the timing.

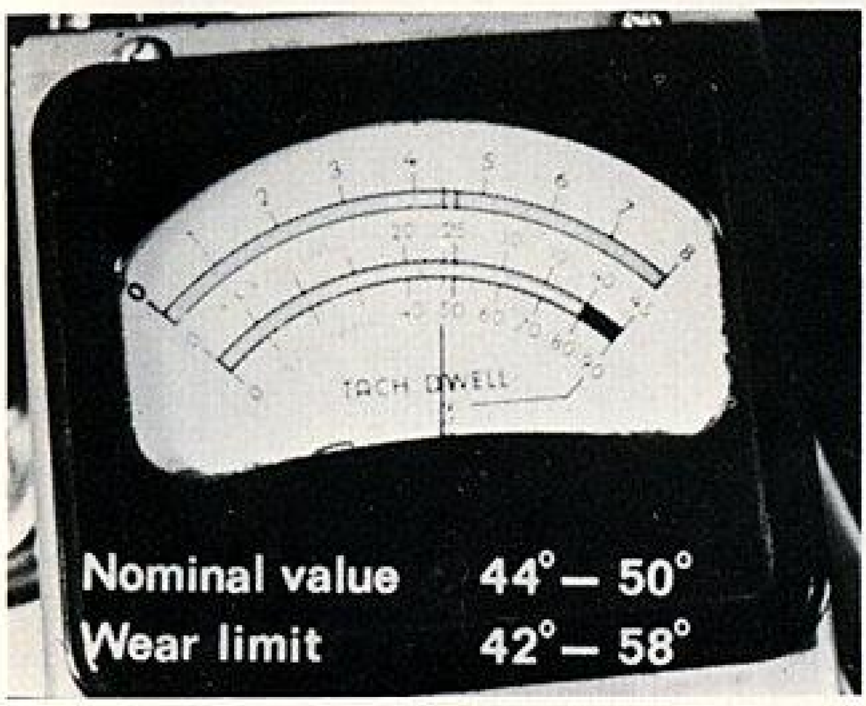


The first adjustment is to set the dwell angle of the breaker points. Dwell angle simply means the number of degrees of distributor cam rotation from the instant the breaker points close until they open again.

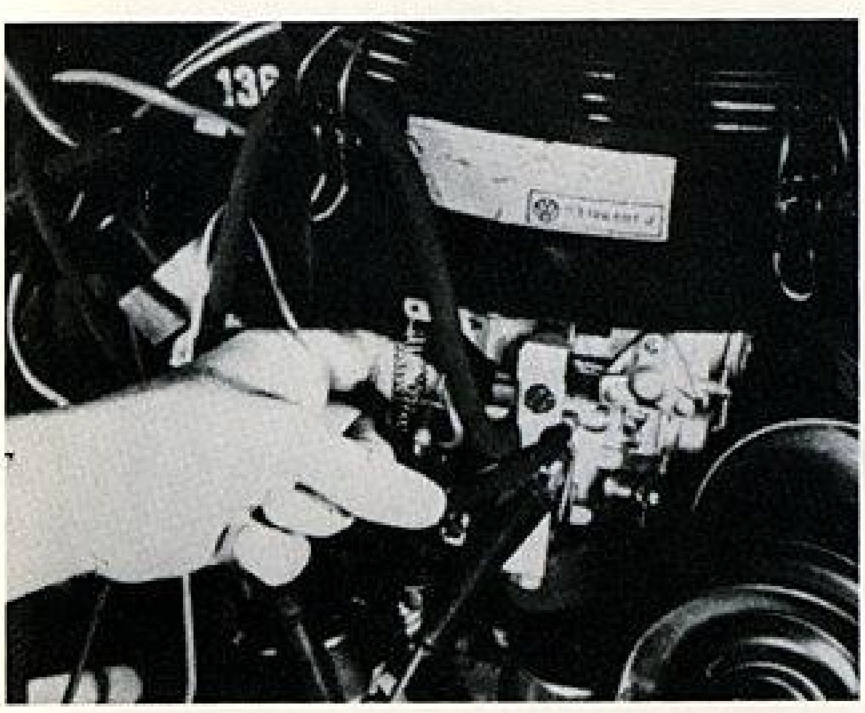


To check, attach a dwell meter between the distributor side of the coil and ground, according to the Workshop Manual or manufacturer's specifications.

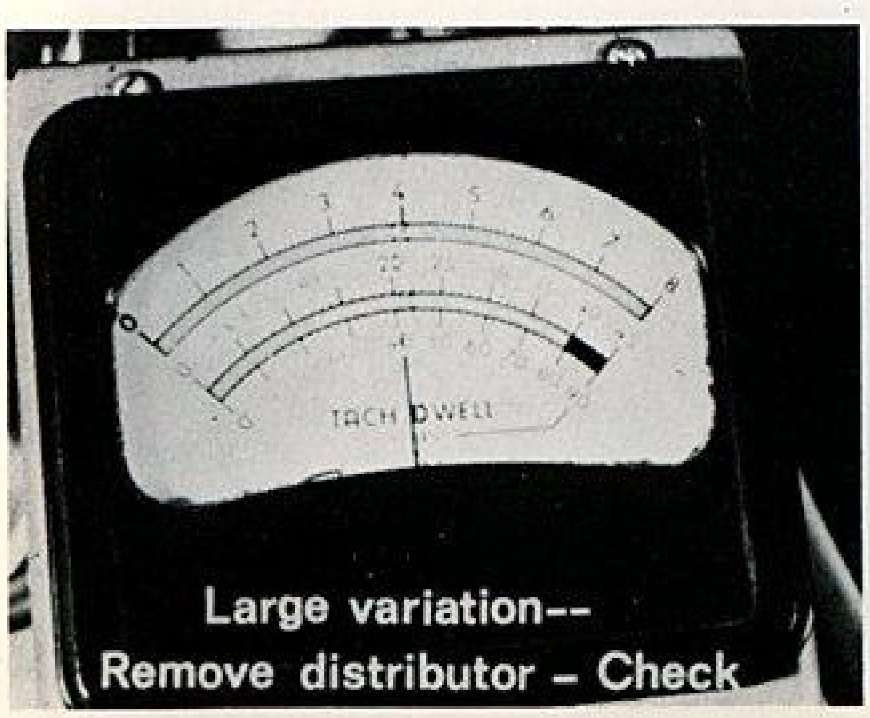
Start the engine and run it at about 1,000 RPM. Read off the dwell angle.



If the points are new, the reading should be between 44 and 50 degrees. Old contacts should not be adjusted as long as the reading is within the wear limit, 42 to 58 degrees.

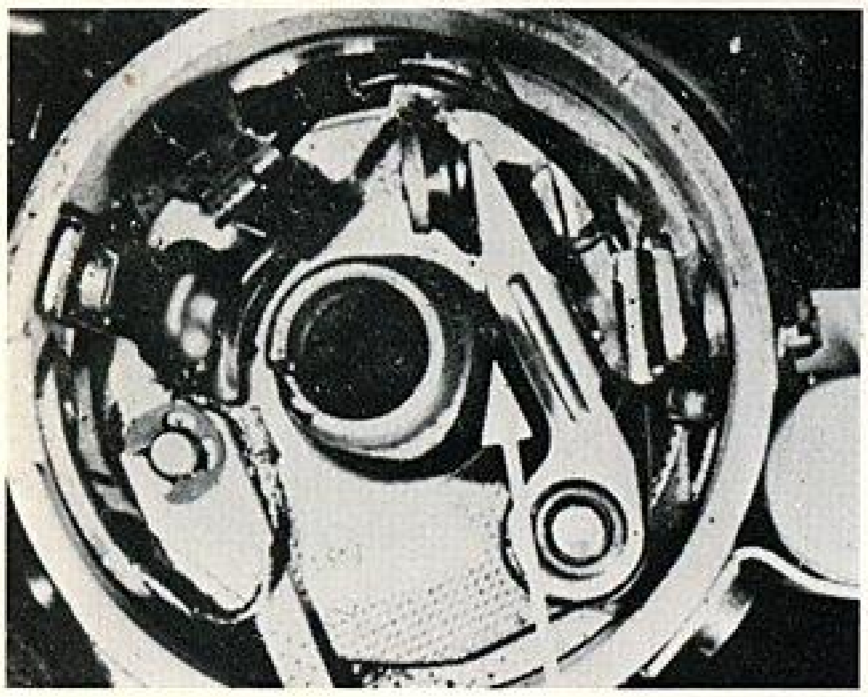


Now, increase the engine speed.

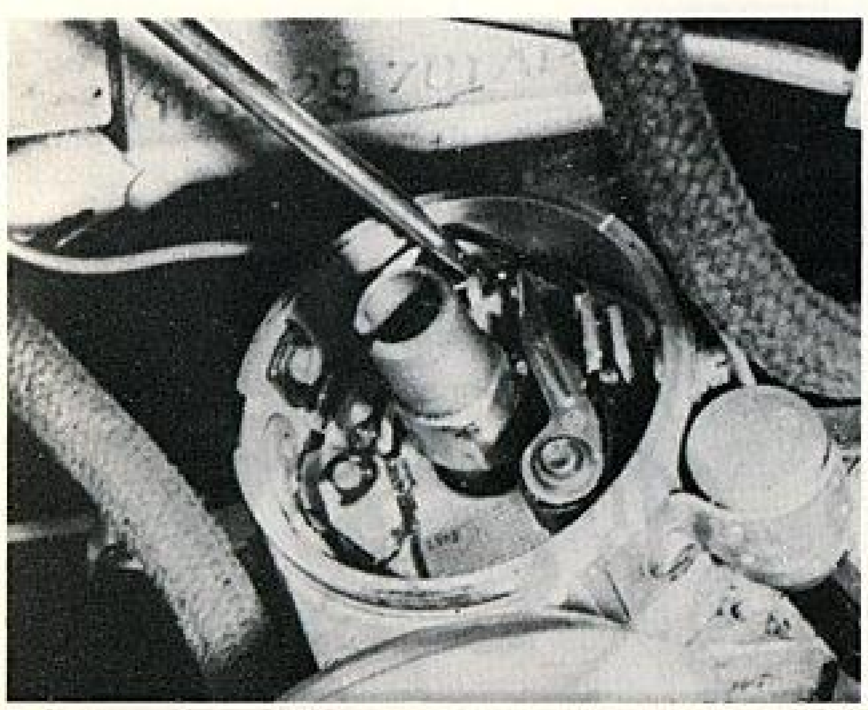


A large variation in the dwell angle indicates distributor shaft wear and the distributor should be removed and checked. If the reading is within limits, no adjustment is necessary.

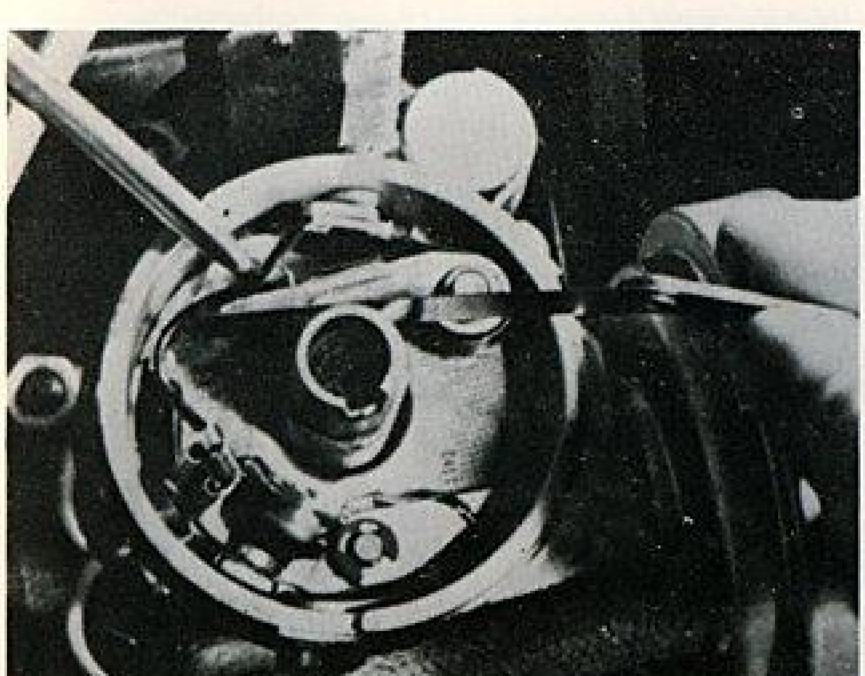
If not, stop the engine and remove the distributor cap and rotor and visually inspect that the points are in good condition. If they are blued or burned, they should be replaced.



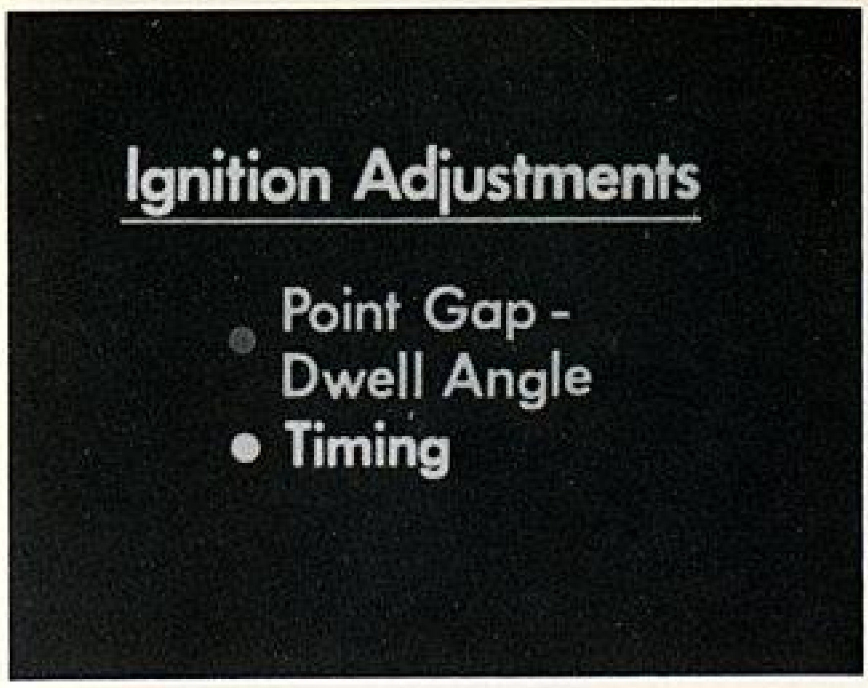
To adjust the points, turn over the engine by hand until the rubbing block is on the highest point of the cam.



After loosening the retaining screw that secures the point assembly, adjust the dwell angle by twisting a screwdriver between the two small pins on the breaker plate and a slot on the point assembly base,

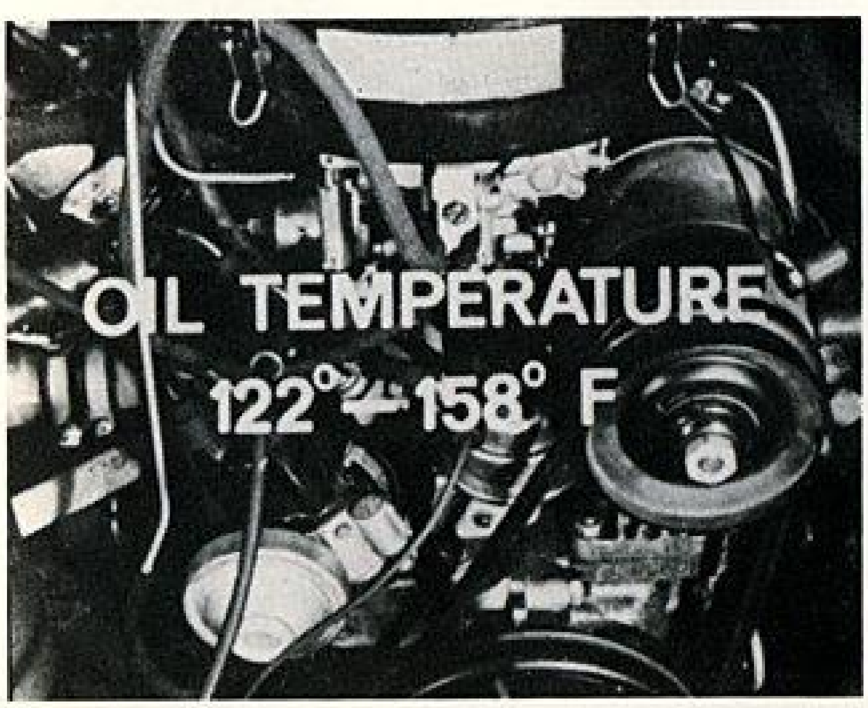


and setting the point gap to 16 thousands of an inch or .4 tenths of a mm. Tighten the retaining screw and again check the dwell angle with the meter.



