# Paruzzi Magazine

*Technical Publication for the classic Volkswagen*

**08**

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Paruzzi
Classic VW Supplies


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## Low and high voltage

The source voltage of our classic Volkswagen is 6 V (volt) or 12 V depending on the battery installed. We discussed how the battery works in the first edition of this technical series on page 34. We talked about the spark plugs in edition 07, the spark plugs will generate the high voltage spark to ignite the fuel mixture within the cylinders.


A 6 V or 12 V tension is not sufficient to generate a spark between the spark plug electrodes. The spark plug gap is only 0,7 mm though on a Type 1 engine, but to get a spark to cross this gap you need more than thousand volts. That is what the coil will do; it transforms the low voltage from the battery into a high voltage of 10.000 volts and more.

Before we start to test the coil on our classic Volkswagen we need to understand how the coil works inside, how is it possible to transform 6 V or 12 V into more than 10.000 V? That is the magic called **induction**!

# testing the coil

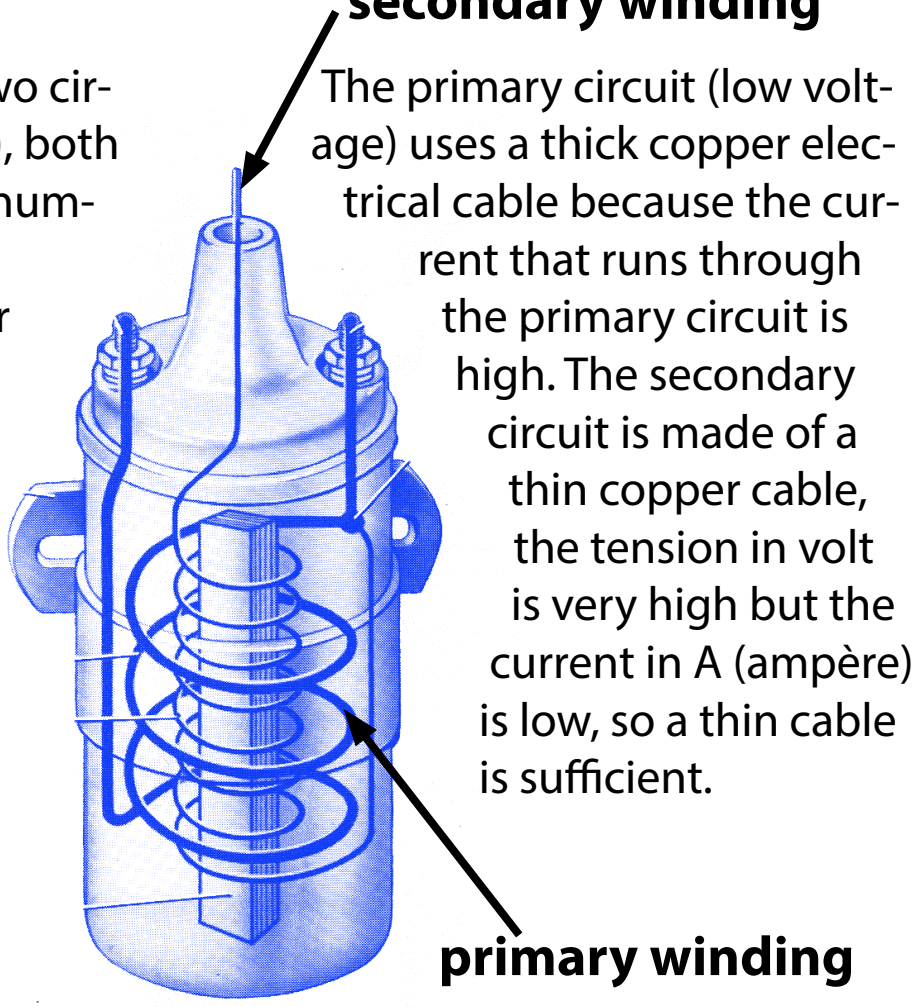
Open your engine lid and you will see the coil attached to the doghouse on a Type 1 engine. The coil can be a 6 V or 12 V one depending on the battery installed, the color and shape can be different depending on the brand.

## What is induction?

A coil is an electrical wire such as copper in a cylindrical form around an iron core. A magnetic field will be generated when an electrical current runs through a coil. When the current in the coil suddenly disappears, it will create a magnetic field in a second coil (the second coil is located nearby the first coil) and it will also create an electrical tension.

The coil in our VW has two circuits (two coils basically), both circuits have a different number of windings. It is the difference in the number of windings between the first (primary) and second circuit that will define the difference in tension between both circuits.

When you connect a low voltage of 6 V or 12 V to the primary circuit of the coil, and then you suddenly disconnect this low voltage, a high voltage more than 1000 times as high will be generated in the secondary circuit. The exact difference in tension depends on the difference in windings between both circuits.

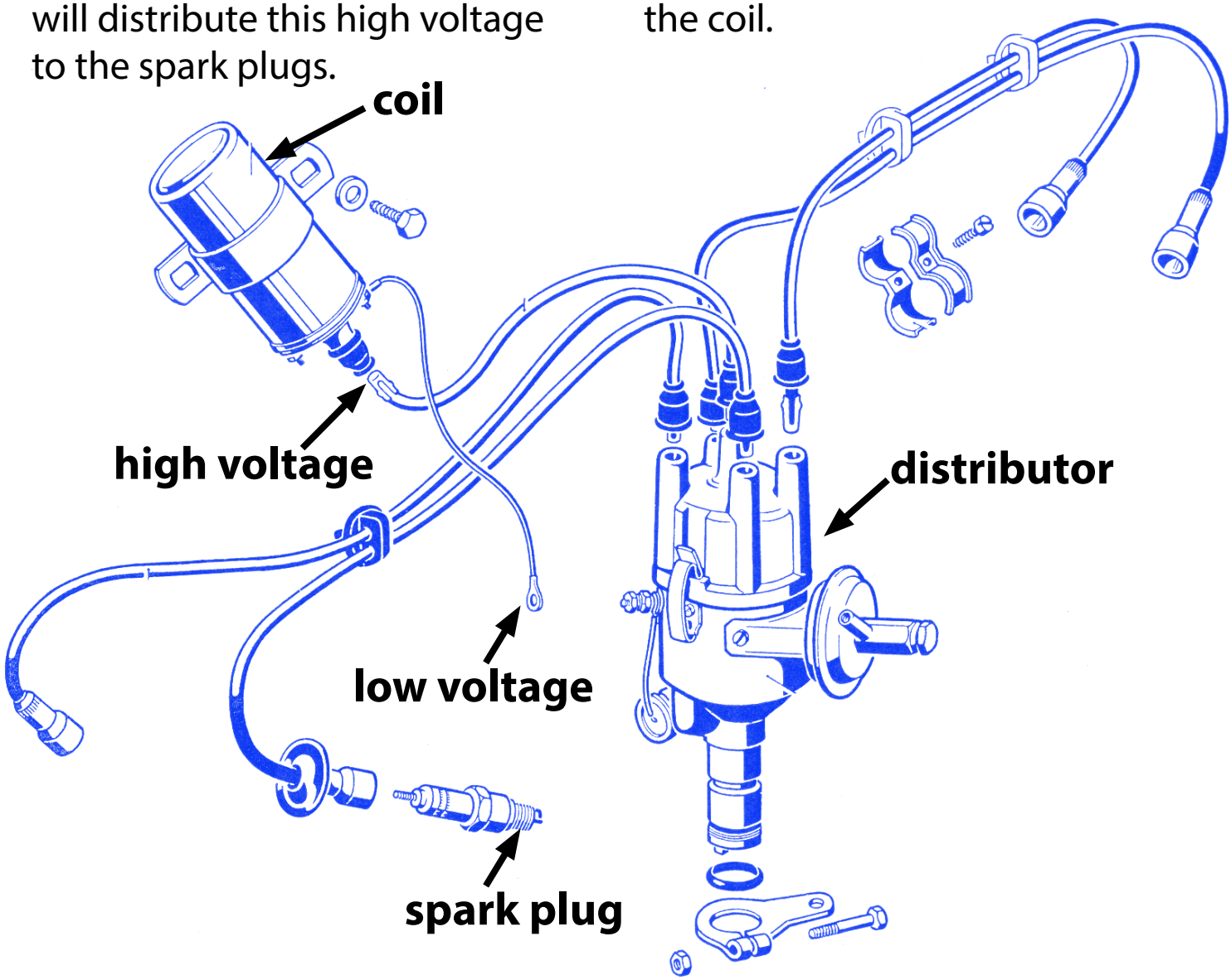



The primary circuit (low voltage) uses a thick copper electrical cable because the current that runs through the primary circuit is high. The secondary circuit is made of a thin copper cable, the tension in volt is very high but the current in A (ampère) is low, so a thin cable is sufficient.

# testing the coil

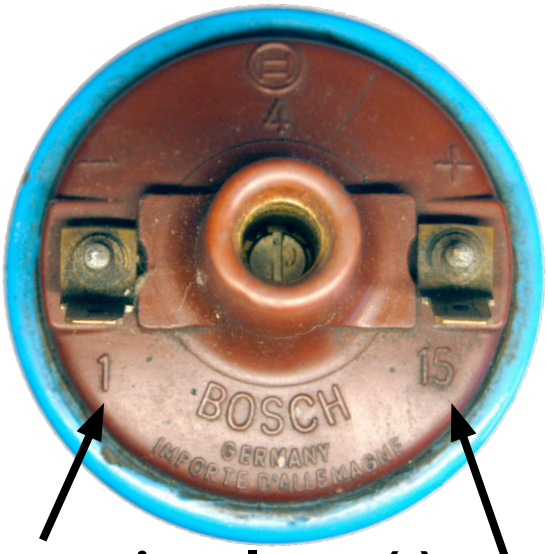
That is just what we are doing with the coil on our VW, we connect a low voltage (from the battery) on the primary circuit and the high voltage from the secondary circuit is connected to the distributor. The distributor will distribute this high voltage to the spark plugs.

The drawing below shows the most important parts of the ignition circuit, these parts are important to generate the final high voltage spark to ignite the fuel mixture. We will now discuss how to install and how to test the coil.



## Connecting the coil

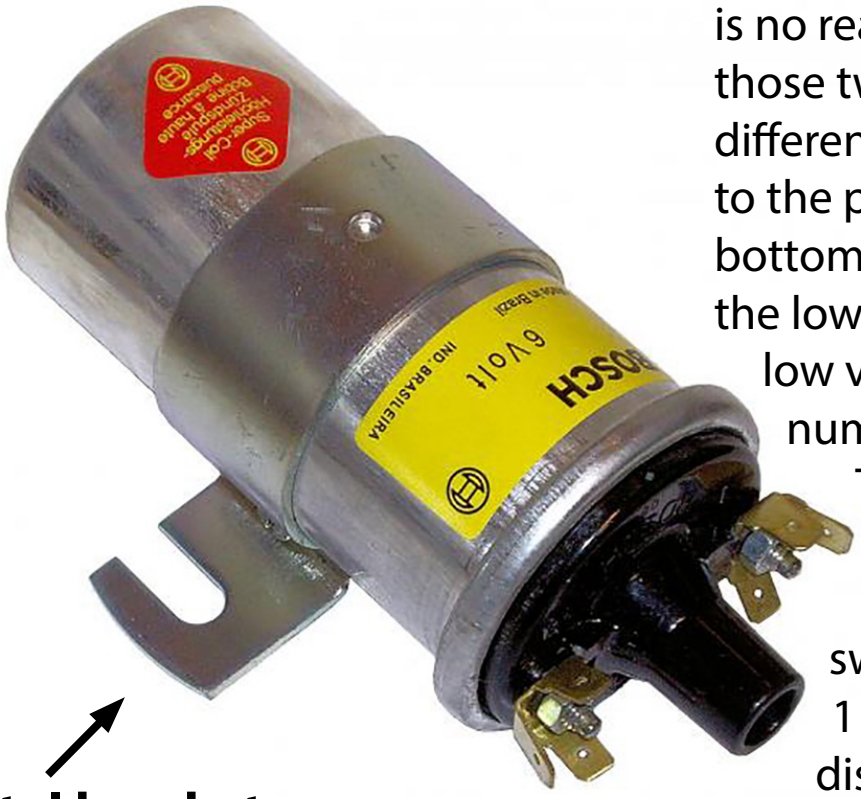
The coil is attached to the dog-house on the Type 1 engine, you will find the coil on different place on other VW types, but the basic principle is the same for all engine types, a metal bracket secures the coil to the engine or the chassis of the car. The bracket isn't used to ground the coil, in fact the coil can be installed without being connected tot the chassis (= electrical ground).




**1: negative clamp (-)**

**15: positive clamp (+)**

Coils from the manufacturers Beru and Bosch have been installed on our classic Volkswagens. There is no real difference between those two brands, they will look different though. The connections to the primary circuit is at the bottom of the coil, these are the low voltage clamps. The low voltage connections are numbered with 1 and 15. The electrical plus is clamp 15 (+) which is connected to the ignition switch inside the car, clamp 1 is connected to the distributor.




**metal bracket**

# testing the coil

to clamp 1 of the coil (-)

The minus (number 1) from the coil connects to the green cable from the distributor. Make sure all cables are well connected and that the clamps and connectors are clean, use some fine sandpaper to clean all electrical contacts if needed.

The coil can fail. It is usually a short circuit in the secondary winding that will cause the failure. You won't notice the failure until the engine is running for some time and the coil gets hot, difficult to diagnose without special equipment.

An oscilloscope could show you the failure on screen, but only professionals will have that handy in their workshop. Removing the old coil and replacing with a new one will be the easy way to go for us VW enthusiast, diagnose by elimination.

## Testing the coil

You can test if the low voltage on the primary winding is fine using a Multimeter or Voltmeter. You can't measure the high voltage on the secondary winding with DIY tools. We will show you how to do it with a simple trick. We'll explain now how to test the low voltage and the high voltage of the coil on our classic Volkswagen.

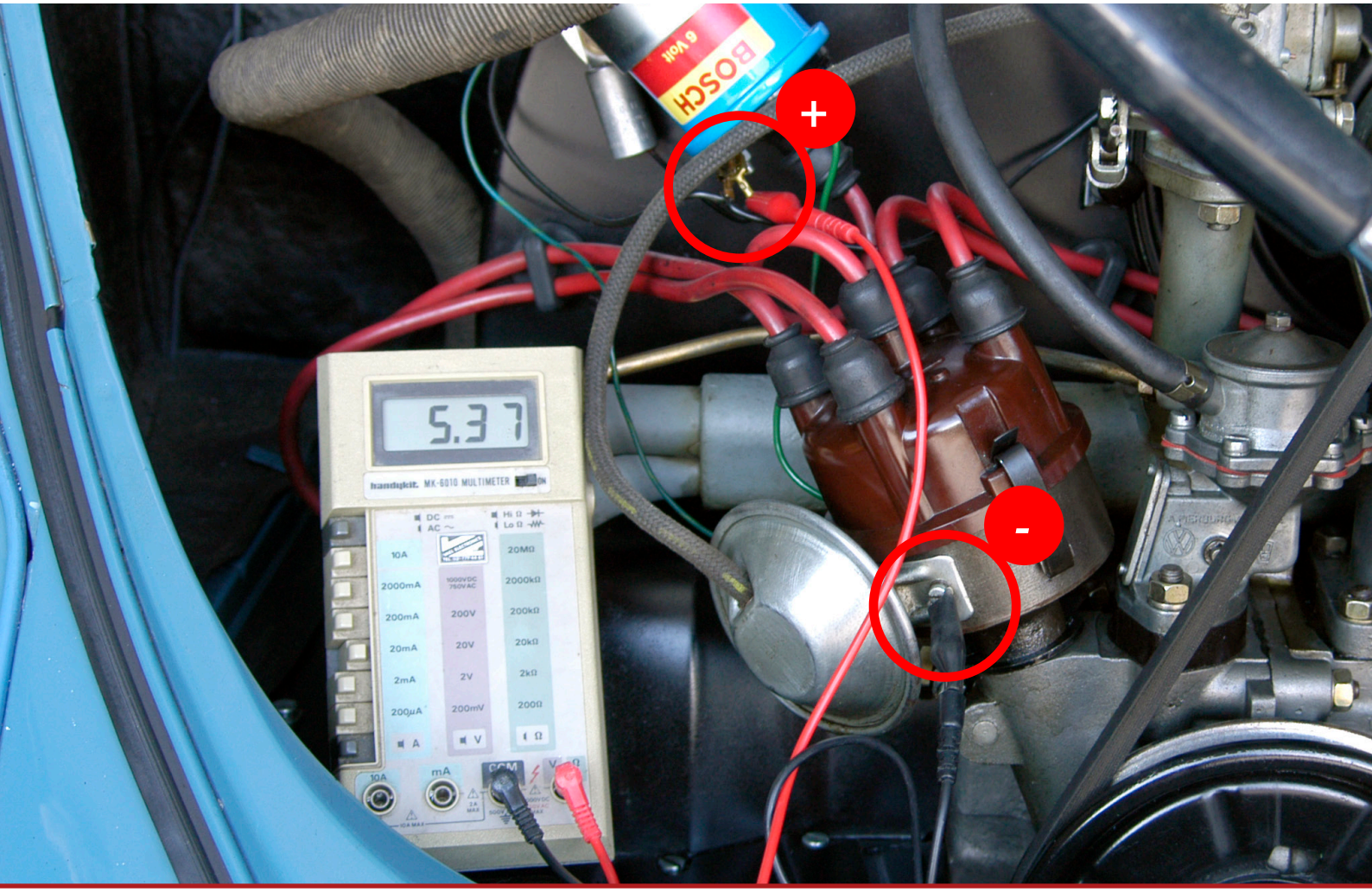
### *WARNING! High Voltage*

Be careful when you work on the high voltage side of the ignition circuit. Don't touch these parts with your bare hands, always use work gloves, use tools that have a good electrical insulation, don't touch the metal parts of these tools with your bare hands.

