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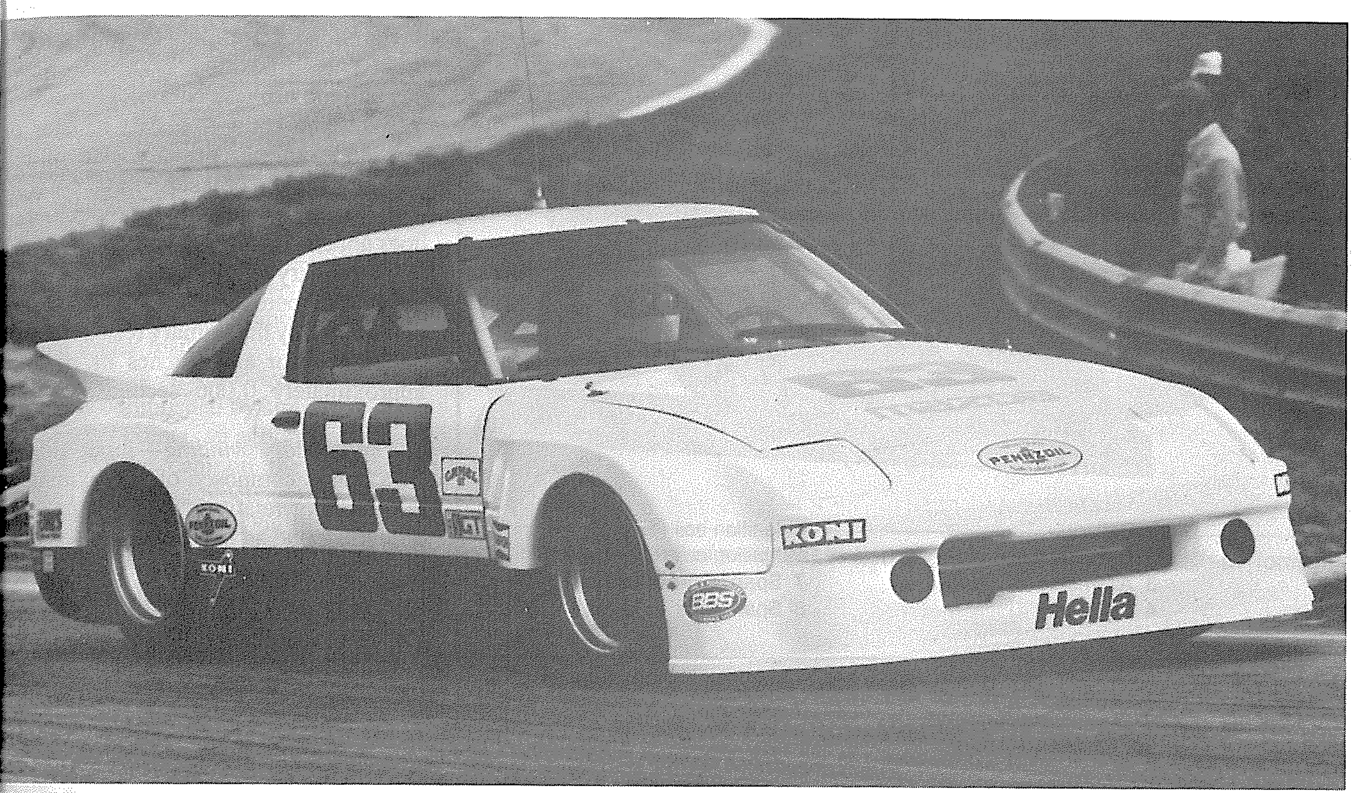
IGNITION



As horsepower levels are increased, so too is the need for a high-energy ignition. Even back in his GTU days, Jim Downing relied on electronic ignitions; he was the first GTU racer to install a multi-spark CD ignition.