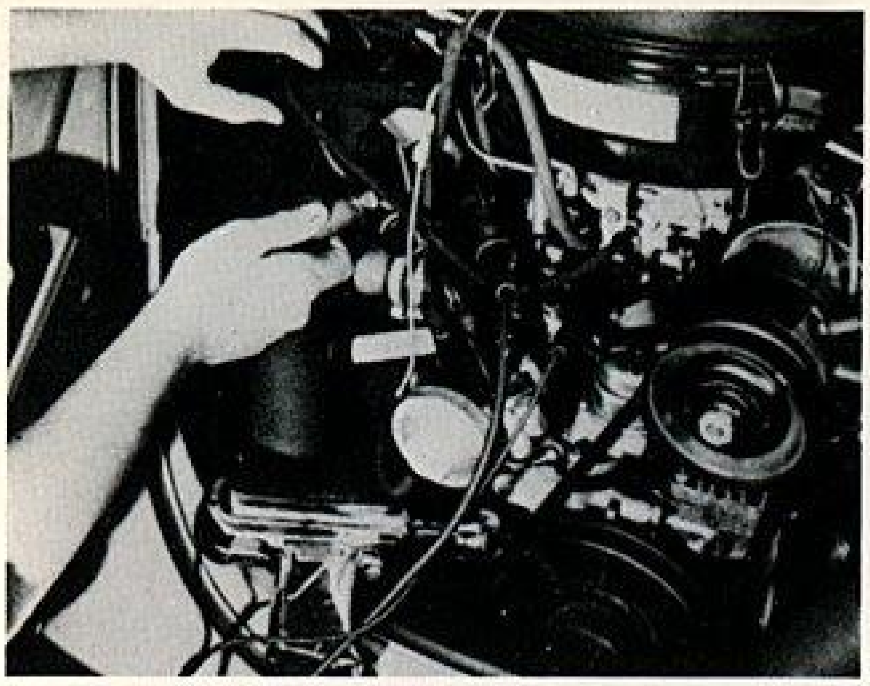
Whenever the dwell angle is adjusted or breaker points changed, engine timing must always be adjusted.

For this operation, a stroboscopic timing light and a tachometer are essential.

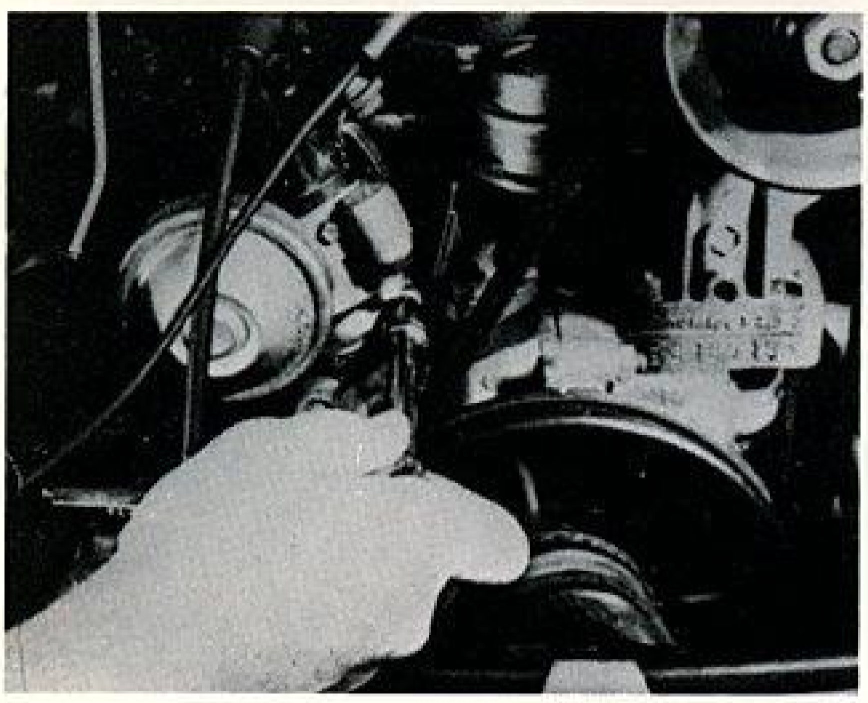


The engine must always be at normal operating temperature, between 122 and 158 degrees F. Otherwise, tolerances will be off, and any adjustment you make will be inaccurate.

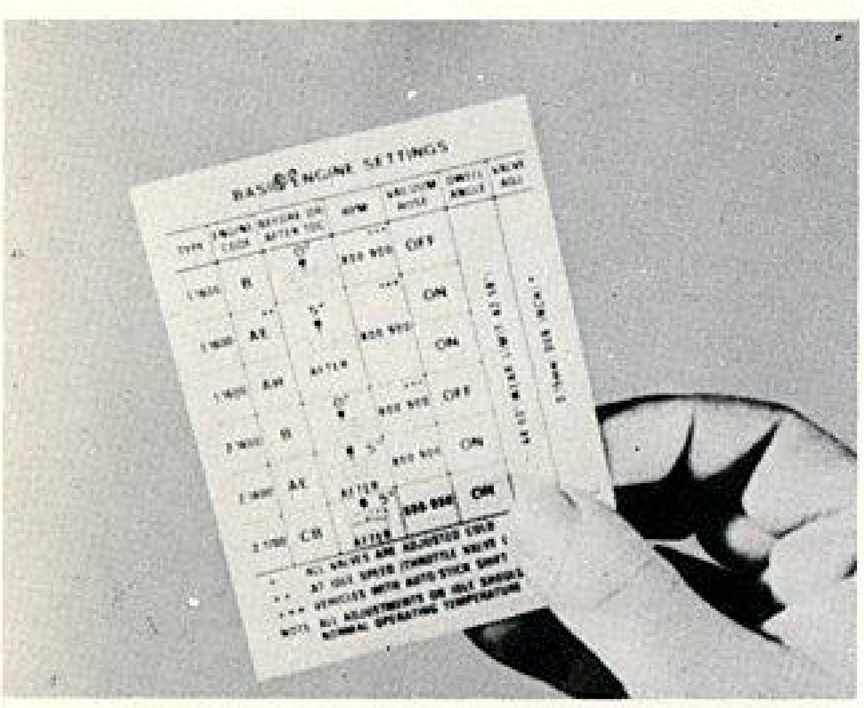
First, connect the timing light as directed in the manufacturer's instructions.



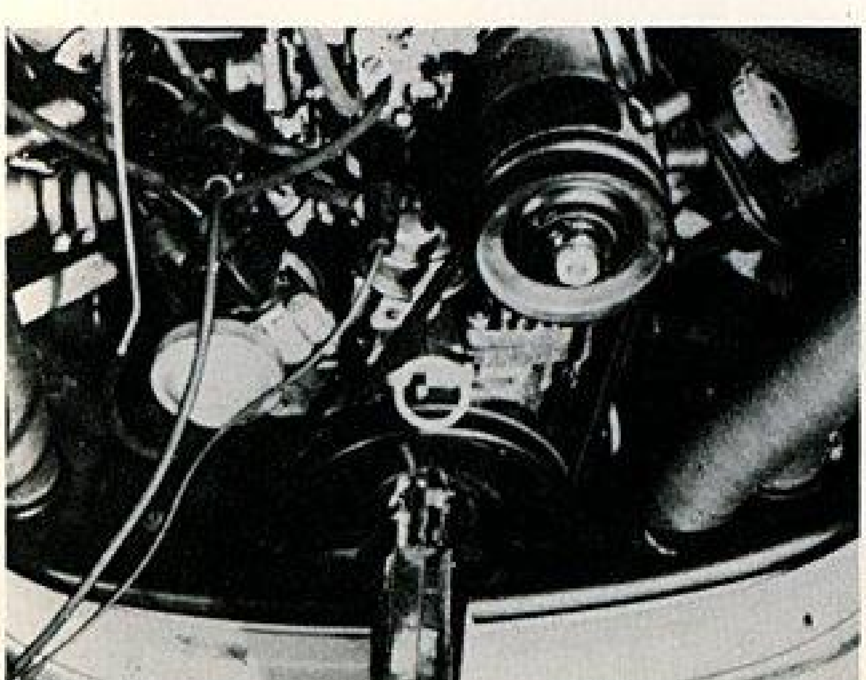
Then connect the tachometer.



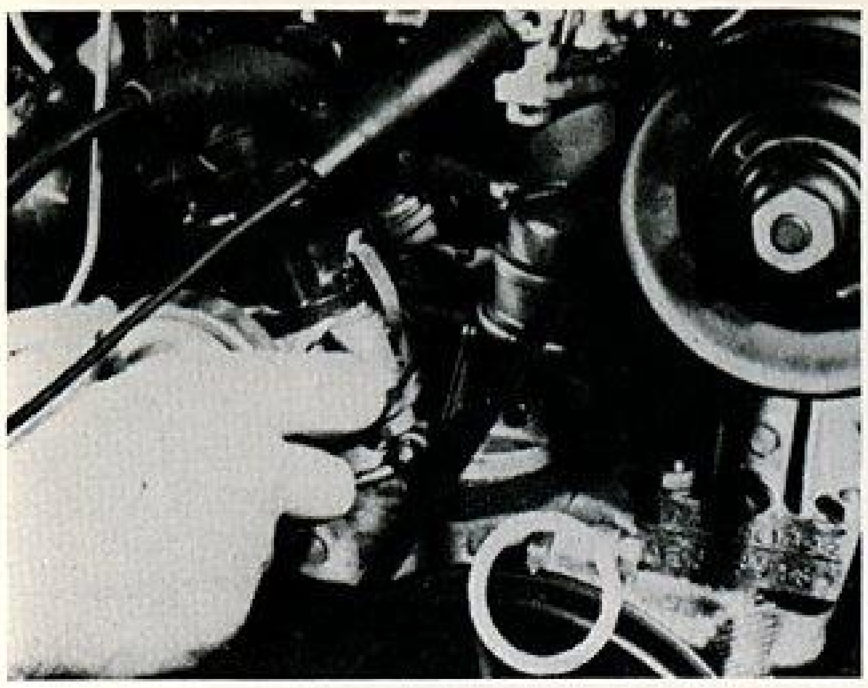
Slightly loosen the nut holding the distributor. Now, start the engine . . .



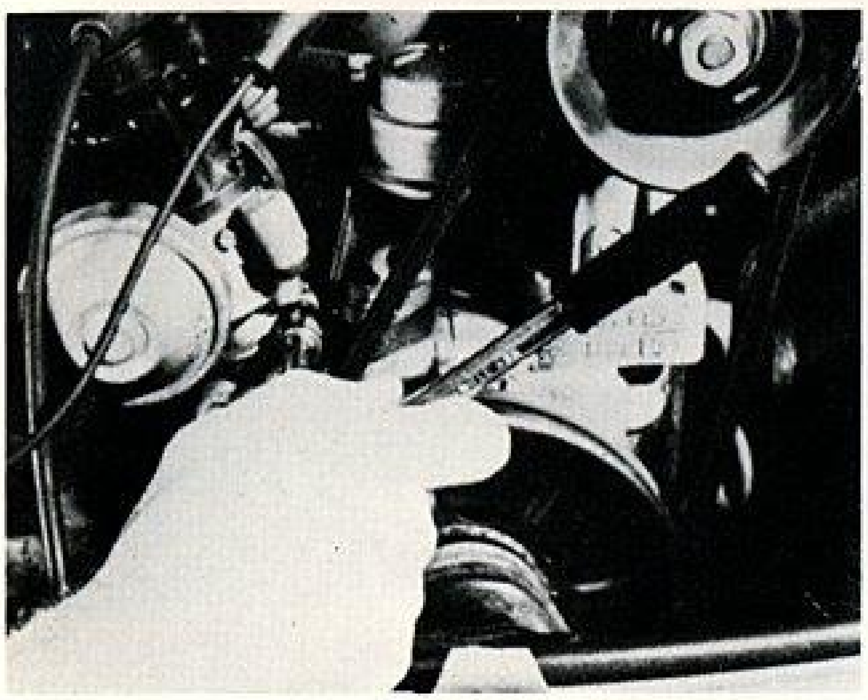
. . . and adjust speed to the correct idle speed, as shown in the specifications.



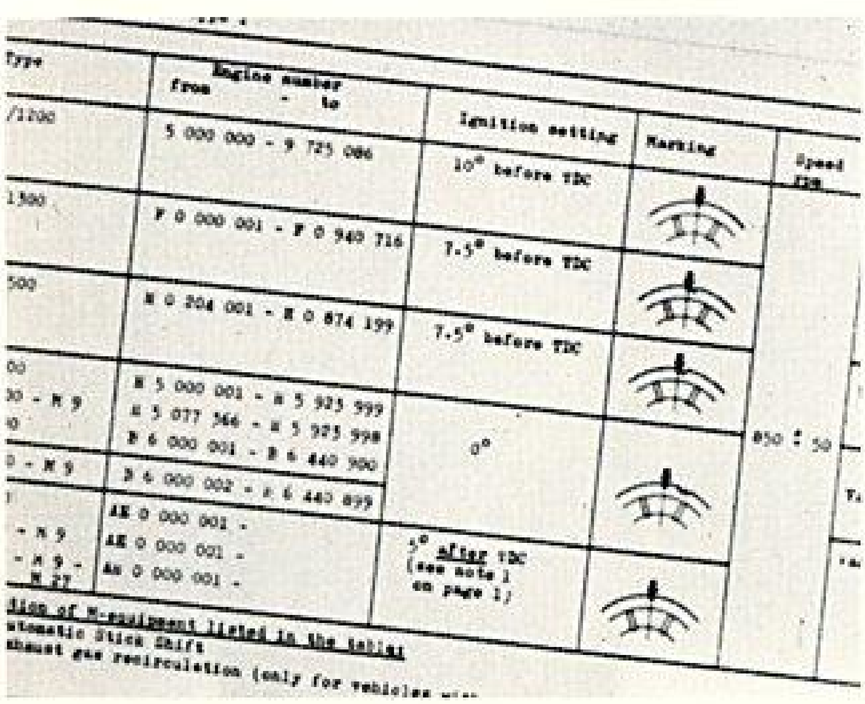
Now, aim the timing light at the split in the crankcase and observe whether the notch is in the proper place. If it is, timing is good.



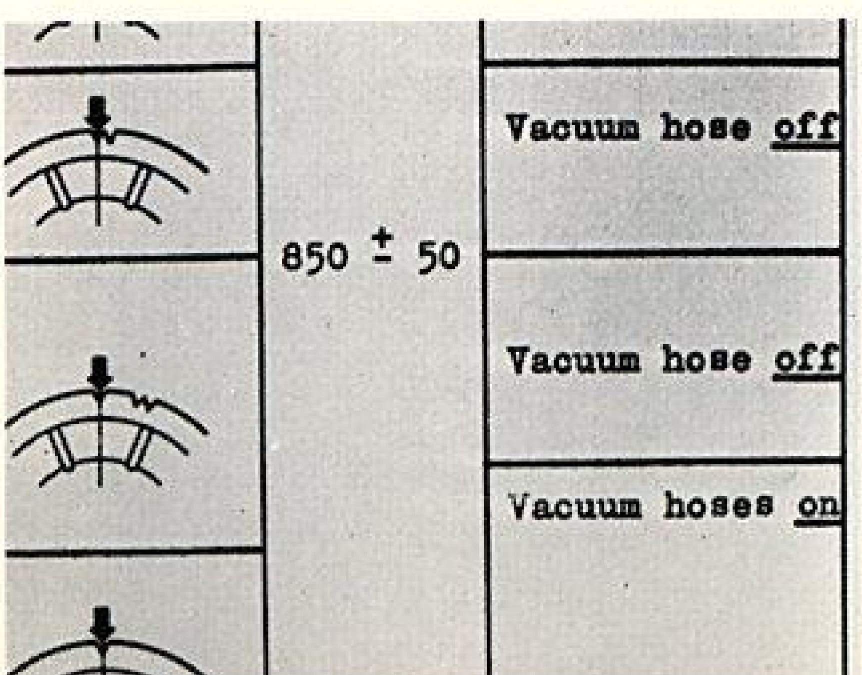
If not, twist the distributor until the notch lines up. Your spark is now firing at factory specifications.



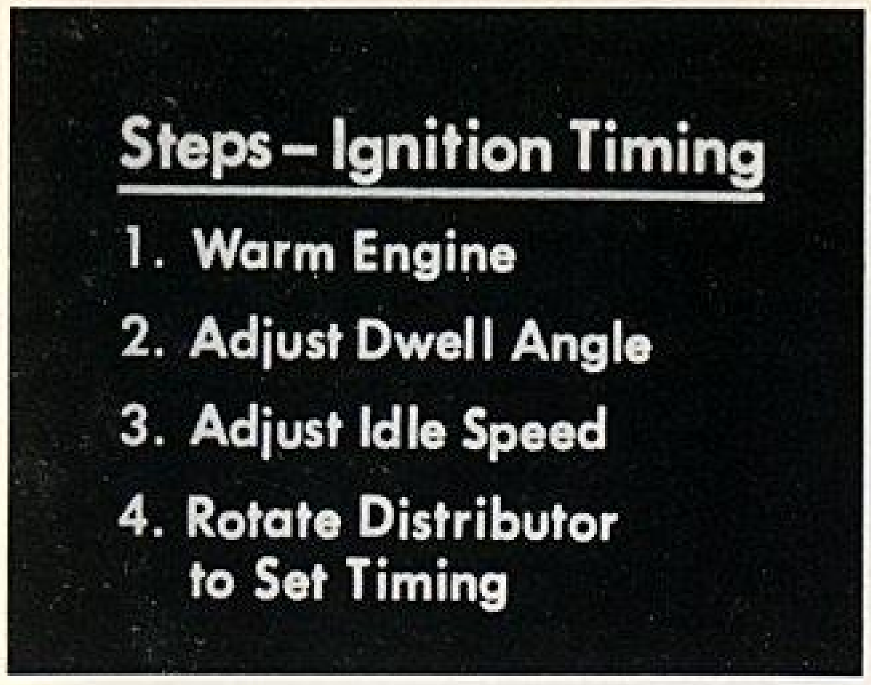
Tighten the nut securing the distributor, and recheck with the timing light. If it has not moved and the idle speed is still correct, the basic timing is completed.



