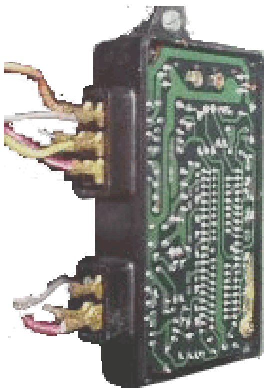
TCI & CDI Electronic Ignition / Stators & Charging Systems

This guide was started for the "YAMAHA VISION" motorcycle group (http://ridersofvision.net/). However, much of this info applies to any ignition / charging / electrical system. Specifically, how this stuff works, how to trace problems, and ultimately how the driveway mechanic might fix an electric, ignition -or- charging problem . If you have comments or corrections... PLEASE email. I will update this when I can. ©1999 Dave "Leather" Draper Jetav8r@JetAv8r.com . My Vision Info Site Here.



YAMAHA

"Yamaha Vision" Motorcycle Electronics / Ignition FAQ

Version 4.0 (July 2005)

UPDATED

Designed for 1024x768 screens

Photos & Diagrams	**Download This Entire Guide As PDF**

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How Does Electronic Ignition Work? (NEW page) The basics & big picture view of typical ignition systems	
Motorcycle Charging Systems and Vision Stator problems (NEW page) Basics of motorcycle charging	
How Vision TCI Works (jump on this same page)	**Disassemble & Repair A Vision TCI (NEW page)**
Electricity Guide (new page)	**Battery Guide (new page)**
Top Vision Links	
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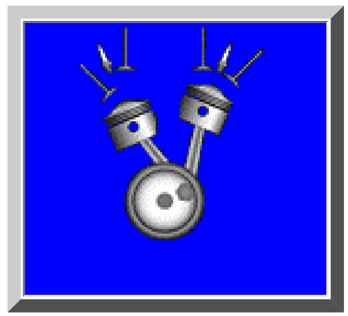
1.0=> INTRO



The document you're reading here (and below) is primarily about the Vision Electronics with emphasis on solving ignition problems. If you want to read about how most all ignitions work then open the new page on ignition basics listed above. If you want to understand basic motorcycle charging systems or have problems specifically with the Vision open the new charging page listed above.

If you're already convinced your Vision TCI is bad and are motivated enough to try a fix it, open the new page above on fixing a TCI. We have not had anyone document in detail fixing a TCI but clearly know that it has been done. Would be great to hear from someone who has done it.

There are also 2 other pages dealing with basic electronic theory and batteries.

The '82/`83 VISION has a "**Transistor Controlled Ignition"** system (**"TCI"**). This type of ignition is used on many older non-automotive motors (look at a Virago...) and is closely related to modern **Capacitive Discharge Ignition** ("**CDI**") systems. While technology advances bring us to the computerized ignition systems of today, the principles of ignition have remained fairly the same.

The 2-cyclinder Vision motorcycle TCI system consists of :

- 2 sensor pickups under the crankshaft cover
- magnet on outside edge of flywheel (triggers sensor pickups)
- 2 spark coils (1 for each cyclinder)
- a solid state module box ("ignitor") that controls the spark

Solid state (electronic) ignitions were introduced in the early 70's (my '72 Outboard has one), became widely used in autos in the mid 80's and are now common on **ALL** motors. The Vision ignition has the typical problems associated with older (and poorly built) solid state ignition systems. The sensors or control module will fail completely ... -OR- ... (more frustratingly) the ignition becomes erratic and usually increasingly worse when hot.

Electronic Ignitions fail usually due to:

- electronic components (switching transistors) in the system breaking down with heat (older transistors were not as good as today)
- material defects (bad or broken solder joints)
- corrosion and bad connections to the module or inside the module
- normal life span ("MTF" mean time between failure rate) of older electronics (diodes, transistors, etc)

Lets face it, electronics don't last forever and I'll bet you don't have your first stereo anymore either (or do you ?!?!! you cheapskate).

A Vision TCI cost about $400 new and about $50 used. If you have ignition problems you know your ride is not worth too much more than that. Still… it's a great ride!! If you want to fix it affordably here's your best chance. Eliminate ignition problems in an organized progression and you will minimize the chance of buying a expensive parts ***you really didn't need***. (..... example: "put the coil back, you really don't need a new coil" ......)

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2.0 => TROUBLE SHOOTING OVERVIEW

top2.1 **[COMMON SENSE APPROACH]**

You want to narrow down **ALL** the possibilities before you replace a TCI, PICKUP, or COIL. If you can get (beg, borrow, steal ..) a good spare ignition then DO IT. ***Bottom Line..*.** You have 2 coils and 2 pickups. So you can eventually tell if one is BAD by using the other in its place. BUT there is no "*SURE*" test of the TCI. You can prove it's bad, but you can't prove it's good. Eliminate every other possibility and then you know it's a TCI module.

- REMEMBER Some Comon Sense Stuff
  - Plugs really do foul bad enough not to work (check spark with plug removed)
  - Don't confuse ignition symptoms for carb problems (again, check for spark)
  - Bad connections (voltage dropout) and fuses can produce all the same symptoms of bad TCI/Pickups
  - *Dude* ..... Is Your Battery Good ????

top2.2 [WHAT ***ARE*** THE SYMPTOMS]

Exactly "WHAT IS GOING ON" ?? Take your time and write it down. Try to pin down your symptoms:

-Is just ONE cylinder misfiring? Which one? It makes a difference!
-What is the Tach doing during the problem since the TCI drives the tach too
-What conditions make it happen/worse?..after getting hot / been running awhile / bumps / etc..

top2.3 [Quick Check List In Priority Order]

[ ] a. Fuses	[ ] i. TCI Power On Test
[ ] b. Connections	[ ] j. TCI module Power/Voltage Checks
[ ] c. Voltage Dropouts	[ ] k. TCI disassembly + inspection
[ ] d. Battery	[ ] l. Sensor Ohm Check / Swap Test
[ ] e. Spark Plugs and Wires	[ ] m. Coils Ohm Check / Swap Test
[ ] f. Side Stand Relay	
[ ] g. Engine Stop Switch	
[ ] h. Rev Limiter Wire	

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2.4 ["The Matrix"]

Symptoms	Possible Problem / Solution
Front Cyl ONLY misfire / Inop	**Sparkplug fouled or Plug Wire bad Rev Limiter -> cut Yellow/Black wire at TCI 6-prong plug Front Pickup -> check / swap Front coil -> check / swap TCI -> check / swap**

Rear Cyl ONLY misfire / Inop **Tach Works fine**	**Sparkplug fouled or Plug Wire bad** **Rear Coil -> check / swap** **Grey wire Bad From TCI to coil** **{TCI is triggering tach correctly, sensor good}**
Rear Cyl ONLY misfire/Inop **Tach Jumps around wildly or inop**	**Rear Pickup -> check / swap** **TCI -> check / swap**
BOTH cyl die together, bike won't run **Tach dies also (goes zero)**	**Side Stand Relay ->** **Cut Black/White wire at TCI 6-prong plug** **TCI-> Check/Swap (Try Power On test).**
BOTH cyl die together **And starter won't work**	**Run switch bad -> Try Separate 12v wire and test**
Both cylinders misfire **Engine runs real erratic** **May run fine high RPM but not low** **(or visa-versa)** **May not start or spark at all** **Worse when hot**	**Most likely TCI problem or bad connection to TCI** **Check connections and voltages** **TCI -> power on tests** **TCI -> Inspection**
Ignition good till under load	**Bad Battery** **Connections - Voltage drop somewhere**
Ignition good some days not others	**Bad Connections** **TCI -> Open Inspect for obvious flaws / moisture**

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3.0 => [OBVIOUS THINGS TO CHECK]

top3.1 **FUSE BOX**

The fuse box under the seat should be replaced. Especially the 10amp ignition fuse! It provides +12v power to the ignition module / coils / safety relays. A poor connection here can result in ALL of the ignition symptoms!!

top3.15 **REPLACING FUSE BOX**

Replace each fuse with plastic "ATC BLADE" type fuses. Get the good ones with a rubber case and snap on tops. Look in a good marine store ("Boats US") or auto shop ("Pep Boys", etc...). Solder these inline into the wiring harness. Use shrink tubing / electrical tape / liquid rubber / or "Die-electric grease to insulate the connections from ground. The idea here is to prevent ANY corrosion from getting in these connections. IT CAN MAKE A REALLY BIG DIFFERENCE!

top3.16 **PROTECTING CONNECTIONS**

A GOOD technique is to use **"Dielectic" grease** to protect fuses and connectors. This is SPECIAL grease that WON'T conduct electricity. Get in good auto parts store. GET THE RIGHT STUFF or you'll have big problems on your hands. Dab the stuff all over connections **AFTER THEY ARE CONNECTED** (not before) you want to protect.

top3.2 **CONNECTIONS and HOW TO REALLY CHECK FOR A GOOD 12 VOLTS**

Most of the wire connections (especially in the plastic plugs) are "crimped on" connectors. These are especially prone to corrosion or getting "loose". A "BAD" connection is easier to find than a "POOR" connection. Here's why.

A "poor" connection will conduct +12 volts (shows good on your multimeter) but may cause enough "voltage drop" that there's **really** no power (amps) going to the thing its supposed to (TCI / COIL / PICKUPS). A poor ground or is EQUALLY BAD! -or- The connector will conduct 12volts ... but only enough to drive the mulitmeter... not the part you really to make sure is working!

If you're not sure what this means.... please read the section on Multimeter use / amp vs volts / testing good connections (**Multi meter Use.)**

My favorite technique when checking a circuit I'm not %100 sure of is to "plug" something into it to see if it works. A good 12v lamp (small headlight) is good for this. If the connection (or gound) will drive the light.... you know it can handle the load of whatever your concerned about.

Now you can check for these bad connections (read the the appendix section on multimeter use) BUT to my way of thinking just make all your connections "bulletproof" (replace if needed) in the ignition system and then you don't have to worry.

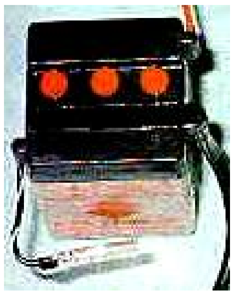
The telltail symptom of a bad connection is ***hot wires and/or melted plastic connectors***.

NOTE : Look at the white plastic connector on left side of bike that connects the Rectifier to the Stator wires. This is a VERY common place to see the "melted connector" effect of a corroded connector. AND.... if this connector is bad the bike is NOT getting the electricity it needs. Most riders recommend you cut and permanently solder this connection to be absolutely sure.

top3.25 **CLEANING CONNECTIONS** 

To CLEAN the plug connectors pull them apart, clean them with a small file or knife. Some people like pencil erasers. Emery boards or 400 - 600 grade sandpaper are OK but remember to clean out the grit (... or you could make it worse). Apply **WD-40 (or CRC)** liberally to wash the gunk out. Reseat all the plugs. There are not that many. Specifically, remove right engine cover. Pull off the 2 plugs into the TCI “IGNITOR” module. Behind the cover the TCI is mounted is the "side stand relay". Reseat those plugs too.

top3.3 **BATTERY**



A subtle problem with motorcycles is it doesn't take much power to "crank" one. So, that's not always a good measure of the battery status. In fact, by the time your battery gets to sounding "low" on the starter its just about gone. AND if it "low" while running it could cause these symptoms: tach jump / tach dropout / random misfire both cylinders.

top3.31 **CHECKING BATTERY Using VOLTMETER**

Pull the 6-prong plug off the TCI (you want no ignition for this). Connect the voltmeter to the battery and crank the engine. While cranking you should NOT see less than 9-10 volts. With the bike running at about idle (2000rpm) you should see about 13-14 volts.

top3.32 **CHECKING BATTERY CHARGING Using AMP METER INLINE**

This is more involved. But ... if you are motivated. As you suspect there is a good relationship between your battery and charging circuit ("STATORS"). The stators in the VISION are notorious. So this may be worth doing. You need a multi meter with a good Ammeter scale capable of 10amps or better. You are going to check the battery charging system while the bike is running.

1- Disconnect the RED cable from the +12 Positive terminal on the battery.

2- Hook the Ammeter between the battery and RED cable. Hook the RED test lead to the RED cable end and BLACK tester lead to the battery terminal. You are completing the circuit from the bike to the battery.

CAUTION:

MAKE SURE THE MULTIMETER IS IN THE 10 AMP MODE !!!
NEVER : DO NOT Run The Bike with the battery completely disconnected from the engine

3- Since you can't start the bike this way (that draws way more than 10 AMPS) you need to make another temporary connection alongside your multimeter (in parallel). Use a jumper cable

4. Start the bike. Then disconnect the jumper cable (the multimeter is still connected between the RED cable end and battery.... so the bike should keep running)

5. The ammeter is now showing the "draw" or "Charge" taking place to the battery.

6. Assuming your battery needs charging (almost always!) the needle should show a positive deflection at around ???? amps at idle and a little more as you rev up the bike.

7. Stop the motor. With it not running but IGNITION ON, look at the amp draw. Ignition and accessories should slightly peg the meter on the left side of case. If you want to see the exact draw swap the RED and BLACK TEST LEADS around. Amp draw without the motor running for stock VISION is about ???? with headlight in low beam.

*** NOTE: Read the Appendix section on Battery Care

top3.4 **MOISTURE**

Moisture inside the TCI module will produce ALL the ignition symptoms. This is addressed later BUT be aware the TCI is **NOT** a sealed unit like most ignition modules. WD-40 stands for "Water Displacement" on the 40th try (long story). The bottom line: spray a bunch on your TCI circuit board can't hurt.

top3.5 **SPARK PLUGS**

Plugs rarely go bad BUT that doesn't mean you can rule it out. Because the VISION uses TCI instead of "CDI" (read section on difference) the plugs are more susceptible to fouling. You can foul a plug bad enough IT WILL NOT WORK! I fouled one this bad while experimenting for this guide. A good spark at the wire end (screw or nail inserted) doesn't show you what the plug is really doing.

Pull out the plugs, clean, and check for good spark with the plugs out and the case grounded. Look for a nice sharp blue colored spark that you can noticeably "hear". Try NOT to run your bike without the plug wires attached to something to spark to. Otherwise, you may encourage a spark out the side of the coil where insulation may be old and poor.

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4.0=>SIDE STAND RELAY

top4.1**[SYMPTOMS]**

The side stand relay must be powered or the ignition unit is "killed". So, if the Side Stand relay or circuit is faulty it will cause the engine to cutout altogether (maybe intermittently). The key here is “ALTOGETHER”. Another words BOTH cylinders together. If the engine runs on ONE cylinder (ever) then THIS IS NOT YOUR PROBLEM. A faulty side-stand relay/circuit kills the WHOLE ignition. The tach WILL GO TO ZERO!

Now if the engine is running intermittently so rough you can't tell if its one -or- both cylinders then this is worth checking!

top4.2**[HOW IT WORKS]**

The VISION has a safety lock to prevent you from running the engine with the side stand down (and the bike NOT in neutral). In the VISION the ignition is “Killed” (tach goes to zero) when the BLACK/WHITE wire coming from the TCI module (6-prong plug) is connected to the frame = GROUND = -12volts. This is done by the “Side-Stand Relay”. Normally, when the side stand is up the relay is energized with +12 power and held “OPEN” to disconnect the TCI module B/W wire from ground. When the side stand is down, the relay loses power and closes, connecting the B/W wire to ground. So, if the relay is not "powered" (bad connections) or is shorting out …it can intermittently kill the ignition and tach.

top4.3**[DISCONNECTING / CHECKING SIDE STAND RELAY]**

Find the BLACK / WHITE striped wire coming out of the 6-prong plug in the side of the TCI ignitor module case. Either remove the wire-pin socket from the plug (harder to do) or just cut the wire and tape the ends. With the BLACK/WHITE striped the wire cut, the ignition can't be connected to ground and will work fine.

If this is the problem…. Fix/replace the relay or connections to the relay. If you leave the BLACK/WHITE wire disconnected… *just remember your bike will run with the side stand down*. Use your judgment, as this IS a safety device.

The side-stand relay is under the right engine cover, behind the plastic cover which the small square “TCI” ignition module is mounted to. That plastic cover also holds the water reservoir.

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#5=> ENGINE RUN/STOP SWITCH

The run/stop switch on the handlebars provides +12 volts to the ignition, coils, starter cutout relay, and the side-stand relay. So it's unlikely this is the problem if you can get your bike to “crank” and start. BUT AGAIN, if your bike is cutting out (totally ,both cylinders, tach goes to zero) intermittently after you get it running… this could be the problem.

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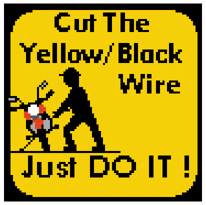
#6=> REV LIMITER CIRCUIT



top6.1 **[SYMPTOMS]**

YES ITS TRUE!. The VISION has a "REV-LIMITER" circuit that kills the FRONT coil ignition if the TACH reads over 12,000rpm. The TACH reads the fire pulse from the TCI to the REAR coil (via the GREY wire from the TCI to the rear coil). That GREY wire splits somewhere under the gas tank. If the tach senses an over-rev it GROUNDS the Yellow/Black wire to the TCI. The TCI kills the front cyclinder coil pulse.

If the circuit malfunctions you'll most likely lose the FRONT CYLINDER ONLY (the tach falsely tells the TCI its overrevved). But, it could also kill the REAR too if the tach shorts out altogether and also shorts the Gray REAR coil trigger wire.

You will not affect ANY part of the ignition /charging system by disconnecting the Yellow/Black wire from the TCI.

Why would you want to keep the Rev Limiter? My best answer would be incase you drop the bike, its laying on its side running with the throttle somehow pinned opn.

top6.2 **[DISCONNECTING REV LIMITER]**

***** CUT YELLOW/BLACK stripped WIRE in 6-prong plug at TCI *** (Tape the ends)**

top6.3 **[HOW TACH & REV LIMIT WORK]**

The Tach has 4 wires connected to it:

[BROWN] = +12 volt Power

[BLACK] = -12 volts Ground

[GRAY] =

Ignition pulse signal that the tach reads. It is a "tap" off the Gray wire from the TCI to the REAR cylinder coil. That splice is under the gas tank.

***** That's why if you lose the rear cylinder ignition you lose the TACH. *****

The GRAY wire signal from the TCI is a "square wave" trigger to the Coils primary winding. It is normally "near" ground and the trigger is +12v to fire the coil and pulse the tach. To be exact: in the Tach I dismantled the GRAY wire became ORANGE after the 3-prong connector block outside the instrument cluster (contrary to every wiring diagram I have).

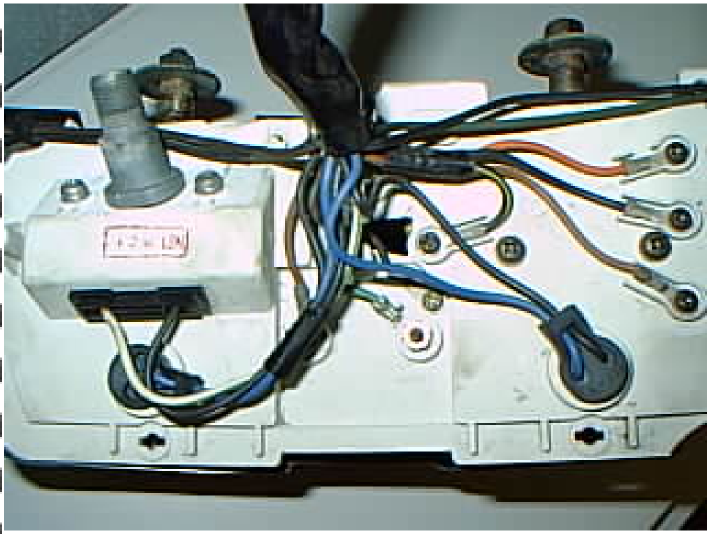
[YELLOW/BLACK stripped wire] =

This is the Rev-Limit connection. This is a single wire between the Tach and TCI. When the "Rev-Limiter" switches ON IN THE TACH it grounds the YELLOW/BLACK wire. You can try this yourself. At the TCI disconnect the YELLOW/BLACK wire in the 6-prong plug in the side of the TCI. Then while the bike is running, ground the pin where the YELLOW/BLACK wire would be connected. It causes the same thing:

The "Rev-Limiter" KILLS THE IGNITION to the FRONT CYLINDER coil at about 12,000rpm.

If you're curious how I know this... I connected an "oscillator" to the Tach, powered it up and ran the tach up to... well, pegged. It thinks it's connected to the engine. At 12,000 exact (on my bike) it grounds the Y/B wire.

top6.4 **[INSIDE THE TACH]**



Inside the Tach are 2 small separate circuit boards. One is the Tach. And the other is obviously this "Rev-Limit" switch. I say "switch", but this is a "solid-state" circuit board switch (NOT a mechanical one). An IC chip on this board is obviously counting RPM.

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#7=> IGNITION SYSTEM OVERVIEW

"*.....plugging in a spare TCI is worth a thousand words.....*" - Author Known

top7.1 **[SYMPTOMS]**

There's are a million of them... but these appear most common:

- While riding one cylinder will stop firing intermittently at higher rpm. The bike still runs on one cylinder but with a lot less power and will be very hard to start if you stall it. The tach MAY go to zero when this happens. Typically this lasts about 2 - 15 seconds and then may cut back in and run normally.

- Both cylinders will alternately stop firing. Sometimes it will not run at all at low rpm. Tach is also at zero or may jump around wildly. Bike backfires badly, etc… Gets worse when its hot.

top7.2 **[WHAT IS “TCI”]**

Ignition systems have evolved over the years and been called many things: Solid State, Ignitors, Breakerless ,Pointless, Distributorless, etc... In outboards they're called "Powerpacks" or "Pulse packs". They go bad about every 5-10 years and also cost a boatload (excuse the pun). Yamaha calls this a "TCI" (Transistor Controlled Ignition) or "Ignitor" pack. In autos we call them "CDI" (Capacitive Discharge Ignition), ECU (Electronic ControlUnit), or DIS (Distributorless Ignition System). **I will say TCI and CDI for simplicity but .....**

top7.21 **["TCI" IS NOT "CDI"]**

I Repeat ..."TCI" is Not "CDI"

The differences are subtle BUT you need to understand them or *BAD* things can happen

To be exact TCI uses transistor switches to ***disconnect*** the coils. This causes a charged coil to collapse and "fire" the spark. This is known as "Kettering" or "Induction" effect. So, in the VISION the coils are powered up all the time except while "collapsing" into spark. The VISION coils are constantly powered up at 12+ volts but the "induction" energy stored in the coils secondary core is about 20,000volts

TCI is an "INDUCTION" ignition system

CDI systems use a different technique. While the pickup and triggering is the same, the output from a CDI ignition module is a short **high voltage** pulse to the coil. In a CDI system the coil doesn't store the spark but instead AMPLIFIES the pulse from the CDI unit to a much higher level. The pulse is from the CDI module is normally about 250-500volts. The CDI coil acts like a transformer and steps the voltage even higher. A CDI coil typically steps up the voltage 100:1. Do the math and you see a modern CDI coil is outputing 25,000-50,000volts (Oh-Baby).The spark coils here are wired directly to ground and are waiting for the high voltage pulse from the CDI module.

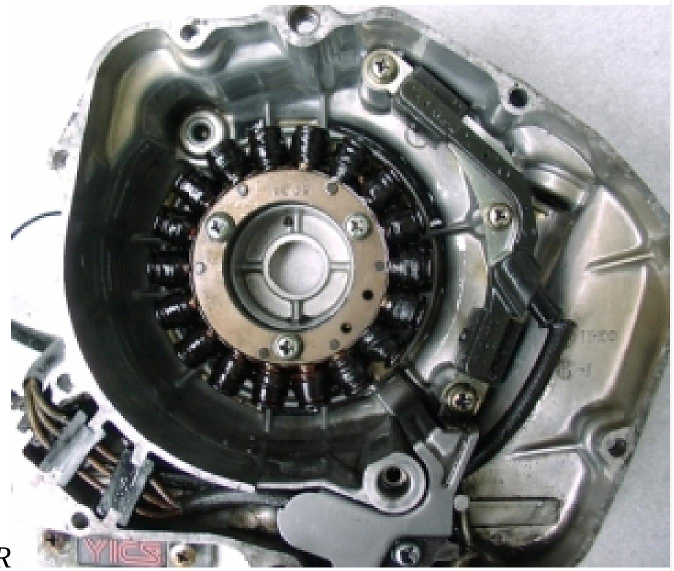
"CDI CAN KILL" :That's why there are warning stickers all over your auto engine bay. The CDI module itself can give you a WICKED shock (not just the coil) and ...the coil output can KILL YOU.

CDI is a "CAPACITIVE DISCHARGE" system

top7.22 **[CDI vs. TCI]**

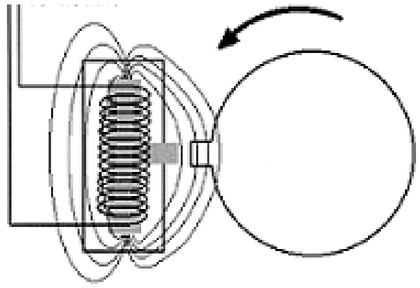
The higher output voltage of a CDI module produces a much higher cooresponding coil output voltage . So, CDI produces a much **hotter cleaner spark**. It is the ignition of choice among race teams and now widely used for everything. The "CD" in CDI means capacitive discharge. This refers to the high voltage output of the CDI module which comes from a "mini" coil circuit of its own. The downside to CDI is the short high voltage spark pulse duration. This is better at high RPM but makes starting difficult. You will notice many CDI ignition systems that use a starting "ballast resistor" type circuit. This circuit ups the spark output in the CDI ignition for starting only. TCI produces a longer spark duration (which some might argue is more reliable).

top7.23 **[How CDI / TCI works]**

Click On Photo For  *BIGGER*	*Click On Photo For*  *BIGGER*
Pickup Magnet on Flywheel Outside	**(2) Ignition Pickups (on right of stator)**

A CDI module picks up a signal sent from a sensor usually otside the flywheel. The sensor can be optical (infared) but most often is electro-magnetic. In smaller or older engines (like motorcycles) the system is usually a magnetic rotor and coil pickup. The other "Hall effect systems" are usually used in auto or newer motors. Hall effect pickups are different and need to be powered, so there is usually 3 wires to those pickups. In the common motorcycle pickup a magnet on the flywheel passes by a small coil pickup. This produces a small electric pulse in the coil just like it does in your larger magnet-stator charging circuit. This small pulse is amplified inside the ignition module and used to switch a transistor which in turn controls the coil.

The flywheel usually has a combination of magnets and pickups. In the Vision, there is one magnet and 2 pickups (one for each cyclinder). Since there is no distributor directing which cyclinder gets the spark each cyclinder has its own coil. Or, 2 opposing (180degrees out) cyclinders can share the same coil and get



twice as many sparks (1 in compression and one wasted in exhaust stroke (Refer to "wasted spark" section).

The gap distance between the magnet and sensor is very important as is the "phase" (when the magnet passes the sensor). The magnet is producing a "sine-wave" (low-high-low voltage) pulse for the CDI .The low to high pulse is the trigger. The peak voltage produced by most sensors is around 5volts.

In the VISION the 2 sensor pickups are under the left crankcase cover at the crankshaft flywheel end. The magnet is built into the outside surface of theVision flywheel.

top7.3 **[HOW COIL SPARK WORKS … EXACTLY]**

The spark plug COIL is exactly that: 2 LONG lengths of thin wire wound side-by-side tightly around a cylinder spool (a "coil" of wire). The first PRIMARY WINDING length of wire is proportionally shorter than the SECONDARY WINDING. As example, the coil may have 100,000 wraps of wire around it but the second winding is 200 times longer (wrapped 200:1 ….whatever). Since the wires are so thin and close, the second wire picks up the same electrical voltage (charge) flowing through the first. If the wires were the same length, connecting +12volts to the primary wire (other end to -12 ground) would charge the second wire up to 12v also. But, in a spark coil the secondary wire charges up to a voltage proportionally higher than the first since the secondary wire is so much longer (literally more wire to "fill" with electricity). Remember, the PRIMARY and SECONDARY wires are NOT connected. But they are just so close to each other that they pick up proportional charges.

In layman's terms: when one end of the primary wire is cutoff, the charge still left in the primary wire flows back to the battery. But the longer secondary wire (charged now to HIGH VOLTAGE) is NOT connected back to the battery and its high voltage charge has got to go somewhere! It gets back to "ground" (the battery) by "jumping" the short gap in the spark plug (or YOU if you happen to be holding the plug wire).

In the VISION the spark plug coil has a constant +12 volts flowing into the "PRIMARY WINDING". This causes the longer "SECONDARY WINDING" wire in the coil to charge up to a high voltage. When the +12 volts of the PRIMARY WINDING is briefly interrupted by the TCI, the coil electrically "Collapses" and causes the high voltage SECONDARY winding to discharge (the Spark). The input to the coil is +12 volts, but the high voltage output spark is over 10,000 volts.

Again, the difference between "Induction" (TCI) and CDI systems is this:

TCI collapses an already charged coil by disconnecting it (TCI switches off briefly). These systems generally use a higher resistance type coil and are known as an "induction" or "Kettering" ignition systems.

CDI sends a brief high (200+) voltage pulse to an uncharged coil which act like a transformer and multiplies it even higher. The step up is normally around 100:1. These systems tend to use low resistance or "racing" oils.

CDI modules normally use low resistance type coils. Remember that CDI is "shooting" a voltage pulse through the coil. TCI (or induction ignitions) use (and expect) higher resistance "induction" type coils. Remember current is flowing through the TCI to the induction coils continuously and the coil is fired when the TCI shuts it off. The importance of this is:

Do Not Use a "racing" -or- low resistance type coil in an "induction" ignition (or TCI) system.
The low resistance coil will flow more current thru the TCI and produce the legendary "Hot Toaster" effect. Though it will work for awhile, you will eventually burn the TCI module out.

In CDI this whole process of charge/discharge is near instantaneous. An 8-cylinder car running 5,000rpm is firing the single coil about 333 times a second. The output voltage of the coil depends on the input voltage and how much longer the secondary winding is. Some modern car ignition coils output well over 40,000 volts. **This can KILL!** The VISION TCI coil is probably (guessing here) about 20,000volts and if you get sparked will just shock the heck out of you.

top7.35 **["DWELL" -or- "DWELL ANGLE"]**

Dwell time used to refer mostly to the mechanical time the distributor points are closed in old ignition systems. This affected the charge time of the coil and spark length. Dwell was important then because at higher RPM the dwell time was not enough to fully charge the induction coil. That meant less voltage spark at higher RPM (...BAD). There was also the problem of how fast a point could open and close without "floating" (a problem you have with valves also). There was a real balance between dwell time at high RPM, how much voltage you needed for high RPM spark, how much voltage you could actually push thru a point without burning it up, and then what would happen at low rpm (long dwell times) when all that voltage was just heating up the coils.

In newer CDI systems this term is near meaningless for several reasons. Solid state devices (like transistors)control the discharge pulses electronically with near instantaneous timings. So the dwell times can be finely controlled to achieve the best coil / spark outputs for a given RPM. Transistors can handle a LARGE amounts of voltage/current (compared to points). And, newer generation coils are extremely (microseconds) fast so charge / discharge times are not a huge factor (unless racing). Newer racing ignitions (like MSD) are NOT producing bigger sparks with long durations but in fact getting more effecient burn by producing very controlled multiple short duration sparks to the plug.

top7.4 **[HOW the TCI Fires The COIL Exactly]**

The flywheel pickup signal is fed to the TCI module. Inside is a “TIMING” chip which controls the length of the spark and also its timing relative to the RPM. As RPM increase the timing is advanced. In the VISION this is 10 degrees (“top dead center”) at 1,300rpm to 38 degrees TDC at 4,000rpm. Remember, in old engines the ignition timing was "advanced" with RPM by using a vacuum driven diaphragm or a centrifugal weight on the rotor. With CDI it is electronically advanced in the ignition "timing" chip based on some mathematical graph the manufacture has developed to maximize the engine horsepower in that RPM range (that was too a long sentence). If you have the VISION service manual you can see the timing graph on page 8-14.

The TCI module uses a "switching" transistor to "fire" the coil. This is how:

- The coil gets a +12 volt input direct FROM the battery (via ignition sw). It is grounded (the circuit completed) BY the TCI. The TCI transistor switches "OFF" the coil ground to collapse the coil and cause the secondary coil winding to spark. If you test the Gray (or Orange) wire FROM (that's right... from!) the coil you'll see +12 volts. If you look at the TCI pin you'll see near ground until the fire signal. Then the TCI actually pulses a +12 volts at the pin. This is a "forceful" way of "cutting"off the PRIMARY wire ground and forcing the SECONDARY winding spark.

The VISION has 2 coils (one for each cylinder). So, the TCI module has 1 timing chip and 2 transistors. One for each coil.

The VISION's 2 coils are mounted REALLY INCONVIENETLY under the gas tank inside the frame. To get to them you need to remove the gas tank. **But coils VERY RARELY go bad!** And when they do they usually stop working period (not intermittently). The odds are REALLY small they both stopped working intermittently.

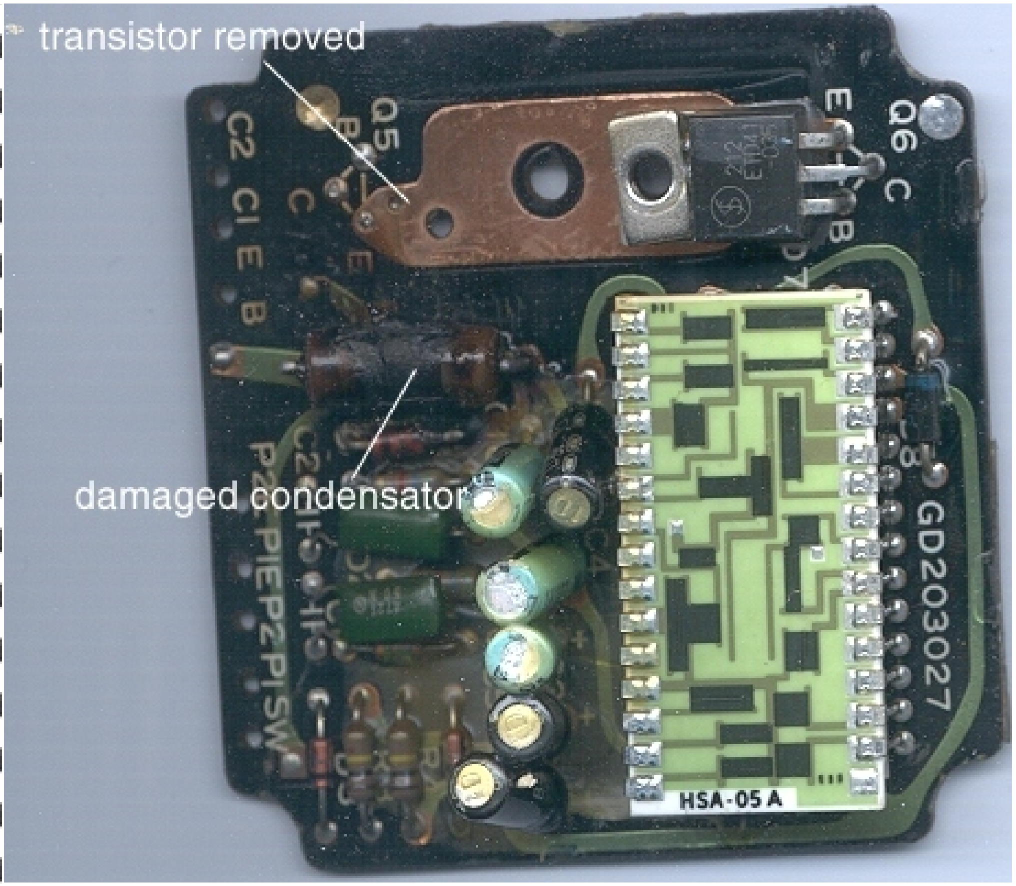
top7.5 **[WHAT"S GOOD ABOUT CDI]**

There are no moving parts like relays/points/rotors to wear out or adjust. In theory, a CDI engine never needs an ignition tune-up again (you know, timing light, etc...) This is not always true. Remember, a car engine has 1 coil. They use a turning rotor under the distributor cap which determines which spark plug gets the spark. This does gets worn a bit since it involves a timing belt to drive the rotor and the rotor itself wears.

In the VISION there are NO moving parts because each cylinder has its own spark coil and there is no rotor.

In newer high tech engines you will see CDI ignitions with seperate coils mounted atop the spark plug for each cyclinder. This eliminates the distributor slop and radio interference problems associated with long plug wires.

top7.6 **[WHAT GOES BAD IN CDIs]**



> **Electronic components HATE heat!!**

That is why most CDI modules have lots of heat sink fins on them (Ever look how your Pentium chip is mounted?). DON'T leave your computer on all night!? But ...**Yea-aah**, don't *turn it OFF and ON 5 times every hour either*....?!? ...... because ....

> **Integrated circuits also hate POWER SURGES!   ....and the THERMAL stress of going from cold to hot to cold.**

The symptoms of ANY CDI type module going bad are very similar. They start to fail when the engine (and it) gets hot. They don't always fail altogether but gradually and intermittently as some or many IC components on the circuit board break down with heat. This is why a good electronic repair shop has cans of a "Freon" type spray (turn your "AIR DUST OFF" spray can upside down.... its the same thing). They will selectively chill each component till they can find the one that’s breaking down with heat. I'll bet many CDI modules that quit after start will work OK if you chill them down.

