TUNE UP

SATISFACTORY performance of modern engines requires scientific testing equipment in order to restore the engine to the original condition in which it operated when new. In conjunction with this testing equipment, the manufacturer's specifications should be closely followed when making all necessary adjustments in order to obtain smooth performance of the engine with economical results.

The fundamentals of engine tune up are (1) compression, (2) ignition, (3) carburetion. Since compression does not depend in any way upon either ignition or carburetion, it should be checked first.

COMPRESSION

The engine cannot be tuned to develop maximum power and give smooth performance unless normal compression pressure is obtained in each cylinder on every compression stroke. In order to have uniform and maximum compression, the following conditions must be present:

1. Cylinder head bolts must be uniformly tight.
2. Cylinder head and spark plug gaskets must seal securely.
3. Piston rings must seal properly throughout the entire piston stroke.
4. Intake and exhaust valves must be properly adjusted and seat tightly.

Cylinder Head Bolts

On overhead valve engines, cylinder head bolts not tightened sufficiently will cause changes in valve lash and may permit leakage past the gasket. And on all type engines, uneven or excessively tightened bolts may distort the cylinder bores, causing compression loss and excessive oil consumption.

Tighten all cylinder head bolts to the proper torque values, using a torque wrench to compress the head gasket evenly and avoid distortion of head and cylinder bores. The bolts should be tightened in the sequence shown in the illustrations in the engine sections. If no diagram is shown, start tightening at the center and work from side to side outward toward the ends.

Installing Spark Plugs

When installing either new or used spark plugs, always blow away dirt from around plug holes, and use new gaskets to insure tight seals without excessive tightening. Excessive tightening may change the gap between electrodes and may crack the insulator.

Make sure the gasket surfaces on spark plugs and cylinder head are clean. Screw the plugs down by hand into firm contact with the gaskets, then tighten them with a torque wrench to the proper torque values. If a torque wrench is not available, tighten the plugs ¼ turn more after contact with the gaskets.

Valve Adjustment

Oil, water and engine temperatures must be stabilized or brought to normal operating temperatures before the valves can be properly adjusted for normal lash. This applies to all engines where the manufacturer specifies that the lash should be adjusted when the engine is warm. Some engine builders, Studebaker for example, recommend that the adjustment be made when the engine is cold, or at normal room temperature.

When an engine is warmed up by running without load in the shop, the oil, water and engine temperatures level off at different points than those obtained on the road; therefore, a wider lash adjustment is required. Thus, if the manufacturer specifies a road operating clearance of .015 inch, best results will be obtained by setting the lash at .017 inch if the engine is warmed up in the shop. Of course, if the adjustment is being made after the car has made a hard run on the road, the clearance of .015 inch should be adhered to.

Some engine builders recommend an additional .002 inch clearance for exhaust valves on engines that are operated continuously at high speeds.

COMPRESSION TESTS FOR LEAKY CYLINDERS

In using a compression gauge the location of the combustion chamber must be taken into consideration. Except for the new engines introduced in 1958 (Ford and Chevrolet) in which the combustion chamber is formed in the block, all other engines have the combustion chamber cast in the cylinder head. When checking compression pressure on engines with cylinder head combustion chambers, it must be realized that the compression pressures in the cylinders of such an engine in perfect condition are not uniform. Car company engineers will tell you that the pressures in the different cylinders of an engine may vary up to 20 pounds. The variation in pressure in some makes of engines is small and large in others. The variation is due principally to lack of uniformity in combustion chamber volumes since it is impossible to make all the combustion chambers in a cylinder head exactly the same size.

In a given engine with a 7 to 1 compression ratio with all combustion chambers the same volume, the compression pressure might be about 120 lbs. in all cylinders. However, if the combustion chamber is ⅓ cubic inch too small the pressure will be 126 lbs. and if ⅓ cubic inch too large it will be 114 lbs. This is a variation of 12 lbs.

In the new engines introduced in 1958 where the combustion chamber is formed in the block, this variation is largely eliminated because the underside of the cylinder head is flat except for slight recesses which provide for valves and spark plugs. And inasmuch as the combustion chamber which is formed in the block and piston head forms a smooth machined surface, combustion chamber volumes are naturally more uniform and, therefore, not subject to possible variations as are cast cylinder head combustion chambers.

Compression Pressures and Ratios

Just to satisfy the reader's curiosity, below is a table showing the approximate relationship between compression ratio and compression pressure at cranking speeds:—

Ratio	Pressure
6.5	110
7.0	120
7.5	130
8.0	140

Various design factors affect the compression pressure. Therefore this table may apply to some engines but not to all. Note also that a carbon deposit will raise the compression pressure at any given ratio by reducing the combustion chamber volume. The greater the deposit the higher the pressure.

Compression Gauge Accuracy

However, even if a table such as this could be trusted, there is the question of gauge accuracy. A gauge passes inspection at the factory if it is not more than 2 pounds high or low when the pressure is 100 pounds. Thus there is a possible error of as much as 4 pounds to begin with (98 to 102) although of course some of the gauges will be almost perfectly accurate.

But even if the gauge is accurate when made it is not likely to remain so. It is a delicate instrument and the first time it is dropped it may read 5 pounds too high or too low.

How to Use Compression Gauge

A compression test should be made with all the spark plugs out. When this is done it is unnecessary to remove the air cleaner or to hold the throttle open because there are always two or more intake valves open when the engine is being cranked and the engine consequently gets ample air at cranking speed without opening the throttle or removing the air cleaner.

Get the Maximum Reading

When testing the compression of a cylinder, hold the gauge in place until the hand reaches a maximum reading, even though this may require cranking the engine through 10 revolutions or so. The pressure in the curved tube within the gauge builds up slowly because the compressed air must pass through a small orifice at the entrance to the tube. Without this orifice, the gauge would be damaged by the sudden application of high pressure.

Precaution with Oil Test

Note that if a compression test is made after putting oil in the cylinder to seal the rings, the compression reading may be much too high because the oil reduces the volume of the combustion chamber. When taking this test, the gauge will first reach a maximum reading. Then keep on cranking until the hand falls to a steady position.

Bad Cylinder Is 25 Pounds Low

If any cylinder in an engine is 25 pounds (or more) lower than the highest cylinder it is probable that the valves in that cylinder are leaking. It does not make any difference whether this test is made with engine warm or cold.

It is a mistake to assume that a cylinder which is 5 to 10 pounds lower than the highest has leaky valves because, as previously stated, the variation with tight valves may be much more than 10 pounds.

A Test for Leaky Cylinders

Another positive method is to apply air pressure to the cylinders one by one and then listen for leakage. This is an old and tried method although not well known. Remove the porcelain from an old spark plug shell and install a tire valve in the shell by brazing.

Remove all spark plugs in the engine. Bring No. 1 piston up to top dead center on the compression stroke. Screw the device just described into the spark plug hole. Apply air pressure. If necessary have an assistant hold the air chuck on the valve throughout the test.

The piston must not move from its top dead center position while making test with air pressure. It won't move if the crankpin is within about 5 degrees before or after top dead center. The fact that it is not necessary to have the piston exactly on center will speed up the work.

When the air is applied, listen for a hiss:—

1. At the muffler tail pipe for a leaking exhaust valve.
2. At the air cleaner for a leaking intake valve.
3. At the oil filler opening for leaking rings.
4. Remove the filler cap on the radiator and look for bubbles which indicate a leaking cylinder head gasket.

Bring No. 2 piston up to top dead center on the compression stroke and repeat the tests—and so on for the other cylinders.

IGNITION

Battery

Since the battery is the source of all electrical energy, its efficiency must first be checked, since starting and idle performance are always poor if the battery and its connections are not up to standard. Besides, a low or defective battery will cause inaccuracies in any tests to the starter, generator or ignition systems.

Specific gravity of the electrolyte must be tested before adding water as water does not mix immediately and a true reading will not be obtained.

A battery in good condition should have specific gravity of not less than 1.250 in seasons when freezing of water may occur, or 1.235 in seasons when freezing of water is unlikely. The battery must be recharged if the specific gravity is less than the above values.

Add pure distilled water to bring level of electrolyte to ¼ inch above the plates in each cell. Do not fill higher as the electrolyte may overflow and cause damage. Turn filler caps down finger tight.

Battery Cables & Terminals

Inspect the battery cable and ground strap for broken insulation, corroded or broken strands, and loose or corroded terminals.

Repair broken or chafed insulation with loom or tape. If cable strands are broken, corroded, or loose in the terminals, the cables should be replaced, being sure the new cable has ample capacity to carry the current.

Since loose terminals are usually corroded, disconnect loose terminals and thoroughly clean contact surfaces by scraping until bright or by washing with a strong soda solution. Coat cleaned contact surfaces of battery post and terminal with vaseline to retard corrosion. Connect the terminal and tighten securely.

Generator

The tuneup job will not remain satisfactory for an extended period of service if the generator output is low because the battery will soon fall below a safe state of charge and ignition then will be starved when the total current draw is heavy.

Remove the cover band and carefully inspect the interior of the generator for (1) worn, rough, or dirty commutator; (2) high mica between commutator segments; (3) thrown solder, which indicates loose connections between the armature windings and commutator segments. These conditions will cause low generator output.

If the commutator is in good condition but dirty, clean off all grease with a cloth soaked with cleaning fluid. Then polish the commutator with a strip of fine sandpaper placed over a wooden block having a smooth, square end. Carefully blow out all dust and replace cover band.

If inspection indicates that the armature requires turning down and undercutting of the mica, this should be done.

Tighten all wiring connections at the generator, regulator, and ammeter.

Primary Ignition Circuit

Carefully inspect the terminals, connections, and visible portions of the following wires: (1) Starter switch to ammeter; (2) ammeter to ignition switch; (3) ignition coil to terminal on distributor housing.

The wires must be securely attached to the terminals and the insulation must be in good condition. If any connections are loose, disconnect and clean the terminals thoroughly, then connect and tighten securely. Turn the ignition switch on and off a few times to be certain it is making positive contact.

Faulty ignition coil operation can be caused by moisture, grease or dirt on the outside shell. Wax leaking to the outside of the coil does not indicate that the coil is defective; it may have been caused by an abnormal heat condition which did not affect the internal structure of the coil.

The high tension terminal socket may be corroded as a result of arcing caused by previous failure to insert properly the end of the cable into the socket. Corrosion also may develop in sea coast areas due to salt air.

Any corrosion will cause resistance to the flow of current. Therefore, the socket should be thoroughly cleaned out with a terminal cleaner, sandpaper or a stiff wire brush, and the cable terminal should be cleaned with sandpaper.

All parts of the distributor which affect the primary circuit must be inspected and tested, and worn and defective parts must be replaced to insure satisfactory ignition.

The contact points may be cleaned and adjusted without removing the distributor, but if the interior is dirty or saturated with oil, or new parts are to be installed, the distributor must be removed from the engine.

To determine whether it is necessary to remove the distributor, as well as to find out what parts are to be replaced, first make all the inspections and tests outlined below.

Centrifugal Advance

This mechanism must operate freely and the springs must return the advance weights to the full retard position during idle speed operation. (1949-56 Ford distributors do not have a centrifugal advance mechanism—only vacuum.)

Sticking advance weights will result in poor acceleration, whereas weak springs will cause a too rapid spark advance, causing the engine to ping, resulting in engine roughness and a decrease in gasoline economy. Sticking weights can be cleaned but weak springs must be replaced.

To test the action of the weights, turn the rotor in the direction required to advance the weights to their fully extended position. Then release the rotor and allow the springs to return the weights to retard position—which will be indicated by a metallic click when the weights strike the stop.

Vacuum Advance

This unit may be inoperative due to a broken diaphragm or spring. To determine whether this condition exists, crank the engine with the starter and hold the choke closed. If the distributor plate will advance and return, the parts are not broken. But the breaker plate will not advance if the diaphragm is broken. If it advances but does not return, the spring is broken.

A leak at the vacuum advance connection will allow excess air to enter the carburetor, which may result in poor gasoline economy through fixed throttle intermediate speeds because of incorrect operation of the vacuum advance mechanism.

If the pigtail leads are broken at any point, or if the distributor housing is worn so that the breaker plate can shift sidewise as it is oscillated by the vacuum advance mechanism, the ignition will be erratic enough to cause flat spots or ignition miss. This condition will usually occur at idle speed or up to 15 m.p.h.

To detect this trouble, disconnect the vacuum line at the distributor. If the trouble disappears, test the pigtail leads, and also check the groove in the distributor housing where the breaker plate "floats."

Condenser

There are several good condenser testers commercially available and when making tests, the condenser must be at normal operating temperature.

The resistance test, measured in microhms, is to determine if there is a high series resistance in the condenser circuit

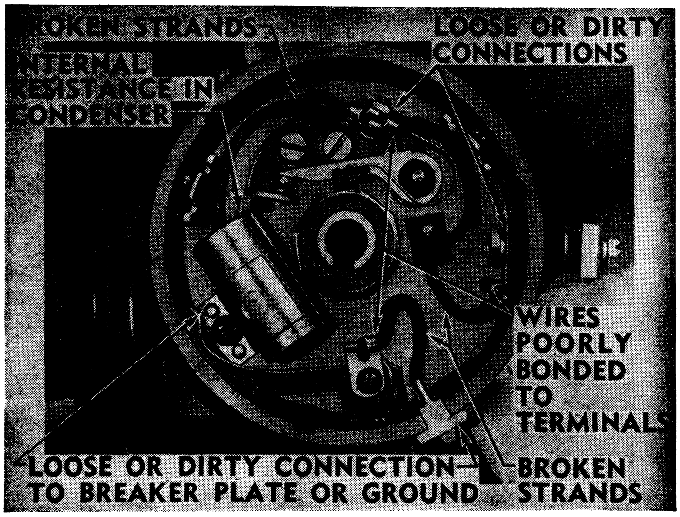


Fig. 1 Points of resistance in condenser circuit

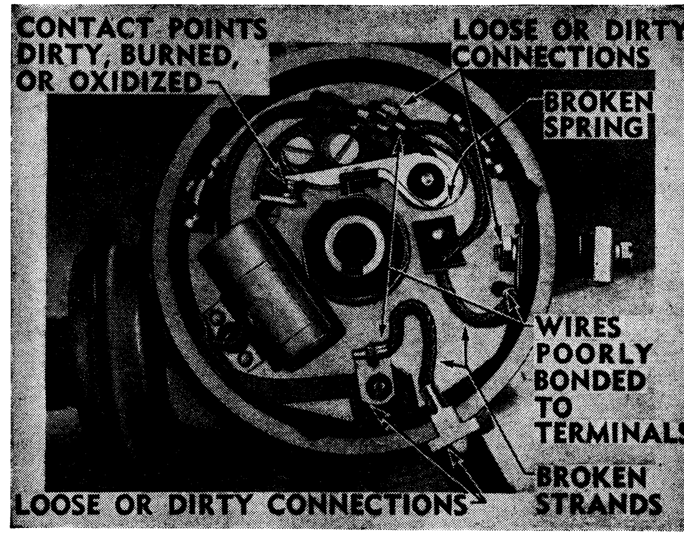


Fig. 2 Points of resistance in distributor primary circuit

caused by the conditions shown in Fig. 1.