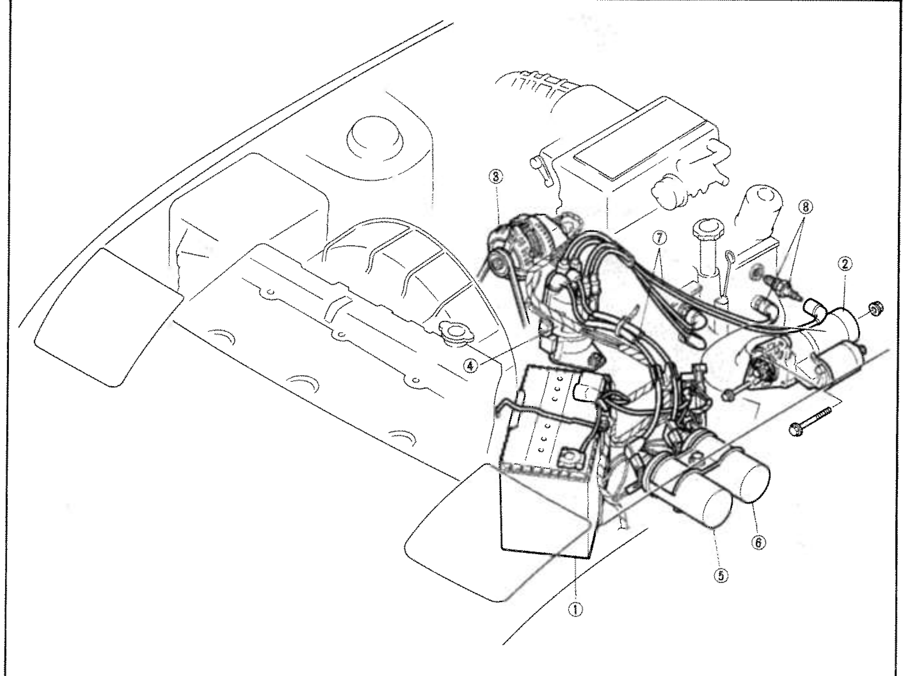
A number of years ago, I stumbled across one of those low-budget "horror" movies that was more comedy than drama. The gist of the story was that a displaced Transylvanian count had taken up residence in Los Angeles and was intent upon brewing up a magic potion that would imbue him with mystical powers. But he ran head first into an insurmountable problem. His recipe called for the blood of three virgins. After weeks of scouring the streets, and numerous false alarms, he came up empty handed and had to abandon his brewing career for something even more sinister.

High-energy ignition systems tend to be the same type of scarce commodity. Plain-Jane voltage, like certain types of blood, is easy enough to find, but a long-duration, high-voltage spark—the electrical equivalent of a virgin's blood—is an entirely different matter. Yet, a high-energy spark must be fired across the sparkplug gap if a high-performance or race engine is to operate at peak efficiency. As might be expected, there are several levels of "high energy." Some are appropriate for high-performance street engines, others are more race oriented; all rely on the magic of electronics.

POINTS & HISTORY

When early motorists walked to their horseless carriages and gave the hand crank a whirl, it was the wizardry of Charles Kettering that caused the air to be filled with the melody of internal combustion. And for all the improvements wrought upon the automobile during the first seven decades of the Twentieth Century, the Kettering designed ignition system survived largely unchanged. It wasn't until 1974 that Chrysler Corporation broke with tradition and began installing electronic-ignition systems on all new vehicles. The following year, a number of other manufacturers followed suit, but Mazda didn't switch to electronic ignition until 1980.

One of the major advantages offered by an electronic system is the replacement of the breaker points with a non-mechanical triggering device—an electronic switch. This is desirable because, with the breaker-point system, point wear increases with mileage, resulting in continual deterioration of



1 Battery
2 Starter motor
3 Alternator
4 Distributor
5 Ignition coil (T)
6 Ignition coil (L)
7 Sparkplug cables
8 Sparkplugs

Ignition-system components. Drawing courtesy Mazda.

ignition-system operation. After 10,000 or so miles, the points are worn like the soles on a pair of 10-year-old shoes and must be replaced.

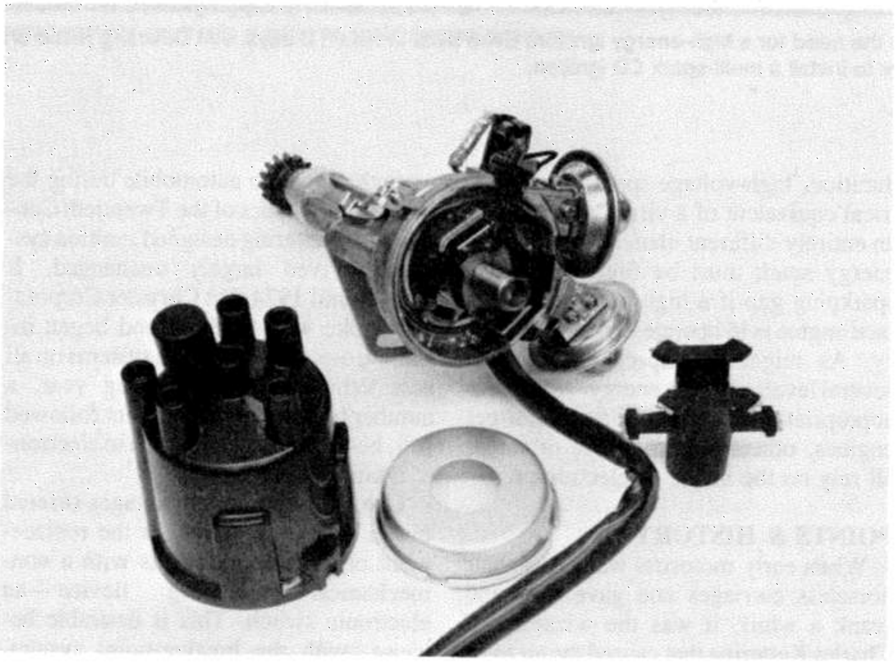
Breaker-point wear, like rain in the summer and snow in winter, is a fact of life. In a point-triggered system, when the ignition key is turned to either the ON or START position, current flows through the primary circuit. This circuit includes the battery, ballast resistor or resistance wiring, primary side of the ignition coil and breaker points. (A condenser is connected to the points, but does not come into play just yet.) Current in the primary side of the ignition coil—up to 4 amperes—increases to a value determined by the primary resistance and ballast resistor and reaches its peak in approximately 0.006 seconds (6 milliseconds).