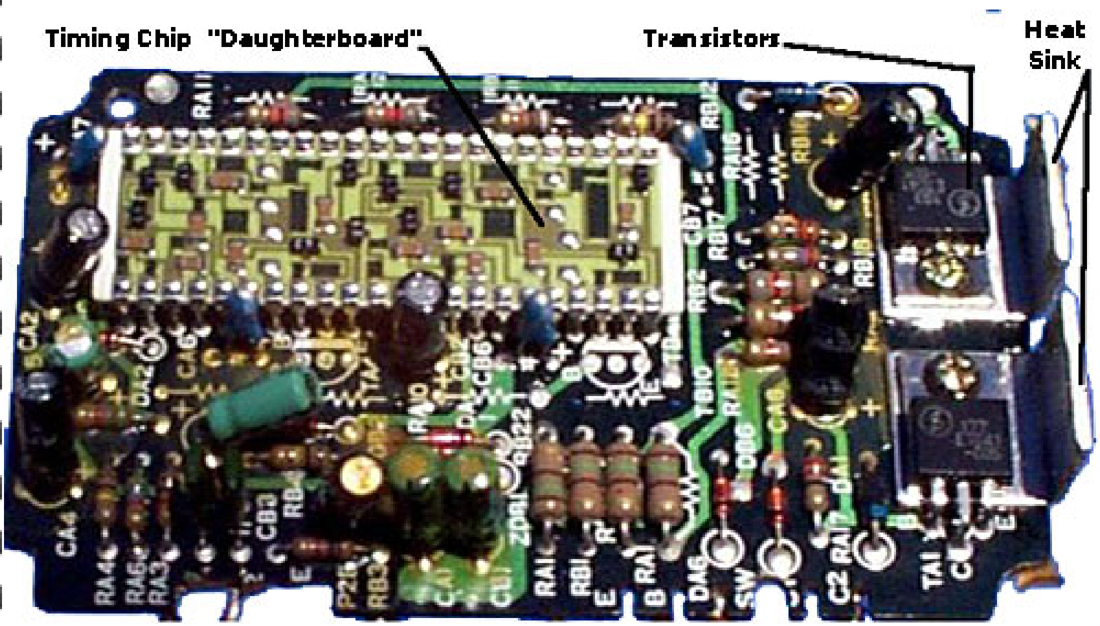
top7.7 **[THE HARSH TRUTH ABOUT BROKEN TCI / CDI MODULES]**

You Cannot Prove A TCI / CDI is Good. You can only prove that its BAD.

With the exception of newer automobiles and high end fuel injected marine motors .... manufacturers make NO "test bed"module you can plug a CDI into which will test if it's good. Worse, most retail parts shops will sell you electronic parts as is and you own them when you walk out the door (whether it turns out later you need them or not). A repair shop has the luxury of having some spares laying around. So they plug one in and see if it works. You can't aford this trial-and-error method because ....

Older CDI modules are pricey ("they" got you and "they" know it). Not just Yamaha or because you have a VISION. Don't take it personally. Most CDI modules cost around $300-400. The Yamaha "TCI" ignitor module costs $500 retail as of 2001 (at least you can get one). To soften the blow($) and *REALLY* to be safer outboard makers are now using separate CDI modules and coils for each cylinder. So when one goes bad it doesn't kill the whole engine and each CDI only costs about $80. And many bikes now use several of them for the same reason. If you do the math, you realize it may not be worth repairing. My wife always seems to be able to do THIS math !??. THANK GOD FOR EBAY !?

top7.8 **[WHAT’S INSIDE A CDI MODULE]**



Most CDI units are encased in Epoxy resin or Epoxy-Rubber resin so you can't take them apart (Epoxy-Rubber resin will dissolves in acetone if you really want to see one apart) . They do this so moisture won't get in. The downside is heat buildup. WHAT YOU'D MOST LIKELY SEE is some resistors, capacitors, a couple transistors (you know, the ones that fire your spark plug coils). You'll also see the "timing chip". ANYWAY.... there's probably $10 in electronic parts and a $20 Ignition chip in a CDI module (I'm feeling generous). That a 1,200% markup!!. I'm in the wrong business.

What goes bad in these things?

Typically it is the "Timing" (Ignition) chip or the Transistors. The transistors really take a beating. That’s what generates heat in the CDI since they're essentially a switch going on and off at 10,000rpm ???. Put your hand on the side of your big wattage stereo amplifier: HOT, same thing! That’s where the heat sinks for the transistors are. And, the Ignition “Timing” chip is like any other IC chip. It's prone to breakdown with heat.

top7.9 [CHECKING THE TCI MODULE]

After reading all this, ***you'll be angry now*** when I tell you there's **NO** definitive test to check the TCI!

You can prove the TCI is bad, but not that it is good.

I recommend this order:

#1. The **TCI "power-on test" (section 12)** will show you right away if the TCI system is NOT working.
Go There Now -> TCI Power-On Tests

#2. Check the **Sensors (section 8).** This is most likely if you have one cylinder missing (not both).
Next Section

#3. Check **TCI voltages (section 9).**
Go There Now -> TCI Connector Checks

#4. Disassemble **TCI for inspection (section 10).**
Go There Now -> TCI Inspection

#5. Rebuild the TCI module.
Go There Now -> TCI Rebuild

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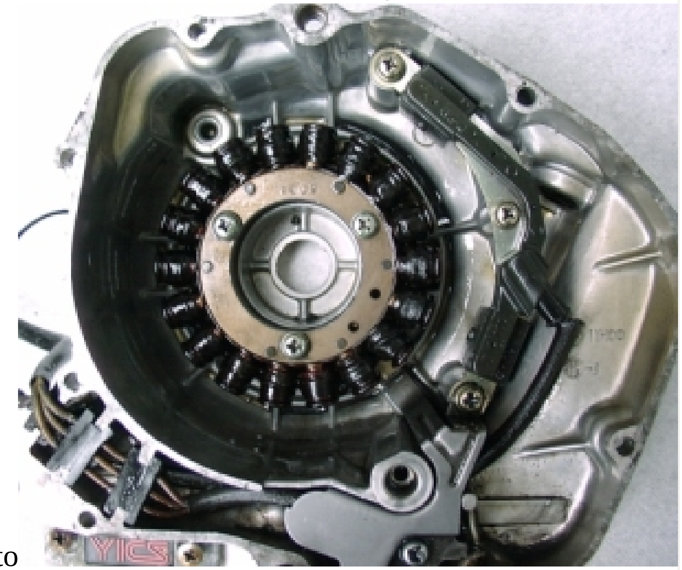
#8=> PICKUP SENSORS

Click for big  photo	Click for big  photo
Pickup Magnet on Flywheel Outside	**(2) Ignition Pickups (on right of stator)**

top8.1 **[TACH symptoms]**

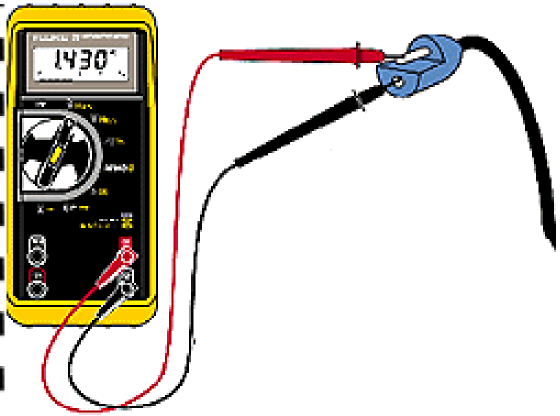
Remember the TACH is **DRIVEN BY** the TCI via the **REAR** pickup sensor. If TACH is good, rear sensor is good.

top8.2 **[BAD SENSOR SYMPTOMS]**

If only ONE cylinder is misfiring then suspect all these: the PICKUP / COIL / TCI. Check all 3! It would seem unlikely for BOTH (one for each cylinder) pickups to go bad together at the same time. That would result in both cylinders misfiring. BUT - pickup sensor "crosstalk" -or- shorting is possible. That WOULD give those symptoms.

top8.3 **[CHECKING PICKUP ohm RESISTANCE]**

The VISION has 2 sensor pickups mounted on a single plate assembly. Each sensor pickup is a small "coil". You can check for "continuity" (no break in the internal coil wire) and also the correct resistance you'd expect of a coil that is not shorted out (or corroded).



Unplug the 4-prong plug from the TCI. At the plug the wires ends are :

BLACK = GROUND (connected internally in TCI to the Black ground wire in 6-prong plug).
This is the ground side of sensors. Both sensor grounds are tied together (one wire).

WHITE = Rear cyl Pickup.
RED = Front Cyl Pickup.

Set Ohm Meter to Rx10 scale. Put Black lead clip on the BLACK wire pin socket of the plug (use a thin wire or safety needle to get in there). Put the RED test lead on the RED wire socket. Then the WHITE wire socket. AGAIN, the RED+BLACK wires are Front cyl sensor, the WHITE+BLACK wires are the Rear cly sensor.

Sensor Pickup should read: 110 ohms (99-121 ohms is acceptable) in both cases.

top8.31 **[BAD NEWS ABOUT PICKUP ohm TEST]**

The continuity/OHM test ONLY checks the basic properties of the pickup coil. It doesn't really tell you FOR SURE if its working. I had an outboard with single pickup that tested perfect years ago. Spent lots of money to replace the CDI and single coil because the engine would die after getting hot. But ultimately, it was a new pickup that solved the problem It had ALL THE SAME SYMPTOMS OF A BAD CDI module?!

top8.4 **[CHECK TCI PINS TO SENSOR]**

Disconnect 4-Prong plug from TCI and check the male (protruding pins) on the module case. Connect the black test lead to the frame (ground), Ignition ON, and look for:

Black wire pin = Ground.

{Connected inside TCI to BLACK
ground wire from 6-prong plug}
Red wire pin = +1/2v (0.5v)
White wire pin = +1/2v (0.5v)

Put RED test lead on black wire and look for 0.5 volts when :

RED wire plugged onto pin (White wire disconnected).
WHITE wire plugged onto pin (RED wire disconnected).

If you have good power at the TCI pin but not after going through the pickup something weird is going on. Suspect a short in pickup or wiring (possibly where it goes into crankcase, etc...). You would have seen a break in the wire with the ohm test.

top8.5 **[PICKUP CROSSTALK / SHORT symptoms]**

Since the pickups share a common ground "crosstalk" or a short between the two sensors is a real possibility. "Crosstalk" would result in one sensor triggering the wrong coil. A short between the sensors could cause unpredictable symptoms

top8.51 **[CROSSTALK CHECK]**

This is unknown. Without the schematic we're not sure how this works. Sorry dudes.

top8.52 **[PICKUP SHORT CHECK]**

You are looking to make sure there is no stray ground in the wiring.

Put BLACK test lead on ground. Pull RED/WHITE/BLACK wires off (whole 4-prong plug) from TCI. Put RED test lead each wire end. You should not see GROUND. If you do suspect a short in the wiring somewhere to the frame or engine.

PROBLEM IS this may be happening with the vibration of the engine. This would be very hard to see. Because of the shared ground you can't run the bike even on one cylinder and check this.

top8.6 **[SWAPPING PICKUPS {suspect one is bad}]**

You have 2 pickups. You can use the good one to test your "Bad One" theory. Simple:

*** NOTE: **DON'T SCREW THIS UP** !!!! *******

If you keep a spark wire connected and start the bike with the pickups swapped ..... the bike WILL misfire B A D L Y

- Pull BOTH!! spark plugs off.
Insert screw into inop plug wire & position near ground.

- Swap the pickup sensor wires in TCI 4-prong plug.
Plug White wire onto Red pin and visa versa (Red wire onto White pin).

- Crank engine. If the bad plug fires (and good one doesn't)
then suspect the pickup (OR COIL) is bad.
Test/Swap coil now and you'll know for sure.

top8.7 **[TEST FIRING a CDI or TCI]**

Obviously, if you can test fire the ignition module..... it narrows your troubleshooting quickly. Anotherwords... how can you "trick" the ignitor into thinking the pickup sensor has "pulsed" and/or get it to fire a plug? If your super lucky...your workshop manual will detail how this can be done. My 1973 outboard CDI could be fired manually and it was part of the factory service guide. The problem is.... there's no universal solution that I know of yet.... Certainly, you're not going to risk frying a good ignition module by trial and error. AND... unfortunately, the workshop manuals for most ignitors don't include this.

I will pass on a backyard trick as told to me by "roadrunner" but I HAVE NEVER TRIED. But it sounds like it should work. He writes:

"Just a quick backyead test. you can use one of them soldering guns, you know the hi current pistal type. It will trick the magnetic pickups to send pulses. becouse the gun creates a dense magnetic feald around the tip. Carfule not to burn something doing this. The pickups will sense these magnetic fealds and send firing pulses at 60 hz to the module . It makes it a lot easer to troubleshoot without kicking the starter each time ."

top8.8 **[HOW TO REPLACE THE PICKUPS]**

Get Haynes or Factory manual for this one. I will say this though. You must take GREAT CARE!! putting the crankcase cover back on and also how you seal (and sealant type)the wire bundle from the sensors out of the engine crankcase. If **this is not done correctly you'll end up with an oil leak out of the crankcase and have to do it all over again.**

top8.9 **[BAD NEWS ABOUT PICKUPS]**

The pickup sensor can fail and take the CDI with it (or visa versa). In other words, they can kill each other. Especially if a transistor shorts 12 volts through the pickup coil (you'd probably see an "open" pickup coil). Or, the pickup coil shorts to ground at higher temp and fries the transistors.

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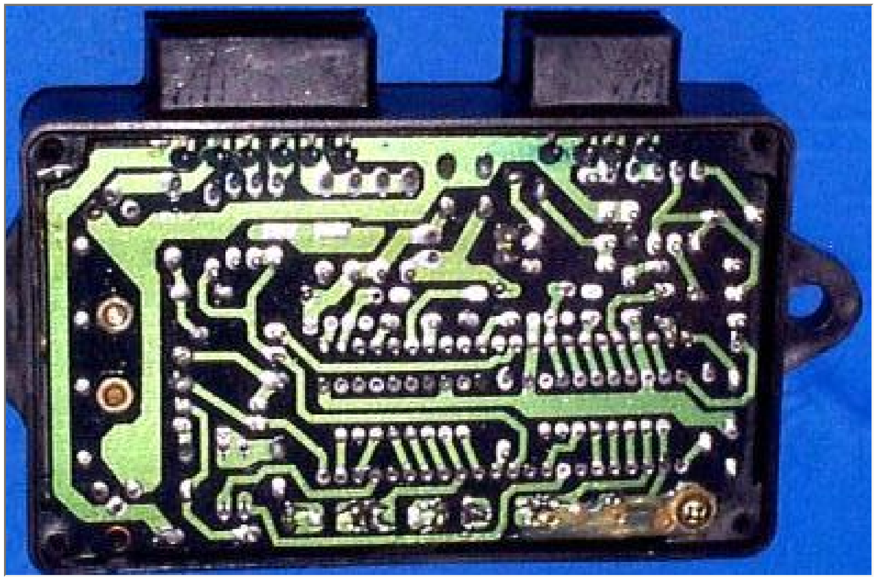
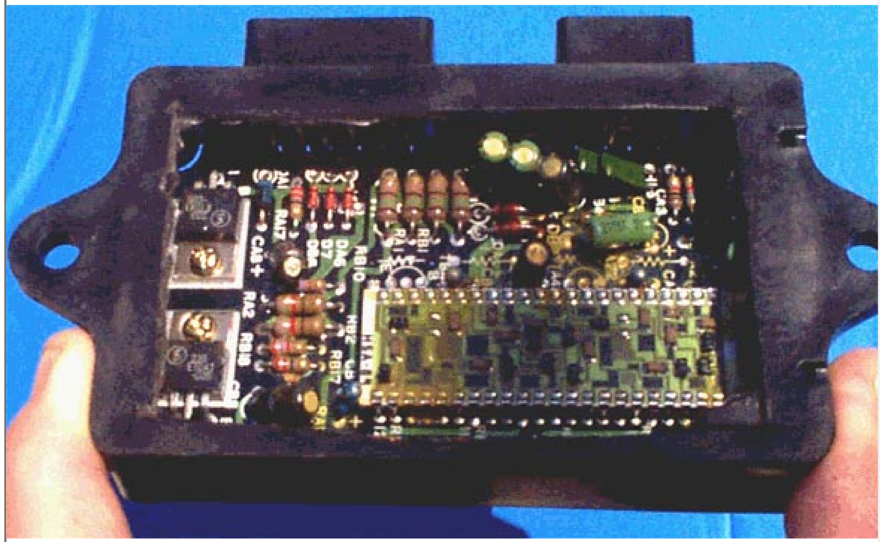
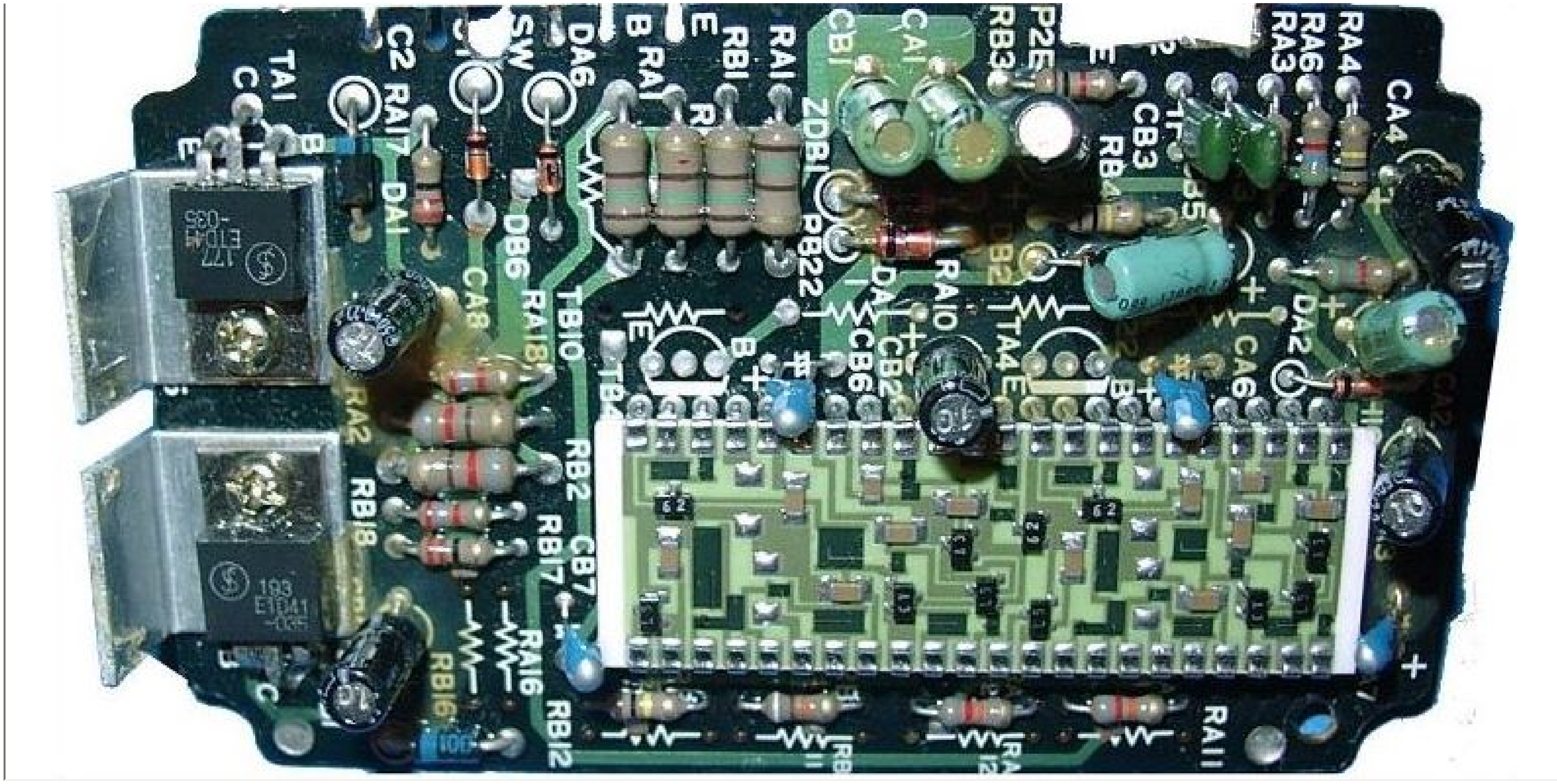
#9=> CHECKING TCI MODULE







top9.1 **[TCI MODULE 6-PRONG PLUG]**

Disconnect the 6-Prong plug from the TCI module, Key ON, and check at the plug:

RED/WHITE striped = +12volts = power for TCI

BLACK = -12 ground = ground for TCI and pickups

ORANGE = +12v = power from Front cylinder coil primary winding

GRAY = +12v = power from Rear cylinder coil primary winding

BLACKWHITE = side stand relay wire. Should NOT be ground or +12 (side stand up!).

YELLOW/BLACK = Rev limiter wire. Cut this + tape ends. Should NOT be grounded!!

top9.2 **[TCI MODULE VOLTAGE DROPOUT TEST]**

Check that you don't have a bad wire or connection to/from TCI. You are looking for voltage "dropouts". You should not see more that 1/4 volts in these checks. More means you have a wire or connector that is literally diverting power or making a poor ground.

>> Set voltmeter to low scale 1-3 volts.

>> Put RED test lead on +12 battery post. Put black test lead on these TCI pins with wires connected :

RED/WHITE striped , ORANGE , GRAY wires

top9.3 **[CHECKING THE TCI WHILE RUNNING]**

Plug both 4-prong and 6-prong plug into the TCI module. Use a safety pin to pierce into the correct wire and check same things above while the engine is running. Maybe there is a bad connection somewhere vibrating loose when the bike runs.

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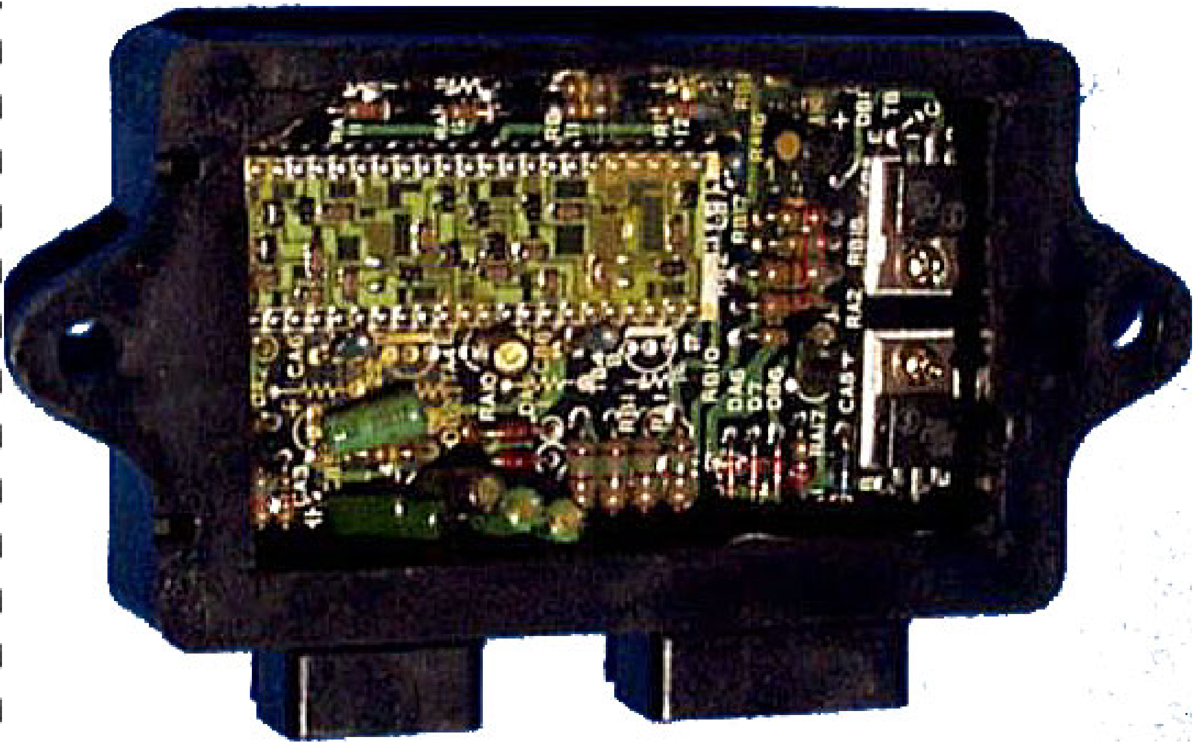
#10 => DISASSEMBLING TCI MODULE



top10.1 **[WHY LOOK INSIDE TCI ??]**

If your convinced the TCI is the problem then this is your last hope. Open the TCI and look for an obvious mechanical problem like : moisture, bad solder joint, bad component.

top10.2 **[GETTING INSIDE THE "Black Box"]**

LUCKILY... you CAN look inside the VISION TCI module. BUT BE CAREFUL!! Take the cover off and your looking at the backside of the integrated circuit board.

*** DO NOT TRY TO PRY IC-BOARD OUT OF THE TCI CASE!!! ***

It is held in by one small Philip screw, and MORE IMPORTANTLY, is soldered to the plug pins molded into the side of the case. To get the board out you have to desolder the pins or break them off when you take it out. You'd then have to solder them (or wires connecting them) back together. There is an easier way.

If you want to see the other side ..... cut a large "porthole" into the plastic "bottom" (other side of the case). Use a dremel tool small cutting wheel. This is risky because you can accidentally cut into IC components on the board. MAYBE BETTER, a sharp knife heated with a torch (so your melting through the plastic). Anyway.... GOOD LUCK (Could be a Darwin award recipient!).

Lay the case flat. Cut down (knife straight up + down) into the case about 1/2” in from the sides. Another words you're cutting a rectangular hole out of the bottom cover 1/2” smaller than the bottom cover size. One end of the module has the metal heat sinks which is why you need to cut about 1/2” in from the sides.

**** **Cut no deeper than about 1/8" or you will cut into IC components** ****

top10.3 **[WHAT YOU WILL SEE]**

You will see the two "TO 220" style transistors with small aluminum heat sinks. The heat sinks are molded into the plastic case side so they're not obvious. In the center you will see the Timing chip attached in a "daughterboard" configuration. Everything else is diodes (the small end banded stuff) and resistors (center banded).

Look for obvious signs of heat damage (discolored components with blistered or crinkled skin). If you're REALLY lucky it could be a bad solder joint. Look for solder points that aren't pretty, look "dull" (cold solder joint), or look disfigured by heat. Chance are slim but... you never know.

top10.4 **[MOISTURE]**

The **TCI is not a "sealed" unit**. If you see any moisture then **THIS COULD BE IT**! I had a TCI with this problem once. Moisture really screws up resistances on an IC board. The case has 2 drain holes, but no good way for moisture to evaporate "out" out of the case. This is why most CDIs are encased in Epoxy-Rubber. Spray the whole thing liberally with WD-40. (If you didn't know "Trivia Pursuit Fans" ... "WD" stands for "Water Displacement" and WD-40 was designed for the military, in part, to dry out wet electronics). Afterwards, blow dry out with spray air (duster).

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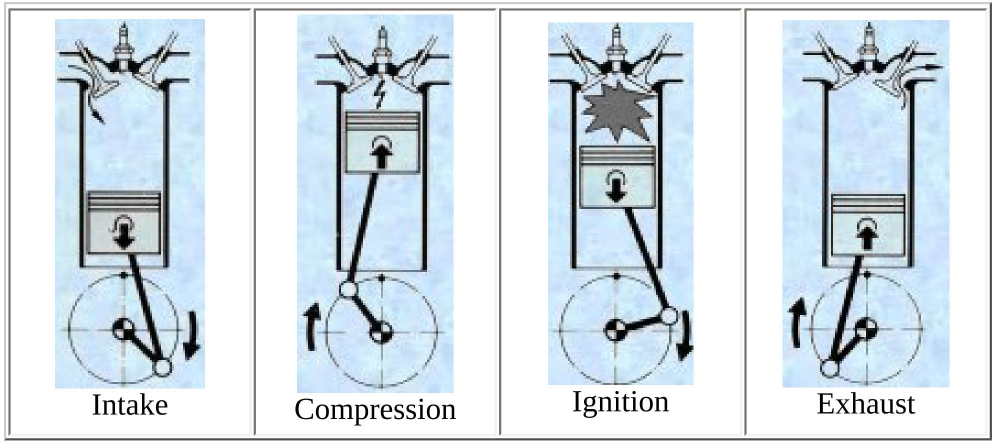
#11=> "WASTED SPARK"



Have you heard "wasted spark" talked about? It is the spark you get during the exhaust stroke. It is "wasted"... but who cares. Here's the story.

top11.1 **[Distributorless - Common Coil Wasted spark]**

An automobile has ***ONE*** coil and a distributor rotor that determines ***WHICH*** cyclinder is getting the spark. ***NOT ONLY THAT....*** but the rotor is geared to spin slower than the flywheel so that the cylinder ***ONLY*** gets a spark when it is TDC ("top dead center") on the compression stroke.

Fast forward to a motorcycle which is ALSO a 4-stroke engine but NO distributor and the firing sensors are on the flywheel spinning 1:1. You see where this is going ??

The Flywheel Pickups fire the ignition spark EVERY revolution. You get a spark on both the Ignition stroke and the EXHAUST stroke.

EXAMPLE: The VISION has 2 coils, one for each cylinder. Makers of some 4 cylinder bikes also use 2 coils!? So, two cylinders share the same coil AND (more importantly) get the SAME spark. Again, this means each cylinder gets exactly twice as many sparks has it really needs. One during the compression stroke and one during the exhaust stroke. WHY DOESN'T THE VISION (or 2 cyclinder) bike share 1 coil? Because you can only share a coil for opposing cylinders that are 180 degrees out. The Vision "V" configuration requires seperate spark coils.

This "wasted" spark is meant to simplify the ignition system. Manufacturers could cut the TCI circuitry in half and save coils , weight, and (OH YEAH) ... and money!!

top11.2 **[VISION (TCI Induced) WASTED SPARK]**

There is another phenomenon of "wasted spark" in the VISION. It's unique to ignitions wired like the TCI. Normal CDI ignitions do not produce this phenomenon.

top11.21 **["WATCH THIS!?!"]**

Pull the rear plug wire off, insert a screw and position near ground. Power up the bike (either with ignition key to ON -or- Run/Stop switch OFF -> then ON). You'll get a single spark out of the rear coil about 2 seconds after power on. You get the same single spark out the front coil but its harder to pull that plug wire off with the sport fairing.

top11.22 **[WHAT'S GOING ON?]**

At key on (or Run/Stop to on), you power up the TCI and coils. The TCI then shuts down since their is no engine rotation. This auto-shutdown is common in all electric ingnition modules. It prevents the ignition from just sitting there powered up if the engine isn't running (which is bad for the transistors).

Since a normal CDI sends a short high voltage pulse to the coil, when it auto-shutsdown... nothing happens. BUT, the TCI is normally grounding both coils. It fires them by momentarily disconnecting the ground. You see where this is going? When the TCI auto-shutsdown, it disconnects both coil grounds. And sure enough, BOTH coils fire one spark out each plug.

Now, this same thing happens if you crank the engine (BUT IT DOESN'T START) and then let go of the starter. Since the engine stops rotating, the TCI shuts off and.... you get a single spark. This explains why you get a DELAYED single misfire/backfire after cranking but get no start. Especially if the battery is low. You have enough juice to crank but not for a good spark. Then you let go and get a GOOD full spark 2 seconds after as the TCI shutsdown. With fuel vapor in the carbs... bang. AND, since you're getting **2 single sparks** regardless of where the engine stops... you could get it in a cylinder "valved" open to the exhaust which has fuel vapors in the muffler.... **KA-POW**!!

Now this is not the same "plug firing" you get IMMEDIATELY after letting go of the starter. In this case, you have managed to catch the timing just right. The powerful ("non-loaded-starter-battery") spark just happens to take place at the correct moment as you let go of the starter.

---

top

#12=> TCI POWER ON TEST

You can test the basic properties of the TCI modules power-up/auto-shut (**read #11 above!**). This is same for both Front and Rear coils. Read Appendix on Checking for Spark if not familiar.

top12.1 **[POWER-ON TEST AT SPARKPLUGS]**

> Unplug Front/Rear plug wire , insert screw, and position near ground.
> Set Run/Stop switch to STOP. Then turn ignition key to ON.
> Every time you turn the Run/Stop switch from OFF to --> ON you should see
a single spark about 2 seconds after power-ON.

If you do not see this spark then:

> coil is bad (check/swap coils, etc...)
> pickup is bad (this will not happen with sensor disconnected from TCI which suggests to me that it will not work with a bad pickup either)
> TCI is bad

To see if the **TCI is trying to fire the coil** check this:

top12.2 **[POWER-ON TEST AT TCI PINS]**

> Disconnect GRAY or rear coil wire from TCI 6-prong plug.
> Leave rest of 6-prong plug + 4-prong plug connected to TCI (normal)
> At the GRAY wire pin on TCI check:

> At Power-ON the pin should read "NEAR" ground (see appendix for "near ground" if unsure)
(**use the ohm setting, NOT continuity**. It ISN'T a true ground connection)
> At 2 seconds after power-ON pin should go +12 (use volt setting)

If TCI is correctly trying to fire the coil, then you have a bad coil or wiring connection at the coil.

**** NOTE : **Test is same for front coil** (ORANGE front coil wire).

top
#13=> COILS

top13.1 **[SYMPTOMS]**

It is rare for a coils to go bad. It would beREALLY unlikely for both coils to go bad at the same time. So think about your symptoms. Usually spark coils either work or they don't. They are rarely intermittent. BUT having said that, coils can produce poor or erratic spark because:

- bad internal wire break or insulation so that spark jumps out the side of the coil (very affected by moisture in the air)
- internal short
- corrosion and poor connections

NOTE: It is always a bad idea to run an engine with a plug wire disconnected. That is because the charged coil want to "unwind" and if there is some leaky insulation in the coil it will fire out the side to the frame. After some time of this you can burn a hole thru the coil insulation and make this phenomenon permanet.

Since the coils are mounted REALLY inconveniently under the tank.... its worth checking what you can before dismantling half the bike. If your tests point to a bad coil... don't forget it could simply be a bad plug wire.

top13.2 [SPARK TEST]

Insert a screw in plug wire cap. Position near engine (a good ground). You should see a nice BLUE spark jump across at least a 1/8 - 1/4 inch gap. If spark seems weak suspect these:

>> low voltage from battery direct to coil via ignition switch
>> poor ground or low voltage from TCI coil trigger wire
>> Bad TCI timing circuitry
>> Bad Plug Wire

In theory I can't see how a bad pickup would affect spark strength... but who knows.

top13.3 [Ohm Test]

**** NOTE: Make sure you don't touch the metal connections here or your body resistance and moisture will throw the resistance readings off.

Check the resistance you'd expect from a good spark coil. Set a multi-meter to Rx1 and "Zero out" the meter. Pull off the 6-prong plug on the TCI.

Put Black test lead on the frame (ground).

TO Check the PRIMARY WINDINGS of the coil, put the Red lead into these plug pin connections below, both should read 2.75 OHM:

GRAY wire pin = Rear Cylinder Coil
ORANGE wire pin = Front Cylinder Coil

To Check the SECONDARY WINDINGS of the coil, pull the spark plug wire off each spark plug. Put the Red lead on each spark wire end. Each should be about 7.9Ohm.

top13.4 [SWAPPING COILS]

If you want to test the "BAD COIL" theory then swap the coil trigger wires. Check to see if you get a good spark out of the coil you think is bad using the TCI pulse wire you know is good. This is like the pickup swap.

****** Don't leave the spark wires connected or you will misfire the bike BADLY! ******

- On TCI 6-prong plug swap GRAY and ORANGE wires.

- Disconnect BOTH!! spark plug wires. Put a screw into plug wire end and position near ground.

- Crank engine and look for spark out of bad coil. If you get a good spark then suspect bad PICKUP or TCI. Swap the pickups to confirm the TCI is bad.

top13.5 **[PLUG WIRE CHECK]**

If coil seems to test bad, could it be bad a BAD PLUG WIRE? A plug wire that has an internal break will still work. It can spark internally across the break. This could make the spark plug (end) spark weaker or erratic. You would have seen this in the Secondary ohm check though.

Also, the plug wire itself can have worn insulation. Then the spark literally leaks out the side into the engine (diminishing the one coming out the proper end)

You need to pull plug wire off COIL and spark plug. Check wire for continuity with voltmeter. And, look at the general condition of it. If you have doubts, replace it. THEY are CHEAP!

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top

#14=> IGNITION CARES

top14.1 **[Ignition Burnout]**

Don't leave your ignition on for a long period with the motor NOT running. You wouldn't normally do this but maybe if you forgot, etc… This can in some cases trash a CDI module (and pickups). The ignition has a circuit that is supposed to shut down power to the transistors and coil if the engine is not rotating. I suspect this circuit fails and over time the powered up TCI fries. That is why older cars always had a separate key position for accessories only.

top14.2 **[Coil Care]**

Avoid running the bike with the spark wire disconnected from the plug. Its OK if you've set up a spark test looking for the spark jump to ground. But if the plug wire can't "spark" somewhere this could damage the coil. The high voltage winding "WANTS TO SPARK" somewhere (ANYWHERE). Especially in humid conditions or with an older coil, the coil can spark internally which can wear/burn/damage the insulation between the Primary and secondary windings.