One note of caution. Factory timing specifications change from time to time due to emission requirements and changes in fuel, and some models have more than one mark. Therefore, always check the latest workshop bulletin for the correct timing mark on the pulley.

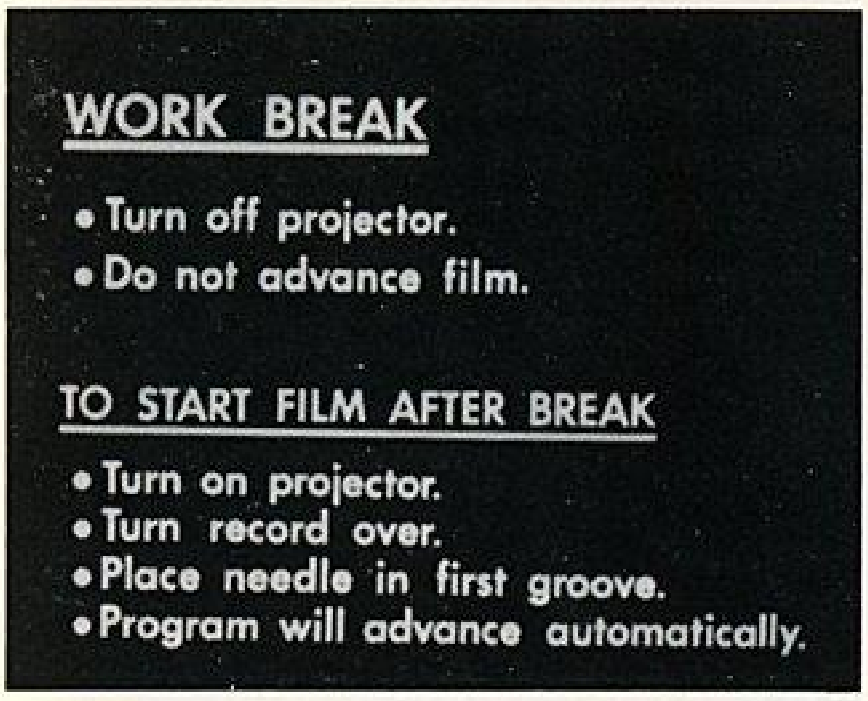


The workshop bulletin will also tell you whether timing is to be done with or without vacuum hoses attached.

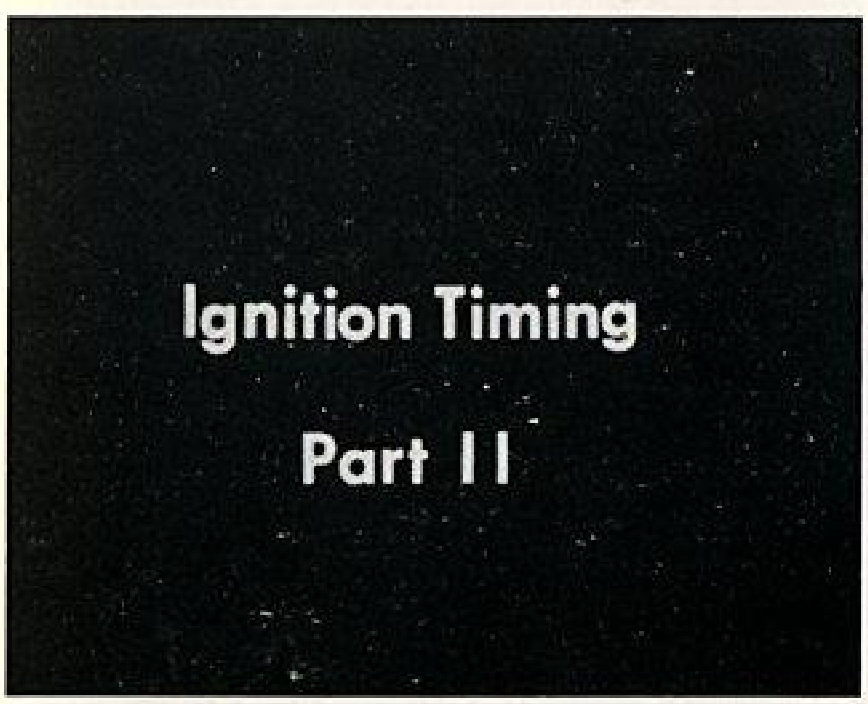


To summarize the steps in timing an engine:

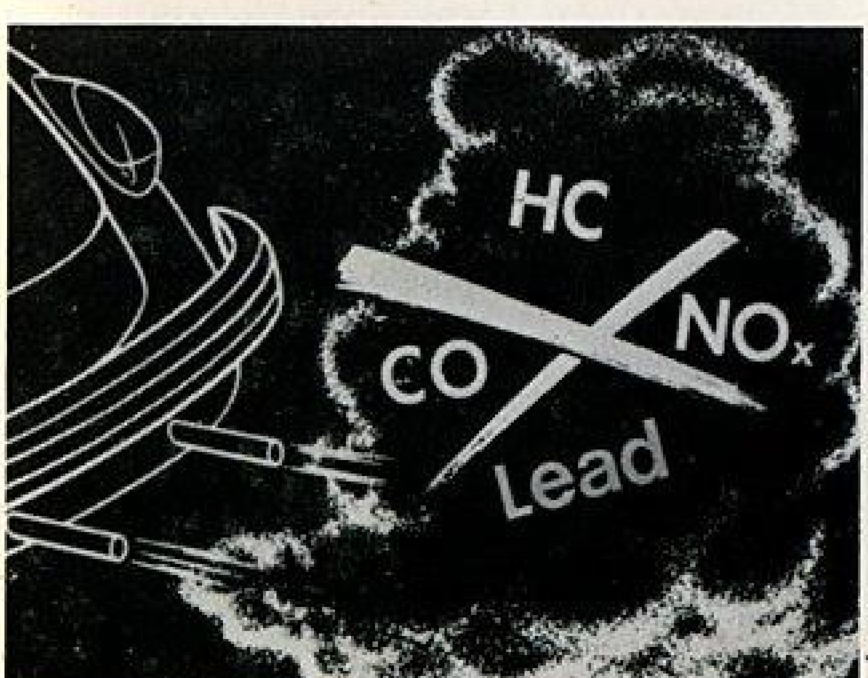
1. Be sure the engine is fully warm.
2. Check the dwell angle and adjust if necessary.
3. Adjust the idle speed.
4. Adjust timing if necessary, by rotating the distributor. (Check the workshop bulletin for the correct timing mark and vacuum hose information.)



(MUSIC UP)

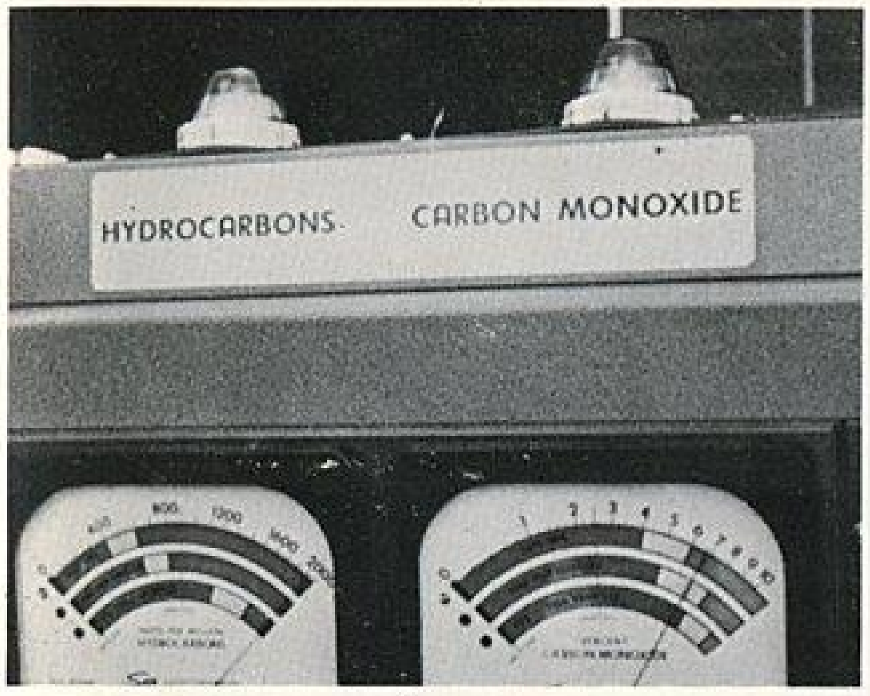


There are several good reasons for being precise and thorough when timing an engine, but today, with the emphasis on ecology and pollution-free air,

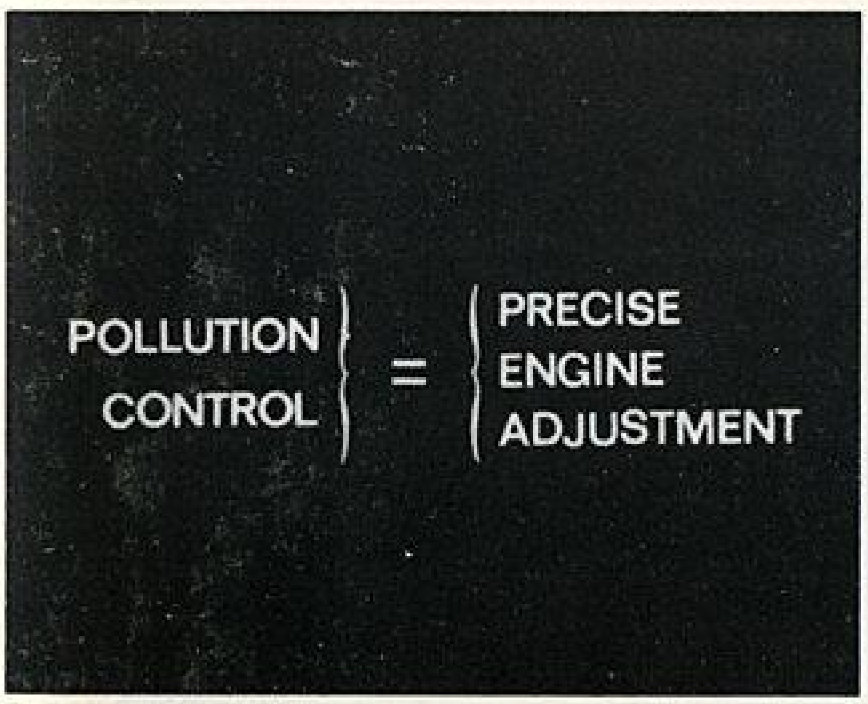


it is more important than ever because many states are inspecting cars and ruling them off the road if they emit too much Carbon Monoxide, Oxides of Nitrogen or Hydro Carbons.

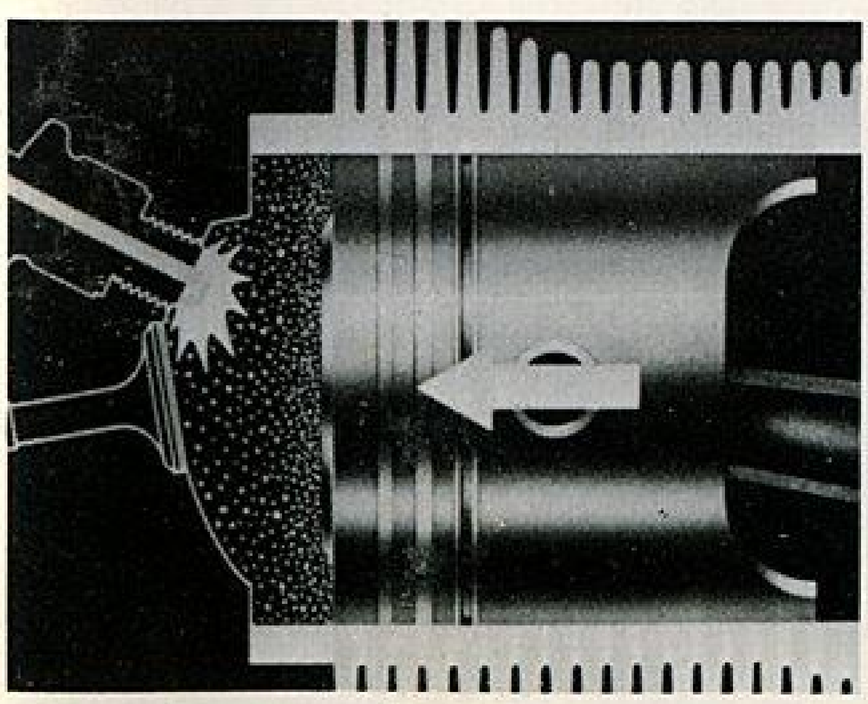
In other words, if the engine adjustments, which include ignition timing, are not done right, your customer may not be able to drive at all . . .



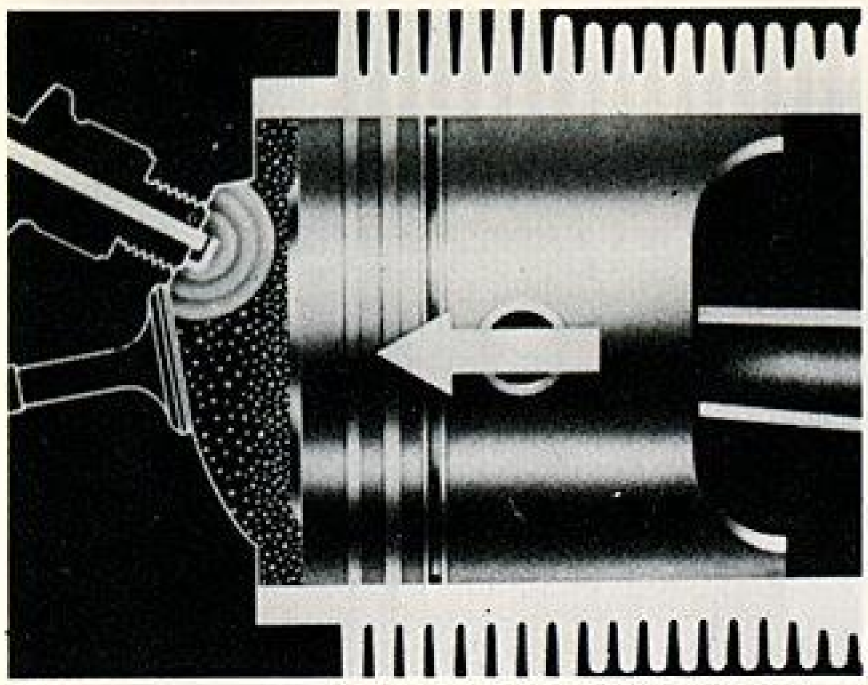
. . . whether he's happy with the way his car runs or not.



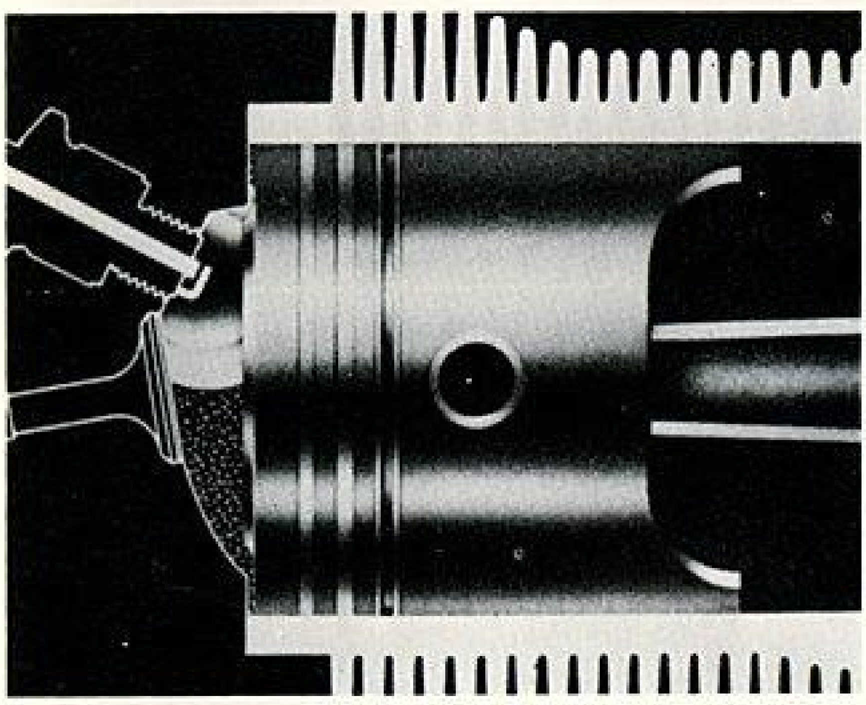
As it happens, our ecological goal – air free of pollution – is reached in the same way we get maximum efficiency from the engine. ADJUSTING THE ENGINE TO PRECISE FACTORY SPECIFICATIONS. Here's why.