The capacity test, measured in microfarads, is to determine if the condenser capacity is actually within specification limits.

The insulation test, measured in megohms, is to determine if the condenser insulation will hold a charge satisfactorily.

Breaker Points

Carefully examine the points for burns, pits, dirt, and see that they are not sticking on the pivot. Check to see that they are properly spaced and have the correct spring tension. Point spring tension too weak or too strong will limit high speed performance, either by the point "floating," which is due to a weak spring, or "bouncing," which is caused by a spring with too much tension. Consult the "Ignition" chapter for the correct spring tension and the method of measuring same.

Breaker points in service for some time will appear dull and gray. This condition is normal, and points should not be replaced or filed if full contact of the mating surfaces is obtained.

If points do not meet squarely, align the contact surfaces by bending the contact arm.

Delco-Remy recommends that points that are blackened or slightly burned or pitted may be cleaned with a special stone or a clean point file. Auto-Lite, on the other hand, claim that their points are so hard that they should never be filed because minute pieces of file are broken off and imbed themselves in the contact surfaces, causing greater concentration of heat and welding of the steel to the contacts.

In filing points, remove the high spots only—it is not necessary to remove all traces of build-up or pit. Do not use emery cloth or sandpaper to clean points as the residue left on the points causes them to burn.

Excessively burned, pitted or worn points cannot be cleaned up and aligned satisfactorily. Therefore, they must be replaced to insure good ignition.

Coil

The ignition coil terminals should be inspected to be sure they are tight and in good condition, the coil insulation checked for burned or chipped places or cracks, the coil case checked for loose seams, dents or punctures, and the coil tested electrically.

The coil must be tested at normal operating temperature because internal defects often fail to show up on a cold test. Coil testers are commercially available for this purpose and the manufacturers of such equipment provide full instructions as to their use.

The high frequency type coil tester is valuable in that it detects such defects as shorted primary or secondary coil turns, especially if only a few turns are shorted. A few shorted turns do not markedly affect the peak voltage which an ignition coil can produce, but they will seriously decrease the length of time each spark lasts, since shorted turns have a dampening effect.

In other words, the length in fractions of an inch of the spark may not change noticeably, but the length of time, in fractions of a second, that the spark lasts is considerably shortened by shorted turns in the coil windings.

Thus, a coil with shorted turns, while it could produce sparks of normal length, might not be able to provide good ignition because the sparks do not last long enough in the engine cylinder to ignite the fuel mixture properly.

It must be remembered, also, that an ignition coil with shorted turns in the primary or secondary winding is on the road to failure, since these shorted turns tend to overheat the coil, causing additional turns to become shorted. Finally, enough turns are shorted to cause complete coil failure. The high frequency coil tester, therefore, serves to detect ignition coils that are still good enough to operate the engine, but will very likely soon fail—possibly on the road.

Distributor Cap & Rotor

Corrosion in the terminal sockets and on the segments of the distributor cap, or on the contact button and segment of the rotor, will cause high resistance in the secondary circuit and a weak spark at the plugs.

Widening of the gap between the rotor and cap segments, due to burning of these parts, will also cause high resistance. If they cannot be cleaned satisfactorily or if they are burned excessively, they should be replaced, using the following procedure:

1. Mark the location of the No. 1 cable on the distributor cap, remove the cap from the distributor and pull the cables from the cap.
2. Thoroughly inspect the cap for cracks and for carbon streaks caused by arcing of current between segments through moisture on the cap. Discard the cap if damaged or cracked. Remove carbon streaks by polishing with fine sandpaper and coating the cleaned area with distributor varnish.
3. Clean the inside of the cap terminal sockets, using sandpaper or a suitable brush. Blow all dust out of sockets.
4. Clean corrosion from contact surfaces of terminal segments inside cap by scraping with a knife. Don't use emery cloth or sandpaper as the residue may cause burning of the segments.
5. Polish the contact button of the rotor with fine sandpaper. Clean edge of rotor segment with a knife, being careful not to remove any metal as this would increase the gap between the rotor and cap segments.
6. Wipe rotor and cap clean, and dry with a clean cloth. Do not wash in cleaning solvent since this will damage the insulating properties of these parts.
7. Install rotor and cap on distributor.

Ignition Cables

Cracked, swollen or deteriorated cable insulation permits leakage of high voltage current, which causes weak sparks and loss of power. Such cables should be replaced, but be sure the new cables have ample current carrying capacity. It is advisable to install a complete new set, since the old cables will be deteriorated to about the same extent.

Wipe the cables with cloth moistened with kerosene. Bend the cables to check for cracks or loose or swollen insulation. Thoroughly inspect the terminals for corrosion, looseness, or poor contact with wire strands.

If the cables are in good condition, clean any terminals that are corroded, and replace any terminals that are broken or distorted. Replace any broken or deteriorated rubber nipples.

Wash all oil out of recesses around spark plugs with kerosene or other solvent and blow out with air to dry thoroughly. Then install the cables in the following manner:

Starting with No. 1 cable in terminal socket previously marked for No. 1, install the cables in the distributor cap according to the firing order of the engine. If the distributor operates clockwise, install the cables in the distributor cap clockwise; if counter-clockwise, install cables thus. Push the ends of all cables into the terminal sockets.

Push rubber nipples (if equipped) down into place to seal the connections against entrance of moisture, which would cause corrosion of terminals. If the nipples grip the cables too close to the end so that they buckle when installed, they may pull the cables partially out of the sockets and cause arcing and corrosion.

Spark Plugs

Under normal operating conditions, spark plugs must be cleaned and adjusted every 3,000 to 5,000 miles. Ignition failure may result from using spark plugs too long before cleaning, or the space between shell and insulator may become so tightly packed with carbon or lead oxide deposits that proper cleaning is impossible.

Carbon or oxide deposits are conductors of electricity and may cause intermittent or steady missing, particularly at high speeds and on hard pulls.

Formation of hard carbon or oxide deposits on spark plugs is a normal operating condition, since they are products of combustion resulting from burning of the fuel. The hard carbon is usually black or gray, while the lead oxide deposits may be red, brown or yellow. Both may be accompanied by blistered spots on the insulator.

Slow speed driving during the new engine "break-in" period, combined with oil leakage past the rings before they are worn to a good seat, may cause formation of soft carbon in the inner end of the spark plugs. Therefore, it is usually necessary to clean the plugs at the 1,000 and 2,000 mile inspection periods.

Excessive carbon formation after the "break-in" period may be caused by an over-rich carburetor or choke, faulty ignition, worn or scored piston rings, or by continuous slow speed driving. If slow speed driving is the cause, it is advisable to install a "hotter" plug.

If the vehicle is driven continuously at high speeds the engine may operate better and give longer spark plug life with

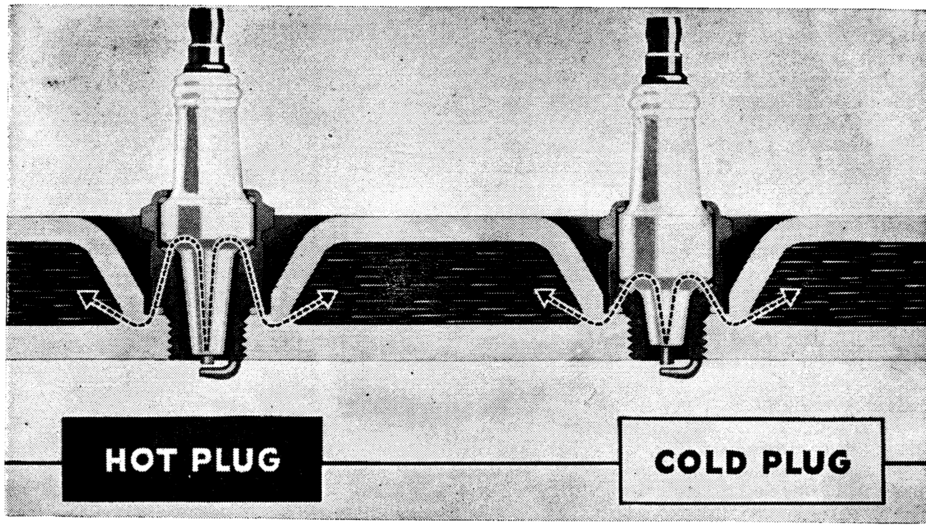


Fig. 3 Heat range of spark plug is determined by the distance heat must travel from center electrode to the cylinder head coolant

a "colder" plug.

Spark plug manufacturers provide for these conditions of continuous slow or high speed driving by making plugs with longer insulators for use in slow speed driving and shorter insulators for high speed driving, Fig. 3.

When removing or replacing spark plugs, use a wrench which fits the plug snugly. An oversize or worn wrench may distort the spark plug shell and crack the insulator. If a socket wrench is allowed to press against the outer end of the plug, the insulator will be cracked or broken.

Carefully inspect the insulators and electrodes of all spark plugs. Replace any plug which has a cracked or broken insulator, or with loose electrodes. If the insulator is worn away around the center electrode, or if the electrodes are burned or worn so they cannot be adjusted for proper gap, the plug is worn out and should be discarded.

Plugs which are in good condition except for carbon or oxide deposits should be thoroughly cleaned and adjusted.

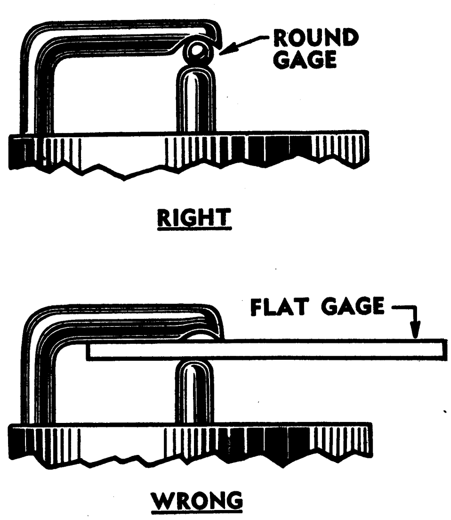


Fig. 4 Correct and incorrect spark plug gauges

To clean plugs, soak them in a carburetor cleaning solvent from 15 to 30 minutes. Thoroughly dry the interior of plugs with compressed air, then scrape out all carbon and oxide deposits from the shells and insulators with a pointed steel scraper. Blow out all scrapings and use sand-blasting equipment to complete the job. Manufacturers of sand blasters furnish complete instructions as to their use.

When adjusting spark plugs, use a round wire feeler gauge of the diameter specified by the manufacturer. Flat feeler gauges will not give the correct measurement if the electrodes are worn (see Fig. 4). Adjust the gap by bending the side electrode only; bending the center electrode will crack the insulator.

Before installing a spark plug make sure that the spark plug seat in the cylinder head is clean and free from obstructions. It is strongly recommended that a new seat gasket be used each time a plug is installed because the old gasket has been flattened and very likely will not provide the proper seal if used again. The plug should be screwed into the cylinder head to fully compress the gasket. The following is the recommended procedure for installing spark plugs:

1. Adjust the electrode gap to the recommended clearance.
2. Thoroughly clean the cylinder head gasket seating surface.
3. Screw the spark plug in by hand as far as it will go.
4. Carefully fit a socket of the correct size over the plug and pull on the wrench very lightly until you feel contact with the seat gasket.
5. Slowly increase the pull on the wrench until the resistance to pull suddenly becomes very great, indicating that the seat gasket has been fully compressed.

Service Note

The smaller the size of the plug the

less pull on the wrench handle is required to compress the gasket. For instance, a 14 MM plug requires less pull on the wrench handle than a ⅞" plug. This is particularly important in the case of 10 MM plugs where only just enough pull should be exercised on the wrench to compress the seat gasket. To avoid the possibility of damaging the plug, use a wrench handle not over 4" long when installing 10 MM plugs.

Installing plugs in aluminum cylinder heads requires particular care as there is danger of stripping the threads in the cylinder head. Do not use graphite or other lubricating compounds on the threads as lubricants will retard heat transfer by separating the metal of the threads which may result in stripping the threads in the cylinder head. Spark plugs in aluminum heads should be tightened while the engine is cool. With cast iron heads tighten the plugs while the engine is at normal operating temperature.

When using a torque wrench to tighten spark plugs the following torque values are recommended:

Plug Thread	Cast Iron Heads	Aluminum Heads
10MM	12 lbs. ft.	10 lbs. ft.
14MM	25 lbs. ft.	22 lbs. ft.
18MM	30 lbs. ft.	25 lbs. ft.
⅞"	35 lbs. ft.	30 lbs. ft.

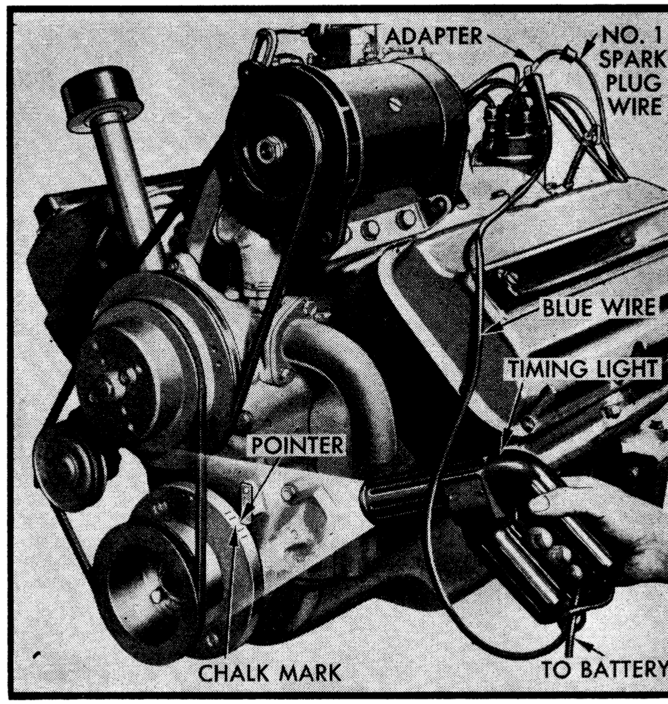


Fig. 5 Checking ignition timing with timing light

Ignition Timing

The use of a timing light, Fig. 5, is recommended for checking and setting ignition timing. Timing that is set back as much as six degrees from the best setting will definitely decrease acceleration and top speed performance.

CARBURETION

Since carburetion is dependent in several ways on both compression and ignition, it should always be checked last when tuning an engine. See the "Carburetor" chapter for adjustments for the unit you are interested in.

Before adjusting the carburetor, consider the factors outlined below and which definitely affect engine performance.

Carburetor Flange

Check the flange for looseness on the manifold. If one of the flange nuts is loose as little as one-half turn, a sufficient amount of air will enter the intake manifold below the throttle plate to destroy engine idle and all engine performance.