APPENDIX

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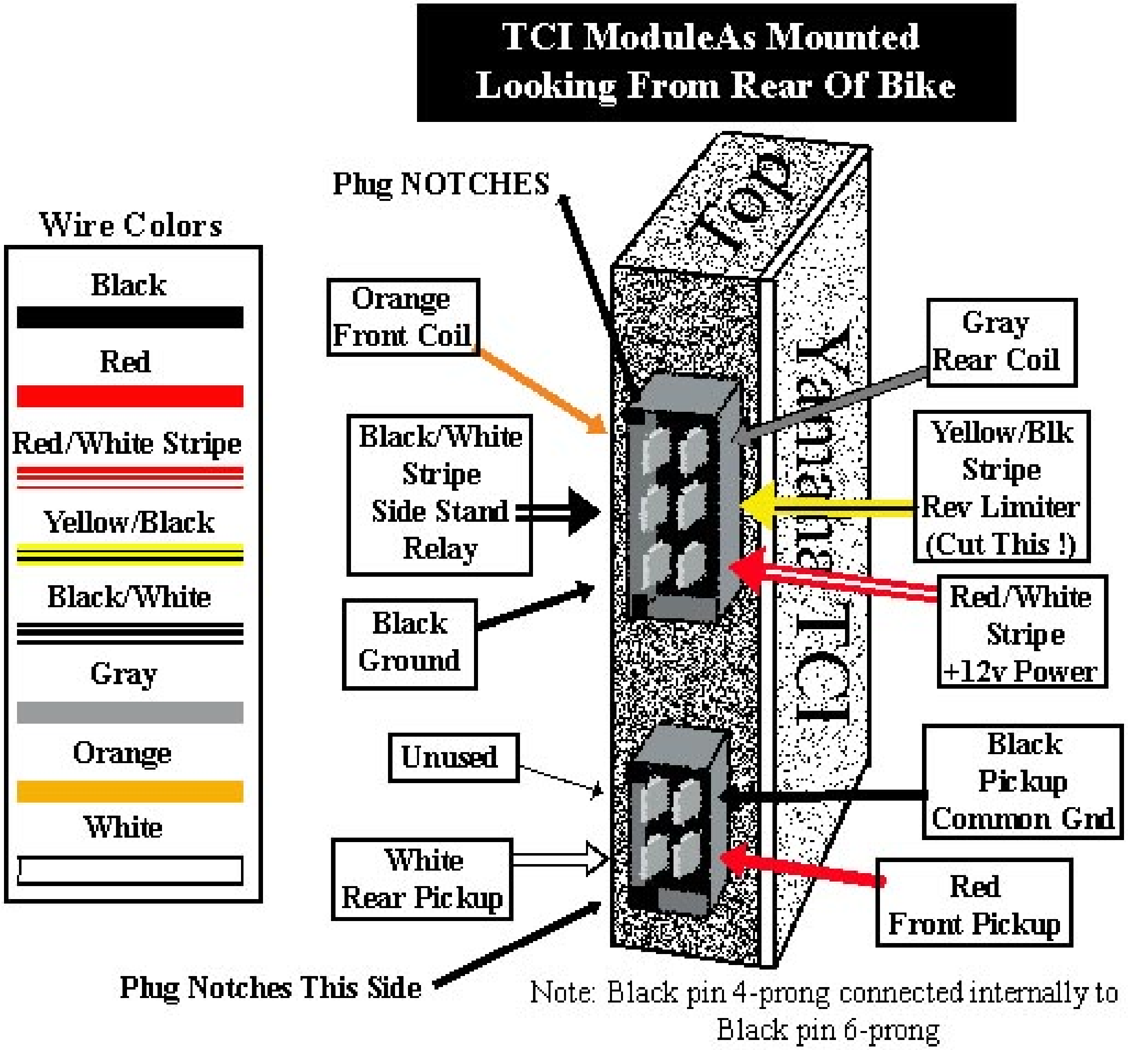
top

#A1. => TCI & PLUG DIAGRAM



>> PINS : Standing at rear end of bike
Looking at side of TCI case as mounted on bike

>> PLUG : Looking at plug from socket end (WIRES OUT FAR SIDE)

---

top

#A2 => [SPARK TESTING]

You want to see the spark from the plug wire. Here's common method:

Pull the plug wire and "cap" off the spark plug. Insert a small thin clean screw into the plug cap. A screw is good because you can lightly screw them in for a good connection. Screw end should protrude about inch out of plug wire-cap end.

Position the plug wire (with screw sticking out) somewhere near a good ground. The engine is good or some clean part of the frame. Spark will jump through painted surfaces but the cleaner the better.

You are looking for strong "Blueish" colored spark to jump about 1/8-1/4 from screw end to engine (ground). If spark is weak make sure you have good connection inside plug cap.

Remember that this does not show you if spark plug is really working !

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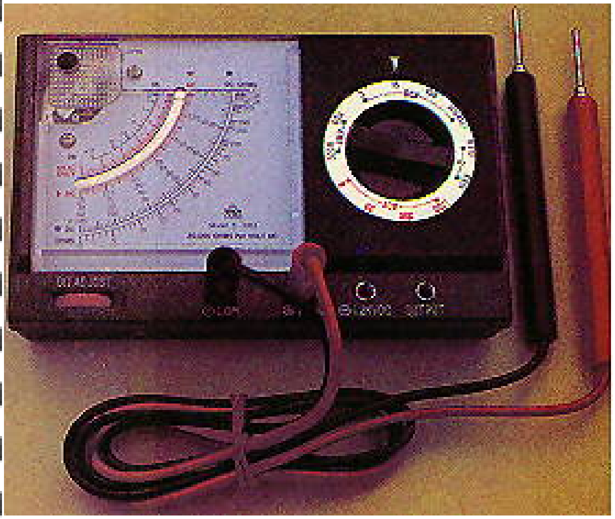
top

#A3 => MULTIMETER USE



top A3.1 **"Zero Out Multimeter"**

Use a digital multimeter if possible. Its usually more accurate for ohm tests and diode test, but are harder to read. If you use an analog needle meter, remember you need to calibrate the display before getting an accurate ohm test. Connect both leads with metal clips only. Don't get your hands on them or it will throw off the reading. Adjust the meter so with leads connected the needle shows zero "Full-Scale" (last bar on the scale). This IS NOT "pegged to side of case"!

top A3.2 **(Volts vs AMPS)**

Remember, the Voltage is the "strength" of electricity in the wire and AMPS is the Volume passing thru it. The typical analogy is a garden hose. The voltage is the pressure of water coming out your faucet (usually 55psi). The AMPS is the volume of water. Obviously, 55psi coming out of your garden hose is LESS powerfull than 55psi coming out of a firemans hose. So AMPS is really the true measure of what the electricity can do. AND, obviously, the size of the hose (and wire) limits the volume=amps you can get. Notice the wire driving your starter is thicker than the wire driving your tail lights. Its the same voltage but you need to conduct more volume (amps) to the starter motor.

ronically, the bigger wire has a smaller size. WHAT?!? Its probably explained somewhere on the net but bigger wire has a smaller "gauge". So, a bigger #10 gauge wire will conduct more amps than a #14 gauge wire (without melting).For once.... smaller is better here.

topA3.25 **THE PROBLEM (HOW TO MEASURE A TRUE +12 VOLTS)**

When you use a multimeter to test a point on a circuit for +12 volts..... all you've done is prove it has 12 volts at that point. You still really don't know if the wire (at that point) is capable of supporting any kind of "AMP" load. This is where a multimeter can REALLY mislead you into thinking you have a good circuit. Anyone who has tried to fix rusty lights on a boat trailer knows what I'm talking about here. Its got 12volts but the lights still don't work !!?? Yeah..... thats because the corroded connectors can only provide 12 volts at like .1 amp. Enough for the multimeter but not for the lights.

SO...... how do you really check this if you think you might have "power" issues?

One technique is to test wire something to that point that really requires a solid +12 volts. A normal (not halogen!) headlight is good for this since they draw about 5-10 amps. You get the drift here. Wire something that requires real power and use it to check for your +12 volts.

CAUTION: Just make sure the item you use doesn't drawn too much power or you will blow fuses and/or melt wires (BAAaaaddd)

topA3.3 **TESTING circuit load (TESTING AMP**

Now, you can indeed measure AMPs on the circuit with a multimeter. You need to break the connection you're measuring and then wire the multimeter inline to complete the connection. To be exact you need to "complete" the connection using the multimeter in AMMETER mode. Then the meter can show both voltage and load.**CAUTION: You must do this right or risk frying the multimeter**

Most multimeters cannot measure amps normally. You must reposition the RED wire to another "AMP" socket and also switch the multimeter into AMP mode. Most good multimeters can measure up to 10amps which is good for automotive work. The small cheap multimeters CANNOT measure amps.

topA3.4 **Voltage Drop**

This is ***hard to explain and hard to grasp***. Here goes. A wire normally has little resistance and so doesn't "use up" any voltage from the circuit. If a wire does have resistance it DOES use up some voltage and this normally translates to heat. Your toaster is the perfect example of this. Or in a badly corroded connection (like in boats) voltage leaks back to ground externally (like through the frame).

If you feel heat/warmth in any wire or connector something is *not right !!*.

This is hard to feel though (on a hot bike, on a hot day).

Your concern here is that the wiring in a circuit has gained some resistance of it own and is using up volts that would normally go to the TCI or Coils or whatever.

You check the end of a circuit with a meter and see +12 volts at the end. The whole circuit "path" is using and conducting 12 volts. BUT, the question is: what is the voltage at any given point along the circuit path. If the wire going to the TCI uses 1 volt, then the TCI in the middle is using 11 volts. It adds up to 12, but the TCI is NOT getting what it needs! Not good!

To check for voltage drops you need to hook the meter up "backwards" from what you'd normally do. You are checking points along the wire that are not a full +12 volts. You do this by comparing it to a good +12 volts. SO... hook up the RED lead to +12 battery terminal. You know THAT is a GOOD +12 volts as a reference point, right?. Now, use the black lead to check points along the circuit path.

If a test point is a good +12 volts you won't see anything ? You can't conduct +12 volts into +12 volts. But lets say a point on the wire is 11 volts because a previous connector is corroded and soaking up 1 volt.? You now will conduct 1 volt from the battery into the wire (there is a 1 volt potential difference). You will see 1 volt on the meter.

Generally, you should see less than a 2% voltage drop in a good connection (=.02x12=1/4volt).

You should not see voltage drops more than about 1/4 volt.

topA3.5 **"Near Ground"**

In solid state circuits (especially) you do not always have "pure" ground connections. The circuit is "near" ground. You cannot see "near ground" on the **Volt** scale or **Continuity** setting. It is NOT a connection that can support that kind of electrical load. Use the Ohm x1 setting instead. The Needle will show near full scale when the probes are touched (use the adjust knob if neccesary). Now check the circuit. The needle will again show full scale with a good "near ground" connection. This happens when a circuit has some small resistance in it (solid state transistor grounds are good examples). The circuit sees ground. You will too if you use the right scale!

- Set the meter to Ohm scale like Rx1
- Put the test leads together and zero the meter (full scale needle)

- Now, put one lead on good ground (frame, -12 battery post)
- Put other lead on test point. Look for needle swing.

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top

#A4 => [Battery Theory and Care]

This page courtesy of Aaron Berg XJ Electrical site. Open this Page NOW.

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top

#A5 => [Removing TCI Wires From The Plug]

To Be Added

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top

#A6 => [ELECTRICAL THEORY & FORMULAS]

This page courtesy of Aaron Berg XJ Electrical site. Open this Page NOW.

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top

#A7 => [Rebuilding A Vision TCI Module]

Open this seperate Page : **REBUILD VISION TCI**

Related Links:

ELECTREX USA
charging systems for motorcycles

David Denowh Virago TCI site
http://members.aol.com/ddenowh/TCI/index.html

Brian Fosh TZ Repair site in UK
http://tzrewinds.co.uk/

Allied Semiconductors
http://www.alliedsemiconductors.com/

NTE Semiconductors
http://www.nteinc.com/

Fairchild Semiconductors
http://www.fairchildsemi.com/

MSD Ignition Systems
http://www.msdignition.com/

Another Ignition Supplier
http://www.mwignitions.com/

Accell Ignition Systems
http://www.mrgasket.com/accel.htm

Misc Ignition Stuff:

http://www.newcovenant.com/features/motors/ignition.htm

http://w3.one.net/~ryanr/triplesite/tech.html

http://dmoz.org/Recreation/Motorcycles/Maintenance_and_Tech_Tips/

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top

#B1 => [Author]

Dave "Leather" Draper A Face To-a-Name

I've added this to dispel any suggestion or myth that I am an expert on Electronics / Motorcycles / TCI / Ignition systems/meaning-of-life, etc.... I am an attack pilot/airline pilot by trade and have a degree in Computer Science and Mathematics. Over the years I have worked on a variety of motors. My father is a radio engineer so I have just enough electrical knowledge to be dangerous and enough mechanical skill to do some real damage. Occasionally it all comes together and something actually gets fixed. Around the house I am known as Mister "Fix-It" but that's just because my kids are still young enough to still believe everything I say (my wife 'cause I'm the only one who knows how to program the VCR). There are much smarter folks out there and that's the beauty of the net. Knowledge is power and I'm just trying to help spread it around.

top

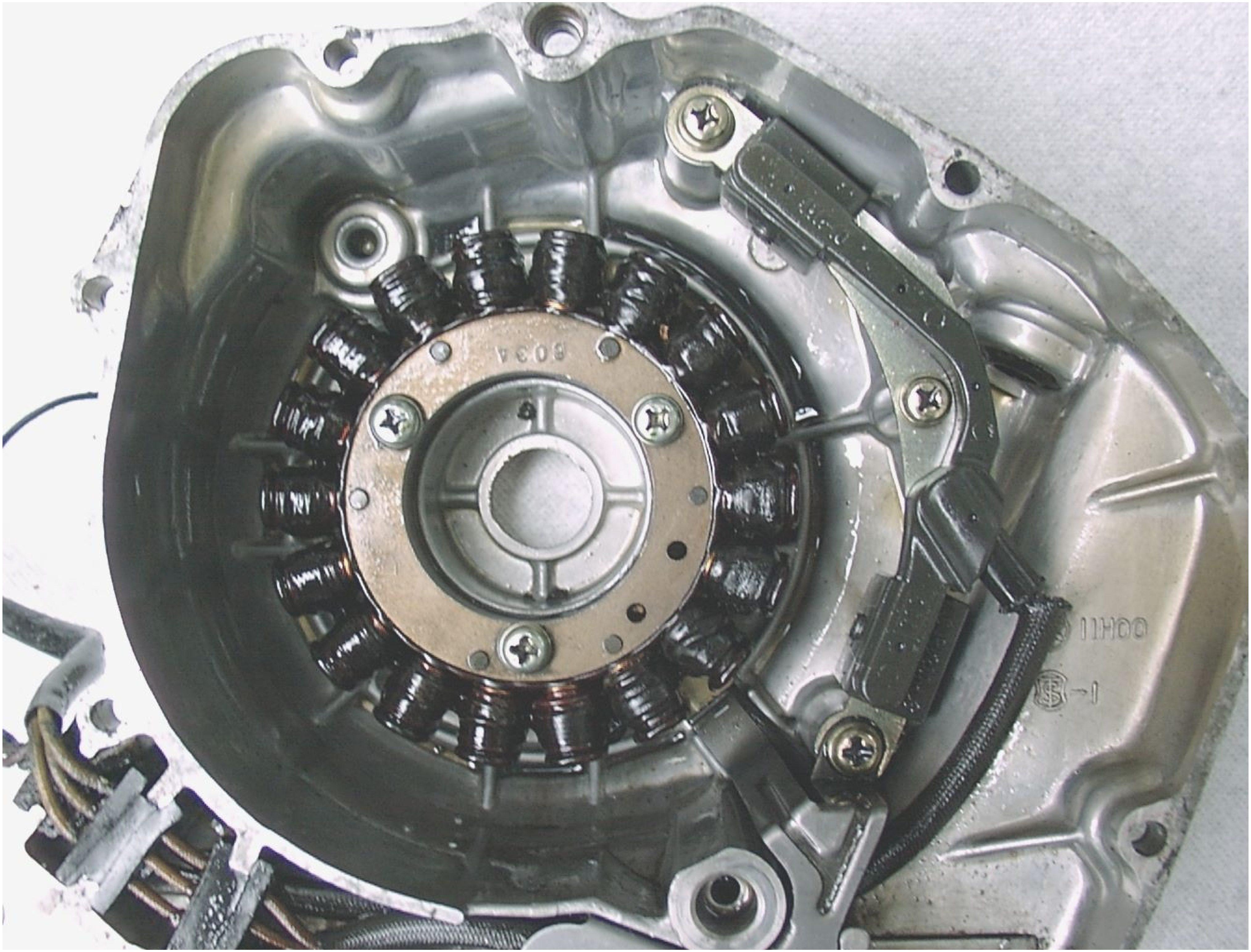
#B2 => [CREDITS and CONTRIBUTORS]

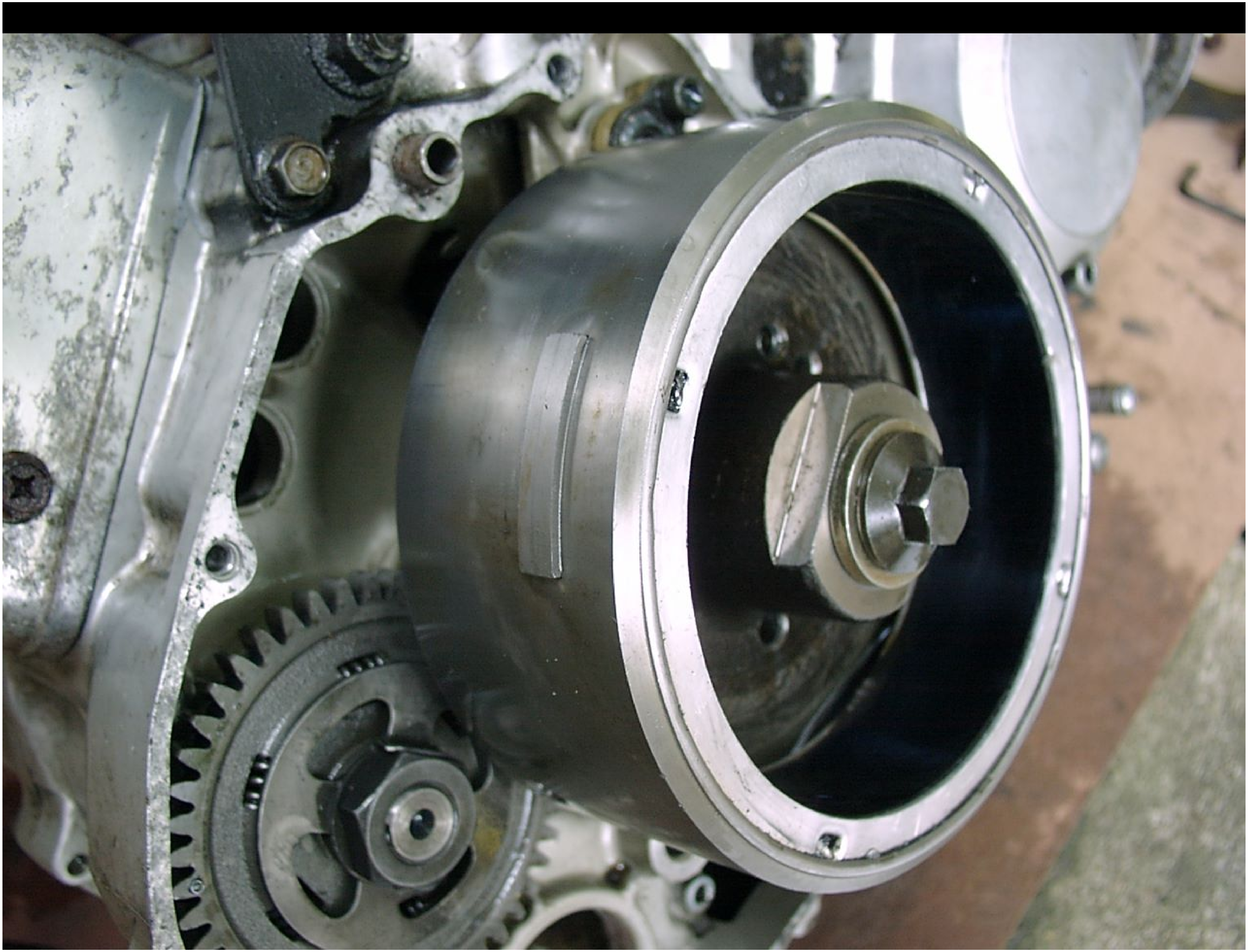
(absolutely no particular order.... although I'll start with my dad who did measure all the component values of a TCI for us)
Bill Draper, Yamaha Vision Riders Group (You crazy guys), "Skip" Johnson", Dale Harris, Ron Ghetti , Jeff Swan, QBS, "Lucky", Aaron Berg, David Denowh, Dick Stelter, Brian Fosh, John Newton, Uwe Werner, Ulrik Moe Noe, rgaard, Steven Ware, Les Rowe, Ric Wade, Jouko Kuisma, Glen Scadden, Dennis Myers, Jim Gardner, Anthony, Apex Racing, Kriss from poland, George McQueen, Roadrunner, Bob R, Jens Eckartsberg, Fransisco Romo, Garret Spears, George Young, Electrex, MSD Ignitions, ...
... and everyone else I forgot: **THANKS!**

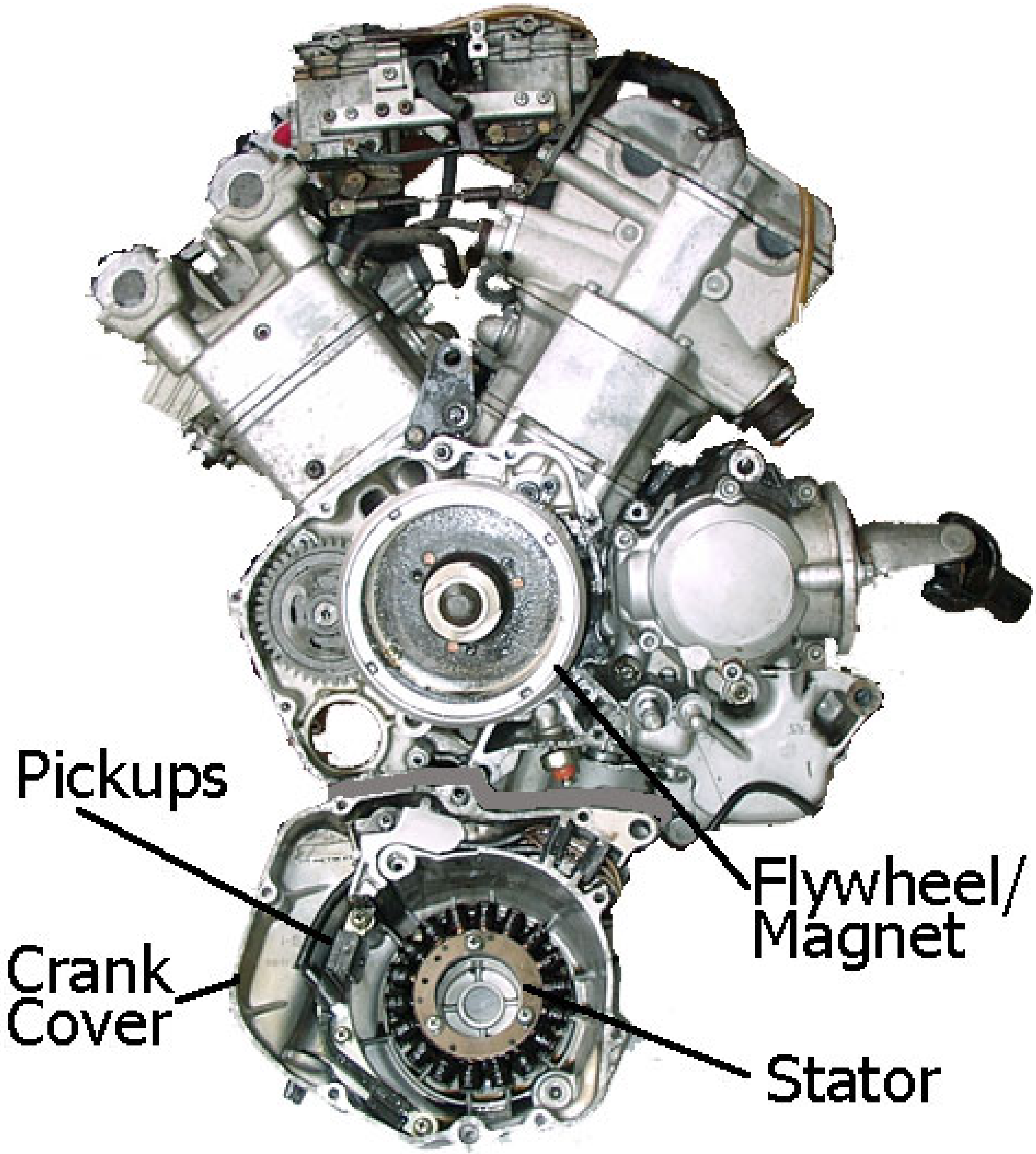
top

#B3 => [REVISIONS & CORRECTIONS]

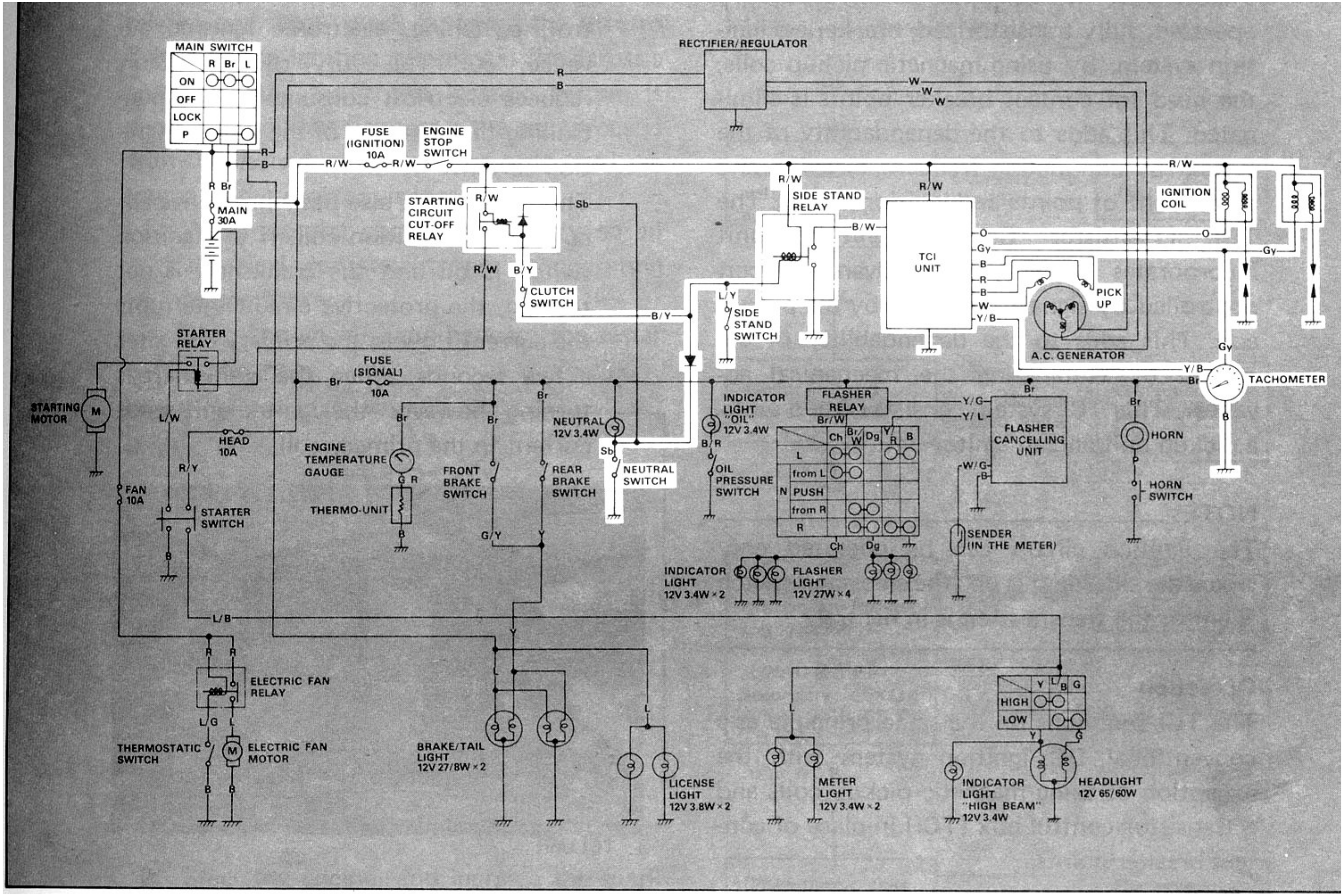
- Rev 1.0 11/01/1999 = Original Guide
- Rev 1.1 07/01/2000 =
  - Changed color Black on White for easier printing.
  - Added Electrical & Battery pages from Aaron Berg's XJ site
- Rev 2.0 05/01/2001 =
  - Added PDF files
  - Added Ignition Links Section
  - Added Ignition Discussion Page
  - Added TCI Repair Page
  - Added Stator Page
- Rev 2.1 10/05/01
  - Minor corrections from E-Mail feedbacks
- Rev 3.0
  - Added many photos / updated text to other pages
- Rev 4.0
  - Text update, corrections as emailed to me, and added larger graphics/images since almost everyone is somewhat high speed now and I have more server space (The original was limited to 5 megs !?)

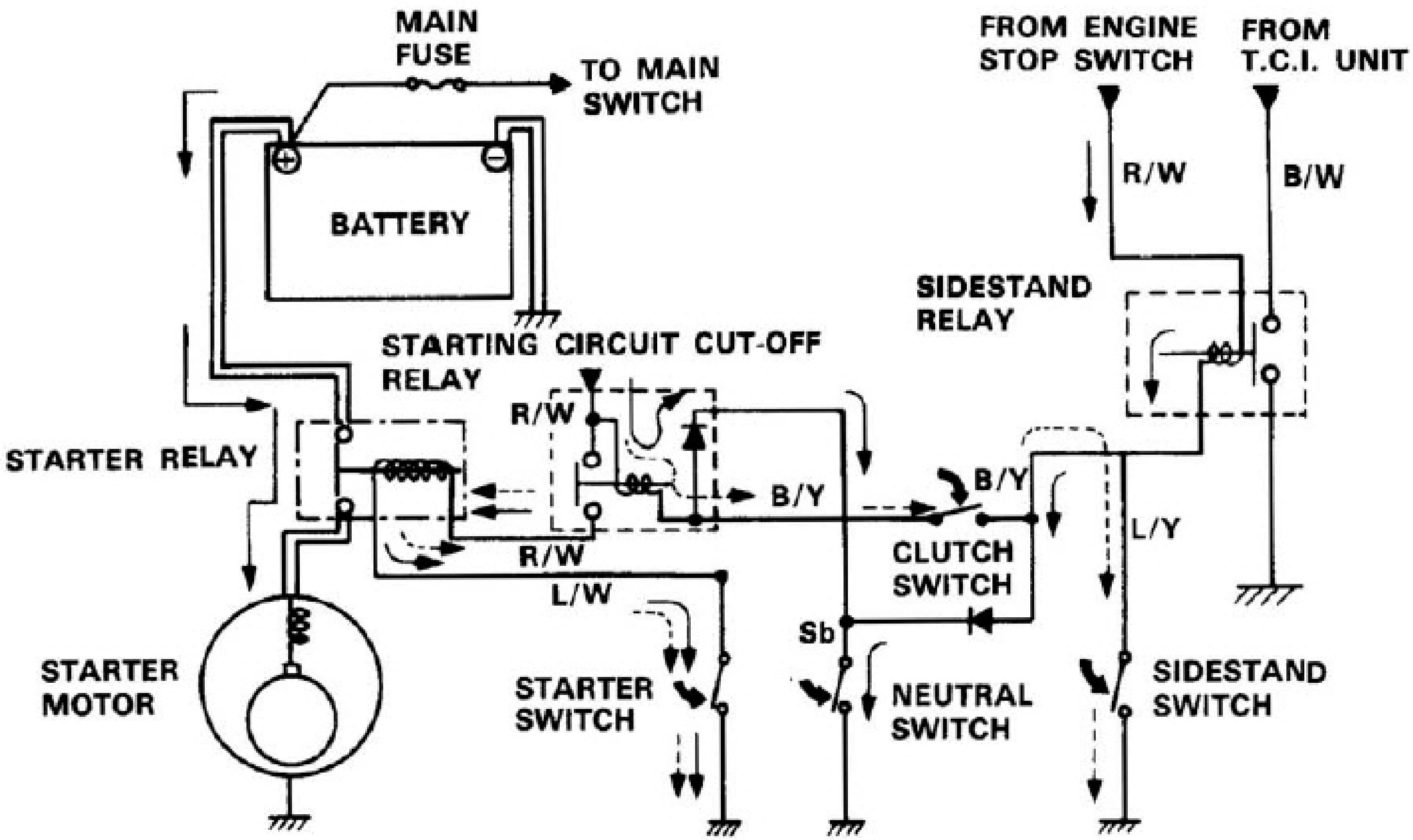






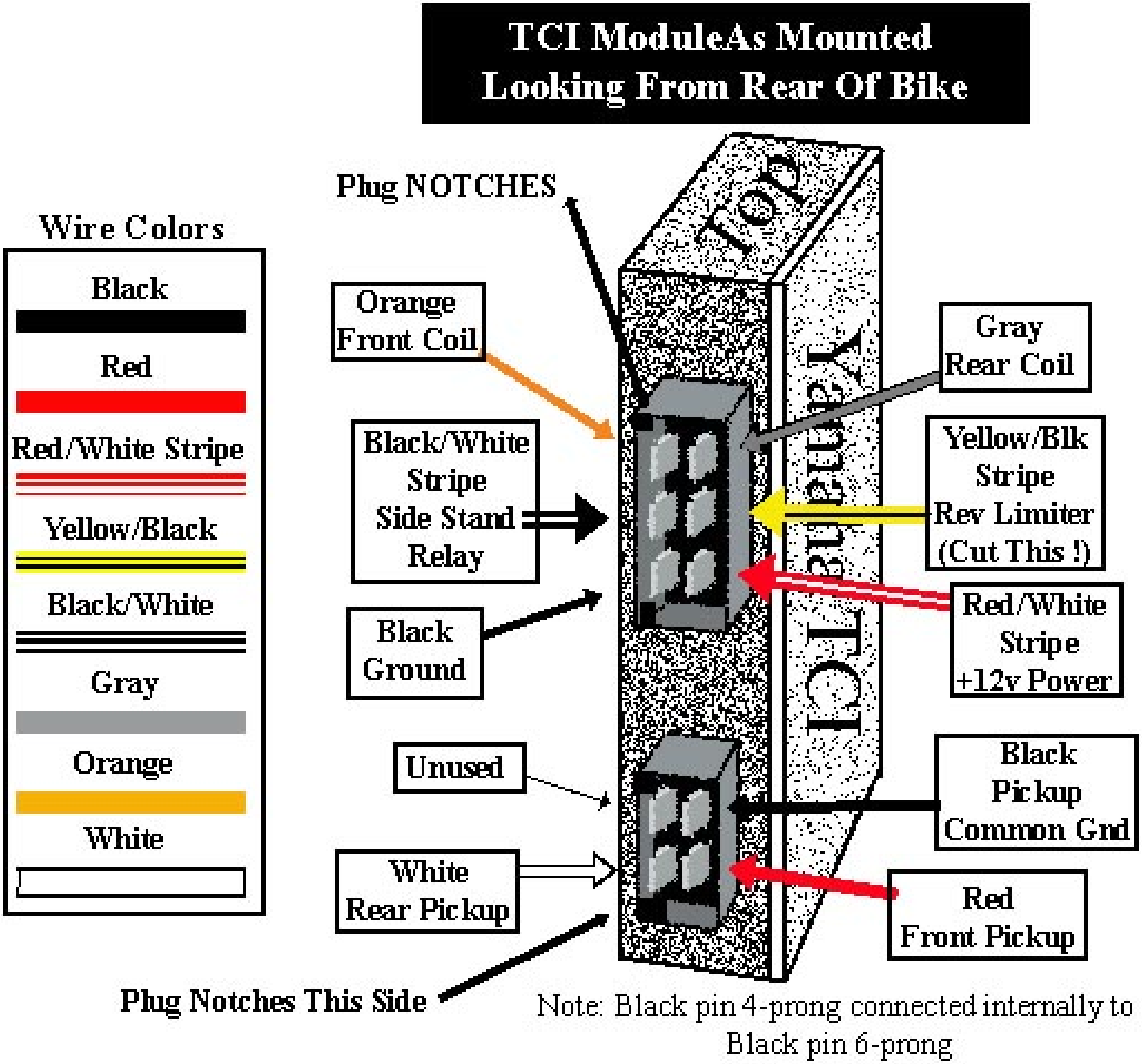
Left Side View
With Crankcase Cover Removed

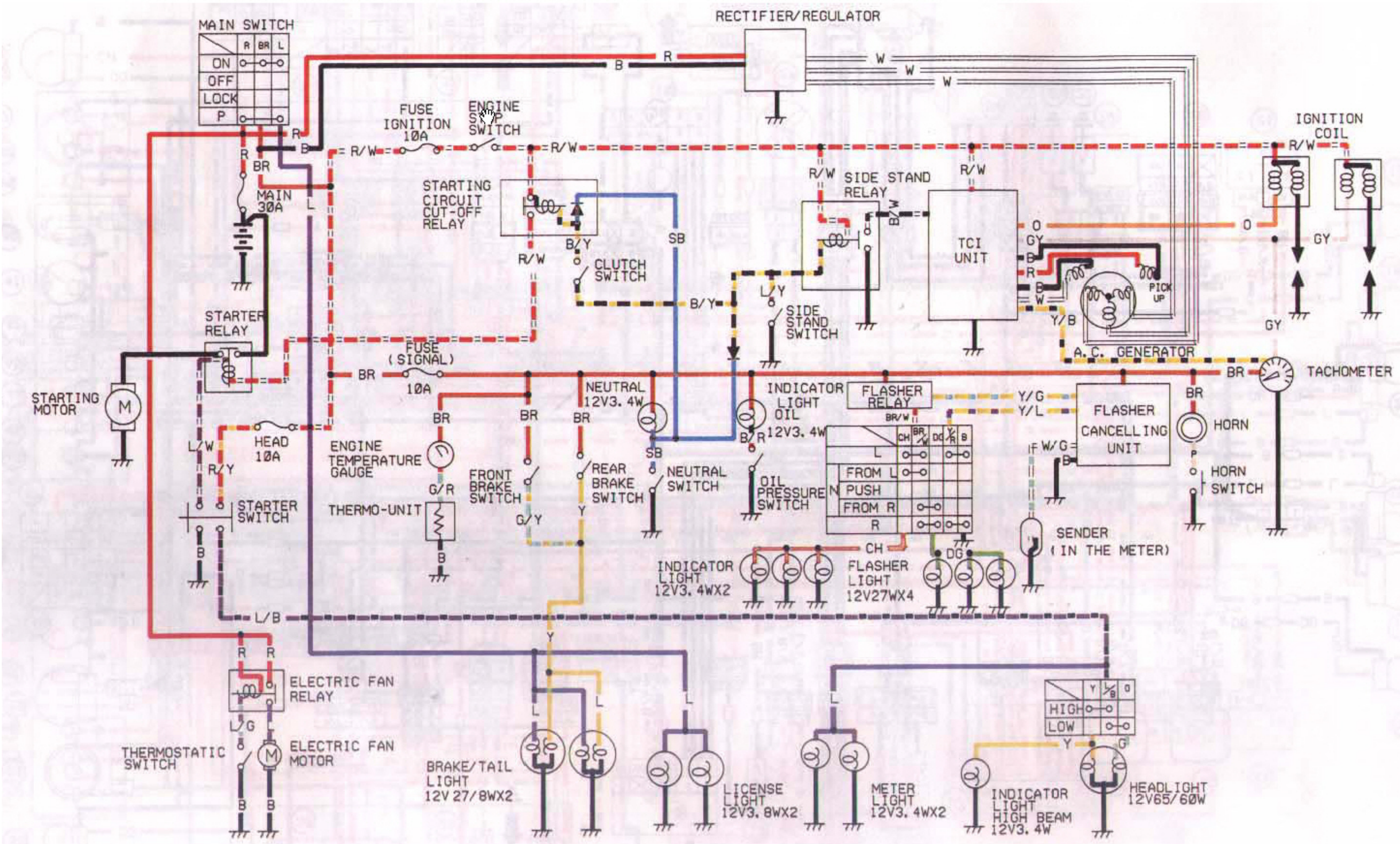

MAIN SWITCH
ON
OFF
LOCK
P
RECTIFIER/REGULATOR
FUSE (IGNITION) 10A
ENGINE STOP SWITCH
MAIN 30A
STARTING CIRCUIT CUT-OFF RELAY
SIDE STAND RELAY
TCI UNIT
IGNITION COIL
PICK UP
A.C. GENERATOR
CLUTCH SWITCH
SIDE STAND SWITCH
STARTER RELAY
STARTING MOTOR
FUSE (SIGNAL) 10A
TACHOMETER
HEAD 10A
ENGINE TEMPERATURE GAUGE
THERMO-UNIT
FRONT BRAKE SWITCH
REAR BRAKE SWITCH
NEUTRAL 12V 3.4W
NEUTRAL SWITCH
INDICATOR LIGHT "OIL" 12V 3.4W
OIL PRESSURE SWITCH
FLASHER RELAY
FLASHER CANCELLING UNIT
HORN
HORN SWITCH
SENDER (IN THE METER)
FAN 10A
STARTER SWITCH
INDICATOR LIGHT 12V 3.4W × 2
FLASHER LIGHT 12V 27W × 4
ELECTRIC FAN RELAY
THERMOSTATIC SWITCH
ELECTRIC FAN MOTOR
BRAKE/TAIL LIGHT 12V 27/8W × 2
LICENSE LIGHT 12V 3.8W × 2
METER LIGHT 12V 3.4W × 2
INDICATOR LIGHT "HIGH BEAM" 12V 3.4W
HEADLIGHT 12V 65/60W
HIGH
LOW



← WHEN THE TRANSMISSION IS IN NEUTRAL

←-- WHEN THE CLUTCH LEVER IS PULLED TO THE HANDLEBAR AND THE SIDESTAND IS UP.


