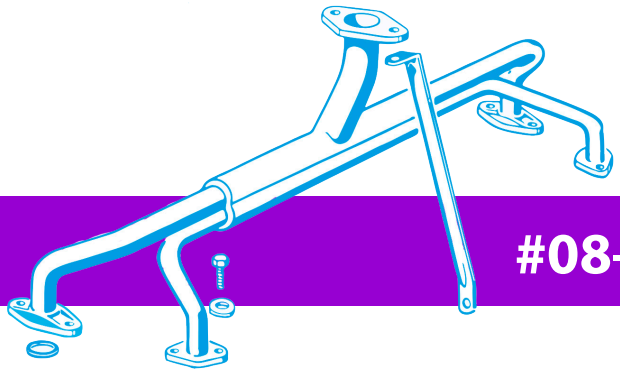
Paruzzi Magazine

Technical Publication for the classic Volkswagen

03



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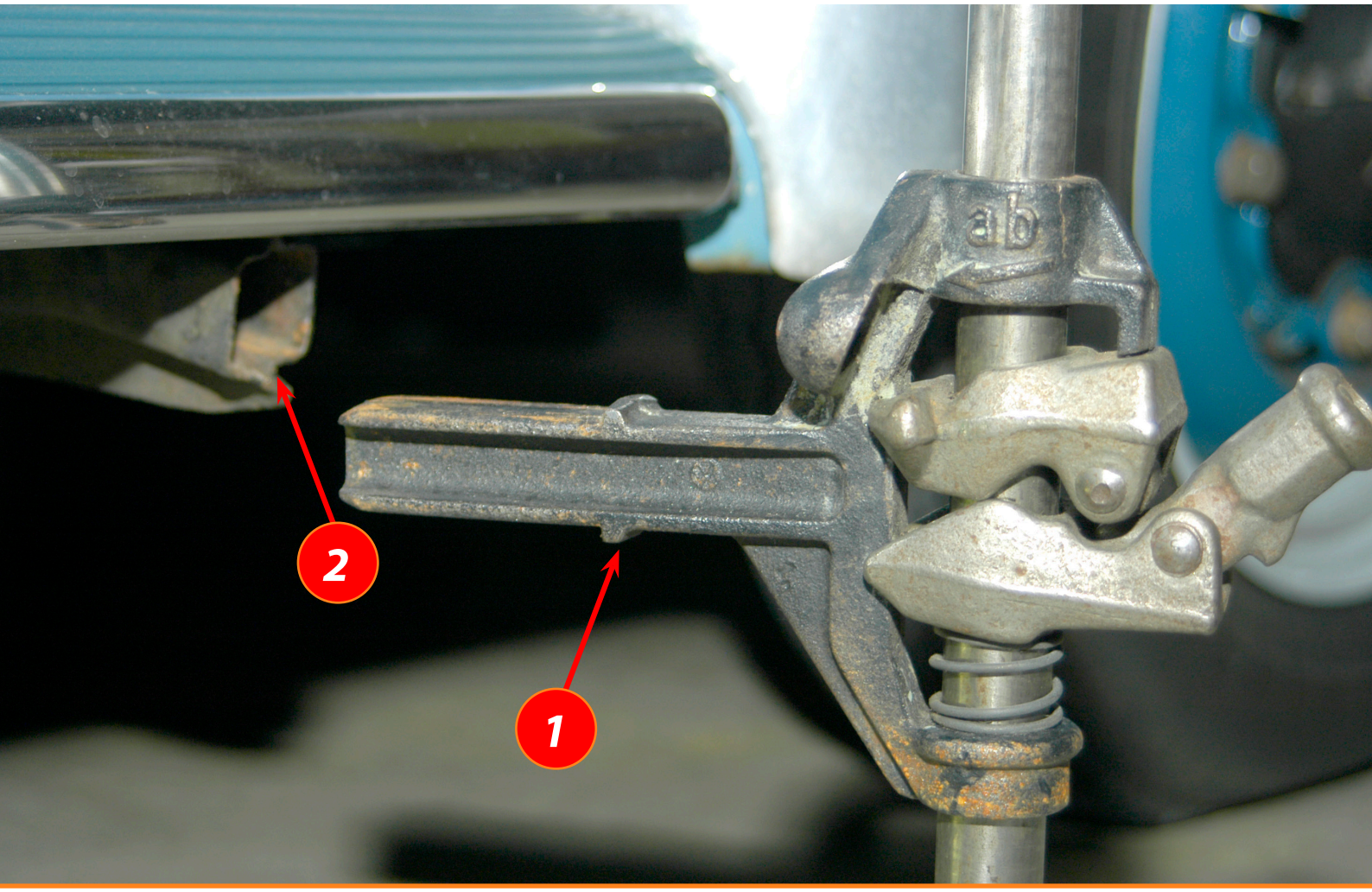
VW car jack

Some repairs are easier to handle when your classic Volkswagen is lifted. The car jack that is included with the VW is a very compact and easy to use tool, but it is designed to use when you have a flat tire for instance, the genuine car jack is not practical to work on under your car for instance.

If you want to use the original VW jack we advise to use the jack that was delivered with your VW model. There are many different VW jacks depending on the VW model you have. Your original jack should not be used to work underneath the car, this small VW jack is not stable



enough! It is very easy to push the car out of balance when it is lifted with the original VW car jack only. Use the original VW jack only on a horizontal and stable floor, such as asphalt, tiles or a concrete floor.

You need to install this type of jack as intended by VW, the metal "stop" (1) should fit nicely against the jack support on the chassis (2). If the jack is not well positioned as described, you risk to damage the chassis.

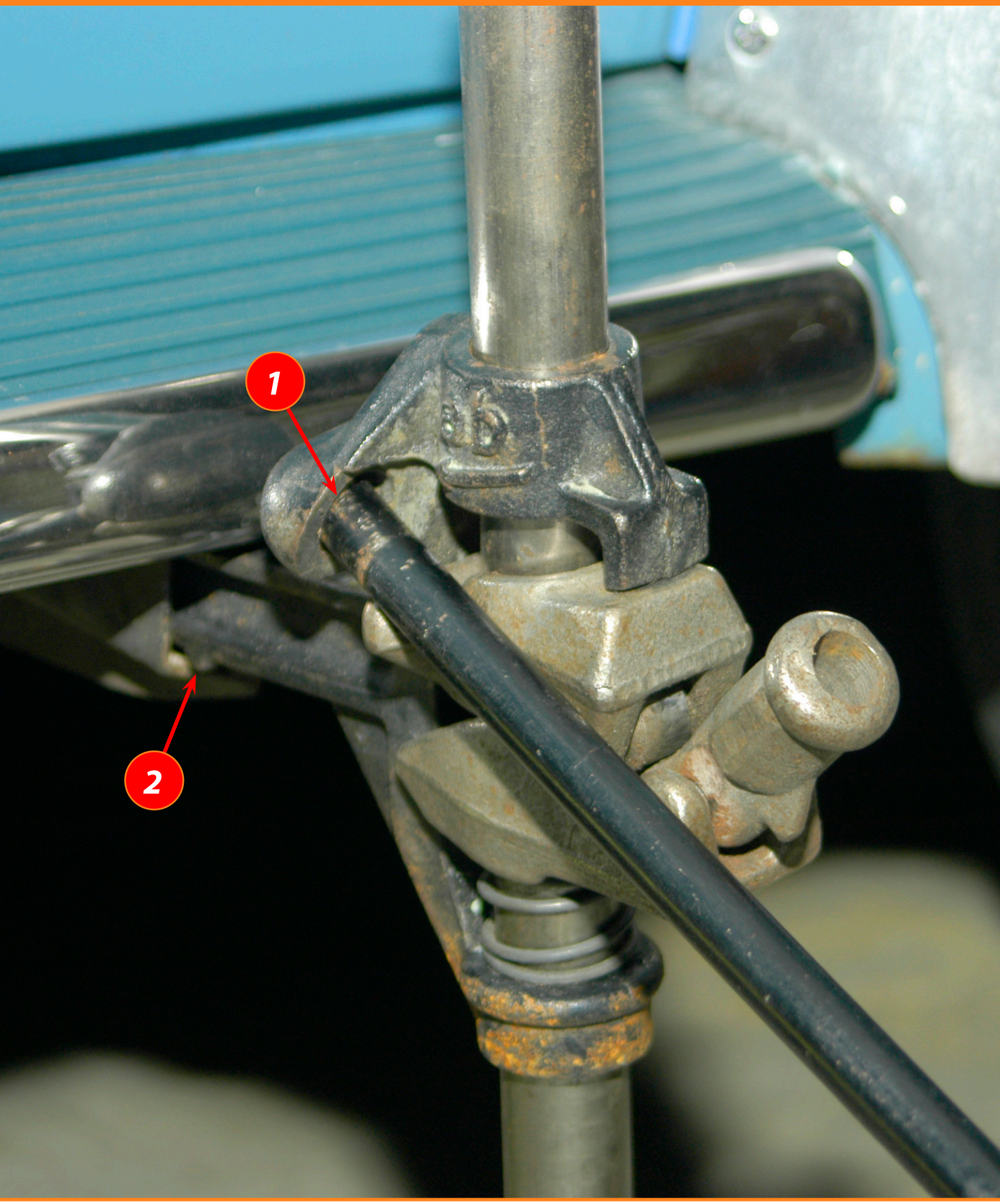
VW designed different types of car jacks. Use the correct jack to avoid damaging your chassis.

When you managed to lift your classic Volkswagen with the original VW car jack, you need to make sure that it is secured properly. Use an additional jack stand for instance to make sure the uplifted position is maintained at all time. We show on the picture on the next page how to lower the lifted car using the original VW jack. You use the rod that you used to lift the car, and push the mechanism to the upward position (1). You also see the metal "stop" positioned against the jack support on the chassis (2) on this picture.

If your classic Volkswagen is not in a good shape, if the chassis shows lots of rust, there is a big chance that the jack support will bend, damaging your chassis and the Beetle running boards. Using an hydraulic car jack is a better option.

On the right, a new jack support (04810) ready to be welded onto your chassis. Below we show a new scissors jack that fits all classic Volkswagens (04114) in case you lost your genuine VW car jack.

the car jack



Hydraulic car jack

If you need to work under your car or do more complex work on your classic Volkswagen, an hydraulic car jack (2) is a better option than using the original VW jack. You will lift your car much faster and with less effort. The professional hydraulic car jacks are much more stable than the original jack, the VW jack was meant for emergency repair, such as replacing a tire, not to lay down under the car.

We advise the purchase of two hydraulic car jacks. If you don't have a professional two post lift or four post lift to work with, our experience says that having a spare hydraulic car jack comes in handy. I can confirm that it helped me a lot, the second hydraulic car jack saved me from awkward situations. Choose a strong, professional model, one that can lift up to 1,5 ton or 2 ton. You will be able to lift a VW Beetle but also a VW Bus up to the T25/T3 Westfalia model. Choose at least one hydraulic car jack with high lift height.

An hydraulic car jack is operated using a long handle. If your car is lowered, makes sure you have a car jack that is able to go as low as your car is (low pickup). Hydraulic car jacks have wheels, which makes it very easy to lift your car on a flat floor. Use a jack support (1) to secure the position of the lifted car, so you are sure the car will not drop suddenly.
The hydraulic car jacks are quite expensive I must say, but if you plan to work on your classic Volkswagen on a regular basis, the hydraulic car jack will come handy. Don't buy the least expensive jack, we talk about your safety, and the safety of your classic car!

the car jack

#07 Technical

All VW models will not be lifted on the same spot using an hydraulic car jack or two or four post lift. The VW 411/412 may not be lifted under the front axle for instance. We will show all the jacking points for all VW types now, just as Volkswagen prescribed. It is of the utmost importance to follow this advice carefully!

When using an hydraulic car jack, you need to lift the car on the recommended spot. Never lift the car on a moving part of the car, such as a silent block. Silent blocks are used to support the transmission or the engine for example, to avoid that the engine vibrations would be passed to the car chassis. So, never lift the car on the engine, transmission, or even the rear torsion bushing.

Lifting the rear

Which spot to use to lift the rear of your VW is different depending on the type of VW. Not following the advice given by the manufacturer can cause damage to the chassis, or mechanical parts such as the suspension, engine or chassis. It is best practice to lift the car gradually using two jack points at the time. You see that having two car jacks comes in handy. If your VW is a convertible, and the chassis is not in a good shape anymore, lifting the car using two jacking spots is not a bad idea, to avoid that the car will be damaged (due to extensive torsion) more than it is already.

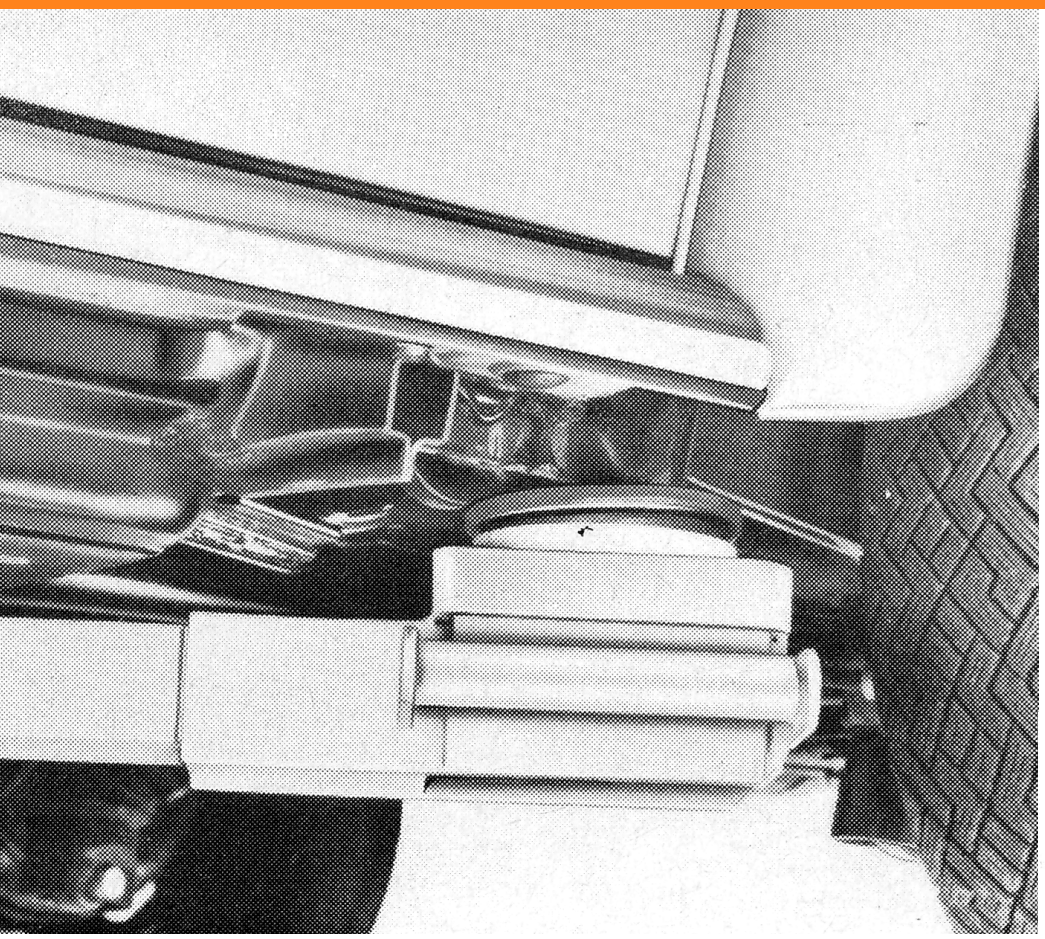
Once the car has reached the correct height, use a jack support (number 1 on page 7), lower the jack gently until the fixed jack support takes over. This will create a secure work environment.

