How much voltage we need
Why we need it
How much we're getting
How we can get more

THE GREAT IGNITION COIL TEST

by Gordon Jennings

● We've just discovered handwriting on a wall most of us have been beating our heads against for years, and don't know whether to feel elated, mortified or incensed. A touch of elation is in order because what we found points the way toward extended spark plug life, smoother running, easier starting and generally improved behavior for whole classes of motorcycles. The mortification comes from having been *told* what to look for a long time ago and knowing that, like simpletons, we ignored an expert's very good advice. And we're incensed because it is now clear that the entire motorcycle industry has been penny-pinching all of us for decades.

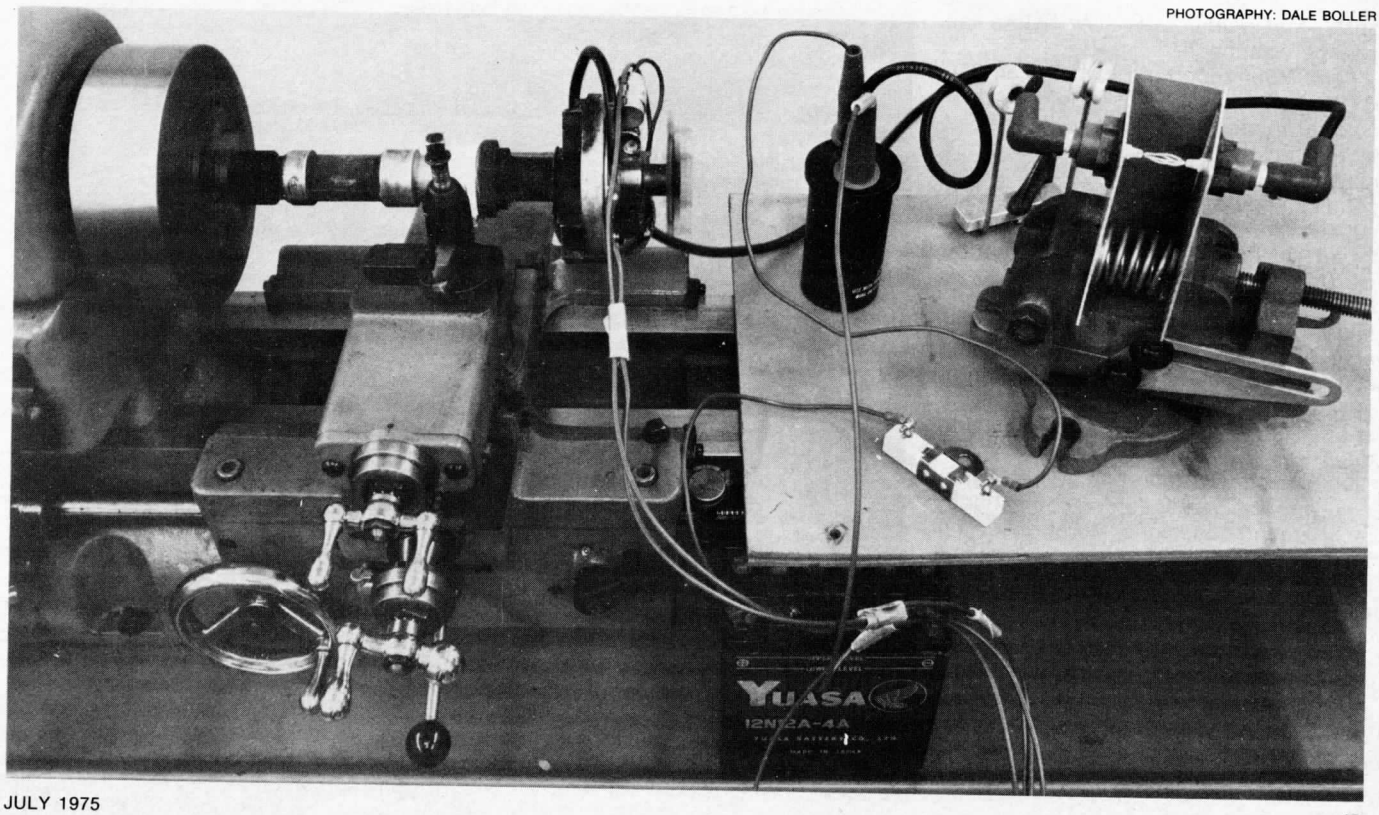
Final enlightenment was cast by the blue-white glare of an electric arc in a scene strongly suggestive of the old Frankenstein movies, as we tested coil after coil for spark output on a jury-rigged apparatus in *Cycle*'s shop. But the matter never would have been taken that far except for sundry items of information we either tripped over or was shoved under our collective nose.

Item: Arnold Frank, who represents the Champion Spark Plug Company in our area, mentioned that his associates had conducted a series of performance tests on motorcycle ignition systems without finding much they could admire. Motorcycles' ignitions, he said, were uniformly and depressingly limp. "Oh, you're absolutely right, Arnold," we chorused, nodding our empty heads in agreement, but events proved that only Jess Thomas fully appreciated what we had been told; the rest of us sat there like dummies, figuring a few hundred volts one way or the other couldn't make much difference if you were willing to give your bike fresh plugs at regular intervals.

Item: Among the various staff-owned bikes under our roof were a couple that almost caricatured the classic symptoms of internal combustion temperament. The two bikes in question would always start, albeit with some coaxing, because they got the kind of treatment usually reserved for rich, elderly relatives; pampered and made comfy and receiving care every time they showed the least sign of displeasure. All this fawning attention kept them going, but would not make them truly eager to start or willing to idle decently until thoroughly warmed (sometimes not even then) and of course they devoured spark plugs like a hungry elephant going after fresh roasted peanuts.