TCI ModuleAs Mounted
Looking From Rear Of Bike
Wire Colors
Black
Red
Red/White Stripe
Yellow/Black
Black/White
Gray
Orange
White
Plug NOTCHES
Orange
Front Coil
Black/White
Stripe
Side Stand
Relay
Black
Ground
Unused
White
Rear Pickup
Plug Notches This Side
Top
TCI Yamaha
Gray
Rear Coil
Yellow/Blk
Stripe
Rev Limiter
(Cut This !)
Red/White
Stripe
+12v Power
Black
Pickup
Common Gnd
Red
Front Pickup
Note: Black pin 4-prong connected internally to
Black pin 6-prong


MAIN SWITCH
RECTIFIER/REGULATOR
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IGNITION COIL
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STARTING CIRCUIT CUT-OFF RELAY
SIDE STAND RELAY
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THERMO-UNIT
SENDER (IN THE METER)
INDICATOR LIGHT 12V3.4WX2
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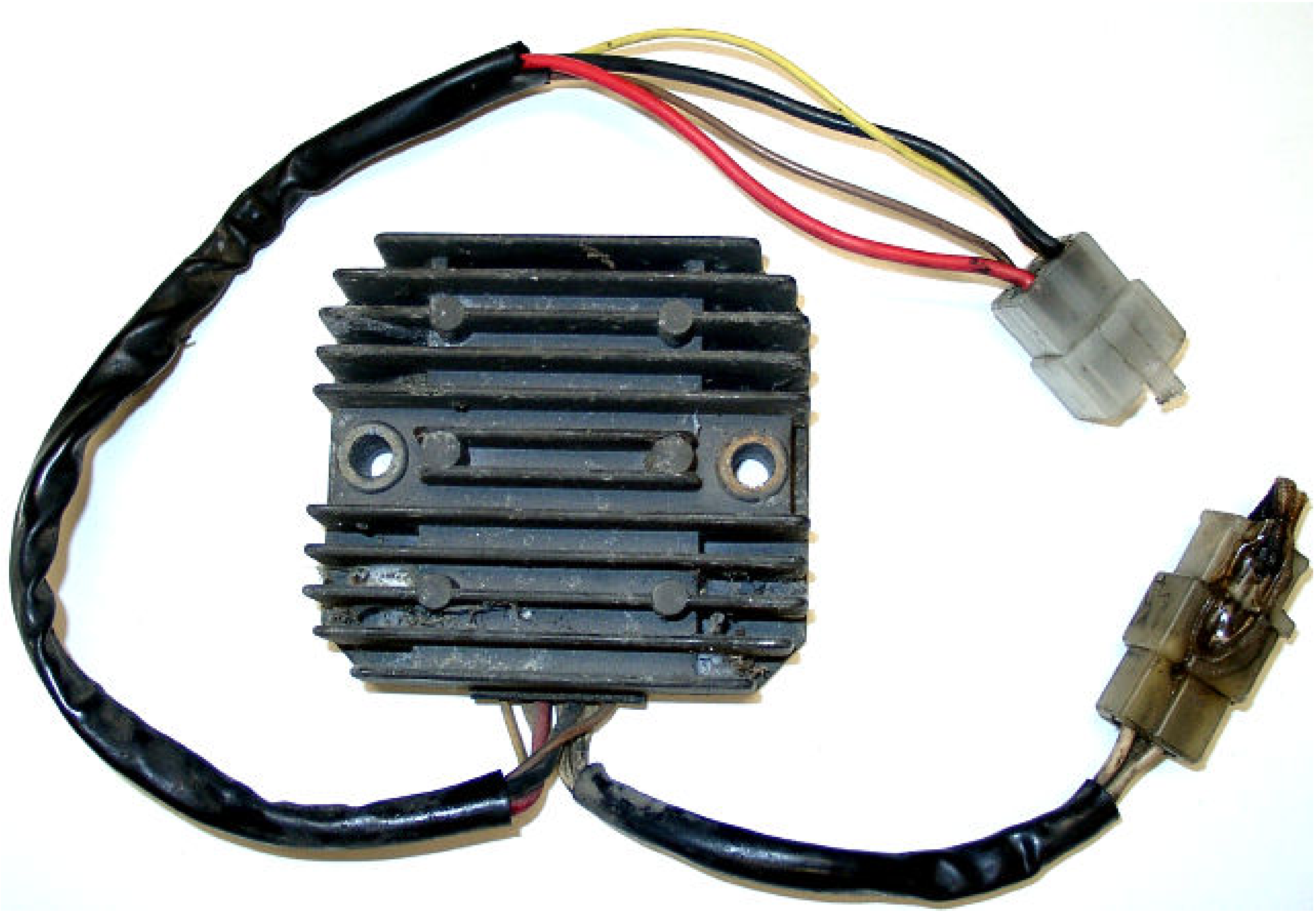
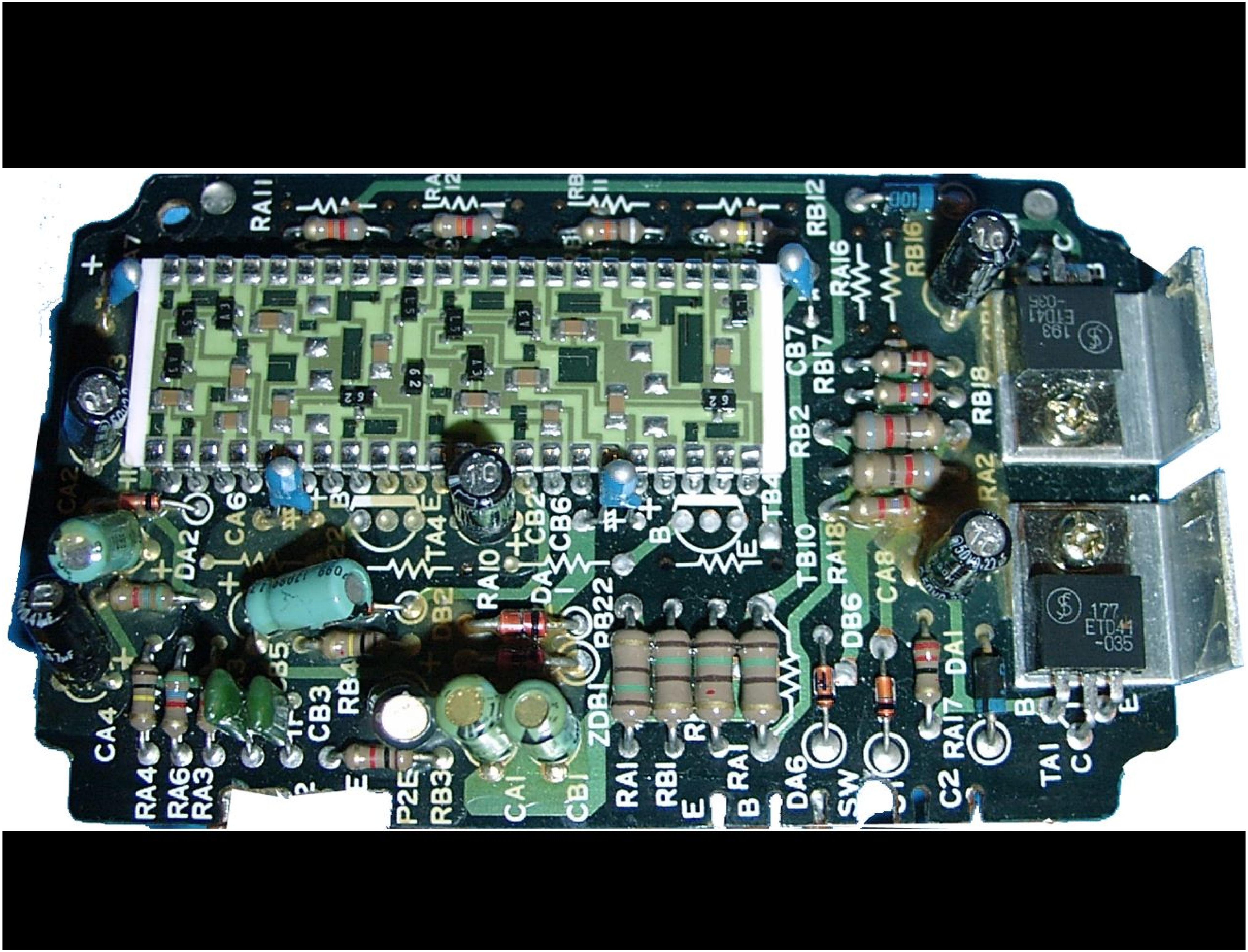
BRAKE/TAIL LIGHT 12V 27/8WX2
LICENSE LIGHT 12V3.8WX2
METER LIGHT 12V3.4WX2
INDICATOR LIGHT HIGH BEAM 12V3.4W
HEADLIGHT 12V65/60W

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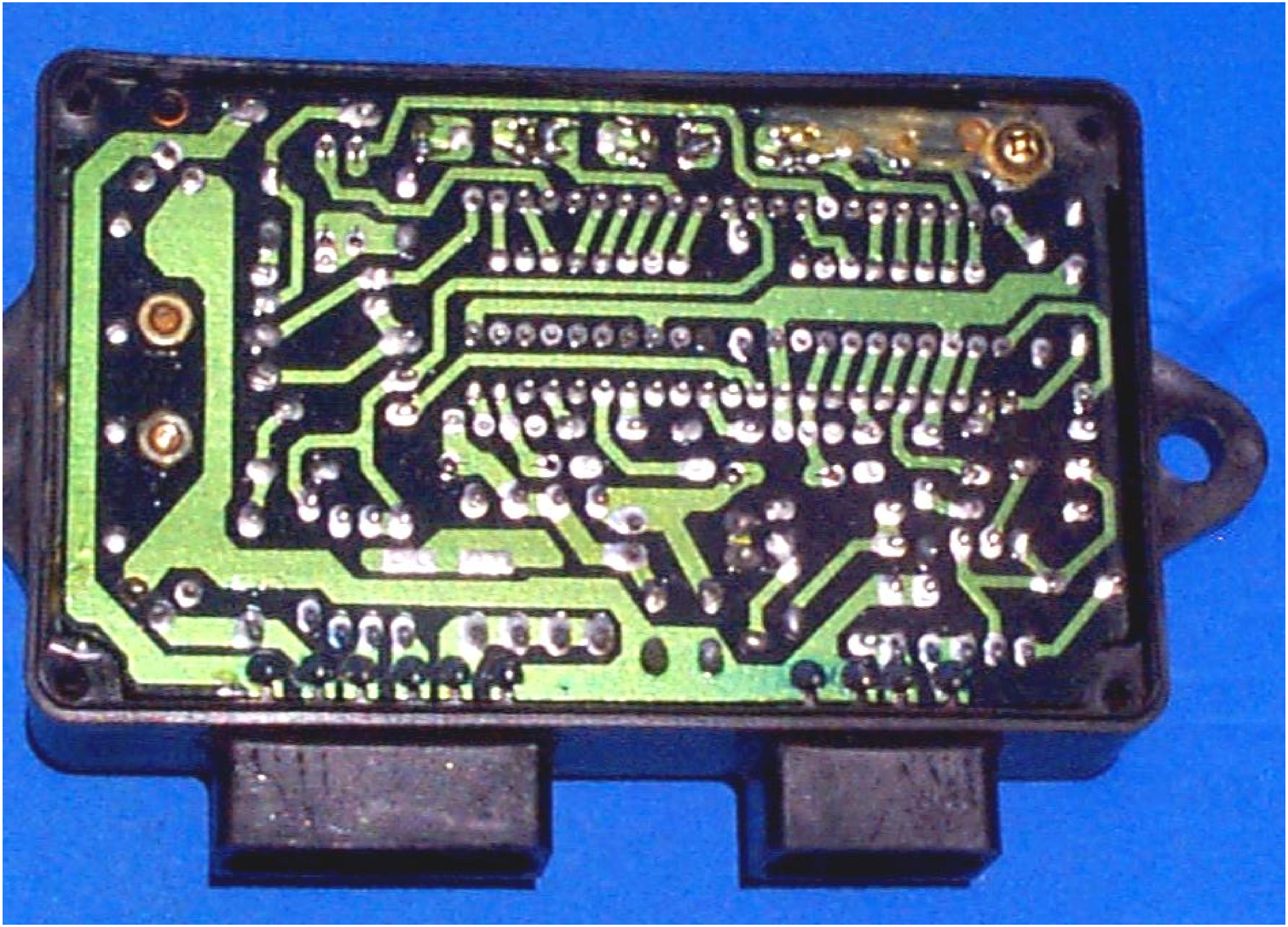
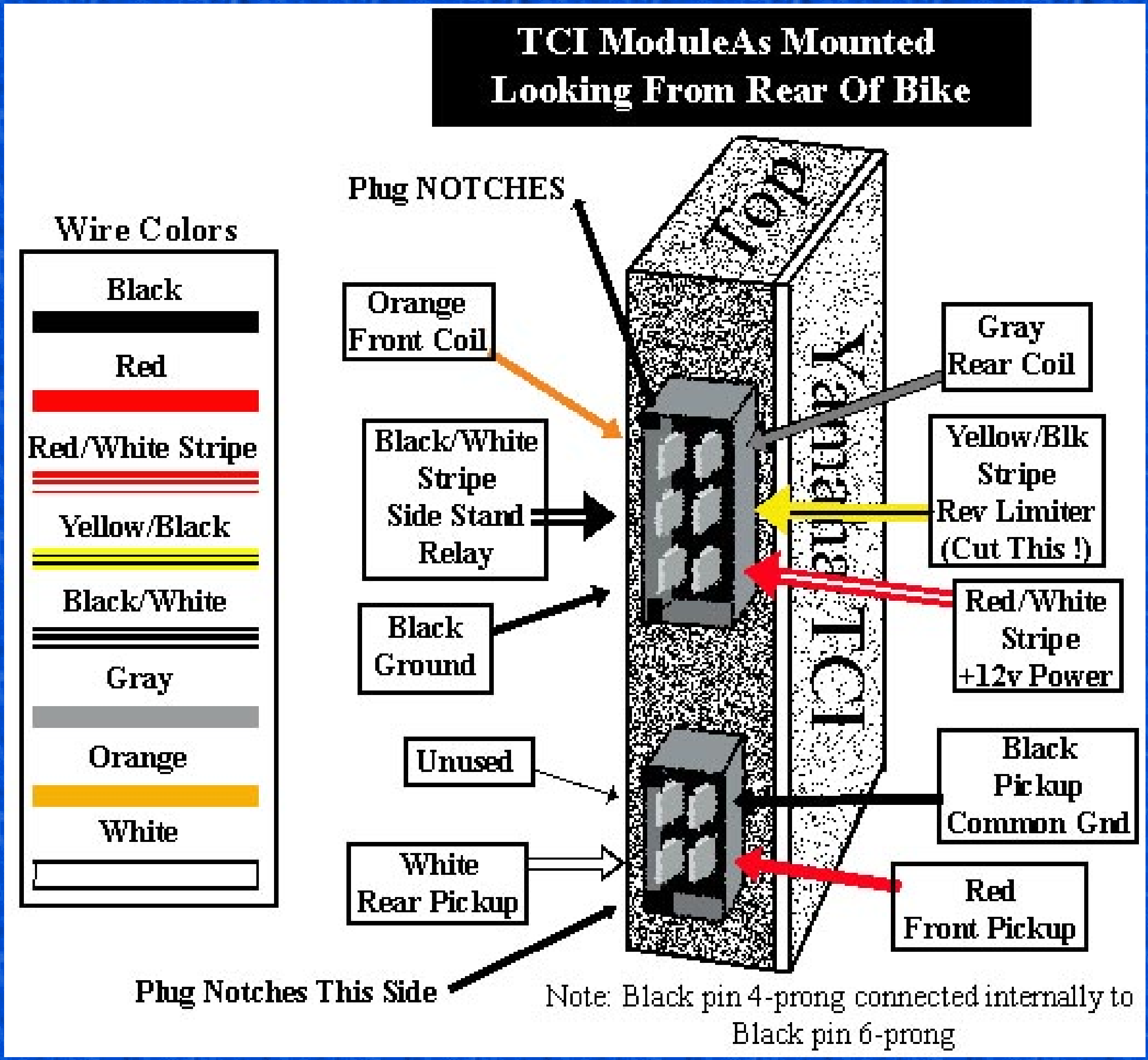
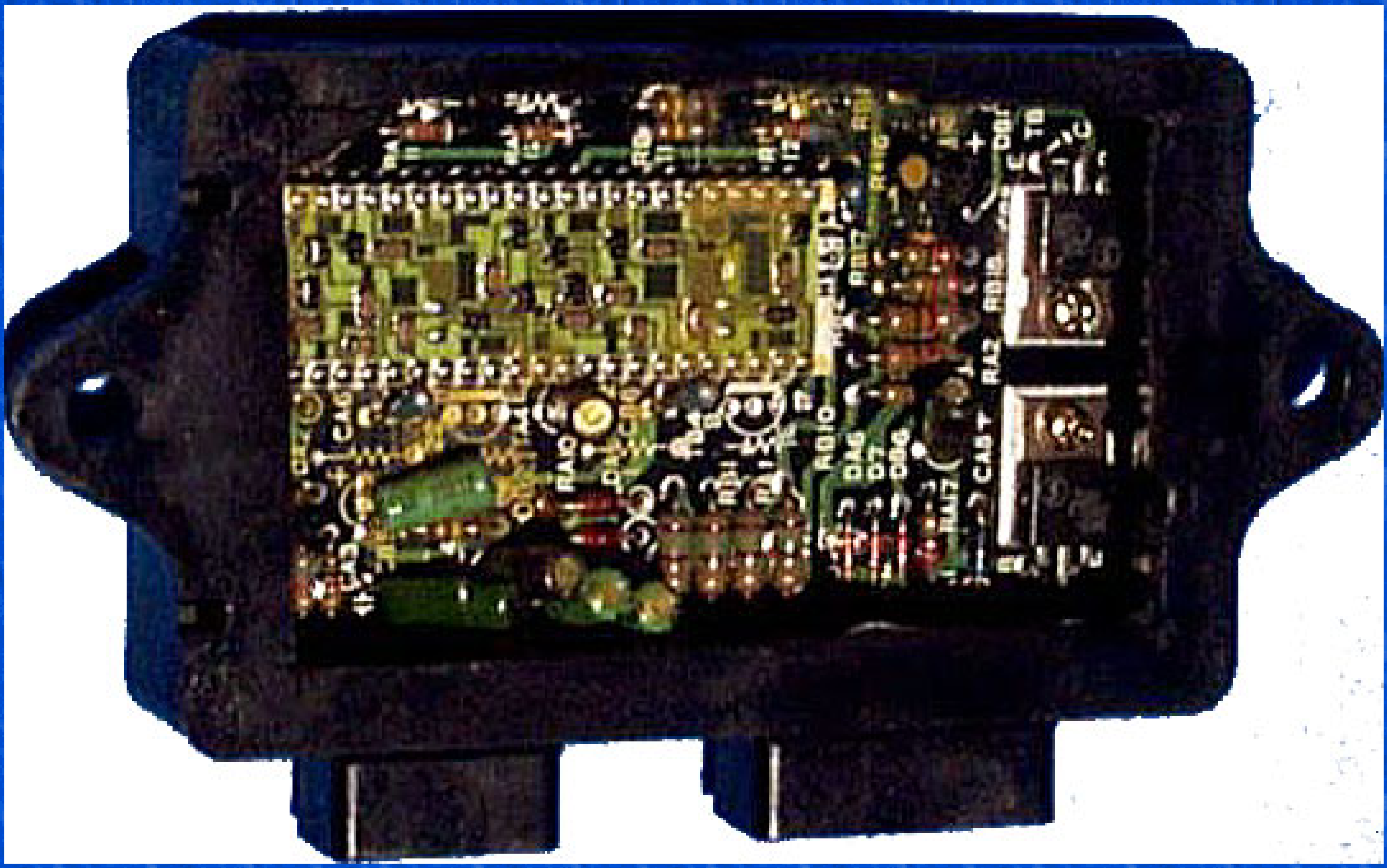



TCI ModuleAs Mounted
Looking From Rear Of Bike
Wire Colors
Black
Red
Red/White Stripe
Yellow/Black
Black/White
Gray
Orange
White
Plug NOTCHES
Top
TCI Yamaha
Orange
Front Coil
Gray
Rear Coil
Black/White
Stripe
Side Stand
Relay
Yellow/Blk
Stripe
Rev Limiter
(Cut This !)
Black
Ground
Red/White
Stripe
+12v Power
Unused
Black
Pickup
Common Gnd
White
Rear Pickup
Red
Front Pickup
Plug Notches This Side
Note: Black pin 4-prong connected internally to
Black pin 6-prong

TCI With "Port-Hole" Cut Open in Bottom



Electronic Ignition
Capacitive Discharge Ignition (CDI)
Transistor Controlled Ignition (TCI)

This guide explains the basic principals and theory behind electronic ignition.
This is linked from the (Yamaha Vision Motorcycle Ignition FAQ) & my (Vision Home Page).
If you have inputs to this page .... PLEASE email Dave "Leather" Draper JetAv8r@JetAV8r.com

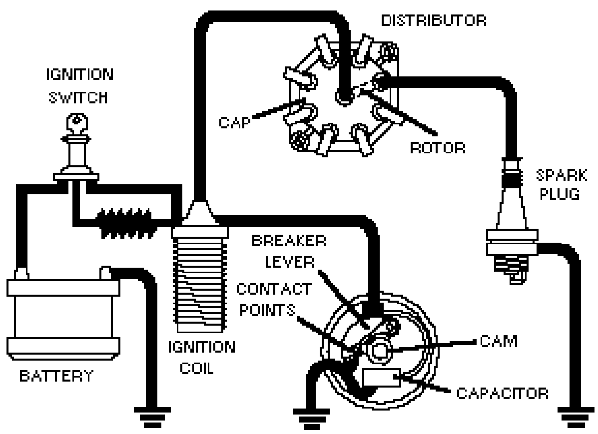
Last Update June 20005. Download This Guide As PDF (Zipped File)

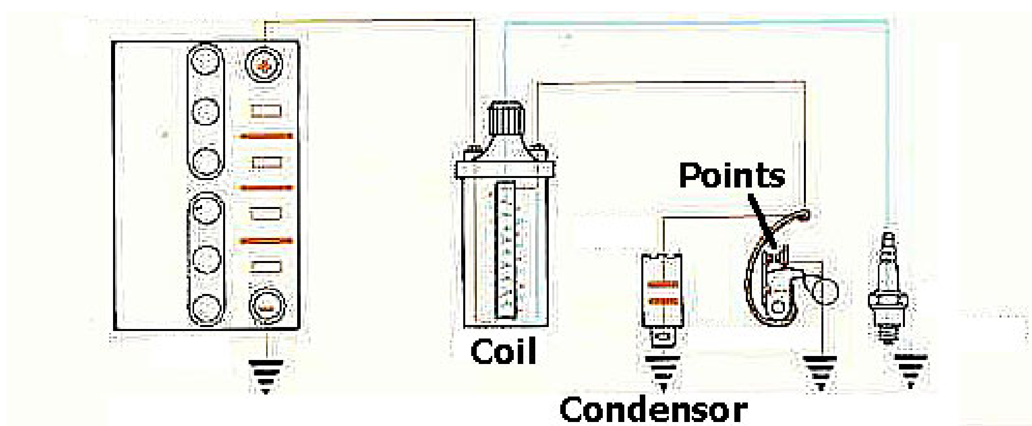
Intro

This guide was started for a motorcycle group seeking to solve common ignition problems. But over time, this has expanded into this stand-alone page because of the interest for a general explanation of gas 4-stroke (not diesel or 2-stroke) engine ignition principals. Everyone at one time or another has suffered through some ordeal caused by a non-working ignition system. Whether its the lawn mower, outboard, chainsaw, or the time you drove your Dad's car through that big puddle..... you've been stuck somewhere or with something that would not run. When troubleshooting non-running engine problems I've always used the "GAS" method : "gas, air, spark". Have those 3... something should happen. So this is a discussion of how we get the Spark part.

Review of basic ignition designs

Basic Points/Distributor/ Coil.
("Kettering" design)



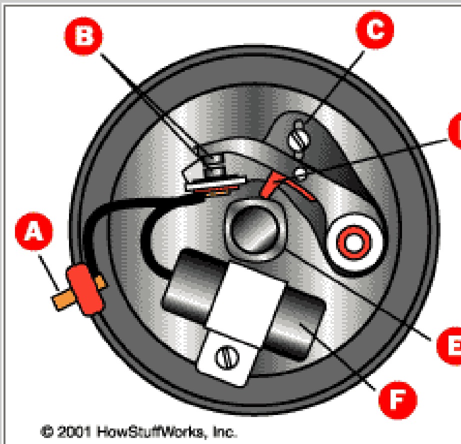


A Frenchman named Etienne Lenoir invented the electronic spark plug in 1860. Spark plugs haven't really changed THAT much since then. But "firing" that spark plug has been a better evolution. The Father of ignition is Charles Franklin Kettering (man pictured left). In 1909, Kettering, in association with Edward A. Deeds, organized the Dayton Engineering Laboratories Company (Delco). As you've already started to guessed from the name... they invented the first automobile generator. That road to the generator invention brought them all the design concepts that would be used to dream up starter motors, ignition system components, etc.. So, it is in 1910 that Kettering began work on new automobiles electrical systems. Also notably, he invented the first "self-starter" in 1912. Within two years, most cars were equipped with this new device. Kettering went on to become head of General Motors research laboratories and Vice President of the Corporation. "Boss Ket" would eventually receive over 160 U.S. patents for his ideas.

It is in 1911 that he developed the first electrical ignition system (or at least the design concepts that lead to that invention). These early patents are hard to trace, but a little research shows Kettering invented the "engine, starting, lighting, and ignition system" (Patent 1171055 featured here in PDF). This early type of ignition design is known as the Kettering system (points/condenser/coil) or "induction" system. It became the standard in the automotive industry replacing magnetos. It is rugged and reliable but has drawbacks as you will see. A "lighting coil", "lighting" system is a more tradition term for an auto/motorcycle type self powered generator system. So you and I know Kettering more as the man who invented the first practical engine-driven generator (known as the "DELCO" generator). This was Patent No 1150523.

A basic Kettering Ignition Design

A chain, belt, or gear from the engine drives a *"DISTRIBUTOR"*. Inside this distributor is a spring loaded contact switch (*"POINTS"*) riding on a revolving cam. The points would open and close to fire a single coil which would produce the spark for the spark plugs. Inside the distributor is also a "*ROTOR*" which rotates to determine which plug wire gets the spark.



A.To Coil

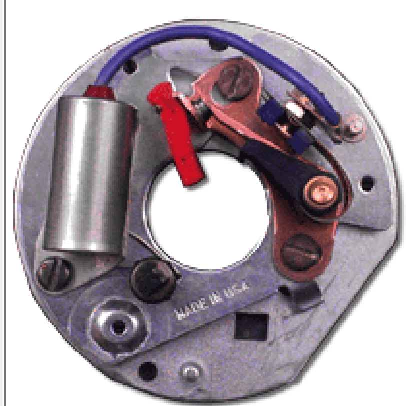
B. Points

C.Points Dwell Adjustment

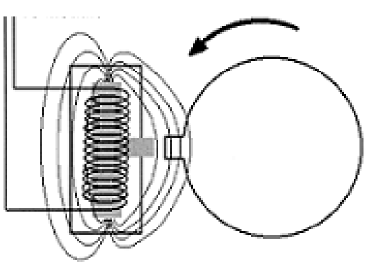
D. Point Riding On Cam

E. Rotating Cam Driven .....by engine

F. Condensor

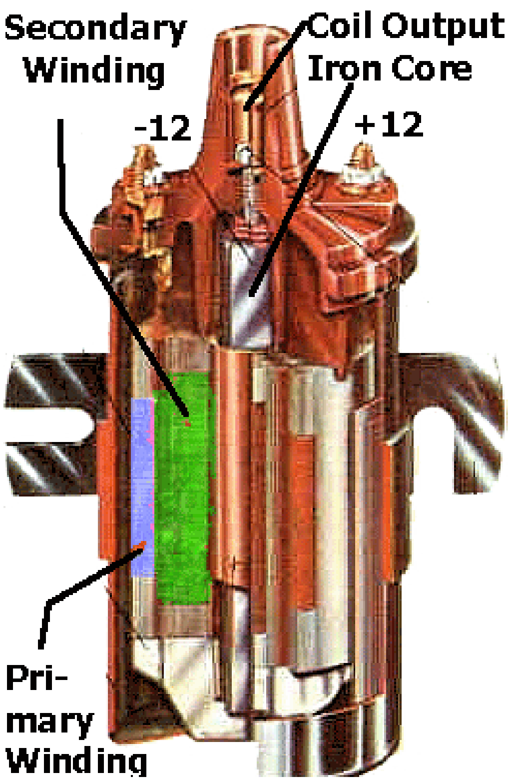


Magnetism and Induced Current



In the mid 1800's Michael Faraday (and others ... though "micro Farads " to this day is the measurement of capacitance) developed the concept that a current passing thru a coil wire creates a magnetic field. More importantly, a **magnet passing by a coil wire creates a voltage current**. The amount of current depends on the magnetic size and speed (rate) the magnetic field passes (or changes) by the coil. The math equation for this is **e=-df/dt**. The change in magnetic field strength is **df** and the time (rate of change) is **dt**. Technically, **e** is the "Induced EMF". But we talk of this as the current produced in the wire coil ... actually a PULSE.

Automotive COIL (also called an *"INDUCTOR"*)



An iron core is wrapped with 2 long "coils" of wire. The "PRIMARY" winding on the outside and the longer "SECONDARY" winding on the inside. The wire length ratio is typically 100:1 (the secondary is 100 times longer than the primary).

The coil is fed 12v to the primary winding. This in turn creates a large (enhanced by the iron rod) magnetic field which also surrounds the Secondary windings. The coil is now storing a large magnetic field (a Flux" field). When the +12v to the coil primary winding is turned off the magnetic ("flux") field inside the coil "collapses". This causes a "Back EMF" (Electro Motive Force) current in the primary wire of about 200-300volts. THIS IS IMPORTANT. Most think the coil converts 12v to 30,000 volts. Not exactly. See, this back EMF voltage of 300volts is now applied to both windings. When the coil collapses this rapidly changing magnetic field is also transferred to the "Secondary" windings as current (remember the discussion above about magnetism... "a changing magnetic field passing by a coil creates electric current").

The Secondary winding is 100 times longer so produces a voltage about 100 times more than the Primary during collapse. Lets do the math. The Primary ("Low Tension") wire is about 300v during the Back EMF spike. So the Secondary ("High Tension") wire is 100 x 300=30,000 volts. This high voltage is going somewhere, somehow to ground. The faster the power cutoff is in the primary, the faster the collapse, and the faster (more powerful) that spark is. So, when the points open (instantly cutting off power to the coil) 30,000 volts goes to ground from the secondary winding via the spark plug.

If you've understood some of this then you should be asking: "how does the primary winding collapse to ground if the points just opened its connection with ground?!??" BINGO! To get the primary winding to collapse in the proper fashion, we got to give it a way to get back to ground during the collapse!

INTRODUCING THE "CONDENSER"

Ok, quick review: Due to magnetic "flux" properties (research Teslar and the "left hand rule" if you want to know more) the inductor (COIL) encourages current flow towards the plug from the secondary winding. But the collapsing magnetic field also produces the phenomenon discussed above called "Back EMF". This 300+ voltage spike in the primary winding would cause a mini-spark of it own across the points. Another words, the primary winding would cause a spark across the points just like the secondary will cause a spark across the plugs. To facilitate the collapse of the primary winding and to prevent point-gap spark a condenser is used.

The condenser is a large capacitor. Only the automotive industry calls it a condenser (and no, I have no idea why). When the points open this coil collapses. Remember, a coil output is strongest when the collapse is fast and sharp. The condenser slows this collapse by absorbing the initial shock (current) of the primary winding. It helps shape the coil collapse to produce the high power secondary collapse AND slows the collapse of the coil just long enough for the points to get far enough apart so the coil back EMF output won't arc across the points. Without a condenser the backflow arcing and heat would destroy the points (sometimes in a matter of seconds). However, the condenser can't be too big either or the coil would collapse too slow and not produce a strong spark. The charge the condenser absorbs while the points are open is releases back to ground when the points close again.

The capacitor also "harmonicly" tunes the coil, raising the peak output voltage and increasing the secondary voltage rise time. This increases the amount of energy transferred to the spark plugs. If the coil secondary voltage rises too quickly, excessive high frequency energy is produced. This energy is then lost into the air-waves by electro-magnetic radiation from the ignition wiring instead of going to the spark plugs where we would like it to go.

Coil output is a function of coil windings "turns ratio" and also voltage input. The more power you put in the more you get out, right? And more power is better, right? Well..... no. We'll talk more about higher coil outputs later, because it becomes a bigger issue with CDI where you can REALLY pump out some voltage. It only takes about 10-15,000 volts to start the spark. Higher voltage is better because it can jump a larger plug gap (which is good for igniting the charge) and for overcoming ignition wear (worn/fouled plugs, wires, etc...). A longer duration is also preferred because the EXACT millisecond the fuel charge will ignite is shifting slightly. But big problems occur with high coil outputs also. "Flashover" refers to the discharge of the ignition voltage anywhere other than at the spark plug gap. Too high a voltage and frequency and the ignition is going to arc wires, leak out the side of the coil, plugs, or convert to EMF.

