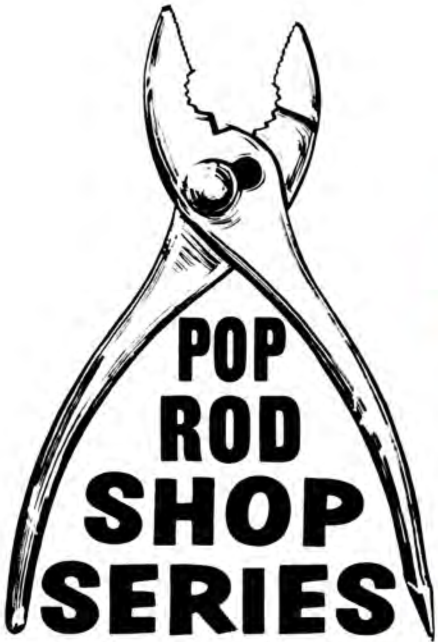

ALL ABOUT IGNITION SYSTEMS

POP ROD'S NEWEST MONTHLY FEATURE GIVES THE HOT RODDER THE LOW–DOWN ON BASIC AUTOMOTIVE SYSTEMS. THIS MONTH WE DELVE INTO THE "MYSTERIES" OF IGNITIONS, LEARNING WHAT MAKES THEM TICK, HOW TO WORK ON THEM AND HOW TO GET THE MOST PERFORMANCE OUT OF THEM.

By Jim McFarland

Smokey the Bear says fire is nothing to play with. We agree wholeheartedly, especially when it relates to "fire" which must ignite the compressed fuel/air mixture which has been packed into an engine's combustion chamber. If the ignition system doesn't supply the right amount of fire at the correct time to "fire" the fuel/air mix, any efforts at improving an automobile's performance in other areas have been wasted. The responsibility of generating, sequencing and delivering this spark belongs to the ignition works—coil, condenser, distributor and battery. Let's discuss each of them, how each works and how they collectively provide the impetus that gets your car down the road, freeway or quarter-mile, as the case may be.

The ignition coil is basically made up of soft iron core around which two sets of wires (windings) are placed. The primary winding consists of a relatively small number of turns (150-200) often located near the inside of the coil case. This location facilitates dissipation of primary winding heat to the air which surrounds the coil body. Cooling fins are also incorporated on some units to assist in the heat-removal function. Inside the primary winding, ordinarily near the soft iron core, are the secondary windings, which carry induced voltage to the spark plugs. The secondary windings are made up of 10,000 or more turns of wire, and this portion of the unit is grounded (attached to a common point in a circuit), often inside the coil case to the primary windings. The high voltage lead to the plugs is formed by the secondary windings' being attached to the distributor cap. Primary and secondary windings are independently insulated within the coil itself, to prevent physical contact among the numerous turns of wire. Windings and iron cores frequently are submerged in an insulating oil inside the coil body.

The ignition points form a "switch", which makes and breaks the primary circuit as required to provide spark to the combustion chamber. A multi-sided distributor cam operates the "switch". When the ignition switch is closed (and the points are also shut for the time being), current can pass through the primary windings, past the points to ground and back to the battery—thus forming an electrical loop or circuit. Take a look at the schematic drawing; it'll take some of the shock out of this somewhat complicated description. Any time the points are opened the circuit is broken, and the primary current stops.

The condenser is a tubular-appearing unit made up of several feet of metal foil and an insulating material wrapped with the foil in such a manner that half the foil area is electrically separated from the other half. In a battery ignition system, condensers work with ignition coils, becoming a sort of "shock absorber". Don't give up yet; we're about to connect some wires.

The distributor routes sparks to the proper plugs, provided there are no wires crossed inadvertently or otherwise. Electrical energy passes from the secondary side of the coil to the wire-laden distributor cap, through the carbon button in the cap's top to the metal strip in the rotor, out to the metal buttons inside the periphery of the cap and on to the plugs via the plug wires. By the way, an air gap (about .030-inch) exists between the tip of the rotor and the cap terminal, and this gap helps prevent spark plug fouling in that the air aids the secondary voltage buildup so that the air space resistence of the plug gap can be bridged which, in turn, prevents the formation of conducting deposits on the center plug electrode. If this is an article on ignitions, why are we talking about spark plug fouling? Just wanted to see if you were still with us.