Item: Hot on the trail of some hard information about the latest, greatest, transistorized, capacitored, pointless, God's-Own-Lightning kind of ignition system, we obtained some of the printed reports issued after the "Ignition and Engine Performance Conference" sponsored by Champion each year. These conferences are international affairs, attended by people from oil companies, engine and ignition component manufacturers, and other interested, expert parties. Questions are asked, and answered, and the gist of all that gets said amounts to nothing less than an annual state of the art report. The edited record is full of information, and in those we obtained was pointed reference to sheer spark-coil output voltage and its influence on effec-

PHOTOGRAPHY: DALE BOLLER



tive plug life and on the plug's spark gap—which was, in turn, a potent factor in an engine's cold starting and idling characteristics.

Item: Jess Thomas, who *had* been listening when Arnold Frank spoke his piece about the pervasive weakness of motorcycles' ignition systems, suggested to the two staffers struggling with overly temperamental bikes that they "stop all that herming around and put some good coils on the things." This was done, and the results were eye-openers: the hard starting was corrected, and the marked tendency toward plug fouling was substantially relieved. Astonishingly, both bikes perked up and began to run more vigorously—and neither was slow before the change was made.

Item: Your reporter's own Ducati 750 GT had steadfastly refused to idle when cold, or to start if its plugs were gapped more than .026-inch. When the stock ignition coils were removed, and a pair of the cheapest available automotive coils substituted, the differences were profound. In the interest of experiment the plug gaps were initially left at the .024-inch that previously had proved satisfactory, and with that gap the only detectable difference was slightly easier cold starting and a willingness to idle, though slowly and uncertainly, after a much shorter warm-up period. But after the plug gaps were opened to .035-inch, the engine picked up 200 rpm at idle when cold, and was perceptibly smoother under all operating conditions. Merely installing fresh spark plugs had never worked that kind of transformation; there clearly was a lot here we hadn't understood.

All these things suddenly began to ask questions and demand answers, and we first went scurrying back to re-read those Champion reports. What we found in them were mostly long, tiresome discussions of how this factor or that was likely to effect exhaust emissions, and such matters are as yet of only peripheral interest to motorcyclists. But there was the occasional gem of information with immediate application to the situation we face, and when you string all the gems together you find that we don't really need transistorized, "God's-Own-Lightning" ignition systems for our bikes. All we need is to catch up to where American automobiles were *twenty-five* years ago and we'll think we've surely died and gone to heaven.

Unless you're dealing with a racing two-stroke engine, which will have special and peculiar requirements, the name of the mixture-firing game is voltage. Forget about space-age technology, solid-state circuitry and magnetic triggering; the biggest improvement possible in most motorcycles' ignition systems is simply a change of coils. Switch to a set of ignition coils that will pump up some real kilovolts and you'll solve problems you never suspected as being related to ignition system performance, in addition to increasing effective plug life.

Some engines, and riders, make greater demands on spark plugs than others, but if we may for the moment ignore such extraneous factors then plug life may be said to be a function of voltage-required versus voltage-available. The voltage required to fire a new, clean spark plug at cylinder pressures attending wide-open throttle running will be in the order of 8–9 KV (kilo, or thousand, volts), but as the plug electrodes lose their sharp edges and semi-conductive deposits accumulate on the insulator, the requirement rises sharply. With time in service the plugs will stabilize, their voltage requirement then being about 5 KV higher on average, and further voltage demands will be made mostly as a result of electrode erosion, which will widen the spark gap at the rate of perhaps .001-inch per thousand miles. To handle just this much, the ignition system will need a potential of 13–14 KV, and in practice you also have to accommodate for the fouling deposits accumulated in traffic, which temporarily raise the voltage requirement even higher. Give an engine an ignition system with a peak potential up around 22–24 KV and its plugs will keep right on firing until erosion reduces their electrodes to scaley nubs; cut the potential to, say, 12 KV and the plugs will begin to misfire after only a few thousand miles in service.

Plug *gap* distance is closely tied to available voltage, and if an engine's ignition system is weak the gap has to be set fairly narrow—which, it turns out, is a very bad thing. Air/fuel mixtures in stoichiometric proportions (that is to say, chemically-correct mixtures) are very easily ignited and will flame quite satisfactorily if hit with nothing more than a wispy spark bridging a very narrow electrode gap. But in practice perfect mixtures are more the exception than the rule. The best of carburetors cannot be jetted and adjusted for more than one air density and one fuel viscosity—both of which vary considerably in the real world. Further, neither carburetors nor fuel injection deliver perfectly mixed air and fuel, which means that the charge actually arriving inside the combustion chamber will always be overly rich at one point and lean at another. So there is no predicting the strength of the mixture that happens to be in and around the gap between the