The goal is to get a good strong spark with good duration and one that jumps a good spark gap. Points are a mechanical switch limited by how much current you can pump through them without burning them up. So, in the ignitions points limit the amount of power you can put into the coil. Points are limited to about 250volts and 5 amps. Coils can handle up to about 7 amps and transistor switches about 10-20 amps. By the way, the math for coil output is: e=L*(di/dt), which is..... voltage = (coil inductance) times (the rate of change of primary current as the stored coil current discharges).

MORE COMPLICATED COIL FOOD FOR THOUGHT

It gets more con"DENSER" than you thought. To really get technical, a coil is really just an iron core transformer (a step up transformer). This concept becomes more important when we talk about CDI. But for now, we'll talk about a transformer we've powered up with 12volt DC. That sounds reasonable except that a transformer only works with "AC" current. What? I'm so confused. Yeah, me too.

The points are opening and closing this electric flow thru the coil (back-forth) at this really high rate. Hmmmmm, that sounds a lot like "AC" current. See, the points have actually created this psuedo sort-of AC current. The whole system resonates at some frequency. That's why you hear car ignitions on the radio. The circuit resonates at some "tuned" frequency that any engine (at some RPM) can produce in the am/fm frequency band.

BALLAST RESISTOR

In order to increase the coil voltage at startup some ignition designs incorporate a "ballast" resistor. The resistor is switched in and out of the supply voltage to the coil. Once running, the resistor is switched in place and the coil is actually getting less than 12volts. When the engine is started, the resistor is removed and the coil gets the full 12volts. This provides a much better spark at startup to compensate for reduced battery voltage drawn by the starter. When starting a cold engine, the plugs and the air are cold, the cylinder pressure is up, and the fuel / air mixture is poorly controlled. The oil is thick, the battery is cold and its voltage drops as much as 60% because of the high current drained by the starter motor.

DWELL

Conventional ignition is affected by "Dwell time" (or dwell angle). Dwell time refers to the time the points are closed thus recharging the coil. Dwell angle refers to the crankshaft angle of rotation made while the points are still closed. As an example, if we talk about a 2 cylinder engine then the available dwell angle would be 180 (360 degrees divided by 2=180 degrees). If dwell time or dwell angle (points closed) is too short the coil may not have enough time to charge at high RPM. So large dwell is better right? But, if dwell is too large (points hardly open) then the points may not be open long enough for the coil to collapse at high RPM. The ratio of closed points to open is usually about 3:1.

The "dwell" time (points closed) has to be long enough for the coil to fully "charge". Typical dwell times (charge time) for a

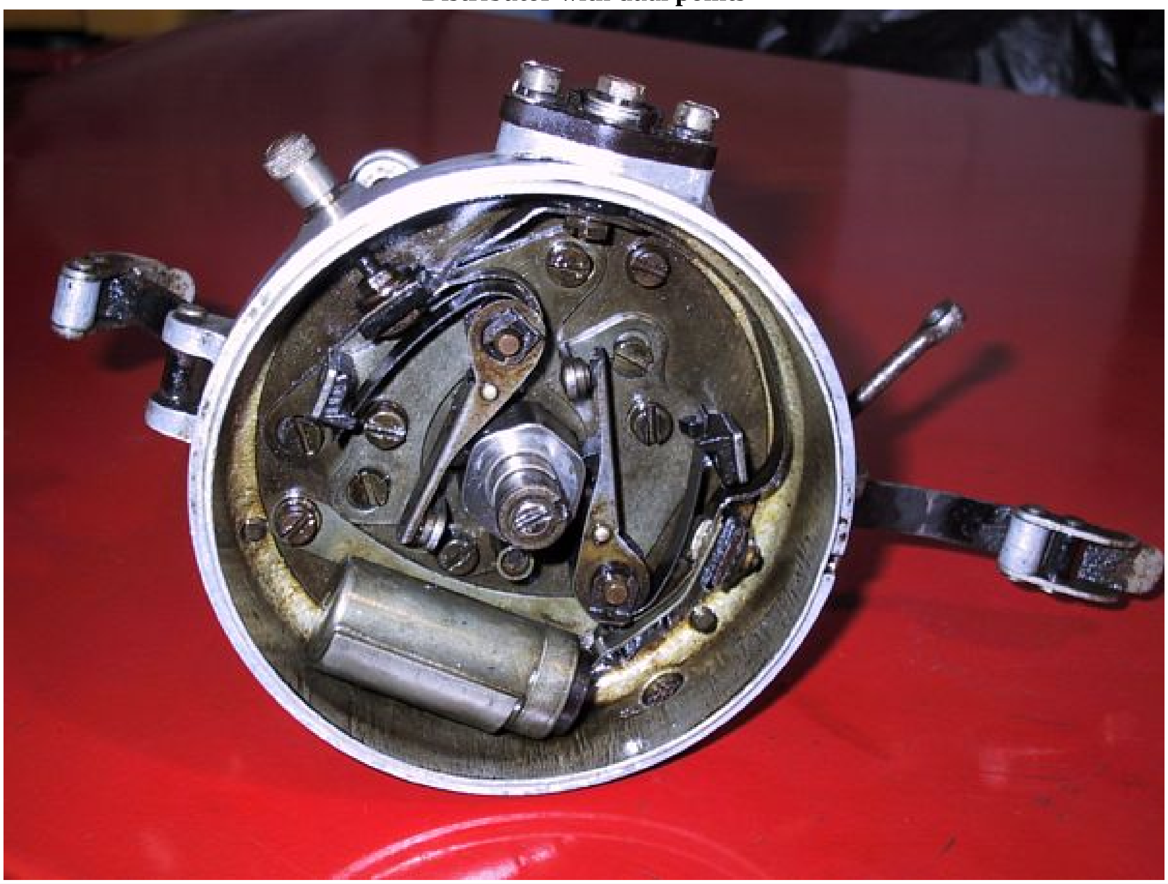
Kettering designed ignition are 1.0 to 6.0 milliseconds. Obviously, dwell time limits the ability of points to control a coil to deliver high power at high RPM. At high RPM you simple run out of time (you simply don't have 6 milliseconds). In addition, points are inherently a sloppy mechanical device to begin with. And worse, at high rpm they start to "float" off the cam. You can't get the points to "spring back" fast enough so instead of opening and closing they would hover just off the cam. Points can also have a phenomenon called "bounce", where they don't ride evenly on the cam. The upshot is that you can't control the coils fast enough at high RPMs. Some race teams got around this by using dual point systems overlapping the dwell times to get what they needed.

CHARGE TIME , VOLTAGE RISE TIME , SPARK DURATION

Again, an induction coil setup charges (is "fully saturated") in typically 1-6 milliseconds. Race teams in higher RPM applications use low resistance coils to speed up the charge to about 3 milliseconds. (We'll see later it takes CDI about 1 millisecond). The time it takes for the coil to collapse and reach %90 of its peak potential voltage is referred to as voltage "rise time". The voltage rise time in conventional ignitions is about 100microseconds. The result is spark durations from inductive coil systems between 1-2 milliseconds.

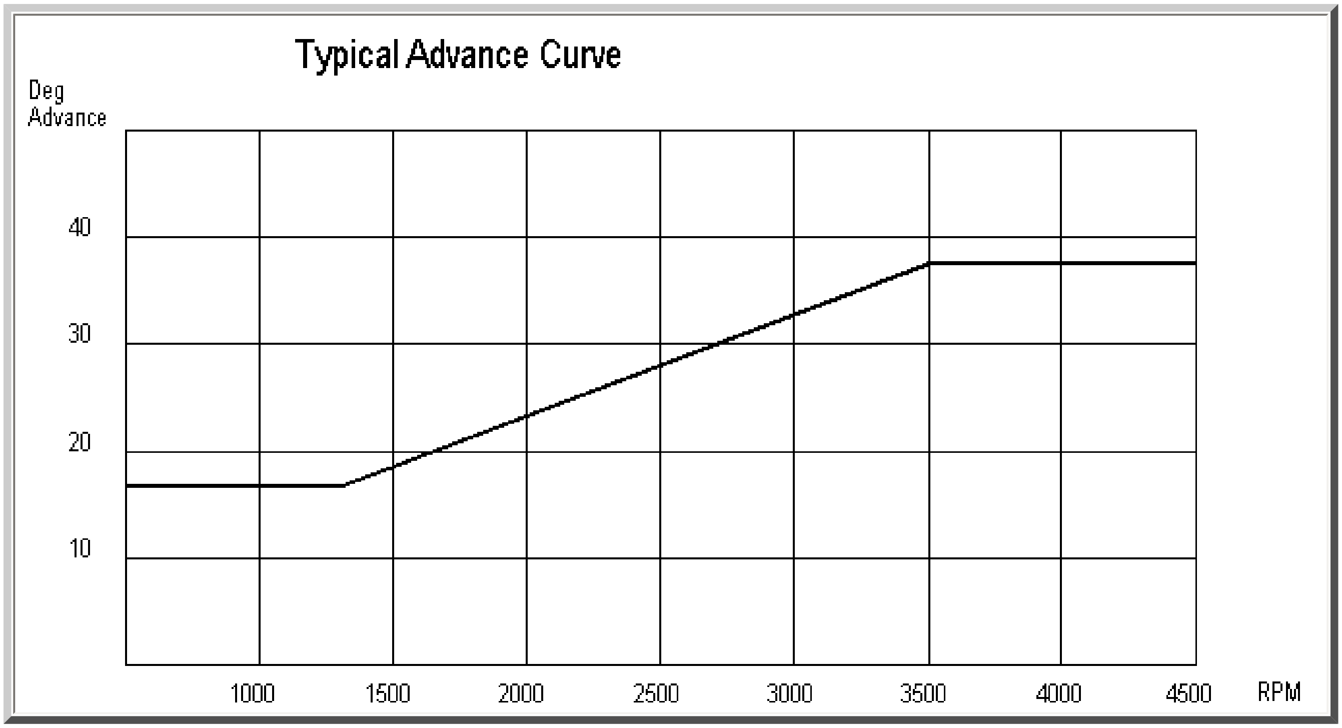
As we'll see, CDI is a different animal. Here the voltage rise time is a short 6 microseconds, but the spark duration is shortened considerably also. The quick charge time is an advantage in high RPM settings but the short spark length is a disadvantage for starting and other high rpm compression/ratio fuel/mix situations. Because of this, the longer duration of inductive discharge systems is sometimes preferred over CDI.

Distributor with dual points



SPARK "TIMING" and COMBUSTION PROGRESSION

Obviously, the timing of the spark is crucial to getting the full horsepower capability from an engine. So, we need to talk about the desired timing of the spark, why that changes, and how that gets changed while an engine is running. Most of us think when the spark plug fires, the gas/air mixture in the piston instantly explodes and that "exploding" pressure is what drives the piston down. Well.... sort of. Except, if the gas really did ignite all at once we ***really*** would have an "exploding" engine (pistons everywhere!). We have to slow down the process and take a millisecond by millisecond look at it.



In the perfect ignition process we would achieve efficient combustion progression at exactly the right time to produce the optimum pressure gradients in the cylinder in complete harmony with the piston movement relative to the piston rod to crankshaft rotation. Say W-H-A-T ??!!

The combustion process does not happen instantaneously-simultaneously in the cylinder but rather (as preferred) in a progressive pattern from the spark. The spark ignites gases near the electrode which then continues to burn (propagates outward) away from the spark plug usually a spherical pattern. You'll often hear this combustion progression across the cylinder referred to as the "flame front". The design of piston and cylinder heads, combined with spark plug placement is largely to get the best flame front possible. The time it takes the fuel/air mixture "charge" to combust changes according to many variables to include: fuel/air mixture ratio, density (temperature), octane, how well the cylinder has filled given volumetric efficiency, the "charge" turbulence inside the cylinder, compression ratio, the physical shape of the combustion chamber and piston head, spark plug placement, rear-end ratio and car weight (both translate to engine "load"), etc...

The important point here is:

The combustion process does take a period of time and the length of that time changes (so when you need to start it changes!).

An Example: Combustion Process Timeline with Before and After Top Dead Center Piston Position Timing at 3,000rpm					
34Btdc	24Btdc	5Btdc	5Btdc - 15Atdc	10-20Atdc	20-25Atdc
Spark Occurs	Combustion pressure actually starts to overtake normal cylinder pressure (without ignition). This 10 degrees of lag is known as "Ignition-delay". Normal cylinder pressure without ignition is called the "compression line"	Cylinder Pressure near double normal (compression line)	Combustion is now very rapid	Peak cylinder pressure ("PCP")	Combustion Complete

The peak cylinder pressure occurs between 10 and 20 degrees "after piston top dead center" (ATDC) on most engines and the combustion process is complete by 20 to 25 degrees ATDC. The rise in cylinder pressure (pressure gradient) is technically called flagregation. Obviously we want the combustion process to occur during the down stroke and that high pressure point at the optimum point of leverage for the piston arm to crankshaft angle. To get this, the spark and combustion process must be started much earlier. Look at the graph above and you'll see at low rpm the spark occurs near 18 degrees before piston TDC (BTDC). From 5 degrees BTDC to roughly 15 degrees ATDC the combustion process is very rapid due to the progressing flame front and the high rate of energy release.

As RPM increases it becomes obvious that we must start the spark earlier or the combustion process will complete later in the "power stroke". Another words, we're not getting the best bang for our buck. Consider an example timeline. At 1,200rpm the crank is rotating 1 per every .05 second. Let's say the combustion process takes about 60degrees of that revolution so... about .008 second. At 6,000 the timeframe is 1/10 of that at .0008 sec. Typically, timing starts at a preset level (about 10-20 degrees) and then is advanced to be earlier as RPM increases. At about 3-4,000rpm the variables that change timing tend to even out and so no further advance is needed. In the example above timing advance caps at about 3,500 rpm to 38 BTDC. The graph above is known as the timing curve and while typical, can quite obviously be hugely different for other motors.

DETONATION ("engine knock", "ping", "pinging")

While not advancing the timing would result in power loss, advancing the time to far ahead is even worse. If spark occurs too early then the combustion (and resulting PCP) can occur before TDC and the piston is still moving upward (not downward). This is **BAD!** Detonation in any form is destroying the piston head. I mean.... you can hear it banging itself to death!

PRE-IGNITION

Pre-ignition is like detonation except it is less related to incorrect timing. Something else is causing the "charge" to ignite too early. Often, a lower octane gas could cause this because of its increased tendency to "auto ignite". Could be a hot spot in the piston head or hot carbon buildup on the spark plug end. Maybe the wrong "heat" rated spark plugs is being used for the type of engine use (plug running too hot). In any event, adjusting the timing can solve this phenomenon. Unfortunately, older motors were not adjusted for this while the motor was running, so the type of gas you used was locked in at the tune-up. Now, there's more lee-way as modern auto engines compensate for engine knock as part of the timing adjustments.

TIMING ADVANCE

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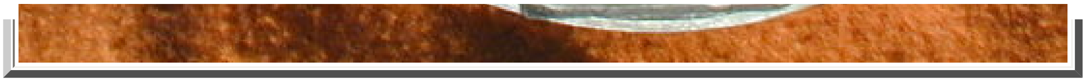
Early Electronic Ignition Distributor with dual points, centrifugal advance, and vacuum advance



In early ignitions the timing was advanced mechanically with RPM. Normally this done was with small weights and counter springs inside the distributor. As RPM increased, the weights were pull outwards by centrifugal force and shifted the points around the cam, changing the time they would open/close. The photo above shows the mechanical advance with spring. Can you notice also that the photo above is an early "electronic" ignition? So, ignition advance is necessary despite the "type" of ignition being used.

VACUUM ADVANCE

We advance the timing trying get the perfectly optimum time for combustion during the power stroke. But as I mentioned earlier, there are many variables that effect how long the complete combustion process takes. So, advancing the timing based solely on RPM probably doesn't cover all the possible scenarios. But how do you tie those other variables into a mechanical contraption to adjust timing? You see the problem. To adjust the timing ever slightly more, autos in the 70's - mid 80's were fitted with an additional device called "Vacuum Advance".

A large factor in the rate of combustion is the density of the fuel/air mix (charge) in the cylinder. A low density mixture burns slower than a high density mixture. So, the spark needs to occur earlier when the fuel/mix charge is less dense which happens at closed (idle) or part open throttle (cruise = flat road) operation. At wide-open throttle (WOT) operation the fuel/air mix is dense and combustion is rapid, so no additional advance is needed.

This additional timing adjustment was made with a "vacuum advance". This is a clever device that ties manifold pressure to a mechanical advance mechanism. At "part-throttle" operation (like cruising on a flat road) the manifold vacuum is high and engine load is low. At full throttle (WOT) the manifold vacuum is low and engine load is high. Look at the above photo. The black device is the vacuum advance. The open port would normally be connected by hose to the intake manifold vacuum lines. A vacuum driven diaphragm on the distributor advances the spark even more when the manifold vacuum is higher. SO.... the spark is advanced more during closed or part throttle operation. Example:

Advance at Wide Open throttle = Initial Advance setting + Advance from centrifugal advance only
Advance at Close or Part-Throttle = Initial Advance setting + Centrifugal advance + Vacuum advance

TIMING ADVANCE SETTINGS/ADJUSTMENTS

In earlier conventional ignitions you could adjust the initial timing by physically moving where the points were screwed onto the distributor. This would need to be periodically changed as the points wore down. They would also need to be changed as the engine got older and the cylinder compression was less due to ring/piston wear.

As for the timing advance: the centrifugal and vacuum advances were set by their physical mechanical design in the factory. No adjustments were normally possible. To change timing you could swap out the device with one from another car or another after market device.

SPARK PLUGS TELL THE TALE

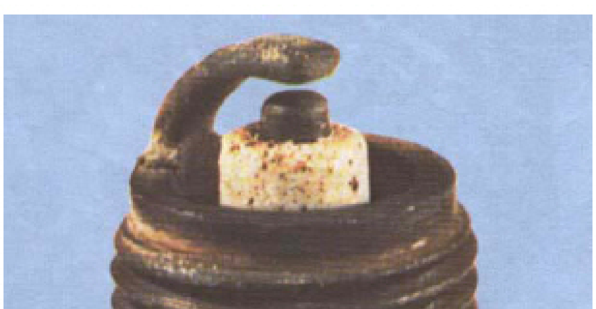
The spark plug itself speaks volumes about how "optimum" the combustion process is. Visually, if the burn is good and combustion heating of the plug is correct (you have the correct plug heat rating) then ..... the plug looks like this. The insulator around the tip of the electrode will appear slightly off-white (light beige). There won't be any heat disfiguring of the electrode and no carbon buildup or soot.

Spark plug conditions: A brown, tan or grey firing end is indicative of correct engine running conditions and the selection of the appropriate heat rating plug

White deposits have accumulated from excessive amounts of oil in the combustion chamber or through the use of low quality oil. Remove deposits or a hot spot may form

Black sooty deposits indicate an over-rich fuel/air mixture, or a malfunctioning ignition system. If no improvement is obtained, try one grade hotter plug

Wet, oily carbon deposits form an electrical leakage path along the insulator nose, resulting in a misfire. The cause may be a badly worn engine or a malfunctioning ignition system



A blistered white insulator or melted electrode indicates over advanced ignition timing or a malfunctioning cooling system. If correction does not prove effective, try a colder grade plug

A worn spark plug not only wastes fuel but also overloads the whole ignition system because the increased gap requires higher voltage to initiate the spark. This condition can also affect air pollution.

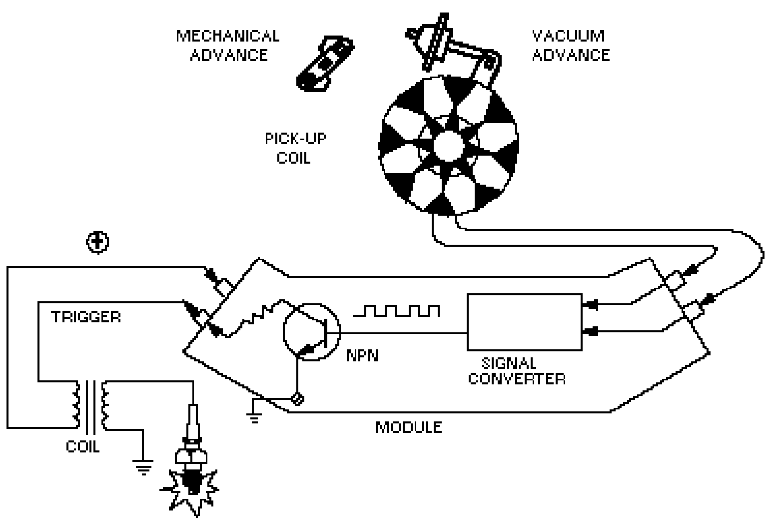
WAIT A MINUTE ....

How important can timing advance be? My lawn mower doesn't have it, or my small magneto outboard, weed-wacker, etc.... Well, your right. And, I don't know exactly. So here's my guess. I won't talk about 2-cycle 'cause that's a different animal. But other small motors... you simply aren't demanding that much out of them (throttle acceleration, load under changing rpm) to notice any major performance loss from no advance. So the motor is set at a worse case timing. Not optimum, but still runs consitantly. At some point the motor and motor load/performance/hp makes timing advance worth it.

Common Problems with a conventional ignition system are:

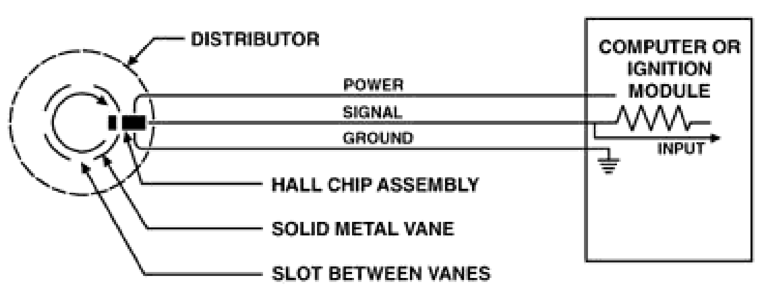
- Points wear and erode (poor current flow and sloppy timing)
- Points limit power input to coil (limiting coil output)
- Point dwell limits and "point float" or "bounce" limit high power at high RPM
- Mechanical Advance and vacuum advance wears
- Advance cannot be mechanically adjusted for all the variables, especially detonation
- Points get wet and stop working altogether
- Timing belt (chain) wears and/or breaks

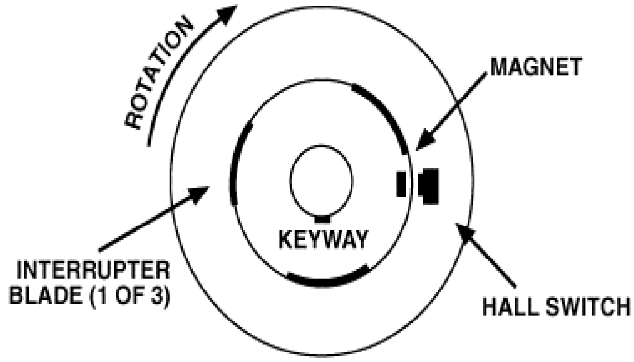
Basic Electronic Ignition Transistors and Pickups Sensors

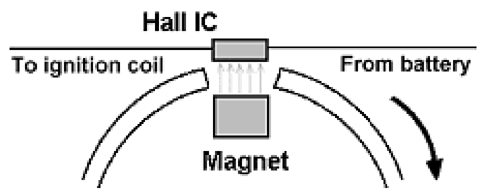


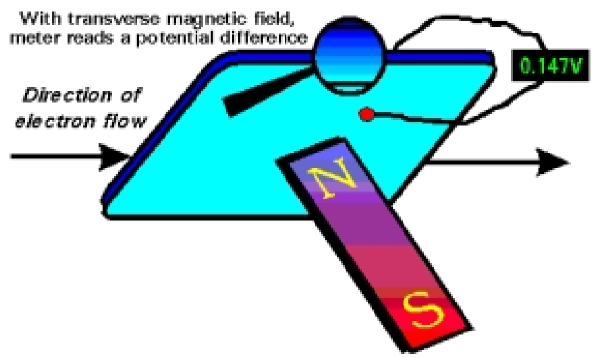
The first improvement of electronic ignition was to replace the mechanical points with a "solid state" semiconductor switch called a transistor (pictured above) This is called a "fast switching transistor" to be exact. The advantage of an ignition transistor is that it can conduct up to near 400-500 volts (more power than needed), is extremely accurate fast (in nanoseconds vs. milliseconds), and can last a long time in the heat / vibration of an engine. The trick of course if how to trigger the transistor switch. The common types of sensor systems that have evolved are: magnetic, "Hall" effect, optical, and (for trivia purposes only) "ECKO". In order of today's usage:

"Hall Effect" Pickups Most Commonly Used in Modern Autos





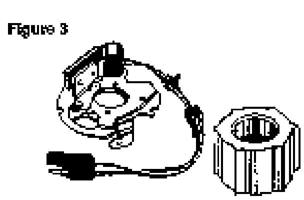




This is the most widely used type of ignition sensor. The Hall effect (named after the American physicist Edwin Herbert Hall, 1855-1938) involves the generation of an "electric potential perpendicular to both an electric current flowing along a conducting material and an external magnetic field applied at right angles to the current upon application of the magnetic field". ***SAY W-H-A-T ?!??*****. Practically speaking, a current is passed though a silicon wafer. When a exposed to a magnetic field this disrupts the current flow and distributes more "potential" on one side of the wafer. This can be measured, conditioned, and amplified to trigger the ignition module. Hall Effect sensors are extremely accurate, they produce a "square" wave signal perfect for solid-state applications, and are very durable against heat / vibration. The rotor magnet does not need to be as strong (you may not feel its pull with a heavy screwdriver).**

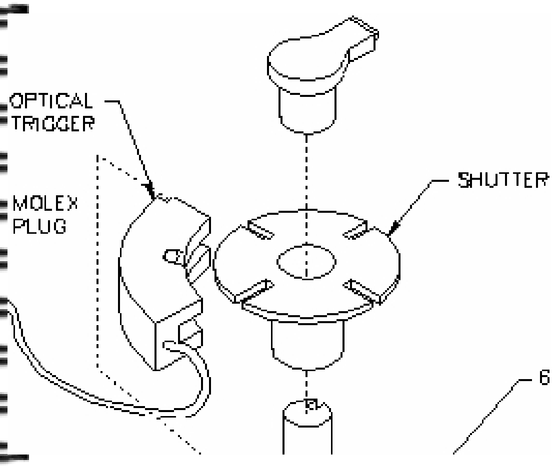
Most Hall effect rotors involve a stationary Hall Switch and stationary magnet. What rotates is an "Interrupter Blade". When the blade passes between the sensor and the magnet it blocks the magnetic pull on the Hall Switch. When a "shutter blade" is open, the magnetic field projects onto the Hall Sensor switching it on. The easy way to identify a Hall system is the fact that it must be externally powered. So, there's going to be that extra wire.

Magnetic Pickups (Most common in everything other than Auto)



This is very popular and still used for many applications today because its a rugged durable design. In addition the sensor is not powered (like in Hall Effect) so it can be used in self powered magneto ignition applications. A coil sensor is used to detect the "flux" a magnet produces when it passes close by the sensor. This magnetic rotor is called a "Reluctor" (I betch ya didn't know that one). The problem with magnetic is that at higher RPM the sensor has trouble seeing "teeth" close together on the magnetic rotor. This is a bigger problem with many cylinder engines and/or high RPM applications. Also, you may remember magnets tend to loose their strength with vibration and heat. Also, reluctors are stronger magnets (you can definitely feel the pull if you get a screwdriver close) which tends to magnify things around it.

Optical



An infrared sensor triggers when a rotor blade blocks the light path. Although accurate, the sensor is sensitive to dirt and dust. This is not used much but is very common in aftermarket ignition kits because its easy to adapt to almost any application.

ECKO

"Eddy Current Killed Oscillator" systems were used by Lucas (yeah, the British "Dark Lord"). It involves a 2 coil sensor that has current flowing. The sensor detects the current disruption cause by a magnet passing by. It is similar to "Hall Effect" in that it is extremely accurate and durable. But for whatever reason is only used mainly in manufacturing automation applications.

Modern Electronic Ignition Modules

For the most part, there are 2 types of ignition systems in use today (or variations of them): Induction ignition (TCI=Transistor Controlled Ignition) or CDI ("Capacitive Discharge Ignition"). Both systems use a sensor (discussed above) to trigger a transistor switch (which has replaced the points). CDI is becoming the standard and you'll see why.

Induction Ignition (Kettering design):

This is called an induction system because the coil is used as a power storage (an "inductor") device for the spark. Remember, the coil is powered up, stores near 30,000 volts, and unleashes it when the coil collapses (power supply cutoff). A feature of induction ignition is the slightly longer spark duration while the coil collapses. This is an advantage when starting and for igniting lean/high compression mixtures at high RPM. These type of systems require coils meant for "induction" ignitions (they have a higher resistance typically than CDI coils). Induction ignitions are simpler in design (cheaper) and used often on less sophisticated motors.

CDI ("Capacitive Discharge Ignition)

Commercial development of CDI happened around the mid 60's. Up till then it was regarded as worthless and even dangerous. Well.. the dangerous part is somewhat right as you will see. If your really bored here's a 1965 Danish sketch of an early CDI design and the bike it was tested on (a 90cc Kawasaki motorcycle). Automotive CDI was pioneered mainly by Bosch in Europe. In 1979 they introduced the "Bosch Motronic". Today we see a variety of names to include: Ford's TFI (Thick Film Integrated), GM's HEI (High Energy Ignition), DIS (Distributorless Ignition System), ECU (electronic control unit), and many others.

CDI ignition is most widely used today on automotive and marine engines. A CDI module has "capacitor" storage of its own and sends a short high voltage (about 250+ volts) pulse through the coil. The coil now acts more like a transformer (instead of a storage inductor) and multiplies this voltage even higher. Modern CDI coils step up the voltage about 100:1. So, a typical 250v CDI module output is stepped up to over 25,000v output from the coil. The CDI output voltage of course can be higher. So you'll see CDI systems claiming coil output capability over 40,000-60,000 volts!!? As you will see this is not exactly what happens at the plug but for math purposes it works out. The huge advantage of CDI is the higher coil output and "hotter" spark. The spark duration is much shorter (about 10-12 microseconds) and accurate. This is better at high RPM but can be a problem for both starting and/or lean mixture/high compression situations. CDI systems can and do use "low" resistance coils.

Again.... the differences Kettering (TCI) vs CDI

With the Kettering Induction ignition design, the coils are powered all the time at 12 volts and are commanded to collapse to spark by the ignition module. Here, the ignition module disconnects the primary winding coil ground. The coil secondary winding collapses to spark at about 30,000 volts. In the CDI design, the coils are not powered. They receive a short high (250 volt) pulse from the ignition module and then amplify that (100:1) to a much larger voltage spike (about 40,000 volts) . Since the potential output of a CDI coil can be over 40,000 volts you have stickers all over your engine bay reminding you that: ***This can KILL you!!***

Advantages / Disadvantages of Electronic Ignition

The advantages of solid state are numerous but the big one is : "no moving" parts. This should translate to control and reliability impossible to achieve in any mechanical system. The term "engine tune-up" is nearly meaningless with respect to modern ignition systems. Outside of replacing plugs and inspecting wiring there is not much else to do. More than a few mechanic shops exploit the public misunderstanding of modern engines. Having said that, the disadvantage of electronic ignition is simply reliability.

A desktop computer circuit board should last a **LONG** time in theory, and yet you know quite clearly it does not sometimes. Ignitions have suffered the same evolution of making electronics that can stand the test of time. Early ignition systems were particularly prone to "component" breakdown. Anyone who has owned an older British sports cars will understand the term "the dark Lord of Lucas" (Lucas Electronics were notorious for their failure).

Solid state components are particularly sensitive to heat, thermal stress, vibration, moisture, and power surges (basically, everything an engine is about). So, great strides have been made to beef up and improve CDI reliability. These include things like:

- Improved cooling and heat sinks
- Epoxy resin or Epoxy-rubber encasing components so they can't get wet
- Using separate ignition modules for each plug (so a single failure won't kill the whole engine). This concept was first exploited in outboards where each plug has a separate "power pack". Power pack failures were a big problem in the outboard industry for awhile and not funny when you are 60 miles from land in a small sport fisherman with 1 engine.
- Heavier duty components that can withstand the heat, vibration, and "duty cycles".

What's Better? Induction -or- CDI?

Clearly, CDI is being used for most all modern auto / motorcycle / marine applications. It is also the choice for most high rpm race engines. This is simply due to the ability to fine tune all aspects of the combustion process electronically. Where simplicity and reliability is a factor, induction systems have an advantage. That is why you see them most often in aircraft engines. High revving RPM control is not the emphasis but rather reliability. The longer spark duration of induction systems gives a better chance that combustion WILL take place! Anyone who has ever flown at night over mountainous terrain and has heard "auto-rough" knows what I'm talking about here.

MISC IGNITION INFO

"Dwell"

Dwell time refers to the time the distributor points are closed. The dwell angle was the amount of rotation of the crankshaft that corresponded to the points being closed. This affects the charge time of the coil. Dwell was important then because at higher RPM the dwell time (points are closed to charge the coil) was not enough to fully charge the induction coil. That meant less voltage spark at higher RPM (...BAD). There was also the problem of how fast a point could open and close without "floating" (a problem you have with valves also). There was a real balance between dwell time at high RPM, how much voltage you needed for high RPM spark, how much voltage you could actually push thru a point without burning it up, and then what would happen at low rpm (long dwell times) when all that voltage was just heating up the coils.

In newer CDI systems this term is near meaningless for several reasons. Solid state transistors control the discharge pulses electronically with near instantaneous timing in the nanoseconds. So the dwell times can be finely controlled to achieve the best coil output. Transistors can handle a LARGE amount of voltage/current (compared to points). And, newer generation coils are extremely fast with charge "saturation" times around 1milliseond. Their coil pulse "voltage rise time" to the plug is VERY fast at around 6 microseconds. So charge / discharge times are not a huge factor (unless racing). Newer racing ignitions (like MSD) are NOT producing bigger sparks with long durations but in fact getting more efficient burn by producing very controlled multiple short duration sparks to the plug.

Electronic Timing Curves

Timing curves can be manipulated in great detail to maximize engine horsepower. Replaceable "high performance" chips for many sport cars are routinely offered by aftermarket companies as a byproduct of racing technology. While it seems logical that auto manufacturers already put the "best timing" they had in an engine design, you could argue that they also may detune an engine slightly to address reliability and longevity of an engine. It has always been a balance between performance (Horsepower) and "how long" an engine will last. You can often squeeze a few more HP out of an engine by improving the timing curves.

Low vs High resistance coils

Induction ignition uses higher resistance coils compared to CDI is ystems that can use lower resistance coils. So....**Do Not Use** a "racing" **-or-** low resistance type coil in an "induction" ignition (or TCI) system unless it is specifically designed for that. The low resistance coil will flow more current thru the TCI and produce the legendary "Hot Toaster" effect. Though it will work for awhile, you will eventually burn the TCI module out.

Ignition shutdown

Obviously, it seems harsh on the components to be powering the ignition system when when the engine is NOT running but the key is on. So, both types of ignition designs employ some auto shutdown of the ignition modules. This is usually tied to the pickup sensors. If no RPM is observed then the ignition is shut off (as well as is the high pressure fuel pumps for the fuel injection system). I mention this because in older Induction (TCI) designs when the ignition module shuts off, it collapses the coil. You would occasionally get a single backfire a second or two after trying to start a engine that didn't run.

The Big Myth: Your engine needs a tune up!

If you've understood any of this then the question that should come to mind is: What do they adjust when you take your car in for a "tune-up". The obvious answer: **NOT MUCH !!** If you own an older electonic ignition (80-late 90's) a shop can:

- Replace the spark Plugs
- Check the plug wires
- Check the wear and replace the distributor rotor (if there is one)
- Check the wear and replace the timing belt (if there is one)

There are no points to replace, no dwell or timing to change.

In the "New Millennium" high-end car & marine engines have neither a timing belt, distributor, plug wires, etc... You guessed it., there ***ARE NO MOVING PARTS*** *and* ***NO ADJUSTMENTS*****. It either WORKS -or- IT DOESN'T.** All they can do is change the spark plugs. AND YOU SHOULD.

Now... in fairness, the truth is: a dealer (or very good shop) **WILL** plug your high end machine into a $300,000 diagnostic computer which will tell whether all those sensors (you don't know about) are working correctly to produce max horsepower, best gas mileage, no knocking, and clean "California" exhaust so LA people can breath what little is left of their air and your catalytic converter doesn't have a Chernobyl meltdown. And... these things could be important.

But generally, if your car is running good (no engine light).... just change your spark plugs occasionally (if you can find them) !?

Ignition Considerations

The common question is: how much power do you need in an ignition system? The more the better right? Well, not exactly. Lately it seems the talk is always centered around high voltage (50,000+) low resistance racing coils, aftermarket ignitions (MSD, Accel), etc... What is really important?

Coil aspects: "Rise time" refers to the time needed for the coil voltage to reach 90% of its peak. Fast rise times are desired as they help prevent and breakdown plug fouling (or "plug tracking"). Plug fouling occurs when the spark is dissipated and runs to "ground" across deposits on the plug's surface instead of across the plug gap. These deposits can be carbon buildup, corrosion, lead salts, water, etc. Rise times for ignition systems are typically 80-120 microseconds for induction systems and 6 microsecond for CDI.