## Testing the low voltage

Turn on the ignition switch inside the car. Connect the positive terminal from your Multimeter with the positive clamp of the coil (clamp numbered 15) and the minus of your Multimeter with the ground (chassis) of your VW. We use the small bolt on the distributor as minus or ground.

You should measure a tension of 5.5 V if you have a 6 V installation or about 10 V if you have a 12 V installation.
Turn off the ignition switch now, the tension you just measured on the low voltage side of the coil should drop to zero. Now you know that the primary circuit of the coil gets the correct low voltage level.



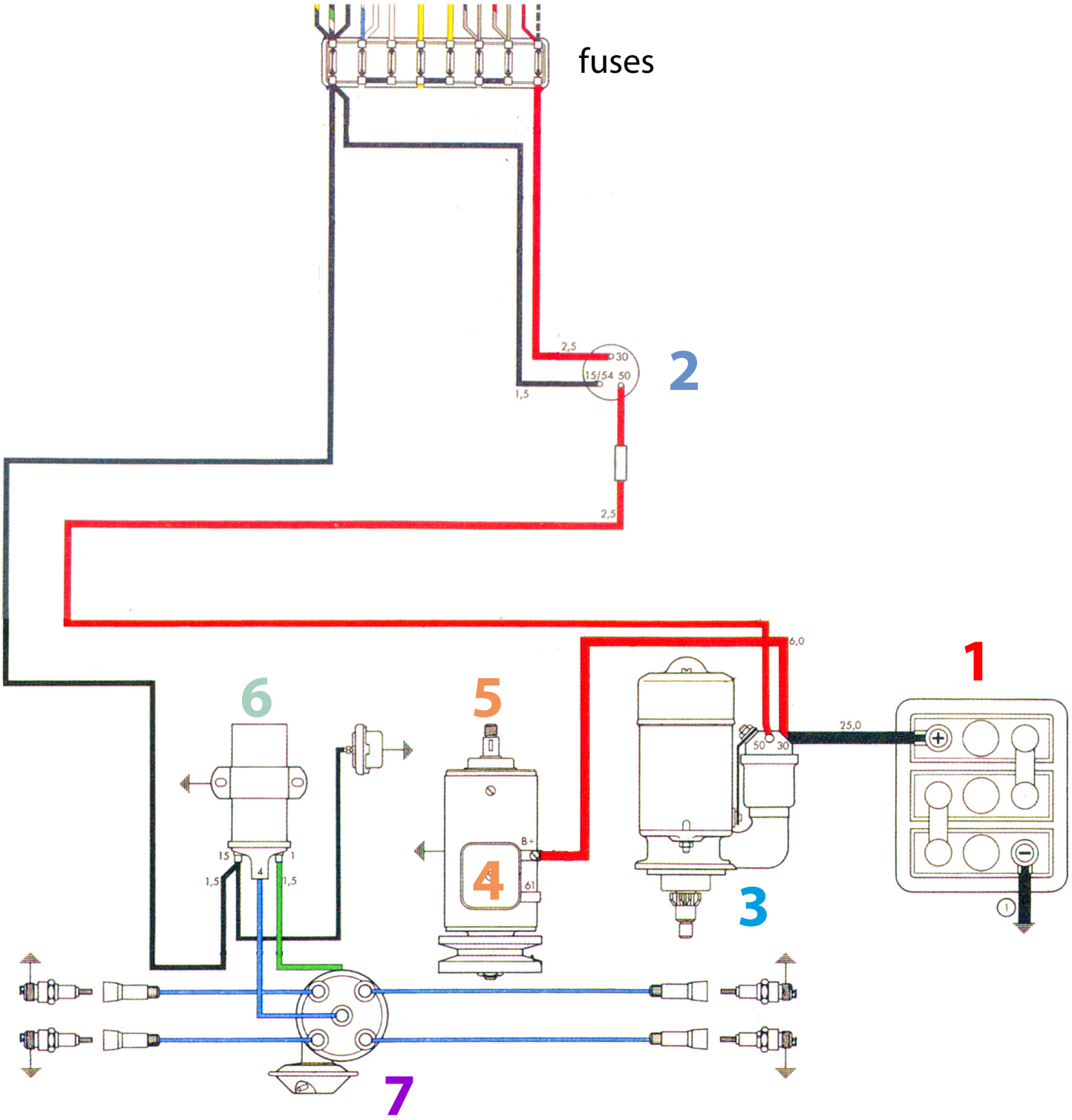
If you don't measure these voltage values on the low voltage side of the coil, then you know that there is something wrong with the power supply coming from the battery through the ignition switch. The tension on the 15 clamp of the coil comes from the ignition switch as we show on the VW electrical wiring diagram on the right page. We explained this diagram extensively in our second edition. We show the coil as number 6, the black cable starts from clamp number 15 on the coil and runs to the fuse box and then to the ignition switch (number 2). The ignition switch is then connected to the battery (number 1 on the diagram). The cable from clamp 15 of the coil doesn't run through the fuse box, it is not protected by a fuse, good to know. A short circuit to the ground or chassis is not prevented by a fuse, so watch out!
If the low voltage fed to the coil is not correct, you will need to diagnose the battery, the ignition switch, the fuse box, the wiring and make sure all these parts are fine before you start to diagnose the high voltage.

The standard automobile electrical installation has 7 basic components, we refer to VWebMAG edition 02 for more information:

1. **the battery (12 V or 6 V for our classic VW)**
2. **the ignition key and the ignition switch**
3. **the starter**
4. **the voltage regulator**
5. **the generator (dynamo or alternator)**
6. **the ignition coil**
7. **the distributor, condenser and the spark plugs**

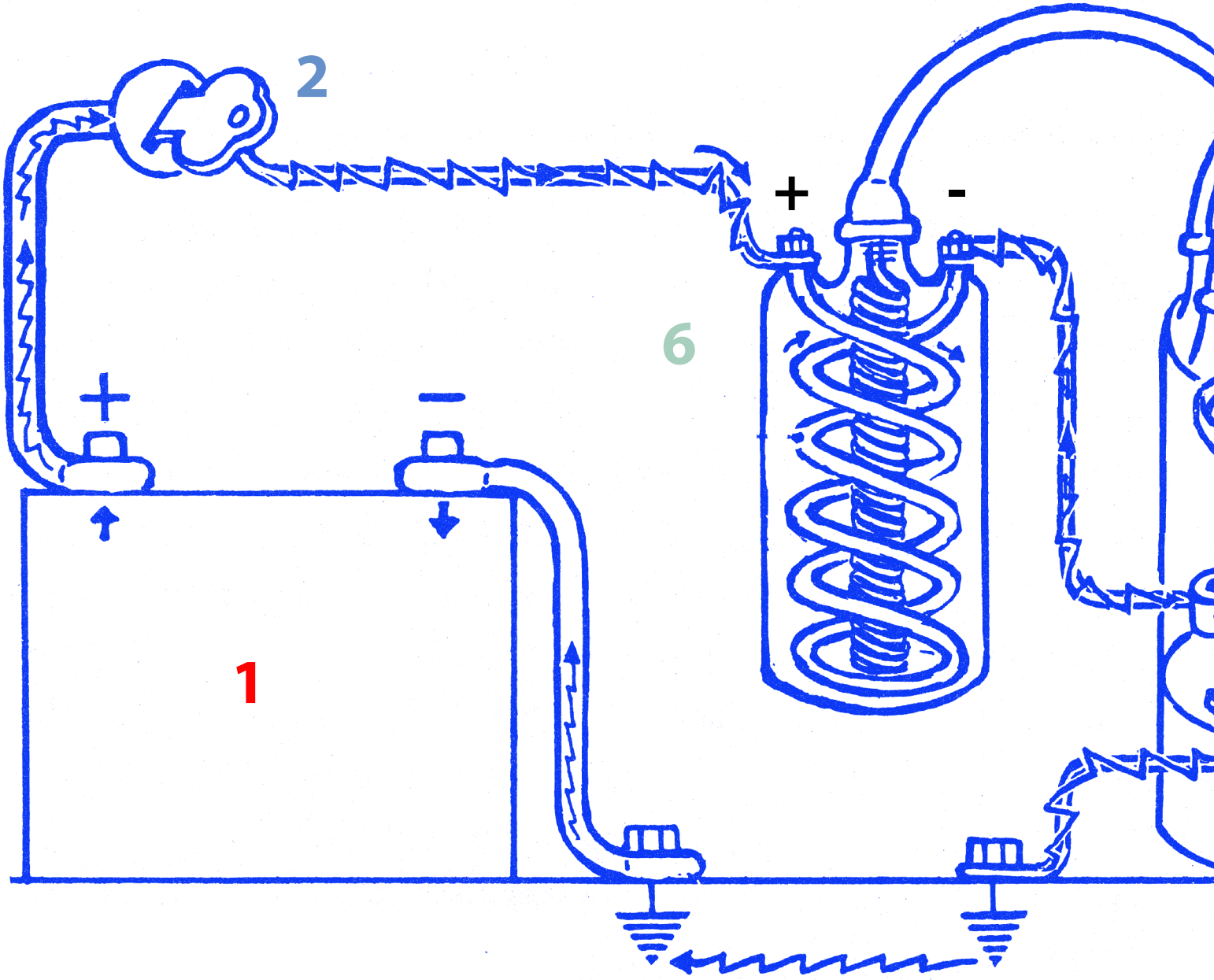


# testing the coil



## Testing the high voltage

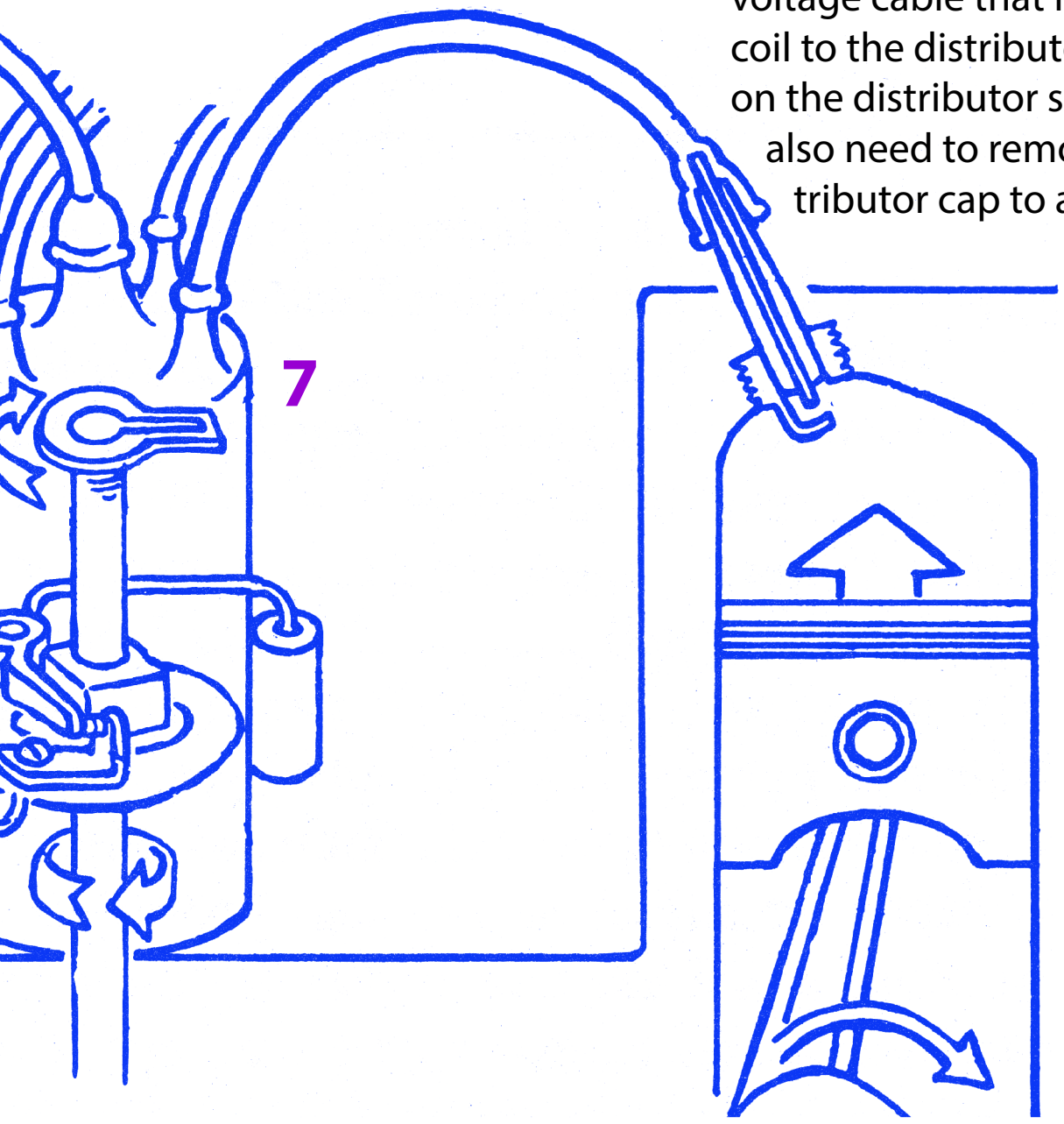
This drawing shows the low voltage and the high voltage circuit of our classic Volkswagen, I find this drawing really nicely done. It originates from a book from John Muir illustrated by the artist Peter Arschwanden back in 1969. This book inspired me to want to learn more about the technical aspects of my VW 1600TL Type 3 back in the days.



# testing the coil

The drawing shows that the primary winding receives a low voltage, a current runs through the ignition points because they are closed.

All parts already discussed in this article are shown. The cylinder with piston and spark plug is shown on the right. To test if the coil is generating a high voltage we need to remove the high voltage cable that runs from the coil to the distributor, remove it on the distributor side. You will also need to remove the distributor cap to access the ignition points.