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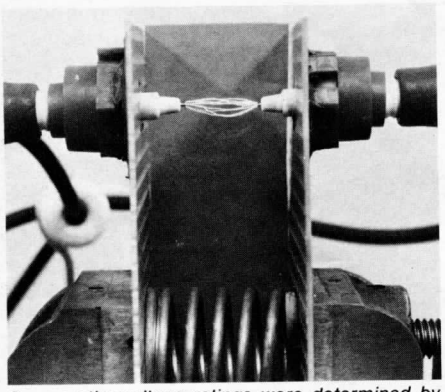
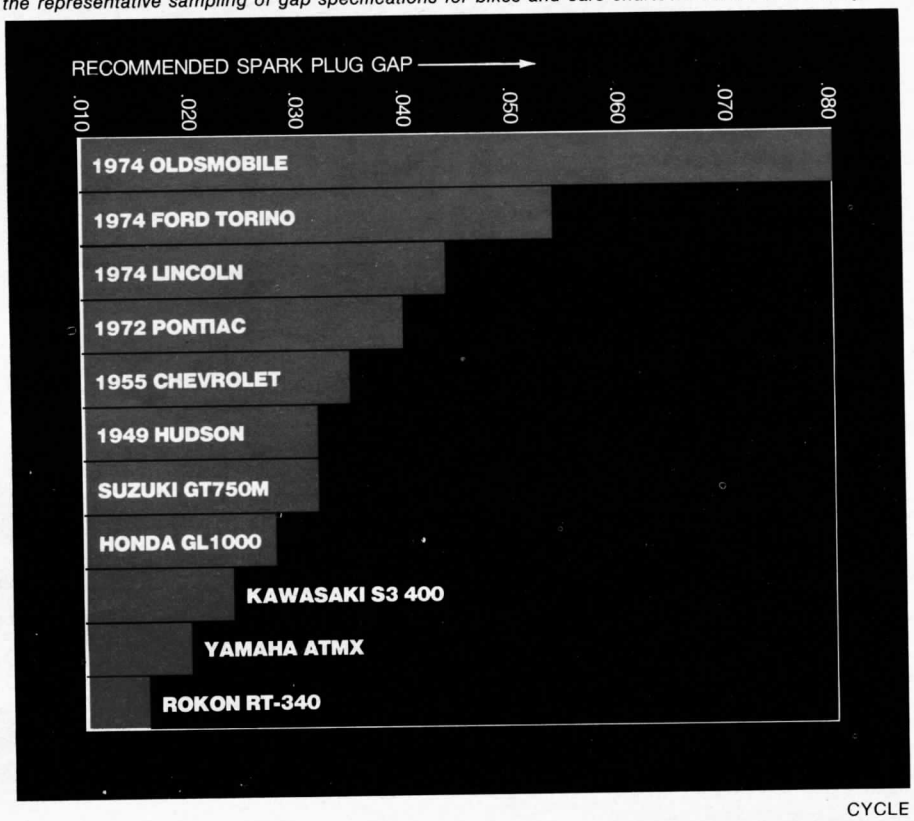
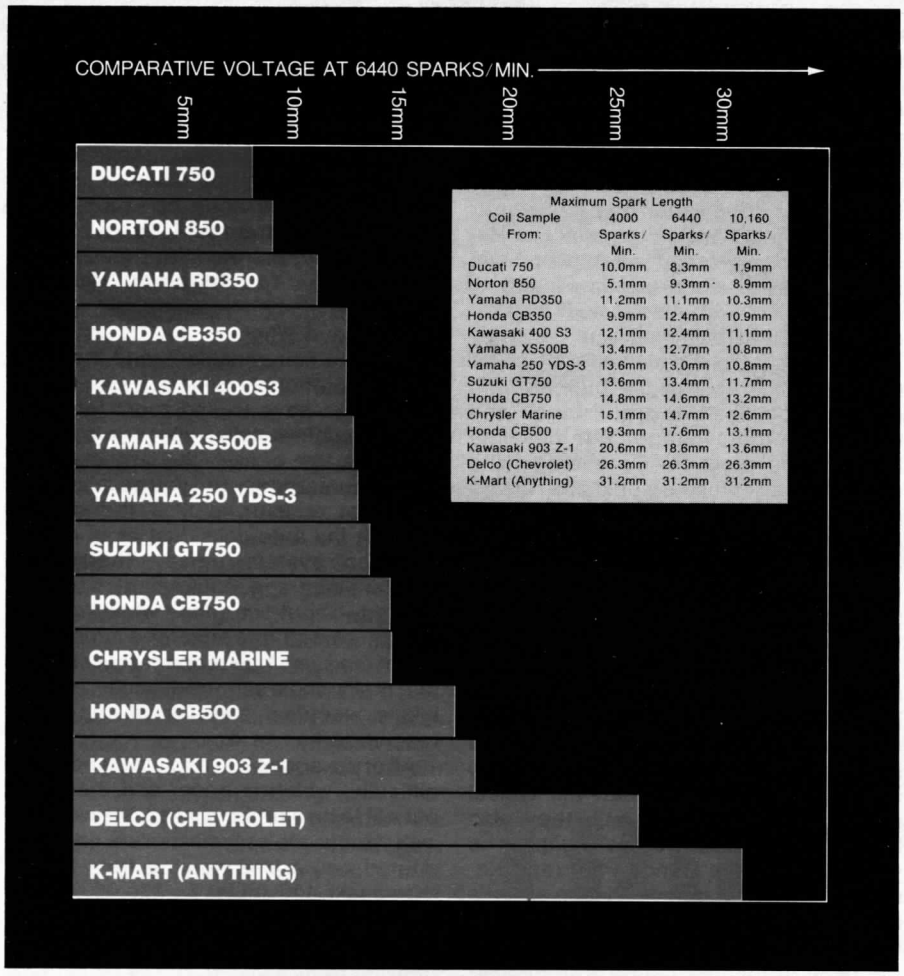


Comparative voltage ratings were determined by forcing the spark across an adjustable air gap.

We have found close correlation between plug gap recommendations and ignition coil output, and the representative sampling of gap specifications for bikes and cars charted here tell a sad story.