If a tight fit cannot be obtained by tightening the nuts, install a new gasket but be sure that all the old gasket material has been removed.

Throttle Linkage

If the throttle linkage is adjusted so that the accelerator pedal will strike the floor board before the throttle plate is wide open, it will result in low top speed.

Fuel Lines

A restriction of the fuel line will result in an apparent vapor lock action or a definite cut-off of gasoline. This can generally be corrected by blowing out the line with compressed air. In some cases, it may be necessary to replace the line.

Fuel Pump

The pump should be tested to make sure that it will draw an adequate supply of fuel from the tank and deliver it to the carburetor under all conditions of operation. If the pump functions inefficiently, proper adjustment and operation of the carburetor is impossible because the fuel will not be maintained at the prescribed level in the idle passages and main discharge jet (or jets) of the carburetor under all operating conditions.

Fuel Tank

The fuel tank should not be overlooked as a possible source of trouble with carburetion. A shortage of fuel at the fuel pump or carburetor may be caused by pieces of filling station pump hose or other material obstructing the mouth of the feed pipe in the tank, or by a restriction of the air vents in the filler cap and neck.

An unusual amount of dirt, water or gum in the fuel filter indicates that the tank is contaminated with these substances, which should be cleaned out to prevent future failure of the pump or carburetor.

Heat Control Valve

The heat control valve performs an important function in carburetion during the warm-up period, Fig. 6. Carbon or rust formation around the shaft may cause the valve to stick or become sluggish in operation.

A valve sticking in the open position will cause slow engine warm-up, excessive spitting and sluggish engine operation when cold. A valve sticking in the closed position will cause overheating, loss of power and hard starting when the engine is hot, and may also cause warped or cracked manifolds. Sticking in either position will adversely affect fuel economy.

Grasp the counterweight and rotate the valve through its entire range. The valve must rotate freely and the shaft must have a slight end play. If the shaft is frozen in the manifold, free it up by gently tapping on the ends with a light hammer, and by rotating the counterweight at the same time.

Lubricate the shaft with a thin mixture of powdered graphite and alcohol or kerosene while moving the counterweight back and forth to work the lubricant into the bearings. Do not use oil as this will form carbon and cause sticking of the valve.

Inspect the thermostat and the anti-rattle spring to make sure they are properly assembled.

Intake Manifold Leaks

Leakage of air into the intake manifold at any point will affect carburetion and general engine performance. Air may leak into the manifold through the joints at the carburetor or cylinder head, cracks in the manifold, cracks or poor connections in the windshield wiper or windshield washer hose lines, or the connections of any accessories which may be connected to the manifold. All such joints should be tested for leaks.

To test the intake manifold for leaks,

apply oil from an oil can along the gasket joints with the engine idling. An air leak is indicated when oil is drawn past the gaskets by the suction of the engine. Tighten the nuts or cap screws holding the manifold to the engine and retest for leaks. If tightening fails to stop the leaks, replace the manifold gaskets. If the new gaskets fail to stop the leaks, carefully inspect the manifold for cracks and test any suspicious area with oil.

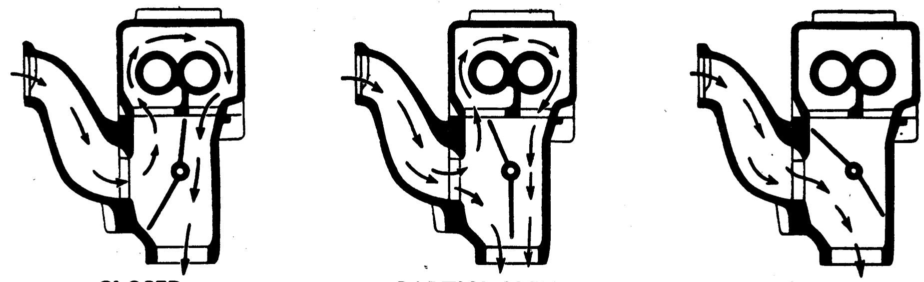
Air Cleaner

An air cleaner with a dirty element, or with oil that is dirty, too heavy, or too high in the sump, will restrict the air flow through the carburetor and cause a rich mixture at high speeds. In such a condition the air cleaner likewise will not properly remove dirt from the air, and the dirt entering the engine will cause rapid formation of carbon, sticking valves, and wear of piston rings and cylinder bores.

Automatic Choke

The choke mechanism must be inspected and cleaned to make sure it is operating freely. Sluggish action or sticking of the choke will cause excessive fuel consumption, poor performance during warm-up and possibly hard starting.

The choke thermostat should be set in accordance with the average air temperature as well as the volatility of the fuel being used. It is desirable to have the thermostat set as lean as operating conditions permit in order to avoid an over-rich mixture during engine warm-up. See the "Automatic Choke" chapter for details.



CLOSED
HEAT ON

PARTLY OPEN
HEAT MEDIUM

OPEN
HEAT OFF

Fig. 6 Operation of a typical manifold heat control valve

PERFORMANCE TEST

After an engine has been tuned up, the truck should be given a thorough and systematic road test to make certain that engine power and performance are up to standard under all operating conditions. The gasoline used in making the test must be of good quality and proper octane rating in order to obtain the performance described in the following tests.

Engine Warm Up

On vehicles with automatic chokes, a cold engine should operate on fast idle for two to five minutes, depending upon air temperature.

At 32 deg. F. the fast idle cam should move to the slow idle position in approximately ½ to ¾ mile of driving. At higher temperatures, it should move to the slow idle position in a correspondingly shorter distance.

If the engine loads excessively or runs rich on warm up due to a rich choke setting, excessive fuel consumption, carbon formation, and spark plug fouling will result.

An engine which is adjusted for smooth idling in cold outside temperature will not idle smoothly for any length of time in a warm building, since the required carburetor adjustment will cause richness of mixture in the warmer atmosphere.

Gradual Acceleration Test

Starting at idling speed in high gear, gradually open the throttle to increase smoothly the speed of the truck through the entire range. Note any roughness, flat spots, or surging in engine performance during acceleration, and the speed at which the unusual condition occurs.

Roughness or poor performance at speeds below 20 m.p.h. indicates improper carburetor idle adjustment, restriction in idle passages in carburetor, tight valve lash or sticking valves, or faulty ignition.

Faulty ignition usually causes a more pronounced roughness than imperfect compression or carburetion.

Roughness or poor performance at speeds above 20 m.p.h. indicates restriction or improper settings in the high speed circuit of the carburetor, or faulty ignition.

Wide Open Throttle Acceleration Test

With the truck running at idling speed in high gear, quickly press the accelerator pedal to the floor and hold it there, meanwhile noting the performance of the engine as the vehicle is accelerated. Repeat the acceleration test, starting at different constant speeds throughout speed range of the vehicle. The truck should accelerate smoothly without hesitation, spitting, or loading of the engine.

A hesitation, spitting, or a flat spot indicates that the accelerating pump is not discharging sufficient gasoline into the engine. Sluggishness or loading indicates that the accelerating pump is adjusted too rich.

Constant Speed Test

Hold the truck speed constant at various points through the speed range and note engine performance. The engine should operate smoothly without hesitation or surging under load at all constant speeds.

At some point between 15 and 22 m.p.h. with the truck rolling along on a level road or slight upgrade, a slight leanness, surging or missing may be detected. Depressing or releasing the accelerator pedal slightly will eliminate this condition and no attempt should be made to correct it by altering carburetion or ignition. This condition seldom appears in the normal operation of the vehicle.

Spark Knock

Light detonation or spark knock will occur when operating with part throttle on a hard pull, even though the ignition is properly timed and Ethyl or other high octane fuel is used. Light detonation also will occur when accelerating with fully opened throttle on a hard pull. These operating conditions are normal and no attempt should be made to eliminate light detonation by retarding the ignition timing.

If regular or low octane fuel is used, detonation will probably be excessive with the standard ignition timing, and it may be necessary to retard the timing, which will reduce fuel economy and over-all performance.

Extreme heavy detonation is injurious to any engine. A truck driven continuously under conditions and fuels which produce heavy detonation will overheat and lose power, with the possibility of damage to pistons and bearings.

Valve Noise

With the valves adjusted uniformly to specifications, the noise level should be very low as observed in the vehicle while driving. The sound of valve action should be audible, however, when the hood is raised or when the engine is operating on fast idle during warm up.

The valve lash should not be reduced below specifications in an attempt to eliminate valve noise, as this will cause formation of carbon on valve seats and stems, which will then increase valve noise and lower the engine performance.

Sticking valves usually are indicated by an intermittent loudness of action, although the valves will be unusually noisy at all times if they are sticking badly. Sticking valves will cause irregular operation or missing on a low speed pull.

MINOR TUNE UP

A minor engine tune up is intended as a preventive measure for engines which are in fairly normal condition. It is usually good on trucks having low mileage or on those which have traveled 5,000 miles or so since having a major tune up. The frequency of use depends upon the conditions under which the truck is operated. A minor tune up should include the following items:

1. Check battery electrolyte specific gravity and level.
2. Inspect battery terminals and cables.
3. Inspect primary wires and ignition switch.
4. Clean coil and terminal socket.
5. Inspect distributor automatic advance weight mechanism.
6. Inspect distributor vacuum control.
7. Clean and adjust distributor contact points, lubricate cam wick and rubbing block.
   and rotor.
8. Reset ignition timing.
9. Inspect and clean distributor cap
10. Inspect ignition cables.
11. Clean and adjust spark plugs, or install new plugs if required.
12. Clean fuel strainer and filters.
13. Inspect and lubricate manifold heat control valve.
14. Check for intake manifold air leaks.
15. Clean and/or refill air cleaner.
16. Inspect and set choke thermostat.
17. Check fast idle cam and choke unloader adjustments.
18. Adjust throttle linkage.
19. Adjust carburetor.
20. Inspect and adjust fan belt.
21. Inspect water pump, radiator and heater hose connections, and radiator water level.
22. Clean oil filter cap.
23. Test performance after tune up.

IGNITION SYSTEMS

THE ignition system can be divided as follows, Fig 1.

1. Battery to supply current.
2. Ignition wiring to carry current to the units in the system.
3. Ignition switch to control the circuit.
4. Ignition coil to increase the voltage delivered to the spark plugs.
5. A distributor to distribute current to each cylinder.
6. Spark plugs to ignite the fuel in each cylinder.

But inasmuch as the "Tune Up" chapter deals with such service as comes within the province of tuning up an engine—such as batteries, spark plugs, testing procedures, etc.—this chapter will discuss the functions and service requirements of the distributor itself, together with any additional data not included in the "Tune Up" chapter.

AUTO-LITE DISTRIBUTORS

Auto-Lite distributors used on trucks contain one or two controls which provide automatic advance of ignition timing according to engine speed and load. Some units are provided with only a centrifugal advance mechanism whereas others provide for both centrifugal advance and vacuum advance. Figs. 2 and 3 show the type with both centrifugal and vacuum advance. The centrifugal governor in the distributor body regulates ignition timing according to speed. The vacuum control unit attached to the outside of the distributor body regulates ignition timing according to load.

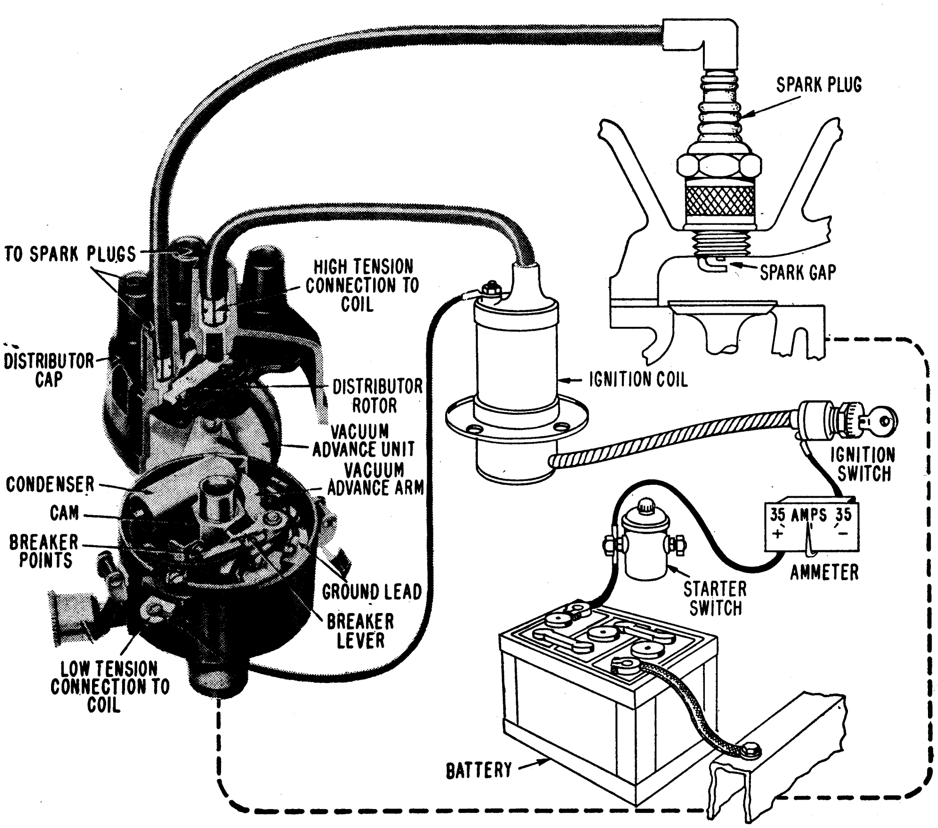


Fig. 1 Typical ignition system

Dual Point Distributor

This type of distributor contains two sets of points, Fig. 4, which permit additional current build-up in the primary winding of the coil. Thus, maximum voltage is induced in the secondary winding.

The two sets of points are connected in parallel and are positioned in relation to the 8-lobe cam so as to provide a 7-degree overlap of points opening and closing. One set of points (circuit *maker* points) closes the primary circuit in the coil and the second set of points (circuit *breaker* points) opens the circuit, causing a spark at the plug. Immediately after the spark occurs, the circuit *maker* points are closed ahead of the circuit *breaker* points, thus providing a circuit to build-up the primary winding. As the cam rotates further, the secondary points close and just before the secondary points open, the primary points open 7 degrees ahead.

Setting Dual Breaker Points

Since the "make" and "break" points are timed to close and open at the exact instant necessary for efficient engine operation, adjustment of the points is an important factor in correct distributor operation.

New points can be adjusted with a feeler gauge. If points are used but are still clean and make flat contact with each other, a dial indicator tool can be used satisfactorily. If points are pitted or badly worn, they should be replaced because metal may be burned, causing a resistance that would cause poor point operation.

Feeler Gauge or Dial Indicator Method— Rotate the distributor shaft until the breaker arm rubbing block of one set of points is on the high spot of the cam. Then, with a screwdriver blade in the triangular opening, close or open the points to the proper clearance by turning the screwdriver blade against the stationary point plate. Check the clearance with a clean feeler gauge or dial indicator.