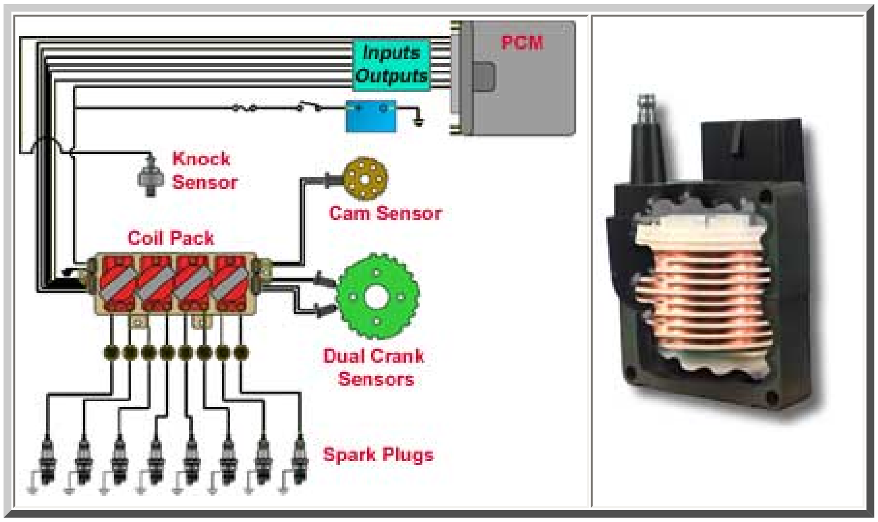
It takes about **10-14,000 volts to initiate the spark** across the plug gap. After the initial arc the voltage required to sustain the arc is much less and drops off significantly. So while you may have a manufacturer claimed 60,000 volt racing coil you can't actually get that across the plug. Since the advantage of CDI is the higher coil output, how does that get used. Well, normally it doesn't. The extra power possible in the coil is "Reserve Voltage". As the plugs wear, fouling, plug wires and connections get worse then the required firing voltage may go up 1-5,000 volts. So the "hotter" CDI coil output can help overcome these obstacles and the ignition system will last longer. So, its not that its working better.... but rather lasting longer that makes a hot coil good. The ideal coil output needed for normal applications is about 30,000 volts.

High RPM / High Compression / Racing applications: Newer techniques are being used to increase spark output. Additionally, CDI typically has a very short spark duration near 10-12 microseconds. As discussed you can't push more than about 20,000 volt across the plug without other strange phenomenon happening. If you were to try you would see arcing down the side of the plug, across carbon buildups at the electrode end, out any weak points in the wire insulation, connections, etc... So how do you get a better spark? Newer ignitions (like MSD-5 for example) are outputting a finely controlled multiple spark pattern into the plug. Instead of one big spark a shower of short duration sparks are flooded across the combustion stroke. This makes for a much more efficient burn. Using this technique newer CDI can achieve longer spark duration times (near 250). This is particularly better for starting, lean mixtures (which are hard to ignite), and high compression situations.

Ignition Memory: Most modern auto ignitions keep a profile of engine performance with respect to recent usage. So the type of gas you use, environment you drive in, and the way you drive with effect how the engine anticipates its timing curves and ignition / fuel / emission settings. Another words, if you drive mostly in Florida and then move to the high altitude Rockies.... you've car is going to run rough for awhile till it catches up. Most ignition memories can be "zeroed" out by removing power from the car for a "noticeable" length of time (30 minutes?)

Ignitions Today and in the Future

The **GOOD NEWS** is the ignitions systems are getting very reliable, accurate, and sophisticated. The **BAD NEWS** is that you can't work on it. I looked under the hood of a new Ford F-150several years back .... and .... "*where's the spark plugs?" **For that matter, where are the spark plug ....wires..... and ..... coil !??!*** Yeah, do I feel dumb.



New generation auto ignitions are designed for more accuracy, better efficiency and reliability. This includes" crank angle" sensors to improve timing and fuel injection accuracy (example, mounting the Hall sensor and magnets on the flywheel). Newer coils will be wound around an "E" shaped pole (not "center wound"). They will look like a square module and not the round cylinder you've seen all these years.

"*DIRECT IGNITION*": (first seen on Saab's and GM's). In this setup each spark-plug has its own coil **-or-** a single coil will supply opposing cylinders. The advantage here is no more rotor. DIS systems are usually inductive ignitions and employ the "wasted spark" strategy. This refers to a coil that supplies the spark on every revolution so the cylinder will get one during compression and also during the exhaust stroke. The wasted spark design cuts the coil charge time in half so is not often used on extreme high rpm race engines.

"COIL ON PLUG": This design is becoming more prevalent. You'll see separate coils mounted directly atop each spark plug. This improves spark power (no plug wires), accuracy, reduces RFI (radio frequency interference) problems, and most importantly eliminates the distributor (the last moving mechanical device to wear in ignition systems). The advantage here is total control, no moving parts, and extreme high rpm capability. This is the design used on most Indy and F1 engines which are generating nearly 15,000-16,000 rpms.

Timing and spark duration times can adjusted across the RPM range. Additionally, timing advance will be calculated for a variety of inputs including increasing RPM vs. decreasing RPM (braking, coasting, or accelerating), throttle position, temperature, altitude, etc. Even "engine knock" (detonation) will be eliminated by timing adjustments (using "listening" sensors like piezoelectric crystals bolted to the engine)

Making Yours a Better Ignition
(For normal operations)

Simple , and in order of importance: **Plugs, Plug-wires, CDI, Coil**.

The biggest enemy against ignition is RFI and insulation leakage. Basically, you want the best insulated (thicker, 12mm?) and well made plug wires you can get. Remember this simple gradeschool phrase: "... electricity takes the path of least resistance". In the case of your engine this will be arc tracking across the plug and/or out the plug wires due to insulation breakdown. Upgrade your CDI module (example: performance timing curves, high output, etc...) if you want to spend a little more for higher performance. Although a good coil is always a plus, we've discussed how meaningless **SOME** manufacturers high output claims can be in practicality.

In short, spend your money on a good well insulated system. As long as the coil and CDI can meet the rpm demand's of the engine you are on top of the game.

Ignition Plug Wires

There are 3 basic types of conductors used in automotive applications: Carbon string, solid and spiral wound. Spiral wound is becoming the more popular so there's probably a good reason. I recommend getting on some really good "wire" sites and scoping out the differences. MAGNECOR or NGK would be a good place to start.

Spark Plugs

This is a bar conversation if ever there was one.....right up there with synthetic vs normal oil. But I believe most standard plugs these days are more than adequate. NGK, Bosche, Champion..... are all good. Platinum plugs are the way to go because they simply last longer. A good plug should last about a years worth of normal use (20-30,000 miles). If using the engine in more extreme load/rpm ranges you should consider a plug with a different "heat" rating. As an example, an engine operated in constant high rpm/power/load situations might benefit from a colder (than "stock") plug rating. Since the engine is running hotter, a "cold" plug would run cooler thereby preventing pre-ignition (helping the plug and engine last longer).

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Ignition Discussion Links

http://www.442.com/oldsfaq/ofign.htm

From dave andrews motorcycle repair page
http://members.aol.com/DVAndrews/timing.htm

dan motorcycle garage
http://www.dansmc.com/IGNITIONTIMING.html

from simple digital systems fm-4
http://www.sdsefi.com/techcomb.htm

runtronic spark ignition
http://www.barbwireweb.com/EELC/jep/runintro12.htm

Some Ignition Links and searches

SEARCHES:

Try to use search word that would only be used in discussion of ignition systems. Examples:

CDI ignitions
capacitive discharge ignition
induction ignition
kettering design
votage rise time ignition
dwell ignition
centrifugal advance ignition
vacuum advance ignition
detonation
preignition
hall effect ignition

Just throwing some names out here IN NO ORDER.

MSD	Accell	Intelligent Ign System (Iss)	Lucas Rita
Dynatek	Boyer	M&W Ignitions www.mwignitions.com/	

UNITED STATES PATENT OFFICE.

CHARLES F. KETTERING, OF DAYTON, OHIO, ASSIGNOR TO THE DAYTON ENGINEERING LABORATORIES CO., A CORPORATION OF OHIO.

ENGINE STARTING, LIGHTING, AND IGNITION SYSTEM.

1,171,055. Specification of Letters Patent. Patented Feb. 8, 1916.

Application filed April 17, 1911. Serial No. 621,512.

What is claimed is as follows:

In a device of the character described, the combination with an engine, of a storage battery; electrical power transmitting devices interposed between the engine and battery and having dual characteristics to translate the electric power of the battery into mechanical power to start the engine and to translate the mechanical power of the running engine into electric current for storage back into the common battery; two sets of gearing connecting the said electric devices and said engine, one set for cranking the engine at high leverage and the second set for driving by the engine for charging; and two separate circuit connections between said electrical devices and the battery, having provisions associated with the first for taking high wattage current from the battery to crank the motor through said high leverage gearing, and with the second circuit for delivering low wattage current to charge the battery by using said second set of gearing.

In a system of the character described, the combination with an internal combustion engine, of a lighting system therefor including electric lamps adapted for relatively low voltage current; a storage battery connected with said lighting system; electrical connections connected with said battery; a high leverage gearing connected with said engine; a lower leverage gearing connected with said engine; and means including electrical power-transmitting devices connected with said gearing and said electrical battery connections for translating relatively high wattage current from said battery into mechanical power applied to said engine through the high ratio gearing to start the engine, and for translating power derived from the engine through the lower ratio gearing, to charge said storage battery with current of lower wattage and of substantially the same voltage as that of the lighting system.

CHARLES F. KETTERING.

Automobile Lighting and Battery Charging System

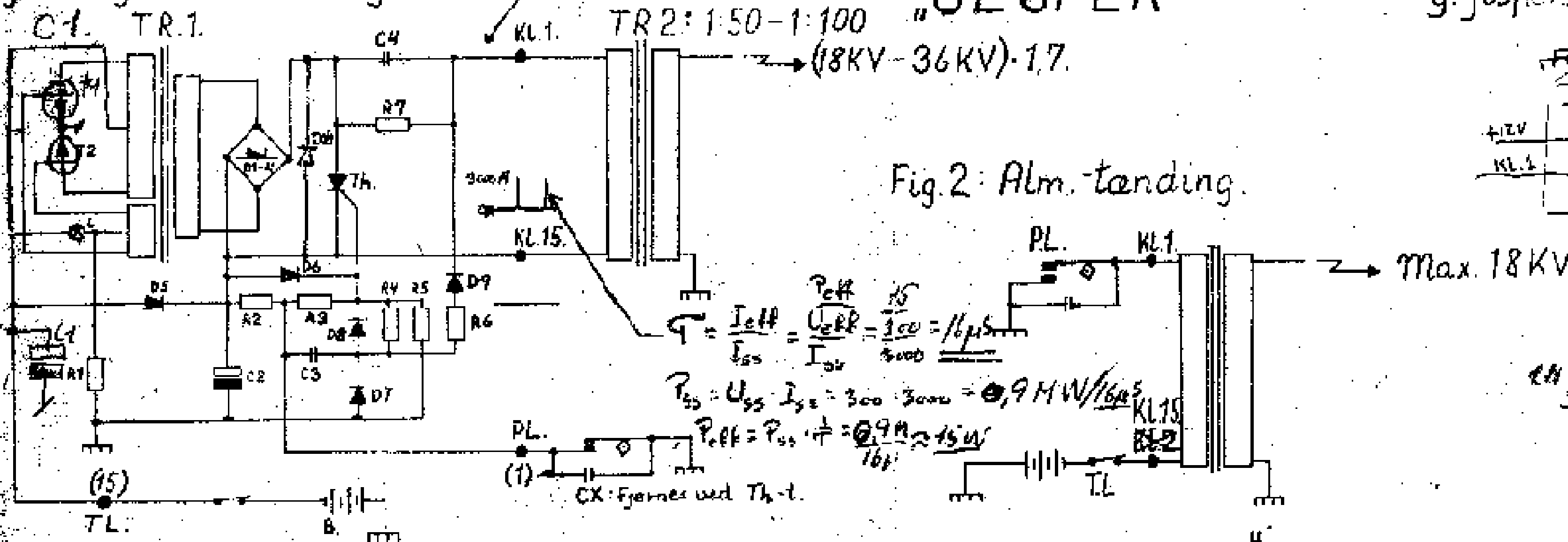
Index Previous Page Next Page

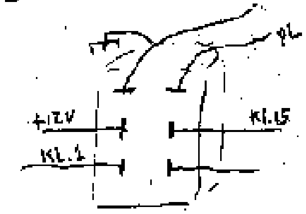
„JESPER"

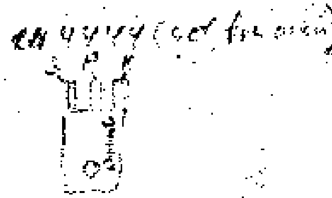
G. Jespersen.

Fig. 1: Thyristortænding.

Fig. 2: Alm. tænding.







Batterispændingen B. = 6V. De i „ " markede værdier for B = 12V.

Obs.: Kun for vogne med ÷ til stel. | D1-D5: 1N4007; D8-9: BY103

R1: ~~100~~Ω - ~~1W~~ „ ~~180~~Ω - ~~2W~~"   ~~C1: 100μF/35V~~ C1: 125μF/16V (32V)

R2: 68Ω - 1W „2W"   C2: (25μF/35V) 10μF/35V

R3: 470Ω - ½W   C3: 0,47μF/400V typ. 5TWD6

R4: 1KΩ - "   C4: (2μF) 1μF/630V - M.P. typ Bosch 0610 300 044

R5: 2,2KΩ - "   ~~D1-D7 BY126~~, D10: F41Z (Silec) el. 1N5060

R6: 1KΩ - "   T1-T2: ~~AD162~~ 2N3055

R7: 330KΩ - 1W

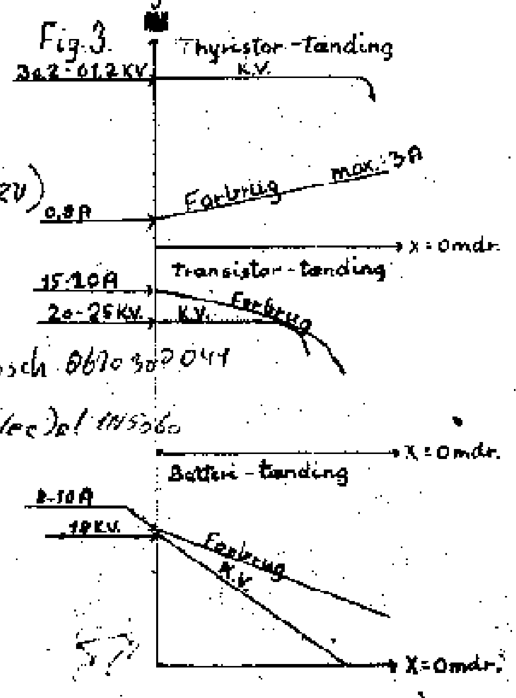
L*: ~~6V/4W~~ (12V/3W) 15V/3W

Th. (2N4188 (MCR2604-7) → 2N4189) 2N4444

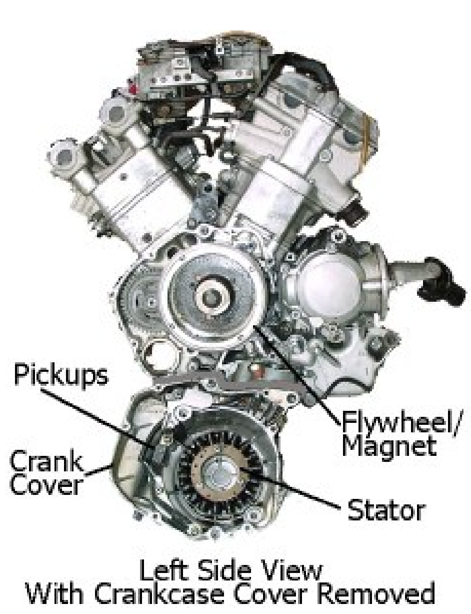
* : PTC - modstand.

Max. tændfrekvens: 320 Hz.
320 Hz ≈ 10 000 omdr. for 4 cyl. - 4 takt.

Fig. 3.




CDI system

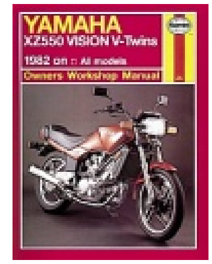


YAMAHA

Motorcycle Charging systems Charging Stators FAQ

Yamaha VISION (xz550 RJ/RK)

Best Viewed At 600x800



UPDATED

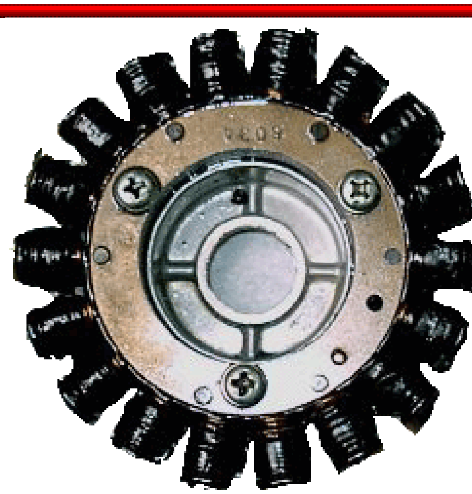
10/1/2002

[Download this page as PDF file](#)

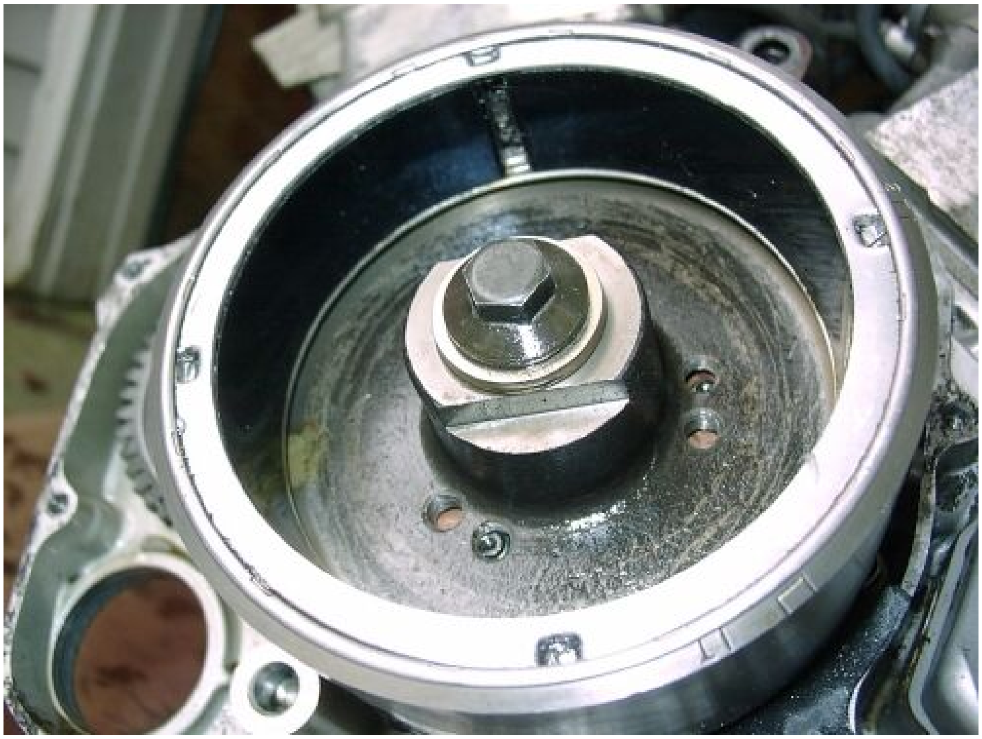
This page attempts to consolidate info concerning the charging system for the Yamaha Vision motorcycle. Much of this applies to any motorcycle charging system. Most of this has come from the Vision Forum, its riders, ELECTREX, and other sources. My thanks to ***EVERYONE****.*

This is linked from the (Vision Ignition FAQ) & my (Vision Home Page).

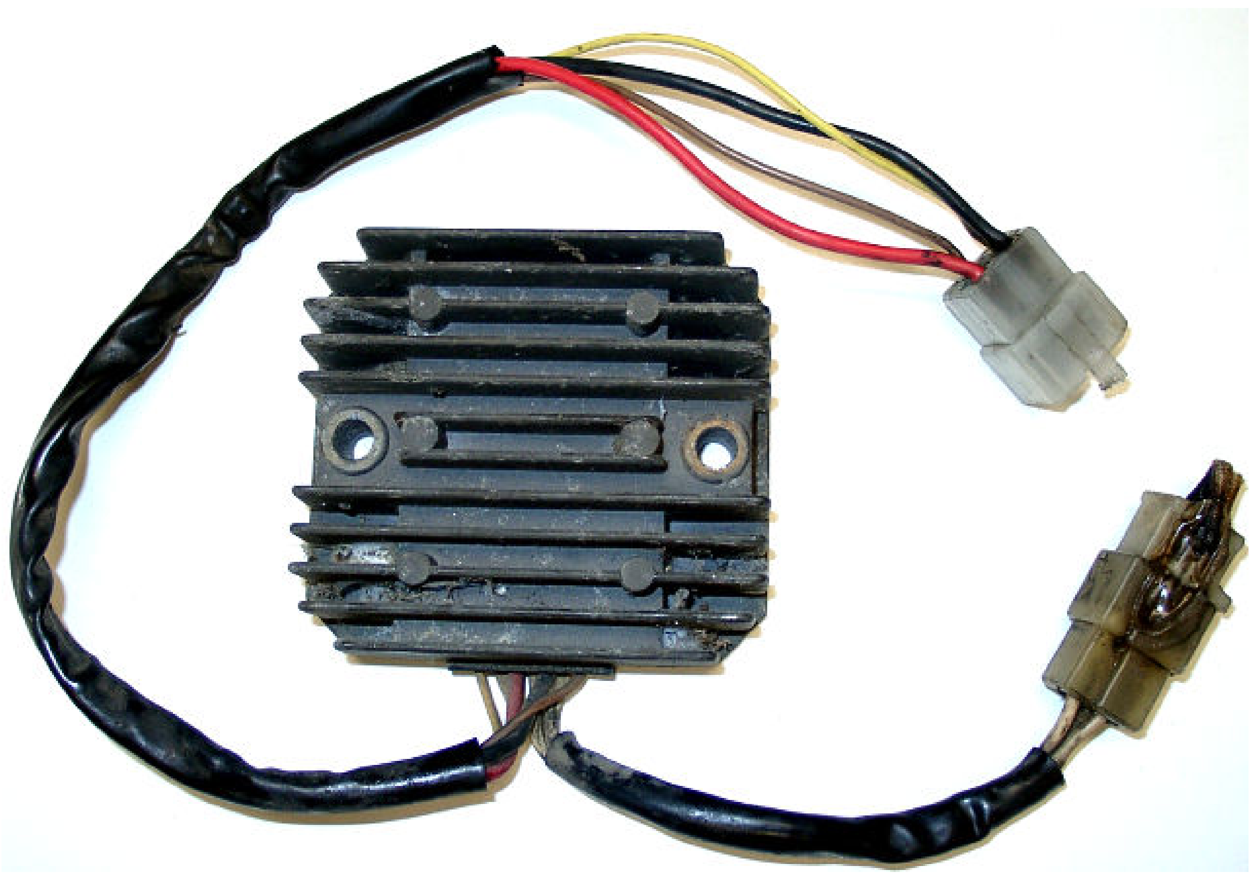
I will update this for fellow Vision Owners (Vision Riders Group).
Dave "Leather" Draper JET_AV8R@CSI.COM



[Fig #1] : Stator



[Fig #2] : Two (2) Permanent North/South Pole Magnets On Flywheel Rotor



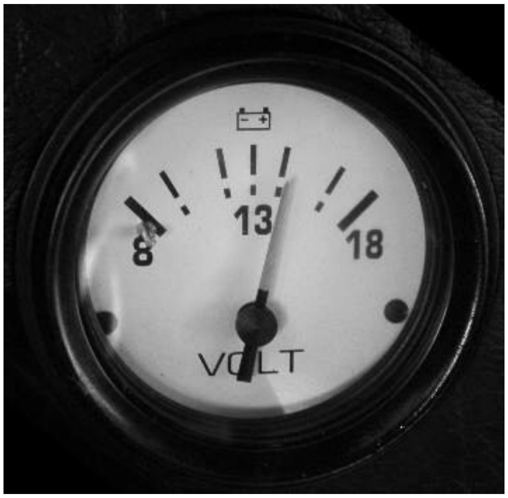
[Fig #3] : Regulator/ Rectifier

Yamaha Vision Charging System

(Reader's Digest Version)

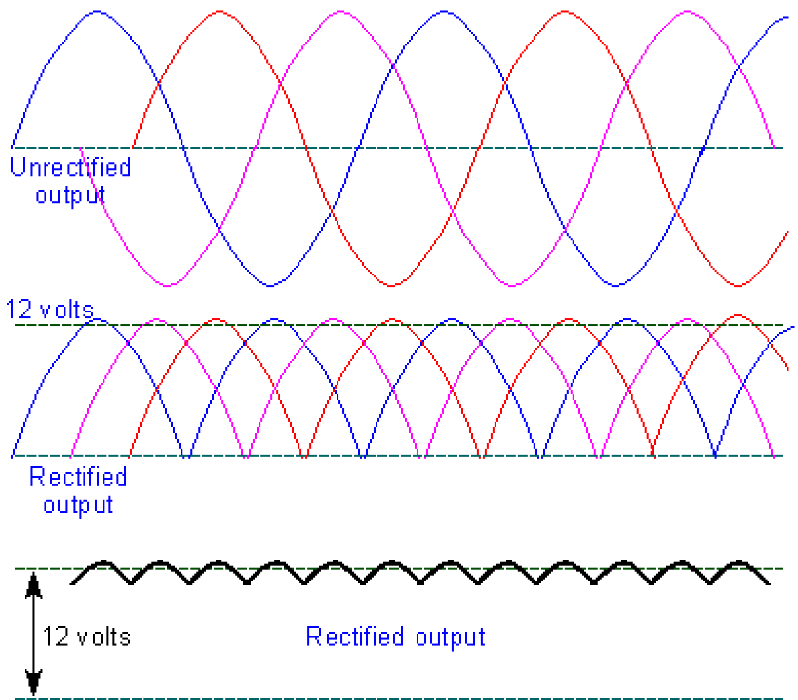
OVERVIEW

The Yamaha Vision (as most motorcycles) has an internal (inside the crankcase) permanent magnet rotor, 3-phase coil stator, and an external "Regulator-Rectifier" (RR) box. That is the whole system. The Vision generator is rated at 20 amps and should produce 14.5 (+/- 0.5) volts unloaded and about 14v loaded when RPM at 3000+. That's what the book says..... Practically speaking your bike should produce a solid 14v at idle.



HOW IT WORKS

A stationary Stator (Fig 1) is mounted to the crankcase cover and sits inside the flywheel Rotor (Fig 1). The Rotor has 2 magnets that (engine running) rotate around the Stator. These magnet produce a "North-South" pole flux (current) in the stator coils. This current is called "A.C." current since it flucuates +/- voltage in a "Sine Wave". The stator is wired so that there are actually 3 circuits producing A.C. current. Each circuit A.C. wave is 1/3 out of phase with the previous winding.

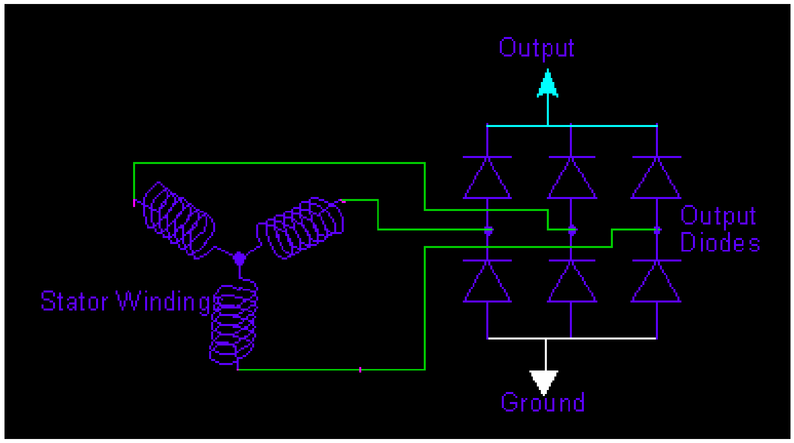


It is important to understand these things:

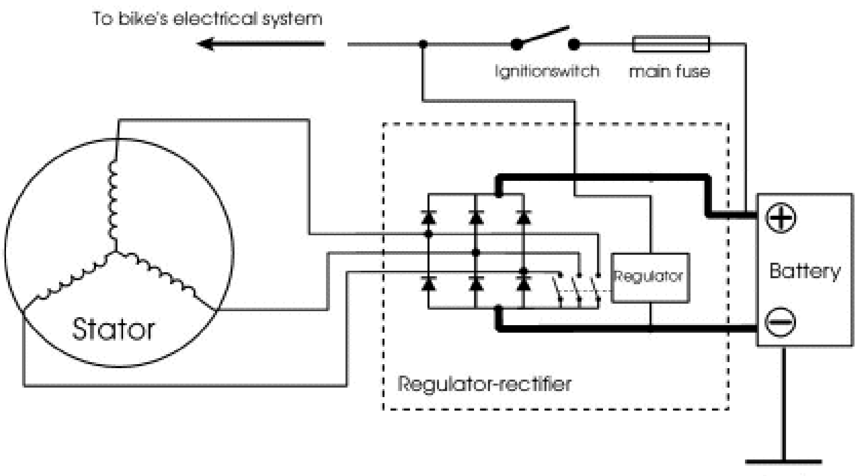
- The stator A.C. output voltage varies with engine RPM. The more RPM the more voltage. So, the stator output must be "Regulated" to provide 12-15 volts into the bike system. The raw A.C. output from each circuit is about 50volts ac at medium RPM.
- The A.C. output is convert to D.C. by "clipping" the bottom (negative) portion of the A.C. wave off. The A.C. current has been "rectified" so that only the positive portion remains.

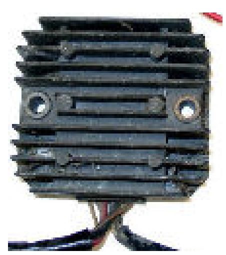
- The "Regulated" and "Rectified" output is shown above. It is 12-14 volts positive DC. Notice that the bottom chart is simply showing that the "rectified" output is somewhat "dirty". Since the negative output is simply chopped off the AC, the positive DC output is more like a slightly fluctuating "sawtooth" wave. This is good enough for automotive purposes but would wreak havoc on delicate computer circuit.
- Lastly, understand that the AC current is provide between any combination of 2 of the 3 white wires coming out of the stator. The AC phase is "floating" above the bikes -12 frame ground. That means that NO white wire is connected to ground. You measure the AC ouput of the stator between white wires only.

RECTIFIER / REGULATOR ("RR")



3 Stator windings & 6 diode Rectifier Bridge





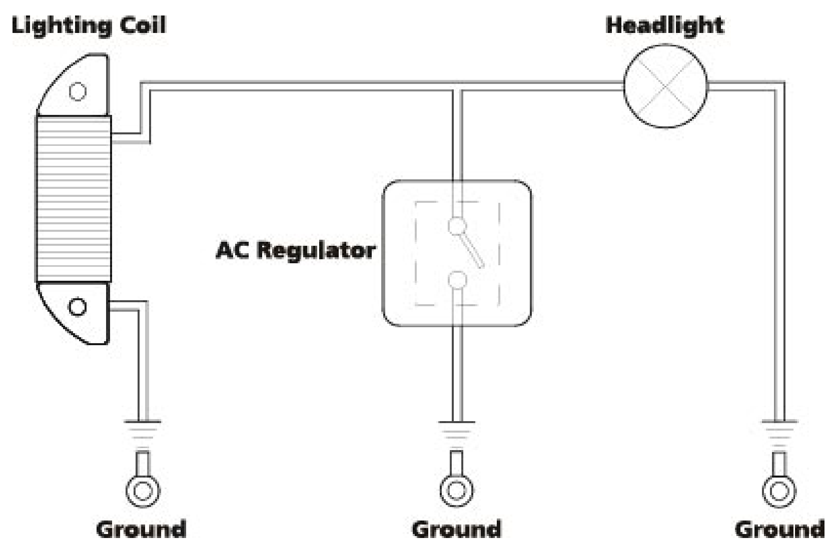
The Regulator-Recifier rectifies the A.C. current by using 6 diodes (2 per phase). The more complex part of the RR is how it regulates the higher DC currrent down to provide a steady state 12-14v. There are several varitions of the process but in simplest terms a circuit monitors the output voltage and "shunts" (partially diverts) the excess portion to ground. Consider these things:

- The RR has a lot of current constantly flowing through it (diodes, etc..). AND, the excess voltage is being divert directly to ground. So, the RR gets very hot in the process. The construction is totally about disappating this heats. Notice the heat fins. Less noticeable is that the RR circuits inside are encased in Epoxy and esentially glued into the heat sink metal body.
- The RR circuitry can regulate the output voltage several ways. How the Vision RR works is not exactly

know but here are some common designs and guesses.

- The RR actually regulates the AC output based on the DC output. It shunts (grounds out) enough of the AC output to keep the DC under 14volts.
- The RR may regulate all 3 phases -or- maybe just 1 or 2. For example: That means that 2 phases are producing full voltage while the 3rd is decreased to level off the DC ouput. Obviously, this puts a bigger burden on the regulator and that 1 phase. A better design regulates all three AC phases equally.
- ***Where*** the RR measures the battery system voltage can be different.
  - The simple setup is that the RR has 2 wires (Red=+12v and Black=ground). The +12 wire is connect direct to the battery. This connection obviously carries a lot of constant current which can (over time) build up some noticeable resistances (voltage drop) due to bad connections.
  - Another common circuit is shown above. This is used on MOST Visions (but not all). Notice that a seperate +12 volt wire is input into the RR. This normally is attached to the ignition (key on +12) and some other points of the bike to monitor voltage. The advantage is that this connection carries less current and is more a accurate picture of the charging output. This results in a normally higher RR output to the battery.

- Some Bikes (not Vision, but often dirt/track) use a "Lighting Coil". This is included for discussion purposes so you understand the slight difference. A Lighting Coil is often a seperate winding on the stator to produce AC current for accessories (typically lights). The "Lighting Coil" output may be regulated (or not) and may not be rectified either. Lights don't need DC (whereas things like relays and displays do). A simple regulated Lighting Coil oputput circuit would look like this:



WIRING (See Electrical Diagram)

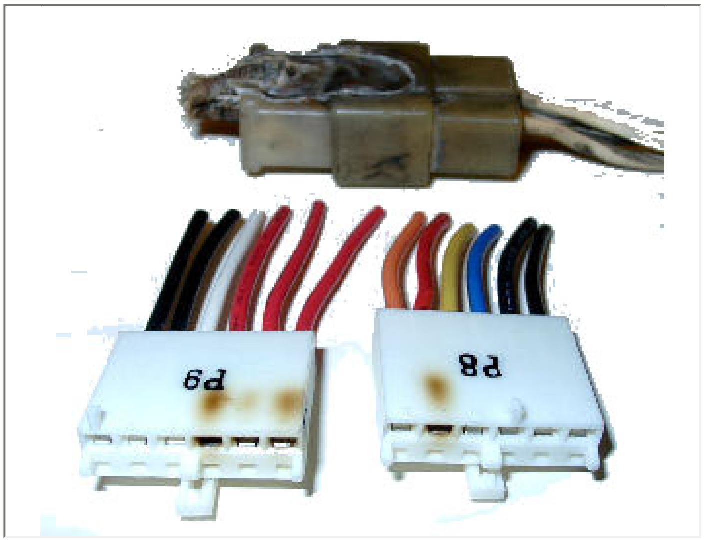
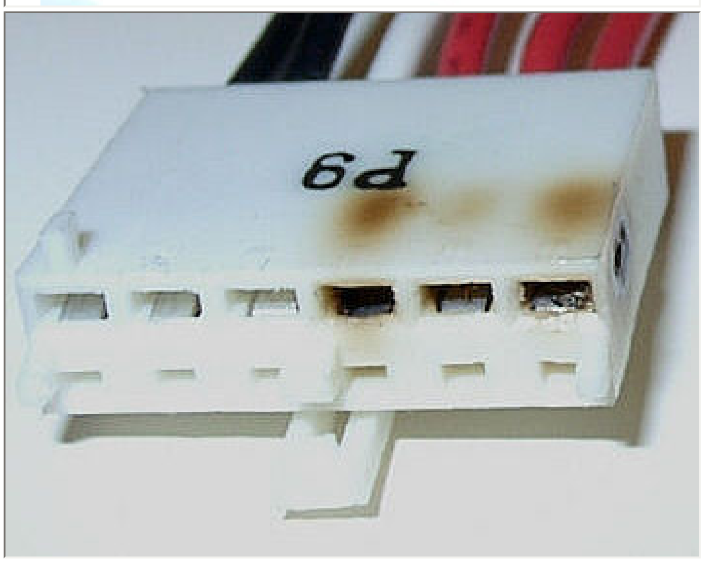
- **3 WHITE WIRES**
  - Connect from rectifier via a "NOTORIOUS CONNECTOR" to stator under crankcase cover (left side of bike). Order is not important. But the connector (pictured with RR top of page) is notorious for getting corroded/dirty and melting from voltage-drop resistance

.

- **1 RED WIRE**
  - Connects from Recitifier to +12 volt hot all the time from battery. This is the main output wire from RR to battery.
- **1 BLACK WIRE**
  - Connect from Recitifier to frame ground
- **1 BROWN WIRE**
  - This is the "Extra" wire found on some RR circuits.
  - This wire is connected to +12 at the ignition when the key is on. It provides the reference voltage to the RR. The advantage is that this is low current circuit and provides a more accurate reference than the main battery wire (RED) above.
  - Disconnecting this wire will have unpredictable results. The most likely screnerio is that the RR will view the reference voltage low (zero) and the RR output will be a constant 14.5 volts at all times. Another words, the RR will constantly charge the battery regardless of battery level.
  - This wire is not shown or used on some models. In fact, is **not** shown on my 1983 "RK" diagram but was clearly used on my bike.
- **1 YELLOW WIRE**
  - This wire is not on any diagram and is not used. Wire ends at the plug an goes no-where.
    Have been told that it was (on some models, Vision and others?) to be source of power for lights on Euro or Canadian bikes. The lights would only come on while bike was running.