The *primary winding*—input side—of a coil is composed of approximately 200 turns of relatively heavy-gage wire wound around an iron core. Between the core and the primary winding is the *secondary winding*—output side. It consists of about 20,000 turns of extremely fine wire. The relationship between primary and secondary windings is known as *turns ratio,* which in this instance would be 100:1.

With 12 volts making the grand tour through the primary winding—with a 4-amp current—a strong magnetic field is developed, inducing a voltage in the secondary winding. Due to the 100:1 turns ratio, voltage in the secondary is stepped up to about 1,200 volts—a sizable increase. This is still not enough to fire a spark across the plug gap.

Once through the coil's primary winding, the current must be given some place to go. However, because there's no more work for it to do, it is simply dissipated through the points and distributor body to the engine which serves as a system *ground*—a return path to the battery. So long as current is flowing through the coil, the magnetic field is maintained. When the points open, the only path available to the current leads it into the condenser, which serves as a temporary energy storage device.

Were a condenser not in the secondary circuit, the current would arc across the opening contact points, quickly burning



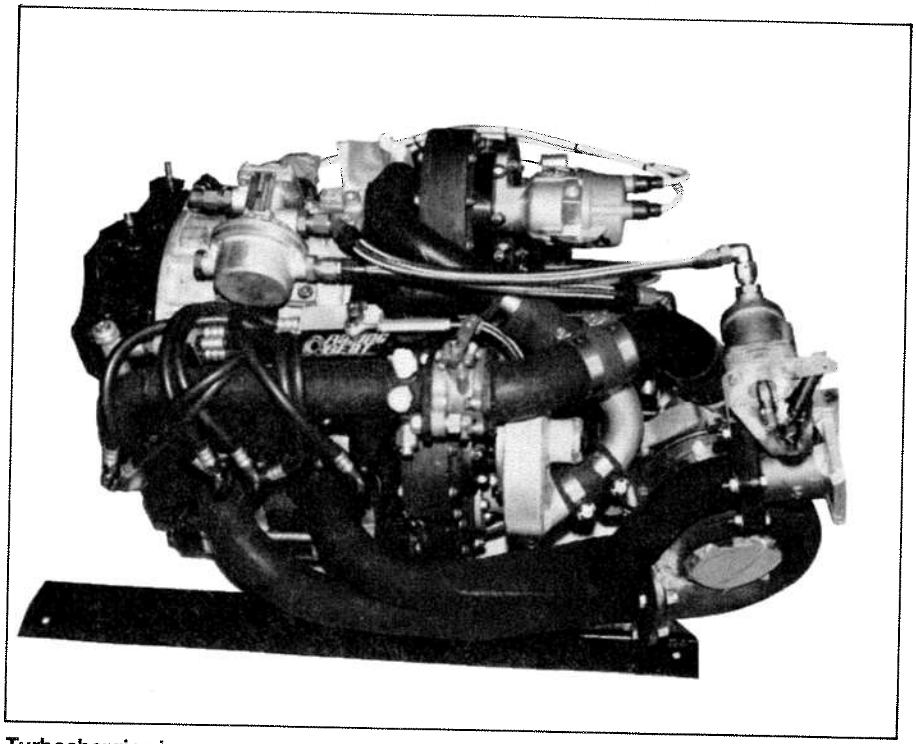
Mazda introduced electronic ignition on 1980 models. Electronic distributors may be installed in any engine originally equipped with a single distributor.

and destroying them. But the condenser serves another purpose; once the points open, the coil becomes charged with high voltage. When it reaches its *saturation point*—coil is fully charged—current flow stops and the magnetic field collapses.