Dwell Meter Method—If this method is used *block one set of points open* with a piece of wrapping paper or calling card. Then adjust the other set of points to the correct cam angle. After setting the points tighten the lock screw. Then turn the distributor shaft until the rubbing block of the second set of points is on the high spot of the cam and adjust the second set of points in the same manner.

DELCO-REMY DISTRIBUTORS

Like Auto-Lite distributors, Delco-Remy units used on trucks contain one or two controls to provide automatic advance of ignition timing according to engine speed and load. Some units are provided with only a centrifugal advance mechanism whereas others provide for both centrifugal advance and vacuum advance. Figs. 5 and 6 show the type with both centrifugal and vacuum advance. The centrifugal governor in the distributor body regulates ignition timing according to speed. The vacuum control unit regulates ignition timing according to load.

External Adjustment Type Distributor

This type distributor, Fig. 7, has a cap with a window which provides easy access for adjusting breaker point gap while the cap is in a mounted position. The circuit breaker plate is located below the centrifugal advance mechanism and uses the outer diameter of the distributor shaft bushing for its bearing surface. The movable plate is held in position by a retainer clip in the upper shaft bushing. The breaker points are attached to the movable breaker plate, the points and plate being furnished as one complete assembly. The vacuum control unit is mounted under the breaker plate to the distributor housing. The molded rotor serves as a cover for the centrifugal advance mechanism.

Adjusting Breaker Points

With the engine running at idle speed, the point gap is adjusted by first raising the window provided in the cap and inserting a "hex" wrench into the adjusting screw as shown in Fig. 6.

Turn the adjusting screw in (clockwise) until the engine begins to misfire. Then give the wrench one-half turn in the opposite direction.

If a cam angle meter is to be used, turn the adjusting screw until the correct cam angle is obtained.

HOLLEY DISTRIBUTORS

"Full Vacuum" Type

This distributor, Figs. 9 and 10, is regulated entirely by the vacuum differential at the carburetor. The spark advance characteristics are controlled by two breaker plate springs working against the distributor vacuum control dia-

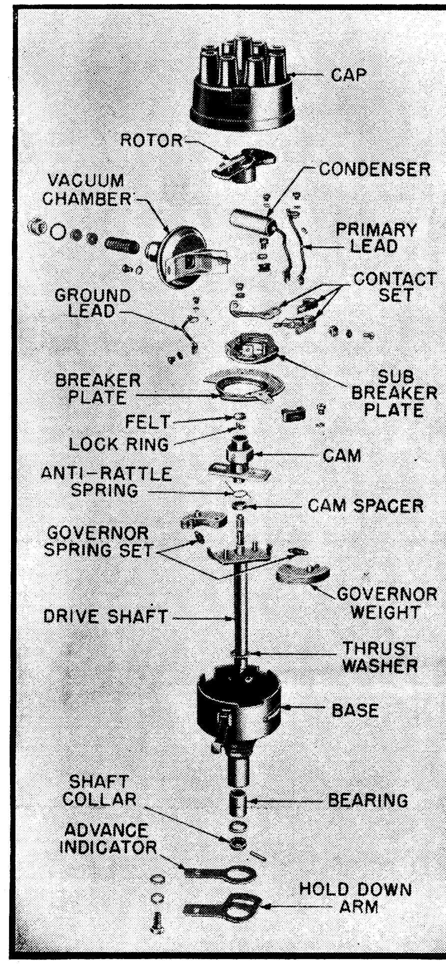


Fig. 2 Typical Auto-Lite distributor

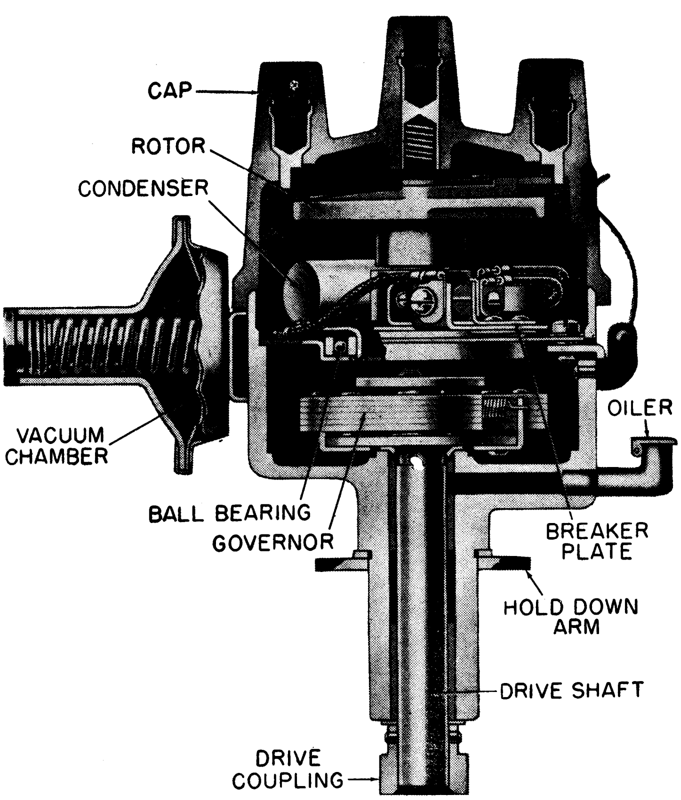


Fig. 3 Typical Auto-Lite distributor

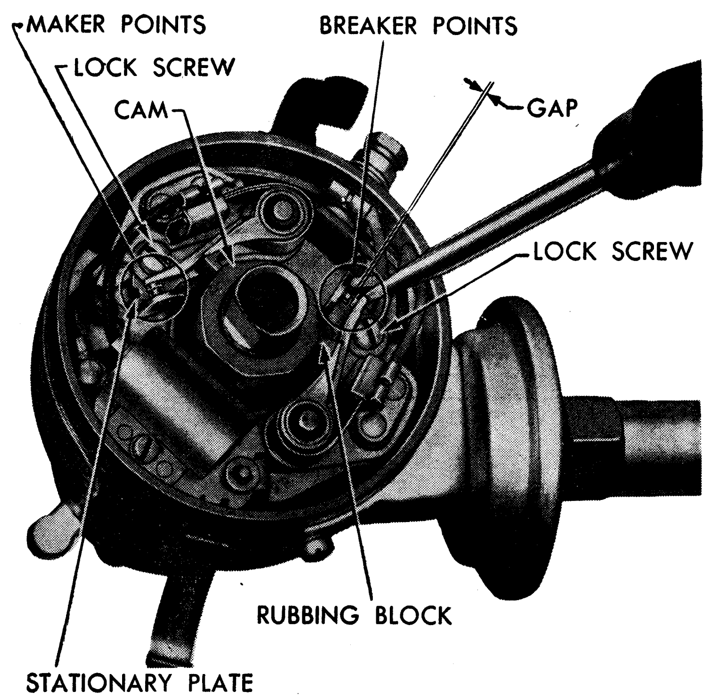


Fig. 4 Auto-Lite dual point distributor

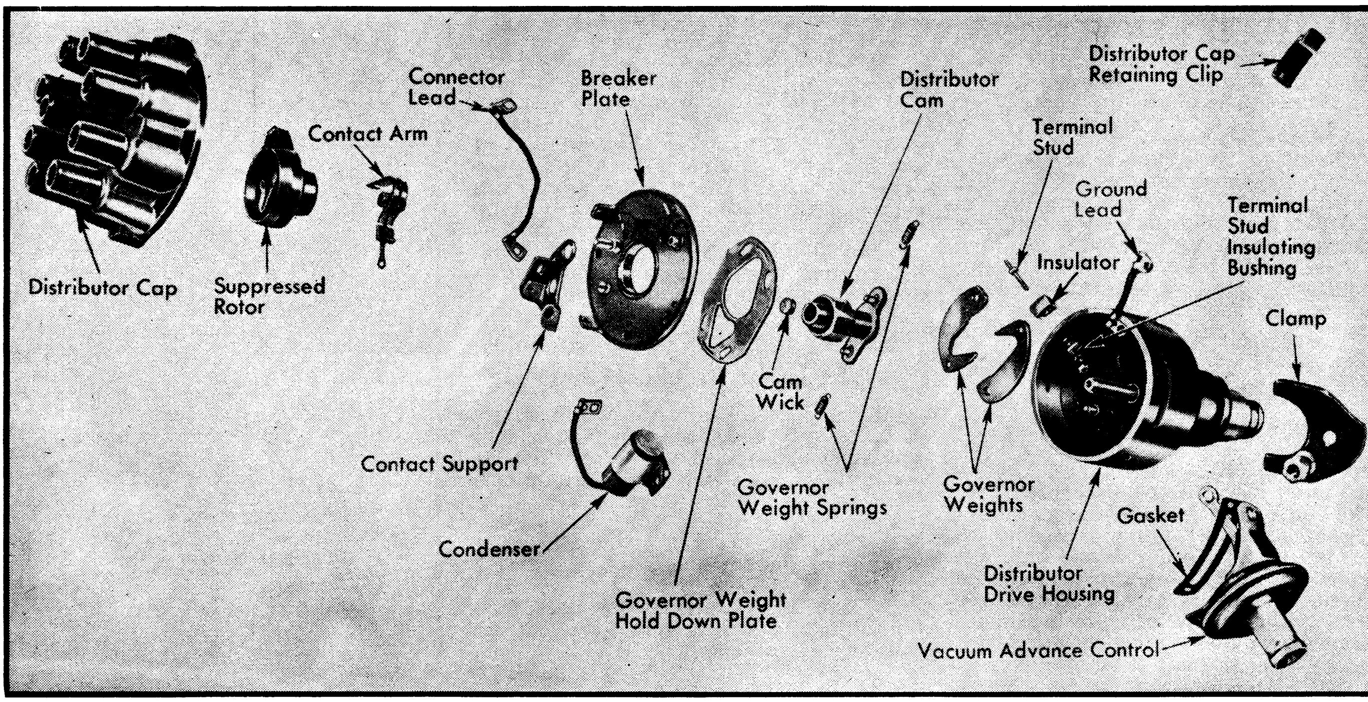


Fig. 5 Delco-Remy internal adjustment distributor

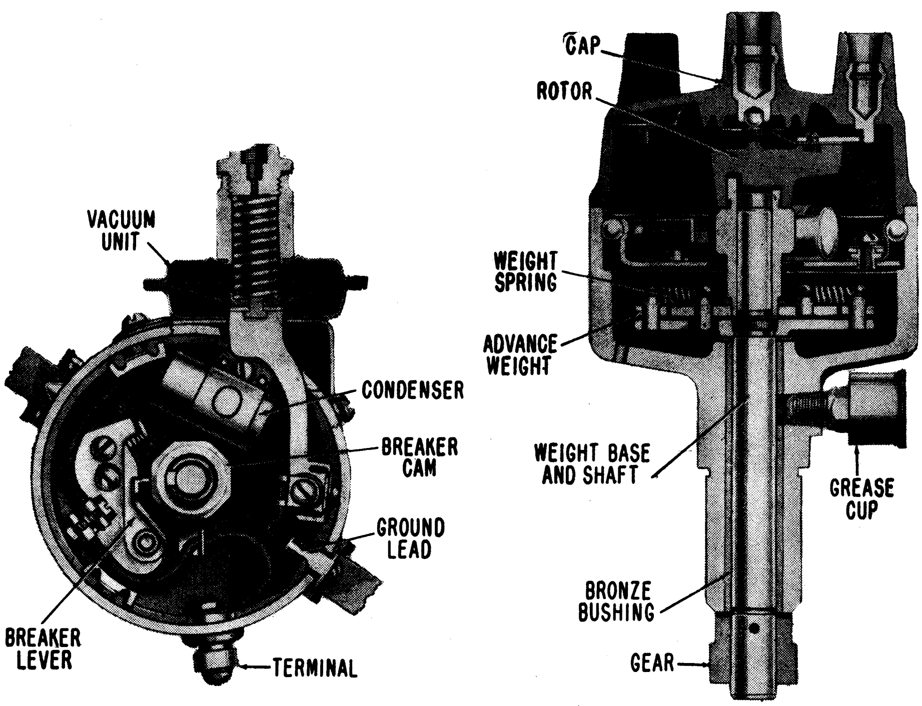


Fig. 6 Delco-Remy internal adjustment distributor

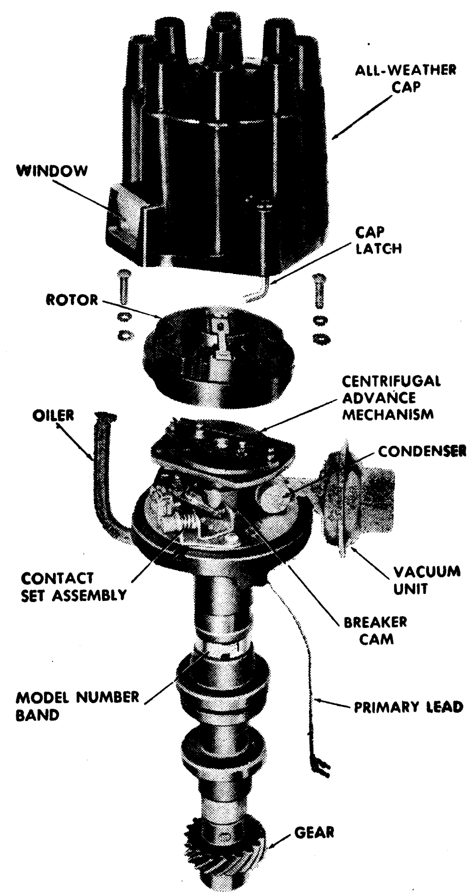


Fig. 7 Delco-Remy external adjustment distributor

phragm. The amount of spark advance is determined by the amount of vacuum supplied to the distributor and by adjustment of the breaker plate springs.

On all 8-cylinder distributors, a vacuum-operated spark control valve is attached to the carburetor throttle body to control manifold vacuum to the distributor and regulate spark advance, Fig. 11.

