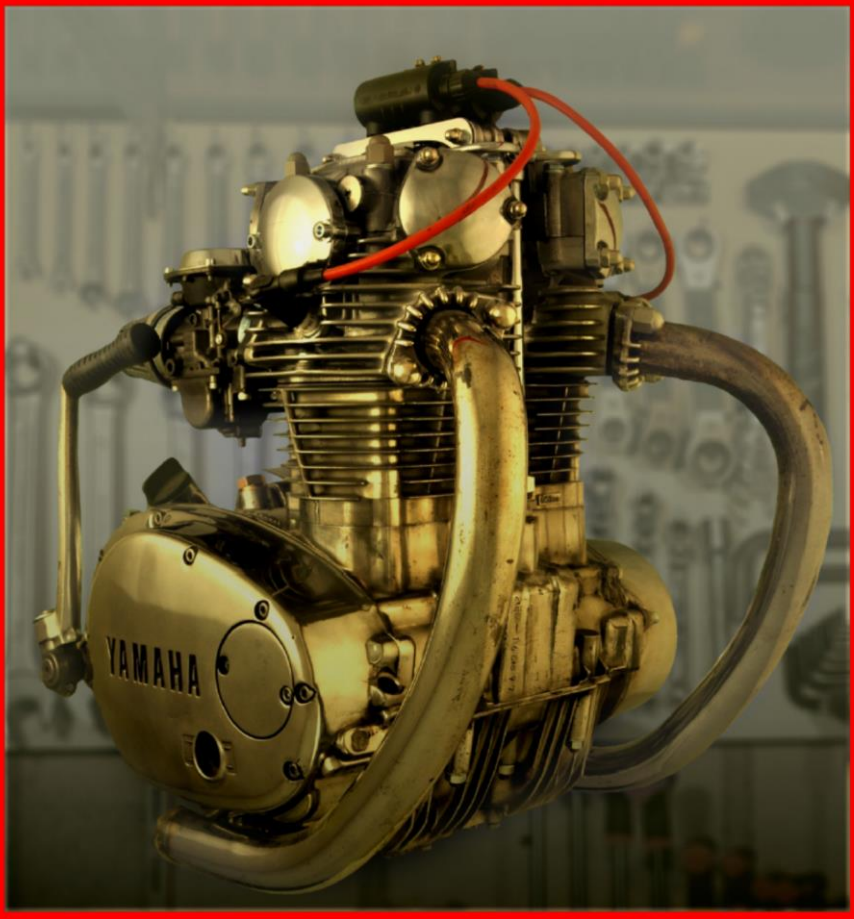
The Yamaha XS 650 Engine

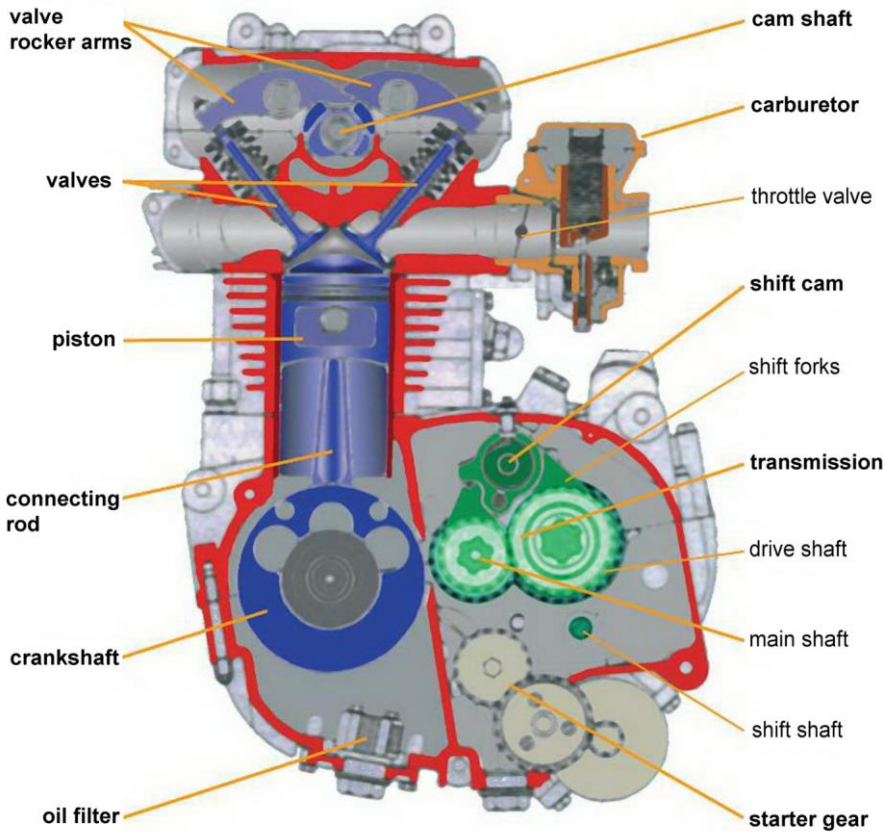


Including the Electric System

Hans J. Pahl

Contents

Vehicle drives consist of the following functional groups: the engine itself, the connection between the engine and the transmission (primary drive and clutch), the transmission for adapting the engine speed to the driving speed and the driving resistances, and the secondary drive. In the case of passenger cars and trucks, these are separate assemblies, which are often purchased as separate units from various suppliers. In modern motorcycle drives - and in this sense the engine of the XS 650 is a modern engine - all components