2CV IGNITION COIL

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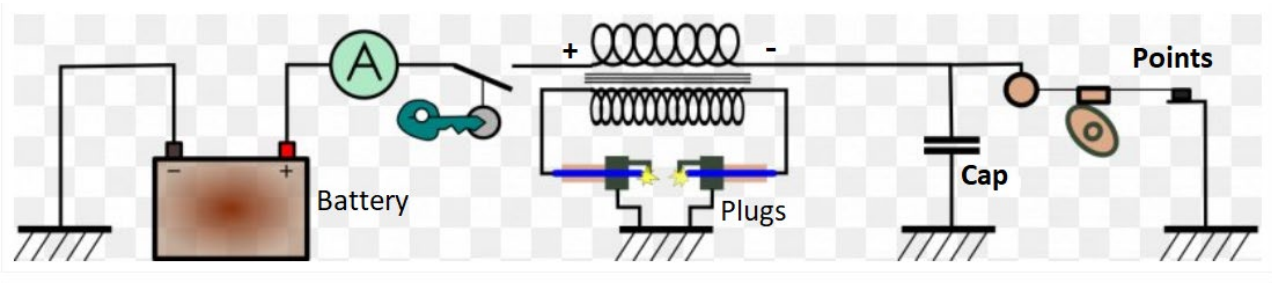
Revision 6

Background: The inductive-discharge ignition coil is an iron-cored electrical transformer comprised of two windings. In various forms, it has been used almost universally in vehicle ignition systems for more than a century. It is usually mounted inside a protective metal, bakelite or plastic housing and is typically a rugged and reliable device. Its purpose is to produce *high-voltage pulses from a low-voltage DC supply for firing the spark plugs.* It is the classic spark coil. The 2CV ignition coil is made up of a laminated soft iron core wrapped in a layer of oil-impregnated paper insulation, followed by the primary winding of around 200 turns of wire. This is wrapped in another layer of insulation, followed by the secondary winding of around 15,000 turns of wire. This provides a turns (step-up) ratio of 15,000 / 200 = 75, i.e. a turns ratio of 75 to 1. The secondary winding is floating, with the ends of the winding brought out to terminals which connect to the spark plug leads.

2CV "Wasted Spark" Ignition System: The diagram below shows the 2CV ignition circuit. (My thanks to the unknown creator and Google Images.) When the ignition switch is turned on, the +12V line from the battery is connected to the positive terminal of the coil primary winding. The points connect to the negative terminal of the coil and the points capacitor (condenser) is connected across the points as shown. The ends of the secondary winding connect to the spark plug centre electrodes via the plug leads, with the engine mass acting as the connection between the spark plug bodies, forming a series-connected circuit per the diagram. Unlike the standard four-stroke engine arrangement where each spark plug fires on alternate crankshaft revolutions, in the 2CV, **both** spark plugs fire on **each** revolution, saving the need for a distributor. The spark in the cylinder at the top of its exhaust stroke is obviously unused and wasted, hence the term "wasted spark", but it does away with the need for a distributor.



Dwell Period: In the points-ignition system, the points are closed during the period known as the dwell period or dwell angle. During the dwell period, DC current from the battery flows through the points and the coil primary winding, creating a powerful magnetic field around the iron core. The magnetic field acts as an inductive energy source, ready to be converted to electrical energy in the secondary winding at the spark plugs' firing time.

The energy contained in the magnetic field in Joules is given by $LI^2 / 2$, where L is the inductance of the primary winding in Henrys and I is the current in the primary winding in Amps. For example, if the primary inductance is 10 mH (0.01 H) and the primary current is 4 A, the energy stored in the magnetic field is $0.01 \times 4^2 / 2 = 0.08$ J or 80 mJ. (One Joule is the energy used in producing one watt of power for one second, i.e. 1 J = 1 watt-second = 1 Ws).