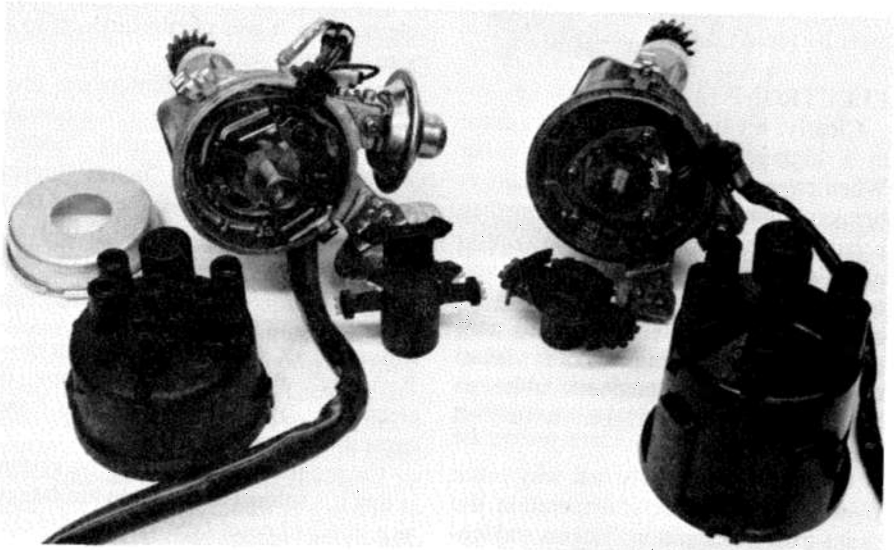
The high voltage built up in the condenser is then discharged back into the primary side of the coil which *steps up* the voltage, by virtue of its turns ratio, to approximately 30,000 volts. This aspect of the condenser's operation explains why an engine will run, but won't perform well if a condenser is damaged or eliminated from the circuit—the ignition system can't produce the level of voltage necessary to initiate combustion in an engine under load.

Interrupting ignition-system current flow is accomplished by simply opening the breaker points, an action that is controlled by the cam on the distributor shaft. The rubbing block attached to one arm of the points rides on this cam. In effect, the points are a mechanically actuated switch used to turn current flow through the coil on and off. But there's a little more to it than that; increasing the time period during which the points *dwell*—remain closed—lengthens the time available to build up the current in the coil. Not too surprisingly, *dwell time* is the term used to note the duration, in degrees of distributor rotation, that the points are closed.

By aligning the distributor rotor with a terminal in the cap at precisely the time that the points are opened, an escape path is provided; current flows from the coil to the distributor cap, across the rotor to a terminal, out of the cap through the plug wire and to a sparkplug. And if, in jumping across the plug gap, the current which is now a spark, encounters a fresh mixture of air and fuel, combustion occurs.



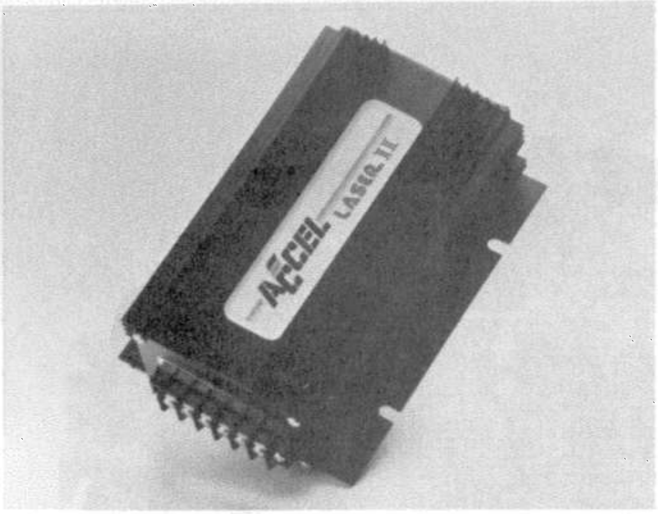
Turbocharging increases pressures in working chambers, so need for high-performance ignition is even more critical.



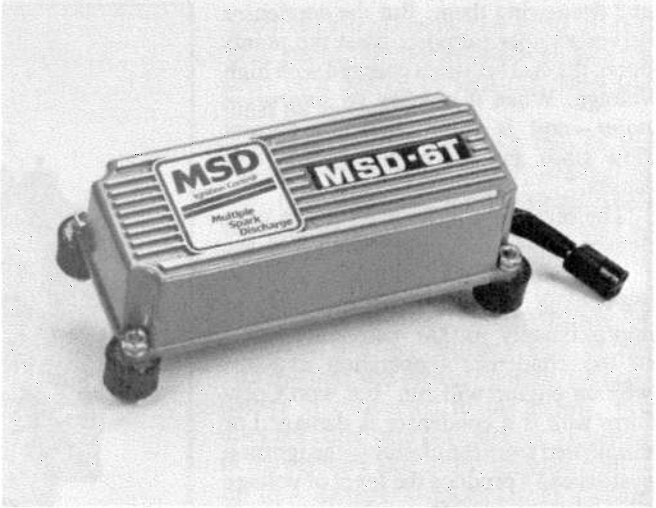
At left is production electronic distributor; at right is competition version. Latter has a single-impulse generator and fires leading and trailing sparkplugs simultaneously.