Adjusting Vacuum Advance

The two vacuum advance springs are precision set at the factory with special stroboscopic equipment. This equipment is available for adjustment purposes in the field. Shops having conventional distributor testers can include a mercury column to take care of the setting of

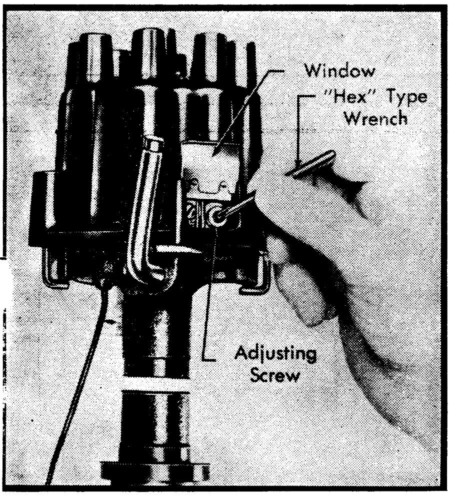


Fig. 8 Adjusting breaker gap through window in distributor cap

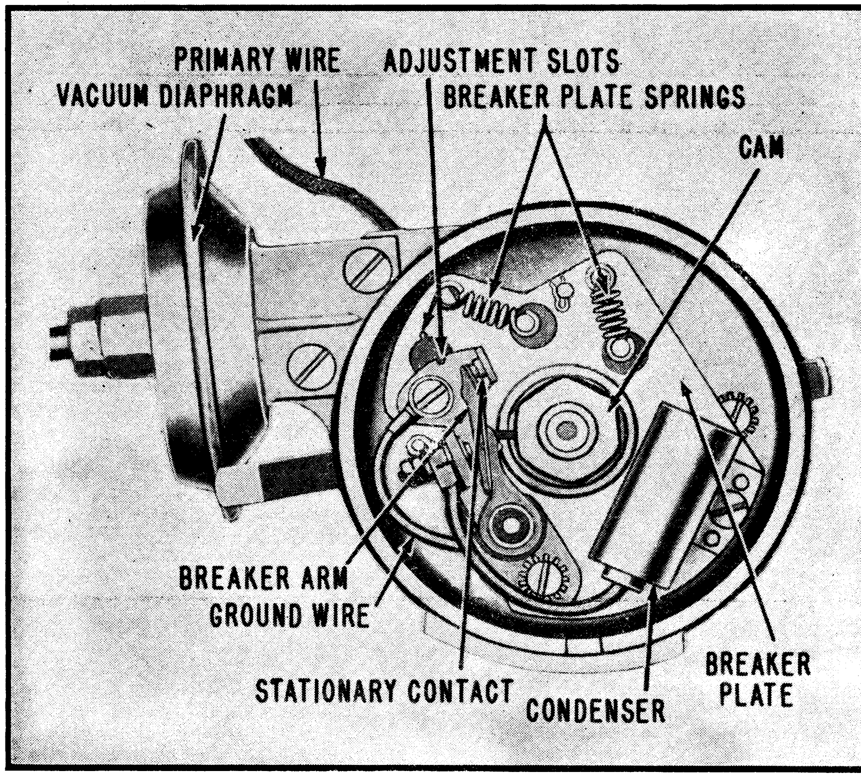


Fig. 10 Breaker plate details of Holley "full vacuum" distributor

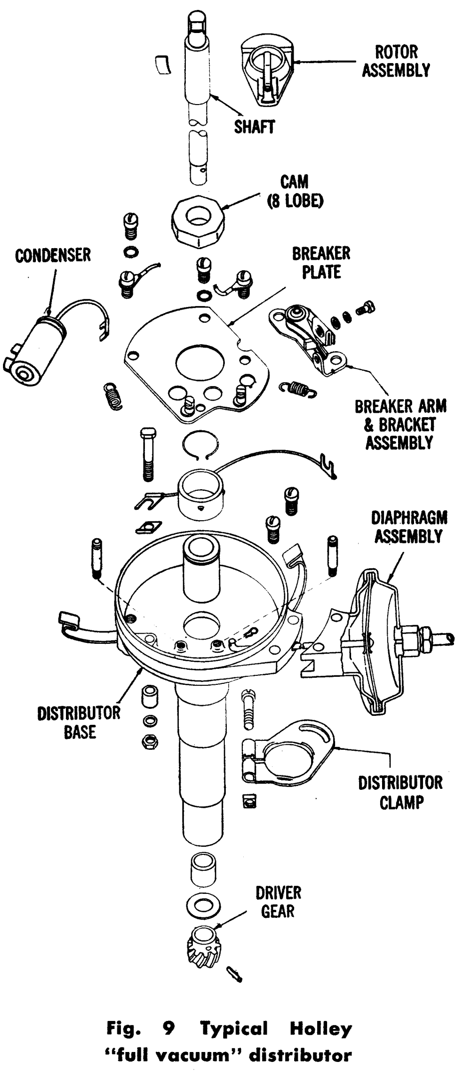


Fig. 9 Typical Holley "full vacuum" distributor

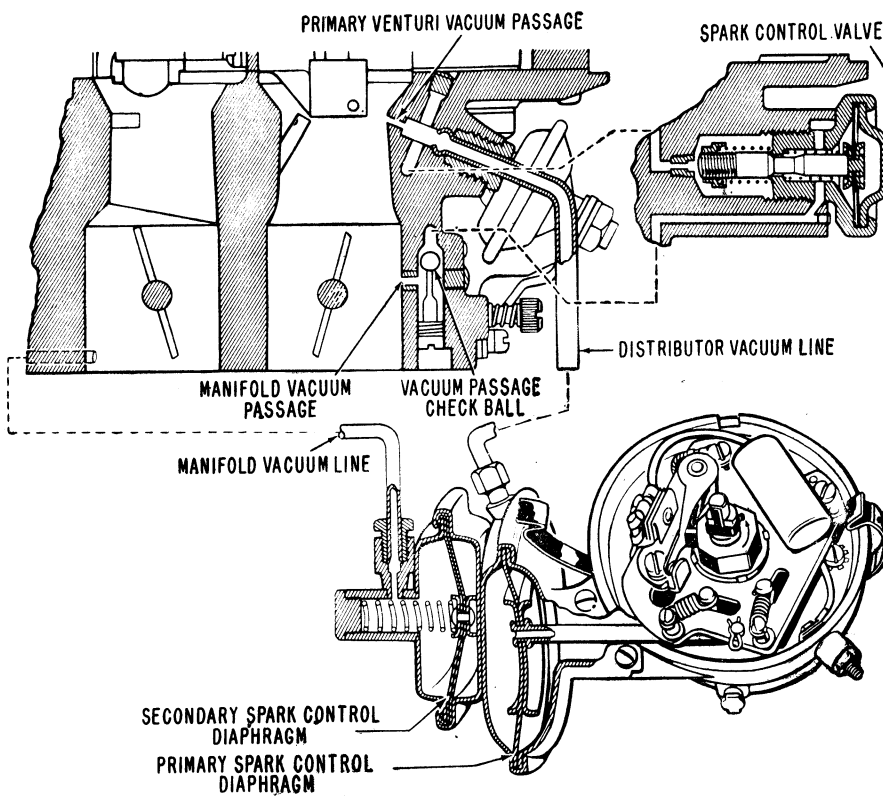


Fig. 11 Showing vacuum-operated spark control valve attached to carburetor throttle body to control manifold vacuum to the distributor and regulate spark advance. Holley "full vacuum" distributor

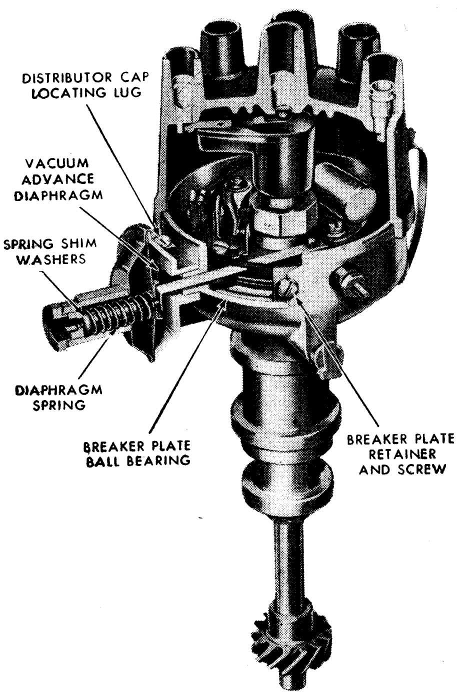


Fig. 12 Holley centrifugal advance distributor

these springs as the ordinary vacuum gauge will not provide the required accuracy.

Taking a typical distributor as an example, set the distributor speed at 500 rpm and apply a vacuum of ½". Then turn one spring clockwise until the spark falls with ½ to 1½ degrees advance. With one spring adjusted thus, increase distributor speed to 1000 rpm and apply a vacuum of 2". Adjust the second spring until the spark occurs at about 5 degrees advance.

Centrifugal Advance Distributor

This distributor, Figs. 12 and 13, is basically the same as the conventional Auto-Lite and Delco-Remy units, the chief difference being that the centrifugal advance mechanism can be adjusted through a slot in the breaker plate as follows:

With the distributor mounted in a test machine, and with the vacuum hose disconnected, operate the distributor in the direction of its normal rotation and increase the rpm until the mechanism begins to advance. Reduce the speed to where there is no advance and zero the advance scale. Increase the speed to the value specified for the first advance reading listed in the specifications (see truck chapters). If the correct advance is not indicated at this rpm, stop the distributor and bend the primary spring bracket with a screwdriver as shown in Fig. 14 to change its tension. Bend the bracket away from the distributor shaft to decrease advance and toward the shaft to increase it.

The primary spring is the spring that is under tension when the distributor shaft is not rotating. To determine which spring is under tension, insert a hook into the adjusting slot and move each spring. The secondary spring will be under less tension than the primary spring.

Check the minimum advance point again, then operate the distributor at the specified rpm to give an advance just below the maximum. If this advance is not to specifications, stop the distributor and bend the secondary spring bracket to give the correct advance.

"Roto-Vance" Distributor

This distributor, Fig. 15, functions as a standard ignition unit and in addition acts as a control unit for the engine speed governor valves located below the carburetor, Fig. 16.

The distributor-governor consists of an adjusting nut, a calibrating spring and governor weight. Below governing speed the weight cannot overcome the spring tension and the air inlet port is open. Thus air is permitted to flow through the distributor shaft, the governor air line and through the engine governor. This air is at atmospheric pressure.

With an increase of engine speed and distributor shaft rotational speed, centrifugal force is exerted on the weight and it moves out against spring tension. Continued increases of engine speed moves the weight far enough to close off the air inlet port. Closing the air inlet port permits vacuum pressure to be impressed on one side of the engine governor diaphragm. The opposite side of the diaphragm is vented to atmospheric pressure through a connecting line to the fresh air inlet line. The resulting pressure differential on the diaphragm causes the throttle valve to be moved towards a partially closed position against the throttle valve plate governor spring tension.

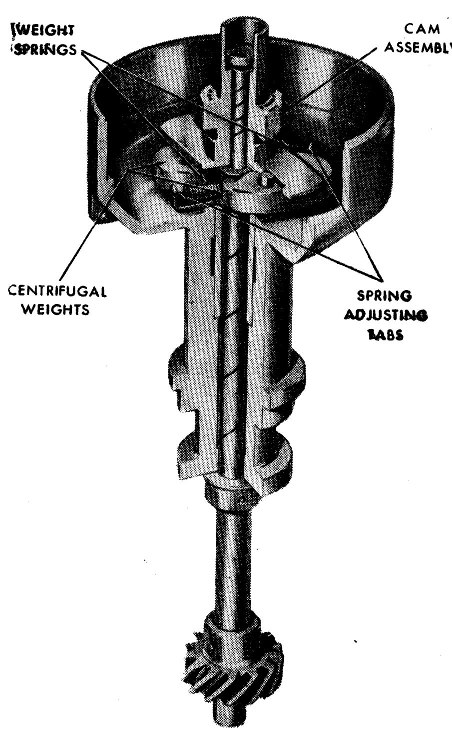


Fig. 13 Holley distributor centrifugal advance mechanism

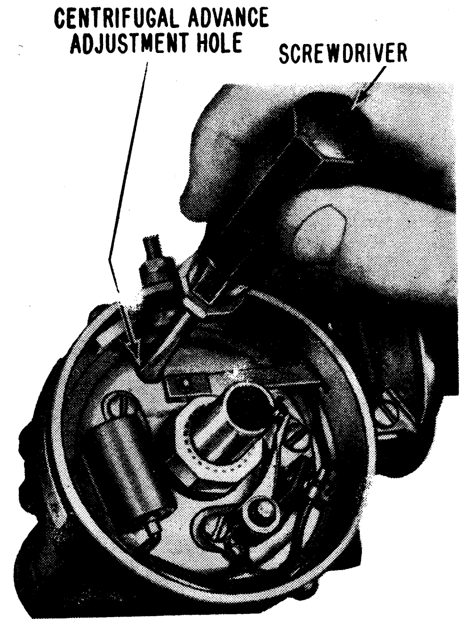


Fig. 14 Adjustment of centrifugal advance

A decrease in engine speed allows the distributor governor valve weight spring to push the weight towards the distributor shaft, thus opening the inlet port and neutralizing the pressure differential on the diaphragm. The governor throttle plate is returned to its fully open position by the engine governor spring.

Automatic Advance Adjustment

Install distributor on a test bench and move the adjusting hole cover plug. Check the operation of the automatic advance against specifications given in Truck Chapters. Adjust the weight springs by screwing in or out on the adjusting nuts, Fig. 17, turning both nuts the same amount. Turning in on the nuts will increase the tension and the rpm required to move the weights and will give a retarded advance. Loosening the nuts will allow the weights to move at a slower rpm and will cause the timing to advance earlier. *Be sure nut flats index lock plate.* Where the initial setting is correct but the advance does not follow specifications it is an indication that the advance springs are faulty or the distributor cam is binding on the shaft.

CAUTION—Care should be taken when adjusting the advance mechanism to approximate the specified curve as closely as possible. The spark timing of the engine in operating range is determined directly by the accuracy of the distributor advance mechanism. *It is important to remember that a one-degree error in the distributor advance settings will produce a two-degree error in spark timing when operating in the engine.*

Testing Engine Speed Governor Valve In Test Stand

Operate the test stand vacuum pump. Pinch the end of the vacuum hose and record the highest vacuum reading obtained. Connect the vacuum line to the lowest fitting on the distributor. Make certain that no leaks are present.