Induced Voltage. At the moment set by the engine timing, the points are opened by the points cam and the DC current flowing in the primary winding is interrupted (cut off). Because the current flow has stopped, the magnetic field surrounding the iron core starts to collapse. It is the collapsing magnetic field which generates the high voltage in the secondary winding by the collapsing flux lines cutting through the secondary turns.

The photo of the black 2CV coil on the left is courtesy of the Burton Car Company. Typically, points-ignition coils are designed and scaled so that a voltage of around 300 V is induced in the primary winding by the collapsing magnetic field. In the 2CV coil, by reverse engineering, the collapsing field induces 300 V in the 200-turns primary winding, so the basic coil design parameter is 1.5 V per turn. The 15,000-turns secondary winding receives, *at the exact same moment*, an induced voltage of 15,000 x 1.5 V or 22,500 V from the shared, collapsing magnetic field.

A Teaching Error!

Many years ago, when being taught the theory of operation of the ignition coil, the writer was (incorrectly) taught that the high voltage induced in the secondary winding (22,500 V) is produced from the voltage induced in the primary winding being stepped up by the turns ratio. While this may be true *numerically*, i.e. 300 V x 75 = 22,500 V, it does not explain the operation of the coil from an *energy* standpoint. High voltage is indeed required to ionize the air mixture in the plug gaps to *create* sparks (arcs) across the plug gaps, but ongoing *energy* has to be supplied by the coil to keep the sparks burning for the *duration* of the spark burn time. Placing the focus on the primary winding as the *energy* source does not hold up.

At the moment the points open, the *energy* held within the coil's magnetic field is converted to *electrical energy* in the two coil windings *in proportion to the square of the turns ratio of the windings*, i.e. $75^2 = 5625$. This means the total *electrical energy* produced in the two windings is shared in the ratio of 1 to 5625, i.e. the secondary winding receives 5625 times *more* energy than the primary winding!

If we consider the example where the energy stored in the magnetic field is 80 mJ, then when the points open, the secondary winding has 5625 / 5626 x 80 mJ or 79.998 mJ of electrical energy made available to it, while the primary winding receives just 1 / 5626 x 80 mJ or 0.002 mJ. It may be observed that almost the entire energy held within the coil's magnetic field ends up being converted to electrical energy in the *secondary* winding. It also may be observed that the energy supplied by the coil to fire the spark plugs and keep the sparks burning for the spark burn time does not come from the energy in the *primary* winding! It comes from the energy in the *secondary* winding, being that the primary winding receives only a smidgeon of the total coil energy!

To summarise, the primary winding serves one purpose only. When the points close, it produces the strong magnetic field in the iron core of the coil (in the dwell period). At the moment the points open and the magnetic field starts to collapse, *the job of the primary winding is completed* and it hands the baton over to the secondary winding. The secondary winding serves two purposes. As the result of the collapsing magnetic field, it provides the *high voltage* (15,000 turns at 1.5 V per turn or 22,500 V) to fire the spark plugs. It also provides the supply of *energy* to keep the sparks burning for the duration of the spark burn time. In view of this, the role of the primary winding *stops* at the moment the points open, while the role of the secondary winding *starts* at the moment the points open.

To conclude, the *voltage and energy* delivered by the secondary winding does not originate from any step-up action by the primary winding. It comes solely and directly from the collapsing magnetic field. Thus the teaching error!

As previously noted, the 300 V pulse induced in the primary winding and the 22,500 V pulse induced in the secondary winding take place simultaneously, being that they result from the (same) collapsing magnetic field. However, while the 22,500 V secondary voltage is fully utilised by the ignition system, the 300 V primary voltage serves *no useful purpose whatsoever*. In fact, not only is it an unwanted artefact of the collapsing magnetic field, it also cannot be ignored and must be separately and specifically managed. More follows on this.

Coil Secondary Voltage Waveform: Now consider the 2CV ignition coil secondary voltage waveform shown on the last page of this document. In the description following, the spark plug references apply to the spark plug on the compression stroke unless indicated otherwise.