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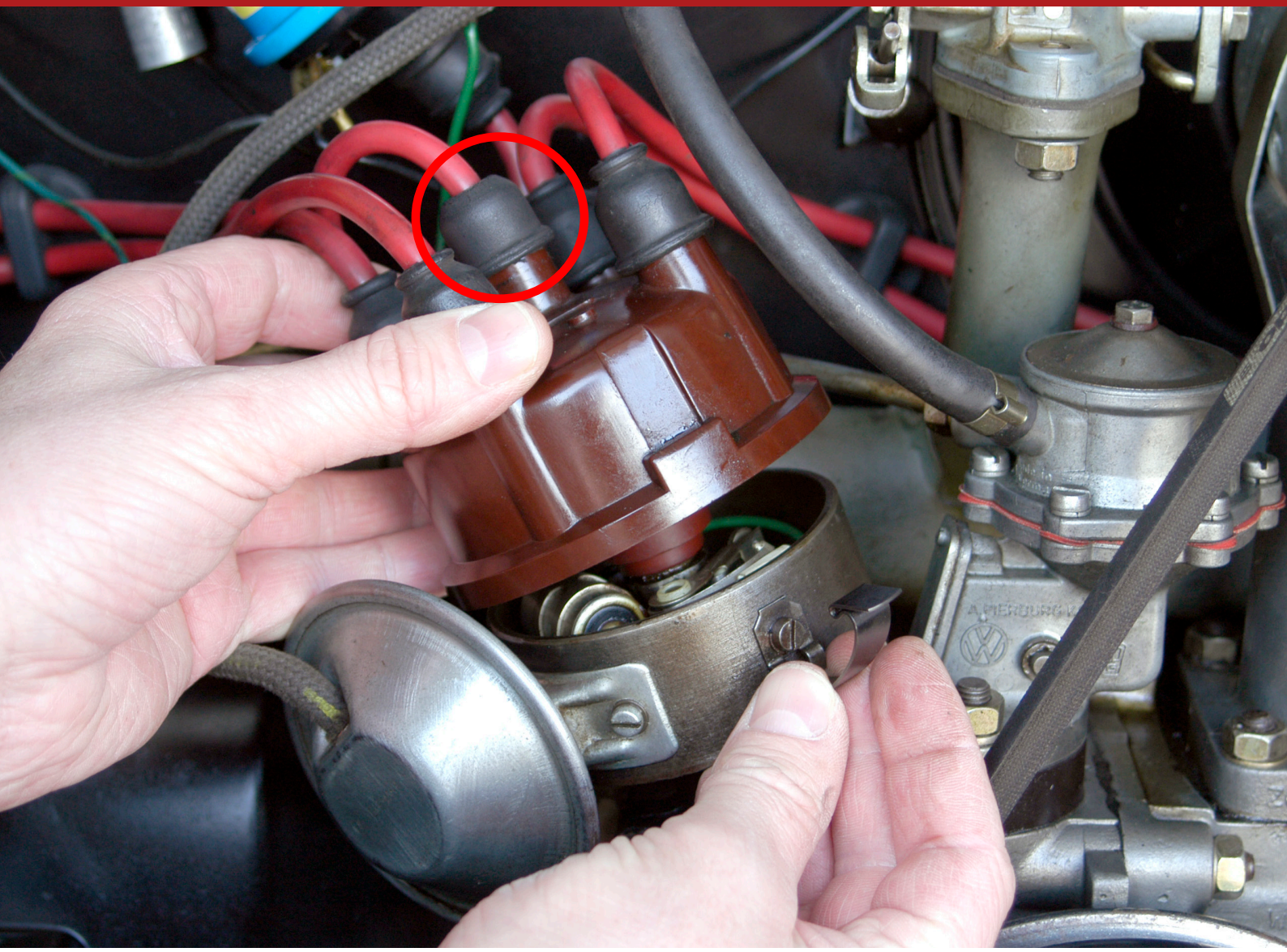
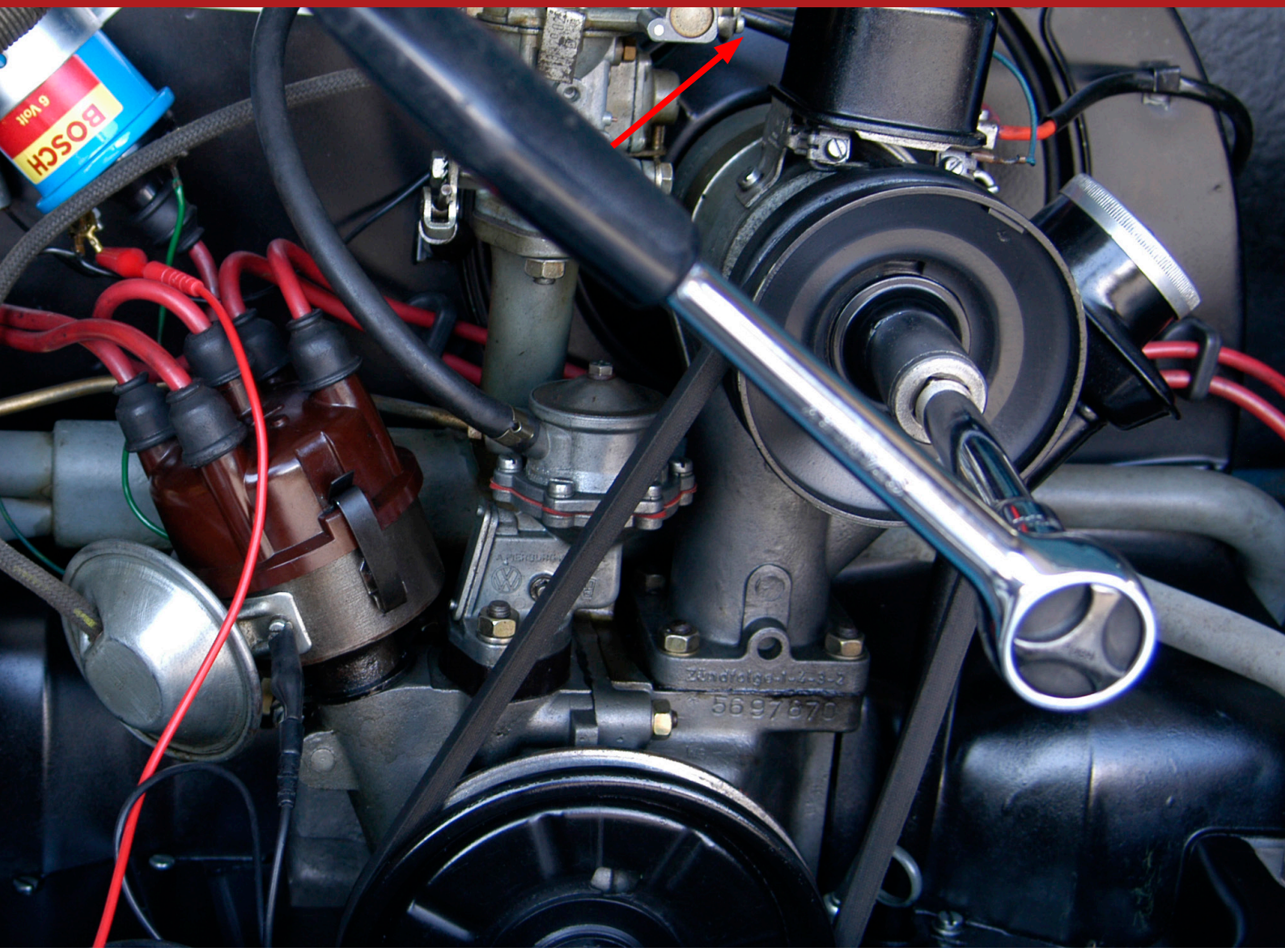


First remove the distributor cap to be able to access the ignition points. Disconnect the high voltage cable from the distributor cap, this is the red cable (can be any color for your VW) marked with a circle on the picture above. You should be able to see the inside of the distributor and access the ignition points.

Use a socket wrench to rotate the pulley, we have explained how to do that in edition 05 when we explained how to set the valve clearance. Rotate the pulley until the ignition points close. This is the situation as shown on the drawing of the John Muir book on the previous page.

# testing the coil



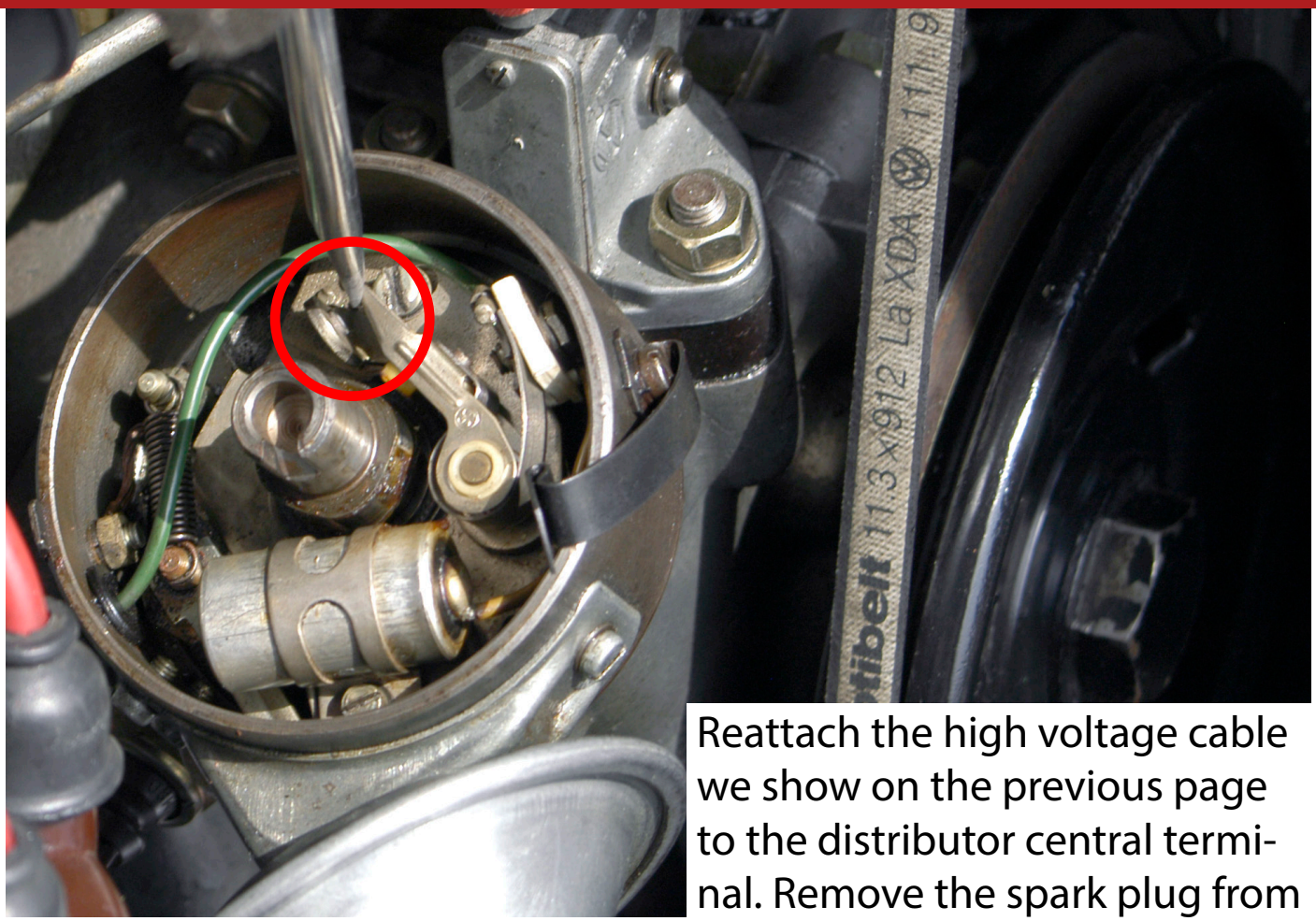

Only when the ignition points go from a closed to an open state will the electrical current in the primary circuit of the coil disappear, this will generate a high voltage in the secondary circuit due to the induction principle as explained earlier in this article. Now, rotate the pulley to open the ignition points.

# #22 Electrical


You disconnected the high voltage cable from the distributor as shown on the picture above. Position this cable about 1 cm from a bare metal grounded metal part, we use the coil bracket but (if you don't mind "damaging" the bracket) you may add an extra cable to the ground to test the high voltage, the spark could create like a welding point in the metal.

Don't do this close to the fuel pump or fuel hoses as the high voltage spark could be hazardous. Turn the ignition switch on. Use a screwdriver to open the ignition point as shown on the picture on the next page. When opening the ignition points, you should see a high voltage spark travelling from the high voltage cable to the ground.

# testing the coil

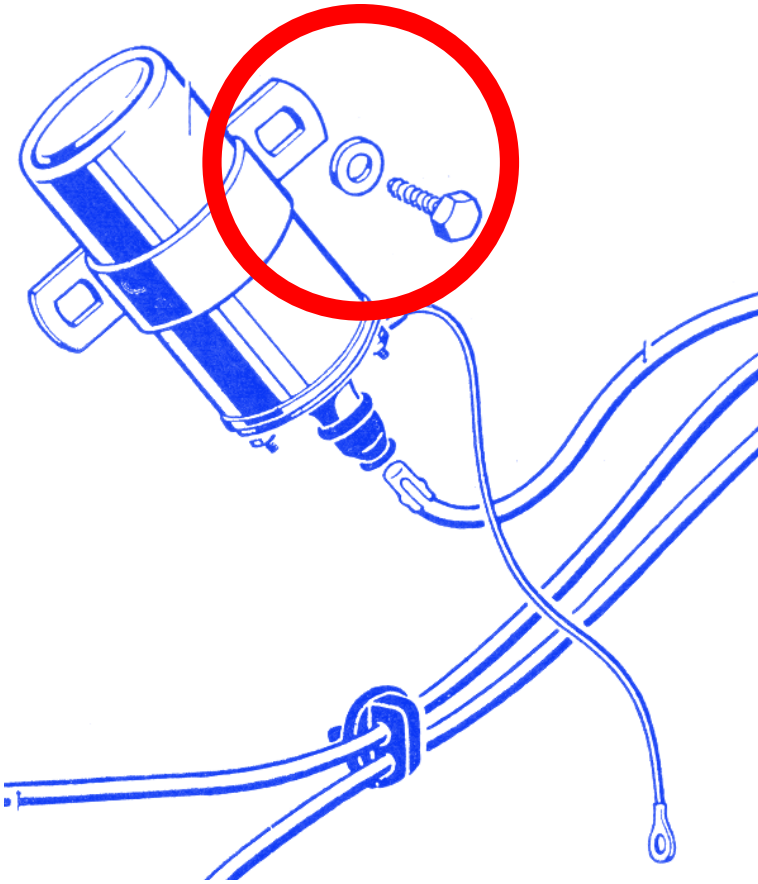


If this is the case you need to test if the distributor cam opens the ignition points. Rotate the pulley with the wrench en watch the points opening, this should also generate the high voltage spark as before. The coil generates the high voltage, that's what we just tested, but it is possible that the high voltage is lost along the way from the high voltage cable to the sparks. We will test if the high voltage reaches the spark plugs.

Reattach the high voltage cable we show on the previous page to the distributor central terminal. Remove the spark plug from cylinder 1 as explained in edition 07. Reattach the ignition wire to the spark plug you just removed. Position the thread of the spark plug close to a bare metal ground as you did before with the high voltage cable. Turn the ignition on and rotate the pulley. You should see a spark between the spark plug electrodes every time the ignition points opens. If this is the case, your spark plus 1 works fine. Do the same for all spark plugs.

## *New coil*

Standard coils are available for your classic VW, but you can also purchase a heavy duty one. These heavy duty coils will deliver a higher voltage than the standard coils. Heavy duty coils will ease the cold start, particularly for 6 V Volkswagens. These heavy duty coils can also, in theory, help to deliver more engine power on high-performance engines.



## *New ignition wires*

New ignition wires (spark plug cables) are available with a copper core (just as the original VW wires) or with a carbon core. The carbon core wires have better electrical conduction specifications than the copper ones. Some ignition wires have half-silicone sheath to resist higher engine temperatures.

## *Removing the coil*

Removing the coil is an easy operation, just remove the two bolts securing the coil bracket to the doghouse and unplug the cables from clamp 1 and 15. A new coil will be delivered with a new bracket, in most cases, so read the information carefully on our webstore before ordering.

## *Installing the coil*

Installing the coil is easy, secure the bracket using the two bolts and reattach the green cable from the distributor to clamp 1 and the black cable coming from inside the car to clamp 15. Watch out, you will not always find the number 1 and number 15 terminals on the same place on all coils, so be careful when attaching the cables to the low voltage side of the coil.

## Conclusion

You can diagnose the coil by testing if the low voltage at the primary circuit is ok, the low voltage is delivered by the battery. If this is fine, you can test if a high voltage is being generated in the secondary circuit of the coil by opening the ignition points and checking if a spark is generated between the high voltage cable and the ground. Checking if a spark is generated between the spark plug electrodes is an extra check to confirm that the coil works fine.

The coil can still fail when the engine gets hot, the coil heats up and the windings will create a short circuit because of the melt down of the insulation, this can cause intermittent failures and it is difficult to diagnose.