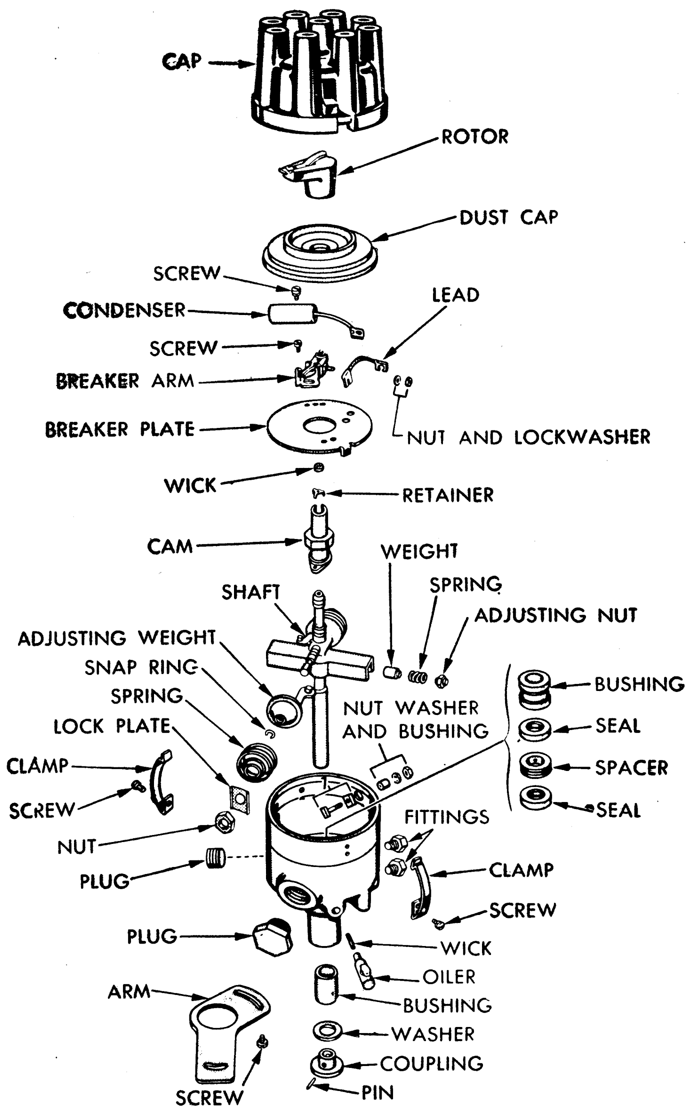


Fig. 15 Holley "Roto-Vance" (carburetor governor control) distributor

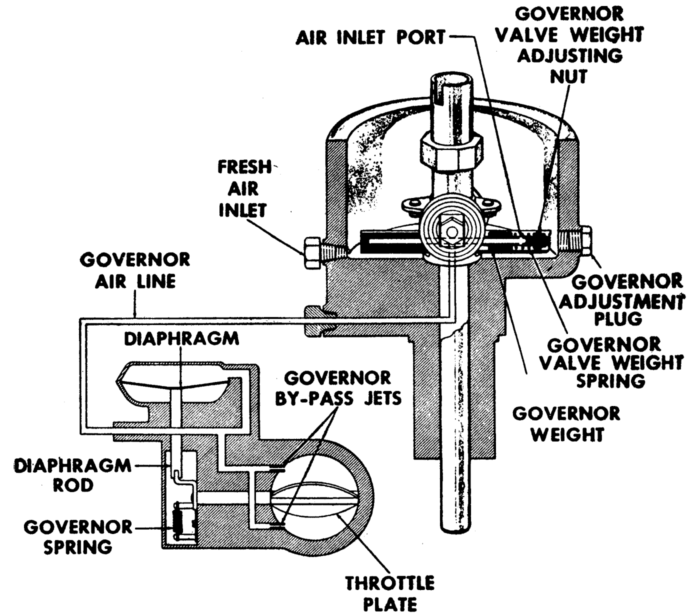


Fig. 16 Diagramatic view of governor system. Holley "Roto-Vance" distributor

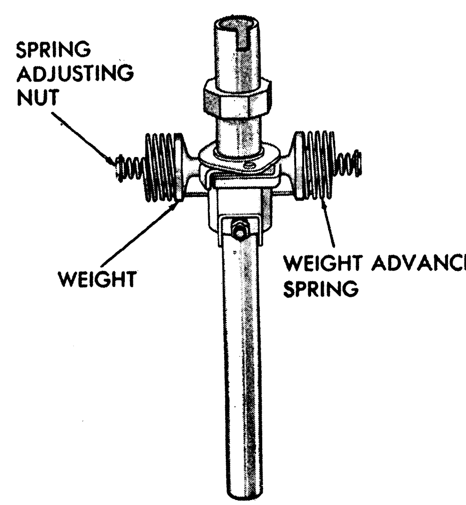


Fig. 17 Adjusting advance weight springs. Holley "Roto-Vance" distributor

Without rotating the distributor shaft, note the vacuum reading on the gauge. If the passages in the distributor are free of obstructions, a desirable very low reading should be obtained. An undesirable high reading will indicate that obstructions in the passages are present, caused by dirt or other causes. The distributor should then be thoroughly checked to determine cause and corrections made.

NOTE—Some test machines have a pipe cleaner type of restrictor. For these tests this restrictor should be removed or an inaccurate reading will be obtained. The vacuum line in the machine must be open.

Rotate the distributor shaft and gradually increase the speed while observing the vacuum gauge. When the distributor shaft speed reaches the rpm necessary to move the governor weight out on its shaft and close the air inlet port, the vacuum reading will "jump" to a high reading almost instantly. The vacuum reading at this rpm and at all higher speeds should be within one or two inches (Hg) of the reading recorded at the start of the test. If the vacuum reading is within the specified one to two inches of the previous reading, it is an indication that the weight valve is sealing the inlet port and that no noticeable leaks are apparent.

Decrease the distributor shaft speed gradually while observing the vacuum gauge. When the speed drops slightly below the governor closing speed, the air inlet port should open, causing a rapid drop in vacuum.

DISTRIBUTOR SERVICE

Distributor Removal

If the inspections and tests given in the "Tune Up" chapter indicate that the distributor requires cleaning or the installation of new parts, remove the distributor from the engine so that the work can be done properly.

Each time a distributor is removed and reinstalled, or when a new one is installed, it is essential that it be properly timed. Determine whether the timing mark is on the flywheel, on the vibration damper or on the lower fan pulley. To make it easily visible, clean the mark and trace a narrow line on it with chalk or white paint.

1. Remove the spark plugs to relieve the compression and crank the engine to the firing position for No. 1 cylinder.
2. Trace the No. 1 spark-plug wire to its terminal in the distributor cap.
3. Mark the distributor housing directly under this terminal, either by

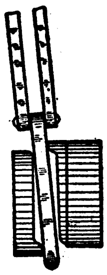


Fig. 18 Contacts out of alignment. A flat .020" gauge spaces contacts .030" to 0.40"

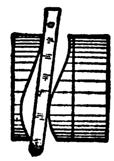


Fig. 19 Contacts worn unevenly. A flat .020" gauge spaces contacts .030" to .050"

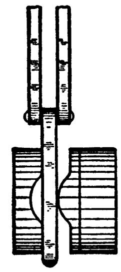


Fig. 20 Contacts pitted. A flat .020" gauge spaces contacts .040" to .050"

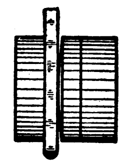


Fig. 21 Only contacts correctly aligned can be correctly spaced with gauge. New contacts are usually made up of one convex surface operating against one with a flat surface

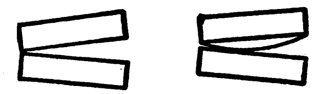


Fig. 22 Showing advantage of employing one convex point as against two flat points when points are misaligned

scratching with a screwdriver or by a chalk mark so that the rotor position for No. 1 cylinder will be known when the distributor is reinstalled.

4. Release the distributor cap clamps and raise the cap (with wires attached) and note the position of the rotor. Its segment should be directly over the mark previously made on the distributor housing. If not, the distributor drive shaft gear or coupling is broken or the drive pin sheared.
5. Disconnect the primary wire at the distributor terminal.
6. Remove the vacuum advance connection (if equipped) and remove the distributor clamp hold-down bolt.
7. Raise the distributor as a unit from its mounting.

Distributor Disassembly

The disassembly procedure on any of these distributors is fairly obvious and easy. On some of the units, there is a rather complex stack-up of insulating, flat and lock washers at the terminals, but a few moments study of this before the parts are detached from each other will aid in reassembling them correctly.

The first step in disassembly is to remove the cap and rotor, if not already done. Next, the vacuum advance mechanism. Then the breaker plate together with the contact points and condenser should be detached from the housing. The drive gear or coupling may then be removed from the drive shaft, and the drive shaft with its centrifugal governor mechanism lifted from the housing. Further disassembly of the braker plate and governor mechanism is obvious.

At this time, the parts should be inspected, tested, assembled and adjusted in the manner described in subsequent paragraphs. Then the distributor should be installed and timed with the engine in the following manner.

Distributor Installation & Timing

Before installing the distributor, check the timing mark on the flywheel, vibration damper or pulley to be certain that the engine has not been rotated while the distributor was off, and that it still remains set on the timing mark for No. 1 cylinder.

If a new distributor is being installed, scratch or chalk a mark on it to correspond to the mark made on the old distributor and use this mark as a guide for the initial position of the rotor as the new distributor is temporarily set in place.

Temporarily set the distributor in its mounting with cap removed, being careful to see that the primary terminal and the vacuum control (if used) are in position to connect to the wire and pipe, respectively. However, do not connect them at this time.

With the rotor in approximately the same position as when the distributor was installed (in line with the mark on the distributor housing), allow the distributor to settle down to its permanent position in the mounting, being certain that the screw hole for the clamp hold-down bolt is in the center of the clamp slot.

In the case of a gear-driven distributor, notice that the rotor will move from the position in which it was set as the distributor is moved into position. When this occurs, raise the distributor and turn the rotor just far enough beyond the desired position to allow for the change made by the gear movement, and again set the distributor in place. Install the hold-down screw. Connect the primary wire to its terminal, and the vacuum pipe to the vacuum control. The distributor should now be properly timed.

However, to compensate for the grade of fuel being used, and for best performance and fuel economy, it may be necessary to alter the timing slightly from the original setting. The best setting is one which will produce a slight spark knock or "ping" when accelerating from about 10 M.P.H. with wide open throttle. (See the "Tune Up" chapter for other methods of setting ignition timing.)

Breaker Points

The normal color of contact points should be light gray. If the contact point surfaces are black, it is usually caused by oil vapor, or grease from the cam. If they are blue, the cause is usually excessive heating due to improper alignment, high resistance or open condenser circuit.

Figs. 18, 19 and 20 show the condition of contact points after they have been in operation for several thousand miles. These illustrations illustrate the difficulty of setting contact points correctly with a feeler gauge. Unfortunately, points do not wear evenly, and with each thousand miles of operation, the surfaces deviate from being parallel with each other. Fig. 18 shows what happens when points are not in correct alignment—they lap over each other.

Fig. 19 shows uneven wear of the contact surfaces, while Fig. 20 pictures the development of a crater and projection, usually caused by a metal transfer from one point to the other.

Fig. 21 shows a view of a new set of contact points. The right-hand contact

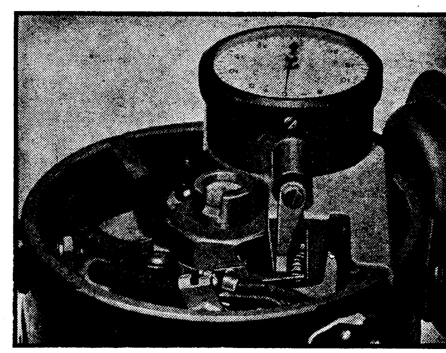


Fig. 23 Dial indicator for measuring contact point opening on Delco-Remy distributor. A similar device is available for Auto-Lite distributors

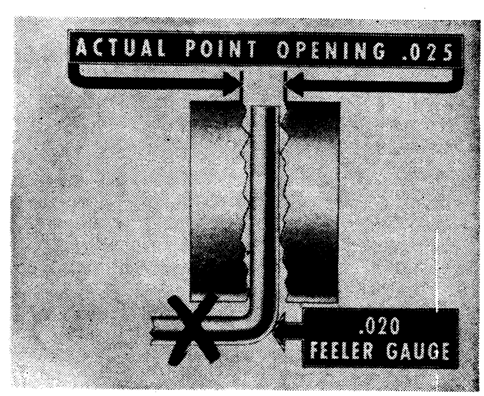


Fig. 24 Showing why feeler gauge will not provide accurate point spacing if points are rough

Fig. 25 Cam angle or dwell is the number of degrees of breaker cam rotation from the time the points close until they open again

has a convex surface, while the left-hand point has a flat surface. This convexity is scarcely visible to the naked eye as it amounts to approximately .002 inch from the center of the point to its outside extremity. The advantage claimed for this design is that the contact of surfaces which break the arc will be nearer to the mass of metal in the two contacts, which gives better heat radiation. A further advantage is that should the points be misaligned, more metal will be in contact when a convex point is used than if both points were flat. Fig. 22 illustrates how this is accomplished.

Auto-Lite is strongly against filing of contact points, because the cutting surface of the file produces high spots on the contact surfaces, which means concentration of current and heat in extremely small areas.

Delco-Remy recommends that contact points which are blackened or slightly burned or pitted should be cleaned with a special point dressing stone or a clean contact point file. In dressing the points, remove the high spots only, as it is not necessary to remove all traces of build-up or pit.

Sandpaper or emery cloth should never be used to clean up points, since particles of sand or emery may imbed in the points and cause rapid burning and wear.

Specifications for contact point opening, as measured with a wire gauge, are given in the "Tune Up" table in the various chapters. However, if at all possible, this opening should be set on a distributor test fixture or with a dial indicator of the type shown in Fig. 23. This not only eliminates the possibility of a wrong gap setting, but if the points are slightly rough, but otherwise in alignment, there is the danger of obtaining an incorrect gap, as shown in Fig. 24.

The advantage of a distributor test fixture or dial indicator is that it not only measures cam angle or dwell, Fig. 25, but it also uncovers irregularities between cam lobes, bouncing of contact points, alignment of rubbing block with cam, alignment of contacts and breaker arm spring tension. Manufacturers of such equipment furnish complete instructions as to its use.

If the contacts develop a crater or depression on one point and a high spot of metal on the other, the cause is an electrolitic action transferring metal from one contact to the other, Fig. 26. This can be the result of some unusual operation of the vehicle. A slow-speed driver in city traffic or door-to-door delivery vehicles will be one extreme, and high speed long distance driving would be the other extreme. It may also be due to an unbalanced ignition system, which can sometimes be improved by a slight change in the condenser capacity.

If the mound is on the positive point, Fig. 27, install a condenser of greater capacity; if the mound is on the negative point, Fig. 28, install a condenser of lesser capacity.