Spark Firing Voltage: When the points open and the magnetic field starts to collapse, the voltage induced in the secondary winding from the collapsing field rises rapidly towards its maximum figure of 22,500 V. Somewhere along the way, the rising voltage reaches the **spark firing voltage,** the voltage at which the spark plugs fire. (The two plug gaps are in series as far as the secondary winding is concerned, so either both plugs fire or neither plug fires.)

Say the spark plug in the cylinder on the compression stroke (with high pressure) needs a firing voltage of 10,000 V to ionize the gas in the plug gap and form a spark, and the spark plug in the cylinder on the exhaust stroke (with low pressure) needs a firing voltage of 5,000 V. In this instance, the spark firing voltage needed is 10,000 V + 5,000 V = 15,000 V, so when the secondary voltage has risen to 15,000 V, both plugs fire and arcs form across both plug gaps.

The spark firing voltage is dependent on many factors such as the load on the engine (the higher the load, the higher the cylinder pressure so the higher the voltage required), plug gap (the wider the gap, the higher the voltage required), plug electrode type, material and size (pointier, thinner electrodes require less voltage due to concentration of the electrostatic field), combustion chamber temperature, the mixture air/fuel ratio, etc.

This can make the spark firing voltage figure seem a little “rubbery”, but for any given set of combustion chamber conditions, the figure is not “rubbery”. What does appear “rubbery” are the combustion chamber conditions themselves, being that they change in response to the moment-to-moment driving demands. As a result, the spark firing voltage may vary from as low as 5,000 volts up to the maximum secondary winding voltage.

Secondary Oscillation

At the moment the spark firing voltage is reached and sparks occur across the plug gaps, the rapid onset of current through the secondary winding triggers an oscillation (resonance) between the secondary winding inductance and the secondary winding (distributed) capacitance. The resistances in the secondary circuit (the secondary winding and the plug leads) produce a loading or self-dampening effect on the oscillation, which falls away after several cycles.

Spark Burn Voltage: From physics, once an arc forms, the voltage required to maintain the arc lowers, reducing the voltage across the plug gaps. The current flow also produces voltage drops across the secondary winding resistance and the plug lead resistances, further lowering the voltage across the plug gaps. Once the initial oscillations have ceased, the plug voltages enter a phase of steady, reduced voltage (spark burn voltage) which continues for the duration of the spark burn time, powered by the continuing supply of electrical energy from the secondary winding (sourced from the collapsing magnetic field).

After the plugs fire, say the voltage on the plug in the cylinder on its compression stroke falls from 10,000 V to 4,000 V and the voltage on the plug in the cylinder on its exhaust stroke falls from 5,000 V to 2,000 V, then in this example, the voltage across the plugs, the spark burn voltage, is 4,000 V + 2,000 V = 6,000 V.

Because of the voltage drops across the secondary winding resistance and plug lead resistances, the voltage delivered by the secondary winding will be somewhat higher than the spark burn voltage.

Spark Burn Time: Immediately the spark burn voltage starts, the spark burn time starts. Traditionally, points-ignition coils were designed to provide a spark burn time of around 1.5 to 2 milliseconds for optimum ignition and burning of the fuel mixture.

The plot of voltage verses current characteristics of a spark gap shows an approximately constant voltage with changing current, so during the spark burn time, the plug gap voltage falls at a slower rate than the current falls as the energy remaining in the secondary winding continues to fall.

As the energy supplied by the secondary winding nears depletion, the current passing through the spark plug arcs falls off, reducing the voltage drops across the secondary winding and the plug leads, allowing the voltage across the plug gaps to momentarily rise near the end of the spark burn time. Eventually, the remaining coil energy is insufficient to sustain the arcs, at which point the arcs extinguish and the secondary circuit current ceases, signalling the end of the spark burn time. The fireball in the nuclear powerhouse of the 2CV is extinguished (well, for this revolution of the crankshaft!).