of the drive train are located in a common housing. Such housings are usually divided horizontally, the crankshaft and the transmission shafts being located in the parting gap between the two housing halves.

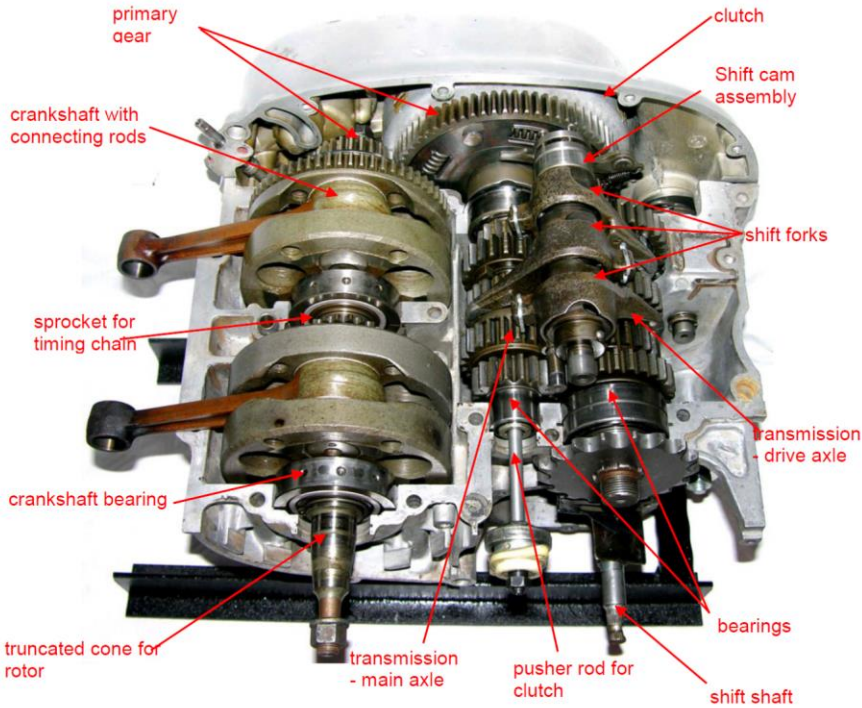


Schematic drawing of the components of the engine
Figure 2-2

Figure 2-2 shows schematically the components of the XS 650 engine. In the following, the term "engine" is used for the whole unit as well as only for the unit consisting of the crankshaft and the camshaft, the pistons and the valve train. The actual engine, is marked by blue color. The

transmission and the gear shifting mechanism are highlighted by a green color marking.