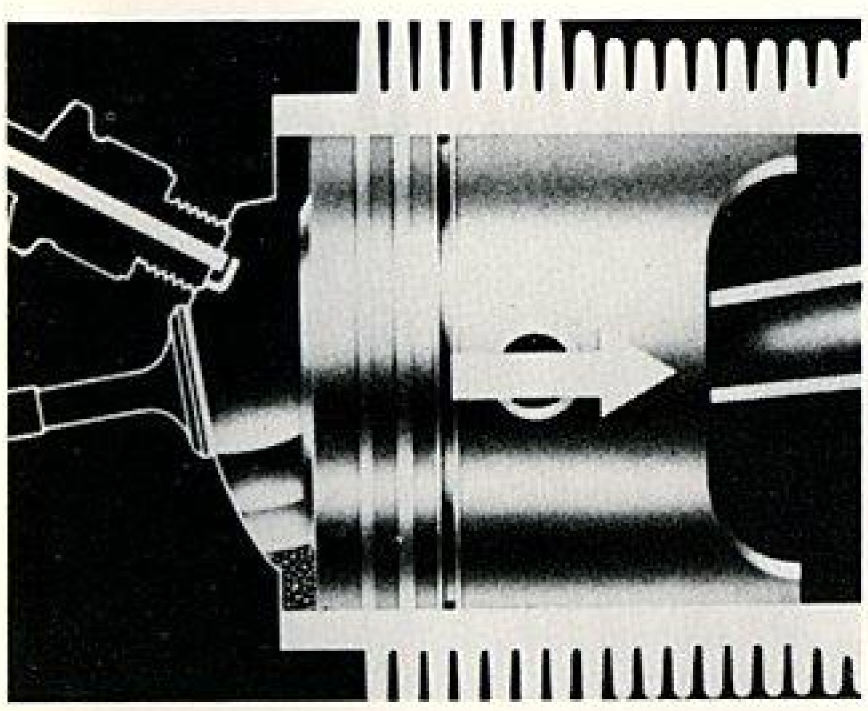
When the ignition and carburetor are both adjusted properly . . .



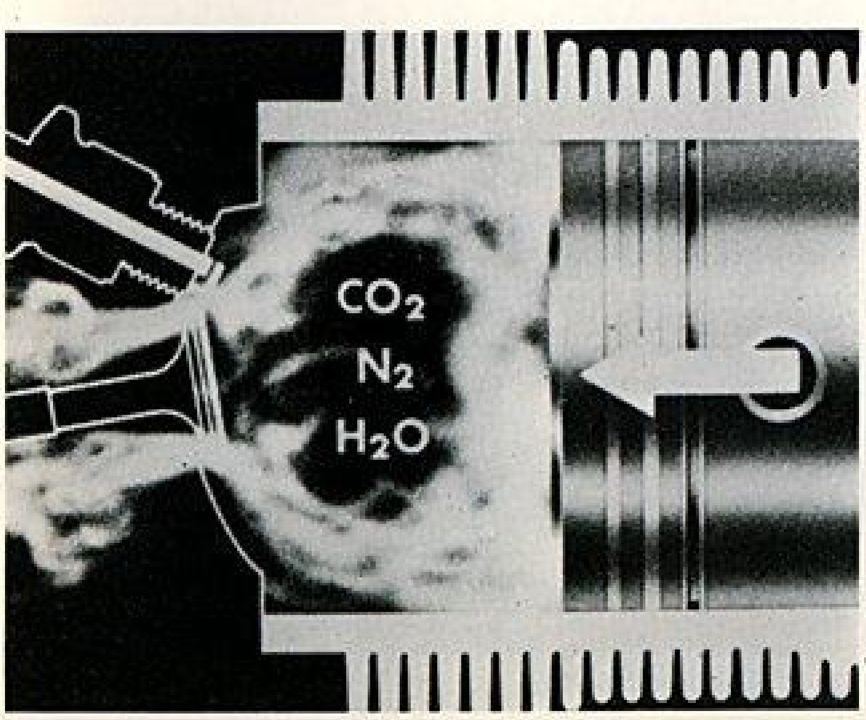
. . . fuel, ignited by the spark plug . . .



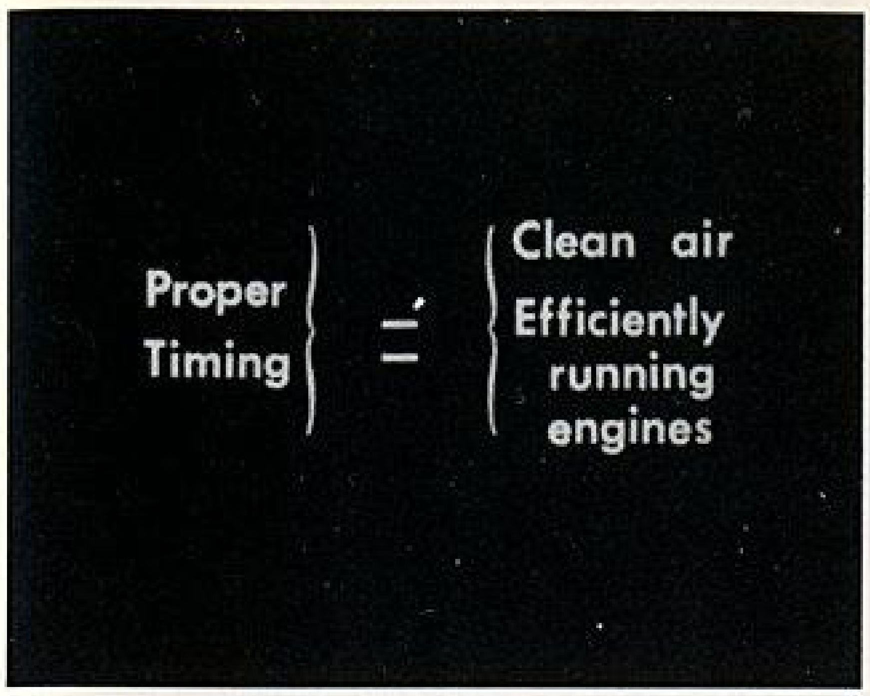
. . . will begin to burn evenly when the . . .



. . . piston is in the right position to begin the power stroke.

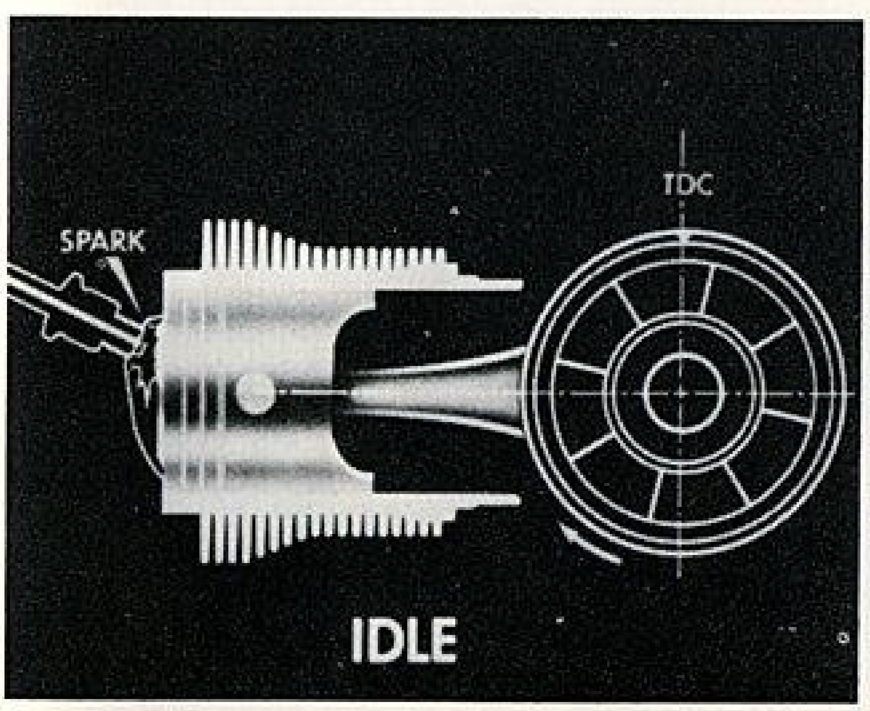


When the power stroke is finished, ideally the fuel will be completely burned, and the by-products coming out during the exhaust stroke will be Carbon Dioxide, nitrogen and water vapor. Our objective is to come as close to this ideal as possible.

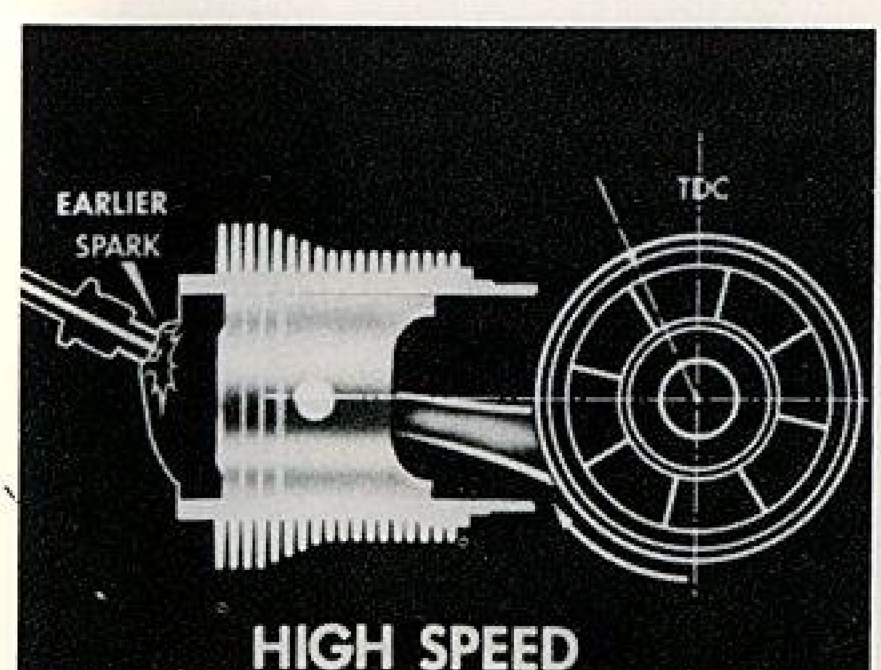


By understanding the importance of proper ignition timing and how to do it, we can clean up the air while we make engines run better.

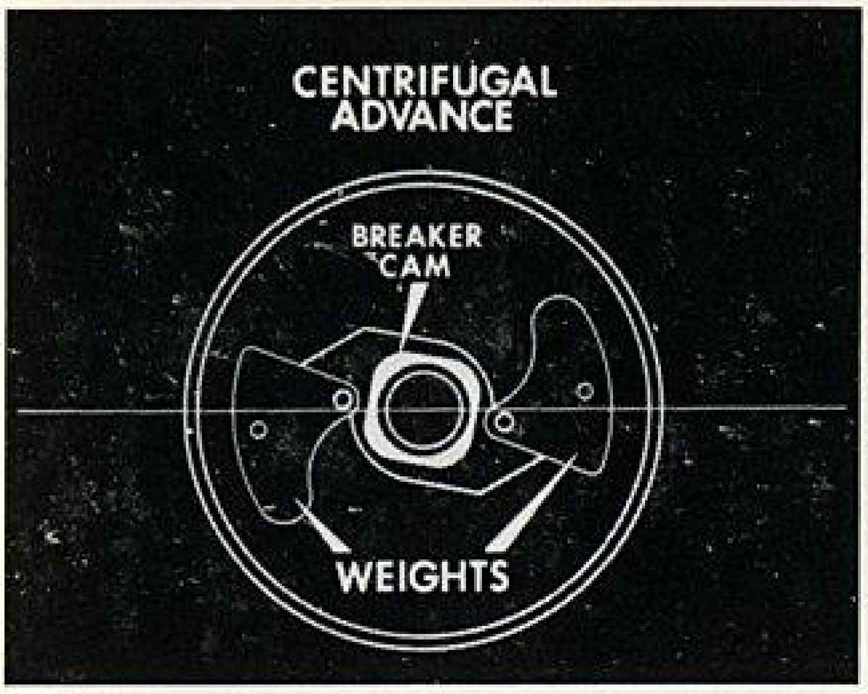
As mentioned earlier, there are two automatic systems for adjusting the moment of ignition based on the speed of the car and the load of the engine. They are the centrifugal advance and vacuum advance. Here is how the centrifugal advance works.



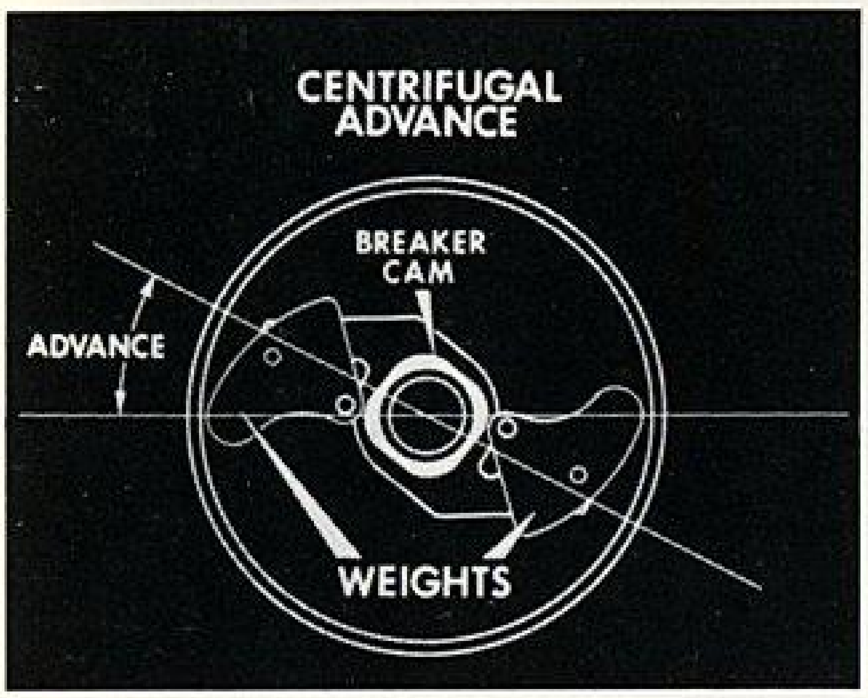
As we know, at idle speed the spark is adjusted to occur at approximately the point where the piston reaches Top Dead Center. The exact point will vary a few degrees, depending on model and latest factory specifications.



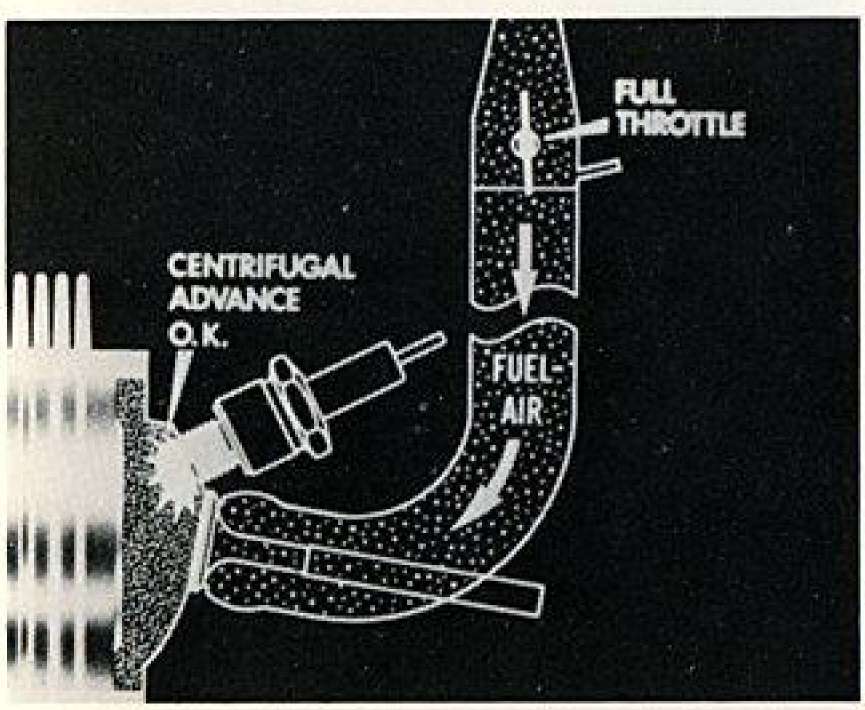
At high speed, it is necessary to deliver the spark to the combustion chamber earlier to give the mixture ample time to burn and deliver its power to the piston.