Lifting the front

Working on the front of your classic Volkswagen requires some care. You need to lift both sides, left and right, gradually and equally. Lifting the car equally will avoid extensive torsion forces on the chassis and the body. Once the car is lifted you may use a jack support positioned under the car, in the middle of the chassis head. Lower the jack gently until the fixed jack support takes over. This will create a secure work environment. This way you will have three or four support.

VW types

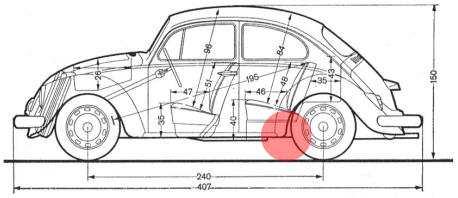
The following pages will show you how Volkswagen wants you to lift your car. We discuss how to lift the type 1 (Beetle or Karmann Ghia), type 2 (Bus), type 3 (Notchback, Squareback, Fastback) and type 4 (VW 411 and 412) with an hydraulic jack or two/four post lift.

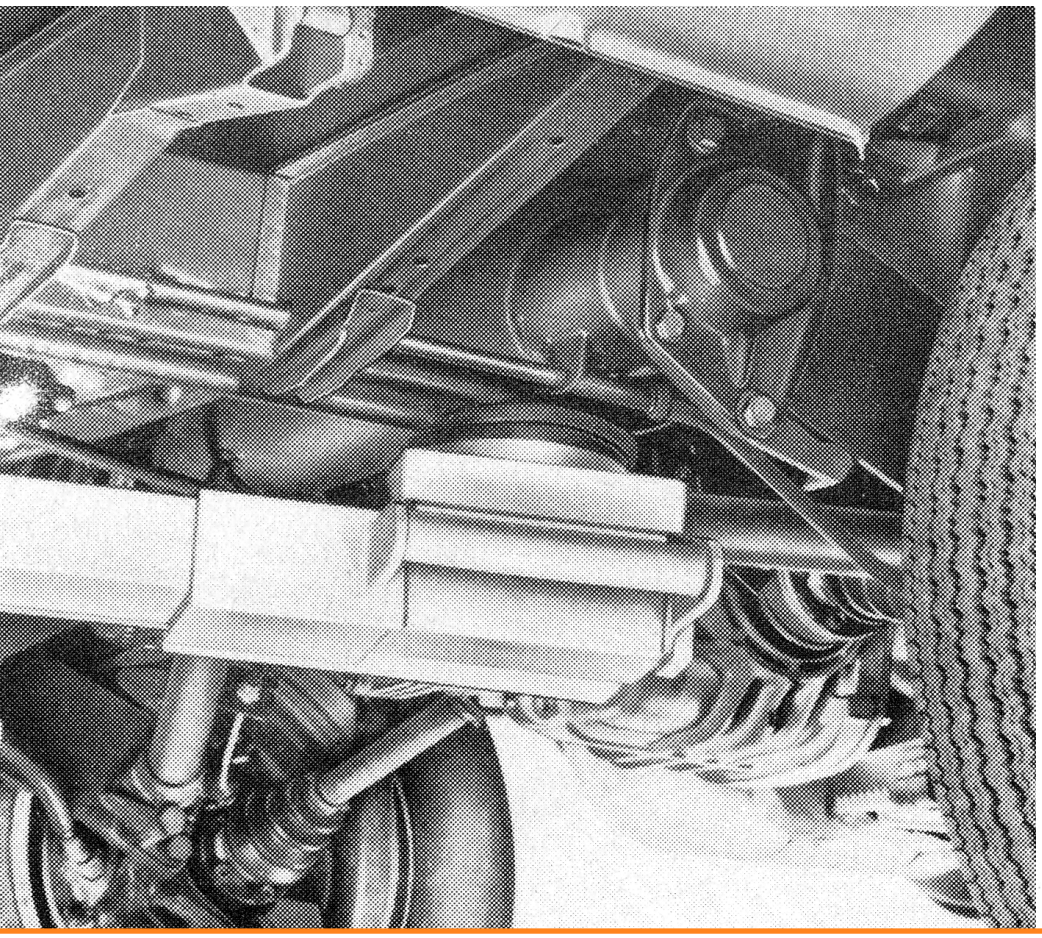


rear

type 1

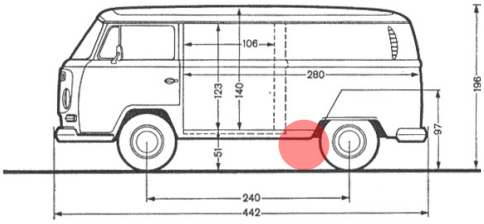
lift on the outer side of the torsion bar tube





type 2

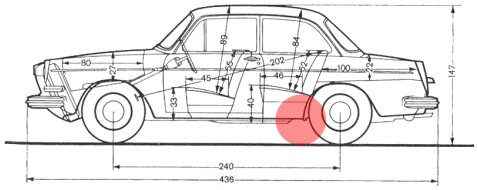
lift on the outer side of the torsion bar tube

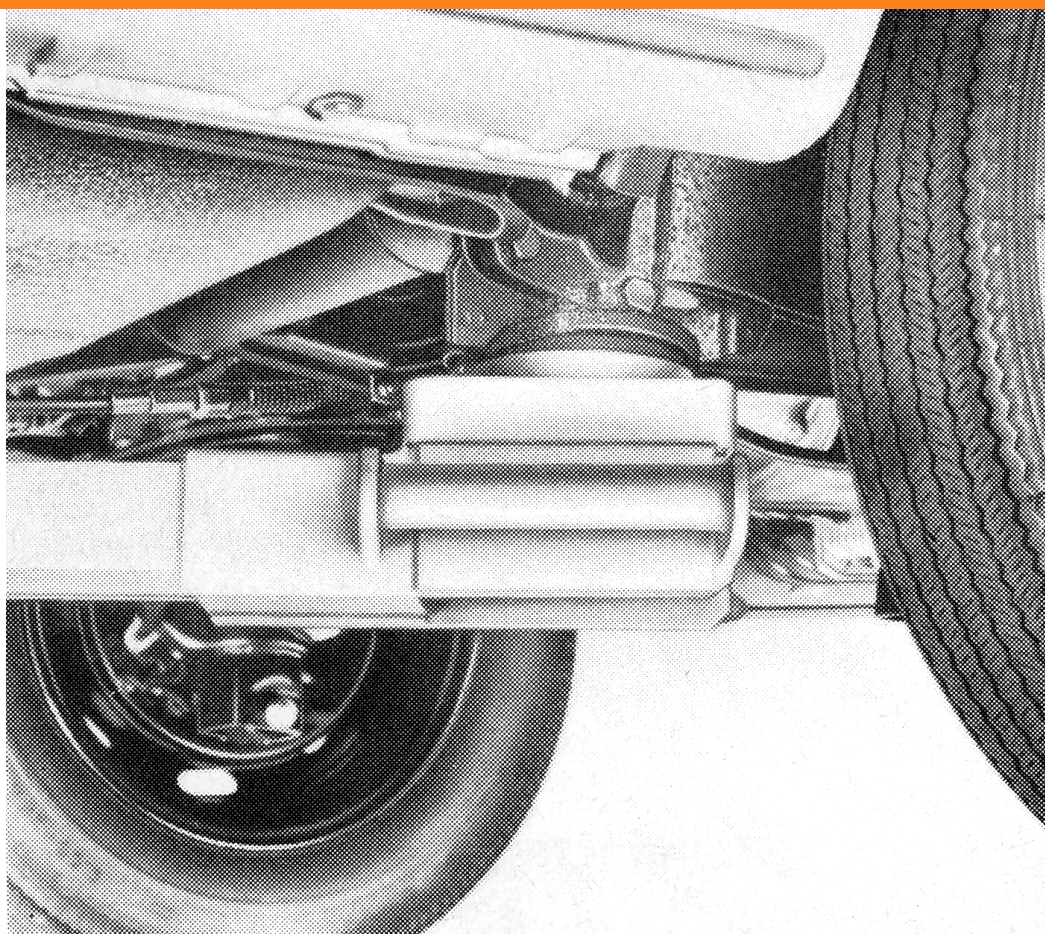


the car jack

type 3

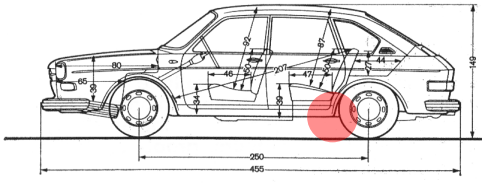
lift on the outer side of the torsion bar tube (same as VW Beetle)