The XS 650 engine is basicly an engine with a very simple design, with the exception of the electric starter. For example, there is no balancing shaft to mitigate the unavoidable vibrations of a parallel-twin. Contrary to the fashion in the 70's there is also only one overhead camshaft. As a concession to the taste of the time, an electric starter has been retrofitted, which is incompatible with the otherwise clear and purpose-built design of the engine with an elaborate execution of its transmission parts. While the whole design of the engine is designed for durability and to be easy to repair, the electric starter's transmission parts wear out very quickly and also affect other components due to the resulting metal abrasion.



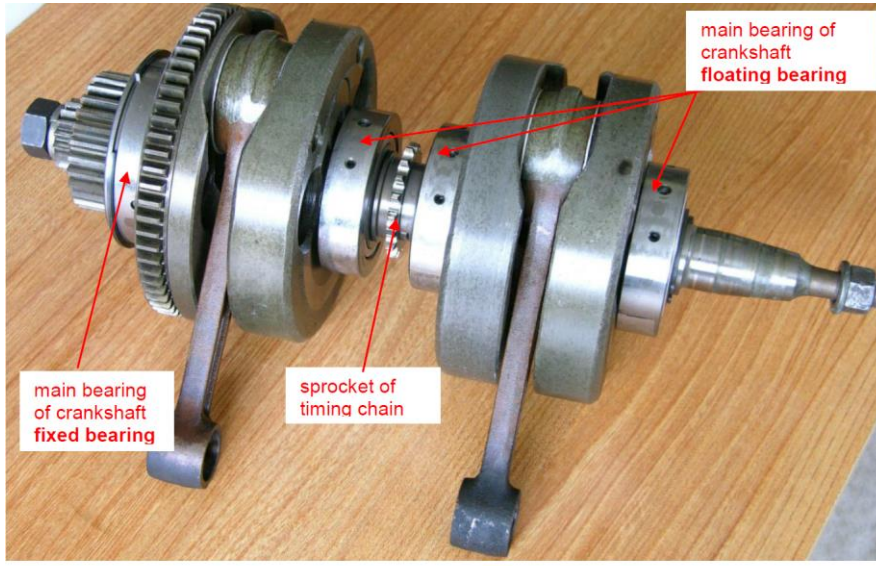
Crankshaft, primary gear, clutch, shifting mechanism and gearbox
Figure 2-3

As far as the durability and repair possibilities are concerned, the XS 650 engine is very elaborately designed. Thus, all rotating parts except the kickstarter shaft are mounted in rolling bearings. A mileage of 150,000 miles and significantly more without extensive repairs is possible with regular maintenance. An overhaul of the engine is worthwhile in any case because all parts subject to wear can be replaced and afterwards a new

The crankshaft is a so-called "built crankshaft", which consists of individual parts and can be dismantled. The individual parts of the crankshaft are shown on page 22 in the original manual. On the following figures 2-5 and 2-6, the crankshaft is shown by means of an explosion drawing from the spare parts list and in the assembled state by means of a photo. A dismantling and reassembling of the crankshaft is only possible with a press, as it is available in engine service workshops. Since dismantling and assembling of the crankshaft is not possible by the means which are available in a conventional workshop, it is not described here.

….

The other three main bearings are axially moveable roller bearings, the outer rings of which are positioned by pins so that the oil bores of the bearing's outer rings are aligned with the oil bores in the lower housing half.



Crankshaft
Figure 2-6

The figures 2-7 and 2-8 show the two central main bearings of the crankshaft with the drive pinion of the timing chain in the middle.

The rollers of the bearings are guided in cages and are not moveable in the axial direction against the inner rings of the bearings while the outer rings on the rollers can be moved in the axial direction in order to compensate for the thermal expansion of the crankshaft.