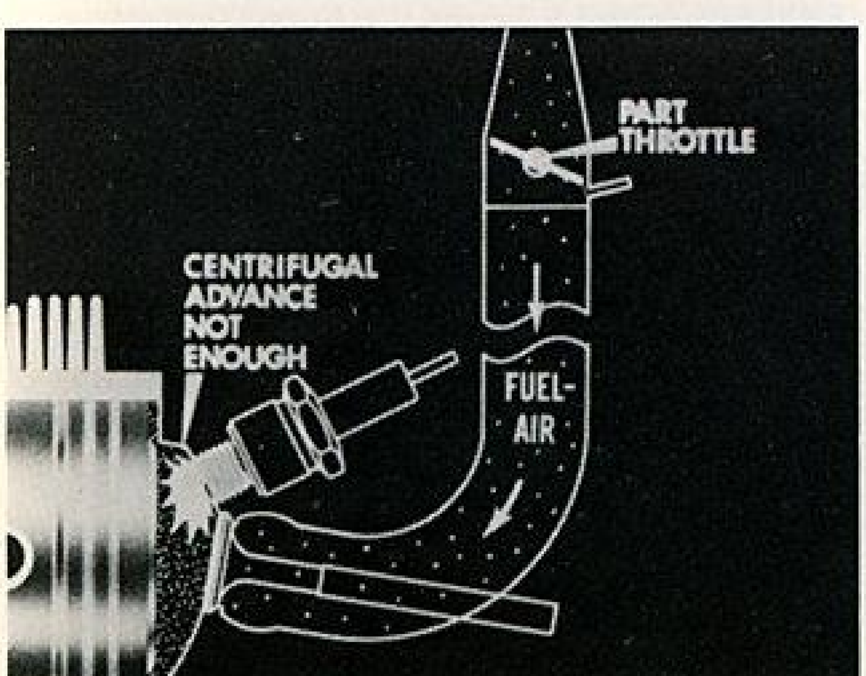
The centrifugal advance does this by two weights that throw out against spring tension as engine speed increases.



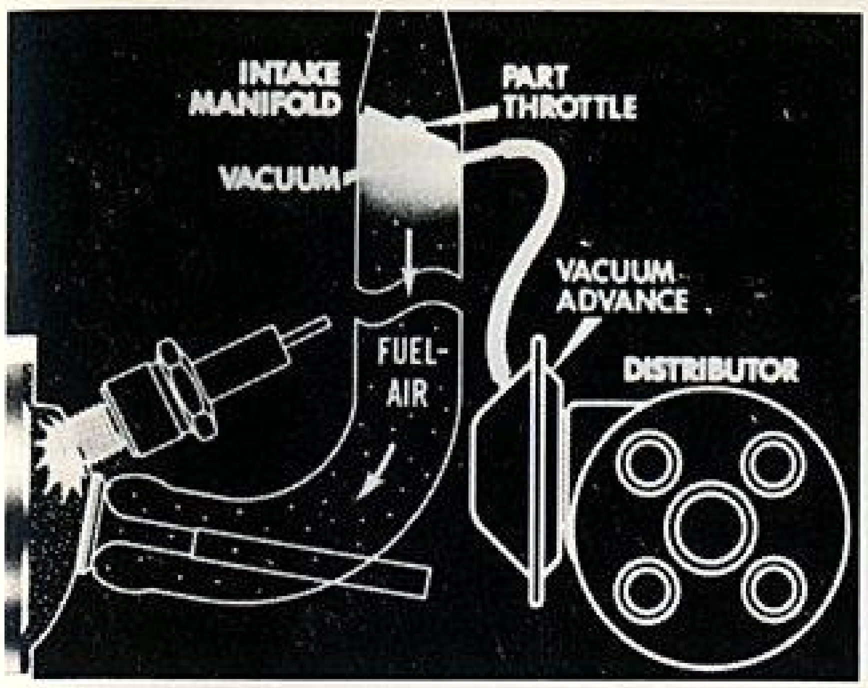
This movement is transmitted to the breaker cam and causes it to advance or move ahead with respect to the distributor shaft. The ignition timing consequently varies from no advance at low speed to full advance at high speed when the weights have reached the outer limits of their travel.



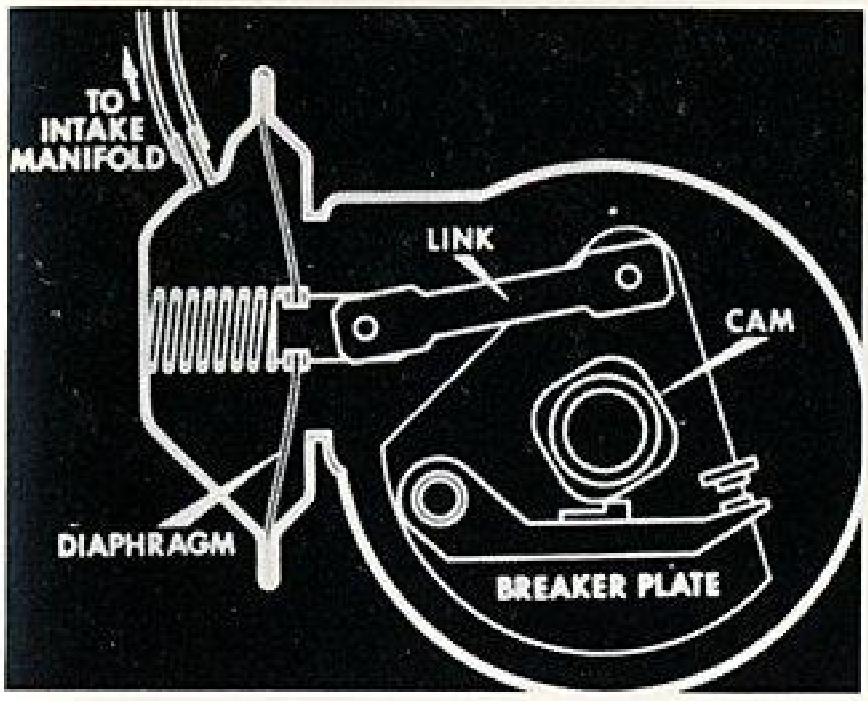
The centrifugal advance takes care of conditions of full throttle at high speed and acceleration at medium speed, but there are other situations requiring spark advance that it can't cope with.



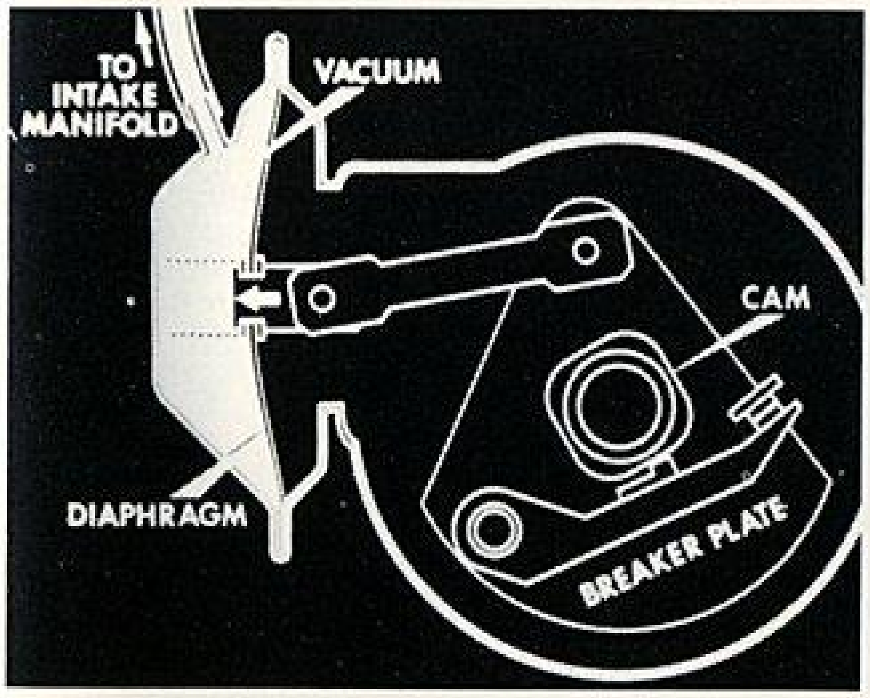
At part throttle, where maximum power is not being demanded of the engine, compression pressures are lower, the rate of combustion is slower, but it is still necessary to advance the ignition timing to obtain satisfactory burning of the fuel-air mixture.



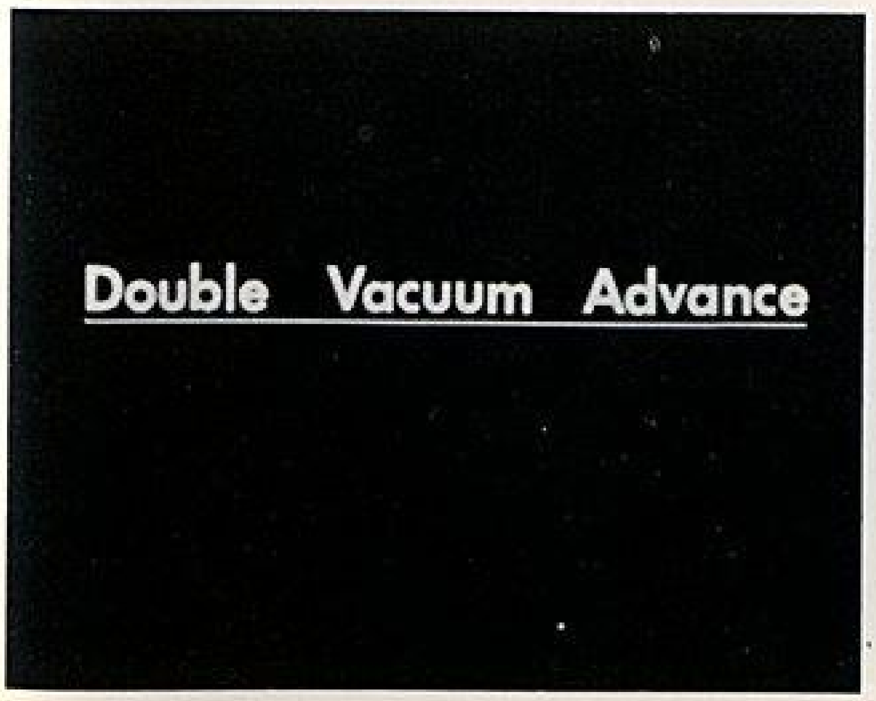
In this situation, the engine speed is too low to throw the weights out far enough, so the vacuum advance helps out. It works like this. Under part throttle a vacuum develops in the intake manifold.



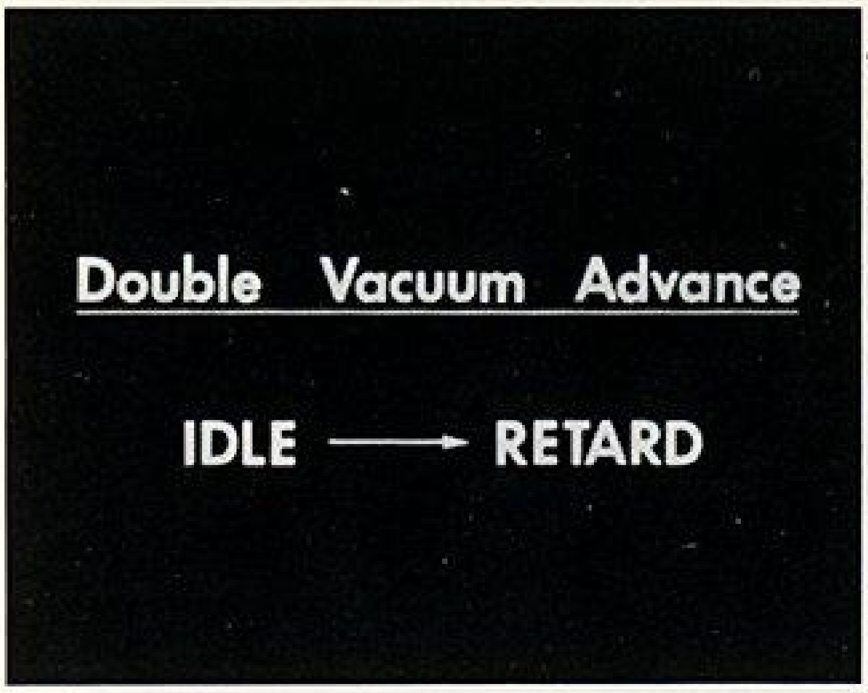
The vacuum acts on a diaphragm which is linked to the breaker plate.



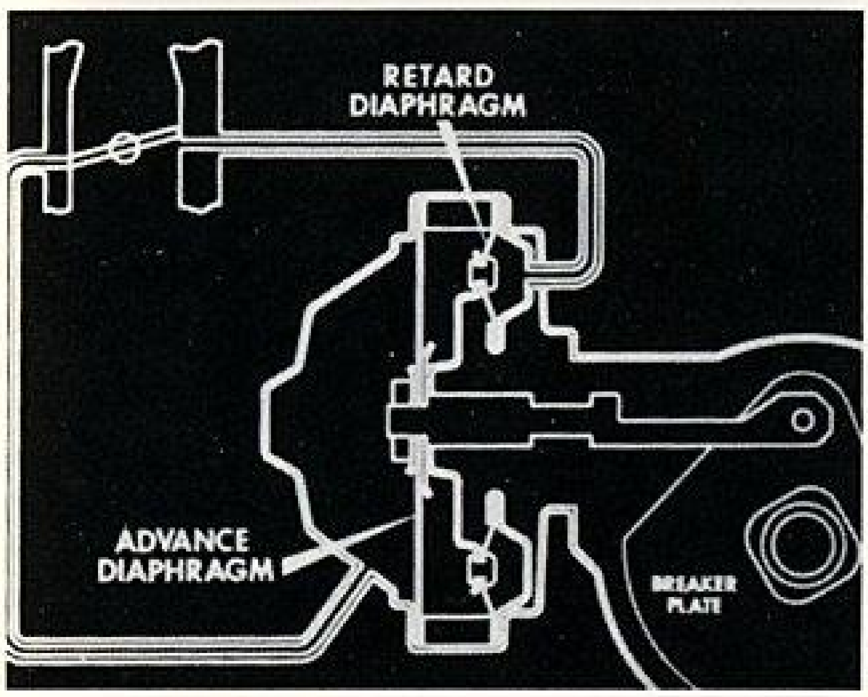
When the diaphragm moves out against spring tension, the breaker plate moves with it and carries the breaker points along so that the cam, as it rotates, closes and opens the breaker points earlier in the cycle.



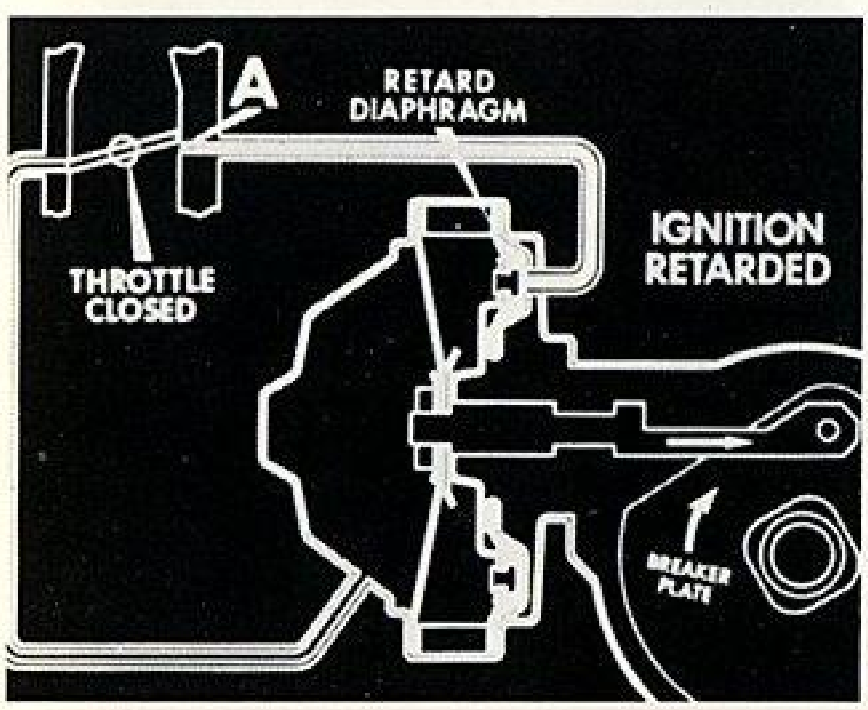
In order to meet low emission requirements, a double vacuum advance distributor has been developed.