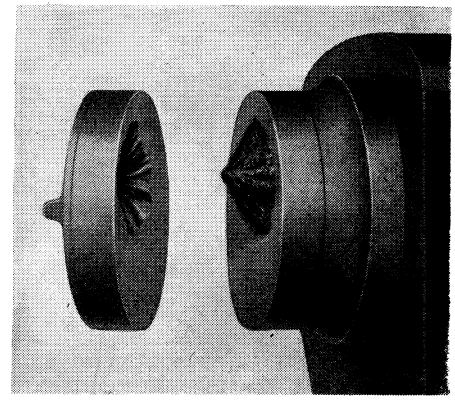


Fig. 26 Showing how metal from one contact point transfers to the other

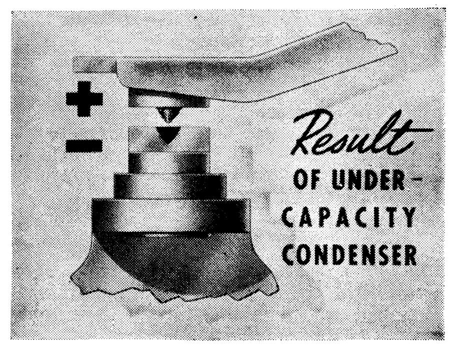


Fig. 27 Mound on positive point

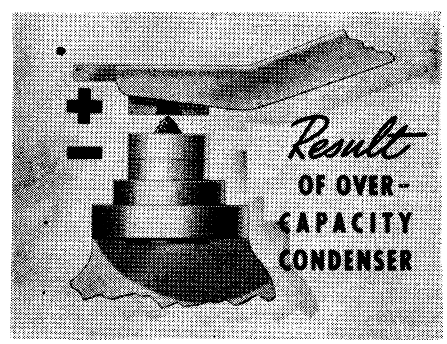


Fig. 28 Mound on negative point

One of the most prevalent causes of contact point failure is the presence of oil or grease on the contact surfaces, usually from over-lubrication of the wicks at the top of the cam, or too much grease on the rubbing block. This condition is indicated by a smudgy line on the point support and breaker plate, Fig. 29. If caught in time the contacts can be cleaned and the residue left on them can be wiped off by drawing a piece of lint-free tape between the contacts.

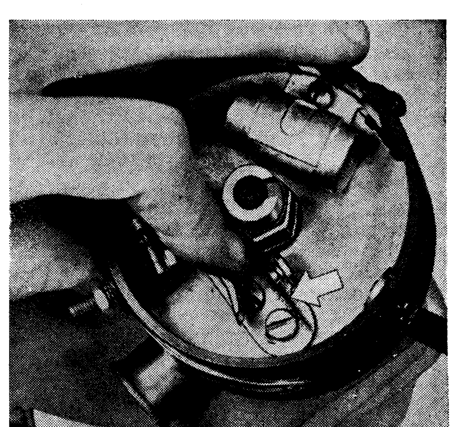


Fig. 29 Oil on contact points indicated by smudgy line on point support and breaker plate

When new contacts are installed, the breaker arm should be free on the hinge pin, the contacts lined up with the outside diameters registering perfectly, and contact made in the center of the contact surfaces. This can be done by bending the contact support. Never bend the contact arm between the rubbing block and contact.

The rubbing block should be lined up with the cam by using a thin strip of white paper and carbon paper, held between the rubbing block and cam. By rotating the cam against the paper, a carbon impression will be made, showing which way the arm should be bent between the hinge pin and rubbing block to obtain correct alignment. When a straight-line impression is obtained from top to bottom of the rubbing block against the cam, even though it may be on only one edge of the block, it will be unnecessary to "run in" the block to improve the contact.

Breaker arm spring tension is extremely important. If the tension is too great, the arm will bounce, causing an interruption of the current in the coil and missing in the engine. If the spring tension is not sufficient, the rubbing block will not follow the cam, causing a variation in the cam angle. The spring tension should always be set at the high limit given in the "Distributor Specification" tables, as it will be reduced as the rubbing block wears. Fig. 30 illustrates how the tension is measured.

Condenser

A condenser should not be condemned because the points are burned or oxidized. Oil vapor, or grease from the cam, or high resistance may be the cause of such a condition.

Condensers should be tested with a good condenser tester for leakage, break-

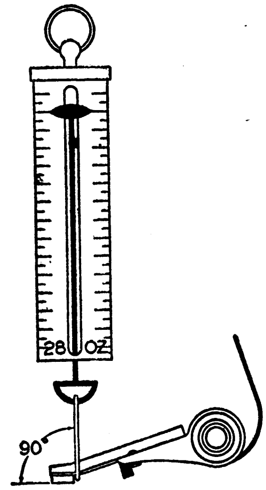


Fig. 30 Measuring breaker arm spring tension

down, capacity, and resistance in series in the condenser circuit. Manufacturers of condenser testers furnish complete instructions as to their use.

Ignition Coil

If poor ignition performance is obtained and the coil is suspected, it may be tested on the car or it may be removed for the test.

Ignition coils are often condemned when the trouble is actually in the ignition switch. A completely defective ignition switch will produce an open primary circuit, giving the same indications as if the coil were completely dead. A partly defective ignition switch will cause a weak spark. Both of these conditions are often blamed on the coil.

By cutting the ignition switch out of the circuit, it can easily be determined whether or not the coil is defective or whether fault lies with ignition switch.

In the case of lockswitch coils, the coil end cover should be removed and a temporary wire connected directly from the battery (or the nearest live battery connection) to the coil terminal that is normally under the coil end cover. In the case of coils without the lockswitch feature, a similar temporary wire should be connected to the terminal of the coil to which the battery wire is normally connected. In either case, this temporary connection jumps the ignition switch. If the trouble is eliminated when the engine is started, it is obvious that the ignition switch was the offender—not the coil.

In the absence of any testing equipment a simple check of an ignition coil can be made as follows: Turn on ignition switch with breaker points closed. Remove the high tension cable from the center socket of the distributor cap and hold it ¼ to ⅜" away from a clean spot on the engine. Then open and close the points with a screwdriver. If the coil and other units connected to it are in good condition a spark should jump from the wire to the engine. If not, use a jumper wire from the primary terminal of the distributor to the engine; if the primary is in good condition a spark will occur.

All ignition coils with metal containers can be tested for grounded windings by placing one test clip on a clean part of the metal container and touching the other clip to the primary and high tension terminals. If the lamp lights or tiny sparks appear at the points of contact, the windings are grounded and the coil should be replaced.

Coil Polarity

The polarity of the high tension terminal of the coil is important, as some car manufacturers specify positive polarity and others negative polarity. A reversal of this polarity when connecting the coil, or when replacing the coil, may affect the performance of the engine (or the radio).

A simple method of testing coil polarity on the car with a voltmeter is shown in Fig. 31. The voltmeter positive lead is connected to the high tension tower of the coil through a resistance of from 17,000 to 25,000 ohms (a radio suppressor of not less than 17,000 ohms is suitable for this purpose). The voltmeter negative lead is connected to the coil primary terminal that is connected to the distributor. With this connection, the voltmeter is across the coil high tension windings.

With the distributor contact points closed, turn the ignition switch on—which will cause the current to flow through the primary winding of the coil. Then turn off the ignition switch and note the movement of the voltmeter pointer. If it moves up the scale, the coil has a positive polarity; if it moves down the scale or below the zero, the coil has a negative polarity.

12 Volt Coil Circuits

The four 12-volt coil and resistor setups in use are shown in the wiring diagrams, Fig. 32.

No. 1 circuit shows a 12-volt coil without any resistor in the primary circuit. The primary winding, however, has a high resistance value.

No. 2 circuit shows the most common Delco-Remy type. It has an external resistor which does not change with temperature. The primary winding of the coil is similar to that of a 6-volt coil but it has a higher resistance value. Note that in this set-up the ignition circuit is wired so that the external resistor is shorted out while the starter switch is operating. The Ford system is similar but no provision is made for shorting out the resistor during starting.

No. 3 circuit is the most common Auto-Lite type. It uses an external resistor whose resistance value changes with temperature. When the car is being started, the cold resistor permits a higher current through the coil primary, resulting in easy starting. As the resistor warms up, its resistance increases to cut down the primary current through the coil for normal operation.

No. 4 circuit shows an Auto-Lite coil with the resistor incorporated within the coil housing.

Use Correct Coil

1. If a 6-volt coil is used with 1 and 4 systems, the coil will burn out and very often the coil housing will burst. Also the breaker points will burn.
2. If a No. 1 system coil is used with 2 or 3 systems, the coil will not function properly or will not operate at all, causing very hard or no starting.
3. If a 2 or 3 type coil is used in 1 and 4 circuits, the points will burn and the coil housing may burst.
4. If a 6-volt coil is used in any 12-volt system the coil will be permanently damaged and the points will be subject to burning and short life.
5. If an open-circuited resistor is left in circuits 2 or 3, there will be no ignition.
6. If a short-circuited resistor is left in circuits 2 or 3, the coil may burst or the coil winding may burn out.

Checking Resistors

Before installing a new coil to replace one that has burst open, check the external resistor as follows:

1. Connect one terminal of a voltmeter to the battery side of the resistor and the other voltmeter lead to a good ground.
2. Turn on the ignition but don't start the engine.
3. The voltmeter should indicate very close to the battery voltage.
4. Leave voltmeter lead connected to ground and move the other voltmeter lead to the coil side of the resistor.
5. The voltmeter should now read sev-

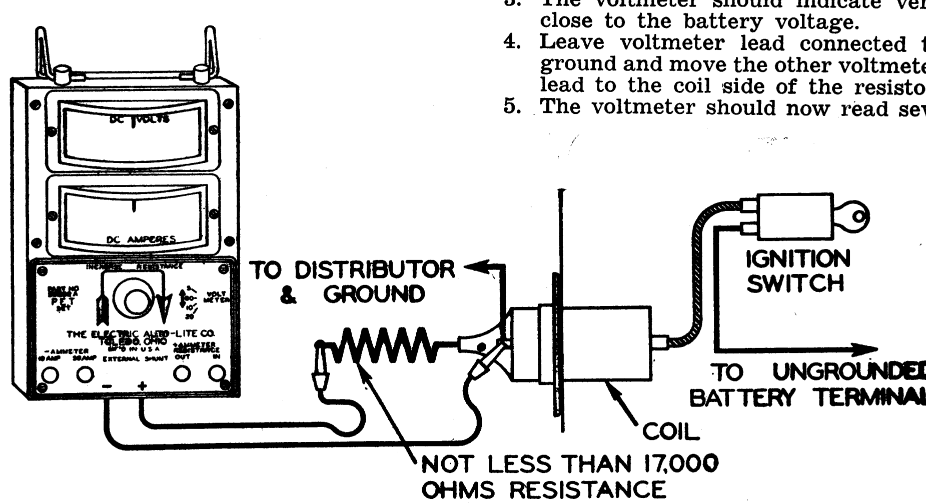


Fig. 31 Coil polarity test

eral volts lower than before.

6. If the voltmeter reading is the same or almost the same in both instances, the resistor is short-circuited. Discard it and install a new one.
7. Be sure to install the correct resistor and coil for each system as they have been designed in matching units for maximum performance. *Resistors used with Auto-Lite, Delco-Remy and Ford coils must not be used interchangeably, for to do so can result in burned points, overheated coils, misfiring, lower coil output and poor operation.*

Distributor Cap

Inspect the cap for cracks, high tension leakage outside and inside, corroded high tension terminals and excessive burned segments inside the cap. Note if the segments show signs of spark jumping on the horizontal instead of the vertical part of the segments.

Ventilation of distributor caps is most important. This is accomplished by one or more holes in the cap, usually located to prevent dirt and moisture from getting inside the cap. If the vent holes are clogged, the ozone gas created by the high tension spark inside the cap could not escape, and in combination with moisture, form an acid which would corrode the metal parts.

Distributor Rotor

Examine the end of the metal strip of the rotor to see that the spark is jumping from the outside end and not the top. If the rotor is too short, the spark will jump from the top instead of the end. Do not file the end of the rotor, even though it may be black from spark action. Clean it with gasoline or other suitable cleaning fluid. Examine the rotor insulation for cracks and leakage.

Inspect the condition of the carbon brush in the center of the cap which rests on the rotor. This should be clean and free to move in and out of the segment so that it will make good contact with the rotor.

Distributor Cam

Examine the cam lobes for excessive wear. This can best be checked with a distributor test fixture. Excessive wear will be indicated by a difference in degrees between the contact opening for each cylinder. A few degrees variation in the cam angle for each cylinder is not so important as the exact spacing of the contact break for each cylinder. As this spacing controls the spark timing for each cylinder, this should not be greater than one degree.

Check for cam end play. The cam should be so located that the breaker arm rubbing block has full contact from top to bottom. If the cam is too low so that rubbing block extends above it, add a thin washer below the cam to raise it.

Side play of the cam with respect to the distributor housing can be checked as shown in Fig. 33. This should be about .005" with five pounds pull on the cam. If more than .008 inch, the cam and governor weight assembly should be removed and the shaft and bushing

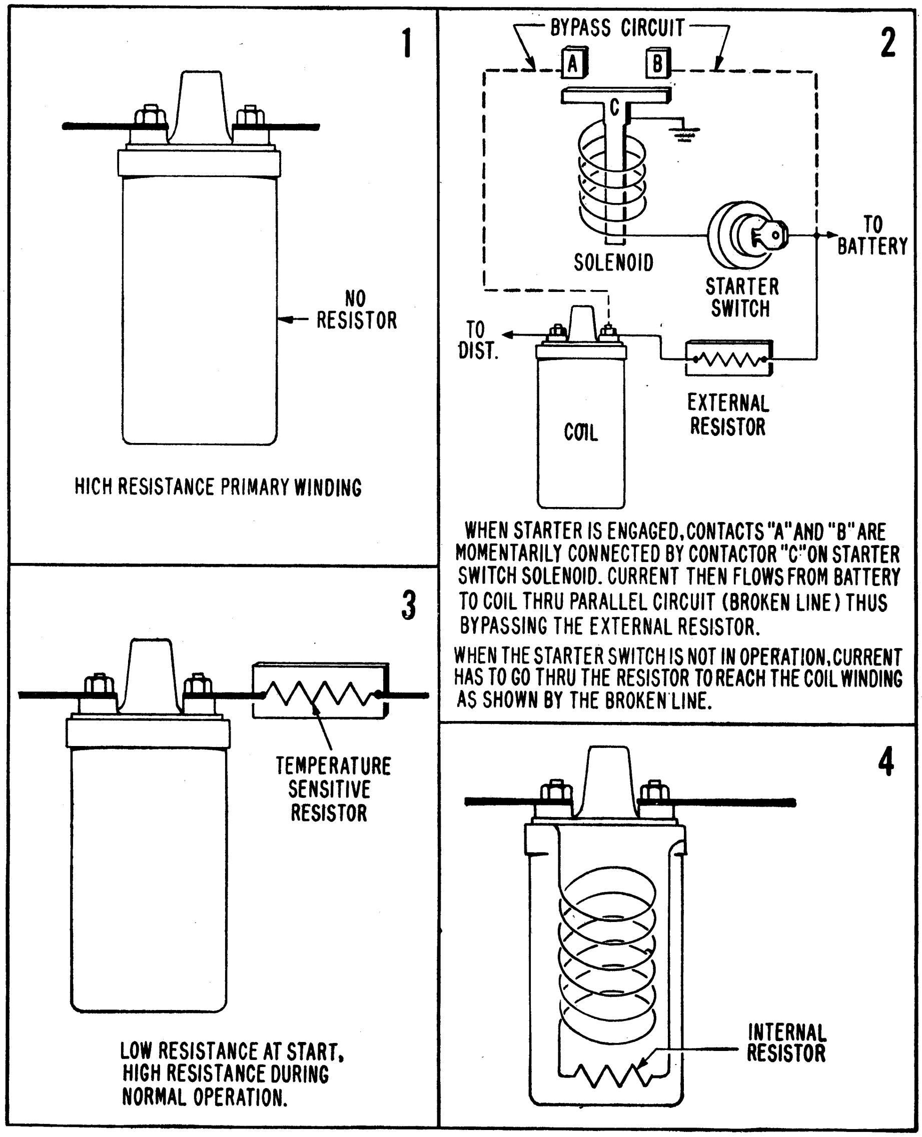


Fig. 32 Wiring diagrams of 12-volt coil and resistor circuits

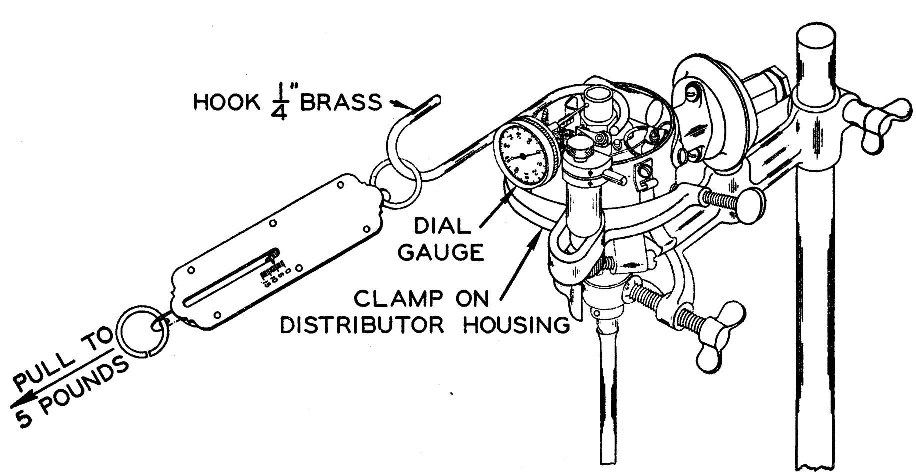


Fig. 33 Auto-Lite recommendation for checking side play of cam. With five pounds full on scale, side play should be about .005" as indicated on dial gauge