Damped Oscillation

The damped oscillating voltage appearing *after* the end of the spark burn time *serves no purpose*. It is a remnant of the electrical energy remaining in the *primary* winding inductance and the points capacitor after being triggered by the induced 300 V spike in the primary winding when the points opened, after being stepped up by the turns ratio. The oscillation soon ceases as the remaining energy is dissipated in the resistance of the primary winding by the circulating (resonant) current.

Points Protection: As noted previously, the 300 V spike induced in the primary winding has to be managed. Consider that the points capacitor is not connected. At the moment the points open and the 300 V spike is induced in the primary winding, the voltage spike appears *instantly* across the points which *instantly* produces an arc between the faces of the points! The points will quickly burn and erode unless steps are taken to minimise the arcing.

The solution is for a capacitor of suitable value to be connected across the points as shown in the wiring diagram above. When the points open, the capacitor allows the oscillating current from the voltage spike to flow in the primary circuit. The capacitor absorbs the initial charge from the spike, **charging the capacitor from zero volts**. Thus, at the commencement of the opening of the points, the voltage across the points and the capacitor starts off at a leisurely zero volts instead of 300 V.

Although the voltage across the points rises as the capacitor charges, at the same time the separation between the points is increasing due to the ongoing rotation of the points cam. Thus, the capacitor voltage (the voltage across the points) **remains below the arcing voltage** of the points. In summary, the capacitor absorbs the initial charge from the 300 V spike and in doing so, sufficiently slows the voltage rise across the capacitor and points so arcing and points damage does not occur. Very clever.

If the points capacitor is too small in value, the capacitor will charge too quickly and its voltage will rise too quickly and cause an arc at the points. If its value is too large, the discharge of any remaining energy in the capacitor through the points when the points close at the start of the next dwell period may result in burning of the points. Yes, the 300 V spike cannot be ignored. It is an artefact in the operation of the points-ignition system.

Spark Colour

An ignition system in good order will produce a strong spark which is bright blue-white in colour and is easily seen in daylight. A not-so-good ignition system will produce a weak spark which is dull red-orange in colour and is difficult to see in daylight.

Ignition Timing: The fuel mixture present between the spark plug electrodes (ie in the plug gap) is ignited by the heat of the spark. The ignited fuel then expands outwards from the plug gap in what is known as the flame front. The flame front continues expanding outwards through the mixture in the combustion space at a specific speed that is essentially independent of engine speed. That is why the ignition timing has to be advanced as engine revs increase in order to allow more time for the fuel to fully ignite and burn, allowing the cylinder pressure to reach its maximum level at the optimum moment to extract maximum power from the fuel. Typically, the aim is to achieve maximum combustion pressure 1 to 2 degrees **after** top dead centre so maximum power can be extracted from the fuel, *regardless of the engine RPM.*

Spark Plug leads: These play a **critical** role in the operation of the 2CV ignition system. Plug leads specified by the vehicle manufacturer should always be used. Why? The resistance of the plug leads must be high enough to ensure the discharge of the spark energy from the coil creates a spark with the necessary required spark burn time, but low enough to ensure a strong spark is produced.

Spark plug leads do not last forever. They are affected by time, temperature extremes, temperature cycling, oil, grease, electrical stresses, and mechanical stresses such as vibration, movement, handling, etc.

If plug lead resistances are too low, the spark energy will dissipate too quickly, preventing proper ignition of the fuel mixture due to insufficient spark burn time. If the plug lead resistances are too high, the spark intensity will be too weak to cause proper ignition of the mixture. Neither a short spark nor a weak spark can properly ignite the mixture, leading to a decrease in power, acceleration and fuel economy and possibly missing, hesitating, stalling or not starting.