Let's take a look at what's happening inside the coil when the ignition switch is closed (at which time current passes from the battery through the points and on to ground—remember that loop we described?). The primary winding (around the iron core) is setting up a magnetic field similar to the electromagnets you piddled around with in science class. This field has magnetic lines of force and continues to build, creating an electrical current in the multitudinous secondary windings. The amount of current depends on the speed at which the magnetic flux (intensity) increases, and this depends on the buildup time of the primary side of the circuit. The induced secondary current, at any rate, isn't great enough to fire the plug until the primary current flow is interrupted by the opening of the ignition points. When this happens, the magnetic field has no place to go, so it collapses into both primary and secondary windings. Current induced in the primary winding in this manner flows in the same direction as the initial current, which tends to slow the collapse of the field. This we don't want; we want a rapid collapse. Seems to be natural to have what we don't want and not have. . .you get the idea. So a condenser is installed across the ignition points to absorb this current and cause the field to collapse quickly. The result? A high voltage is induced in the secondary side and sent to the plugs. Run that by again? OK, points close, magnetic field builds in the coil, points open, field collapses, high secondary voltage is induced and a plug is lighted. To add to the "fog" which may surround your comprehension at this point, consider the fact that this sequence takes place about 12,000 times per minute in an eight-cylinder engine at a crank speed of 3000 rpm. The free-wheeling, 10-second, 6000-rpm-capable vehicles at the local drag facility make and break an ignition circuit 4000 times in the course of traveling that quarter-mile! Begin to understand why we emphasize the role of an engine's ignition system? Let's continue.

The time at which a set of plugs should receive sparks varies, depending on engine speed. Combustion processes take time, and a crank speeds increase the plug(s) must be fired at times other than when the piston is at its top dead center position. During starting and low engine speeds, timing can be near TDC,but at high rpm such timing would deliver the spark well after the TDC position had been passed; therefore, spark timing has to be advanced for high rpm applications. Optimum power is obtained from the highest expansion rate of burning gases, and because of this fact, spark timing needs to vary in accordance with crank speeds.

Assortment of centrifugal advance springs permits various tailored advance curves of equally as assorted engine applications. Stretching or loop-clipping of stock springs helps, but use of special spring designs often provides best curve shape and resulting ignition performance.

Two types of advances are often used to provide this automatic control of spark timing, vacuum and centrifugal.Vacuum units ordinarily have a diaphragm located in a line so that changes in intake manifold vacuum will advance or retard rotation of the point plate in the distributor. Centrifugal devices are connected to the distributor shaft and pivoted at one end (of the weight) so that the centrifugal forces of the rotating shaft pull the ends of the weights out toward the edge of the distributor housing, thereby changing the relationship (timing) of point-set to distributor cam. The change actually exists between the distributor cam and the point plate. Combination vacuum and centrifugal units supply automatic spark timing to meet overall engine variations. Vacuum units afford greater economy but are the first to go when greater initial spark without total over-advance is desired.

Thus far, our discussion has been focused on battery ignition elements and what each does to create the spark an engine needs. Our ignition "setup" has been a single coil, single point-set unit. In order to achieve the strongest magnetic field possible, thereby supplying adequate plug voltage for the various engine needs, a number of non-stock approaches have been made. Let's take a look at the more popular ones.

Installation of a high-voltage ignition coil is a first step for many automotive enthusiasts. A stronger field results from a larger number of windings, which produces beefier secondary voltage. A new condenser should also be installed along with the

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Fundamental to any ignition point and condenser installation is thorough cleaning (buffing) of mating surface on point plate. Good electrical contact here assures proper electrical ground for both condenser and points.