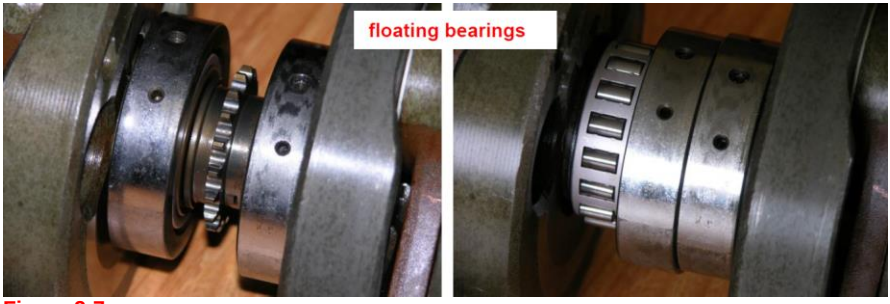
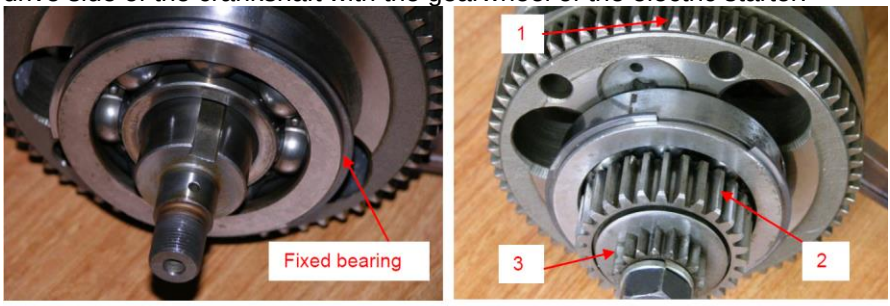


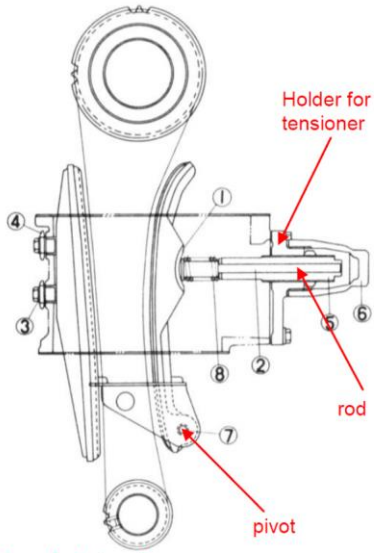
Figure 2-7

Generator side of the crankshaft wit floating bearing
Figure 2-8

Figure 2-8 shows the left main bearing of the crankshaft with the outer ring removed and a part of the tapered crankshaft stub for accommodating the generator rotor. The inner ring of the bearing is fixed in the axial direction by a retaining ring. Figure 2-8 also shows the pressed-in crank pins of the left-hand connecting rod, as well as two relief holes which compensate for the unbalance caused by the weight of the crankpin. Figure 2-9 shows the drive side of the crankshaft with the gearwheel of the electric starter.

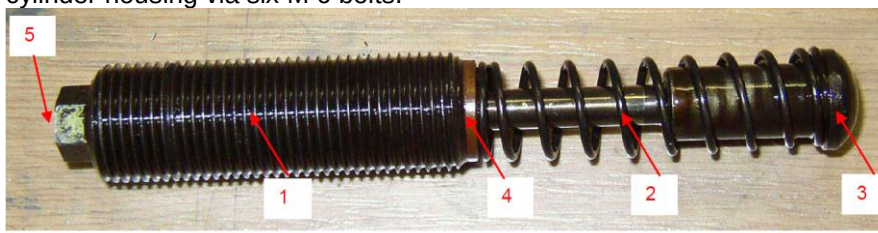


Drive side of the crankshaft and right main bearing (fixed bearing)
Figure 2-9



Timing chain tensioner
Figure 2-15

The timing chain is guided and preloaded by two guide rails. The guide rail at the front of the engine is bolted to the cylinder housing. The rear guide rail is rotatably mounted with its lower end in the upper part of the engine housing. The center of rotation is indicated by an arrow mark in Figure 2-15, which shows the guide rails in the form of a graphic and a photo. Both guide rails are made from aluminum, which is covered with a plastic sliding layer. The rotatably mounted guide rail has a shaping on the rear side, into which the tensioning mechanism engages. This tensioning mechanism consists of a housing part with an internal thread, which is connected to the cylinder housing via six M 6 bolts.