If the resistance of the plug leads is excessively high, either of two things will happen. If a spark *can* be formed at the plugs, the spark will be too feeble to properly ignite the fuel mixture and the engine will not start. If a spark is *not* formed at the plugs, not only will the engine not start, but the secondary voltage will be able to keep rising towards its maximum voltage where it may eventually break down (flash across) the internal insulation layers between the coil windings. A conductive carbonised track can be formed inside the coil along the spark discharge path, rendering the coil useless. More follows.

Ignition coil failures: Coils can fail for a variety of reasons, be they modern coil types or early types and whether of new or old age. Heat and vibration can damage the coil windings and the insulation, causing short-circuits or open-circuits in the windings. Multiple turns or multiple layers of turns can become shorted because of failure of the enamel insulation on the wire or failure of the insulation layers. Shorted primary turns or shorted secondary turns can reduce the spark voltage, spark energy and spark burn time and can also cause the coil to run hot. **A serviceable coil does not run hot!** Show me an ignition coil which runs hot in normal use and I will show you a faulty ignition coil!

Overheating: Coil damage resulting in failure of the coil can also occur if the ignition key is left on without the engine running. (When the engine is turned off, the pistons generally stop around mid-way through the stroke because of compression pressure, where the points are still closed.) The 2CV coil primary winding has a resistance of 3.6 ohms and the current flowing through the coil will heat the primary winding. The power dissipated will be approximately 12^2 (volts) / 3.6 (ohms) = 144 / 3.6 = 40 watts which is a hugely significant amount of heat inside the coil's sealed black bakelite housing. This will cause the coil to run **exceptionally hot** and may cause the bakelite housing to expand and crack and potentially result in damage to the secondary winding. At the very least it is **highly** likely to crack the housing, letting in moisture, dirt and contaminants, causing corrosion to the copper windings and leading to coil failure. It may also allow the PCB liquid coolant to escape. More follows.

The heat may also result in the oil-impregnated paper insulation between the windings becoming damaged, lowering the insulation breakdown voltage between the windings and allowing arcing to take place within the coil. The coil will need to be replaced. Perhaps the car may start when cold but may not continue to run or start again once it has warmed up. Again, the coil will be faulty and will need to be replaced. The coil may **forever** overheat in operation and produce performance issues, confirming without any doubt that it is indeed faulty and needs to be replaced.

Also, don't rely on the resistance readings of the windings as an indication of the serviceability of a coil. If a coil has been overheated and its insulation has broken down, the resistances of the windings may still be correct. It provides no guarantee of the serviceability of an ignition coil. The best way to check on a coil? Test with a known-good coil.

Extended Idling Periods: If the vehicle is left running at idle for an extended period, there will be no forced air flow over the coil for cooling so the coil's temperature is going to increase. This may end up causing damage to the coil because of its elevated temperature, particularly in warm weather.

PCB Oil Leakage: Like many industrial transformers of the day, the original Citroen black 2CV coil uses polychlorinated biphenyl (PCB) oil as a dielectric, insulator and coolant which is contained inside the coil housing. PCBs were traditionally used during the 1930s to 1970s, for example, for cooling the electricity transformers seen along our streets on power poles. Those metal pipes and small cylindrical tanks we see attached to the transformers were filled with PCB oil during that period. Because of its harmful health effects, PCB oils were phased out.

Should liquid be observed leaking from a black 2CV coil, **it will be PCB oil.** You definitely do not want this on your skin. Use rubber gloves and **immediately** remove the coil from the vehicle for proper disposal. Clean the area thoroughly then fit a new coil. The oil leakage may well be the result of the coil having experienced a previous overheating episode which damaged the seal between the two halves of the bakelite housing, allowing the oil to escape.

High-Voltage Flash-Over: The standout major cause of ignition coil failure is high-voltage flash-over. If spark plug lead resistances become too high or spark plug gaps become too wide, sparking at the plugs will not take place. If the sparks are unable to take place, the coil's output voltage can continue to rise to a point where it may ultimately flash across (burn through) the coil's internal insulation between the primary and secondary windings.