Coil Sample From:	Maximum Spark Length 4000 Sparks/ Min.	6440 Sparks/ Min.	10,160 Sparks/ Min.
Ducati 750	10.0mm	8.3mm	1.9mm
Norton 850	5.1mm	9.3mm	8.9mm
Yamaha RD350	11.2mm	11.1mm	10.3mm
Honda CB350	9.9mm	12.4mm	10.9mm
Kawasaki 400 S3	12.1mm	12.4mm	11.1mm
Yamaha XS500B	13.4mm	12.7mm	10.8mm
Yamaha 250 YDS-3	13.6mm	13.0mm	10.8mm
Suzuki GT750	13.6mm	13.4mm	11.7mm
Honda CB750	14.8mm	14.6mm	13.2mm
Chrysler Marine	15.1mm	14.7mm	12.6mm
Honda CB500	19.3mm	17.6mm	13.1mm
Kawasaki 903 Z-1	20.6mm	18.6mm	13.6mm
Delco (Chevrolet)	26.3mm	26.3mm	26.3mm
K-Mart (Anything)	31.2mm	31.2mm	31.2mm

Testing showed the best motorcycle coil to be clearly inferior to the average for cars, and a six-volt coil for the old Yamaha YDS-3 proved stronger than those for the latest XS500B.

plug electrodes at the moment the spark occurs, and this unpleasant fact of internal combustion life requires that the ignition system itself supply a measure of mixture tolerance. And the most effective measure anyone has discovered is a wide spark gap.

From what we are able to learn, it seems that the widened spark gap works to aid the ignition process in a couple of ways: it extends the spark duration, and increases the volume of mixture being exposed to the spark at any given moment. Both of these factors tend to improve the chances that a combustible portion of the fast-swirling charge will pass through the plug gap while the spark is present. The improvement thus obtained is then reflected in several areas, beginning with an engine's willingness to idle. Fuel atomization and vaporization is comparitively poor when an engine is idling, but if its plugs are gapped wide the mixture tolerance will be broadened enough to cope with this condition. Similarly, the mixture reaching the cylinder tends to be very uneven when an engine is cold, and wide-gap plugs can turn a "cold-natured" machine into one that coughs once on a chill morning and then is ready to get moving. And if there's a slight carburetion problem, like a lean condition at part-throttle cruise, the widely gapped plugs will keep it from becoming manifested as surging or hesitation.

There usually is a slight improvement in fuel economy, too, with increased plug gaps. However, most motorcyclists will be more interested in the wider gap's influence on other areas of performance. It would be nice to report that there's a solid, across-the-board power increase with higher spark voltages and wider plug gaps, but that isn't the case. All the increased distance between plug electrodes does is to decrease an engine's mixture sensitivity; the high voltage allows the use of wider gaps, and extends plug life. In short, the overall effect of such measures is to civilize engines rather than make them stronger.

Even among motorcycles civility is a desirable trait, albeit rare, yet in the areas under discussion here everything conspires against it. Motorcycles have relatively large-throat carburetors, almost invariably provided on the basis of one per cylinder, and that may be good for full-throttle performance but has a bad effect on low-speed atomization of fuel. Further, motorcycles do not have the automobile engine's heated intake manifold to aid in the vaporization of fuel. Finally, motorcycle carburetors tend to be comparitively crude instruments, not near as refined as those fitted on cars. These things combine to make the motorcycle engine's air/fuel mixture an especially variable, uncertain thing and all motorcycles conspicuous candidates for the compensating effects of ultrawide plug gaps. Similarly, factors involving engine design and circumstances of use make life very difficult for the motorcycle's spark plugs, which means that our two-wheelers—even more than cars—need ignition systems that deliver a lot of reserve voltage.

A quick glance through almost any spark plug catalogue will tell you that however much motorcycle engines might benefit from wide plug gaps, they aren't getting them. The motorcycle manufacturer's plug-gap recommendation is given in most examples, and a scan of the specifications in the 1975 NGK catalogue shows an average of about .024-inch, with several down around .016 to .020, and a high (ignoring a couple of CDI-fired Kawasakis) or .032. Read through the same kind of specifications for American cars and you won't find anything *less* than an .032-inch plug gap. Your neighbor's decade-old Chevy, the one you borrow to shop for plugs for your bike every month or so—and which gets *its* plugs replaced semiannually—rates a gap recommendation of .035-inch. Late-model Fords are up in the .044 to .054 range and some of the new Delco coils are made to push sparks across gaps up to .080-inch, which will fire even extremely lean mixtures with unfailing regularity and is of enormous importance in emission-control work.

So why the skimpy plug-gap specifications for motorcycle engines? That's a very good question, and one for which there is a straightforward answer: our ignition systems are too limp to handle anything but narrow spark gaps and still provide even marginally satisfactory plug life. We had long suspected motorcycles needed some help in this area; we didn't know how much—despite Arnold Frank's forthright comments—until after we had done some testing of our own.

Engineers whose specialty is ignitions systems surround themselves with elaborate and costly instrumentation, and fret over microseconds and millijoules and spark scatter and a host of other high-voltage minutae. But all the expert-written reports total up to an overall impression that sheer voltage is the first ignition system consideration, and you can learn a lot about that just allowing sparks to arc across an air gap. There will be a very direct correlation between the width of the gap a system is able to bridge with a spark and its voltage output. You really need an oscilloscope to assign voltage numbers; the spark gap is quite satisfactory for comparative testing—especially if you confine your interest to, and draw conclusions only from, large-scale differences. The spark gap method tells you nothing about rise-times, secondary firings or any of the less important nuances.

With a number of practical considerations in mind, we decided to test only battery-energized coils, and constructed a suitable apparatus on our trusty Sears Craftsman lathe. The variable-speed lathe was used to drive a Delco distributor at

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500, 805 and 1270 rpm, and the distributor's eight-lobe cam thus gave us 4000, 6440 and 10,160 make/break cycles per minute at its contact points, which were controlling the current from a 12-volt Yuasa battery through the coil being tested. The distributor head was one rescued from a salvage yard, but was fitted with a new set of points and a new .22 microfarad condenser just to make sure the coils were being properly energized. The electrodes for our adjustable air gap were removed, with their insulators, from a new pair of Champion gold-palladium spark plugs. These electrodes were chosen because, while we did not anticipate problems with electrical erosion at ambient temperatures, we did not want their sharp edges to become blunted as testing proceeded. Such blunting would have changed (increased) the electrical pressure required to force a spark across any given gap, and we didn't want to introduce any unnecessary error. For the same reason, we kept close watch over the condition of the contact points, and maintained the battery at full charge. All spark gap measurements were taken at the distance at which sparking was regular, though some of the coils tested would fire intermittently across slightly wider gaps than those for which numbers were actually recorded.