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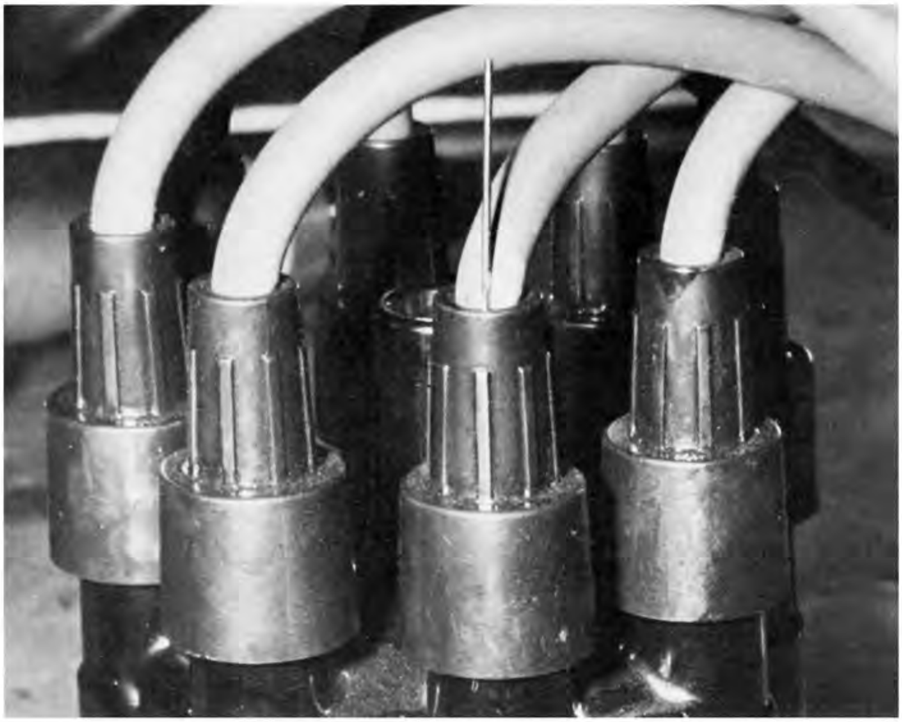
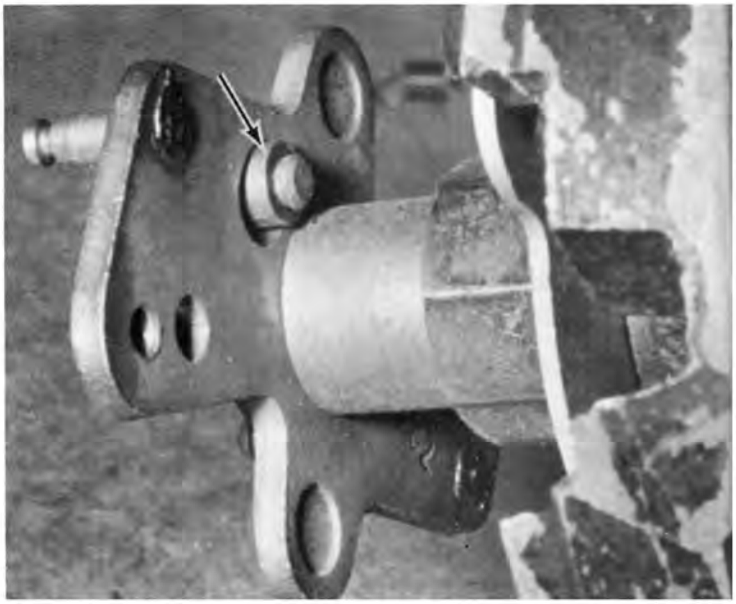
New igniter unit from the old Spaulding "flamethrower" days is this "don't touch the hot lead" distributor/exit package that's reported to be worth as much as 0.2-second ET boost and requires less total ignition advance. Would you believe a one-inch spark jump from Tom Spaulding's new toy?



new coil. If one isn't supplied with the particular coil purchased, the following "shade-tree" approach may be of assistance. Get an old distributor which has operating points and fit the shaft to an electric drill chuck. The best arrangement is to use a tool which rotates at about 1500 rpm, for this speed will approximate a 60-65 mph road speed. The distributor body should be anchored to the drill body so that the housing is stationary. Connect a pair of small stiff wires such as coat hanger wire to the coil terminals, making sure the wires are cut square-faced and there is an adjustable gap left of about 3/8-inch. Hook a condenser across the points, turn on the drill and watch the spark at the above-mentioned gap. The condenser is operating if a spark exists; by trying

Quick tie-point for timing light attachment can be set up by inserting short section of stiff wire into No. 1 plug wire socket in distributor cap. Wire can be left in place for ready and quick timing checks.

Vacuum advance control is simple feature if you'll construct adjustable arm as show. Simply trim the adjustable spring-loaded ignition point pad from a set of GM points, tack-braze this cutoff section onto the bottom side of a stock vacuum advance plunger arm guide (the flat strip section) and use the screw stop to limit advance movement of the diaphram plunger rod. Limitation of rod action permits increased crank lead (initial timing) without total disruption of fuel-saving vacuum unit.