Common Problems and Remedies

- **#1. Poor connections.** I believe this is this single biggest cause of stator/RR failures (besides the fact the Vision system is cheaply built). Yes, this is my opinion and here's why. A bad connector creates a resistance in a circuit. That resistance will generate heat. The most obvious example is the connector to the stator. You are generating 14v and 20amp. That's a lot of current and over time the conector get dirty / corroded. If the connector is dirty that current that HAS to go somewhere. ABSOLUTELY make sure you have good connections. Run new wires if you have to, remove connectors and solder suspect connections:
  - From Stator to RR
  - From RR to Frame Ground (Black Wire)
  - From RR to +12 post battery (Red Wire)

	**Here is melted stator plug. VERY TYPICAL on Vision. What do you think is happening in other parts of this circuit?**
	Here's a fun example of the same problem of voltage drop. This plug came from a desktop computer that died with all the symptoms of a bad motherboard: wierd video, strange sounds, no post, no boot, etc.. Guess what it was? Bad (5 yr old) plugs from the power supply. **DOES THIS LOOK FAMILIAR?**
	The heat and charring make this a cascading event. It just gets worse (slowly) over time.

TIP : Cut out and directly solder the 3 white wires on left side of bike going to internal stator.

- #2. The Vision Stator fails internally. Usually 1 of the 3 stator wire circuits breaks ("opens") internally or shorts through bad insulation to ground (the engine).

NO ... I repeat NO white wire should have continuity with ground! EVERY White wire should have continuity with another WHITE wire in any combination 1-2,1-3,2-3.

- #3. The Rectifier fails internally. You can use the fault chart from Electrex to isolate and check this. But it does require a good meter, some understanding of electronics, and paience. The RR is a heat sink surrounding an Epoxy filling circuit board. You cannot inspect it since a dismantled RR looks like this below (after using a grinder).

NO ... I repeat NO white wire should have continuity with ground! EVERY White wire should have continuity with another WHITE wire in any combination 1-2,1-3,2-3.

- **#4. Charging circuit testing and everything else is BEST described at: WWW.ELECTREX.COM**
  - In short (excuse the pun) this is what you are trying to do. You check to see if you have the correct DC output. If not, then check to see if the stator wires are good and also producing the correct AC current when engine running. If they are then the regulator is suspect. Check the diodes in the regulator. To be more precise:
    - Output after regulator box should be 14.5 volts DC engine running no load
    - Each stator wire should have continuity with the others (0.32 ohms by the book).
    - **No** stator wire should have continuity with ground (short or bad insulation)
    - Engine running, each set of stator wires (1-2,2-3,1-3) should produce 50v AC.
    - Test all 6 diodes to check they block current flow in the correct direction

- **#5. Keep your oil level high.** The stator is partially cooled by oil in the flywheel sump.

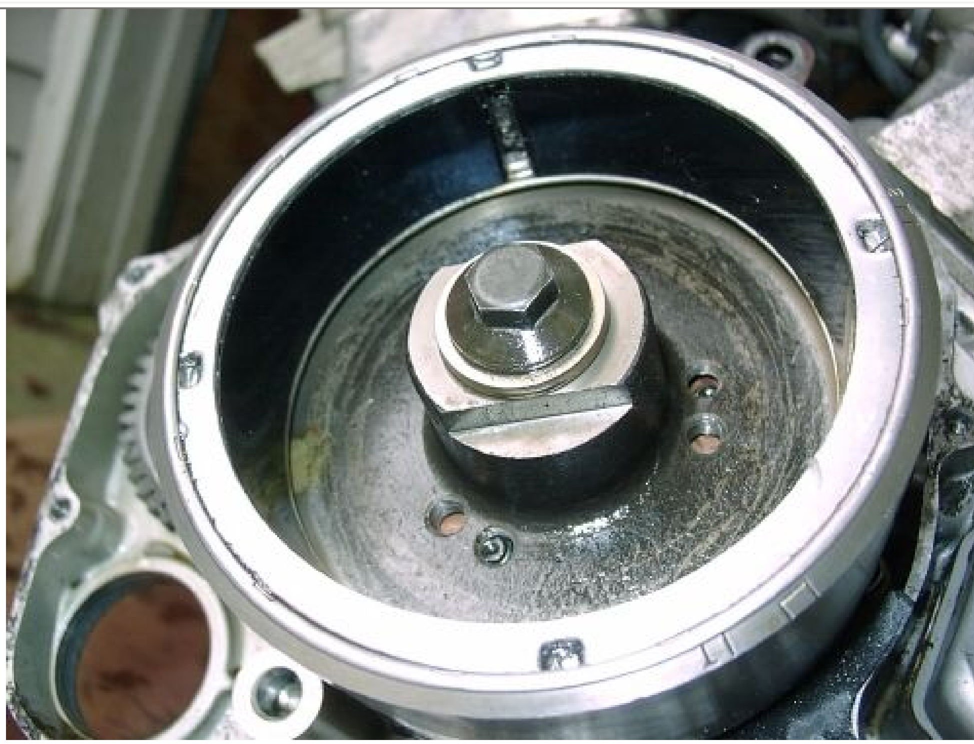
- **#6. To replace the stator** you must remove the left crankcase cover. This is NOT a big job. **BUT,** you must reinstalled the cover and wiring correctly **OR** engine oil will leak out of the crankcase bottom and you'll have to do the whole job over. One word: Yamabond #4.

- **#7. Oh Yeah ....**Make sure you have a good battery. A bad-old-dead battery will load down the charging circuit till it overheats and dies. You know when you put a battery charger on a dead battery and it PEGS the amp-meter? Well, that's what a bad battery is doing to your bike.

Cautions & Warnings

1. **NEVER run an engine with the battery disconnected. YES you can do it and YES it will fry your charging system.**
2. **DO NOT jump the battery with the positive/negative cables reversed. You will fry the regulator. YES, jumping a good battery under normal circumstances is perfectly O.K.**
3. **DO NOT confuse the stator wire plug with the TCI pickup plug. They both look the same (4-pin connector) and if you plug the stator plug into the TCI (because you have removed the TCI to get to the stator plug & regulator box) you will fry the $400+ TCI module. YES, a good but unlucky rider has done this.**

Stator



Flywheel with 2 magnets inside

WHAT A GOOD CHARGING SYSTEM LOOKS LIKE

Engine Off

On (NOT running)

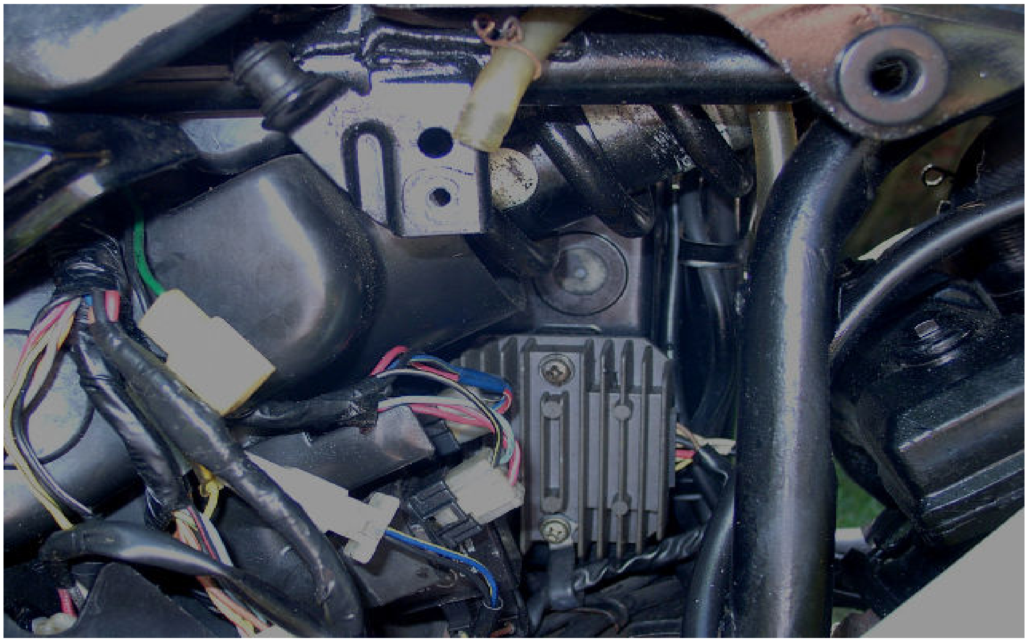
Engine Runnning

I installed a voltmeter onto my bike to be sure I knew what was going on. There are other ways to achieve this. A circuit to light GREEN when the battery is charging and RED when the battery discharging would be good. There are commercial version of this available for about $40. The voltmeter above is made by TELEX. Its a cool piece because it was made for watercraft and so is waterproof. AND... Telex is selling off this line so if you can find one in your marine stores they going for about $25 now (9/2002).

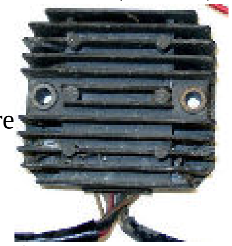
What should a good charging system look like on the Vision. Well, there it is above. Little over 14 volts when running and the battery needs charging. And unless you're doing long rides.... the battery always needs charging.

Click For The BIG Picture

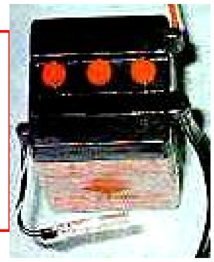
What Goes Bad and Why



Charging systems have typical failures, and some more common than others depending on how well built they are. Here are the common failures.

- Stator Winding failure
  - One of those 3 wires in the stator as broken internally or (worse) has shorted to the engine and ground. This is most typical because the stator is exposed to a lot of heat and vibration inside the engine. Wire insulation also decays over time. Lastly, if the regulator fails or the current draw from the bike is too great (bad battery or bad corroded connections) the stator wiring and connections can begin to melt over time. You will see melted plugs and scorched stator bodies when this happens. Lost phases will decrease AC (and DC) output. And/or shorted wires can fry the stator and regulator too.
- Rectifier failure 
  - The rectifier uses 6 diodes arranged to "chop" the AC output from the stator to DC current. The DC is conditioned a little bit more with capacitors, etc... since "rectified" AC is still a little "choppy" and not good for newer LCD microchip driven displays and other solid state devices. Needless to say, if the diodes burn out you have problems. Depending which diodes go the DC voltage output can be lower to nonexistent (zero).
- Regulator failure
  - Less likely but possible is that regulator circuitry fails and the output will be too little or too much. Too little and the battery eventually dies. Too much and the battery will overheat, bubble over and self-destruct.
- Heat Disappation
  - There is a VARIETY of discussion about the stator and/or rectifier overheating and failing:
    - The stator is cooled by the oil under the crankcase. If the oil is allowed to get low then the stator can potentially overheat and fail.
  - The rectifier does not charge the battery all the time. If the battery is full up then the rectifier will "SHUNT" the electric pulse from the stator back to ground. In laymans terms ... "SHUNT" basically means the white wires are grounded. The stator pulse goes nowhere. This is not exactly what's happenning but close (DON'T GROUND THE WHITE WIRES!). When this happens the electronics in the Rectifier are handling the excess power and things get hot. That's why it has heat fins on it.

- **WHAT DO I BELIEVE ??**



  - **Hey.. since I write this I get editorial license ==>>**

    I personally believe most everyone's charging problems stem from either a bad battery, low oil or MOST IMPORTANTLY bad connections on the bike. ANY bad connection on the bike induce voltage drops acroos the charging circuit that overheat every component in it. It will melt the WHITE 3-wire stator connector (VERY TYPICAL), and ultimately overheat the STATOR and Rectifier. A bad battery will overtax the charging circuit and melt it.

Common Scenarios

- Bad connections in the charging system wiring causes a "voltage drop" across the wiring. This in turn causes an increase in current draw from the generator. The extra power going to bad connection is converted to heat. The heat produced in either the stator or rectifier causes a failure. You might see the signs of melted plugs and wires or heat deformation on stator or rectifier bodies.
- The battery itself is causing the heavy current draw mentioned above. This could be a bad battery -or- a drained battery that you are charging with the motorcycle charging system. People often associate charging system failures with "jumping" a battery. Its not the jump that did it most likely (unless you hook the cables up backwards which instantly fries the rectifier usually). The problem is that your motorcycle charging system is not heavy duty enough to charge a dead or bad battery.
- Crappy components. The truth is the Vision stator is cheaply built. The stator wiring fails. Also, both the stator and regulator could be cooled better for durability. Any way you look at it the system tends to fail prematurely.

Myths

These are some myths concerning charging systems and here are a couple:

- **"Jumping starting will damage your system"**
  Done correctly .... **untrue**. If you jump a dead battery that is not good (will not hold a charge) the charging system may carry a heavier load for longer than it was designed for. Remember the Vision system is "rated" in a perfect world for 20amps ... but **NOT** for the next 2 hours. Add to that some bad connections, headlights, the stereo and A/c (I'm kidding here), and .... you get my point. You may overheat and ultimately fry some part of the system (stators , regulator, both...). If you jump the battery with the cables reversed you will also cream the system (most probably the regulator).
- **"Disconnect one of the 3 stator circuit wires will help the stator run cooler and last longer because there is less unused electricity flowing through the system"**
  This actually sounds good in theory. No, really. But...... **untrue**. Don't take my word for it. Call any knowledgeable shop in the world please. And, really, if this were true this technique would be used on every generator in the world and quite clearly it is not, so_ooooo.....
- **"Magnets never go bad"**
  Sort of ....**untrue**. Magnetism is a nebulous thing (how often do you get to use that word) and from grade school science you should remember that iron magnets tend to lose strength with vibration and heat. Where are those stator magnets again? How often is this a problem. RARE. About as rare as a spark coil going bad. BUT, it is possible and should not be totally left out of your thinking. I had an alternator rewound twice for a car that never quite put out a great solid voltage when loaded up to its rated amp output. What's left that can be wrong? Crappy magnets. Remember in a motorcycle (unlike an all-parts-in-one alternator) your charging parts (stator, magnets, regulator) are all separate pieces.

Preventive Measures For The Yamaha Vision charging system

Unless you buy and install a newer aftermarket stator and regulator (see ELECT REX link below) you can't make it a "better" system. So, the trick is to make what you have bullet proof. Here are the tricks **recommended by others** lifted verbatim from the Vision Forum archives.

- Make all connections in the charging system clean and protected. Solder wires to their respected plug pin ends. Use WD-40. Use dielectric grease on the outside to "water-proof" connectors.

- **QBS**

  Using plain simple common wheel bearing grease, put a light coating of grease in the internal areas of the stator coil connector. An even better permanent fix would be to clip off the male and female components of the connector and hard wire/solder the connections. The wires are white in color on both sides of the connection so it's not critical which ones are soldered together as long as a bike wiring harness wire is connected to a stator wire. If for some reason this connection needs to be broken in the future, simply cut the soldered wires and then resolder them upon reassembly.

  Electrical system operation:

  The V alternator puts out 100% of its capacity ability all the time, given the RPM it is operating at. What the bike load doesn't use is shunted to ground by the regulator. The connector carries whatever amps the alternator is putting out all the time regardless of bike load. Low Rpm = low amp output = low amps passing through connector= electrical needs deficiency made up by battery. High RPM=max amp output=max amps passing through connector=amperage left over after bike load is serviced is shunted to ground. Note that is both cases all amps pass through the connector before any electrical distribution or alteration is done. The alternator always puts out the most it can no matter what is happening down stream. Therefore, the connector is always passing (or attempting to pass) the max amps available.

  The way the problem develops:

  When the connector is rendered inefficient due to corrosion the alternator continues to put out all the amperage it can. It doesn't know or care about the condition of any of the electrical components that follow after it. It just stays busy doing its thing. However, since the connector is now not able to pass through 100% of the energy going into it, it passes what it can and the rest of the energy backs up in two places and defaults into heat at both places. One place is the connector itself and the other is the alternator stator coil. The heat in the connector melts the connector plastic which turns all gunky and greasy and nasty and generally adds to the connectors' ineffeincy which in turn compounds the problem. The heat in the stator coil melts the coils' insulation which eventually fails and allows the energy the coil creates to go to ground via the engine cover that the coil mounts on. That is why the test for a failed coiled looks for continuity between any one of the stators' 3 coils (accessed through the 3 white output wires in the stator side of the connector) and ground (the engine). Continuity indicating a failed stator coil. Don't forget to please not loose track of where the problem originated, namely corrosion within the stator connector. The Big Clue here is the condition of the connector. A melted nasty connector got that way from heat. Where did the heat come from, inside or outside the connector? If inside, what was the source?

  The way I see it you have two options. 1. Clip off the female and male halves of the connector and then solder each former female wire to a former male wire. Of course, each resulting soldered joint must be individually insulated. It doesn't matter which former males are soldered to which former females. All the wires on each side of the connection are white. This what I have done and it has served me very well for the last six years even under extreme heat and load(130/100 watt headlight bulb)situations. The only usual reason to use the connector is replace the stator coil. That problem is now fixed and the side left engine side cover shouldn't need removal for a very long time. When that time comes, simply clip the soldered connections and then resolder them upon reassembly. 2. If you are paranoid about clipping off the connector and it is still serviceable, clean the connector pins and sockets to bright and shiny condition and then apply a thin film of common non metallic wheel bearing grease to all metal connector surfaces. Then reconnect as usual. This process forms a vapor barrier that keeps air borne water away from the connector metal, thereby inhibiting corrosion formation.
- Make sure you have and keep a good battery. You can use a multi meter to measure the amp draw on the battery after starting. With lights off it shouldn't be more than about 5 amps (if that). Much more and you have some problem going on there.
- "The stator rotor is coated. Definitely don't damage it with steel wool. It produces an electrical field with the stator, and should be left alone. "

Repair and Maintenance of The Yamaha Vision charging system

Get and Use A repair book !!

The following discussions have been copied verbatim from rider messages on the Vision forum. They concern repair or replacement of the Stator under the left crankcase cover. In short, you must carefully seal the crankcase cover back to the engine or you will have dreaded oil leak. This is particularly important around the stator and spark pickup wires which exit the crankcase cover.

Stator Wires exiting crankcase cover pictured on left.

- **Yamabond #4 by Dan**
  1) Go to Yamaha dealer and obtain a tube of Yamabond #4...nothing else(including Permatex#2) is quite like it as far as tenacity is concerned.
  2) Take left cover off again, clean ALL old goo out thoroughly.
  3) Using fine sandpaper, clean carefully ALL aluminum surfaces that the grommets come in
  contact with ...every stinking edge...until bright shiny and clean.
  4) Clean ALL old goo off of every bit of the grommets themselves...and wires.
  5)Run a thick ring of Yamabond around both grommets, and directly on the wires where they pass through the grommets...work the wires in and out of the holes a bit to ensure the sealants coating the holes.
  6) Wait about ten minutes for the Yamabond to set up a bit.
  7) Smush the grommets back into the slots they belong in...carefully place a NEW gasket onto the left side of engine case, and re-assemble.
  8) Wait 12 hrs if you can before refilling with oil to make sure the stuff sets up well. NO LEAKS SO FAR IN DOING THIS TWICE THIS WAY AFTER 4 PREVIOUS ATTEMPTS TO SOLVE SAME LEAK.
- **Charge cures by bernard lajoie**
  source a re-wind from "Rick's Stator"(west coast)or Cycletronics(use to be"Willy's")in Alabama(east coast). For reg./rect.replacement, throw the yamaha part in trash,go to salvage yard,use either Honda or Kaw. For Honda use cm-400/450 twin or cx-500/650twin only! Wire in this order,3 yellows to stator(one per leg)red w/white to battery pos.,small black wire to (switched HOT)this is the volt reg.wire. If not hooked up bike will over charge(16-19volts,not a good thing). Last hook green wire to battery ground. Some Honda reg./rect. will have (2)red w/wht@(2)green just splice together(red to red,grn to grn). For Kaw.use late model kz/zx 550,kz/zx750,kz/zx 1000/1100 (these are the 2-valve motors,zx=GPZ)or 600r(ninja)4-valve,wire in this order,3 yellows to stator(one per leg)white w/red to battery pos.,brown(smallwire)to(switched HOT). This is reg./rect.wire,black to battery ground(IMPORTANT:you will need the gang plug that plugs into reg./rect.w/2-3in of wire to wire correctly I.E.cut from main harness as nessary,sometimes the salvage guys don't like this). Your bike will now charge@14-14.5v,also ck.battery pos.&ground cables,these are prone to fail.
- **Removal tips by QBS**
  Regarding removal of the three Phillips Head screws (and for that matter, all Phillips Head screws in general) that attach the stator coil to the left engine cover: If you don't have an impact screw driver with a properly sized bit, don't touch them until you do.

  Specific to the V: after the left engine cover is off, lay it on its' side, outside down, on a wooden surface. Then use the impact driver and hammer to loosen the three screws. Reattchment with the impact driver is the reverse, being carefull to not over tighten the the screws. First tighten the screws as tight as you can by hand. Then give them one or two (Max!) impact driver blows. who it might be that may have to remove them in the future.

  Another tip: If you haven't got an impact driver, or the screw heads are too trashed to be of any use, but you do have a little room to work with around the screw head area: Use the smallest Vise Grips you can get and grab the screw head very firmly and attempt to turn the screw head in a counter clockwise direction. I've used this technique many times over the years and never fail to get a small thrill of satisfaction everytime I overcome the challange of a screw head that at one time would have caused me hours of frustration and grief.

  Another tip: If you don't have an impact driver, you can simulate one using a screw driver and a hammer. Insert the tip of the screw driver into the screw head, firmly grasp the screw driver
  handle and preload the screw in the desired direction of screw rotation, then hit the head of the screw driver with a stout hammer blow. This technique can be used for either direction of screw rotation.

  Another tip: A damaged screw head, bolt head, or nut can sometimes be loosened by using a sharply pointed punch and hammer to rotate it in the desired direction.
- **It's time by QBS**

It's time to reattach your starter clutch. Get a Haynes manual. Remove your stator rotor/flywheel. Remove the three allen screws that attach the SC to the back of the rotor. Inspect the clutch rollers for flat spots and replace all damaged rollers. Inspect the clutch housing for cracks in the roller area. Replace or repair(weld cracks) housing as necessary. Reassemble and reinstall SC. When attaching SC to back of rotor, use new allen screws that protrude 2 or 3 threads beyond the inside surface of the rotor. Use Loc-Tite on these screws and between the very clean oil free mating surfaces of the SC and rotor. After the screws are tightened, pean their protruding threads. Reinstall the rotor SC assembly. If the future ever requires removal of the SC, grind the peaned threads level with the surface of the rotor and unscrew them as usual.

Before final assembly of the left engine cover, do a continuity check of the stator coil as described in the Haynes manual. If continuety is found, replace the stator coil. When reassembling the left engine cover, inspect the stator coil connector for corrosion related internal heating damage. If found, seriously consider clipping off the connector and hard wiring (soldering) the connection. If the connector is still servicable, at the very least you should lightly grease the inside of the connector. If you don't, stator coil replacement certainly lies in your future. If the above SC attachment and stator coil connector procedures are performed, the left engine cover should not require removal for many years, if ever again.

After you reattach your SC you'll be amazed at how quite the engine is at idle. Your information regarding V engine life is correct. A well maintained V should go at least 100K with no major internal problems. Mine is working on 73K.

- **Flywheel removal by pat sullivan**
  I recently removed my flywheel to inspect the starter clutch. I used an impact wrench, and with it I did not have to hold the flywheel at all. I checked with the local Yamaha shop in Santa Clara, CA and they indicated that they use pullers for Automotive Harmonic Balancers that they get from local suppliers. I bought one of these for around $30 and it worked fine. Later I found out that you can rent these at several tool supply rental houses.

  As indicated earlier in this forum, you have to whack the bolt on the puller quite hard in addition to using the impact wrench. I thought for a while I wasn't going to get it off, but eventually it popped off when I hit it. Put a padded box under the flywheel while you are doing this to catch the flywheel and the starter clutch rollers and springs that are likely come out when the flywheel finally comes off. You'll probably also need a impact socket to do this. I split my regular socket on the first try.

  Took stator flywheel off on december of last year because I needed to change the roller pins and get the base where those pins go to welded back as it was cracked. This is how I did:

  o Remove left cover

  o Put the appropriate size socket + wrench on the flyhweel nut (a.k.a big nut even though right now I do not remember if it was a nut or a bolt. Who cares? =)

  o Get a bolt like 2-something inches long (a.k.a. small bolt) and then turn the flywheel (using the wrench on the big nut) until you can jam the bolt between the bike frame and those holes that were drilled on the outside of the flywheel for balancing. The idea is to use the small bolt to stop the flywheel from turning while you play with the big nut.

  o Holding the small bolt, so it will not pop out when there is no compression load on it, loose the big nut

  o Using an adequate puller, take the flywheel off. What I used was a a 3-bolt puller like the ones used to, say, pull steering wheels off (something that can be found at your friendly Autozone or similar store). Now, the 3 bolts where the wrong size and pitch for my need, so I went to a hardware store that specializes in nuts and bolts and got 3 bolts (allen, not that it matters) that would fit on the thread and would be long enough so they would be in the puller when I threaded them into the 3 flywheel holes. So, their length really depends on the puller you are using.

  When you are ready to put the bugger back, do remember to align the flywheel as there is a key/notch arrangement between flywheel and the conical base where the bit nut is bolted to. Besides that, use the small bolt to hold the flywheel in place as you tighten it and you should be home free.

Misc Discussions

Voltmeter?

- **Voltmeter by Burke Storti**
  Has any body figured out how to install a volt meter or other indicator which can tell the
  condition of your charging system while the bike is being ridden?
  With this, at least we would have some warning that the stator is "pushing up daisies".
  I had a similar experience as Dan. I came home from a 150 mile ride to discover my battery

was dead when I killed the motor in front of my house & could not get it to start.

- **I have a voltmeter, and some comments on what it shows by John Logan**
  I installed a voltmeter, a clock, and an oil pressure gauge across the dashboard inside my '83's fairing. I glued a hardboard backing to the thin plastic dash for more support.

  The gauges I chose were the "Cockpit" series from VDO. They match the Vision's instruments, except that they have blaze orange rather than yellow needles. They have held up perfectly for many years.

  It's a very pretty setup. The wiring for a voltmeter couldn't be simpler: you just need a hot wire and a ground. One thing I have found is that the voltage tends to vary in mysterious ways, even when the stator and regulator are new. Revving the engine produces a drop in voltage over certain rpm ranges, even though there is sufficient voltage at idle.

  I also have an indicator LED on my TDM 850 that glows green, yellow or red depending on the voltage. This too shows strange voltage drops during parts of the rpm range.

  Following the excellent diagnostics given in the electrexusa.com site, I systematically brought the resistances and voltage drops in the Vision charging circuit within specs. This helped but did not completely remove the strange voltage dips with engine rpm I have always seen with the voltmeter.

  The voltmeter is a great help when the stator is failing, since it gives the warning you need to avoid getting stranded. The rest of the time it should not be too closely examined.
- **Regular voltage check question by QBS**
  Thank you for an excellent gauge piece. Could one get the same benefit of impending stator doom warning by doing a multi meter voltage check across the battery terminals before the first ride of the day at say 3500 RPM and keep a mental note of the reading for future comparison., kind of like checking the oil. Battery access is very easy. I realize this a somewhat of a nuisance and won't reveal problems that may happen later in the day, but stators don't seem to fail catastaphically. Rather, they sort of sneak away and before you know it they're gone.
- **makes sense to me by John Logan**
  I think your procedure makes sense, but it would be more than I could ever force myself to do routinely. For the '83, a voltmeter in the dash is cheap and easy. Some cost well below $20. For the '82, I'd recommend the LED type -- it's just a little button with a glowing bulb in it, and should be easy to find a spot for. You need a couple of inches of clear space below the mounting hole.

Stators Cooling

- **Stators Cooling by Mark Moreland**
  Just found this site. Read a few dozen messages but did not see a suggestion on stator cooling.

  I was an REV member about 1990. I obtained several years newsletters. One had a tech tip that suggested adding an oil spray orifice to the bolt in the oil gallery of the stator end of the crankshaft. I recall the orifice was drilled at ~.040" dial, and was counter bored larger to help break up a stream and make the oil sling outwards to the stator.

  Does anybody recall this?
- **Red: stator cooling by Chris Arrowroot**
  I've seen that fix too, but I can't believe spraying hot oil on the stator would improve its situation.
- **Oil Cooled Stators by Dale**
  The Vision's stator is already oil cooled, but the flow is too limited or not even, resulting in the over heating at high Ramps. Increasing the oil flow would help but I have no idea as to how to make sure that it is flowing (in and back out).
- **Possible source for this stator cooling tip**
  by John Logan
  I do not know whether drilling the rotor bolt helps the stator longevity problem, but I have a clipping from the March, 1984, issue of Rider Magazine discussing a similar fix for the Venture, which is very much like a four-cylinder version of the Vision:

  "One of the foremost problems acknowledged by Yamaha has been stator failure. The alternator has been running in an insufficient oil bath, which has caused the stator wires to overheat and short out. Ours failed at 11,500 miles. Most have been giving up at around the 8000- to 10,000-mile mark. In order to lower the operating temperature and increase the reliability of the AC generator, an improved rotor bolt with a 0.7 mm [0.0276 inch -- JAB] oil passage must be installed. This supplies additional oil to the generator area to cool the rotor and stator. An improved [Venture] stator has been designed for '84."

I'd be interested to know if anyone has experience with this type of fix for the Vision or has examined the improved rotor bolt for the '83 Venture. If the latter just has a bore through its center, that should be easy to accomplish. Note that the article's bore is smaller than the value Mark gave. I would be worried about effects on oil pressure -- does anyone have information about this?

- **response by Jason Morris**
  Yes the Venture has a hole drilled thou the bolt but it is larger closer to the crankshaft.A "wire" rests inside the hole keeping it clean and free from blockage.The hole is only about 1/64" at the case cover side.This keeps the volume and pressure high at all times.My '83 venture had the update and was standard '84 on.But you can't use a Venture bolt,the size is completely different.You'll need to have your bolt drilled at a machine shop or do it yourself with a cobalt or titanium drill bit on a drill press.
- **Fix the problem by Jeff Swan**
  The problem with the stators is the excess heat created by the corrosion on the connections. The drilled stator bolt was a stop gap measure by Yamaha when stators started burning up. I guess they thought they needed more cooling when the problem was the connection and they knew they couldn't get everyone to clean the connections. I did this mod to my Vision, but that hole is welded up now as I have become better informed. I don't feel it will keep your stator from burning up but will delay the inevitable. I say keep the oil where it can do it's job (in the main and rod bearings) and fix those connections. Use some synthetic oil for cooler running oil tamps if nothing else.

Battery Trivia

Cranking Amps:
Cranking amps is the spec that tells you how much current a battery can produce for 30 seconds at a temperature of 32° F and not have the voltage on any of the individual cells drop below 1.2 volts (7.2 volts for a 6 cell automotive battery). This may also be known as MCA or marine cranking amps.

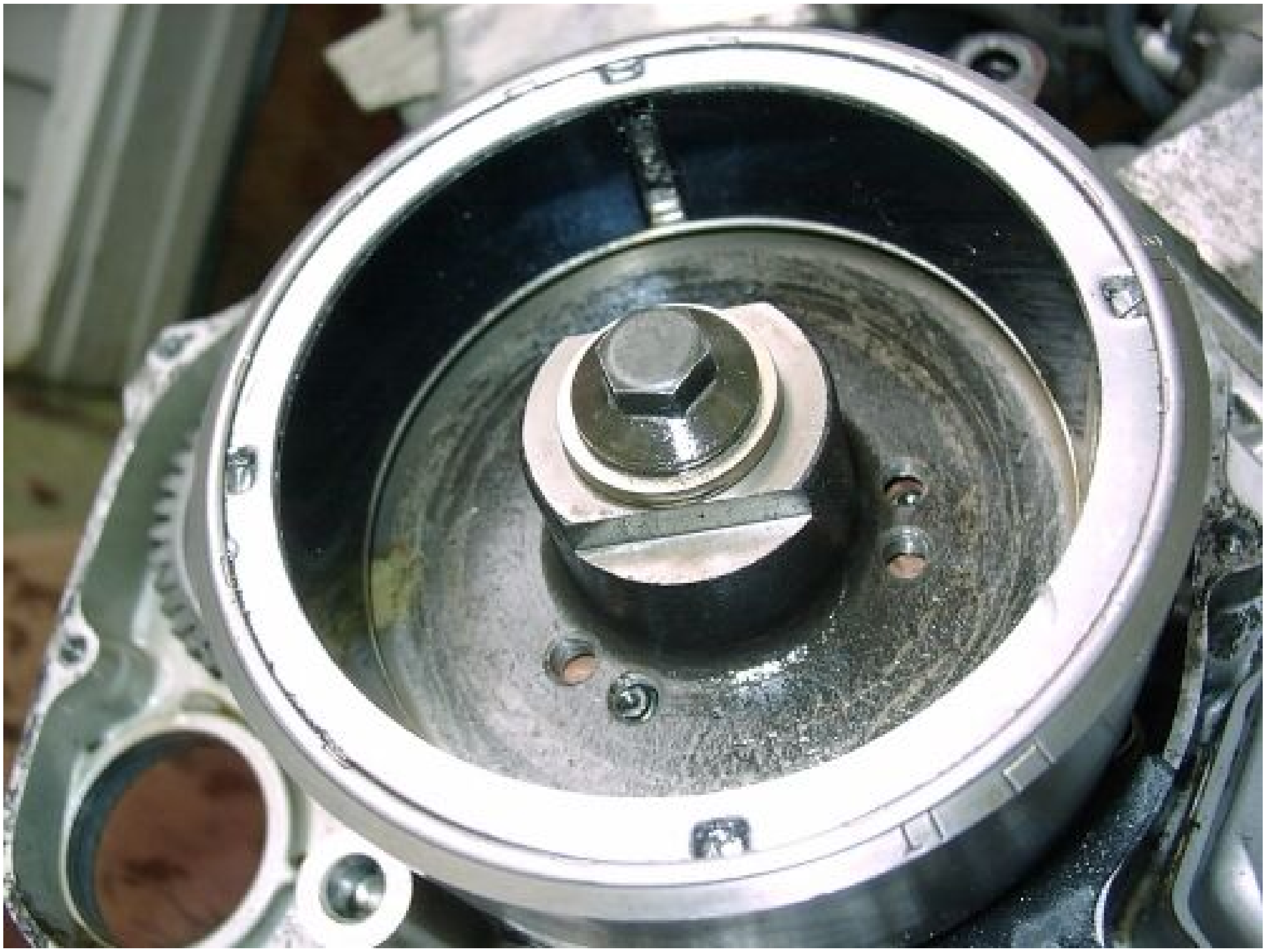
Cold Cranking Amps:
This is the same test as cranking amps but is done at 0° F. The CCA spec is especially important if you live in a really cold climate. Since the chemical reaction that produces electrical current in the battery slows down as the temperature drops, the battery can produce less current at colder temperatures (especially below freezing). When comparing the current capacity of batteries, make sure that you have some standards to qualify the current ratings. If you see the current rating without CA or CCA, you don't know how the battery was tested and the current rating is virtually useless.

Reserve Capacity:
The reserve capacity is the time that a battery can produce 25 amps at 80° F before the individual cell voltage drops below 1.75 volts (10.5 volts for a 6 cell automotive battery).

Deep Cycle vs Standard Battery:
A normal lead-acid battery will be damaged if it is completely drained (even if it's only one time).
A deep cycle battery is designed to survive being drained multiple times. Deep cycle batteries have more reserve capacity but have less cranking amps for a given size. A standard battery would have more total surface area on its plates when compared to a deep cycle battery of equal size. This extra surface area provides more area for the chemical reaction to take place and therefore produce a higher output current.
The electrolyte in a deep cycle will be a slightly more concentrated sulfuric acid than a standard battery.

Links

[WWW.ELECTREX.COM](http://www.electrex.com) ElectrexUSA at (888) 369-8359 or (760)433-0184
ELECT REX are the motorcycle stator guru's. They carry new stators for everything including the Vision at about $125.00US and have a full one year warranty. Ask for Ritzo or Paul. Their downloadable flow chart (PDF-or- DOC format) for diagnosing charging system faults is right on. Their stators (I believe) are made in England, but they have a fully stocked location in California.




TEMP
FUEL
km/h
mph
x1000rpm
VOLT
OIL
HIGH BEAM
NEUTRAL
YAMAHA

Rebuilding The Yamaha Vision Motorcycle TCI Electronic Ignitor Module / Electronic Ignition

This guide explains the basic theory behind possibily rebuilding a Yamaha Vision TCI (or any motorcycle ignitor box for that matter). Have I done it. No. Has it been done by others. Yes. Unfortunately, we don't have any "DETAILED" explanation of a rebuilding project. But there is enough info here to get you pointed in a GREAT direction.

This is linked from the (Vision Ignition FAQ) & my (Vision Home Page).
If you have inputs to this page .... PLEASE email. I will update this for fellow Owners (Vision Riders Group).