Points of Limitation—In spite of its excellent record for reliable performance, point-type ignition systems contain a number of built-in limitations:

- Breaker points must carry a relatively high amount of current (2—3 amps) which leads to erosion of the contact surfaces.
- As engine speed increases, the time available—dwell time—to build high voltage in the coil decreases, dramatically reducing spark intensity.
- Breaker-point opening and closing timing tends to be irregular. As the rubbing block wears and contacts erode, dwell time and, consequently, spark timing is altered. Distributor-shaft bushing wear also leads to timing irregularity.
- At high engine speeds, the rubbing



Accel's Laser II capacitive-discharge system produces excellent spark characteristics. In addition to high voltage, Laser II puts out a long-duration spark with plenty of energy and is compatible with Mazda electronic distributors.



MSD's 6T module puts out multiple sparks at lower engine speeds. This effectively lengthens spark duration and keeps sparkplugs clean. MSD's 6A module is similar in construction, but designed for less demanding street applications. MSD modules may be easily connected to Mazda electronic distributors.

block may not stay in contact with the distributor cam with the result being *point bounce,* which leads to misfire.

- Because both the point contacts and rubbing block are subject to wear, they must be replaced periodically.

ELECTRONIC IGNITION

Clearly, breaker points have no place in a high-performance rotary engine. When connected to electronic circuitry, breaker points become nothing more than a pulse generator that tells the control module when to discharge the coil voltage into the distributor. This being the case, it is possible to use a non-mechanical triggering device. Most commonly, these are magnetic, although optic and Hall effect triggers have been used successfully.

One could reasonably ask why, after over 50 years of successful operation, did point-triggered ignition systems suddenly become inadequate? The answer is simply that when high compression is combined with high engine speed (rpm), conventional systems can't meet the energy demands on a consistent basis. Then too, at the original-equipment level, there developed a trend toward wider sparkplug gaps and leaner mixtures as a means of increasing fuel efficiency. This resulted in more fuel being exposed to the heat of the spark. As plug-gap width is increased, so is the voltage requirement for firing a spark across this gap. But an increase in spark duration is also desirable because it gets combustion off to a more vigorous start.

So, in addition to eliminating problems related to breaker points, electronic systems fire a considerably "hotter" (increased voltage) and "fatter" (higher amperage) spark across the sparkplug electrodes with gaps up to 0.080 in. These systems obviously produce considerably more spark energy than a conventional system.

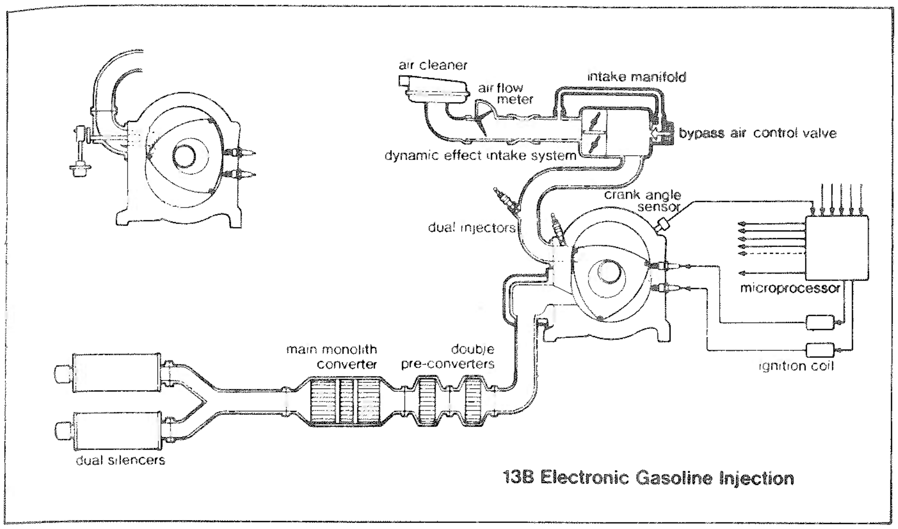
Inductive vs. Capacitive Discharge— Basically, there are two types of electronic ignitions: inductive and capacitive discharge (CD).