If any doubt, just replace your coil wit a new one, this will solve your problem rapidly.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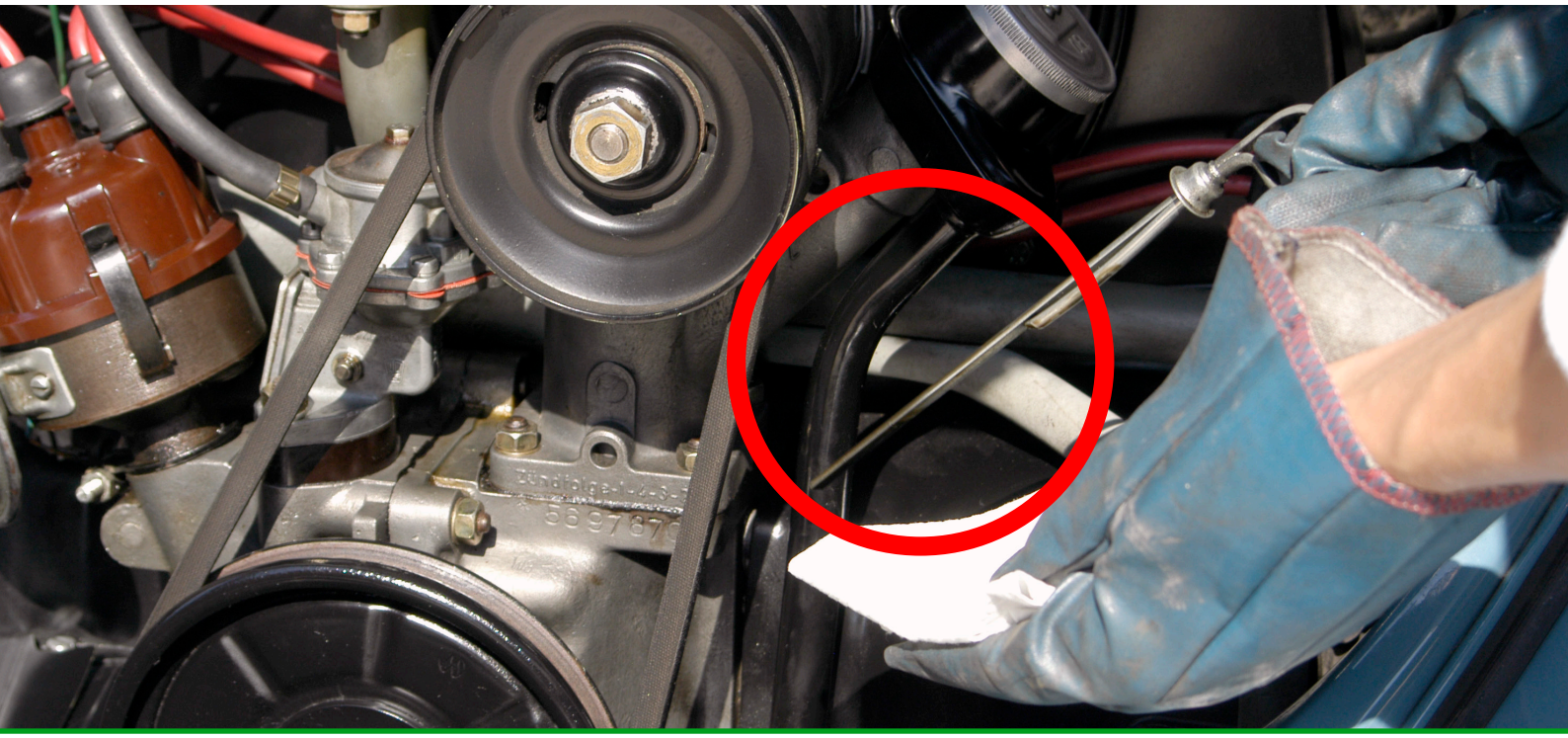
# Oil consumption versus oil leakage

We discussed different ways your VW can leak oil. These oil leaks are easy to repair without having to remove the engine in most cases. We kept the more "serious" issues for this article, we didn't title this one "oil leakages part 2" but "oil consumption". It is not always easy to see the difference between leakage and consumption, I hope it will become clear after you read this technical story.

We will talk about the following topics in this article:

1. **condensation**
2. **piston rings**
3. **blow-by**
4. **cylinder head & cylinder**
5. **crankcase halves**
6. **crankshaft pulley**
7. **crankshaft seal**

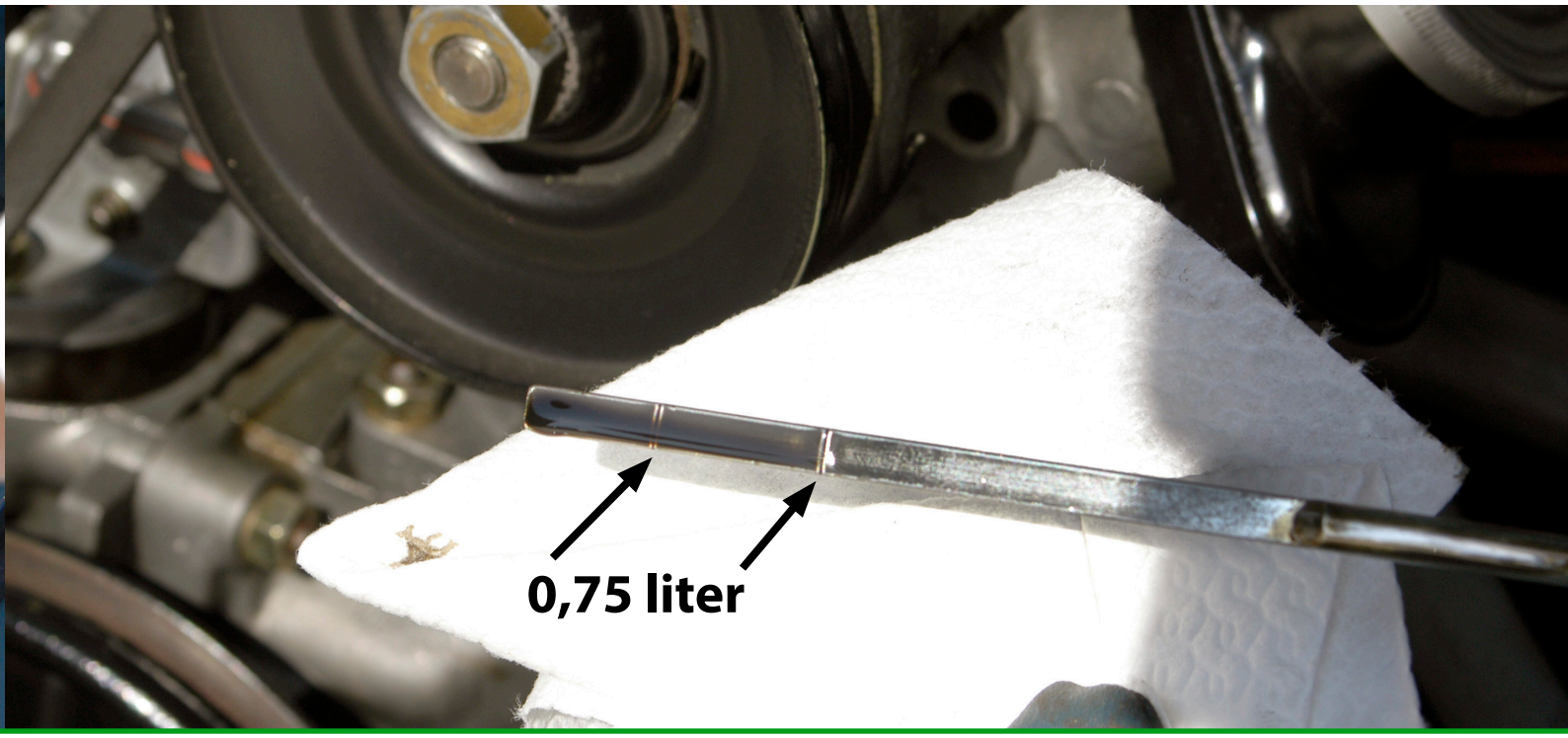


# oil consumption

How much engine oil should a healthy air-cooled boxer engine consume? One liter per thousand kilometer is the standard for most of our engines.

The difference between the top mark and lower mark on the oil dip stick on a Volkswagen Beetle with Type 1 engine is about 0.75 liter. The air-cooled boxer engine has larger engine tolerances than the modern water-cooled engines. So, 750 km for one liter could be defined as the minimum you should be able to drive with your VW.

You need to measure the oil level when the engine is cold and the engine is cut off in contrast with the Porsche 911 where you need to measure the oil level when the engine is running and at operating temperature.



## 1. Condensation

An unexpected player in the oil consumption story is condensation. If you drive short runs there will be a lot of condensation piling up in the engine crankcase, the engine doesn't have time to reach operating temperature to evaporate the water vapor accumulated in the crankcase. The excessive condensation will mix with the engine oil, modern oils are very well engineered to be able to absorb water. As you understand now the absorption of water will increase the oil level. So, if your engine is consuming a lot of oil and you drive a lot of short runs all the time, the oil level won't drop too much, well, at least that is what it looks like. The drop in oil level will be compensated by water absorption, it will look like your engine is not consuming a lot or not consuming at all.
You need to change the engine oil on a regular basis, if you don't drive too much or your drive lots of short runs, you need to change the oil at least once a year. A mixture of oil and water is not a good lubricant for your engine, bad lubrication can lead to severe engine damage. We show an example below, the connection rod bearing ceased as you can see.

## 2. Piston rings

Worn out piston rings can be diagnosed by watching the exhaust fumes. If the fumes are colored blue when cranking up the engine or when releasing the throttle, this is a sign of worn out piston rings. Engine oil will leak through the piston rings and/or the valve guides into the combustion chamber in the cylinder. A little bit of blue fume tells you that the valve guides are worn out.  Only the intake valve guides will suck engine oil into the combustion chamber, the exhaust valve guides mostly process compressed air, this compressed air will flow to the rockers under the valve cover. The massive blue "oil" exhaust when you release the throttle tells you the piston rings are dead, because much more oil can flow through the piston rings.

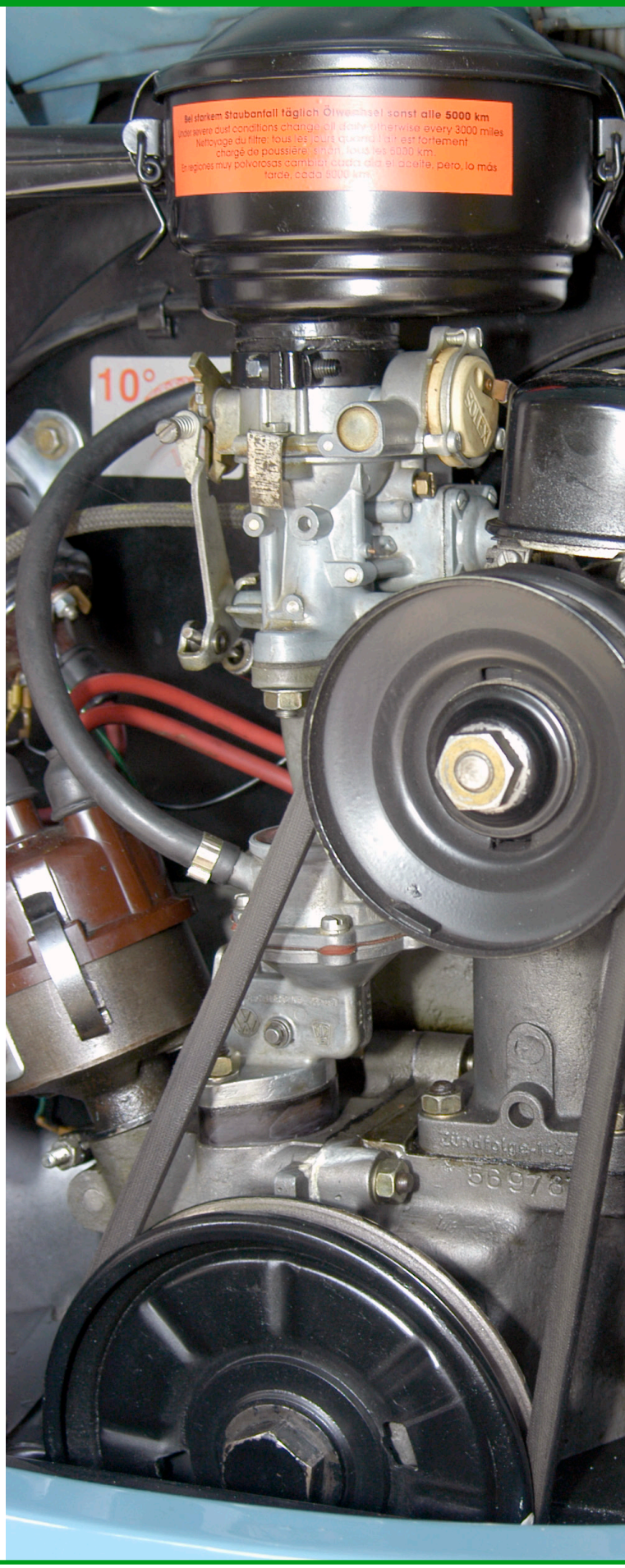
Our air-cooled VW uses pistons with three piston rings. We explained that in edition 06 when we talked about measuring the engine compression.

The bottom two piston rings on the drawing on the left are compression springs, the top one is the oil scraper ring. If the piston rings are worn out you will probably need to overhaul your engine unfortunately.

## 3. Blow-by

An additional consequence of worn out piston rings, in addition to the blue oily exhaust fumes caused by the engine oil flowing through the piston rings, is that the compressed fuel mixture flows into the crankcase. This unwanted mixture of fuel and air and exhaust fumes will accumulate into the crankcase at eventually try to escape from it.

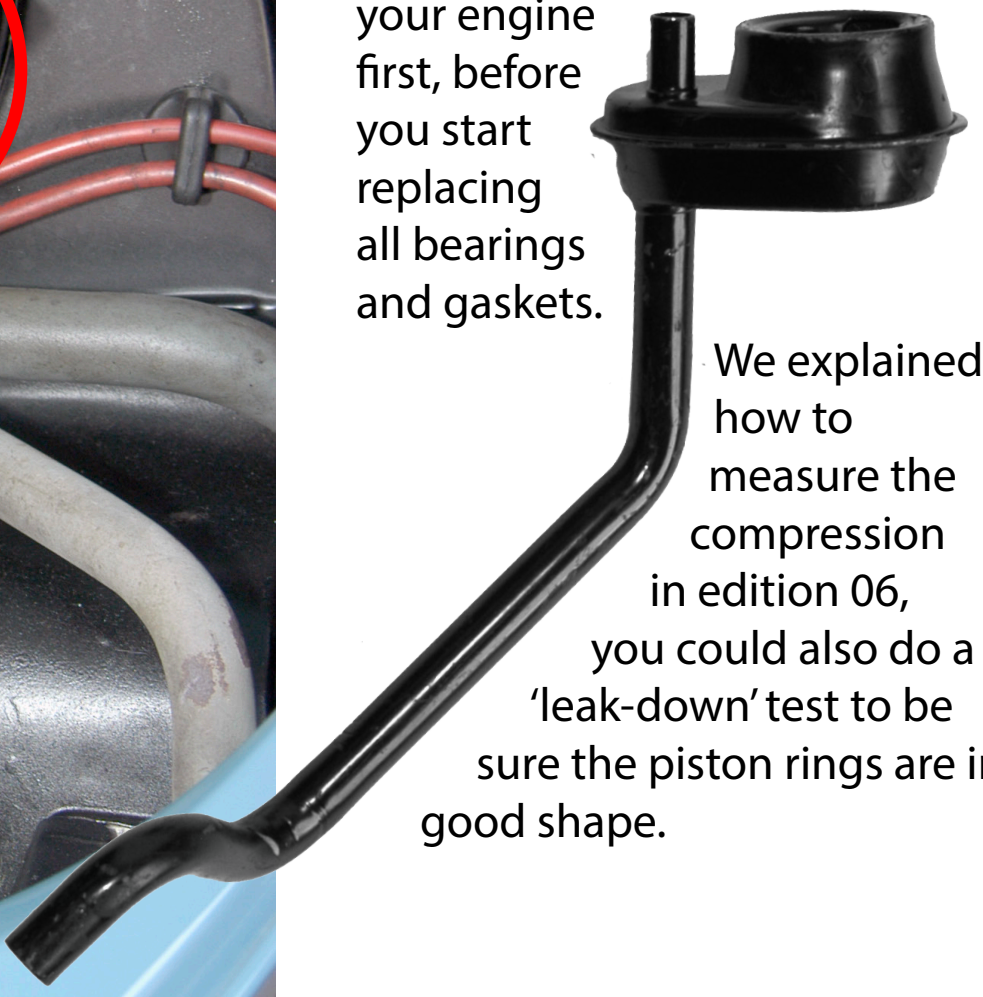
The easiest way for the unwanted fumes to leave the crankcase is via the crankcase breather. The standard breather in our air-cooled engine is not big enough to evacuate the unwanted compression and fumes caused by worn out piston rings, so this will cause leakages though the crankcase cracks wherever possible. The latter is called 'blow-by'. Most (oil) bearings, gaskets or seals are not designed to endure the extra compression caused by blow by.