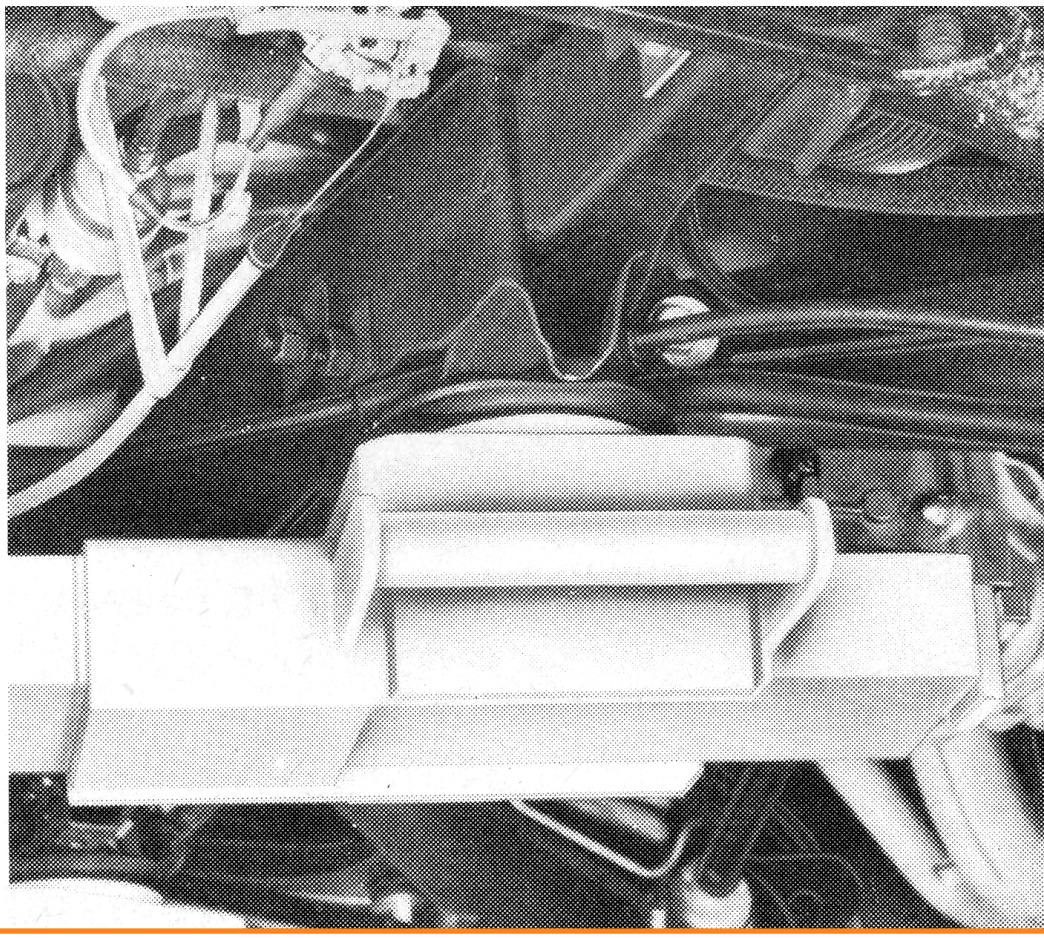




type 4

lift on the support plate of the rear axle

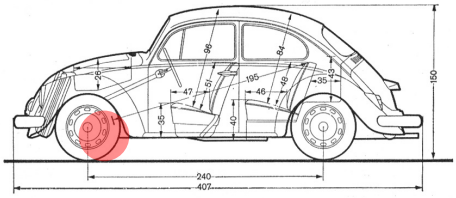


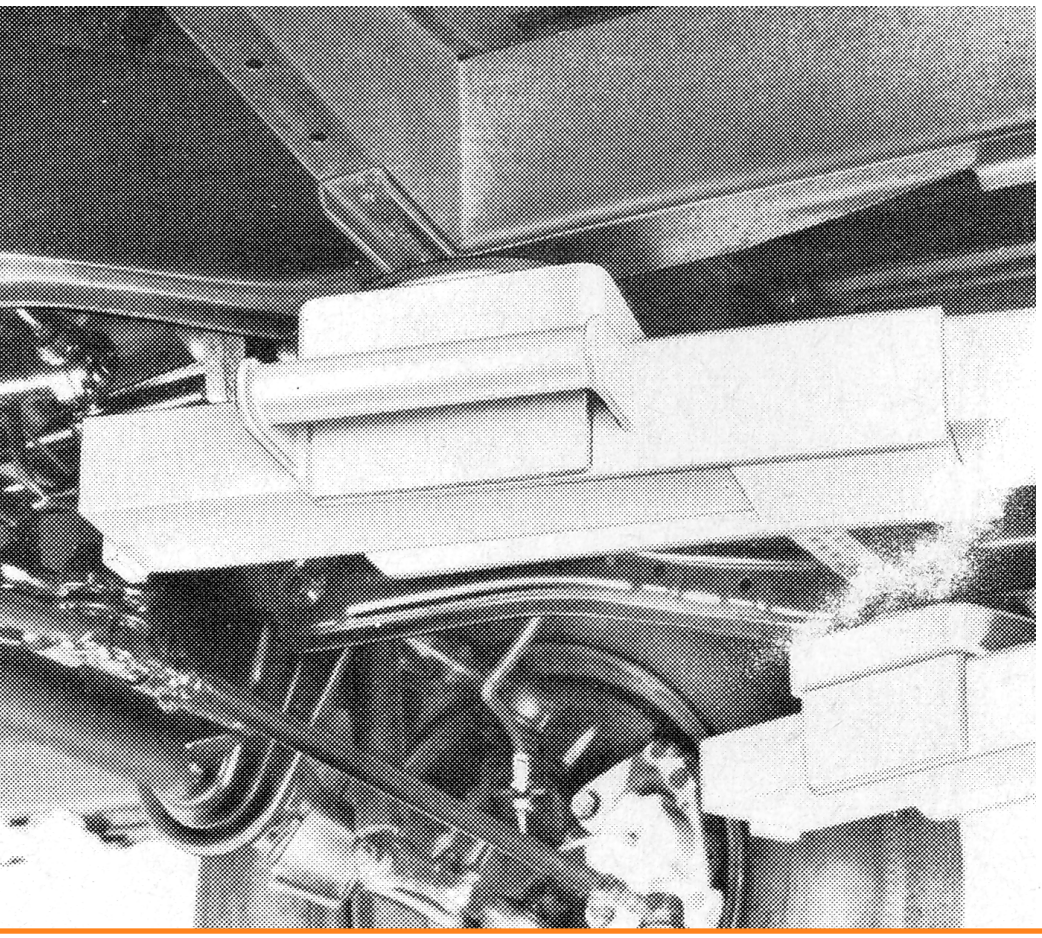


front

type 1

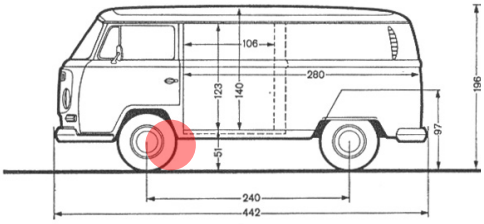
lift on the
chassis head





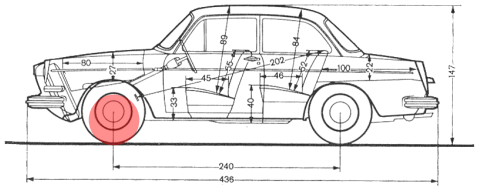
type 2

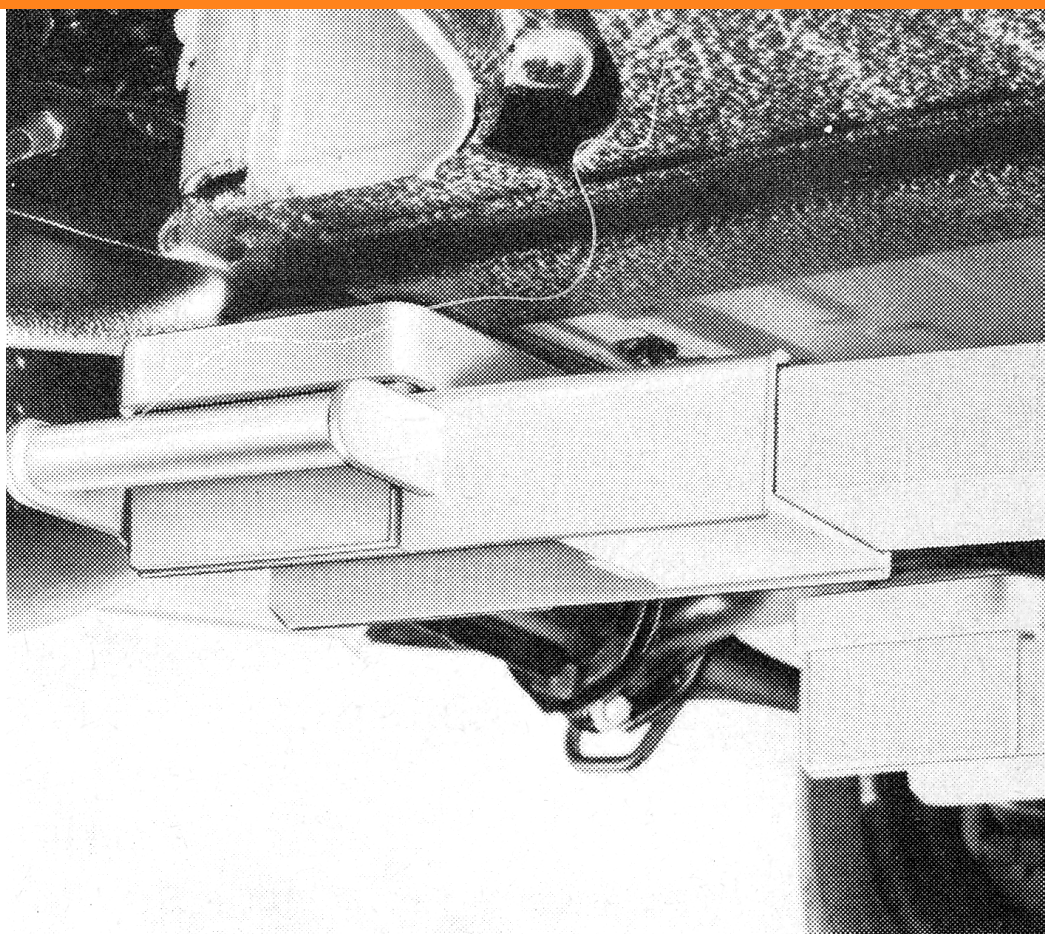
lift on the front
cross member



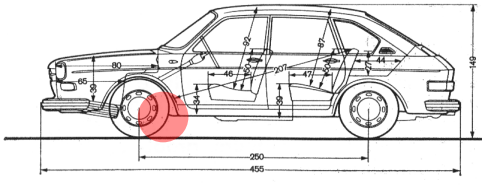
the car jack

type 3
lift on the front
cross member





type 4
lift on the front
cross member




Paruzzi
Classic VW Supplies

#08 Carburetor

My engine stalls when I try to accelerate?

I have tuned my distributor and carburetor to manufacturer specifications, the CO level seems to be correct, I have tweaked the acceleration pump twice already, my engine still tends to stall when I accelerate.

My VW doesn't accelerate smoothly, I get this problem mainly at low rpm in second or third gear. This problem seems to be amplified when the outside temperature is lower than 10°C!

What can be the source of this problem, can you fix this yourself?

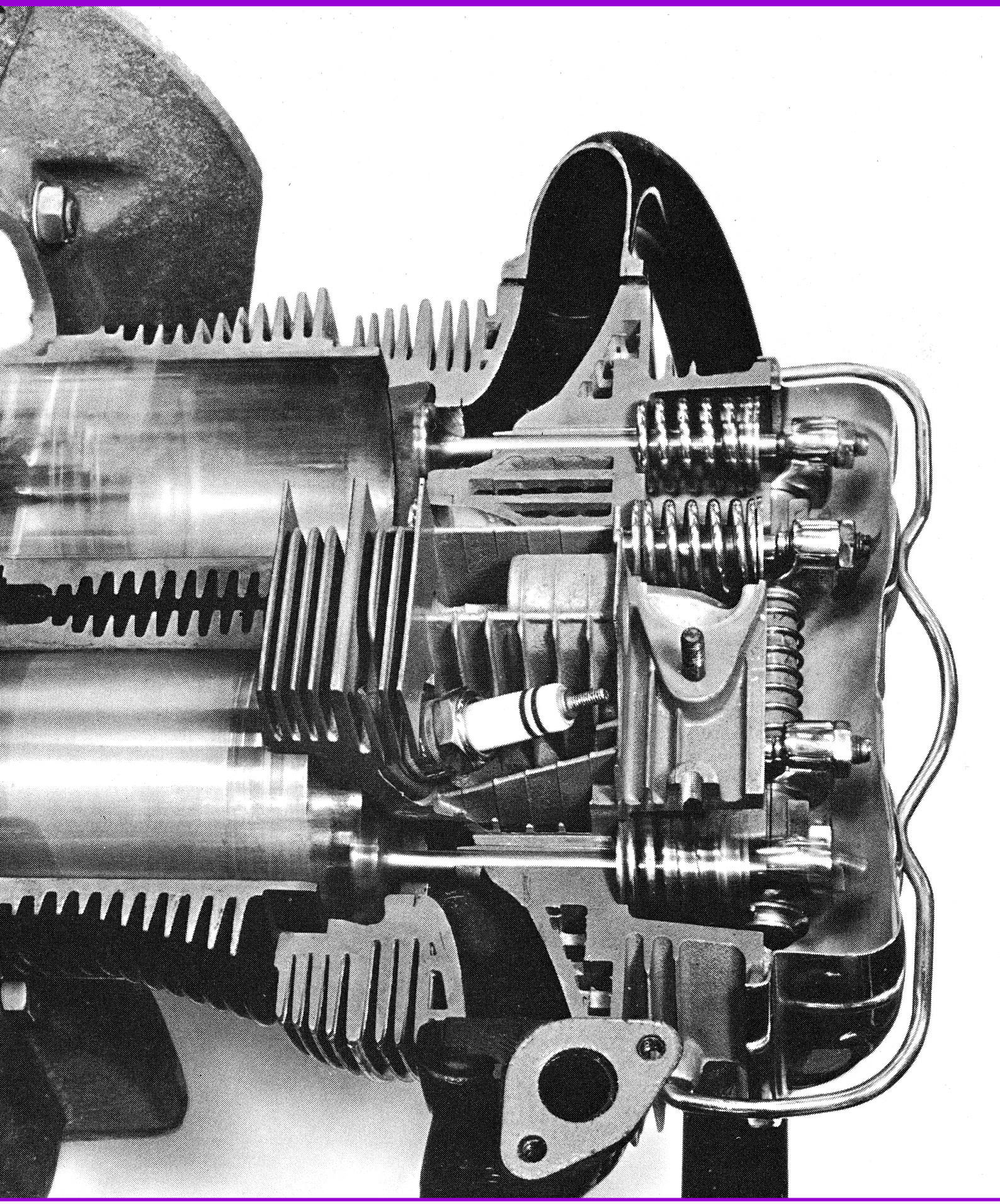
A bad combustion of the fuel mixture will cause your engine to behave badly, the engine will stall while accelerating because the fuel mixture is not ideal. The fuel mixture in your classic Volkswagen is a mixture of air and fuel. If this mixture has too much air, or too much fuel, the engine will not behave as it should. The fuel mixture will not combust as it should resulting in a loss of power, this translates into a stalling engine.

The air filter - inlet manifold - exhaust manifold - trajectory can cause problems with the fuel mixture if one of these components are not well designed or defective.

We will discuss the factory 1600 cc type 1 engine from 1970 and later, this is the original engine installed on the Beetle, Karmann Ghia and VW Bus T2 (Bay Window).

We show on the next page the cylinders and cylinder heads (right engine side), the valves and pistons. The spark plugs take care of igniting the fuels mixture.

mixture preheating



#08 Carburetor

The fuel mixture

You want the fuel mixture to combust for 100%, in the cylinder, this will generate the best engine performance. The ideal fuel mixture contains 1 part of fuel for 15 parts of air. If your fuel mixture is different from the prescribed mixture, your engine will not perform as it should.

Lean fuel mixture: When there is too much air in the mixture or not enough fuel, then we talk about a lean fuel mixture.

Rich fuel mixture: When there is not enough air in the mixture or too much fuel, then we talk about a rich fuel mixture.