Tensioner of the timing chain
Figure 2-16

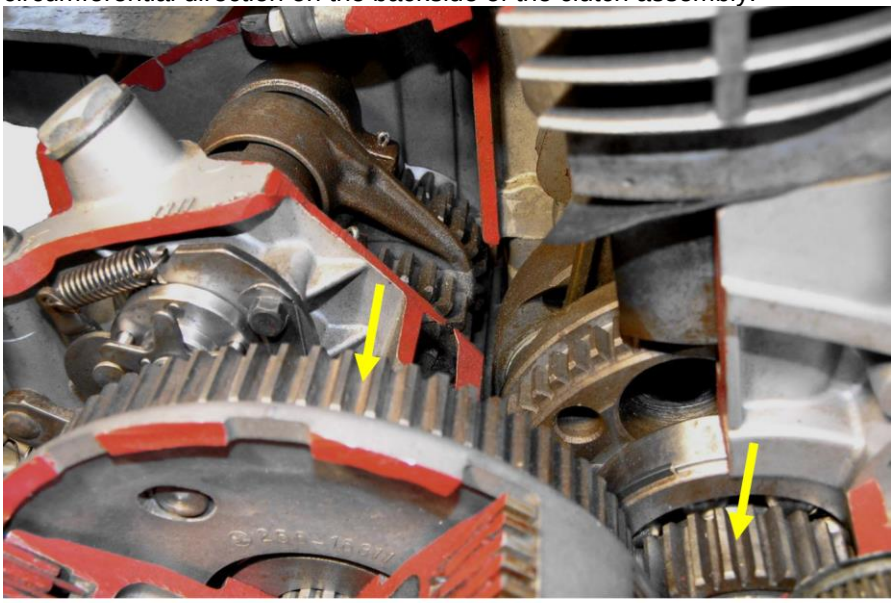
The actual tensioning element consists of a hollow-bored bolt with an external thread and a hexagon at one end (item 1 in figure 2-16) which is screwed into the housing with an internal thread. The threads serve to adjust the tensioning of the timing chain. In the tensioned state, the timing chain is loaded by a pressure spring (item 2), which is actuated by a pin

Power Transmission

The rotation of the crankshaft is transmitted to the rear wheel via the primary drive, the clutch, the transmission (gearbox) and the drive chain. The components up to the sprocket of the drive chain are described below.

Primary drive

The primary drive (Figure 2-24, yellow arrows) consists of straight toothed spur gears of which the smaller one with 27 teeth is fixed to the right side of the crankshaft by a wedge. The larger one with 72 teeth is attached to the rear of the clutch assembly. The torque is transmitted from the smaller gearwheel of the primary drive to the larger gearwheel and to the pressure plates of the clutch hub via 6 compression springs arranged in the circumferential direction on the backside of the clutch assembly.



Primary drive
Figure 2-24

The Clutch

The clutch consists of an outer part, the clutch housing, which is connected to the large spur gear of the primary drive in a torsion-resistant manner by means of six damping compression springs arranged in the circumferential direction. On the transmission input shaft, the clutch boss is rotatably