# oil consumption

The blow by consequences could look like worn out bearings, gaskets or seals. One could be misled by the oil leaking and start to replace all bearings and gaskets, with no result. Once everything is replaced, the same leaks will reappear again and again.

Measure the compression from your engine first, before you start replacing all bearings and gaskets.

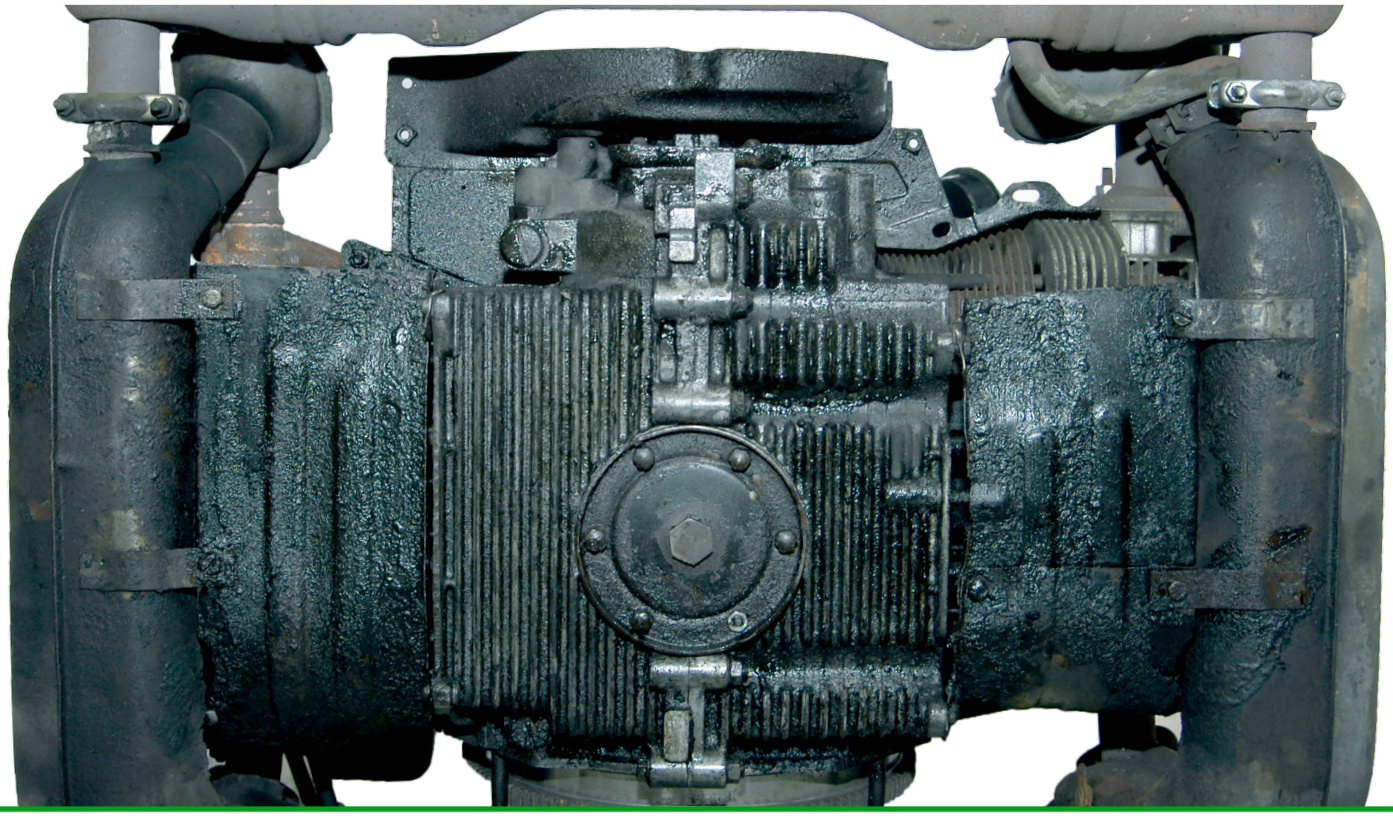


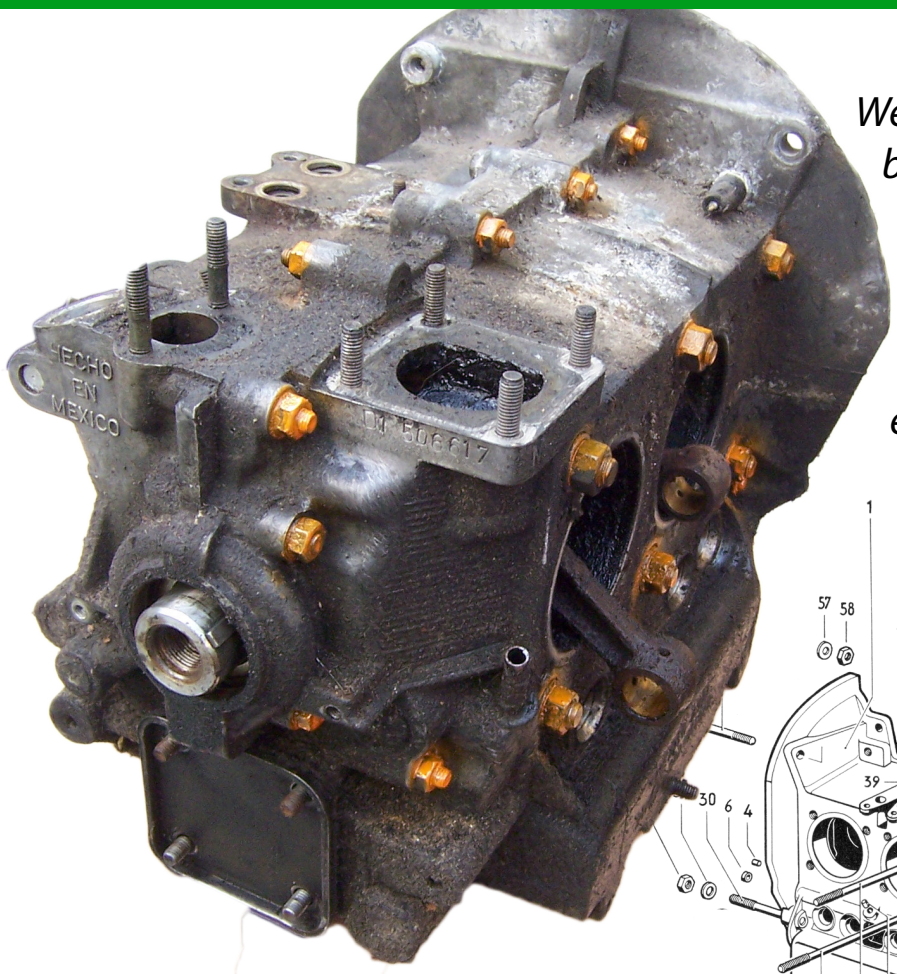
We explained how to measure the compression in edition 06, you could also do a 'leak-down' test to be sure the piston rings are in good shape.

## *4. Cylinder head & cylinder*

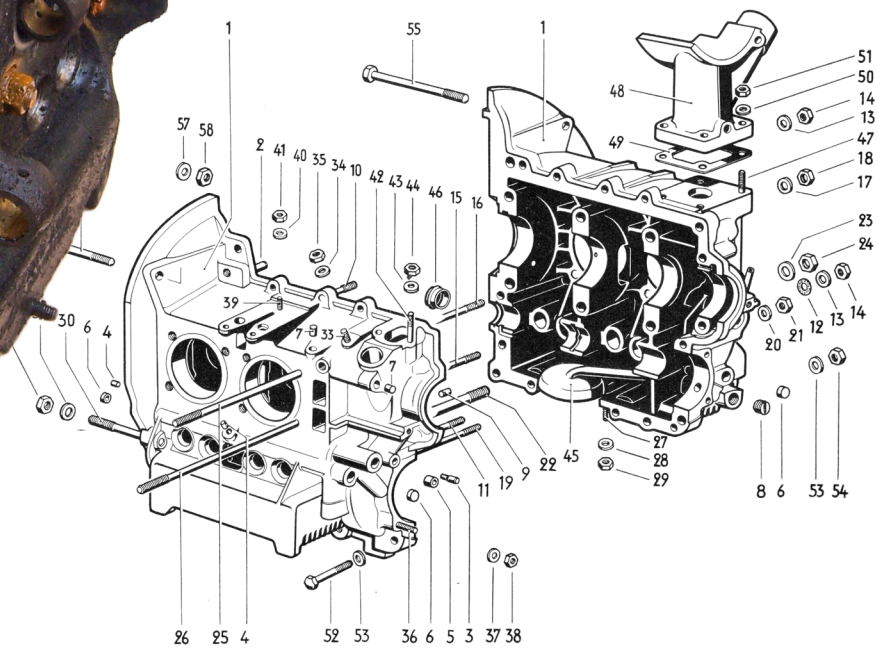
This is a tricky one, when the cylinder head or the cylinder is leaking, you will see oil dripping on the cylinder head top and bottom cool fins. What really happens is that the engine is leaking compression. This will happen when the engine is running under high load, you won't see it when the engine runs idle, which makes it difficult to diagnose. This type of leakage can happen on both the Type 1 and Type 4 engines.

Type 1 engine cylinder head leakage will happen most often on the 1600 cc engines, in particular the Volkswagen Bus engines. The 1600 cc engines have the biggest cylinder diameter resulting in the smallest cylinder to cylinder head surface. Oil leakage will occur most often on these engines when the engine overheats. If you want to know more about engine compression, read edition 06 of this technical series.






*We show on the drawing below both crankcase halves, you can see the crankcase halves nuts on the picture left. Oil leakage through the crankcase halves is not so common really, if so, your engine needs a total overhaul.*



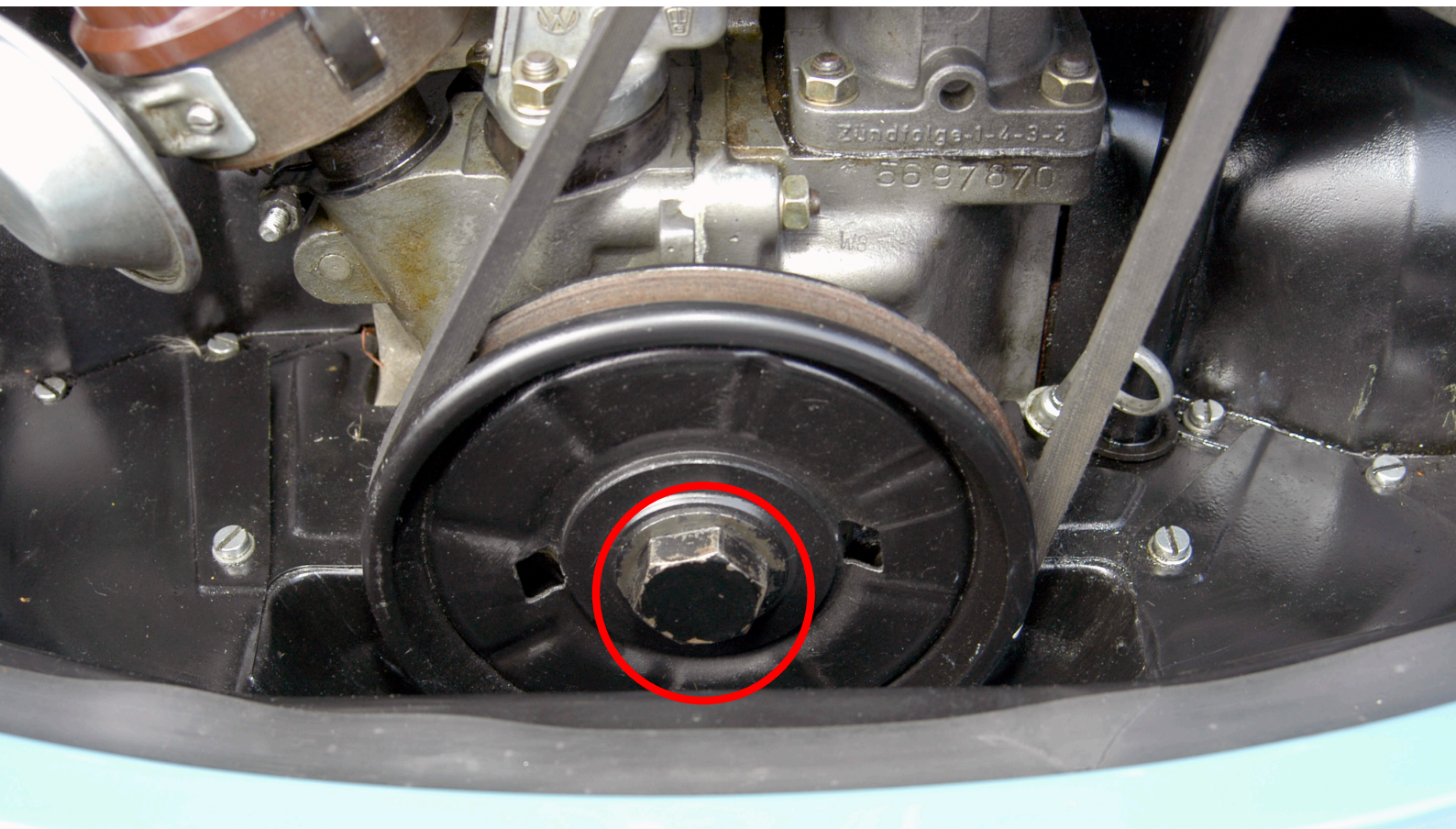

## 5. Crankcase halves

The crankcase of the air-cooled boxer engine is made of two parts, two halves. Oil leaks coming from these connections between both halves are not very common, sometimes it looks like oil is coming from there but it generally comes from another place. Oil will drip from the crankcase when there is an oil cooler leak, so it will look like a crankcase halves leak. Another reason to make sure your engine is cleaned before you start any attempt to diagnose oil leak or oil consumption sources. If you finally conclude that oil is leaking from between both crankcase halves, your engine probably needs an overhaul anyway.

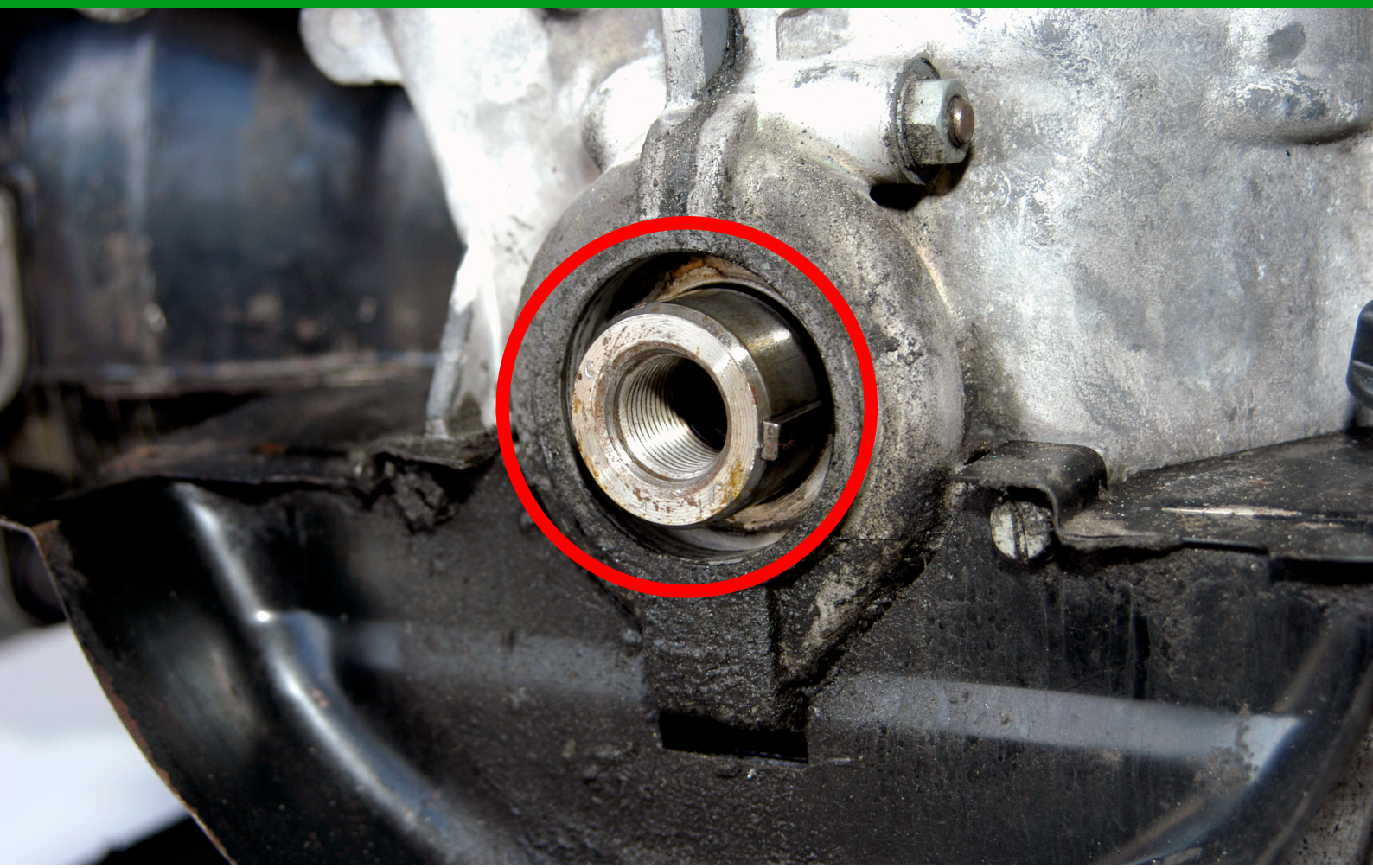
## 6. Crankshaft pulley

The crankshaft pulley (only for Type 1 engines) is the pulley connected to the crankshaft, as the name reveals. The pulley rotates the V-belt. This V-belt rotates the dynamo/alternator (generator pulley) pulley. If the V-belt is installed too tight the crankshaft pulley and the generator pulley will wear down. You've got yourself two problems. Adjusting the V-belt is very important as you understand now.