This internal discharge creates either a short-circuit or a resistive carbon track along the discharge path between the windings. The coil will be forever damaged and will need to be replaced as it cannot be repaired.

All inductive discharge ignition coils are subject to permanent damage from high-voltage flash-over, new or old, including the black 2CV coil! The degree of initial impairment may vary due to the circumstances, but it will only worsen over time, never improve!

And it's goodnight from him: At the very moment of the high-voltage flash-over, the coil's damage can take on different forms. Insulation breakdown and carbon tracking between the two windings can enable the two windings to become shorted or cause shorted turns in the fine wire of the secondary winding. This reduces the spark voltage, spark energy and spark burn time which can cause misfiring under load, etc. Backfiring may also occur. The coil may cease to operate altogether, preventing the engine from starting or running. If any such starting or running symptoms appear, the coil may have already been damaged from high-voltage flash-over. One single spark occurring internally within the coil can potentially destroy it. Should this damage occur to your black 2CV coil, the coil must be replaced.

The reality: While most of us have at least a general awareness of the need to replace spark plugs on some periodic basis, the writer suspects such awareness is not held in regard to plug leads, and is why plug leads are the number one cause of flash-over failures.

Lack of attention to the resistances of the plug leads ensures they remain "out of sight, out of mind" for perhaps an unknown number of years, until such time as they reach a point of sufficiently high resistance where they cause starting or running difficulties and gain our attention, by which time the coil may have already suffered damage from high-voltage flash-over. Sometimes such occasions are the only time plug leads receive attention! Much too late, he cried!

Do you know the age of your plug leads? Do you know their resistances? When you find a high resistance plug lead, always replace both plug leads.

How to prevent coil damage? To ensure the coil is protected against high-voltage flash-over damage, replace spark plugs leads when the resistance of either lead reaches 5000 ohms, otherwise every three years. If the plugs are replaced annually, the plug gaps will have barely changed, so the plugs will not be responsible for creating coil flash-over damage. If the resistances of the plug leads remain below 5000 ohms, they will not be responsible for creating coil flash-over damage.

Damage from flashover can also occur if the plug leads are disconnected from the plugs and the engine is turned over while the coil (or electronic ignition unit) is still connected to the +12V line via the ignition key! Easiest and safest way? Disconnect the +12V line to the coil (or the electronic ignition module if fitted) and **leave the plug leads connected!**

These simple precautions will protect your 2CV coil from damage caused by high-voltage flash-over.

The writer has not experienced a black coil failure, but if it occurs, it will simply be an isolated bad luck event, as plug lead resistances are checked at least twice annually.

Note that if the offending high resistance plug leads remain in the vehicle after a new coil is fitted, the new coil may instantly suffer high-voltage flash-over damage! $$Ouch!

Citroen-specified 2CV plug leads: Citroen specified the Bougicord 3166 plug leads for the 2CV. These plug leads will provide your 2CV with textbook-perfect operation. They have a resistance of 3000 ohms each when new. The leads are available, for example, from Der Franzose with part number 14306. The spark plug leads are a critical part of the 2CV's ignition system so do not use substitutes.

Common plug leads: Do not use common spark plug leads from local auto parts suppliers. These typically have resistances of 6000 to 15000 ohms, making starting much harder for the 2CV and possibly end up causing permanent damage to the coil from the resulting high-voltage flash-over!

Always gently handle plug leads, especially when disconnecting them from the spark plugs. Never pull directly on the leads or you will indeed hasten their failure.

An example: To get a feel of the stresses experienced by the ignition components in the 2CV, consider this. Say a 2CV is driven 5,000 Km per year at an average speed of 50 Km/h, taking 100 hours of driving. At 50 Km/h in top gear, the engine runs at 2500 RPM so there will be 2500 points openings (sparks) per minute or 150,000 sparks per hour or **15,000,000** sparks per 100 hours of operation, i.e. per year! Over a period of 30 years at 5000 Km of driving per year, your black 2CV coil has been called to produce **450,000,000** sparks! Yes, that's four hundred and fifty million sparks! An astonishing number! The points, capacitor, coil, plug leads and plugs are subjected to a stressful life and is why a little care goes such a long way!