As a first step, we ran an ordinary Delco automotive coil on our test rig, using the companion ballast resister to make the results valid. What we wanted was a baseline number against which all other coils tested could be compared. Relatives of the Delco coil we used can be found in literally millions of General Motors products (Chevrolets, Buicks, Oldsmobiles and Pontiacs) and we really don't think this coil sets unreasonably high standards for voltage output. The people at GM don't ask it to work against plug gaps wider than .035-inch in engines with moderate compression ratios, and you can buy the coil for less than $15.00, retail, almost anyplace in the country.

Triggered to give 6440 sparks per minute, the Delco coil fired with impressive regularity out to a gap 26.3mm in width, beyond which point leakage from the high-tension terminal across the insulator and down to the battery/points terminals began to dampen its enthusiasm. This test was repeated a half-dozen times, with the same result, so we tried the Delco coil at 10,160 sparks/minute. At the higher rate output must have dropped, due to the short time available for magnetic saturation of the coil, but we still got a 26.3mm spark distance.

With that baseline established, we went forward with the testing of our collection of motorcycle spark coils. The only way these could have emerged from the testing looking good would have been if we had used a Zippo lighter to produce our baseline spark. We didn't try every motorcycle coil, but we had a representative sampling of those energized by a battery and controlled with mechanical breaker points, and this sampling was uniformly lousy. Some were slightly better or worse than their fellows, but the bulk of them fizzled at about half the gap distance (and half the output voltage) our baseline Delco would produce. On average, the motorcycle coils tested would push an arc just over 13mm at 6440 sparks/minute, and around 12mm at the higher rate of delivery. Most of the numbers shown on the chart presented with this story compare very unfavorably against the figures for our baseline Delco.

Honda Four owners may read the numbers and figure that they have been given the best of a bad deal, but that's not necessarily true. Honda's twin-lead spark coils, used on all Fours, do pump up a bit more voltage than the typical single-lead motorcycle coil; they also have to fire across *two* spark gaps. The voltage path for a Honda Four (and Kawasaki Z-1) coil is out one lead to a plug's center electrode; from there it jumps to the ground electrode and passes through the head to another plug's ground electrode; jumps a second gap to yet another center electrode and then returns to the coil *via* the second lead. Taking into consideration that one of those jumps is a "reverse-polarity" affair (going from the cool ground to the hot center electrode, which takes more voltage than the other way) and the existence of the extra gap, the net improvement is slight. The marginal nature of the improvement is reflected in the plug gaps recommended for Honda's CB350 Twin, with a single-lead coil, and the CB750 Four: both, according to NGK, should have their plugs gapped at .028-inch.

If no motorcycle coil were conspicuously better than the rest, one distinguished itself by being a lot worse. The coil Ducati provides with its 750 twins, the little beauty that did so much to encourage this investigation, stands in about the same relationship to other bike coils as *they* occupy relative to the Delco. We checked six Ducati coils, and the miserable little spark we got from the best of the lot is responsible for the depressing figures you see on our chart. At 6440 sparks/minute the Ducati coil was straining to bridge an 8mm gap; at 10,160 sparks/minute it would just wisp its way between electrodes 1.9mm apart. Of course in real life the Ducati coil never has to crank out more than 4500 sparks per minute, so to give the thing a break we tried it down at 4000—and it responded by leaping a miserable 10mm gap. It's no wonder that my own Ducati perked up when it started getting spark voltage from a pair of automotive coils.

We very strongly suspect that there are few motorcycles that wouldn't benefit from a similar switch in coils, but many just aren't eligible. Magneto and CDI systems pretty generally require special coils, which the Delco is not; neither can standard automotive coils be used as replacements for the twin-lead items used on Honda Fours, etc. That leaves only bikes like the Yamaha twins, bikes with conventional, battery-energized ignition systems and single-lead coils as candidates for a coil transplant, and there are problems (though minor) even among these. You have to find room for those big automotive coils, which are nearly twice the size of even the largest motorcycle counterparts, and you have to insert a ballast resistor to limit the current through the auto coils, just as in a car's electrical system. Finally, there's the greater amperage requirement to be considered—about two amps while running, compared with one amp for a motorcycle coil at the same rate of spark delivery—but that really isn't a serious difficulty, as most bike's electrical systems will have the reserve to handle it.

All of the above leaves a single potential difficulty, which is price, and that turns out not to be a problem at all. We checked with various motorcycle dealers and were quoted coil prices ranging from $10.00 (Kawasaki 400 triple) to $30.00 (Honda CB750 Four). Delco coils go for about $15.00, and automotive ballast resistors retail for around $2.50, so you can fit your ailing Double-Zoomy twin with a trick ignition system for a grand total of maybe $32.50, plus tax, and light a mighty fire in your fussy two-stroke triple for less than $50.00—even if you can't get a volume discount on the coils.

Phil Schilling beat the current-draw/ballast resistor problem by buying a pair of Chrysler Marine coils for his Ducati Super Sport, and you might want to give them a try. Phil worked a swindle and bought his wholesale for $16.00 apiece, and was truly delighted with them because they are very small and fit right into the stock coil brackets, and they made the Super Sport run a world better. He lost only a little of his enthusiasm for them when testing showed (see chart page 47) that while they were a whole lot better than the Ducati coils and slightly stronger than the average for all motorcycle coils, they fell far short of matching the larger car coils' output.