Engine oil can leak through the crankshaft pulley opening on Type 1 engines (picture on the right page). You can recognise this kind of leak because the inside of the engine lid will show oil splashes and you will also see a lot of oil on the engine metal sheet. The dripping oil will become more visible after you removed the crankshaft pulley (picture on the right).



# oil consumption

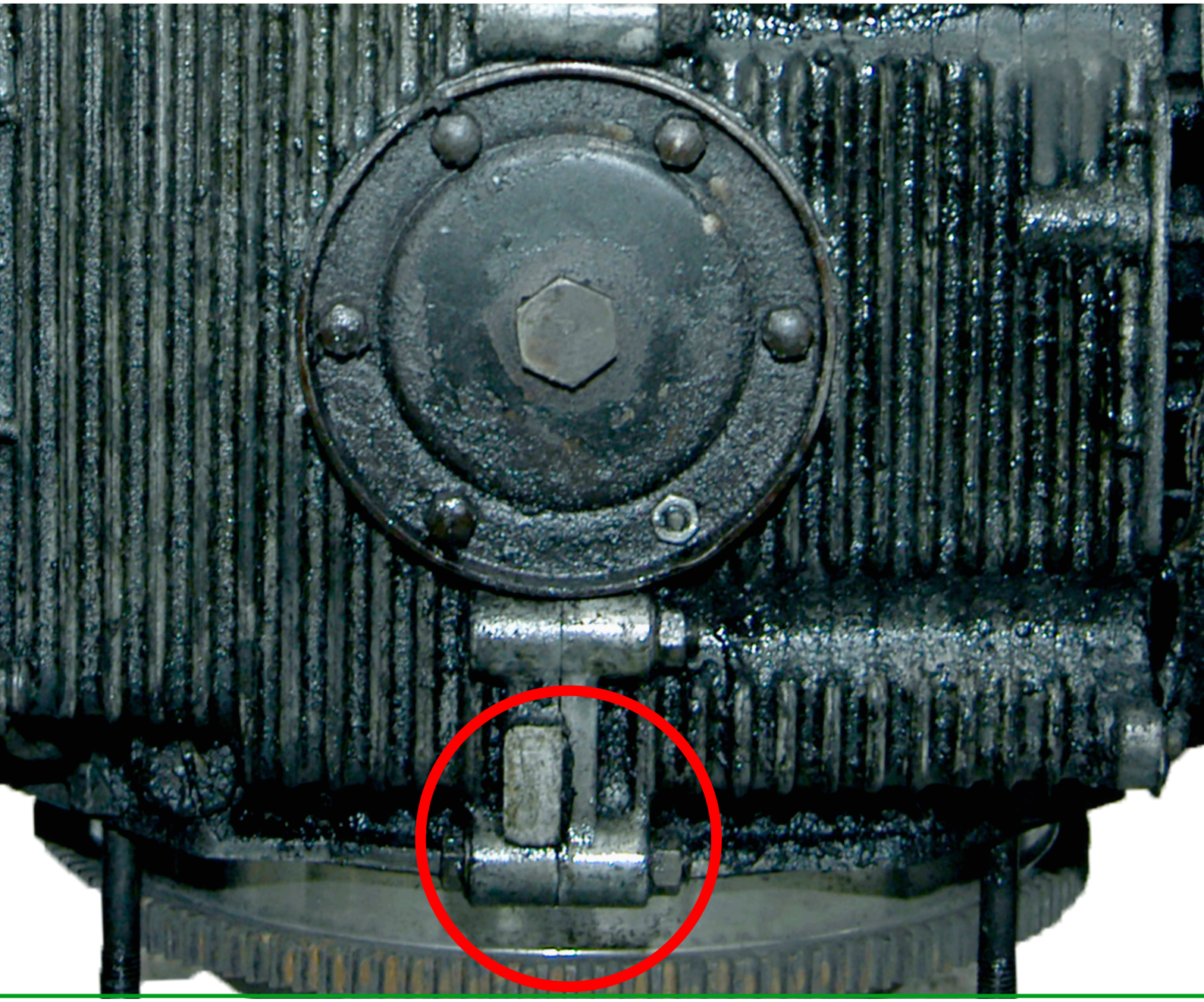


There is no oil seal installed on Type 1 engines (or bearing) to keep the engine oil to leak out of the crankcase. You could install a new crankcase pulley (not standard VW) that includes an oil seal. The problem is then solved. This new (aluminum) crankshaft pulley will be positioned a little further away from the engine, so you will also need to adapt the generator pulley.

Oversized Volkswagen crankshaft pulley: some old VW engines already received a new crankshaft pulley from the official VW dealer to solve this type of leak. Watch out not to use this type of crankshaft pulley in a standard (not oversized) crankcase!

## *7. Crankshaft seal*

You could check under your car if the engine isn't leaking oil from the crankcase seal. We show the bottom of the engine on the picture below, there is an opening, shown with the red circle, that will evacuate all excess oil dripping from the crankshaft seal.



# oil consumption

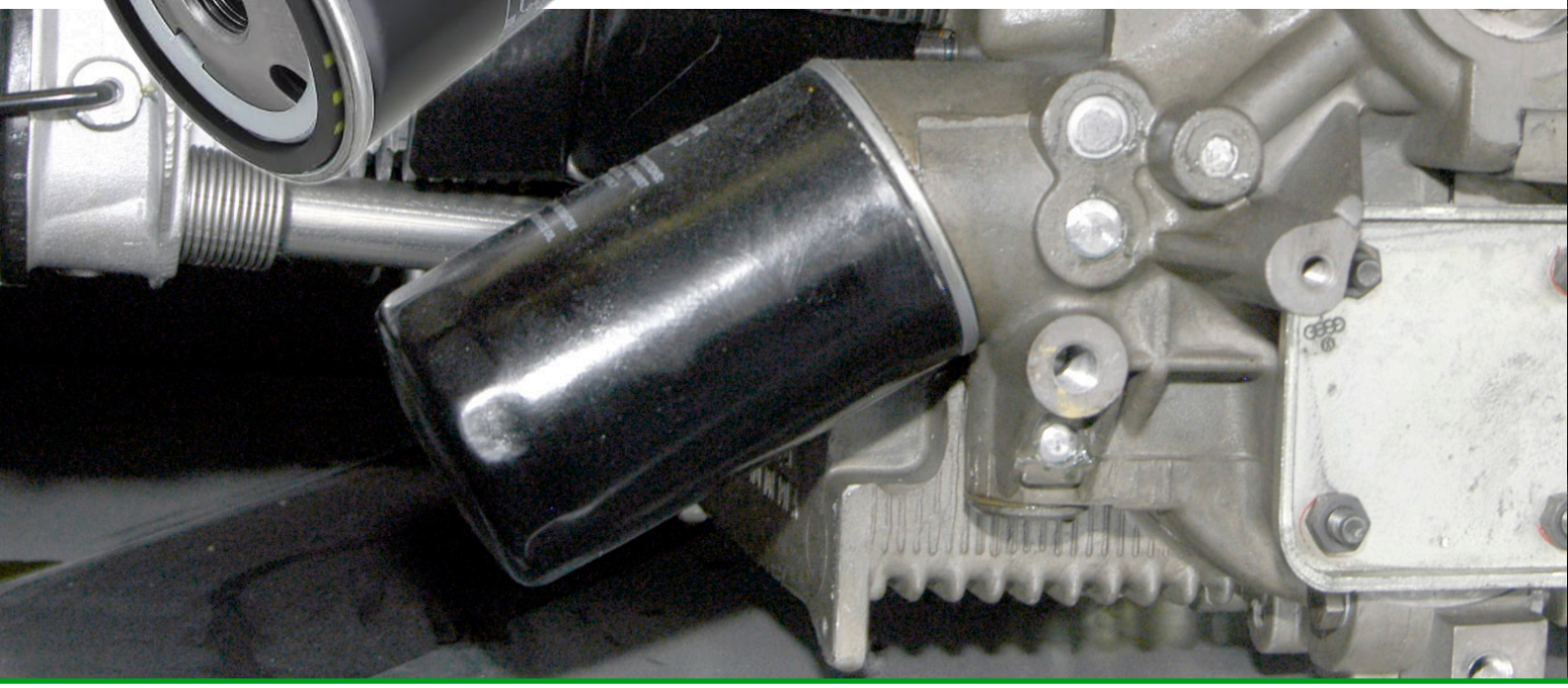

We show the flywheel side on the picture above, the clutch and flywheel have been removed. The paper gasket or oil seal or O-ring is installed behind the flywheel. You will need to remove the engine to diagnose this type of oil leak. Replacing the seal can solve the problem, but sometimes you need to overhaul the engine because the crankshaft play is too big.

We'll discuss the latter in another issue of this series.

## *External oil filter*

This is a special one, you won't find an external oil filter on most of our Vintage air-cooled boxer engine Volkswagens. You'll see this on most Type 4 engines though. It is easy to reach the external oil filter on a Type 4 engine, it is located on the left side at the bottom of the engine.

Some Type 1 performance engines also have an external oil filter. If you didn't attach the oil filter correctly, not tight enough for instance, it could leak. You can't tighten the oil filter too tight though, this would deform the rubber seal and the filter will leak. Never use the special oil filter tool to tighten the external oil filter, you will have too much torque with this tool, just use it to remove the filter only. To install the filter just rub some engine oil on the rubber seal and hand-tighten it.

## Conclusion

It should be clear now that not all oil leaks are fatal, you will not always need to overhaul your engine. Some leaks are easy to fix as we discussed in the previous edition of this magazine.

We discussed the more critical oil consumption issues in this edition. You can also fix these, but they will require to remove the engine and in worst case to overhaul your VW engine. Just take it easy and keep on enjoying your classic Volkswagen.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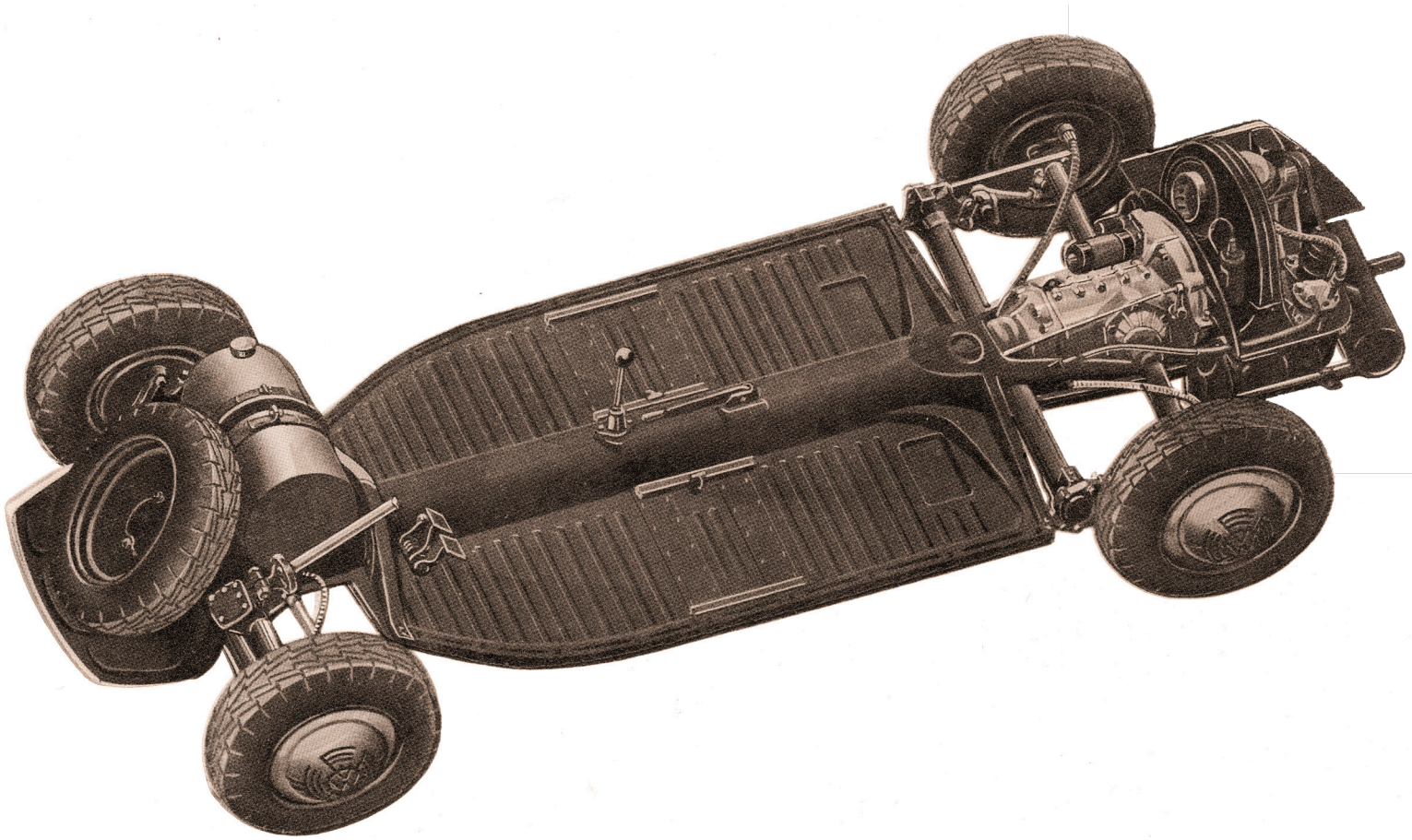
# #24 Front & rear axle