In summary, the black coil is indeed a marvellously rugged and reliable device. All we have to do to keep it running perfectly **is not cause it any damage through our actions or inactions!**

The evidence? The black coil seems to have become a target for some unwarranted pasting in some internet circles. Why is this so? For every black coil which failed:

1. Had the coil ever been used with plug leads having excessive resistance?

2. Had the engine ever been turned over with the plug leads disconnected and the coil (or electronic ignition module) still connected to +12V via the ignition key?
3. Had the ignition key ever been left on without the engine running?

The first two events can result in the destruction of the coil from high-voltage flash-over, while the third event can result in the destruction of the coil from overheating. It may take only **one** of these events for the coil to be decisively and permanently destroyed! Should a black coil fail because of such events, keep in mind the black coil did not *cause* its failure. The operator did!

Yes, we hear and read about stories from 2CV owners giving the thumbs down to the black coil. No shortage of free advice there! What we never hear or read about are the follow-up stories with answers to the above three questions in regard to those coil failures. Yes, the silence is deafening! Anyone?? No, I didn't think so. Still, why would someone admit to their error in a public forum??!!

In summary, the black 2CV coil, like most points-ignition coils, is very rugged and reliable and will provide a long life if it is not subjected to abnormal events like those mentioned above. The coil was not designed to endure such conditions. **All** points-ignition coils are put at risk of failure for the same reasons if subjected to the same events! This is not just about the black 2CV coil.

"Exotic" coils: The black 2CV coil is in widespread use in the planet's 2CV population and is very much alive and well! Internet forums sometimes discuss the failures of the black coil as though it is because of some inherent weakness within the black coil, arguing for its replacement with a modern, expensive "exotic" coil. The writer would contend that those punishing the reputation of the black coil are unaware of the possibility of coil failure resulting from damage from high-voltage flash-over or overheating and are unaware of the circumstances causing these failures and how they can be prevented.

There may also be commercial imperatives at work which **knowingly and silently** support the punishing of the black coil while supporting its replacement with an "exotic" coil, even though the failure mechanisms and their causes and preventions discussed here may be known!

The promise: Consider the advertising line: "With the brand xxxx coil, your 2CV will start and run much better". Let us analyse that statement.

Better starting? Consider the view that the "exotic" coil improves the starting of your 2CV. If the "exotic" coil starts your 2CV **significantly** quicker, it is because your 2CV ignition system is in less than ideal condition. The car's systems were working fine the day the car left the factory way back when, so why not now? Why? Because of age, temperature cycles, stresses, vibration, dirt, moisture, total operating hours, etc, etc. These all conspire to bring the life of every electrical component (and every other component in the vehicle for that matter!) to an end at some point!

Every ignition system is made up of individual parts in various states of ageing, and it is the sum of the parts which make up the system we have to work with, er, drive with! If the ignition system is presenting a fault, there **will** be a part in the ignition system with a fault. No rocket science there. All we have to do is identify and attend to the faulty part! Business as usual when dealing with motor vehicles!

The Fault: Take this a little further. If the "exotic" coil starts your 2CV **significantly** quicker, then the fault will lie with either the black coil (reduced spark voltage, reduced spark energy, reduced spark burn time) or the points and capacitor (faulty or worn if fitted) or the spark plug leads (excessive resistance) or the spark plugs (excessive wear) or the ignition system wiring (excessive resistance in the connections).

The Solution: If it is the black coil, replace it with a new standard black coil. If it is the points and capacitor, replace them. If it is the spark plug leads, replace them with new Bougicord leads. If it is the spark plugs, replace them. If it is the ignition system wiring, disconnect, clean, thoroughly inspect and tightly reconnect all the associated wiring and connectors in the entire ignition system, including all +12V supply wiring and ground connections. Don't forget to check the ignition switch wiring and the ignition switch contacts as these are in the 12V supply path. Keep in mind the age of your 2CV!