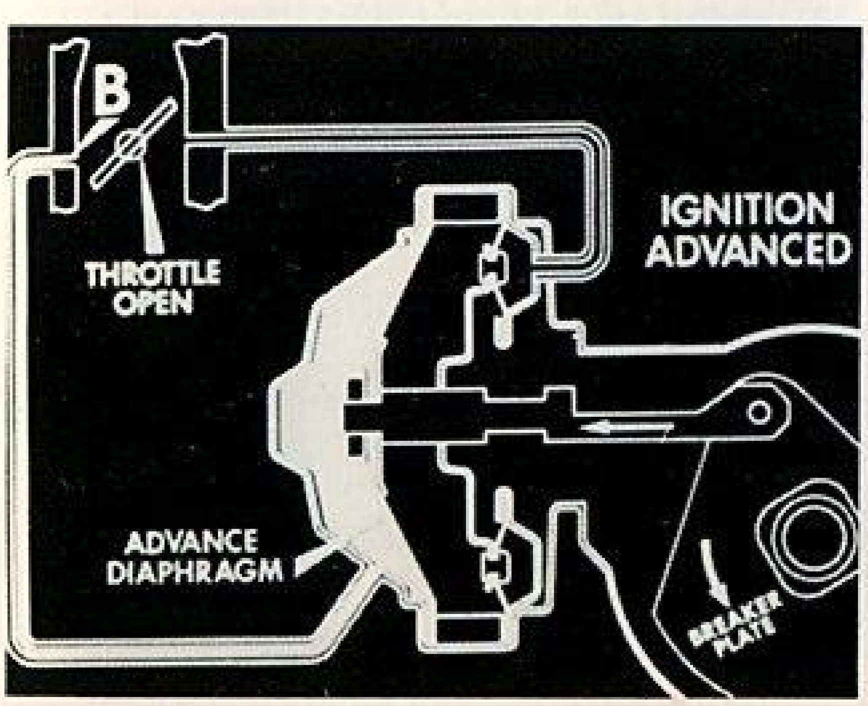
Its purpose is to assure that the spark will be fully retarded when the engine is idling, assuring fullest combustion of the fuel and, therefore, minimum exhaust emissions.



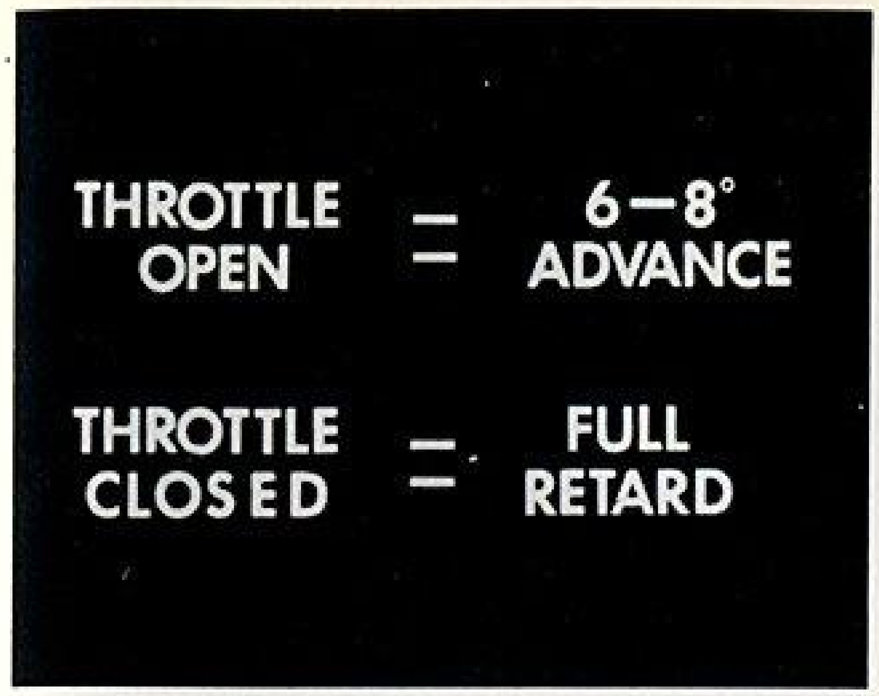
Briefly, there is a separate diaphragm and vacuum chamber for retard position that works opposite to the advance diaphragm.



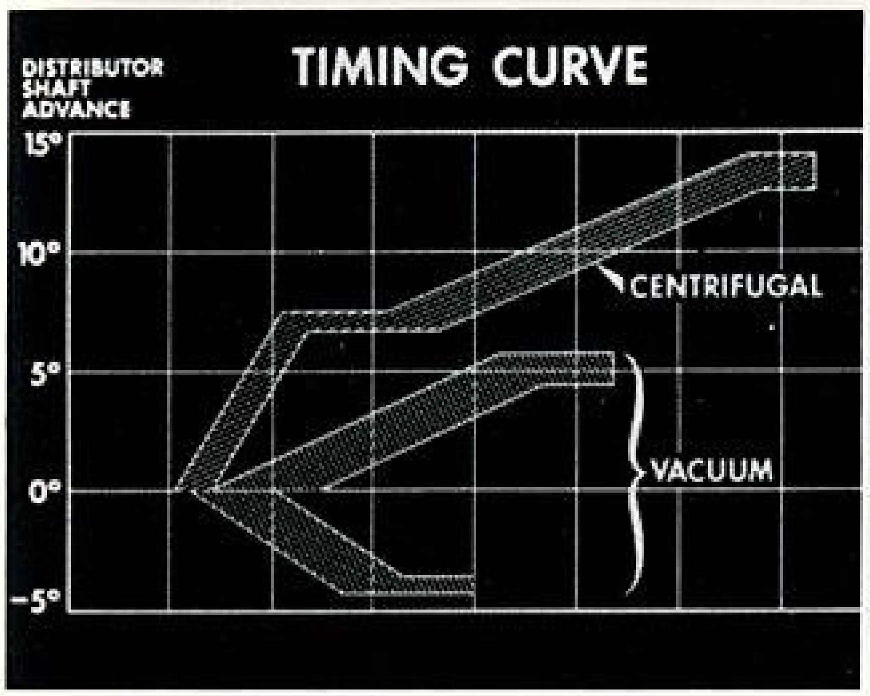
When the throttle is closed, a vacuum at tube A acts on the retard diaphragm which moves the breaker plate to retard ignition.



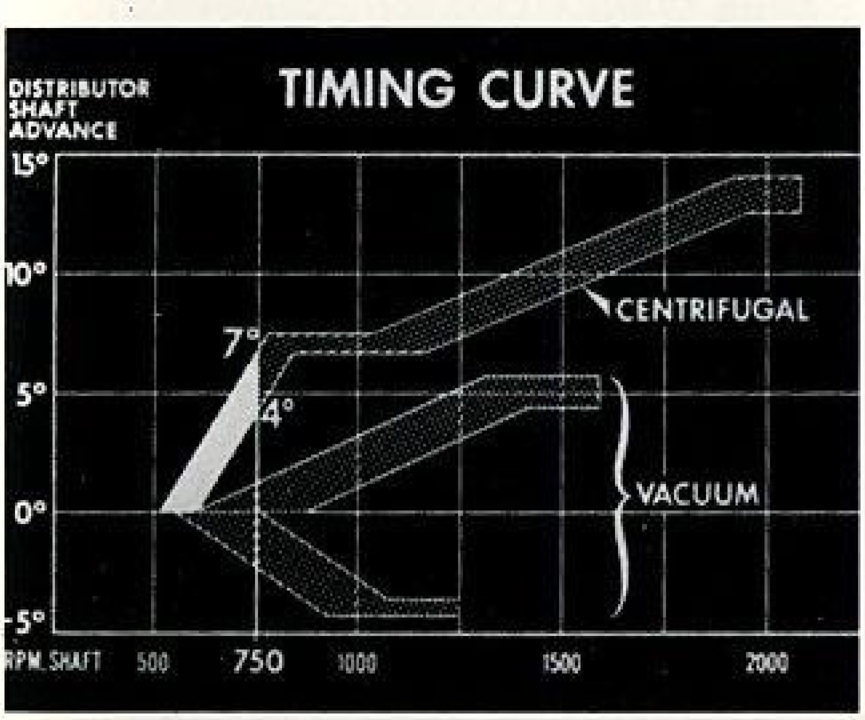
When the throttle is partly opened, it uncovers tube B, causing a vacuum which acts on the advance diaphragm, moving the breaker plate to advance ignition.



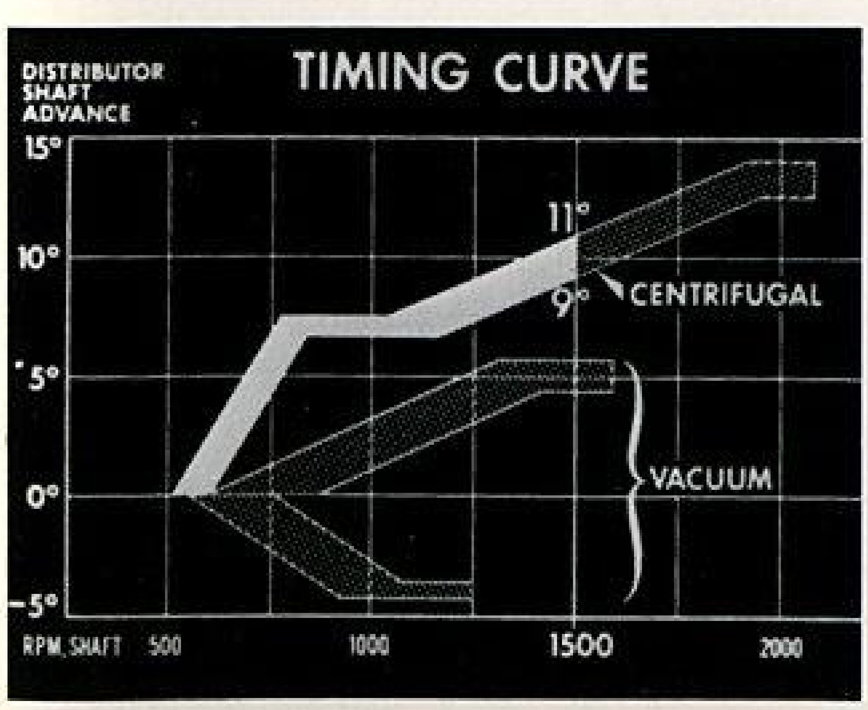
The result is — as soon as the throttle is opened, the advance jumps ahead 6 to 8 degrees; and when it is closed, the spark is quickly and fully retarded.



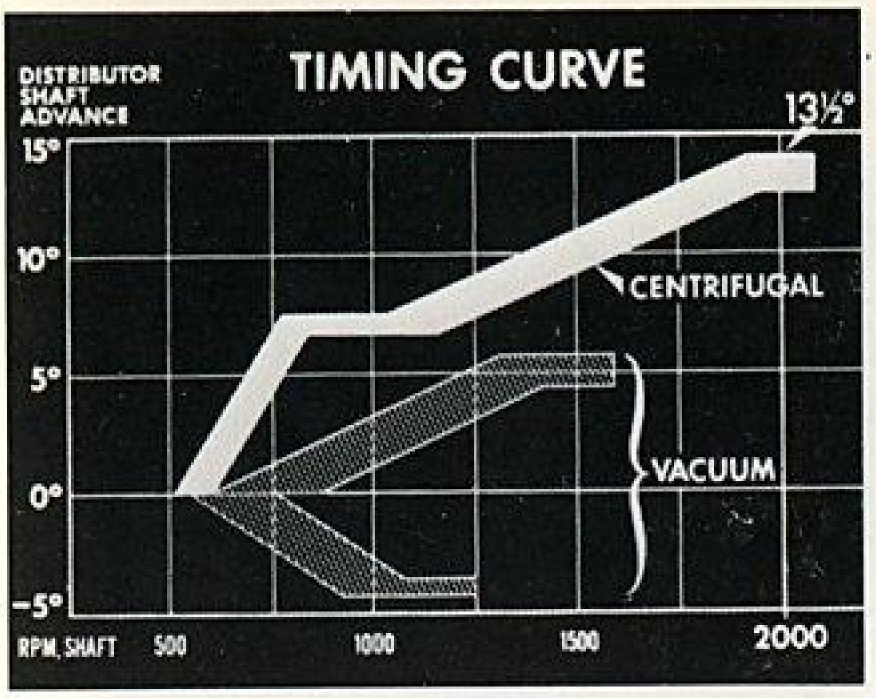
This is a typical timing curve, centrifugal in red, and vacuum in blue. Both advance mechanisms of this particular distributor should operate within the colored areas. For example:



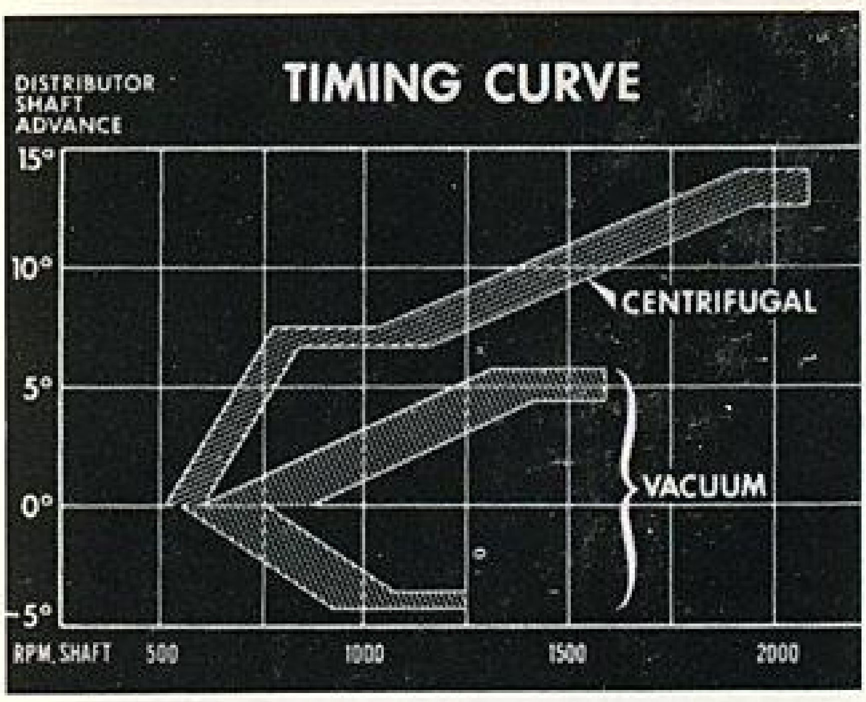
At 750 RPM, the distributor shaft should be advanced between 4 and 7 degrees due to centrifugal action.



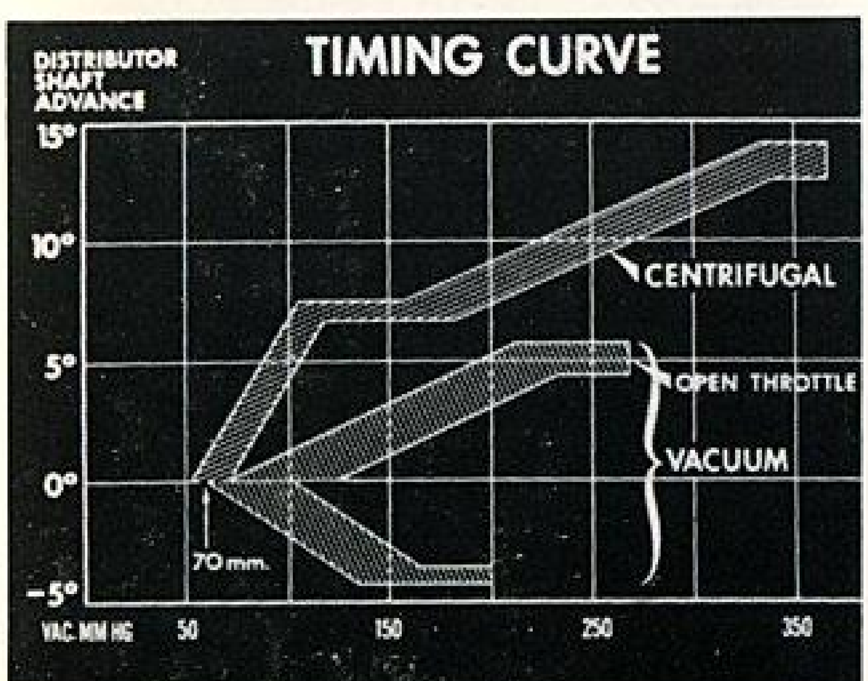
At 1,500 RPM, rotation should be between 9 and 11 degrees.