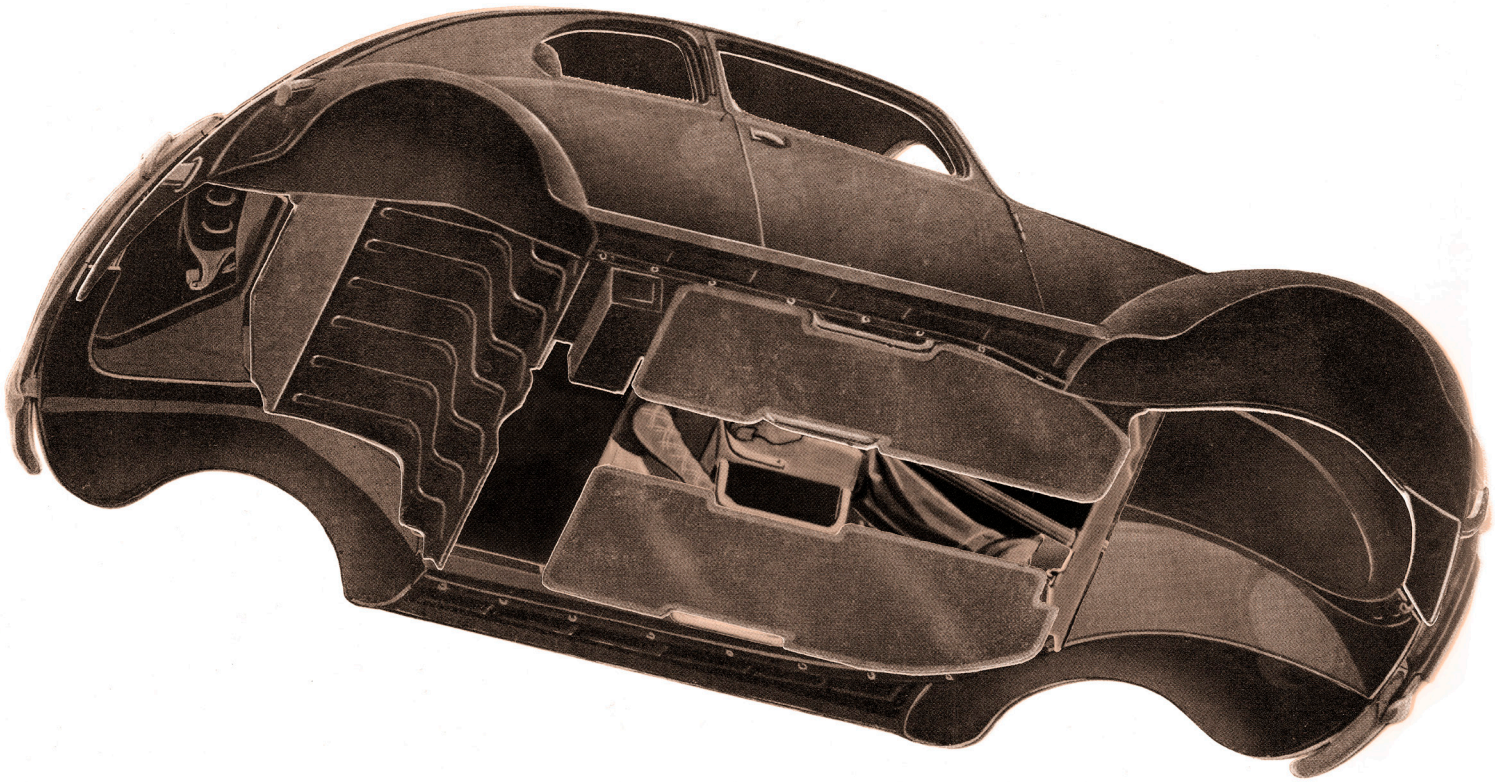
## The VW chassis

Ferdinand Porsche created this genius concept in the beginning of the previous century. A car that was built on steel metal plates with on top a separate "unibody" construction. Most cars from that period were built using metal tubes chassis. The Volkswagen Beetle (still named Kdf-wagen at the time) was a revolutionary concept.

The chassis consisted of two metal plates connected to a central tunnel. The chassis takes care of the rigidity or stiffness of the car. The level of rigidity defines the driving characteristics of the Volkswagen Beetle, it defines the level of security and handling of a car.



# VW suspension



The metal chassis plates or floor pans are preshaped to create additional stiffness. If the chassis floor pans would be flat without shapes they wouldn't be as strong as they are now. The central tunnel acts as a backbone, just as with us human beings.

The chassis structure and the body are welded together on the VW Bus compared to the VW Beetle and Karmann Ghia where they are two separate items, additional metal tubes are added to reinforce the structure. The VW 411 was the first luxe-sedan from Volkswagen to have used this same concept, the body and chassis are one on this VW 411 and later the VW 412. These drawings are just beautiful, they show the first Kdf car from Mister Porsche. You can see that the chassis and the body are two separate parts, on the drawing on the left you see the suspension which we will discuss now.

# #24 Front & rear axle

## Suspension and shock absorption

The gear box on a classic VW is mounted on the chassis using silent blocks. These silent blocks will capture the vibrations of the engine and the transmission to improve the driving experience and the comfort. The wheels are constantly in contact with the road, the suspension and the shock absorbers will "isolate" the chassis of the car from the imperfections of the road.

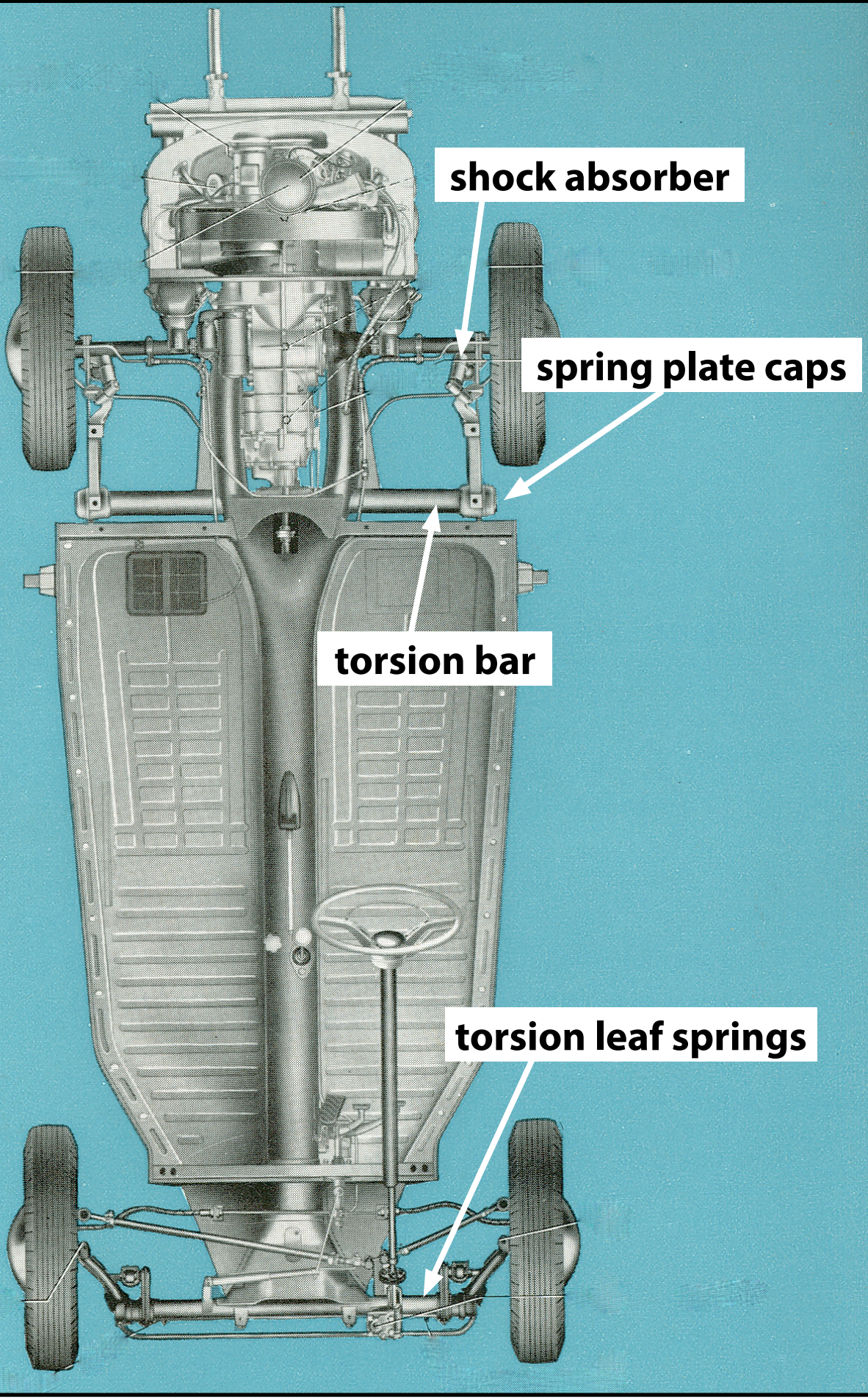
The suspension will make sure that the car is stable independently of the road, a good suspension will improve the safety of the car. The shock absorbers make sure the car doesn't bounce too much, the suspension tends to work as a trampoline so to say, the shocks will dampen the up and down movements caused by the suspension. We show the front and rear suspension parts of a VW 1200 from 1960 on the drawing on the right page.

Adding a suspension to a car has many advantages, the comfort when driving the car is improved, a rugged road will suddenly feel less difficult to drive, the rotating sound of the wheels will be attenuated. The suspension will also compensate movements of the car due to the speeding up and slowing down of the car.

When you use your brakes the car will nicely "bend over" because of the suspension, the car tends to continue to move after you brake. If the suspension wouldn't take care of this downward movement the car wouldn't brake well. The suspension is not only for esthetics, it has a very important functional goal. The original VW suspension will not fail rapidly, you don't need to replace it if no changes were made to the original setup. The only part that will wear down are the shock absorbers.



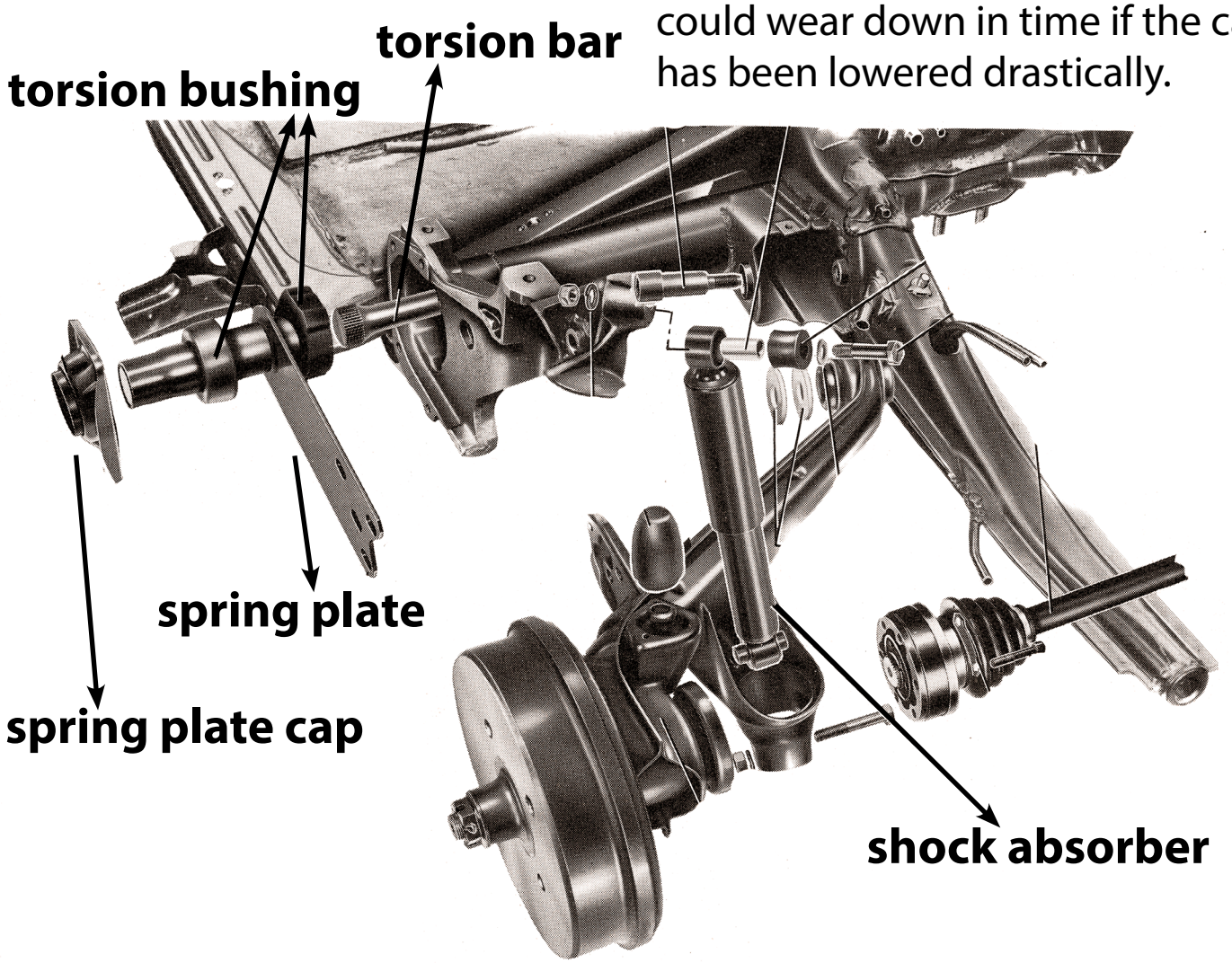
# VW suspension



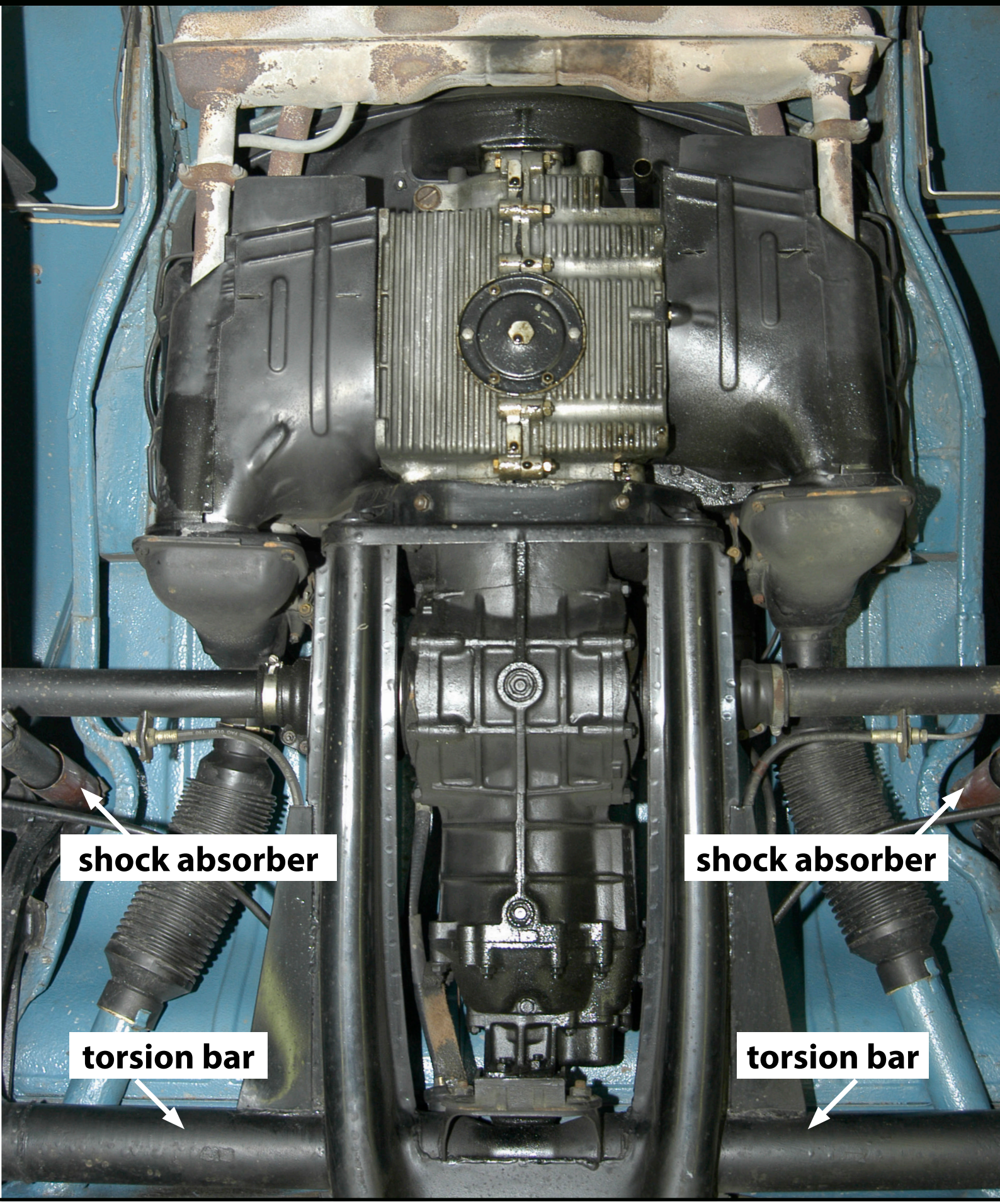
# #24 Front & rear axle

## Rear axle

All air-cooled Volkswagens have a rear suspension based on the torsion bar principle. Since the first production car until the last Beetle manufactured in October 2003, the Ultima Ediçion Beetle. Torsion bars are thick preloaded metal bars (preload means they get extra counter-torsion from the factory). These torsion bars will carry the weight of the car at the rear including the transmission and the engine. There is one torsion bar installed on the right of the car and one on the left. Each torsion bar length is about half of the car width. The original VW rear suspension should never fail, the concept is made to last forever. The torsion bar bushings and caps could wear down in time if the car has been lowered drastically.