Total centrifugal advance (limit) can be regulated by change of shape of stop-bushing (in GM type distributor shown). Limiting rate and total amount of centrifugal advance can provide room for additional crankshaft timing boosts, resulting in improved low rpm response and economy without attending over-advance when rpm surpasses limit of centrifugal advance.

Shim-stack between distributor drive gear and lower portion of distributor housing should leave no less than 0.060-inch air gap between gear and housing. To add or remove shims, simply knock out gear retainer pin, slip on the shims (or remove'em), and return the pin to its original location. Nothing to it.

different-capacity condensers, one which best matches a given coil can be found. Naturally, the hottest-looking spark is what we're after. Pardon. . .we digressed from alterations to the system.

The additon of a second set of igniton points is the next most popular alteration. The idea is that an added set of points increases the time period (closed time of one point set plus the phase difference between both sets) during which primary current can flow. This permits magnetic field strength in the coil to build higher, thereby producing a hotter, stronger secondary spark. Also produced are cleaner firings and somewhat higher rpm. This performance boost is relatively inexpensive, for dual point plates are available for most distributors.

Dual coils, condensers, sets of points and a dual-tipped rotor–which comprise a "double" ignition system–also increase the field buildup time. The two separate ignition systems result from the use of distributor cams having half as many lobes as engine cylinders. The former single system which delivered 10,000 sparks per minute is altered to provide two circuits which each provide 5000 impulses per minute. Time allocated for coil field buildup is thereby doubled, and secondary voltage output increases.

Ignition design has been greatly influenced recently by semiconductor electronics, and the transistorized packages which enjoyed instant popularity a few years ago have a strong competitor in the capacitive discharge units. A capacitor can be considered an electrical storage bin. Voltage which developed comparatively slowly by induction in the multi-wound coil could be forced into the primary winding from current stored in a capacitor. Since a rapid rise time in primary current intensifies the field quickly, a strong secondary punch is produced. Use of a capacitor to load the primary side of the coil–almost eight times faster than without the capacitor–produces higher secondary output throughout the range of engine speeds. Spark delivery and recharge are almost instantaneous, point life is extended, and adequate, accurate ignition control at crank speeds as high as 10,000 rpm is possible.

Another alteration which improves performance of an ignition system involves changing the advance curve. Any engine will operate best at some quantity of total ignition advance. A maximum amount is specified by manufacturers, and there is not much leeway in alteration to the advance. But the advance rate can be changed to enhance performance. You'll need to find a distributor testing facility and plot graphically the existing centrifugal advance curve. The shape of the curve toward which you are building will generally be one that rises sharply at low crank speeds and levels as it approaches a maximum value higher in the rpm range. Most tuners increase the initial advance by as much as 70 per cent by removal of metal to reshape the curve (see sketch). Weights removed allow the boost in advance, although the total number of degrees has not been exceeded. For example, an advance curve (beginning at 1000 and increasing in 500-distributor-rpm increments) of four, seven, ten and twelve degrees might be modified by weight chopping to six, ten, eleven and twelve.

A second method involves leaving the weights as they are and limiting the amount of centrifugal advance by stiffening the springs. Taking a coil or two from each spring will permit more intitial spark lead for low-speed response increases without overadvancing the engine at high rpm. Caution has to be advised as you experiment to find the best rate; detonation can be an unwanted by-product of too much chopping of weights or springs. Exercise patience, and you'll come up with what you're after.

We're strong advocates of proper maintenance of all parts of an engine, and we'll pass along the following with regard to the ignition system as a whole and individual units in particular.

The battery should be kept free from corrosion and full of water or whatever liquid is being used. Connections should be clean and tight, and specific gravity should be checked frequently. Ignition ballast resistors should be used whenever they're prescribed; they'll help protect the coil. Insulation sleeving will offer better terminal protection. Both ends of secondary igniton wiring should be soldered to the respective connectors. Don't keep old plug wiring and don't tape plug wires together. Keep them away from hot exhaust manifolding, too. While the distributor is moderately hot (so that cold grease isn't taking up normal clearances), check for shaft sideplay. Application of small amounts of special high-melting-point grease on distributor cam lobes will extend point rubbing-block wear and help the operation of automatic advance units.