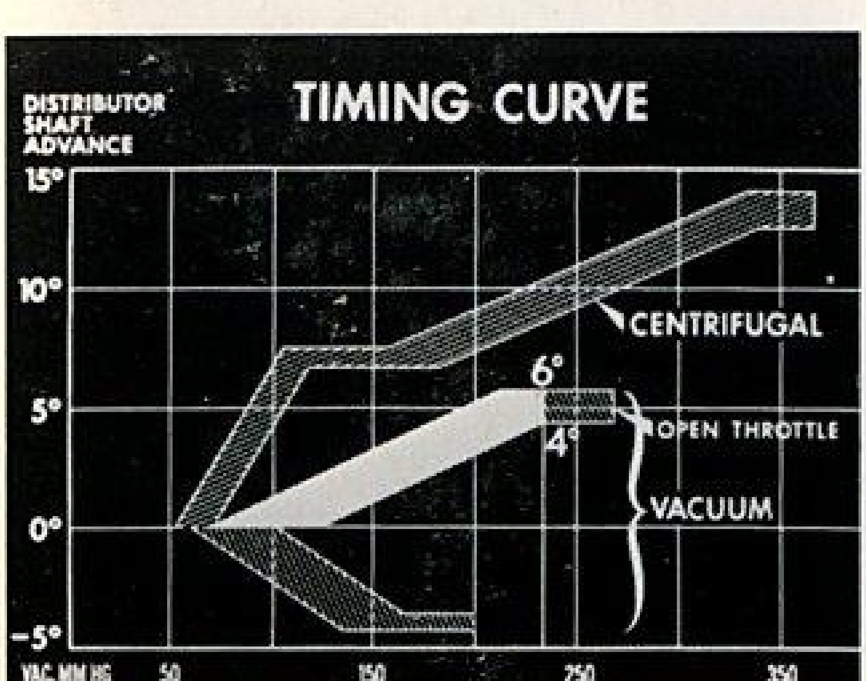
And at 2,000 RPM, rotation should be at its maximum 13 and a half degrees.



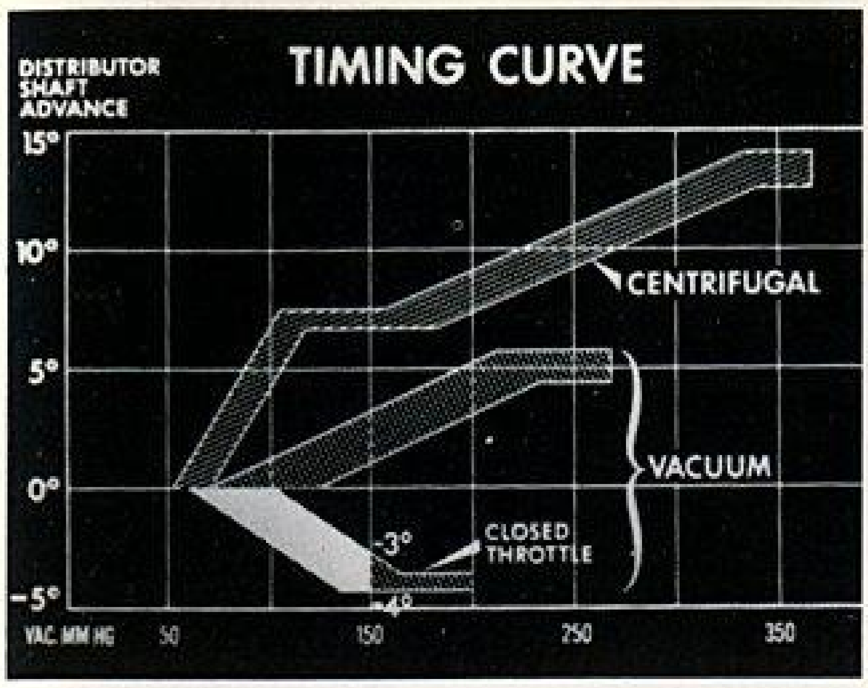
Note that RPM and degrees of advance are expressed in distributor shaft rotation and not crankshaft RPM, which would be twice as much.



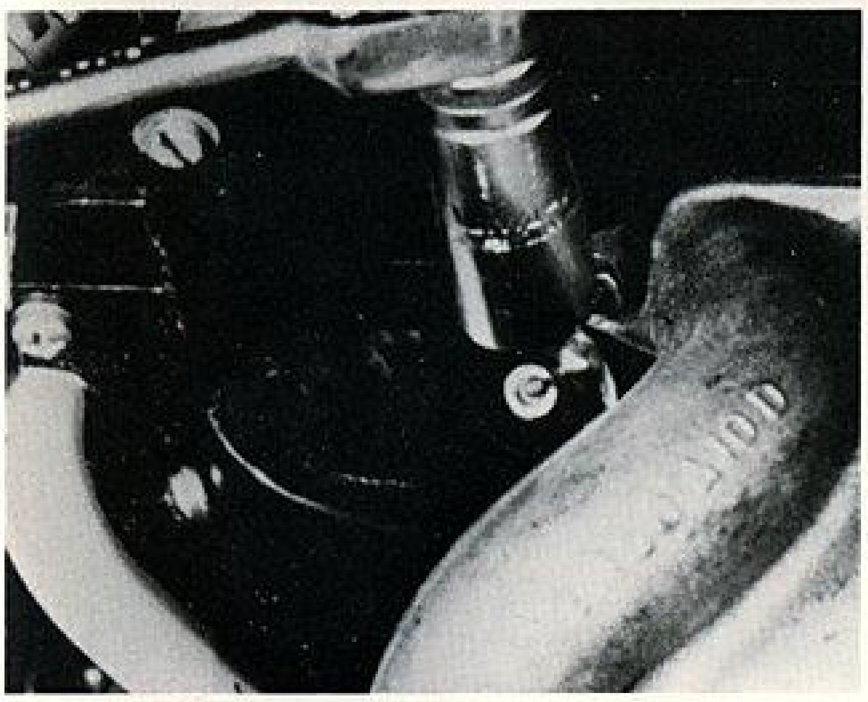
With the throttle open, the vacuum advance starts to operate at 70mm of mercury.



At 230mm, the vacuum advance reaches its maximum and no increase in the vacuum will cause this system to advance the spark any further.



With the throttle closed, the distributor shaft is retarded between −3 and 4 degrees when the vacuum reaches 150mm of mercury.

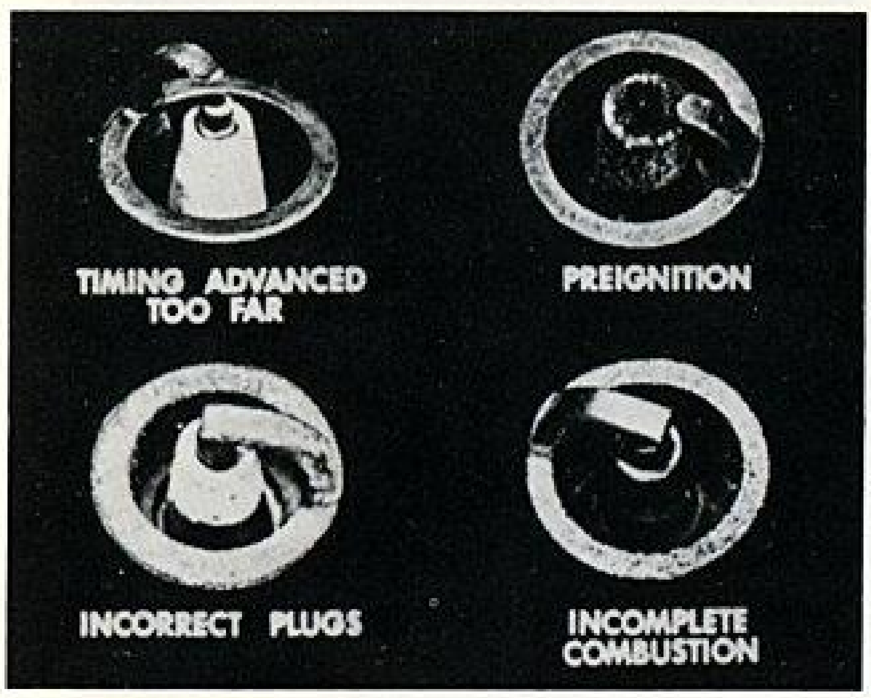


When adjusting timing, always check the spark plugs.

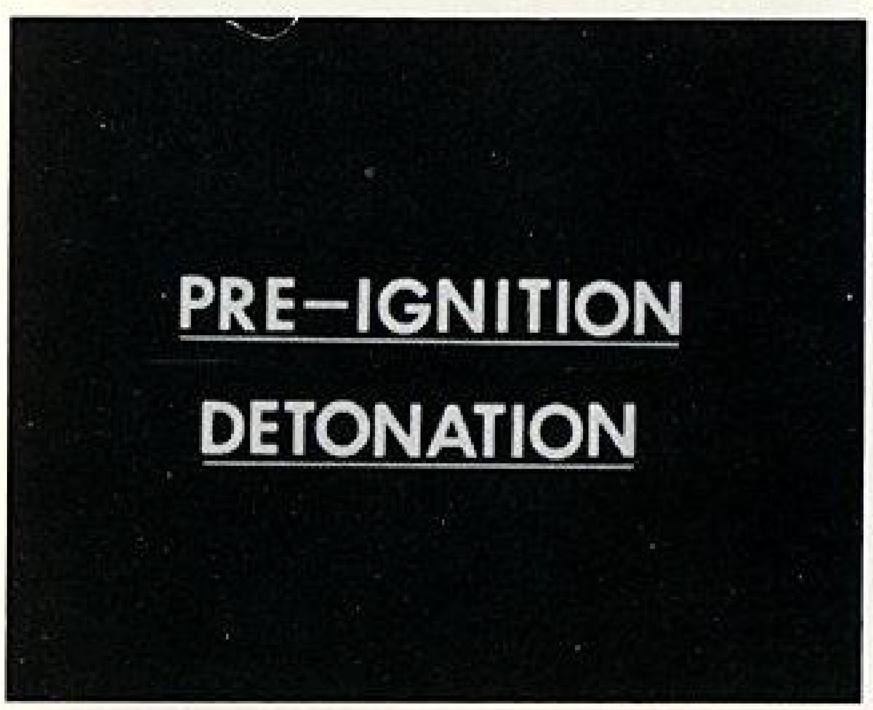
If they are in good condition, clean them and adjust the electrode gap; if they are badly worn or damaged . . .

. . . replace them with plugs in the proper heat range.

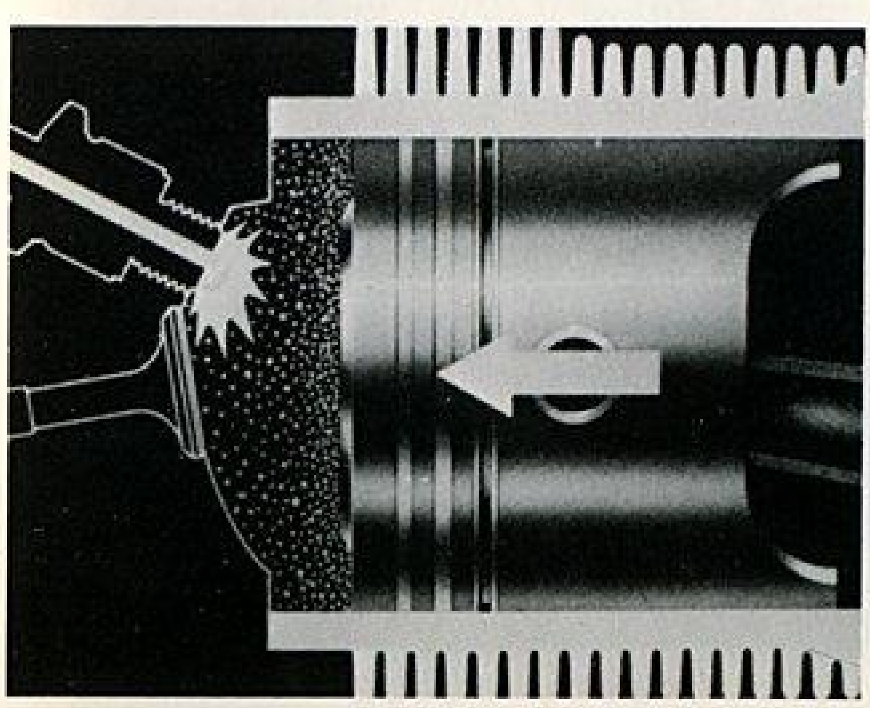
A careful inspection of the spark plugs can often reveal a source of trouble.



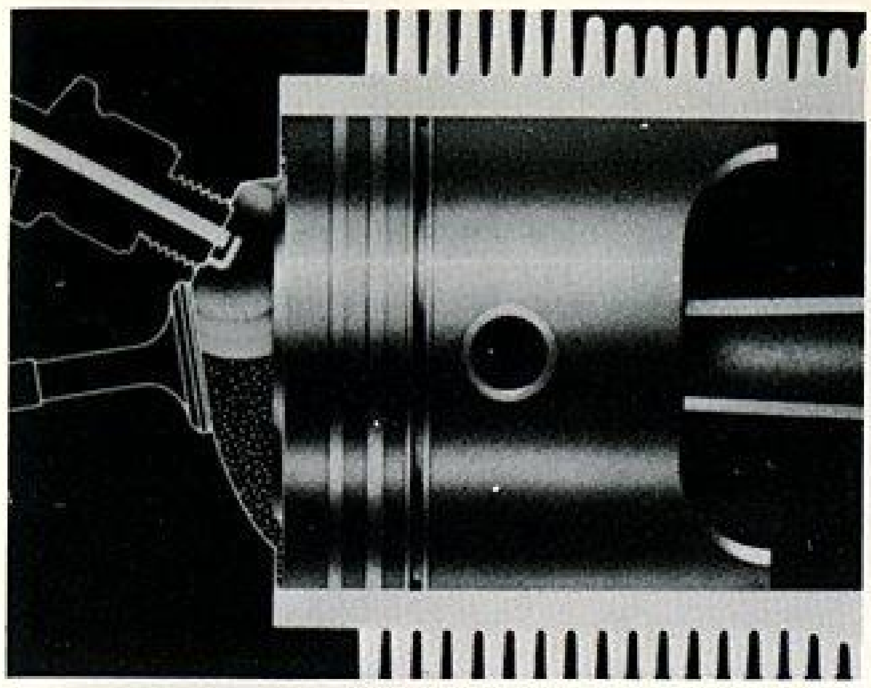
These plugs show only four of the many problems that can be diagnosed by careful inspection. Ignition timing advanced too far, Pre-ignition or detonation, fouling caused by incorrect spark plugs, incomplete combustion.



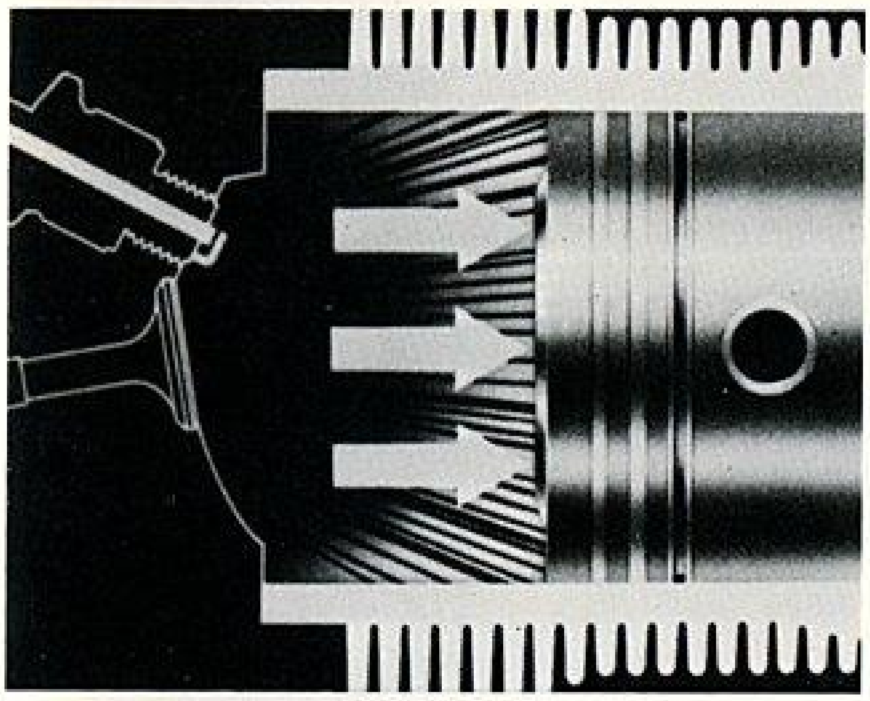
Pre-ignition and detonation are related problems, and both can be caused by improper ignition timing. Let's look at normal combustion.