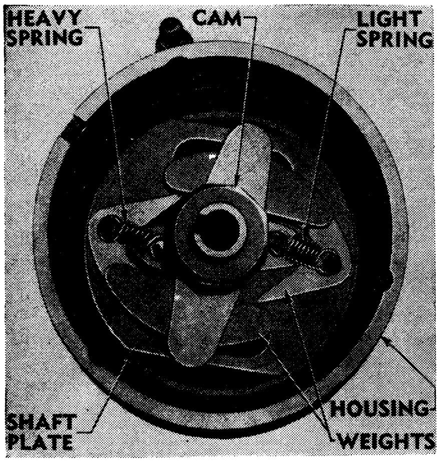


Fig. 34 Top view of Delco-Remy distributor with breaker plate removed to show centrifugal governor mechanism

checked. Excessive side play can usually be corrected by installing new bushings in the distributor housing, or by replacing the cam, although replacement of both cam and bushing is sometimes necessary.

Automatic Advance Mechanism

Except for Holley "full vacuum" distributors, all other distributors utilize an automatic advance mechanism which functions by virtue of centrifugal weights. Some distributors employ both centrifugal and vacuum advance mechanisms, while others make use of only the centrifugal mechanism.

When engine speed increases, the spark must be introduced in the cylinder earlier in the cycle in order that the fuel charge can be ignited and will have time to burn and deliver its power to the piston. To provide this spark advance based on engine speed, the centrifugal governor mechanism is used.

This mechanism, Fig. 34, consists of centrifugal advance weights which throw out against spring tension as the engine speed increases. This movement imparts, through a toggle arrangement, rotational motion to the breaker cam, causing it to rotate a number of degrees with respect to the distributor drive shaft. This causes the lobes on the cam to close and open the contacts earlier in the cycle so that the spark is induced and is delivered to the cylinder earlier with respect to the position of the upward moving piston.

When the engine is operated under part throttle, there is vacuum in the intake manifold and consequently the fuel taken into the cylinder is not so highly compressed. With lower compression in the cylinder, the spark must enter the cylinder earlier so that the mixture can be ignited, burn, and give up its power to the piston.

Lower compression means a slower rate of flame spread in the cylinder as the spark occurs. If the spark occurs earlier in the cycle, that is, if there is some additional spark advance, full burning of the fuel and maximum economy is achieved. This additional advance is obtained by a vacuum advance mechanism—about which see below.

In servicing the distributor, all weights should be removed from the hinge pins, cleaned and checked for excessive wear, either in the weights or pins, or the plate which is slotted for the movement of the pins on top of the governor weights. Replacement should be made if there is any appreciable wear in the slots, as any wear at this point would change the characteristic of the spark advance.

If these parts are in good condition, the hinge pins should be lubricated before being reassembled, by greasing the hinge pins and filling the pockets in the governor weights with grease. Do not use vaseline for this purpose as its melting point is comparatively low.

When installing new centrifugal governor assemblies, it is important that the spacer washers between the housing and shaft be installed correctly. If incorrectly installed, the governor assembly will be too high, causing it to rub against the bottom of the breaker plate.

On some distributors, both springs are alike, while on others there is one heavy and one light spring, as in Fig. 34. Another combination that may be found is an additional flat spring on the outside of the outer spring posts, Fig. 35. As the governor speed is increased, the flat springs are first pulled against the posts by the eyes of the coil springs to provide a rapid spark advance of a few degrees before the coil springs pull against the spring posts.

Vacuum Advance Mechanisms

The two types of vacuum advance mechanisms used on Auto-Lite and Delco-Remy distributors are illustrated in Figs. 36 and 37. Both types make use of a

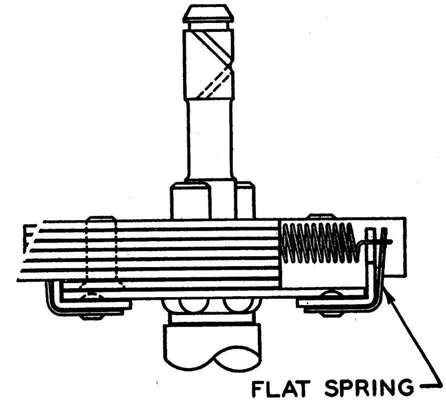


Fig. 35 Flat spring used on some governors to provide a rapid spark advance

spring-loaded diaphragm which is connected through linkage to the distributor. The spring loaded side of the diaphragm is air tight and is connected through a vacuum line to the carburetor above the throttle plate so that idling performance will not be affected.

When the throttle is open vacuum from the intake manifold is introduced into the vacuum advance mechanism and the diaphragm is pulled against the spring causing the distributor to advance.

In Fig. 36 the mechanism is attached to the distributor breaker plate so that the breaker plate rotates. In Fig. 37, the mechanism is connected to the distributor body so that the entire distributor moves. In both cases, the rotational movement carries the contact points around to an advanced position so that the breaker cam closes and opens the points earlier in the cycle.

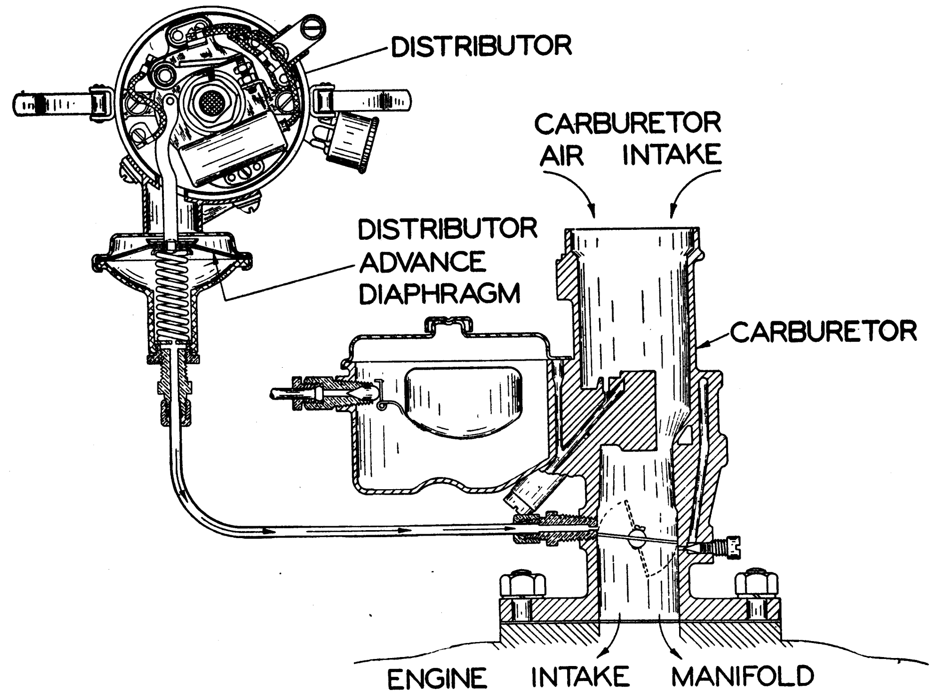


Fig. 36 Auto-Lite vacuum advance mechanism of type mounted on side of distributor. Breaker plate is supported on a ball bearing, and the breaker plate alone rotates in the housing as vacuum conditions change

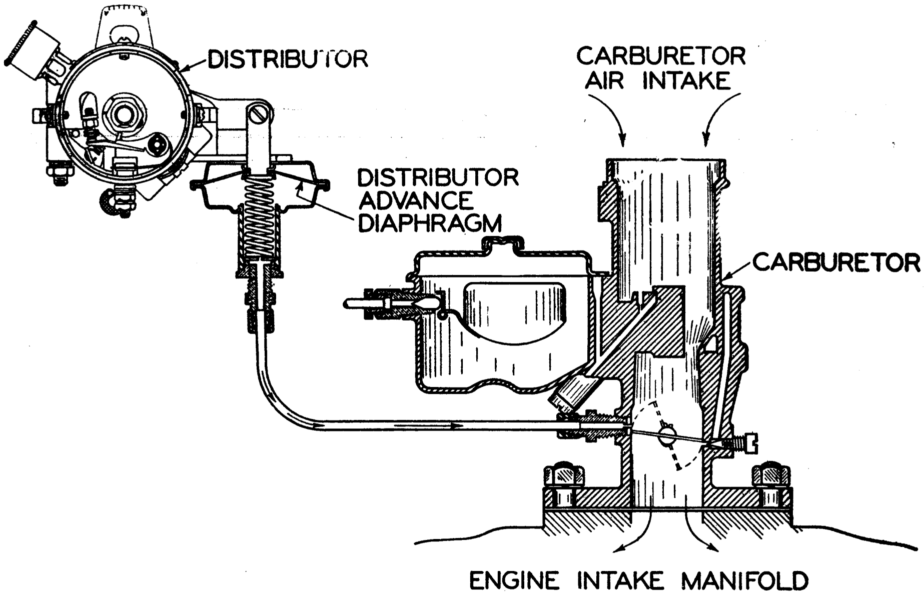


Fig. 37 Auto-Lite vacuum advance mechanism of type clamped around distributor so that entire distributor is rotated as vacuum conditions change

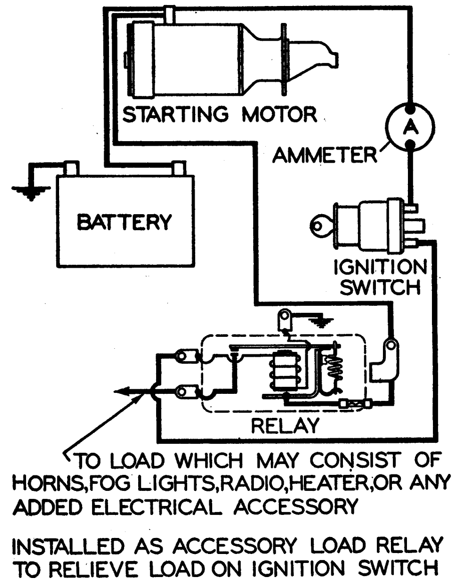


Fig. 38 Showing relay connected in ignition circuit to prevent overloading of ignition switch when accessories are connected through the switch

Ignition Wiring

The current carrying capacity of all ignition wiring should not be less than that specified by the vehicle manufacturers. All terminals should be securely soldered to the wires and all joints and connections should be clean and tightened with lock washers.

The connecting leads in the distributor should be installed so that the terminals are screwed down tight and in such a manner that they will not interfere with the cap or rotor.

When testing the leads for open circuits, a slight tension should be placed on them, or they should be moved back and forth to find broken wires inside the insulation, which may make contact temporarily during the test.

All leads inside the distributor should be bent away from contact with the housing or other moving parts so that the insulation will not chafe and cause failure due to rubbing or vibration.

The high tension wiring is subjected to high voltage and, therefore, insulation is important. Leakage may exist without being visible, causing poor engine performance. See the "Tune Up" chapter for inspecting and testing data. Special attention should be given to any part of the cables surrounded by metal manifold or brackets, as any weakness of the insulation inside the metal would cause current leakage and cross-firing, resulting in poor engine performance, especially in wet weather.

Metal manifolds and metal cable brackets should be grounded to the engine. Troublesome engine missing has sometimes been corrected by a good ground connection for these metal parts.

Ignition Switch

Ignition switches are usually designed to carry the ignition circuit only. When accessories such as heater, radio, fan, defroster, etc. are connected through the ignition switch, the switch is overloaded, causing overheating of the switch, which results in the reduction of the energy delivered to the ignition circuit.

When it is desirable to connect accessories to the ignition switch to prevent their being accidentally left on—which would discharge the battery—they should be connected through a relay, Fig. 38, to prevent overloading and consequent ignition switch trouble.

GENERATORS

A sectional view and an exploded view of typical automobile generators are shown in Figs. 1 and 2.

If the charging circuit does not perform to specifications, the trouble can easily be isolated without instruments as described in the TROUBLE SHOOTING section of the *Generator Regulator* chapter. It is worth repeating, however, that all that is necessary to prove whether or not the generator is at fault is to ground the field terminal momentarily. Then if no output is indicated on the dash ammeter, the trouble is in the generator. But if the ammeter shows a charge, the trouble lies in the regulator or wiring.

When There Is No Output

The first step is to remove the cover band and inspect the interior of the generator for:

1. Sticking brushes.
2. Worn rough or dirty commutator, Fig. 3.
3. Commutator out of round.
4. High mica between commutator segments, Fig. 3.
5. Thrown solder, Fig. 4, which indicates an open circuit between armature windings and commutator segments.

NOTE—Fig. 5 shows the construction of the new type Delco-Remy generator first used on some 1952 cars. This unit differs from the conventional type, Figs. 1 and 2, in that it employs an extruded frame. And since it has no cover band, inspection is made through the openings in the end frame. The use of a mirror will aid in the inspection.

If the inspection shows that any of the above conditions are present, the generator must be removed from the car for servicing. But if none of these con-