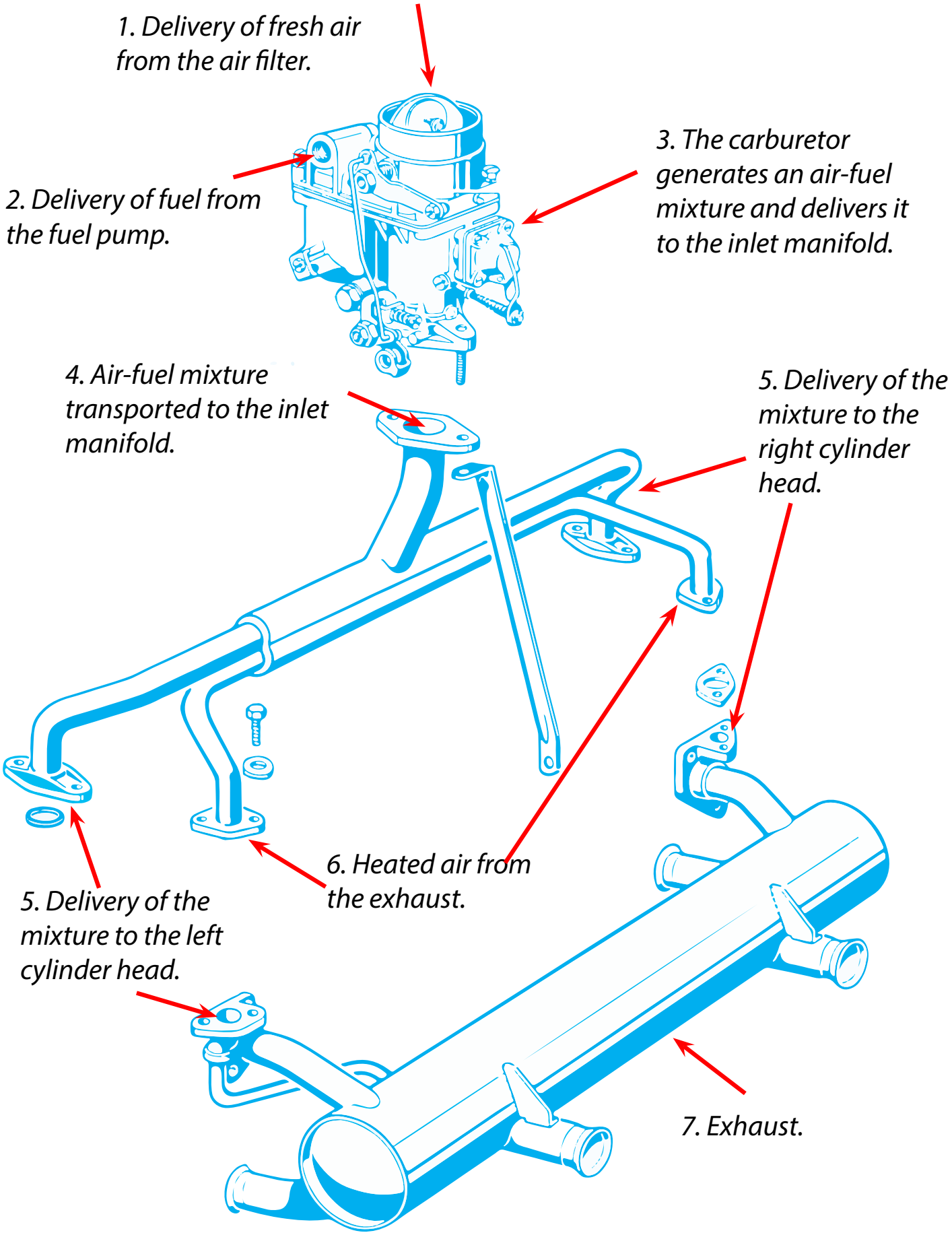
The challenge is to have the same fuel mixture in all seasons, during warm summers and cold winters, and while driving on the beach (sea level) or in the mountains (idle air).

This issue is not present with injection engines, an injection engine does not have to transport a mixture of air and fuel, like the carburetor engine.

Our carburetor engine will deliver this ideal mixture (fuel-air), this mixture will be transported through the inlet manifold to the cylinders. The carburetor is installed in the middle of the engine, between both cylinders. The distance between the carburetor and the cylinders on our flat 4 boxer engine is quite long compared to other engine constructions. The fuel mixture has to be transported over a long distance through the inlet manifold, a lot can happen with the mixture over this long distance.

We show on the next page all the components necessary to create the air-fuel mixture and to transport this mixture to the cylinders.

mixture preheating



#08 Carburetor

We all know that fuel is a liquid and air is a gas under normal circumstances. The carburetor will mix both air and fuel and create an atomized mixture. The atomized fuel parts, generated by the carburetor, will react slower and move slower than air, this can cause problems.

There are different systems engineered to make sure that the air-fuel mixture is ideal under all circumstances and to avoid the problem mentioned above. These systems will avoid the stalling problem at low rpm described earlier. It is now time to study these systems installed on our air-cooled Volkswagen.

On the next page you see the first generation air-cooled boxer engine build for the VW Beetle, this early type boxer engine is easy to recognize due to the generator support that is part of the crank case. The preheating tube is already present on this model (6). This design was never meant to survive that long, but it did.

The inlet manifold connects the carburetor with the engine (cylinder head). The shape of the inlet manifold has a major influence on the performance and behavior of the engine.

2. Delivery of fuel from the fuel pump.

4. Air-fuel mixture transported to the inlet manifold.

5. Delivery of the mixture to the left cylinder head.

6. Heated air from the exhaust.

7. Exhaust.

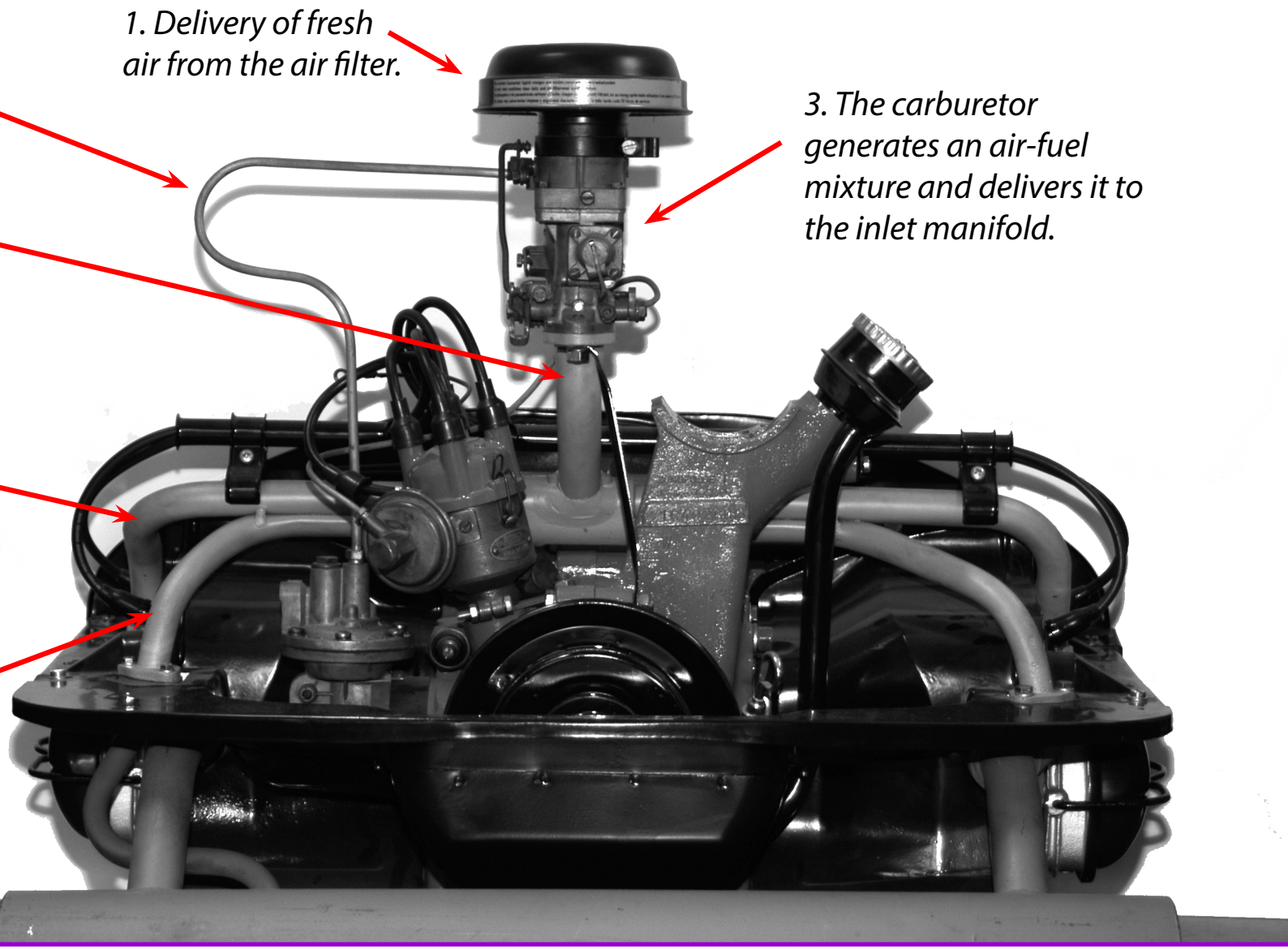
mixture preheating

We want an inlet manifold to take care of:

1. **a high filling of the cylinders with air-fuel mixture**
2. **an equal filling of all cylinders**
3. **an equal air-fuel mixture in all cylinders**

We need to design the manifold to have the following specifications:

1. **the inlet manifold needs to be short, straight and smooth**
2. **the suction tubes need to be of equal length**
3. **the inlet manifold tube should be of equal diameter overall**



#08 Carburetor

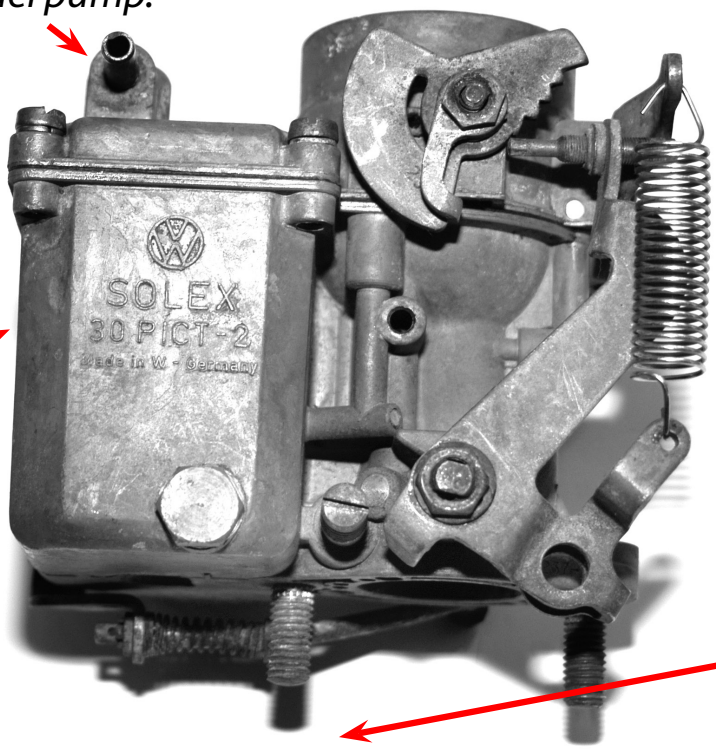
How does these specifications compare to our Volkswagen inlet manifold? Let's have a look at the inlet manifold of a 50 hp 1600 cc engine.

Our Volkswagen inlet manifold does not match these criteria at all. The original design from Porsche is a little awkward to say the least. In defence of the creator of our air-cooled VW, we must say that the VW Beetle was designed based on some specifications, one was to build a car that was affordable for all people, so there was no room for expensive designs. This awkward design is not really an issue when all components are working properly, once one part is out of specs, the misery starts.

One reason your engine will stall is because of the condensation of the fuel inside the inlet manifold, the mixture breaks apart (air and fuel). The mixture that reaches the cylinder heads will be too lean because a part of the fuel in the air-fuel mixture was lost along the way. Another issue is that not all cylinders will be filled with the same amount of mixture, which causes performance loss.

1. Delivery of fresh air from the air filter.

2. Delivery of fuel from the fuel pump.

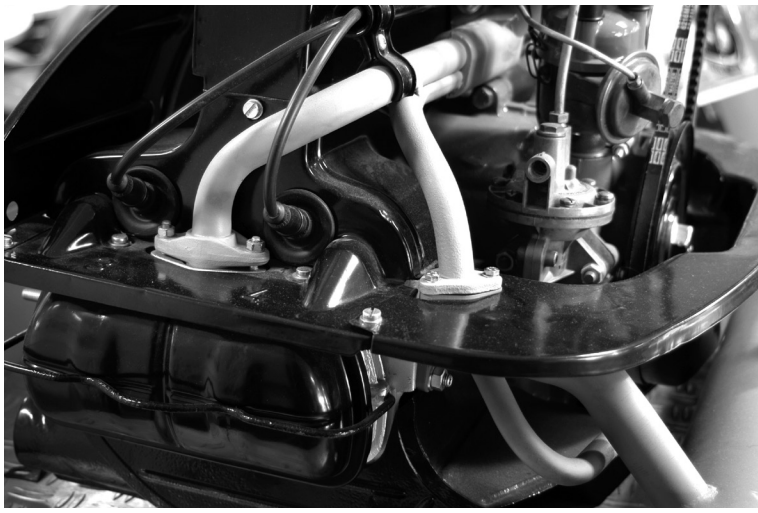


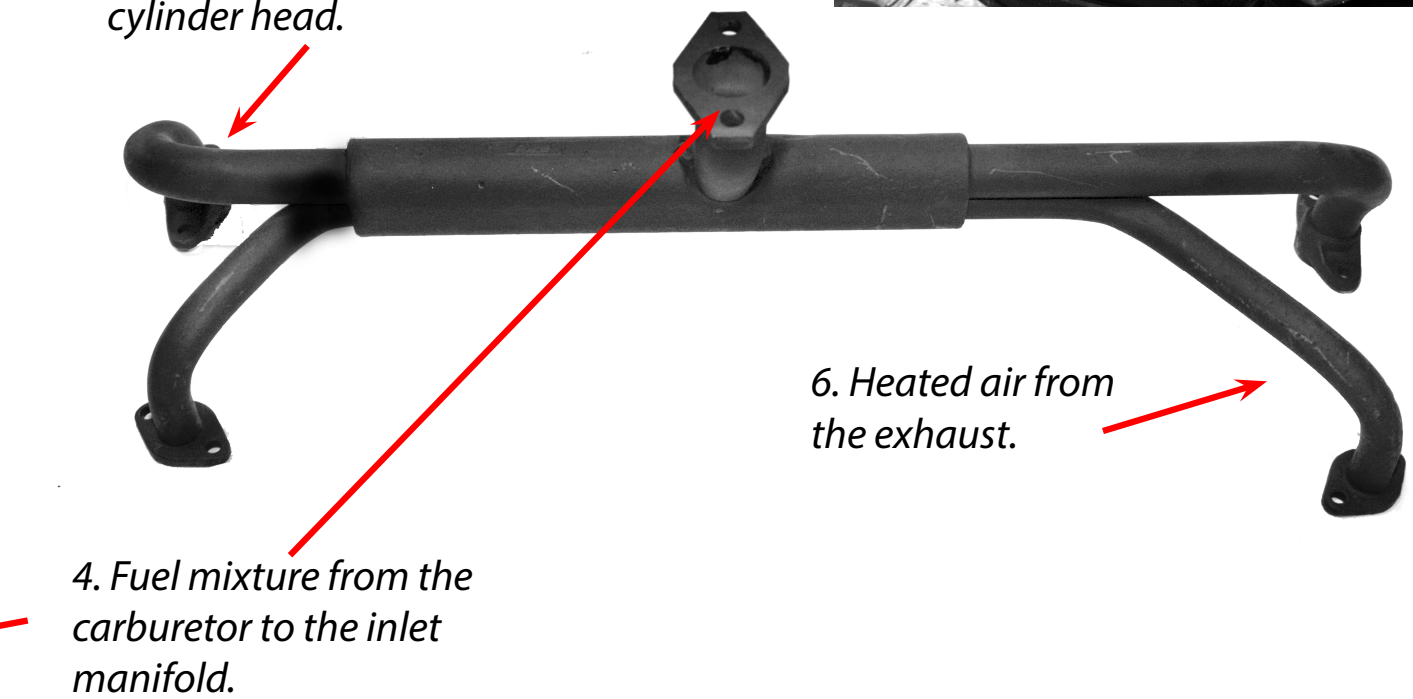
3. The carburetor mixes the fuel and air and delivers the mixture to the inlet manifold.

mixture preheating

The breaking apart of the mixture is more common at low rpm. You will feel the effect of this phenomena when driving away at low speed and low rpm, mainly in second and third gear. Why will a perfectly good air-fuel mixture generated by a well tuned carburetor fall apart in the inlet manifold? More about this follows now.