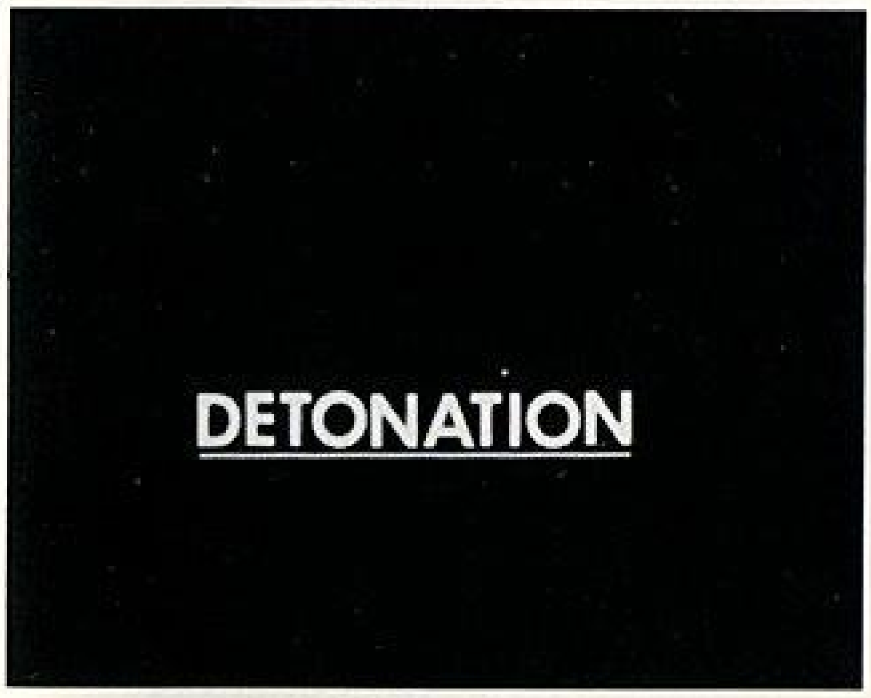
As the piston arrives at or nears the top of its compression stroke, the spark occurs and begins to burn the compressed fuel.



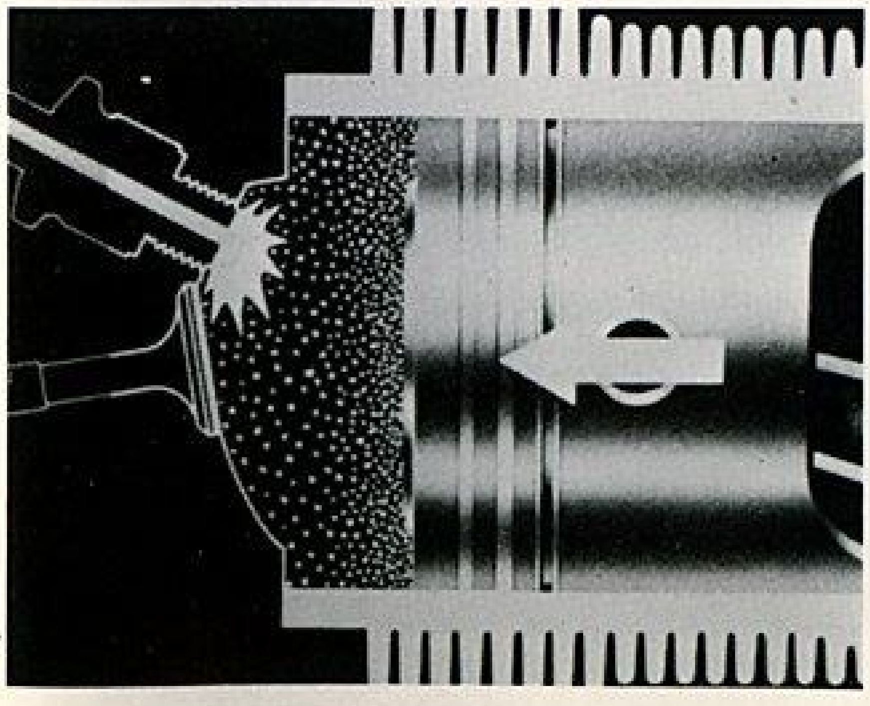
Combustion sweeps evenly across the confined area containing the fuel/air mixture.



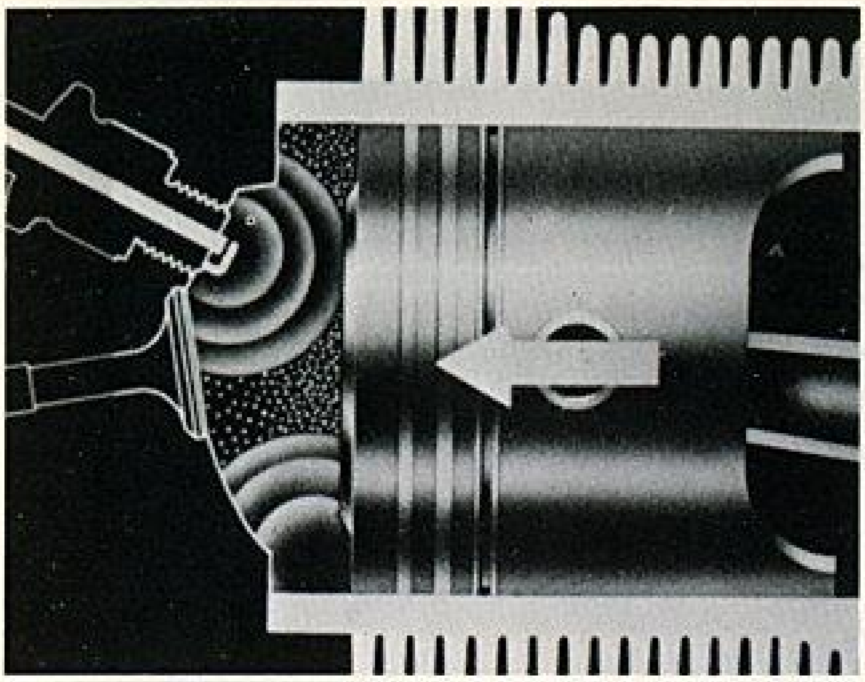
The burning process causes a rapid expansion in the gases, causing a pressure on the piston and driving it down.



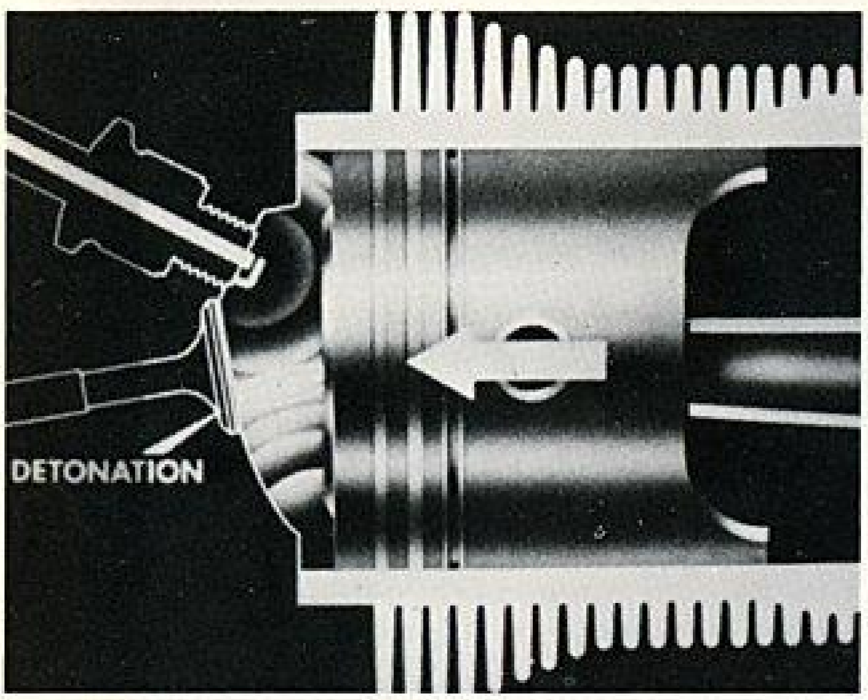
Detonation on the other hand, can occur, especially under load and with heavy throttle pressure with abnormally advanced spark.



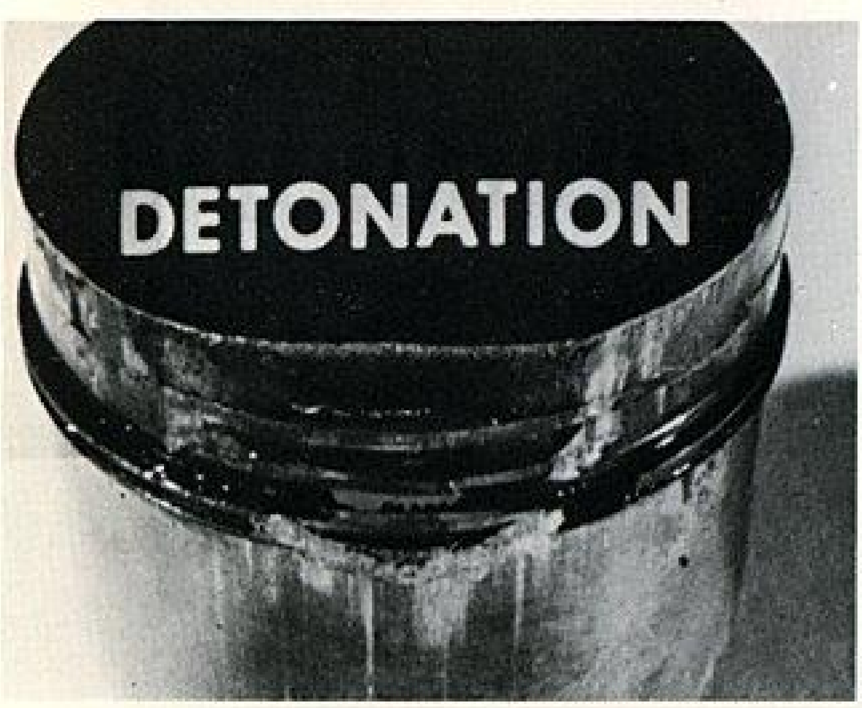
For example, let's say we get a spark when the piston is only three quarters up and compression rate is at its maximum.



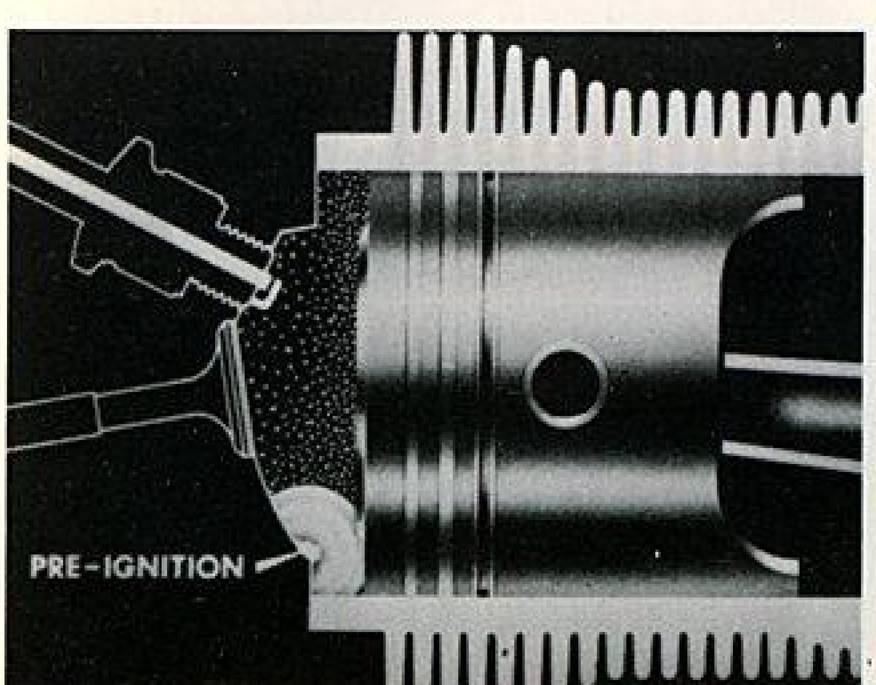
This pressure produces heat which, added to the heat of the burning fuel, causes a portion of the fuel charge to ignite spontaneously.



The two flame fronts meet and the resulting detonation causes a noisy hammering pressure on the piston and stresses on other engine parts.



This is what can happen. The piston head has literally disintegrated due to persistant detonation.



The effect of pre-ignition is very similar to detonation. The main difference is that the spark plug fires after the false ignition instead of before.

"KNOCKING"

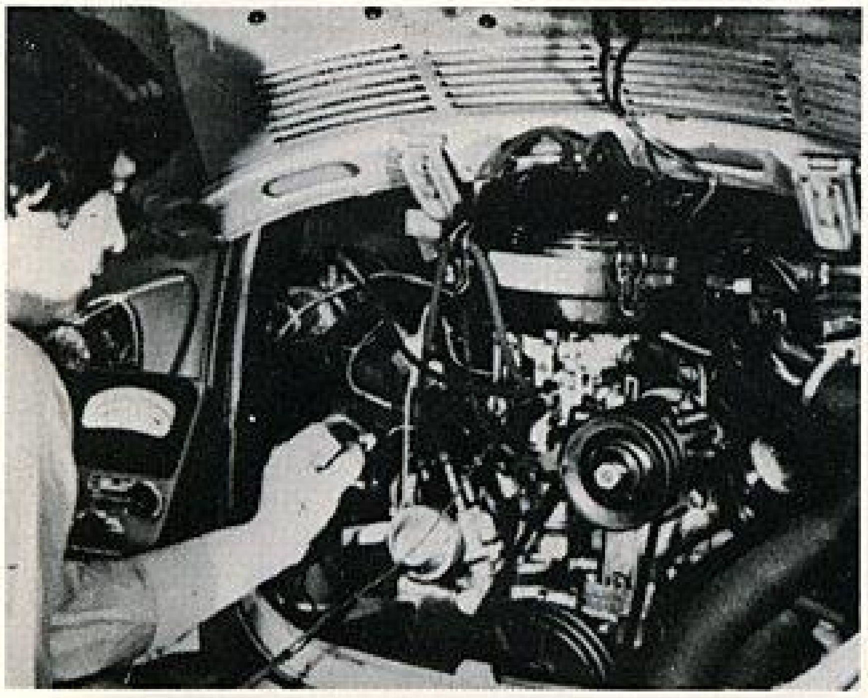
(also from fuel of wrong octane)

Both conditions are usually called knocking and can also be caused by fuel of improper octane rating.

CORRECT IGNITION TIMING

- Cooler engine
- Higher power/fuel ratio
- Longer engine life
- Lower exhaust emissions

We have seen that a properly timed engine will run cooler and deliver more power per gallon of fuel. The engine will last longer and the exhaust will be cleaner.



Considering all the benefits of proper ignition timing, it doesn't seem possible that incorrect timing is the most common automobile problem.

Ignition Adjustments

- Point Gap - Dwell Angle
- Timing

If you follow these simple adjustment procedures according to the book, you will know that the cars that you work on will not add to this problem.

QUESTIONS

1. The strokes of the 4 stroke cycle engine are called the intake stroke, the compression stroke, the ________ and the ________________.

2. The vital parts of an ignition circuit are the battery, ignition switch, ignition_____, ________________, ________, distributor and spark plugs.

3. Check the correct statement.
   High voltage needed to create the spark is produced by:
   a. The coil secondary having many more turns than the primary ____
   b. Breaker points opening ____
   c. Magnetic field in the coil collapsing ____
   d. Condenser sending stored current back to coil ____

4. Which component is most effective in preventing pitting of the breaker points.
   a. Coil ________
   b. Condenser ____
   c. Spark Plugs ____
   d. Distributor ____

5. The spark should jump the gap between the spark plug electrodes when the piston is at approximately ________ ________ in its compression stroke.

6. Dwell angle of new points should be between ___ and ___ degrees.

7. Two advance mechanisms are ________________ and ________________.

Mark the following true or false.

8. Timing should always be done with the engine cold.
   True False

9. The proper engine timing for lowest emissions is also best for maximum power. True False

10. The distributor shaft rotates at twice crankshaft speed.
    True False

NOTES

ANSWERS

1. *The strokes of the 4 stroke cycle engine are called the intake stroke, the compression stroke, the POWER STROKE and the EXHAUST STROKE.*

2. *The vital parts of an ignition circuit are the battery, ignition switch, ignition COIL, BREAKER POINTS, CONDENSER, distributor and spark plugs.*

3. *Check the correct statement.*
   High voltage needed to create the spark is produced by:
   a. *The coil secondary having many more turns than the primary* ✓
   b. *Breaker points opening* ✓
   c. *Magnetic field in the coil collapsing* ✓
   d. *Condenser sending stored current back to coil* ✓
   (*None are Wrong* **)**

4. *Which component is most effective in preventing pitting of the breaker points.*
   a. *Coil* ____
   b. *Condenser* ✓
   c. *Spark Plugs* ____
   d. *Distributor* ____

5. *The spark should jump the gap between the spark plug electrodes when the piston is at approximately TOP DEAD CENTER in its compression stroke.*

6. *Dwell angle of new points should be between 44 and 50 degrees.*

7. *Two advance mechanisms are CENTRIFUGAL and VACUUM.*

8. *Timing should always be done with the engine cold.*
   FALSE

9. *The proper engine timing for lowest emissions is also best for maximum power. TRUE*

10. *The distributor shaft rotates at twice crankshaft speed.*
    FALSE

NOTES

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