Last Update June 2003 ©Dave "Leather" Draper JetAv8r@JetAv8r.COM

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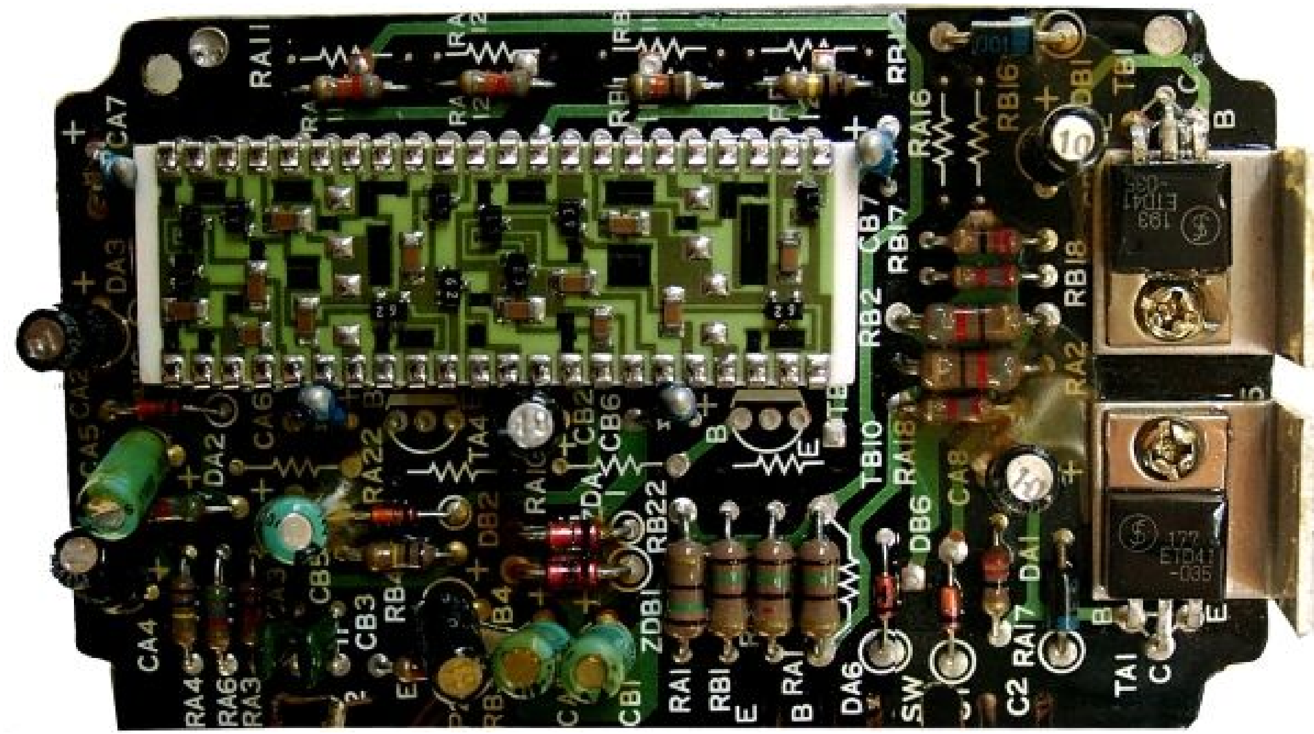
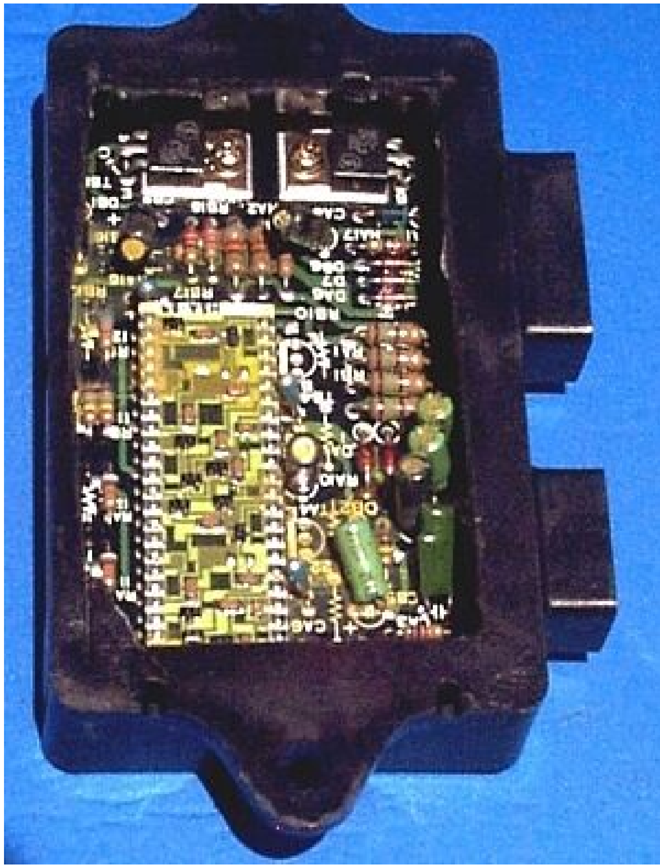
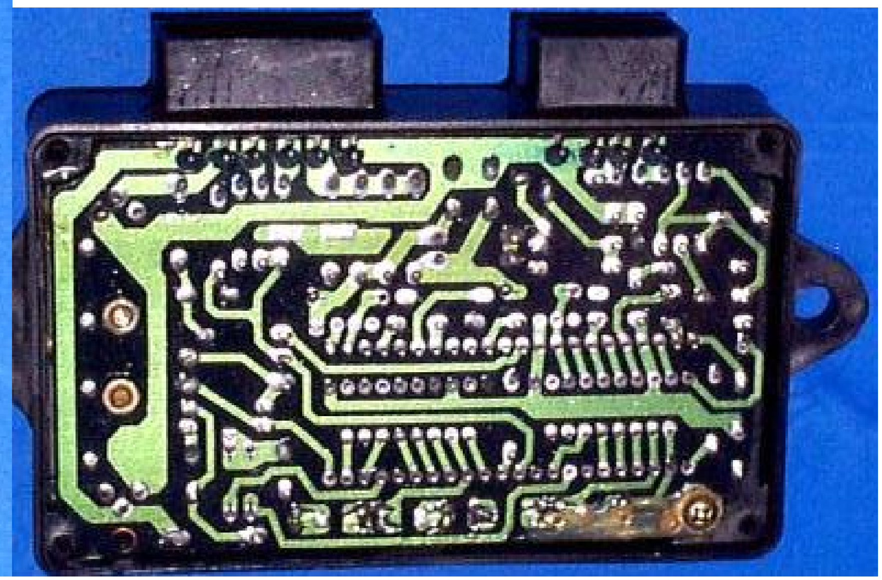
Link Back To Ignition FAQ

TCI Circuit Board

Click On Photo For Even Bigger Version



PCB Board taken out of box

TCI box with "porthole" cut away in bottom -------- TCI box with Top cover removed

Component List for Yamaha Vision Hitachi 12-06 TCI Ignitor box

TA1 / TB1	Manu facter	Type Size	Transistor FAST Switching Power Transistor Darlinton NPN	Comments
	Fuji	T-220	**ETD41**	
Recomended Replacement. Has been tested successfully				
$1.60	**ON**	T-220	**MJE5742** **Spec Sheet is HERE as PDF File** **Found at** www.Digi-Key.com	Perfect for this application Same size as original
$2.50	**NTE**	T-218	**NTE2317** http://www.nteinc.com/specs/2300to2399/NTE2317.html	Good heavy duty alternative Larger Footprint Than Original

Resistors		
RA1	RB1	150 Ohm 1/4 w
RA2	RB2	620 Ohm 1/4 w
RA3	RB3	1000 Ohm 1/4 w
RA4	RB4	100,000 Ohm 1/4 w
RA6	RB6	5600 Ohm 1/4 w
RA17	RB17	22 Ohm 1/4 w
RA18	RB18	2700 Ohm 1/4 w
** RunTime Resistors		
RA11	RB11	62,000 Ohm 1/4 w
RA12	RB12	90,000 Ohm 1/4 w

**** RA11/RB11, RA12,RB12 are "run-time" components. That means they are selected at the time of actual assembly to adjust some values on the board. No 2 TCI are alike here and the resister values can't be predicted. The values here are examples of what was found in (1) TCI module.**

Electrolytic Capacitors		
CA1	CA2	10 mfd @ 25v
CA2	CB2	2.2 mfd @ 50v
CA4	CB4	.47 mfd @ 50v
CA5	CB5	10 mfd @ 25v
CA6	CB6	.1 mfd @ 35 tantalum
CA7	CB7	.1 mfd @ 35 tantalum
CA8	CB8	.22 mfd @ 50v

Mylar Capacitors		
CA3	CA3	472k @ 50g

Diodes		
DA1	DA2	1N1001
DA2	DB2	Small Signal Glass
DA6	DB6	Small Signal Glass
ZDA1	ZDB1	Zener 8.2volts

Rebuilding a TCI or Ignitor Box

*My thanks to Dick Stelter, David Denowh, Uwe Werner, Brian Fosh of TzRewinds, Dennis Meyers and **many others** for what follows.*

There is a good chance you can repair the TCI module!
(A little soldering skill may be all it takes.)

We know some have repaired their own ignitor boxes. General speaking, it is most likely the transistors which have failed on the circuit board. Also, some have reported loose solder connections that have been corrected with some cleaning and resoldering.

DO NOT rule out simple moisture. The Vision TCI is NOT encased in resin or rubber like most ignition modules are. So.... if there is moisture on the board it would not work well. WD-40 and let it sit in the sun would be good advice here.

The Vision TCI circuit board is a "doublesided plated thru design". This means the components are mounted on one side but soldered both top and bottom (and thru the board). This is a strong rugged design and makes weak solder joints less likely. The Virago TCI which is very similar uses a single sided design where the components are mounted on the topside but soldered only on the single circuit foil on the bottom. This makes it more prone for the circuit foil to peel up and fail due to vibration. This problem less likely on the Vision TCI board which has circuit foil both sides and soldered all the way through. Look at the pictures above.

The Vision TCI is more prone to component failure where the Virage TCI oftens fails to mechanical failure (bad connection on board).David Denowh is currently reconditioning TCI for the Virago group. He has been VERY successful doing this but comments that many Virago TCI have simply failed from loose components. His link is worth a look: http://members.aol.com/ddenowh/TCI/index.html

Dave is so busy in fact that he has (for now) declined the possiblity of repairing Vision TCI. But he demonstrates that it can be done.The problem of course is testing what you have done and Dave has no easy way to test a reconditioned Vision module (since he has no bike). Here are some of Dave's comments:"I have been very lucky with the Virago repairs thus far. I have done over 240+ TCI units and they ALL have had similar problems. Resoldering the board has repaired them all with only a few needing the transistors replaced. I suspect these went bad because the bike either had a bad coil or had a wire pinched somewhere. The transistors on the Virago are a bit different. The part number is either a ETD051-030 or a D1071. Both have the S with a line through and a circle around the logo like the Vision ETD41. I have replaced these with a RCA part #SK9431. I suspect that any transistor that is similar or stronger will work as a replacement. It is just a switch after all :-)".

In the UK Brian Fosh is successfully rebuilding TZI at http://tzrewinds.co.uk/ and testing them with a test bench setup. He mechanically rotates a magnet with a variable speed 15,000rpm motor past the pickups to simulate the engine RPM. This site is also worth a look. He seems interested in this project and is a big help.

Lastly, some misc info for general discussion:

- **There are no known schematics of these Hitachi ignitors.** We have one from Uwe Werner posted on the XJ850 Triples site (http://w3.one.net/~ryanr/triplesite/tech.html). It is in German and (of course) a triple. Not too useful but you can generally see what's going on. He reverse engineered a box to create this schematic.
- **There is no way (no test bench box) to test a TCI module**. This is true of most any ignition module made in the world since manufacturers WANT you to buy a new one. In this case, you'll need to use your bike. Just BE AWARE that if you mess something up you risk taking out other components equally important (like the magnetic pickup sensors). Good luck, but be thourough.
- **Test firing the TCI may be possible:** I will pass on a backyard trick as told to me by "roadrunner" but I HAVE NEVER TRIED. But it sounds like it should work. He writes:

  "Just a quick backyead test. you can use one of them soldering guns, you know the hi current pistal type. It will trick the magnetic pickups to send pulses. Becouse the gun creates a dense magnetic feald around the tip. Carfull not to burn something doing this. The pickups will sense these magnetic fealds and send firing pulses at 60 hz to the module . It makes it a lot easer to troubleshoot without kicking the starter each time ."

  Of course.... this has limited use even if it does work since you would need spare pickups to try this. But just passing the info on.

Here's what we think we know so far:

The Vision TCI ignitor was supplied by Hitachi as part #TID 12-06. The semiconductor (fast switching transistor) inside marked ETD41 was made by Fuji Electronics. Fuji also produces ignitors and maybe even builds them for Hitachi too!? They also produce a line of after market ignitors, some advertised under other brand names for homebuilt aircraft.The ETD41's are diode protected Darlington NPN transistors. You want to replace these with heavier duty substitutes. We can make a good guess at what that would be based on the TCI and coil voltages/ currents. This should probably be something that can handles 10 amps+ at the collector and double that for peak. The best replacement so far would seem to be the MJE5742 listed above. It was available from www.digi-key.com. It is a T-220 footprint so the same size as the original. The NTE2317 should also work. The NTE2317 is slightly more expensive (we're talking a couple dollars total here) but is more readily available on the net. It is a T-218 so is larger than the original and would require you to "shoehorn" it to the board somehow with heat sink.
http://www.nteinc.com/specs/2300to2399/NTE2317.html

Again, the Virago is similar in vintage and electrical design so notice that the power semiconductors in a Virago ignitor are marked D1071. They have also been replaced successfully with the BU806 and ST9431.All the components in the Vision TCI have been identified and are listed below. The exception is the 'piggy back' board on the printed circuit board (called a Hybrid) which has an IC mounted on it. This is most likely the timing curve. This can't be fixed and there's no obvious replacement.

Fixing the TCI
This would be my recommended order of things till you get it working.

1. Gain access to the PCB ("Printed Circuit Board").

Remove the top cover to the TCI (held by 4 screws).

***** DO NOT TRY TO PRY IC-BOARD OUT OF THE TCI CASE!!! *****

It is held in by one small Philip screw, and MORE IMPORTANTLY, is soldered to the plug pins molded into the side of the case. To get the board out you have to desolder the pins or break them off when you take it out. You'd then have to solder them (or wires connecting them) back together.

There is an another way.

Try to avoid pulling the PCB out of the case. Replacing any components while leaving the PCB still in the plastic box would be good. Ultimately you'd like to reuse the case / wire plugs , the whole setup. To get to the other side ..... cut a large "port-hole" into the plastic "bottom" (other side of the case). Use a dremel tool small cutting wheel. This is risky because you can accidentally cut into IC components on the board. MAYBE BETTER, a sharp knife heated with a torch (so your melting through the plastic). Anyway.... GOOD LUCK (Could be a Darwin award recipient!).

Lay the case flat. Cut down (knife straight up + down) into the case about 1/2” in from the sides. Another words you're cutting a rectangular hole out of the bottom cover 1/2” smaller than the bottom cover size. One end of the module has the metal heat sinks which is why you need to cut about 1/2” in from the sides.

**** **Cut no deeper than about 1/8" or you will cut into IC components** ****

2. Look for obvious melted components, bad solder joints, corrosion points, or moisture and correct.

3. Replace transistors. Try it.

4. Replace capacitors and/or diodes. Try it.

5 . Replace resistors. Try it.

6. You're f cked)

Related Emails

I have read your instructions on fixing Yamaha TDI units with glee, since I have been long searching for information on the control box for my 1988 VX250. However, I believe I have stumbled upon a more suitable replacement for the T-220 footprint NPN Darlington power transistors used in my box. Using this device will be a simple swap, rather than requiring shoehorning the larger T-18 size devices you list. Hopefully this information can help others. This device is readily available for $1.60 each from Digi-Key (www.Digi-Key.com), with no minimum order.

Dennis Meyers

You were right. ZDB1 and ZDA1 are the same and equal 8,2 [V].

In my case, it turned out, that the only ZDB1diode was broken.
I exchanged this zener diode to new one and finally I've got a sparks on both cyclinders.
Both transistots (ETD41-035) were ok.

Unfortunately I was not able to ran the engine.
There were the noise came out from the engine so I stopped running it.
I am going to look inside the engine, and try to find out what's going on.

If you have any questions let me know.

Best regards,
Kriss (from Poland).

I own a 90' Suzuki gs-1100R. Nice bike, except that recently the TCI module went bad.

One of the transistors that drive the coil was shorted. So I couldn't find a replacement anywhere, its code is D1071. This doesn't appear in any replacement book I've searched(national, ECG (now NTE), Archer (RCA)), nor on the webpages of these manufacturers.

I found that in your page you make a comment that this transistor (D1071) was replaced succesfully with the BU806 and/or SK9431. I know this is not the same ign. module than in a virago, but I decided to give it a try. Tried the NTE2315. To make a long story short, I'll just say that it worked for less than 10 seconds. After this short time, the newtransistor blew again.

I was lucky enough to find a guy here that says he has new D1071's. In any case, I was able to learn that there is another replacement, the NTE2317, specifically designed for ignition modules, that according to this guy does work in my bike's TCI.

See: http://www.nteinc.com/specs/2300to2399/NTE2317.html

This is a bigger chip, that will require some mods to the heat sink to make it work. I don't know if it will handle the 10k+ rpms of the bike, but I wish I had tried it.

At 12.000 rpms, my bike wasted spark coil setup are making 200 sparks per second per coil. That is a spark every 5ms, not important when compared to the longer fall time from the 2317: 15us.

I looked for your heavier-duty recomendation, the TIP142 (nte270). This doesn't seem appropiate for ignition circuits. The nte2317 can handle way more current (15amps continuous!), and can handle spikes of up to 500volts(almost a must in coil circuits).

It was nice to find your help page !!

Francisco

Related Links:

David Denowh Virago TCI site
http://members.aol.com/ddenowh/TCI/index.html

Brian Fosh TZ Repair site
http://tzrewinds.co.uk/

Allied Semiconductors
http://www.alliedsemiconductors.com/

NTE Semiconductors

http://www.nteinc.com/

Digi-key
www.Digi-Key.com

Fairchild Semiconductors
http://www.fairchildsemi.com/

MSD Ignition Systems
http://www.msdignition.com/

Accell Ignition Systems
http://www.mrgasket.com/accel.htm

Misc Ignition Stuff:

http://www.newcovenant.com/features/motors/ignition.htm

http://w3.one.net/~ryanr/triplesite/tech.html

http://dmoz.org/Recreation/Motorcycles/Maintenance_and_Tech_Tips/

NPN Silicon Power Darlington Transistors

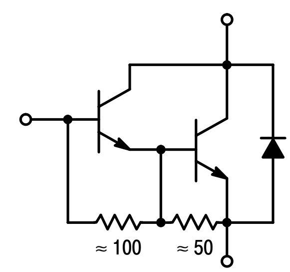
The MJE5740 and MJE5742 Darlington transistors are designed for high–voltage power switching in inductive circuits. They are particularly suited for operation in applications such as:

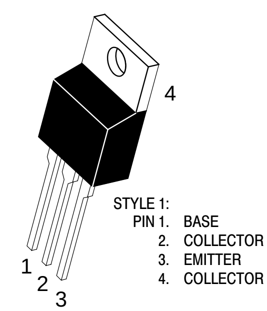
- Small Engine Ignition
- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls

MJE5740
MJE5742*

*ON Semiconductor Preferred Device

POWER DARLINGTON TRANSISTORS
8 AMPERES
300, 400 VOLTS
80 WATTS





CASE 221A–06
TO–220AB

MAXIMUM RATINGS

Rating	Symbol	MJE5740	MJE5742	Unit
Collector–Emitter Voltage	$V_{CEO(sus)}$	300	400	Vdc
Collector–Emitter Voltage	V_{CEV}	600	800	Vdc
Emitter Base Voltage	V_{EB}	8		Vdc
Collector Current – Continuous – Peak (1)	I_C I_{CM}	8 16		Adc
Base Current – Continuous – Peak (1)	I_B I_{BM}	2.5 5		Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	2 16		Watts mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	80 640		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +150		°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle = 10%.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.56	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	62.5	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8″ from Case for 5 Seconds	T_L	275	°C

Preferred devices are ON Semiconductor recommended choices for future use and best overall value.

April, 2002 – Rev. 5
Publication Order Number:
MJE5740/D

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (2)					
Collector–Emitter Sustaining Voltage (I_C = 50 mA, I_B = 0) MJE5740 MJE5742	$V_{CEO(sus)}$	300 400	– –	– –	Vdc
Collector Cutoff Current (V_{CEV} = Rated Value, $V_{BE(off)}$ = 1.5 Vdc) (V_{CEV} = Rated Value, $V_{BE(off)}$ = 1.5 Vdc, T_C = 100°C)	I_{CEV}	– –	– –	1 5	mAdc
Emitter Cutoff Current (V_{EB} = 8 Vdc, I_C = 0)	I_{EBO}	–	–	75	mAdc
SECOND BREAKDOWN					
Second Breakdown Collector Current with Base Forward Biased	$I_{S/b}$	See Figure 6			
Clamped Inductive SOA with Base Reverse Biased	RBSOA	See Figure 7			

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS (3)					
DC Current Gain (I_C = 0.5 Adc, V_{CE} = 5 Vdc) (I_C = 4 Adc, V_{CE} = 5 Vdc)	h_{FE}	50 200	100 400	– –	–
Collector–Emitter Saturation Voltage (I_C = 4 Adc, I_B = 0.2 Adc) (I_C = 8 Adc, I_B = 0.4 Adc) (I_C = 4 Adc, I_B = 0.2 Adc, T_C = 100°C)	$V_{CE(sat)}$	– – –	– – –	2 3 2.2	Vdc
Base–Emitter Saturation Voltage (I_C = 4 Adc, I_B = 0.2 Adc) (I_C = 8 Adc, I_B = 0.4 Adc) (I_C = 4 Adc, I_B = 0.2 Adc, T_C = 100°C)	$V_{BE(sat)}$	– – –	– – –	2.5 3.5 2.4	Vdc
Diode Forward Voltage (4) (I_F = 5 Adc)	V_f	–	–	2.5	Vdc

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
Typical Resistive Load (Table 1)						
Delay Time	(V_{CC} = 250 Vdc, $I_{C(pk)}$ = 6 A I_{B1} = I_{B2} = 0.25 A, t_p = 25 µs, Duty Cycle ≤ 1%)	t_d	–	0.04	–	µs
Rise Time		t_r	–	0.5	–	µs
Storage Time		t_s	–	8	–	µs
Fall Time		t_f	–	2	–	µs
Inductive Load, Clamped (Table 1)						
Voltage Storage Time	($I_{C(pk)}$ = 6 A, $V_{CE(pk)}$ = 250 Vdc I_{B1} = 0.06 A, $V_{BE(off)}$ = 5 Vdc)	t_{sv}	–	4	–	µs
Crossover Time		t_c	–	2	–	µs

(2) Pulse Test: Pulse Width = 300 µs, Duty Cycle = 2%.
(continued)
(3) Pulse Test: Pulse Width 300 µs, Duty Cycle = 2%.
(4) The internal Collector–to–Emitter diode can eliminate the need for an external diode to clamp inductive loads. Tests have shown that the Forward Recovery Voltage (V_f) of this diode is comparable to that of typical fast recovery rectifiers.

TYPICAL CHARACTERISTICS

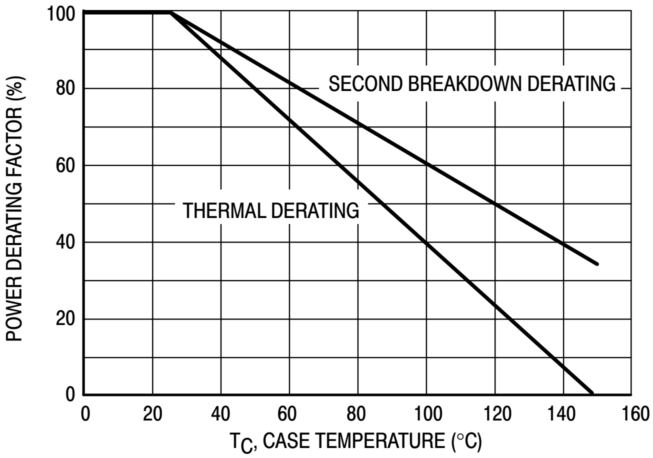


Figure 1. Power Derating

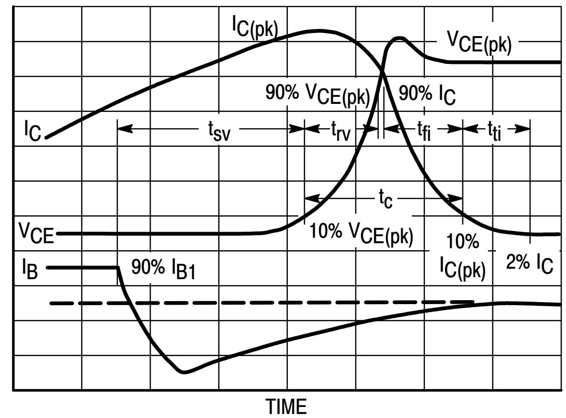


Figure 2. Inductive Switching Measurements

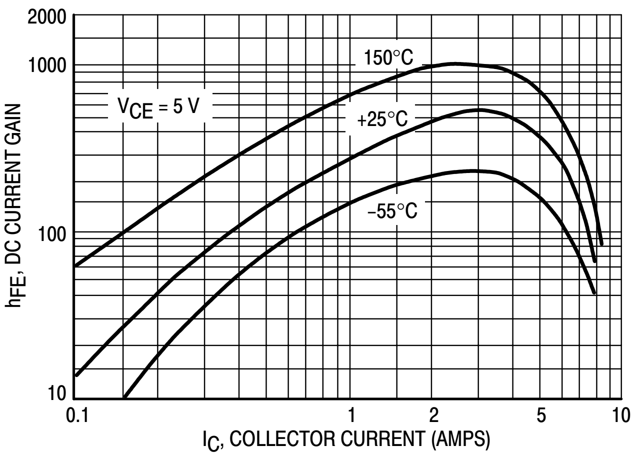


Figure 3. DC Current Gain

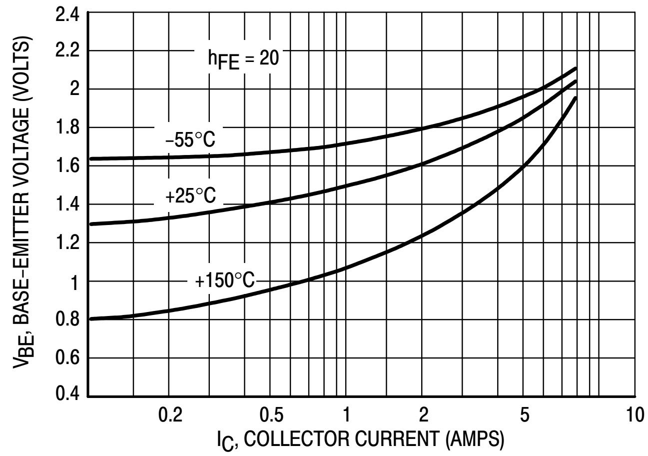
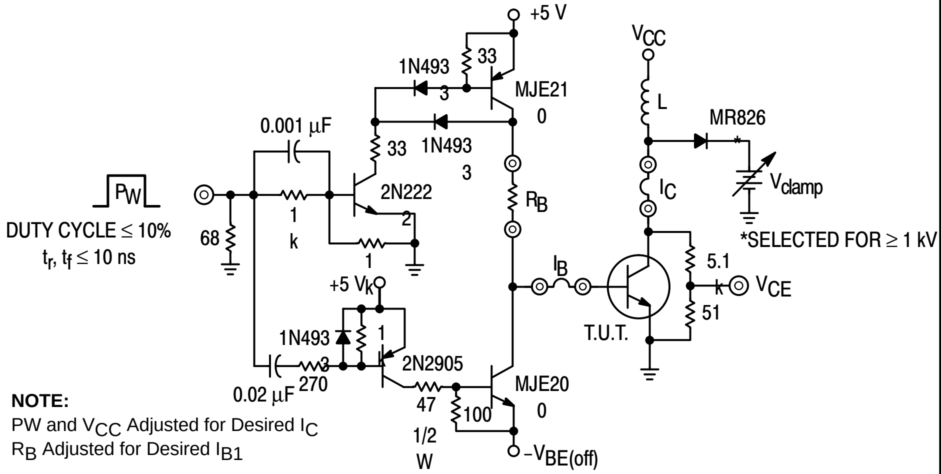
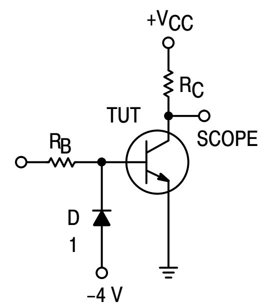
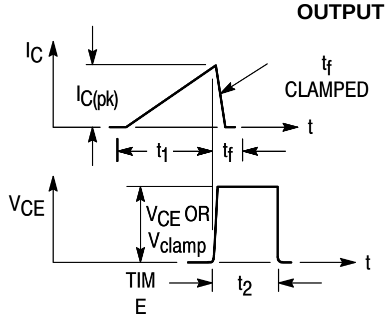
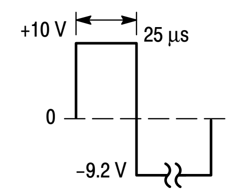


Figure 4. Base−Emitter Voltage

Table 1. Test Conditions for Dynamic Performance

	REVERSE BIAS SAFE OPERATING AREA AND INDUCTIVE SWITCHING	RESISTIVE SWITCHING
TEST CIRCUITS	 **NOTE:** PW and V_{CC} Adjusted for Desired I_C; R_B Adjusted for Desired I_{B1}	
CIRCUIT VALUES	COIL DATA: FERROXCUBE CORE #6656 FULL BOBBIN (~16 TURNS) #16; GAP FOR 200 μH/20 A L_{coil} = 200 μH; V_{CC} = 30 V $V_{CE(pk)}$ = 250 Vdc $I_{C(pk)}$ = 6 A	V_{CC} = 250 V D1 = 1N5820 OR EQUIV.
TEST WAVEFORMS	**OUTPUT WAVEFORMS**  t_1 ADJUSTED TO OBTAIN I_C; $t_1 \approx \frac{L_{coil}(I_{Cpk})}{V_{CC}}$; $t_2 \approx \frac{L_{coil}(I_{Cpk})}{V_{clamp}}$; TEST EQUIPMENT SCOPE−TEKTRONICS 475 OR EQUIVALENT	 t_r, t_f < 10 ns DUTY CYCLE = 1% R_B AND R_C ADJUSTED FOR DESIRED I_B AND I_C

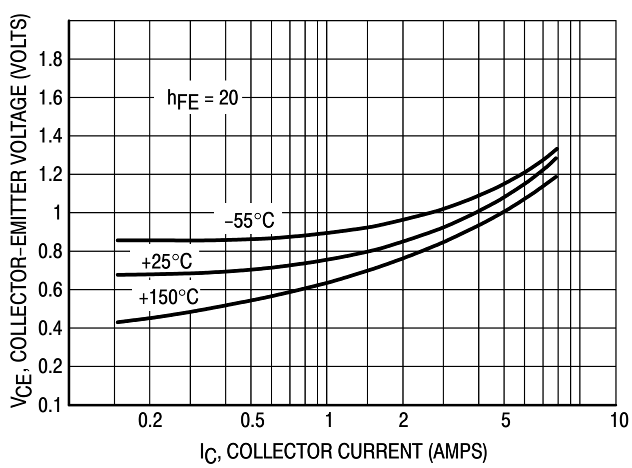


Figure 5. Inductive Switching Measurements

SAFE OPERATING AREA INFORMATION

FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 6 is based on $T_C = 25°C$; $T_{J(pk)}$ is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when $T_C \geq 25°C$. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 6 may be found at any case temperature by using the appropriate curve on Figure 1.

REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn–off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage–current condition allowable during reverse biased turnoff. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 7 gives the complete RBSOA characteristics.

The Safe Operating Area figures shown in Figures 6 and 7 are specified ratings for these devices under the test conditions shown.

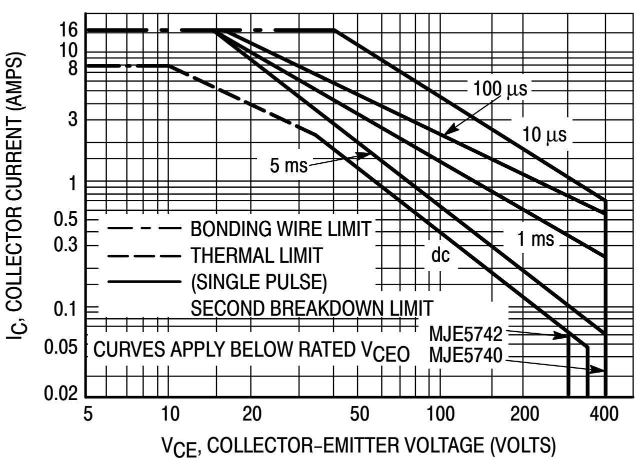


Figure 6. Forward Bias Safe Operating Area

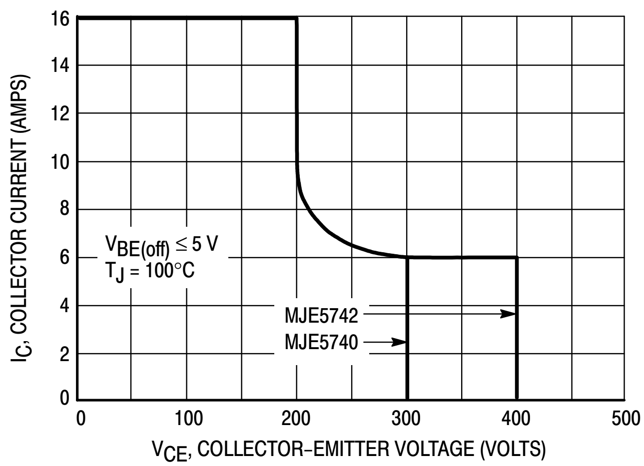


Figure 7. Reverse Bias Safe Operating Area

RESISTIVE SWITCHING PERFORMANCE

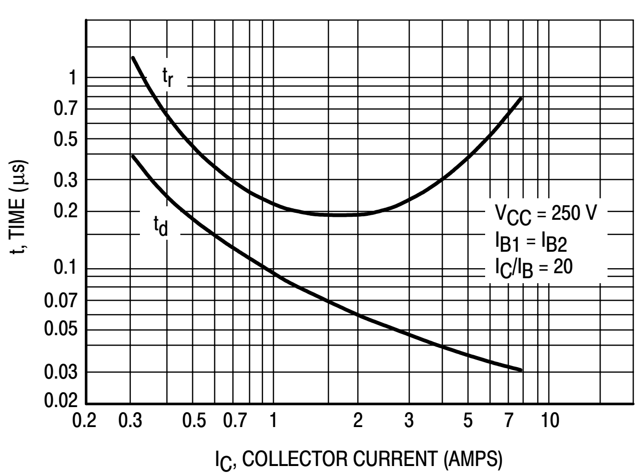


Figure 8. Turn–On Time

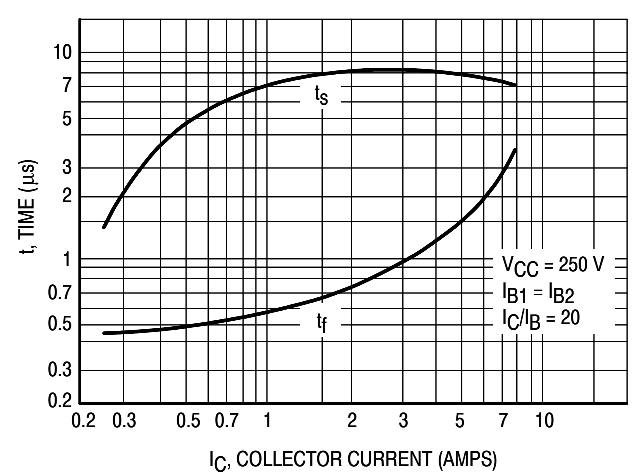
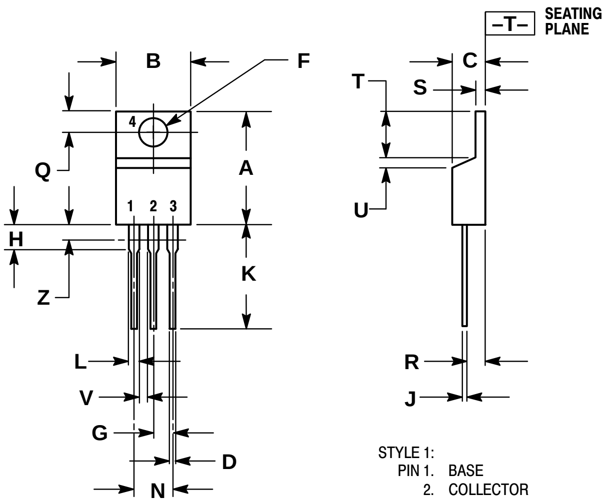


Figure 9. Turn–Off Time

PACKAGE DIMENSIONS

TO–220AA
CASE 221A–09
ISSUE AA



STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.570	0.620	14.48	15.75
B	0.380	0.405	9.66	10.28
C	0.160	0.190	4.07	4.82
D	0.025	0.035	0.64	0.88
F	0.142	0.147	3.61	3.73
G	0.095	0.105	2.42	2.66
H	0.110	0.155	2.80	3.93
J	0.018	0.025	0.46	0.64
K	0.500	0.562	12.70	14.27
L	0.045	0.060	1.15	1.52
N	0.190	0.210	4.83	5.33
Q	0.100	0.120	2.54	3.04
R	0.080	0.110	2.04	2.79
S	0.045	0.055	1.15	1.39
T	0.235	0.255	5.97	6.47
U	0.000	0.050	0.00	1.27
V	0.045	---	1.15	---
Z	---	0.080	---	2.04

Notes

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