And the spark-throwing, electrode-sizzling champion of our coil test? It is an all-purpose automotive coil sold by K-Mart, along with discount-priced shoes and bath oils. We don't know who makes the K-Mart coil, but the thing retails locally for $6.66 and is the spark-producing bargain of the year. The K-Mart coil (which may be sold by other discount stores, under other names) is a little shorter than the Delco coil it is made to replace, making it a bit easier to mount, and like the Delco its output limit is reached not with

(Continued on page 105)

COIL TEST *Continued from page 48*

an over-widened spark gap but when it begins firing heavily between its own terminals. We tried gobbing silicon grease around the spark lead boot and the side terminals, and with the spark gap pulled out to the distances shown on our chart it would cross-fire furiously. Any coil that strong will fire plugs even if the electrodes are half-gone from erosion and their insulators ankle-deep in accumulated deposits. A pair of them make for an ignition system for any twin that will out-trick the average magic-box wonder, and at a total price of $15.82. They'll save the typical Ducati owner that much every month just in the spark plugs he doesn't replace.

If the results of our testing, and experimenting, had been less dramatic, the motorcycle industry's techo-mavens could argue with the results. Our test equipment was, after all, not terribly sophisticated, and we cannot state with certainty that one kind of motorcycle coil is clearly better than another. The point is, our testing has shown that no motorcycle coil is appreciably better than the really dismal average, that none is in the same league with American automotive coils, and that improvement is needed. Maybe we can find K-Mart's supplier and get those people to make coils for motorcycles; the motorcycle industry surely isn't doing much in terms of ignition systems an honest man could talk about without blushing. ◉

COILS II

By Gordon Jennings

• A couple of months ago, in our July issue, we presented results from a two-level investigation into the matter of ignition voltage requirements versus actual spark coil performance. The article, titled "The Great Ignition Coil Test," made the point that motorcycle engines have plenty of voltage requirement but don't get much spark; outlined the consequences of ignition voltage insufficiencies; showed the wide-margin superiority of automotive ignition coils; and mentioned that most bikes would benefit from having a coil transplant.

The sheer volume of written and telephoned communications in response to our "Coils" piece says it was well received by the readership; the content of these communications tells us we erred in concentrating on *why* automotive coils may be expected to improve motorcycles' behavior while giving short shrift to the details of *how* such transplanting should be done. What follows is intended to re-establish a balance.

Those who missed our July shot at bike coils have to be acquainted with the substance of the information presented. It all concerned the importance of sheer voltage in such seemingly unrelated matters as spark plug service life and engines' sensitivity to mixture strength. Spark plugs will fire satisfactorily on a mere 8–9 kv when new, but their voltage requirement rises with time in service. If an ignition coil's output is weak, then the spark plug will quickly demand more voltage than it can deliver. Weak coils also accentuate any shortcomings in carburetion, because mixture tolerance increases with the width of the gap between spark plug electrodes. And of course the voltage requirement rises as the between-electrodes gap is widened.

You can get a pretty good feel for the relative merits of automotive and motorcycle coils just by looking at the plug gap recommendations for cars and for bikes. Chevrolets old enough to vote run plugs gapped at .035-inch; the average for motorcycles is about .024-inch, and bikes have all the cold-starting and idling problems theory predicts for too-close electrode gaps.

We went beyond the reading of spark plug charts and actually tested a sampling of ignition coils. And we found exactly what the various gap recommendations had suggested: that car coils really are much stronger than those we get with bikes. The big surprise was the enormity of the difference. An ordinary Delco coil, of the kind used in millions of older Chevrolets, has roughly twice the output of the average motorcycle ignition coil. That fact accounts, in no small part, for the American car's steady idle, smooth part-throttle operation and ability to squeeze so many thousands of miles of running out of a set of spark plugs.

Does any of the above transfer to a motorcycle when it is fitted with automotive coils? Our experience says it does. Car coils have been installed in three staff-owned motorcycles, and there was a marked improvement in cold-start characteristics, etc., in every case. But we already told you about that in the first "Coils" article; here we will focus on the problems of those who have been convinced that the car/bike coil transplant is a good thing, and are wondering how to go about it.

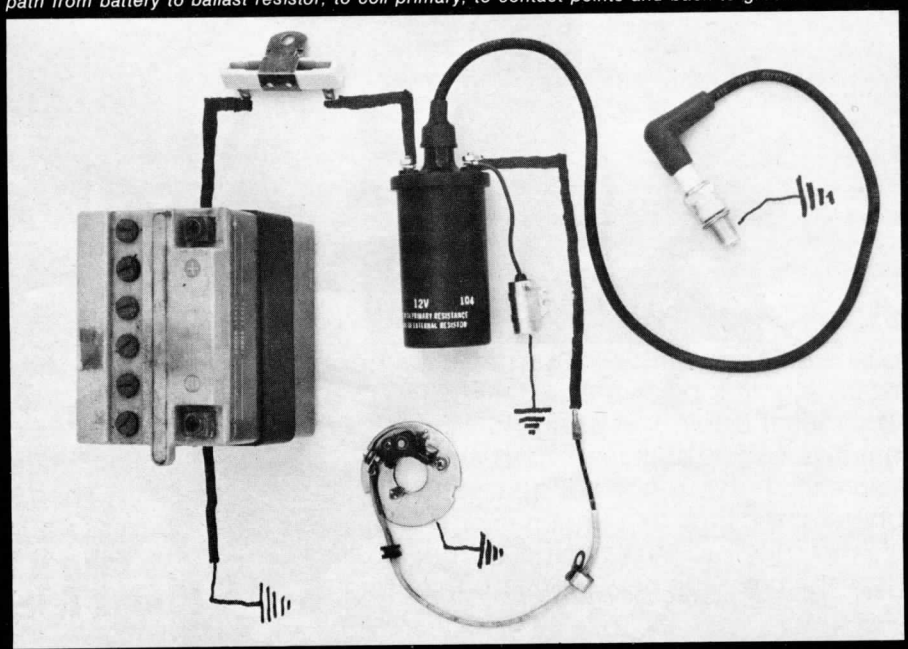
Many people seem troubled by the car coil's electrical current draw, which is (like its output) about double that of the typical motorcycle coil. Somewhere there undoubtedly is a motorcycle that lacks the generating capacity to handle the added amperage, but the vast majority of bikes' systems won't even notice the difference. The added current draw, for a twin-coil ignition, is about the same thing the electrical system handles when a bike's stoplight flashes on; it just isn't enough to worry about.