The problem with the inductive system is that it's subject to the same limitations as a standard point-type system. Specifically, current is induced in the coil and, therefore, spark output is dependent upon the amount of time between firings. At high rpm, there is insufficient time to build up current in the coil, therefore spark output is reduced.

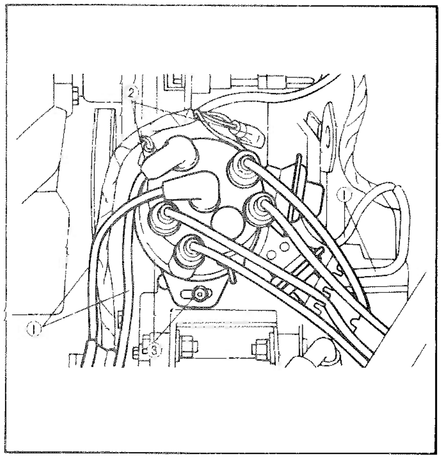
Conversely, in a capacitive-discharge system, capacitors are used to store electricity that is discharged at a later time. The primary advantage of this arrangement is that a capacitor can be charged in a fraction of the time required to induce voltage in a coil. (The time needed to build maximum voltage is known as *rise time.*) Therefore, in a properly designed CD system, output is virtually unaffected by engine speed as high as 12,000 rpm—even though current still flows through the coil. This is possible because the coil is used as a simple transformer to step up the voltage fed to it by the CD unit. But instead of 12 volts, the coil will receive an input of 375—450 volts which places output in the 35,000—50,000-volt range irrespective of engine speed.

On the other side of the coin, inductive electronic systems that may produce up to 55,000 volts at low speeds can drop to less than 15,000 volts as engine speed approaches 5,000 rpm. Inductive ignitions constitute the majority of original-equipment ignition systems because they're cheaper to produce than CD systems. And they supply adequate energy for average street-driving conditions.

But when a vehicle like an RX-7 is operated in a high-performance or racing environment, it is both desirable and necessary that the engine produces its full potential in both maximum power and



Find distributor in this drawing and win a free trip to Japan. But don't hold your breath—late-model 13B engines are distributorless. Timing is controlled by on-board microprocessor. Drawing courtesy Mazda.



To remove an electronic distributor, coil wires and vacuum-advance hoses (1) must be disconnected, as well as igniter couplers and condenser lead (2). The distributor hold-down nut (3) is then removed and distributor can be pulled out.

rpm. In this respect, original-equipment systems come up short. But, basic capacitive-discharge ignitions aren't the answer either. One of the most commonly heard criticisms of CD ignitions is that, in spite of their ability to fire a plug under the most adverse conditions, spark duration is too short to reliably initiate combustion.

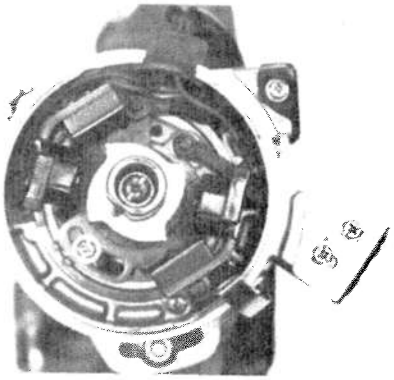
In response to this shortcoming, aftermarket ignition manufacturers have developed systems that combine the advantages of the CD system's fast rise time to an inductive system's longer-duration spark. Several high-energy, capacitive-discharge ignitions are available, but the systems manufactured by Autotronics Controls Corporation (MSD) and Accel Performance Ignitions are the most widely used.

For drag racing and other short-duration events, the MSD-7AL-2 is appropriate. However, heat build-up and current draw can be a problem in long-distance racing, which is why Downing/Atlanta race cars are equipped with a pair of MSD-6T modules. Accel's Laser-II is also ideal for long-distance and street use. Both of these systems are easily connected to rev-limiters.