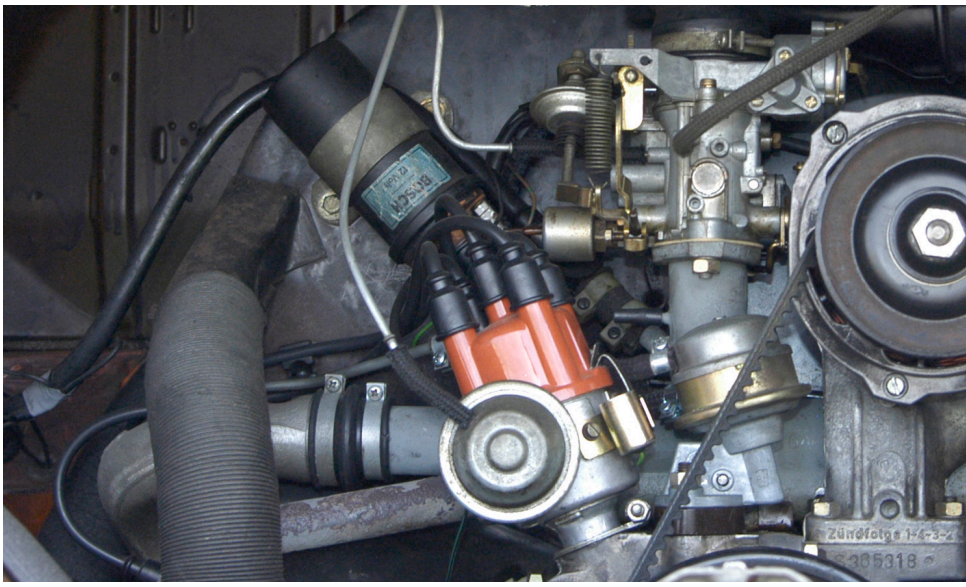
The preheating of the inlet manifold has changed over the 50 years of development of the air-cooled Volkswagen, however the principal stays the same: making sure the air-fuel mixture doesn't condense (fall apart) within the inlet manifold. Below you see an inlet manifold for a single port engine.





#08 Carburetor

The double port engines have a five part inlet manifold. The inlet manifold part that is bolted onto the cylinder head connects with a rubber seal with the main inlet manifold part. If the rubber seal is damaged, air will enter the inlet manifold and the air-fuel mixture will contain too much air, the mixture will be too lean resulting in overheating of the engine. The preheating tube is connected to the main inlet manifold tube.



You see in the picture above a Bay Window Bus with double port engine.

mixture preheating

The most important reasons for failure:

1. The mixture is not flowing fast enough through the inlet manifold. This will cause the mixture to create liquid drops on the inside of the inlet manifold tube. The longer the inlet manifold and the more curves the mixture has to travel the more the chances are that the fuel will separate from the air.

Don't forget that fuel and air have different masses. Air will travel much easier through curves than fuel, inlet manifolds with many curves will cause the air to flow while the fuel stays behind.

We don't have an influence on the speed at which the mixture will flow in a standard VW engine.

2. Condensation of the fuel on the cold inlet manifold walls. We have to explain a little bit about thermodynamics, this effect is described in the 'gas law':

$$P \times V = m \times R \times T$$

P= pressure
V= the volume
m= mass of the gas
R= gas constant
T= temperature

R and m are constants and not important now, you can't change them anyway. What is really important is the relation between pressure and temperature defined in the gas law; when the pressure drops, the temperature drops.

when the pressure of the mixture drops in the inlet manifold then the temperature of the mixture will also drop

#08 Carburetor

What needs to happen with the fuel mixture?

The fuel mixture (air-fuel) generated by the carburetor flows into the inlet manifold because of the low pressure created by the engine. This low pressure or vacuum is created by the pistons that move back and forth in the cylinders.
The temperature drops in the inlet manifold because of this low pressure, just as the gas low predicted. The cold inlet manifold will cool down the fuel mixture and condensation will happen, it is the same effect as when you get into your car and your windows get wet on a cold winter day.

Volkswagen has found some solutions to reduce the condensation of the fuel mixture in the inlet manifold by influencing the fuel mixture temperature. The mixture temperature is the only variable that we can influence really.
If the temperature of the fuel mixture is higher we make sure that a higher amount of fuel will evaporate, condensation should be a problem of the past.

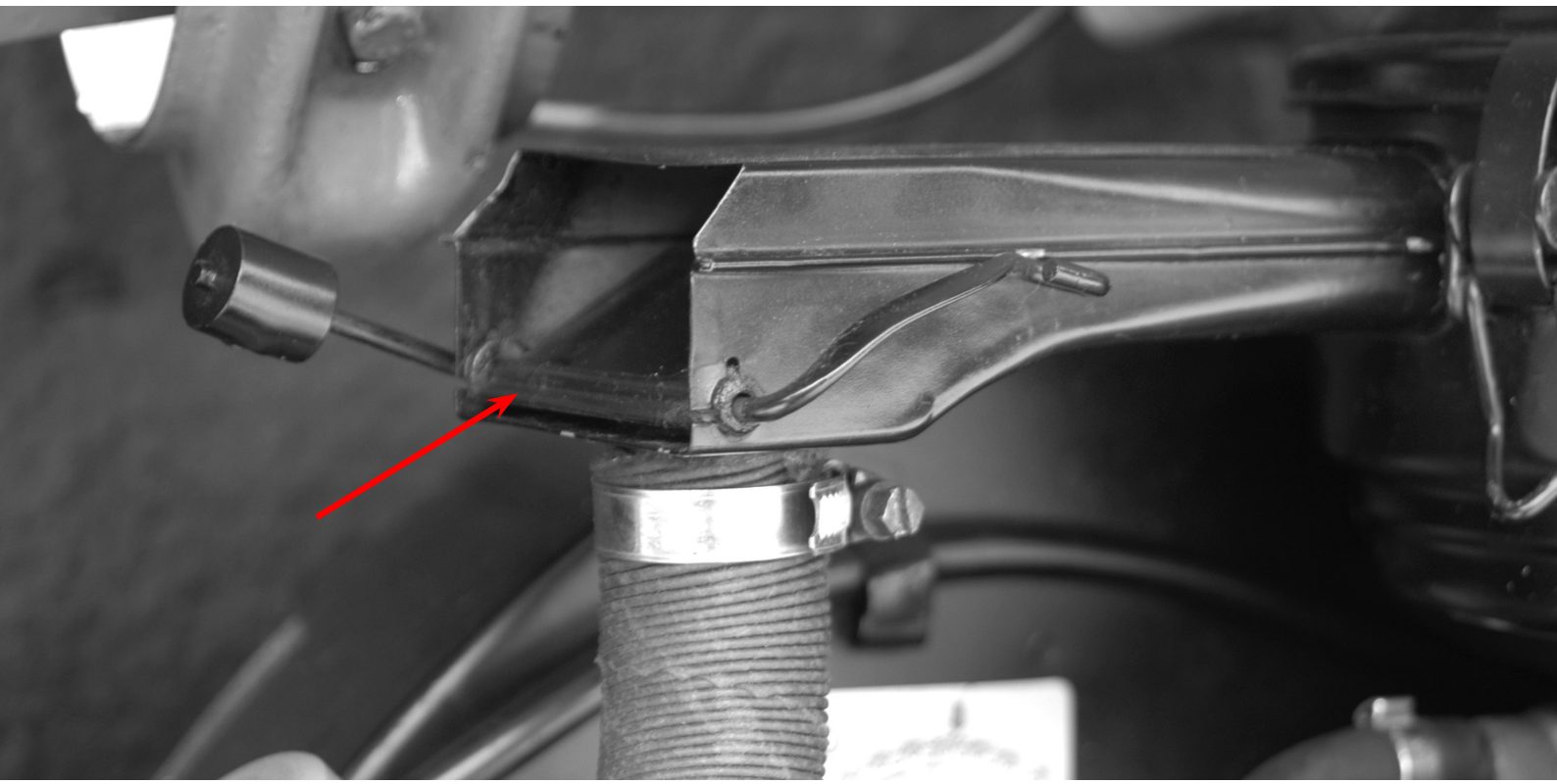
To generate the hotter fuel mixture, Volkswagen designed the following systems into our air-cooled Volkswagen:

1. ***air filter heating system***
2. ***inlet manifold preheating***

Failures on the systems mentioned above can cause major headaches! Lets have a look how these systems work in our classic Volkswagen.

1. Air filter heating system

This system will make sure that the incoming air is heated before reaching the carburetor. The ambient (cold) air is mixed with warm air coming from the exhaust system. Different systems have been installed on the air-cooled Volkswagen during the production years, some systems needed to be set manually (picture below) depending on the season. The lower the rpm the more warm air gets in, the higher the rpm gets the more cold air will flow into the air filter. Later systems were mixing the cold and warm air automatically. The basic principle is always the same though, a valve installed in the air filter unit regulates the cold-warm air mixture. This system will deliver hotter air to the air filter, this hot air will be used to create the air-fuel mixture in the carburetor.



The older air filter units have a valve with a counterweight to regulate the cold-warm air mixture, the big flexible tube delivers the hot air from the exhaust.

#08 Carburetor

Later models have a valve on the air filter that is controlled by a cable connected to the cooling flaps. How much warm air will flow into the air filter depends on the temperature of the engine, this system has been used only for a few years, so it is very rare.

Younger Volkswagen models with plastic air filter units have a thermostatic regulated system. The thermostat measures the incoming (ambient) air temperature and tries to offer the ideal air temperature to the carburetor.

The thermostat controls a valve (picture on the right), the valve regulates the incoming ambient air and heated air from the exhaust. The final result is a constant air temperature in all seasons and at all rpm's and all engine temperatures. The ideal system.

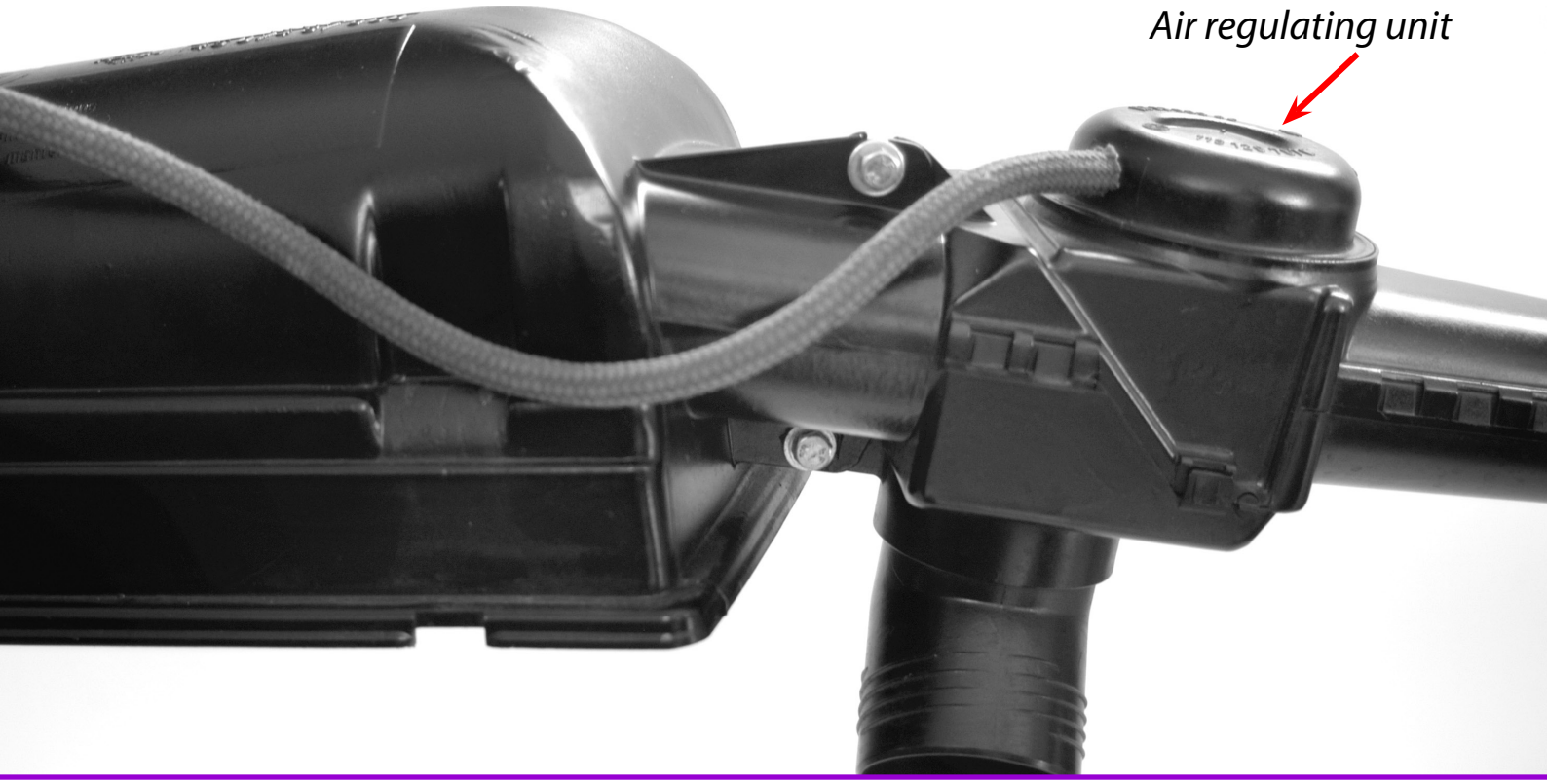
The bad news is that this more modern system tends to fail after some years, this is not just a piece of plastic as many think, the thermostat can fail if not handled gently. Many VW enthusiasts have spend hours trying to have their engine run smoothly, after replacing the air filter unit that the problem was solved.