Another point much misunderstood is the nature and function of the ballast resistors almost universally employed in automotive ignition systems. Ordinary resistors are simple electric restrictors, with substantially fixed voltage/current reducing properties. Ballast resistors are electrical flow regulators, and will pass the current for which they are rated even though voltage (electrical pressure) varies a lot. Or, to put it another way, ballast resistors will vary the voltage at an ignition coil's primary windings and thus hold the current at a constant level. We've checked the primary voltage in a ballast-resistor-equipped ignition system, and got readings ranging from a high of nine volts down to a five-volt low, depending on engine speed. It was the ballast resistor doing its job, which is to maintain the coil's primary current (and thus its output) at a very nearly constant level. It just isn't possible to get the same kind of even performance out of an inductive-type ignition system that applies line voltage directly to its coil primaries.

In any case, ignition coils made for American cars are intended to be used in combination with ballast resistors, and you should not try to side-step the makers' intentions in this matter. Neither should you fret yourself about getting a particular kind of ballast resistor, as all those made for American automotive coils seem to have very nearly the same current limiting properties. Simply step right up to the man at your local auto parts store and ask for an ignition system ballast resistor. If he's the worrisome type, and wants to know what kind, tell him you want one to use with a 12-volt Delco coil (even if you really plan to fit up a set of K-Mart or Sears car coils).

You probably won't need more than one ballast resistor, even if—as usually is the case—your bike has two or more coils. The little cam that opens and closes a bike's ignition contact points usually is shaped so that it holds the points open

Here is the hardware for a car/bike coil-transplant ignition system, with lines to show the current path from battery to ballast resistor, to coil primary, to contact points and back to ground.



most of the time, dropping a particular set closed just long enough to produce magnetic saturation in the coil and then lifting them open again to produce a spark. The closed period is in many instances so brief that only one of a bike's two or three coils is active at any given moment. When that situation exists, a single ballast resistor inserted in the circuit between the ignition switch and the coils will suffice, because it is being asked to control the current to only one coil at a time. Only when there is an overlap, with more than one coil drawing current, is there any need to have more than a single ballast resistor.

A word of advice here: when you turn on the ballast-resistor-equipped ignition system the very first time, you probably will get wisps of smoke floating up from the resistor coils. Don't panic, thinking something awful is happening; it will simply be a little oil left over from the manufacturing process being scorched off the hot resistor element. Do your worrying when the smoke is rising from one or more of the bike's insulated wires.

Mounting those big automotive coils will be a real pain in the neck, if you're trying to get them installed in the same location as the originals. More often than not, they won't fit because the space up under the fuel tank is limited. And they aren't going to fit into the stock brackets because of the automobile coil's larger size. You should try to position the replacements in roughly the same spot as the originals, as that will enable you to use the existing electrical leads, but if there's just no extra space at all you can solve the problem by hanging the big car coils on the front frame downtubes—and hold them there with hose clamps until you get around to making up some proper mounting brackets. Coils don't have to be grounded to the frame.

Condensers do have to be grounded, as their outer cases constitute one of their two electrical terminals. Bikes often have their condensers do have to be grounded, as their outer cases constitute one of their two electrical terminals. Bikes often have their condensers buried cheek to jowl with the engine internals, and that's not good because condensers are more apt to fail when subjected to high temperatures. A far better spot for the motorcycle's condensers is up next to the coils, where they will be cooler—and they don't feel any significant difference, electrically, in that position. You simply mount the condensers so that their cases are grounded to the bike's frame (remember, paint is an insulator) and connect their leads to the points-side coil primary terminals. Here again, as was true of the ballast resistors, you shouldn't worry about matching coils and condensers. It is a verifiable fact that nearly all ignition condensers have a capacitance of .22 microfarads. You should get a set of American automotive condensers to go with your coils, because you can't beat them for price and reliability.

Conventional inductive-type ignition systems are so simple that it's almost impossible to botch the coil transplant seriously unless you get excessively creative in doing the job. American automotive coils won't work as part of a CDI or magneto system, but they can be spliced into any of the numerous motorcycle systems that have mechanically operated contact points and battery-energized coils. As is shown in the schematic drawing that accompanies this text, all you need is a wire leading from the non-grounded battery terminal to the ballast resistor, from there to one primary terminal on the coil, then off the other coil primary terminal to the points—which lead to ground. The condenser also leads to ground, if very indirectly, and can be wired in anywhere between the coil and the points. In practice, the lead to the coil will take a detour through the ignition switch, but that's a small complication.