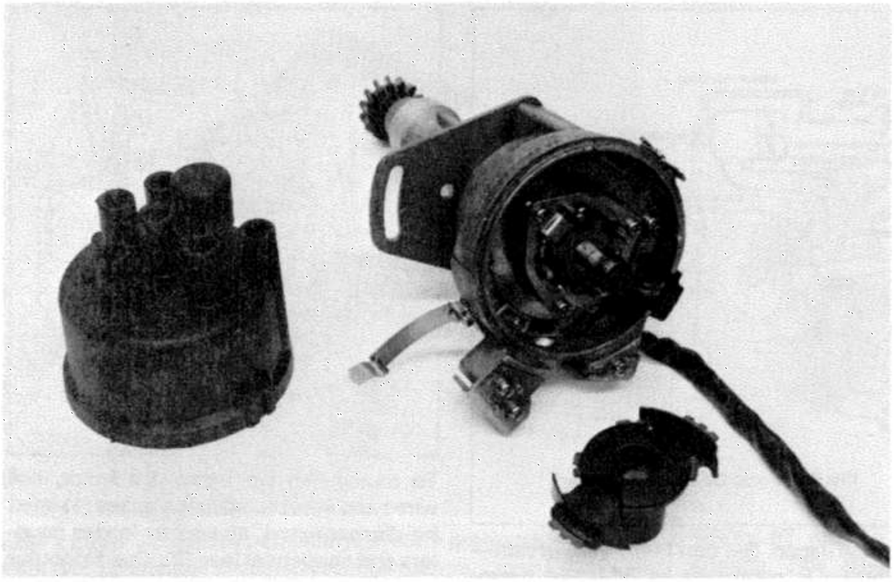
Adapt Stock Distributor—It may come as a shock, but nothing more exotic than an electronic distributor from a 1980 RX-7 was installed in the Camel Light race cars that Jim Downing and John Maffucci drove to the national championships in 1985 and '86. This distributor may be retrofitted to any 12A or 13B engine originally designed for a single distributor (1974 and later). The most popular use is as a means of eliminating points in 1974—79 engines. If a 1974—79 point distributor is to be used in a high-rpm application, it should be fitted with Mazda Factory Race points, available through Racing Beat or Mazmart.

In 1980, the Mazda electronic distributor included an impulse generator, but the ignitors were contained in a separate box. In 1981, the ignitors were incorporated in the distributor, making it an integrated system with only the coils being externally mounted. The later distributor is more expensive, so if an aftermarket high-performance ignition module—like an MSD or Accel—is to be used, the 1980 distributor is the one to use. It will keep costs somewhat in check and simplify the system. This distributor is wired with leads that may be connected to whichever "black box" is selected. In conjunction with either a stock or high-energy CD ignition system, the RX-7 stock factory coils—from either 1979 or 1980 models—have proven to give the best reliability.

Although a single distributor makes for a simpler, more compact package, there is no particular justification in converting a pre-74 engine. Before a single distributor can be installed, the front-cover housing must be replaced. Obviously, if an engine is disassembled for a rebuild, and the front housing must be replaced, substitution of a 1974 or later housing will allow use of an electronic distributor.



Production electronic distributor contains two impulse generators—also called *magnetic pickups*—that take place of breaker points. When a reluctor tip passes generator, an electric pulse is generated. Pulse travels to control module where it is interpreted as a signal to fire sparkplug. One pickup is used for leading circuit and other for trailing circuit.



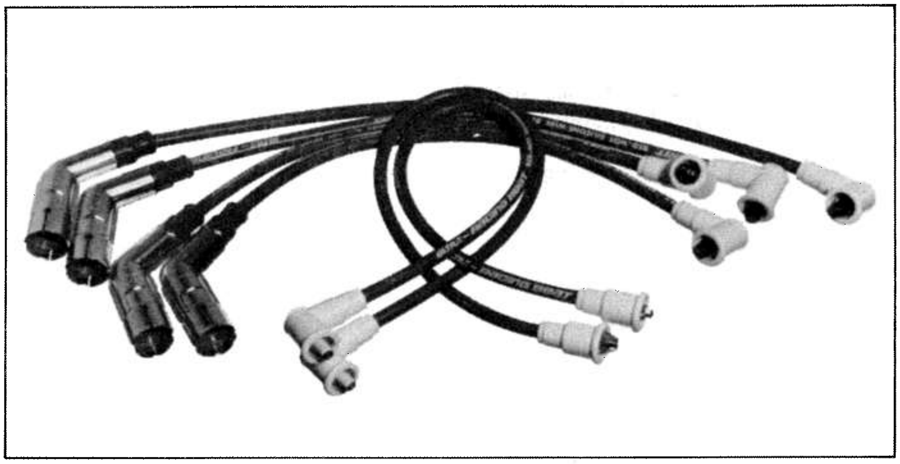
Mazda's competition distributor is based on production housing, but features special internal components. While distributor is simpler than production model, it does not allow leading and trailing spark timings to be separated.

High-quality ignition wire is absolutely essential for optimum ignition-system performance. Accel offers several types of silicone wire that is highly resistant to heat. Either spiral-core or suppression wire should be used, even on race engines.

GETTING WIRED

Irrespective of the distributor selected, all wires must be adequately separated. Otherwise, cross-fire may result and cause a serious problem, especially with a high-performance CD ignition.