Thermostat

Not many VW enthusiast know the existence of the thermostat within the plastic air filter unit. This air filter unit type is more than just plastic and a paper filter element. On the left we show the thermostat unit, this one can fail if not handled gently.

mixture preheating

This air filter has a regulating valve installed that will mix the cold (ambient) air and the hot air (coming from the exhaust). The final goal is to offer air with ideal temperature to the carburetor. This plastic air filter with thermostat regulation was installed on the later Volkswagen types.

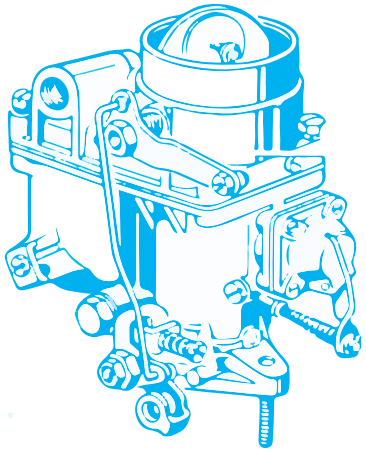


2. Inlet manifold preheating

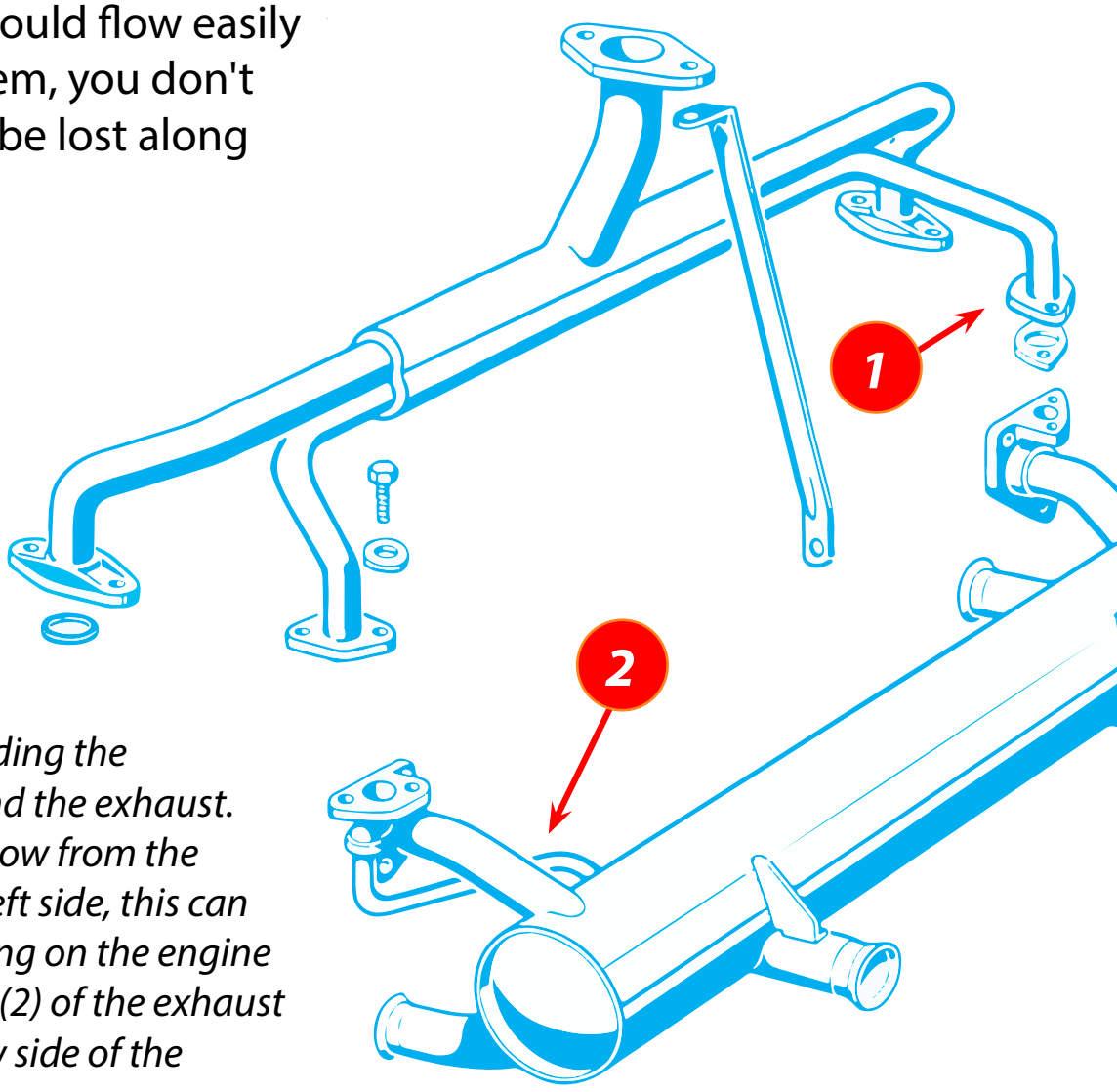
So, the air getting in the carburetor is being preheated by the systems we just discussed, you need to make sure this air filter incoming air preheating systems works well before continuing. Now we need even more heating, but in the inlet manifold this time. The gas law tells us that the temperature of the fuel mixture will drop because of the drop in pressure in the inlet manifold. Volkswagen solved that problem by attaching a metal tube to the inlet manifold, hot air coming from the exhaust flows through this additional tube (we show this on the picture as number 1). These is the well known preheating system from Volkswagen.

This system is based on the same principle as the heat exchangers that are used to heat your car interior. The inlet manifold is heated by a heat exchanger tube that receives hot air coming from the exhaust. It is very critical that the central part of the inlet manifold gets very hot, this part of the inlet manifold is the most critical when condensing of the fuel mixture is concerned. The central part is where the inlet manifold connects to the carburetor and then splits to the right and left to both cylinder heads. The strong curve is the source of condensation, remember are story earlier, fuel will flow slower than air, especially in the curves. Keeping the inlet manifold temperature high will avoid the condensation of fuel.

mixture preheating



You need a lot of heat to do the job, all the air-fuel mixture should be heated to avoid the condensation problem. The exhaust fumes should flow easily through this system, you don't want any heat to be lost along the way.



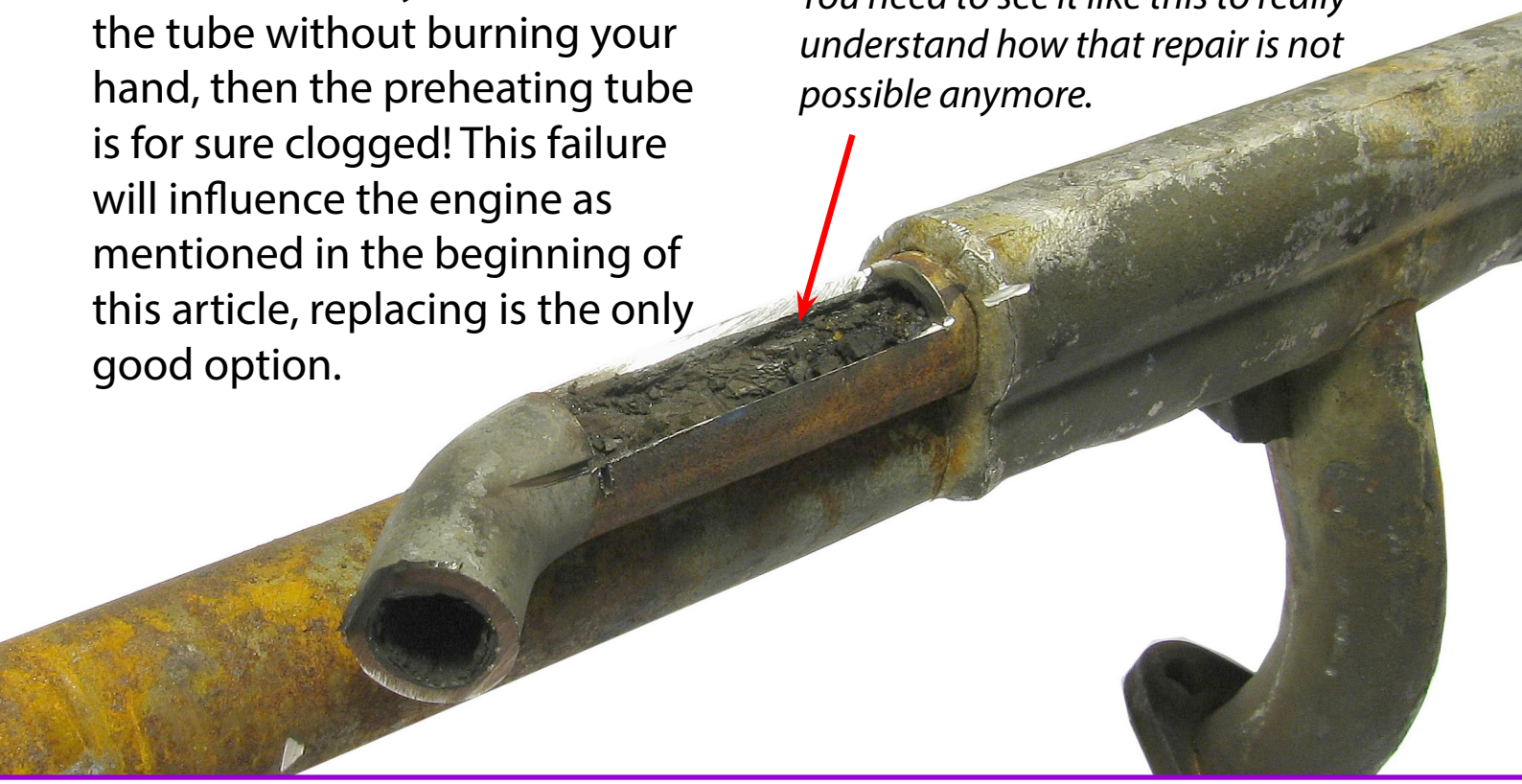
On the right you see a 1960 type 1 (Beetle, Ghia, Bus) inlet manifold, including the carburetor on top and the exhaust. The exhaust fumes flow from the right side (1) to the left side, this can be different depending on the engine type. The small tube (2) of the exhaust is always the outflow side of the system.

#08 Carburetor

We experience that many Volkswagens have issues with the inlet manifold preheating, the preheating tube is clogged as you see on the pictures on this page and the next page. Exhaust fumes have been passing this narrow tube for many years. Rust and charcoal residues block the preheating tube passage, the hot exhaust fumes are not able to heating the fuel mixture anymore. A simple test that you can perform on a hot engine, is to feel the center of the inlet manifold, if it feels cold and you can hold the tube without burning your hand, then the preheating tube is for sure clogged! This failure will influence the engine as mentioned in the beginning of this article, replacing is the only good option.

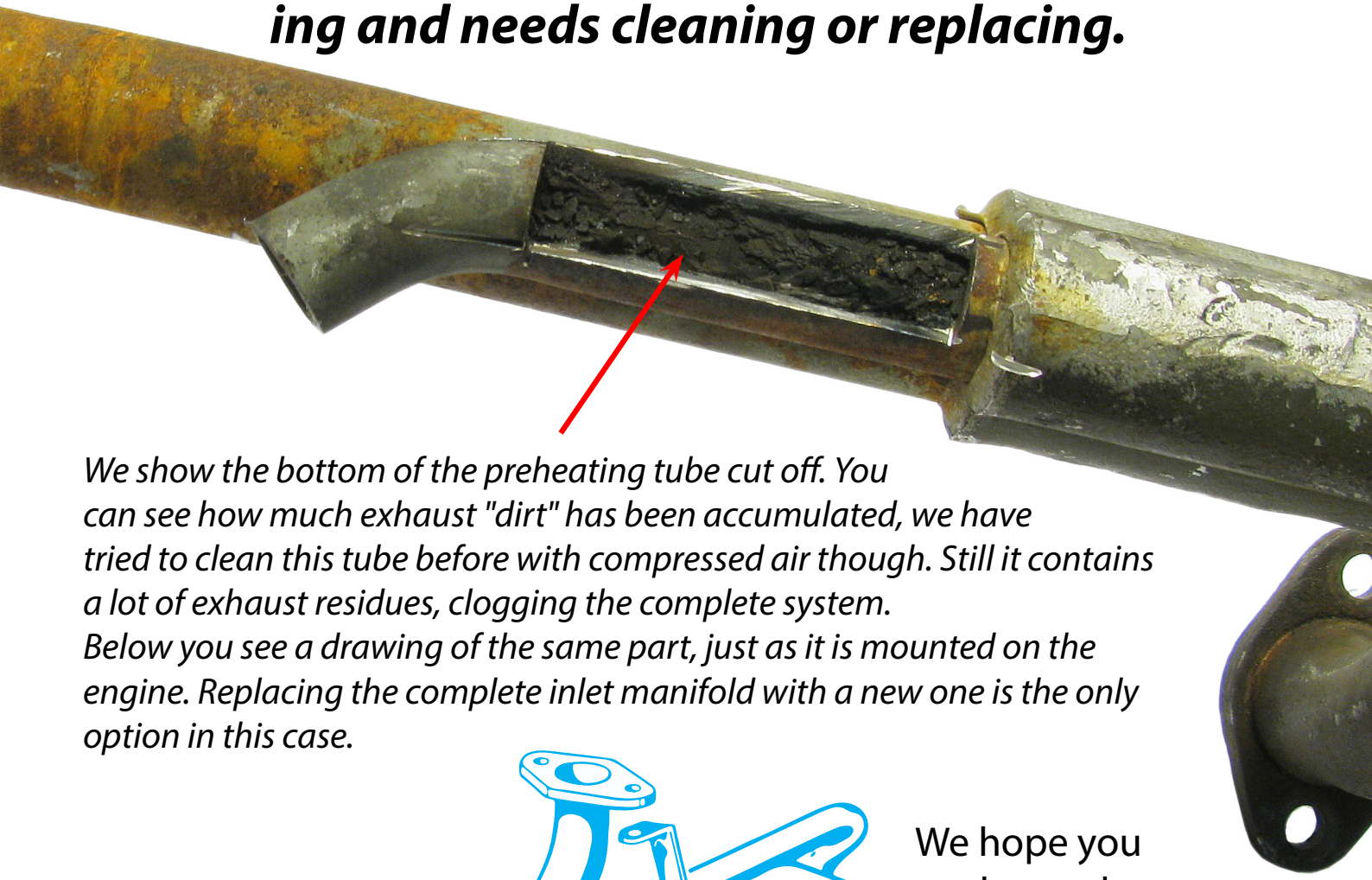
We have tried to blow compressed air into the preheating tube, but if the engine has never been restored, 40 years of exhaust (from a maybe badly tuned engine) will be difficult to clean. We cut the inlet manifold preheating tube on an old engine we had in the workshop (picture below and on the right), you understand now how big the damage is and how much problems it can cause during a cold winter day.