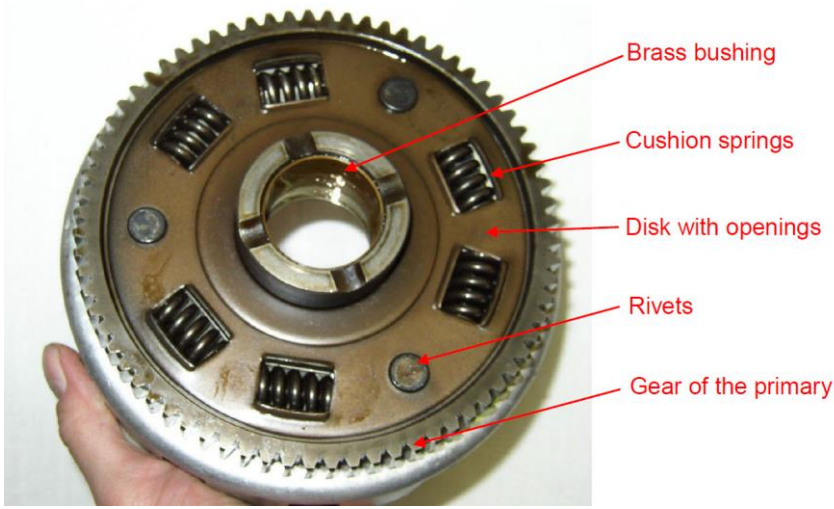


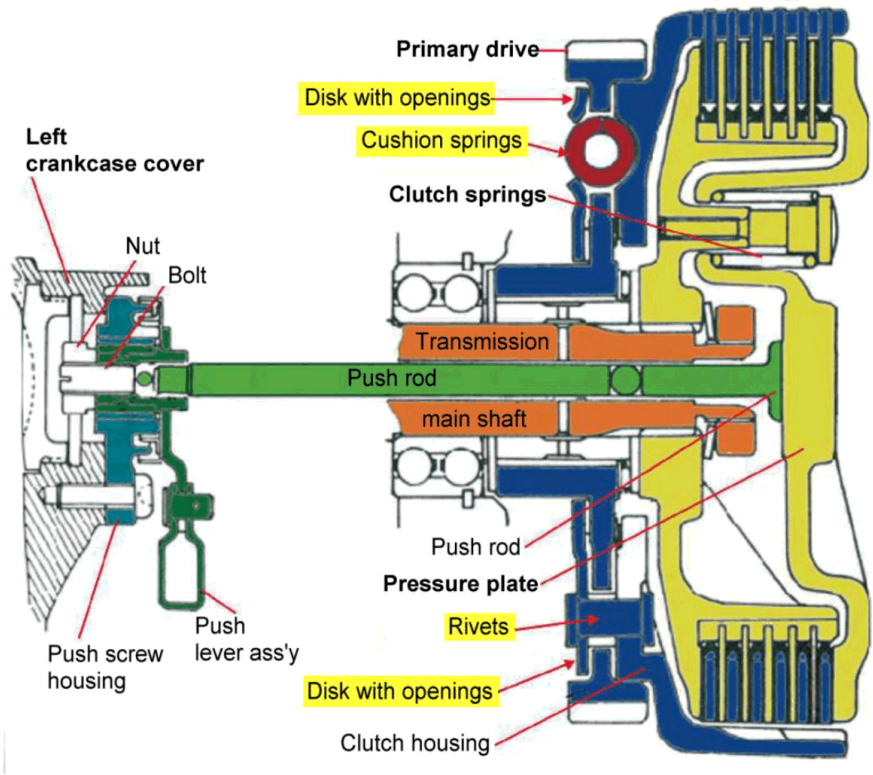
Figure 2-27

When looking at the end face of a spring, the upper third of the damping spring is located in the recess of the sheet metal disc shown in figure 2-27. The middle third of the damping spring is surrounded by a rectangular cutout in the end face of the gearwheel of the primary drive. The lower third of the damping spring is then again located in a corresponding recess of the clutch housing.

Figure 2-28 on the next page shows the funktion of the clutch by means of a sectional drawing. The end face of a damping spring and its arrangement as described above is indicated by a red color marking. The clutch housing, indicated by blue color marking, is driven by the primary drive. The clutch plates, also marked in blue, rotate together with the clutch housing. The inner part of the clutch (marked yellow) is firmly connected to the orange-colored transmission input shaft.