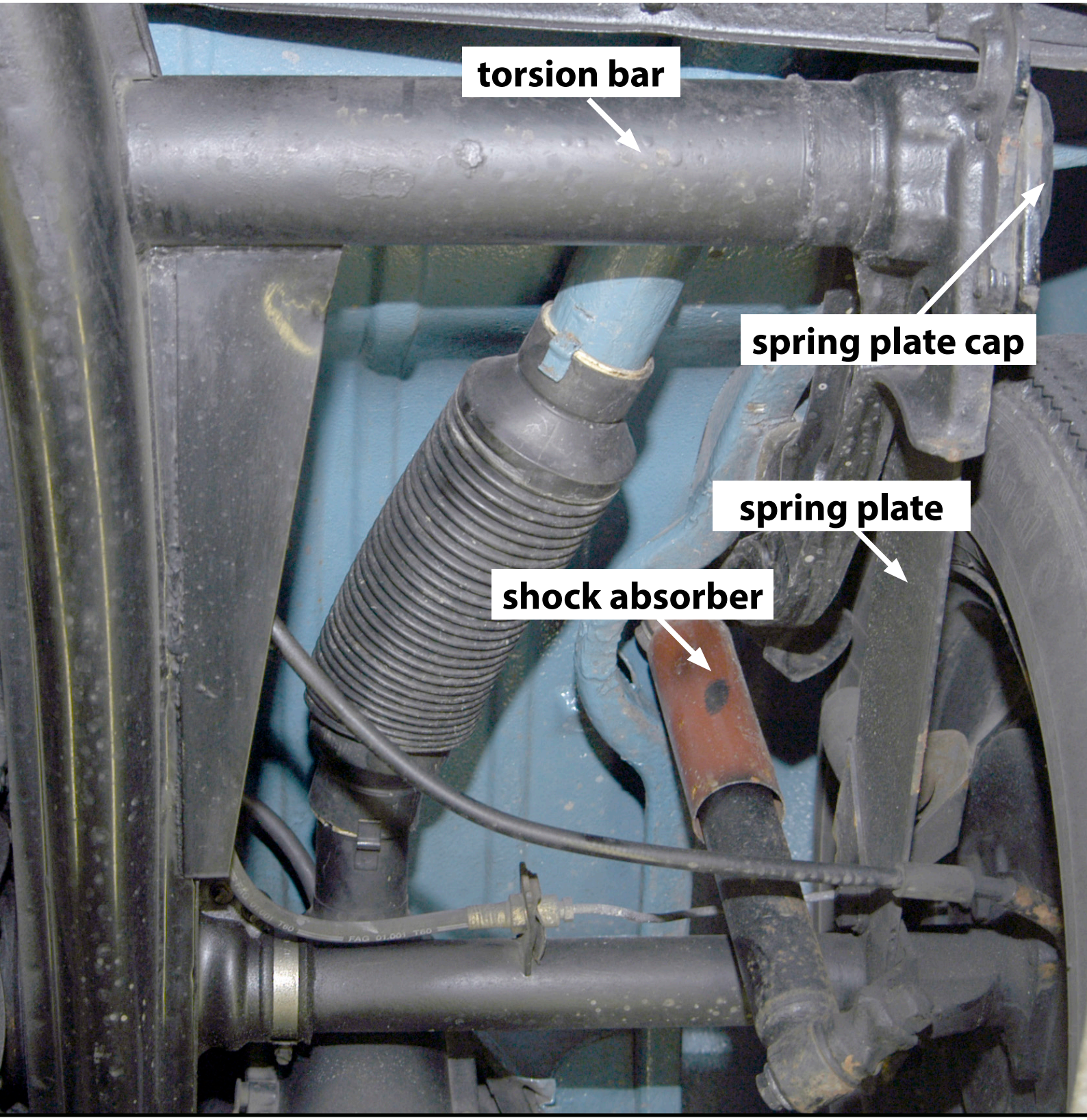


# VW suspension



# #24 Front & rear axle

We show all parts of the rear suspension on the picture below and the picture on the previous page. The rear left shock absorber is also visible on our VW 1200 from 1960.



# VW suspension

## torsion bushing

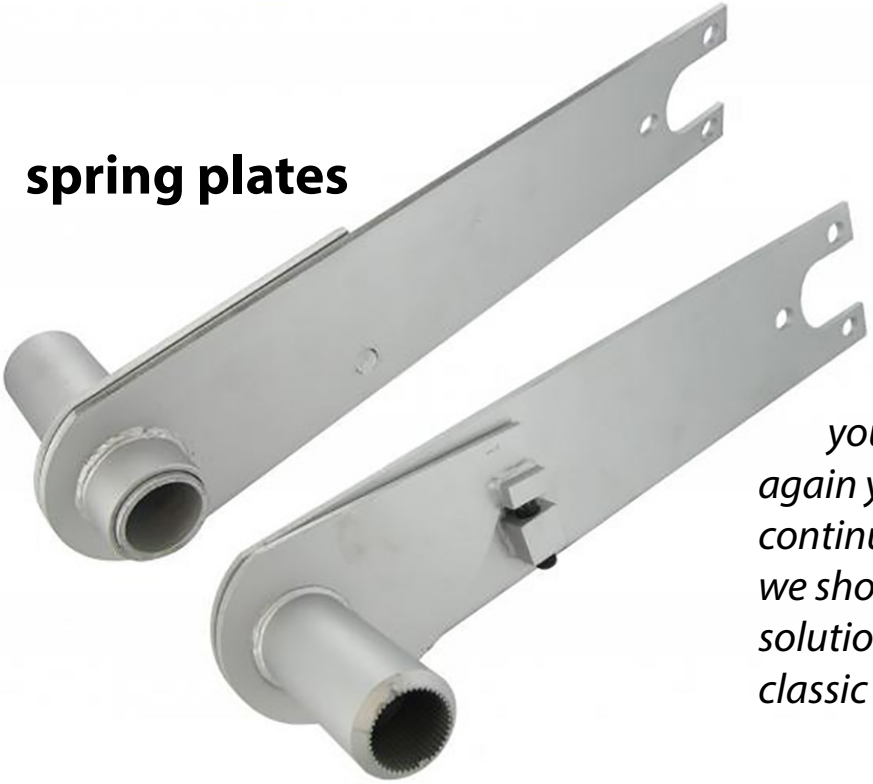
*These rubber bushings are hidden behind the spring plate caps (outer bushing), when you remove the torsion bars there is another bushing (inner bushing). If you hear a cracking sound at the rear of the car it is possible that the torsion bar has damaged the bushing and it presses against the spring plate cap.*

## spring plate cap

## torsion bars



## spring plates

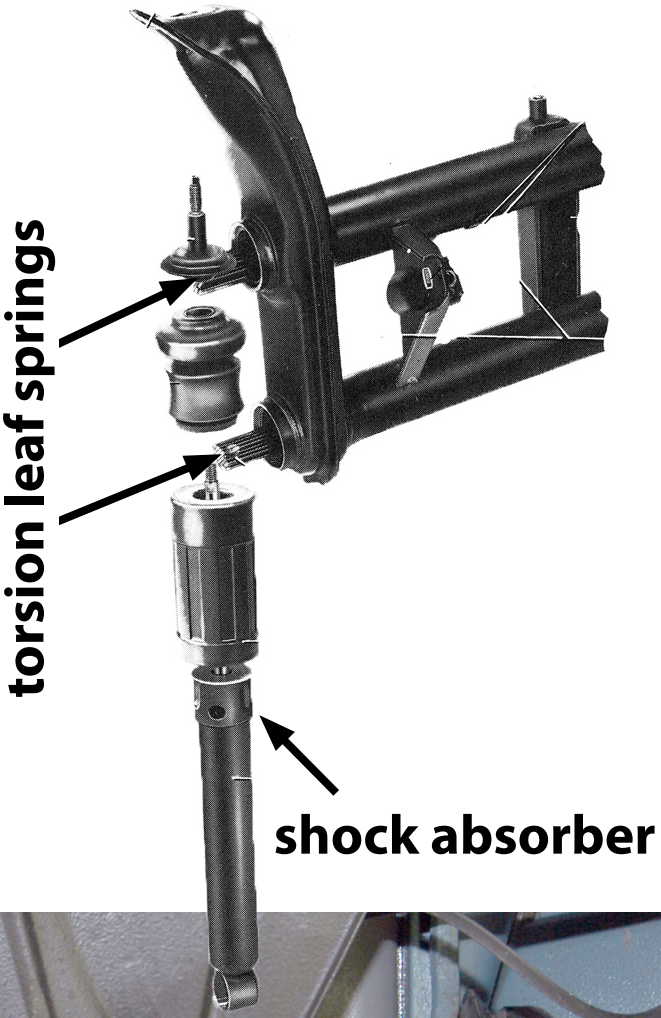


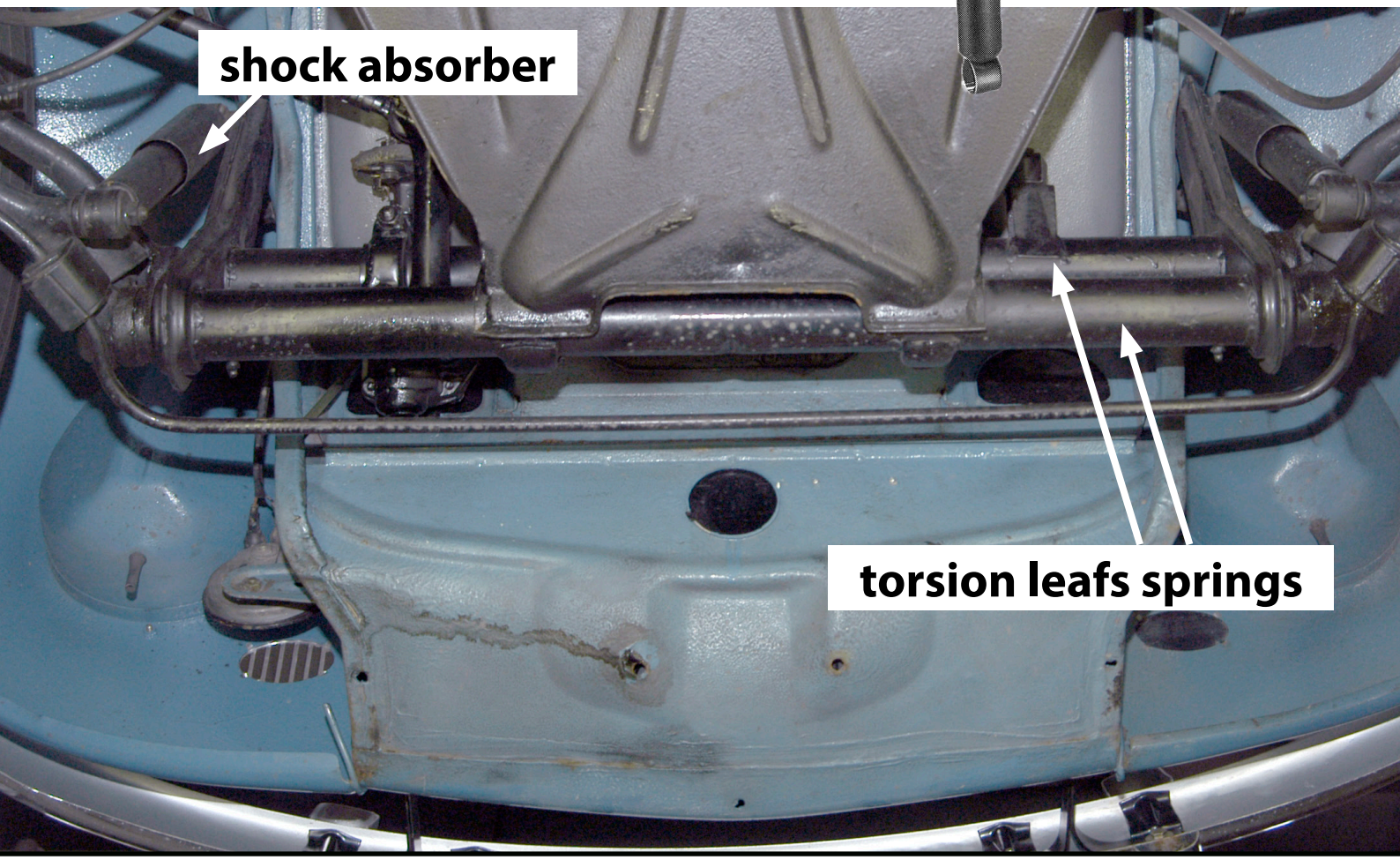
*You can adapt the height of the car at the rear by changing the position of the spring plates. This is a difficult job and if you want to change the height again you need to start all over. These continuously adjustable spring plates we show on the left offer a flexible solution to adapt the height of your classic Volkswagen.*

# #24 Front & rear axle

## Front axle

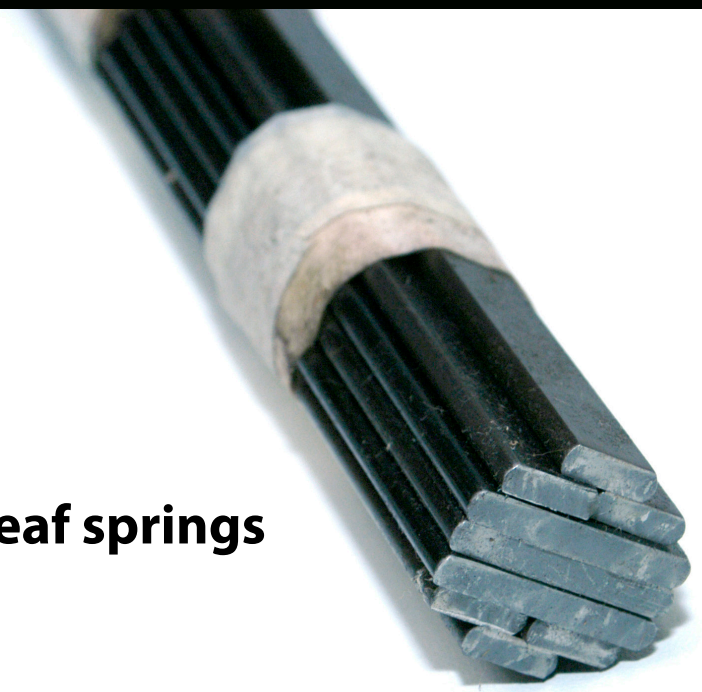
The front of our Volkswagen uses torsion leaf springs built in the front axle beams (they look like metal plates really, as shown on the picture on the right page). This is a typical VW concept, it is cheap to manufacture and it doesn't take a lot of space in the front of the car. These torsion leaf springs are greased using grease fittings. Shock absorbers are used to absorb the up and down movements of the car.



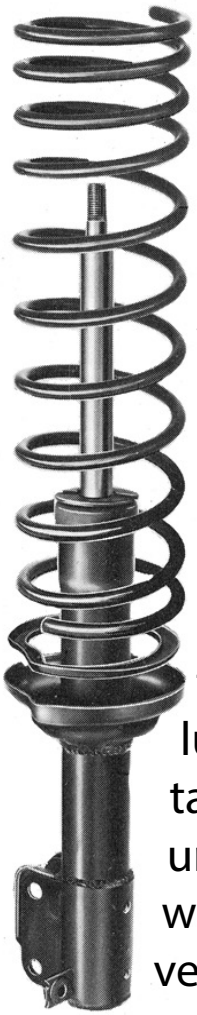
# VW suspension

*The VW Beetles until 7/1965 use less torsion leaf springs than models after 8/1965 as shown on the picture. These torsion leaf springs will wear down after some decades, replacement is the only solution.*



**torsion leaf springs**

The 1302 and the 1303 introduced a new era for the front suspension of our classic Volkswagen, the newer and more modern MacPherson suspension was introduced in the beginning of the seventies. The "old" torsion leaf springs in the front were replaced by a spring with integrated shock absorber. The downside was that this MacPherson suspension took more space in the front, the Beetle got wider, the upside was that these drastic changes offered more luggage room in the front. The fuel tank had to be positioned higher under the front lid and the spare wheel was placed horizontally instead of vertically in our Vintage Beetle.

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