The same picture below as the one on the right but from a different angle. You need to see it like this to really understand how that repair is not possible anymore.

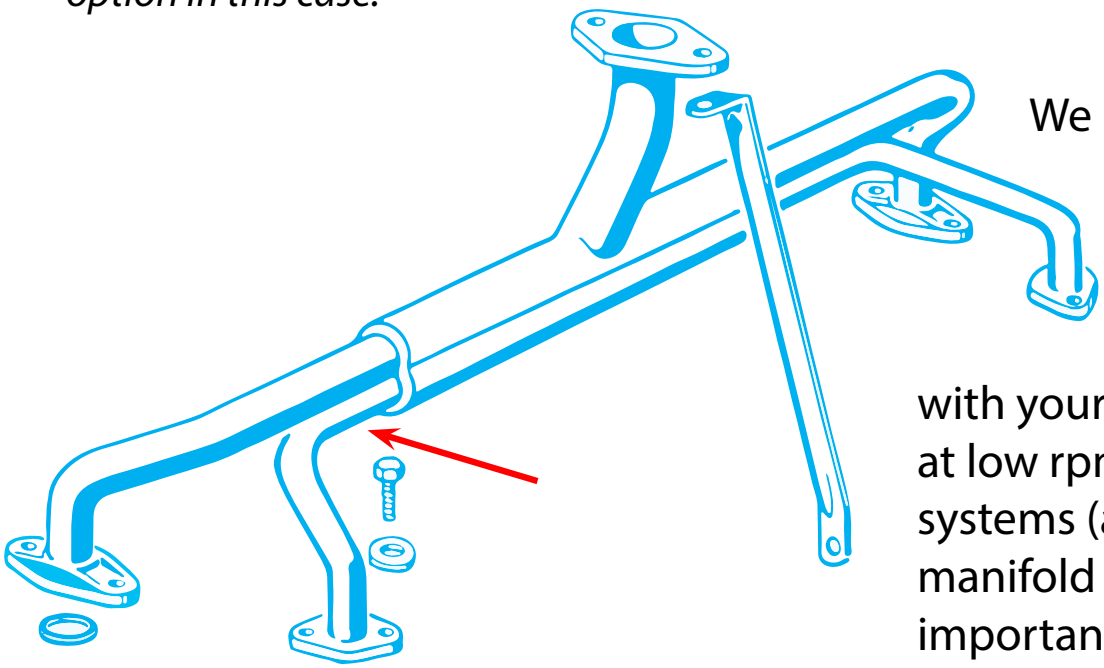


mixture preheating

If you can touch the preheating tube while the engine is hot, the preheating system is probably failing and needs cleaning or replacing.



We show the bottom of the preheating tube cut off. You can see how much exhaust "dirt" has been accumulated, we have tried to clean this tube before with compressed air though. Still it contains a lot of exhaust residues, clogging the complete system.
Below you see a drawing of the same part, just as it is mounted on the engine. Replacing the complete inlet manifold with a new one is the only option in this case.



We hope you have a better understanding on how to solve the problem with your stalling engine at low rpm. Both heating systems (air filter and inlet manifold preheating) are so important to have a healthy running engine.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What is my original battery voltage?

The VW Beetle 1200 cc was equipped with a 6 volts electrical system until the beginning of 1970, the 1300 cc Beetle received a 12 volts system in 1968. The VW Bus and VW type 3 (Notchback, Squareback and Fastback) were the first air-cooled Volkswagens to get a 12 volts system in 1967. The type 4's (VW 411 and 412) always had the 12 volt system, these cars were available at the end of the sixties, having a 6 volts system on a "luxury" car was not an option anymore by then.

Many classic Volkswagens have been "upgraded" from 6 volts to 12 volts by their previous owners, or they have a mixture of 6 and 12 volts on board. We encountered many car with a 12 volts battery combined with a 6 volts starter. These kind of situations don't make it easier to find out what the original electrical installation was. Spotting a "Bosch 6V" sticker is also not a guarantee that this car used to be a 6 volts VW. Checking the chassis number could help, but one never knows if this is really the genuine chassis for this car. Many Volkswagen have a older chassis with a newer body.

6 volts

6 volts and 12 volts

Why do you need a higher voltage?

Why did Volkswagen change the voltage from 6 volt to 12 end of the sixties? That is a really good question we need to address.

The younger VW's have a 12 volt electrical system, the older VW's have a 6 volt electrical system. Upgrading from 6 to 12 volt was necessary end 1960 to address the issue of more accessories and more powerful engines. These trends requested more electrical power to feed the radio, electronic injection systems, air-conditioning, power steering and many more new gadgets. More powerful engines also required more electrical power to feed the ignition system, more power to feed the spark plugs, and the starter was bigger to crank the higher compression engines. Well, you start to understand that the 6 volt system was not adequate anymore. But why couldn't we keep the old 6 volt system? That is the question we will answer now? To answer this question, we need to discuss some theoretical background first. Back to school!

12 volts

Voltage, current, resistance

Quick explanation without mathematical formulas

To generate more electrical power at a given voltage (e.g. 6 volt) you need to generate a higher electrical current. A higher current means you need to have thicker electrical cables. If the diameter of the cable is not big enough to carry the electrical current, the cable will melt. The solution is simple, when you double the voltage (from 6 volt to 12 volt), you don't need a higher current to generate the same electrical power, and you don't need thicker cables, easy enough?

So, what is electrical voltage? Let's have a closer look to the relation between voltage, current and electrical power in a more mathematical, scientific way. Hang on now.

6 volts and 12 volts

Electrical voltage

What is electrical charge?

Electrical charge, defined as Q (coulomb), is the charge transported by a constant current of one ampère in one second. Electrical current is de amount of electrical charge delivered per second (time=t). Current uses the letter "I" (intensity) as a symbol and it is measured in ampère (A).

Electrical charge: Q = I . t

What is electrical voltage?

Voltage is defined with the letter U, and measured in volt (V). 1 volt is the voltage needed to generate an electrical current of 1 ampère through a resistance (R) of 1 ohm (Ω) .

That is how we come the famous law of Ohm, that says:
U = I x R or I = U/R (current is equal to voltage divided by resistance.

What we said on the previous page is the same as what we just described in the formula above; to generate twice as much current through the same resistance you need to double the voltage. That is exactly what Volkswagen did at the end of the sixties.

Voltage: U = I x R or Current = U / R

#09 Electrical

What is electrical power?

Electrical power tells you how much energy is available to ignite an electrical light bulb for instance. Electrical power is defined as following:

Electrical power (P) measured in watt (W) = Voltage x Current or U x I

Electrical Power: P = U x I

P = U x I (power is equal to voltage multiplied by current)

Below we show a practical example using a light bulb. How much electrical current does a 12 watt light bulb need in a 6 volt car and a 12 volt car:

with a 6V battery: **12W = 6V x 2A**
with a 12V battery: **12W= 12V x 1A**

So, the resulted electrical power is the same for both cars, but with the 12 volt system you need half of the current compared to a 6 volt system. The electrical cable needs to be half as thick in the 12 volt car compared to the 6 volt car. The electrical wire loom in a 12 volt car doesn't need to be bigger to carry double of the electrical power compared to a 6 volt. Why is this? We didn't discuss that yet, we need to talk about the role of the resistance of the electrical cables in your air-cooled Volkswagen.

6 volts and 12 volts

What is resistance?

The electrical resistance of an electrical cable is defined by its length (l), its electrical resistivity (ρ) defined by the type of material the electrical cable is manufactured and the diameter of the cable. Resistance (R)= (length in meter x resistivity)/(diameter in mm^2) or as a mathematical formula:

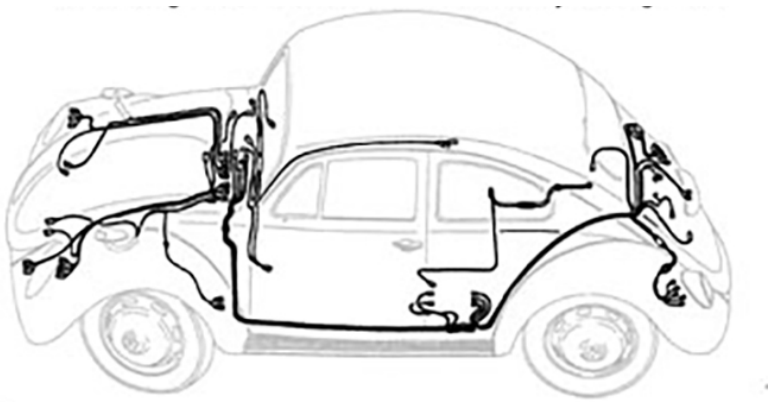
Resistance: R = (l x ρ) / d

Each material has its own electrical resistivity. The electrical resistivity is defined as the resistivity for a cable of 1 meter with a diameter of 1 mm^2 at a temperature of (15°C in the table on the right). On the right we show a table with the electrical resistivity for most used conductivity materials. Copper has the second lowest resistivity, silver is lowest. Silver would be the best choice to use for electrical cables, but you understand that silver cables are out of reach , too expensive, for cars. The difference is very low between both materials. The lower the resistivity the smaller the cable can be to carry the same electrical power.

Material	***ρ 10^{-6} Ωm***
Aluminum	0,03
Gold	0,0222
Copper	0,0175
Lead	0,21
Brass	0,07
Nickel	0,12
Platinum	0,12
Tin	0,13
Iron	0,13
Silver	0,016

#09 Electrical

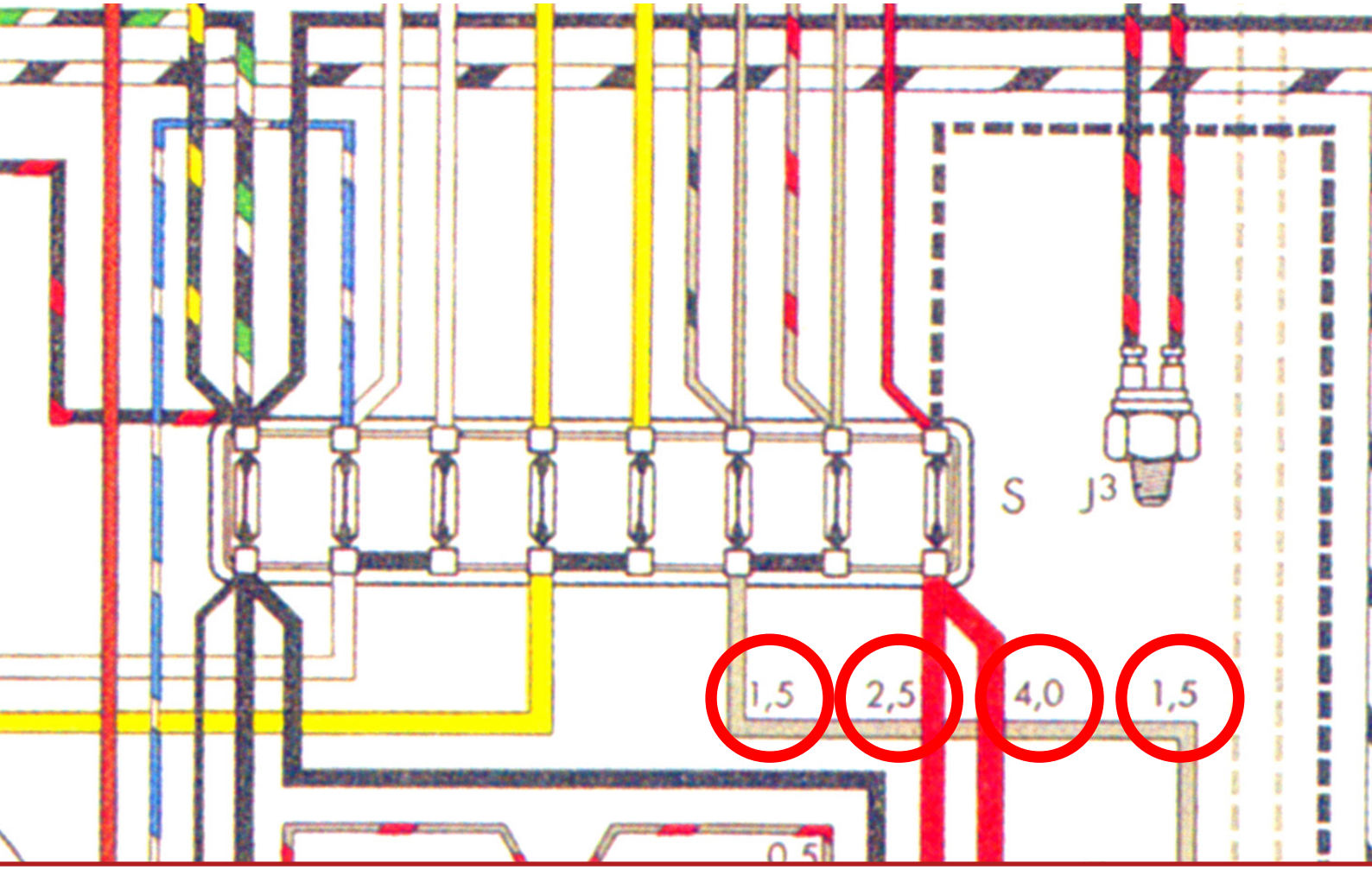
Your VW has a wiring loom that carries the electrical current to all accessories. This wiring loom is designed especially for your VW model, so that the cables are as short as possible to have the lowest resistance as possible. If the cables would be too long, the electrical resistance would become to high, and the accessories would not get the power they need.