A truism: Fitting an "exotic" coil as the "fix" for a faulty black coil or faulty points and capacitor or faulty plug leads or faulty plugs or faulty wiring **is expensive, illogical, inappropriate and completely unnecessary!**

In summary, show me an **otherwise serviceable** 2CV with an ignition system fault which is "fixed" by an "exotic" coil and I will show you a 2CV with a fault in its ignition system!

Better running? Now consider the view that the "exotic" coil improves vehicle running (performance). In a properly conducted dynamometer experiment to test a fully serviceable, properly maintained 2CV fitted with either a new "exotic" coil or a new standard black coil, you can bet London to a brick that the power and torque readings taken over several dynamometer runs alternating between the two coils will show no statistical differences. **This means you will not be able to tell which coil is fitted to your 2CV when you drive it,** in which case, either coil will do the job perfectly!

Conclusions:

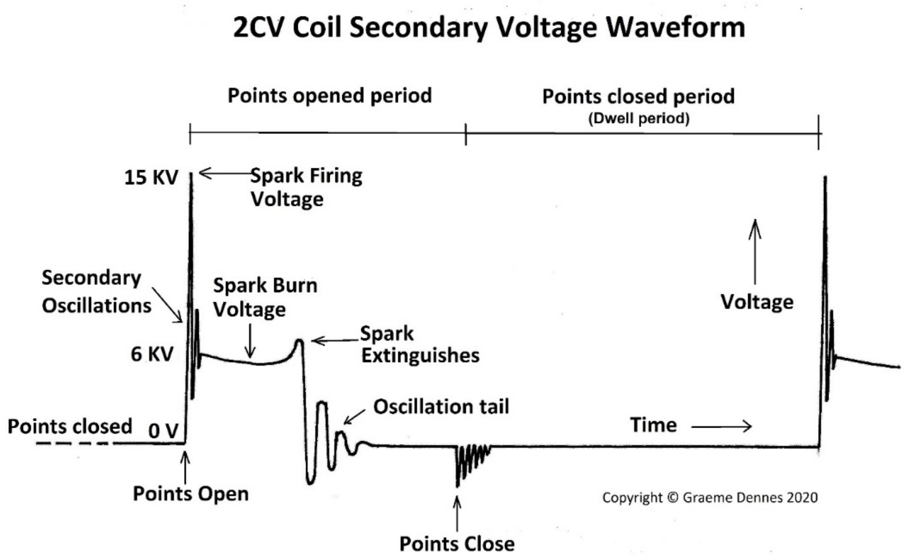
1. The black 2CV ignition coil and the Bougicord 3166 plug leads are critical items in the 2CV. These two items were designed by Citroen as an integrated pair specifically for the 2CV engine. Their individual electrical characteristics complement each other and provide maximum performance from the 2CV, where every performance opportunity is important as we know! Citroen's combination of coil and plug leads for the 2CV is a very successful, highly reliable formula. **Do not change it.**

2. In the writer's view, if your 2CV is properly maintained and it starts and runs correctly with the standard black coil, your 2CV and the black coil are working perfectly, exactly as Citroen intended, so no benefit will be gained by replacing the standard black coil with an "exotic" coil. If it ain't broke, don't fix it!

3. By far the greatest cause of failure of the black 2CV coil is high-voltage flash-over damage resulting from either a lack of maintenance of the plug leads or turning the engine over with the plug leads disconnected. The coil may also run hot, confirming its failure! It will need to be replaced. **Do not blame the coil. It did not *cause* the failure!**

4. If your black 2CV coil is faulty, replace it with a new black 2CV coil.

5. In summary, ensure the ignition key is turned off when you leave the vehicle, take good care of your plug leads and keep the plug leads connected. Your black 2CV coil will reward your efforts by providing a long and healthy operational life!



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