Do be careful with the coils' spark leads. Car coils are so strong that you can mount them clear back on your bike's rear fender, with spark leads five feet long, and they'll still deliver more than enough voltage at the spark plugs unless you let the voltage escape somewhere along the way. Don't tape the spark leads to the frame tubes. If there's a pinhole in the lead insulation the spark will leap to ground there instead of at the plug electrodes, and even if the insulation is perfect there'll be some voltage loss due to certain weird inductive and capacitive effects associated with long conductors and nearby masses of metal.

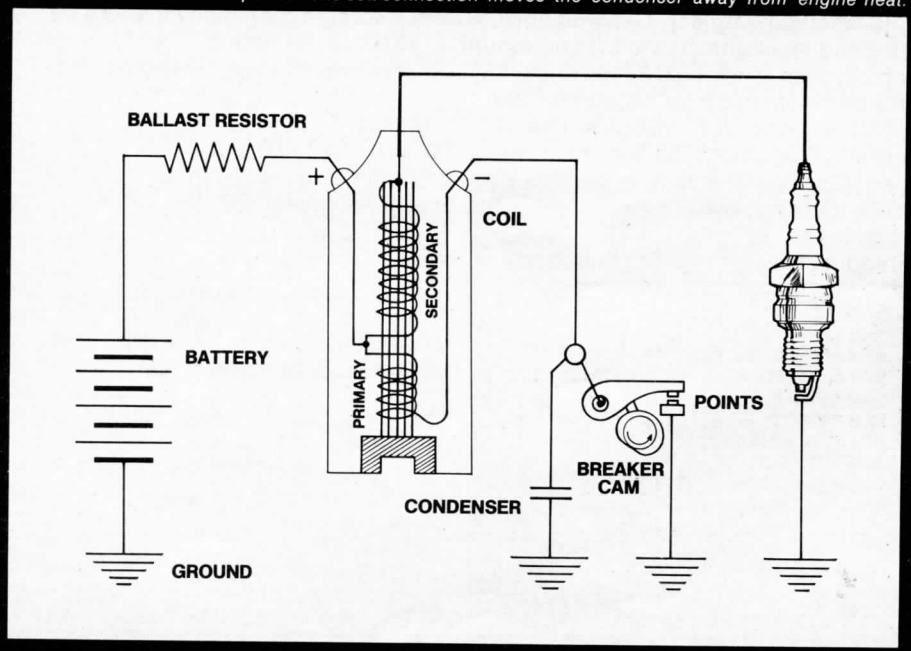
Another place the voltage can be lost is around the coil terminals. Give the coil a chance and it will send sparks zapping down from its high-voltage terminal to a frame tube or its own primary terminal lugs. Coils really need those rubber boots that fit tightly around the spark leads and their nose. You can get by without such insulation sometimes, but a little dust and moisture on the coil's insulated end will cause a massive short-circuiting of the coil output.

Do your neighbors a big favor and use either resistor-type plugs or spark plug caps that incorporate a resistor. Without resistance in the high-voltage leads your ignition system will be a fairly powerful radio/TV transmitter, and when the public's reception is upset and they figure out that the problem is motorcycles, then our reception is going to suffer. Radio noise from ignition systems is almost as annoying as the more direct output from badly muffled exhausts; it's just not quite as obvious. Those in-line resistors verge on being more than motorcycle coils can handle, but an automotive coil's output is too high to be seriously weakened by their voltage-squelching effects.

Some of the letters we've received express concern that a whooping increase

(Continued on page 100)

This electrical schematic is for the ignition system illustrated on the opposite page, but with the condenser shown connected at the points. The coil connection moves the condenser away from engine heat.



COILS II *Continued from page 75*

in ignition voltage, which is what you're going to get with car coils, will cause problems with spark plugs or require switching to another plug heat range. There won't be any noticeable difference in either aspect, assuming that the plugs you are now using are correct. If the plug heat range is too cold, then the extra voltage available from the coil will tend to keep them firing instead of fouling. Electrical erosion of the plug electrodes will be a problem only if the plugs' heat range is off on the hot side, in which case the spark will tend to carry metal away from the overheated center electrode. The only shift in spark plug specification concerns the electrode gap. Half of the overall reason for boosting ignition voltage is to allow the use of a wider plug gap, and you'll want to switch from the .024- to .028-inch gap presently specified for your bike to something wider: we'd recommend a gap of between .035- and .040-inch. Car coils will fire even wider gaps for a while, but you'll get most of the wide-gap benefits at .040-inch and anything wider will just use up the voltage reserve needed to keep the plugs firing after time in service has blunted their electrode edges and coated their insulators with fouling deposits.

Our experience with mixed car/bike ignition systems, though not yet extensive enough to be offered as positive proof of ultimate durability, indicates that car coils—though much stronger than the bike equivalent—don't cause any difficulties with battery drain or accelerated contact surface burning of the points. They just work, and work well, even if you get the primary voltage polarity reversed and in general do a half-shabby wiring job. The automotive coils are strong enough to overcome such piffling difficulties. They also are strong enough to render unnecessary any further electrical/electronic complications, such as "dwell extenders," or any of the other miracles of magic box science. All you have to do is make your motorcycle's ignition system as strong as the one in a typical 1955 Chevy, and you'll have done all that's necessary.

Finally, don't ask us if you can work pairs of automotive coils off a single set of points in a Honda or Kawasaki four. We haven't tried it and don't know. The fours, like all the twins and triples, would benefit from stronger ignition systems but there's nothing available at present to replace their dual-lead coils. Neither will we supply detailed instructions for converting specific motorcycles. The wiring diagram we have provided is what you'll find (minus the ballast resistor) working one coil in a Suzuki or Kawasaki triple, Honda twin or whathaveyou. The only thing missing is a little inventive improvisation in making coil brackets and switching leads from one set of coils to another. That part you'll have to supply yourselves; we think the results will be worth the effort. ◉