6 volts and 12 volts

When you have a closer look to the electrical scheme of a 12 volt Volkswagen, you will see that the diameter is mentioned for every cable. The cable diameters are between 0,5 mm^2 and 6 mm^2, only the cable connected to the starter and the battery plus are thicker (25 mm^2). When you compare a 6 volt and a 12 volt Beetle there are not so many differences in cable diameter.

The younger 12 volt Beetles have a more complex wiring loom because more accessories are installed, there are more cable, but the cable diameters are very similar to the 6 volt Beetles. Doubling the voltage (from 6 volt to 12 volt) makes it possible to carry twice as much current, so twice as much power.

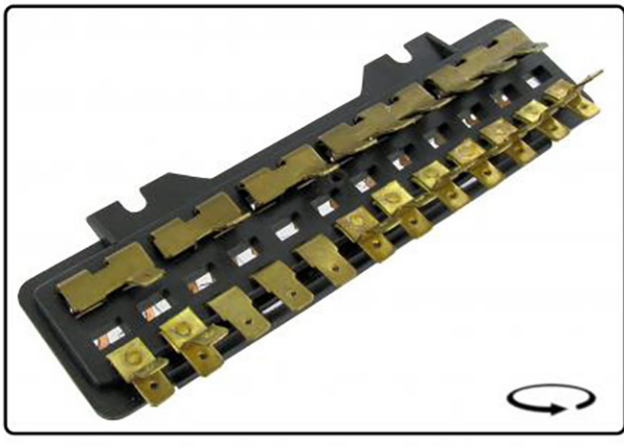


Diameter and current

The diameter of the electrical cable will define how much current is able to flow through that cable before it melts down. On the right you see a table showing the maximum current that can flow through a specific diameter before it melts down.

This information is a guide to understand which fuses will be needed to protect which cable diameter. An electrical cable of 2,5 mm^2 for instance will be secure with a 16 amp fuse. The cable can support up to 20 amp, so a 16 amp fuse should protect your electrical cable.

diameter (mm^2)	*maximum current (A)*
0,5	8
0,75	9
1	11
1,5	14
2,5	20
4	25
6	31
25	100



Conduction and electrical losses

Electrical losses can occur in the electrical circuit of your car, this means you will lose electrical power along the way from the battery to the accessory (e.g. light bulb). Bad electrical connections and rusty clamps will cause power losses. Why will that create an electrical loss? Bad connections will increase the electrical resistance of your cables, a really rusty clamp or bad connection can generate an additional 3 ohm of resistance in your circuit.

Imagine an electrical consumer (e.g. light bulb) that has a resistance of 3 ohm, you connect this consumer to a power supply (e.g. battery) of 6 volt , ideally you would measure a current of 2 ampère in ideal circumstances:

current = voltage divided by resistance or
I = 6V / 3Ω = 2A

If there is a loss of 3 Ω on the contact between the battery and the light bulb caused by a bad connection, the electrical current will be half of what it should be in ideal circumstances, so only 1 A will flow through the light bulb.

I = 6V /(3Ω + 3Ω) = 1A

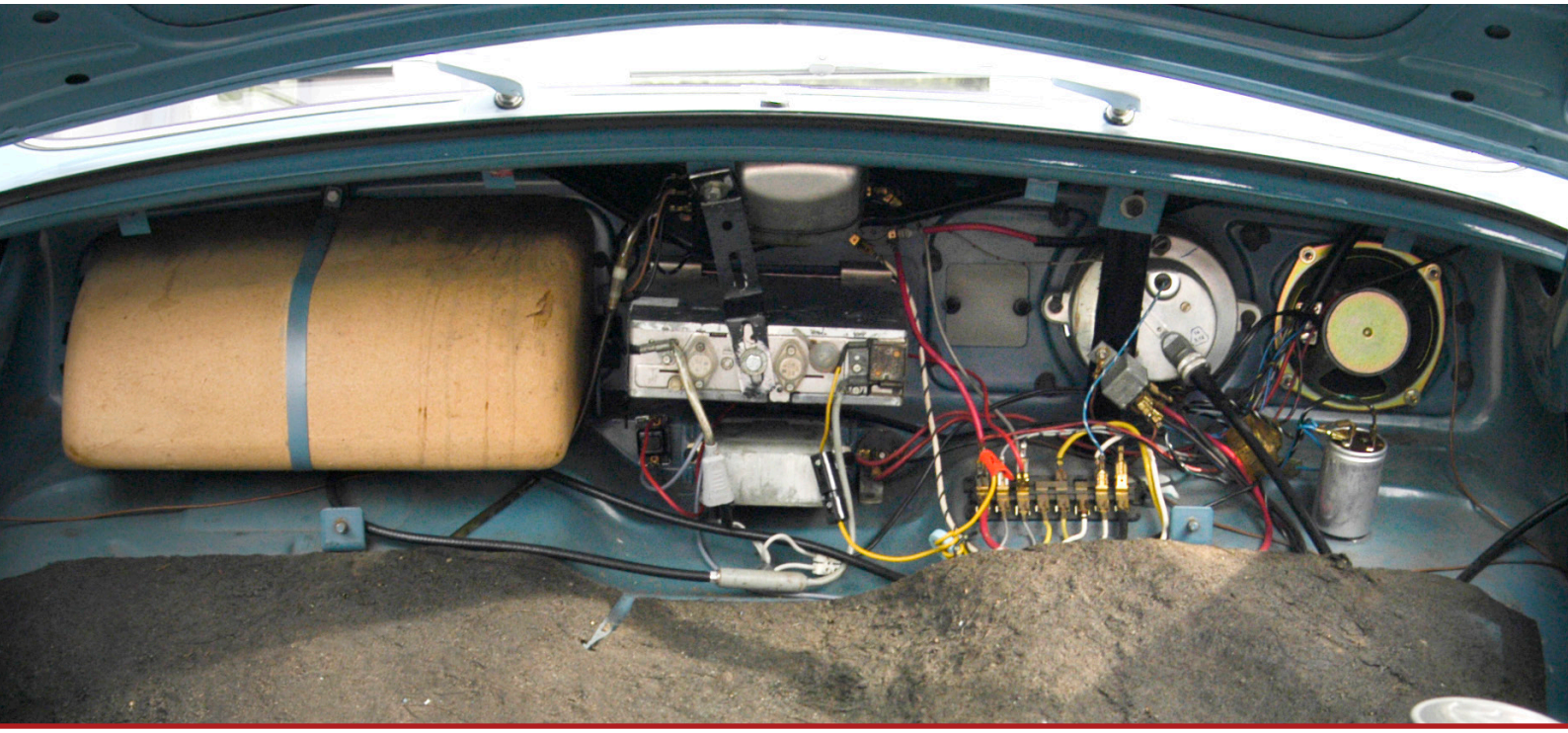
If the electrical consumer is a light bulb then the amount of light generated will be too low. If the consumer is an electronic ignition system then the ignition will not work at all or your engine will not get a good spark and fail. If the consumer is the starter, then your VW will not start easily or not start at all, the starter will rotate but will have a lack of power.

#09 Electrical

The electrical cables in your car have a very low resistance, a 2 mm^2 copper cable with a length of 10 meter has an approximative resistance of 0,1 ohm. The biggest resistance is not caused by the electrical cables (the distances in our VW our not that big) but by the connections, the electrical clamps. One major resistance issue is the fuse box, you will not have the reflex to check out the fuse box in your VW, but in many cases the contacts are bad and replacement of the complete fuse box is the best option.

So, make sure all your electrical contacts are optimal, don't add unnecessary additional connections, try to have cables in one piece. Use a soldering iron to finish of your electrical connections, use heat shrink tubing to make sure the cable is well insulated. Use battery terminal grease to protect your battery terminals.

Taking care of the electrical connections in your air-cooled Volkswagen will help to make your classic car more reliable and run better.



Do you need to migrate to 12 volt?

Is upgrading your VW from 6 volt VW to 12 volt really necessary? I heard so many times that a 6 volt Beetle has weak headlights, the wipers are not working well (they barely move from left to right), the turn signals are almost not blinking anymore. Well, when this 6 volt VW was delivered back in the sixties, everything worked properly, I agree it was not a modern car as we know them now, but nobody complained about not working wipers. So the problem is not the 6 volt installation. If your Volkswagen has a 6 volt installation, you need to check all the electrical connections one by one. Check if the clamps are tighten, check for corrosion, check your fuse box rust and worn out clamps. So, make sure all connections are in good conditions. If problems still occur, maybe the electrical consumer is an issue.

The starter motor or the electric motor of the wiper is tired. When you are finished with checking and replacing, you will experience a totally different 6 volt VW.

12 volt consumer in a 6 volt Volkswagen

If you need to connect one 12 volt consumer (e.g. a radio) in your 6 volt VW, you don't really need to upgrade the complete car. You may install a voltage converter. This solution is less invasive for your VW.

Upgrade to 12 volt

In some cases, you need to upgrade to 12 volts. When you install a high performance engine for instance, or a huge stereo system, upgrading to 12 volts may be inevitable. You loose the originality of the car of course, so think about it very carefully. Lets have a look to what you need to replace to upgrade from 6 volts to 12 volts.

Battery

The battery is the source for the electrical circuit. Make sure your new battery has enough power to supply all the consumers you want to install. The strength of the battery is measured in Ah (ampère x hour).

You need to replace the mass cable, the 6 volts mass cable is located on the other end of the battery compared to a 12 volts battery, so the mass cable needs to be longer on a 12 volts battery.

Starter

Sometimes VW owners keep the 6 volt starter motor in their upgraded 12 volts car. We don't think this is a good idea. The starter will rotate much faster, too fast, this could damage both the starter and the engine flywheel. The 6 volt starter will also consume too much power compared with a 12 volts.

6 volts and 12 volts

All light bulbs

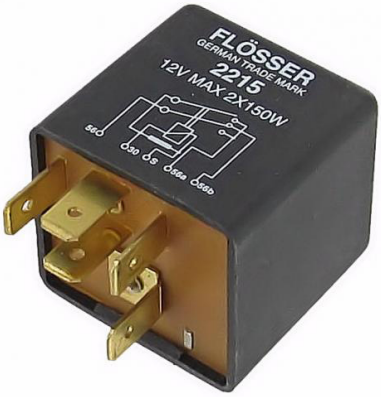
No need to tell you that you will need to replace all your 6 volts light bulbs with 12 volts bulbs. Don't forget the bulbs in the dashboard for instance, a 6 volts light bulb connected to a 12 volts power supply can cause a short circuit and damage the electrical cables.

Dynamo and voltage regulator

You will need to replace the original 6 volts dynamo with a 12 volts alternator. Don't forget to remove the original 6 volt voltage regulator and replace it with a 12 volts regulator. Some 12 volts alternators have a built-in voltage regulator. The connections on the alternator are different compared to the 6 volt dynamo. We refer to page 25 of edition 02.

High beam relay

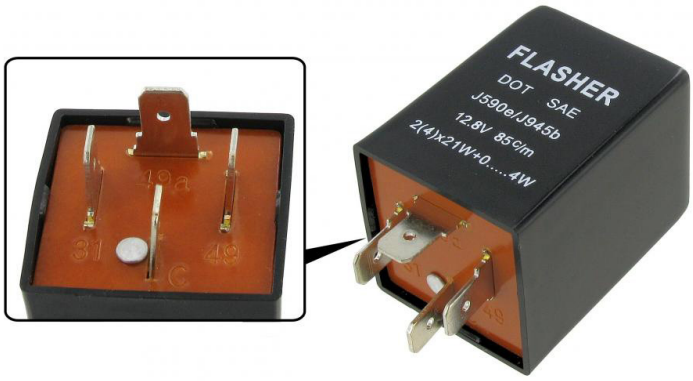
This relay is not always present in older Volkswagens. The early VW's had a high beam foot switch, you don't need to replace the foot switch of course. Only Beetles from 1967 to 1972 have a 6 volts beam relay that needs replacement.



#09 Electrical

Turn signal relay

Every Volkswagen has a control switch, on the dashboard or on the steering wheel, that uses a relay to operate the turn signals. This relay is available in both 6 volts and 12 volts, you will need to replace your 6 volts relay with a 12 volts one.



Coil

The coil will transform the low voltage (6 volt or 12 volt) to a high voltage that is necessary to feed the spark plugs. You will need to replace your 6 volts coil with a 12 volts coil.

Carburetor

You don't need to replace your carburetor, but you need to replace the electrical parts on your carburetor. The 6 volts electrical choke needs to be replaced with a 12 volts one (some older VW's don't have an electrical choke but a mechanical one operated with a cable, so replacement is no needed in this case).

If installed, you will need to replace the idling cut-off valve.

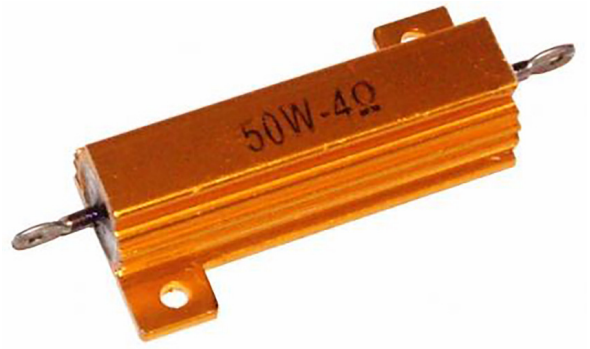
6 volts and 12 volts

Horn

The horn is hidden behind the front fender, easy to forget. Both 6 volt and 12 volts horns are available. If you connect your old 6 volts horn to your new 12 volts battery, it will fail rapidly.

Wiper motor

Replacing the wiper motor will take some hours and it will be quite expensive. Another issue is that 12 volts wiper motors can have a different form factor than the 6 volts motor, so replacement is not that easy. A simple and quick solution is to use a voltage converter as shown on the right, this converter will make it possible to connect your old 6 volts wiper motor to a 12 volts battery.



If you purchase a 6 volts VW that has been upgraded to 12 volts, make sure that all electrical components have been replaced properly. A good electrical system is the base for a healthy VW.

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