A strip gauge should be used for point setting, after the faces of points have been given attention and dressing. A dwell meter provides better adjustment results, but regardless of the method, be sure settings are accurate. Too small a gap will cuase late spark timing, and too wide a gap will create an advanced timing situation. Ignition timing can be set with either a timing light or by road test. The accuracy of the timing-light method depends on reference pointers and marks on the engine, of course, and does not compensate for actual combustion conditions in the cylinders created by the fuel octane level being used. The road-test method consists of a series of 10 mph, high-gear, full-bore acceleration starts to determine ignition ping. By slowly advancing the timing to the point of slight ping, and retarding timing slightly once this point is reached, you'll come up with the proper adjustment positon.

Point alignment is of vital importance, but only the stationary point should be bent during alignment corrections. A trick of some "super-tuners" of dual-point ignitions is to inactivate alternate sets of points by disconnecting the proper pigtail lead rather than by inserting a piece of

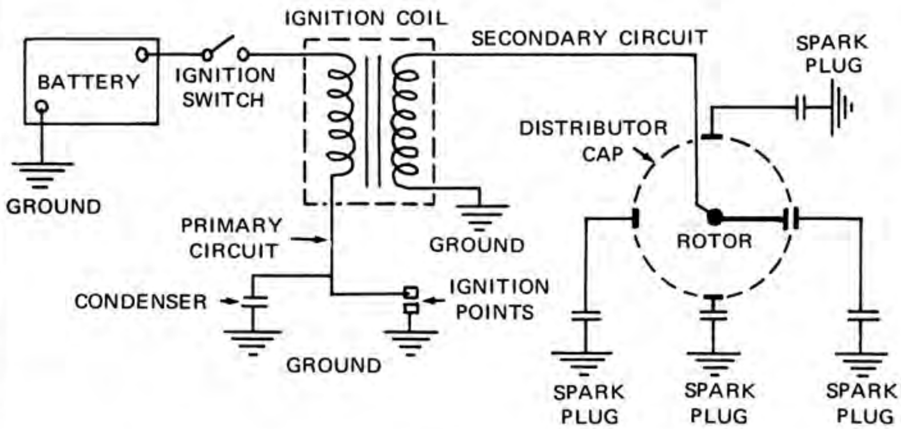
Stock centrifugal weights (GM Delco-Remy shown) are often too thin and of too little weight. Use of early GM weights permits greater control overall advance curve shaping. Notches can be ground into weights to provide alteration of initial and/or final advance levels.

Distributor cap maintenance should include checks for oil deposits (slung off by rotor and/or distributor cam), carbon tracking, moisture and the short-circuiting it can cause, electrode corrosion or wear (or breakage), presence of center-carbon electrode, cap cracks and alignment lug conditon (absence of nicks or chipping).

cardboard or other insulating material in the point set. The separation of point rubbing-block and distributor cam will alter the side-thrust positon of the shaft, giving erroneous point dwell after the points are placed back in contact with the cam, according to the experience of these same tuners.

You can remember the direction in which a distributor housing should be rotated for timing advance by noting the rotational direction of the rotor and turning the housing opposite to this direction--against rotor rotation. Timing can be retarded by turning the distributor in the same direction as the rotor turns. A spot of paint on the number one plug wire (inside the distributor cap) provides a quick reference point for checking firing order and for plug wiring, just in case you become the target for some "crossed-wire" prank. Attention to the distributor should include keeping moisture out of the cap, discarding a cap once carbon tracking or spark etching occurs and checking spring tension. The distributor cam only opens points; point springs do the closing and should be kept in proper order. As cylinder pressures are increased (through higher compression ratios, shortened valve timing, or what-have-you), the spark must fire through a pressure barrier. Any kind of electrical leaks in the system can provide an alternate path for the current which needs to be delivered to the plug tip. So make sure the system is kept capable of handling the results from boring and stroking or that new set of pop-top pistons.

The ignition system literally provides an engine's spark of life. Make sure it's adequate and adequately maintained. A boost in compression, installation of a hot cam, an out-of-sight gear set and a 10-gallon tank of nitro won't get you out of the garage without some fire—and like Smokey says. . . . .Thanks for bearing with us.



Point plate wobble is a definite problem with many stock (and modified stock) distributors. To cure the ailment, you can tack-braze the point plate to the housing, eliminating wobble and attending timing and point dwell variations (for distributors not incorporating vacuum advance mechanisms or those whose vacuum units are disconnected).