As Rick Engman states, "You need to keep the impulse-generator wires away from the high-voltage wires. As an example, on an MSD unit, they run about 450 volts through the wires that go to the coil. The wires leading to the impulse generator, which operates in millivolts, can actually pick up the signal from the high-voltage wires . . . that will cause trouble. Also, you need to keep both the impulse-generator wires and high-voltage wires away from the ignition (sparkplug) wires. It is also absolutely necessary to use *wire-wound* wire—it's also called *helical-core* or *spiral-core* wire—to reduce radio-wave transmission. I've had to stress that to everyone who's called me for advice. There's always a problem with solid-core wires. I know of a case with a very competitive race car where solid-core wires didn't hurt the ignition, but they messed up the rev limiter. It isn't as bad with a stock ignition, but I avoid using solid-core wires."



Racing Beat's "Red Hot" ignition wires are available in street or race form. Both types employ stranded copper wire and a wire-wound carbon resistor in sparkplug boot. Resistance is much lower in race-wire sets. Shielded sparkplug boots enhance electronic noise suppression.

Many times resistance-type plug wires seem as attractive as a snake bite because stock Mazda ignition wires don't last very long. A number of performance-oriented ignition companies offer high-quality, 8mm resistance wiring with a high-strength conductor and silicone jacketing. In addition to resisting temperatures up to 500F, the conductor will last almost as long as its solid-core counterpart. However, for both street and racing, wire-wound wire is preferred.

PLUGGING A MAZDA

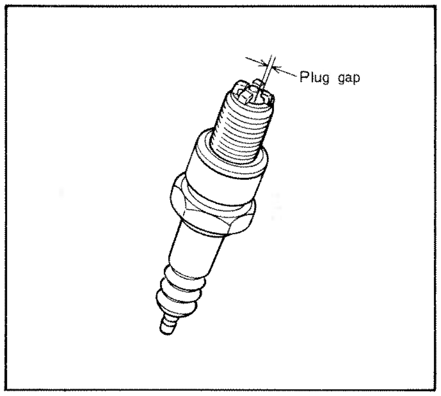
The last link in the ignition chain is the sparkplug. For long-duration racing applications, the Downing/Atlanta crew has a decided preference for Champion

N539C or N513V sparkplugs. The N539C is a single-electrode plug, but both the center and ground electrodes are oversized. N513V plugs, which are extremely difficult to find, are of the *surface-gap* variety. Both of these plugs have a very cold heat range. Consequently, they will foul easily if the air/fuel ratio is excessively rich.

The intense heat that characterizes combustion in a rotary engine takes its toll on sparkplug life. Multi-electrode plugs were developed specifically to cure this problem. With two-, three- or four-ground electrodes, plug life is significantly increased. Depending on the degree of modification, a street-driven rotary calls for either a Champion N180B or N178B plug. For racing and high-speed autocrossing, an N80 is more appropriate for stock and mildly modified engines.

Gaps—As a means of avoiding any possibility of a misfire, Engman opts for a relatively narrow plug gap of 0.020—0.025 in. Although a wider gap is conducive to improved operating efficiency, with the temperatures and pressures encountered in endurance racing, Engman feels that a little insurance is definitely in order.

The dynamics of air and fuel movement in the working chambers must also be considered when adjusting plug gap. Unlike a reciprocating engine where the intake charge is contained beneath the sparkplug, in a rotary engine it is pushed past the sparkplugs, and is moving laterally as it is ignited. In effect, the moving mixture is attempting to blow out the spark in the plug gap. Wide-gapped plugs have consequently proven to be much more prone to misfire when used in a rotary engine, especially under racing conditions.



In stock engines with electronic ignition, a plug gap of 0.055 in. is specified. Plug gap is varied according to application and type of ignition system.

Such a conservative approach is generally not warranted for an unmodified street-driven Mazda. With a high-energy electronic ignition and four-electrode sparkplugs, gaps of 0.045—0.060 in. are often specified as a means of improving fuel economy and idle quality. While 0.060-in. gaps may be excessive, gaps of 0.040 in. are livable for street and highway use with multi-electrode plugs. Single-electrode sparkplug gaps should be kept with the 0.020—0.025-in. range. The wider setting should be used only when a high-output ignition system is supplying the zap.

A special sparkplug socket is required to remove plugs from 1981 and later engines. Photo courtesy Racing Beat.

Go Around the Boss—Beginning with 1981 engines, a boss was added to the rotor housings as a means of limiting the types of sparkplugs that can be used only to those recommended by the factory. However, in another demonstration of "Yankee Ingenuity," Racing Beat offers a special thin-wall sparkplug socket (part no. 11529) that will slip by the boss and tighten or loosen all conventional 14mm, 3/4-in. reach, 13/16-in. hex sparkplugs.