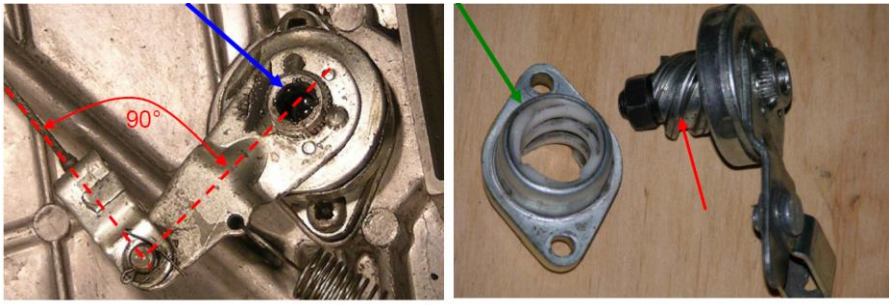
The clutch push rod is located inside the transmission main axle, which is hollow. The clutch is disengaged by moving the clutch push rod (light green color mark) from left to right against the yellow-marked plate of the clutch.

The clutch pressure springs are compressed and thus the pressure between the friction plates and the pressure plates is released, so that the clutch housing can rotate against the clutch boss and the transmission main axle.



Function of the clutch
Figure 2-28

1.1.1 Clutch actuation



Release mechanism of the clutch
Figure 2-29

Some owners replace the two-piece clutch pressure rod with a one-piece rod so that one can find both variants when working on a second-hand engine.

If the clutch does’nt release properly, the reason is most often too much friction inside the bowden cable or an incorrect adjustment of the angle between the bowden cable and the lever of the disengagement mechanism. **Since the force for disengaging the clutch increases with increasing distance, the transmission between the hand lever and the disengagement mechanism must get "more favorable" with the increasing travel of the hand lever, and reach its maximum with the hand lever fully pulled.** This is achieved when the angle between the bowden cable and the lever of the disengagement mechanism is 90° when the lever is fully pulled.

Gear box

Figure 2-30 shows the five-speed gearbox together with the shifting mechanism, the primary drive, the clutch and the kickstarter in the built-in state using a cutaway model.

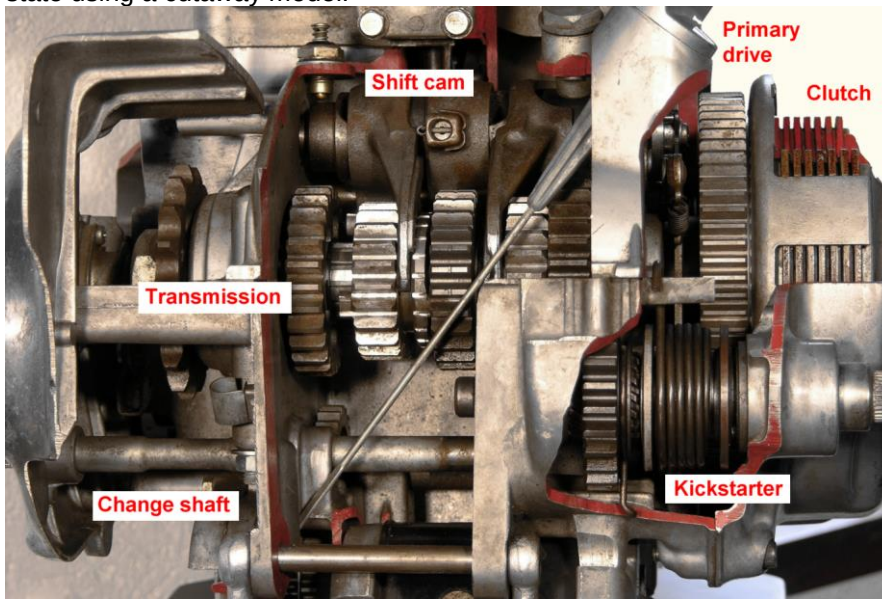
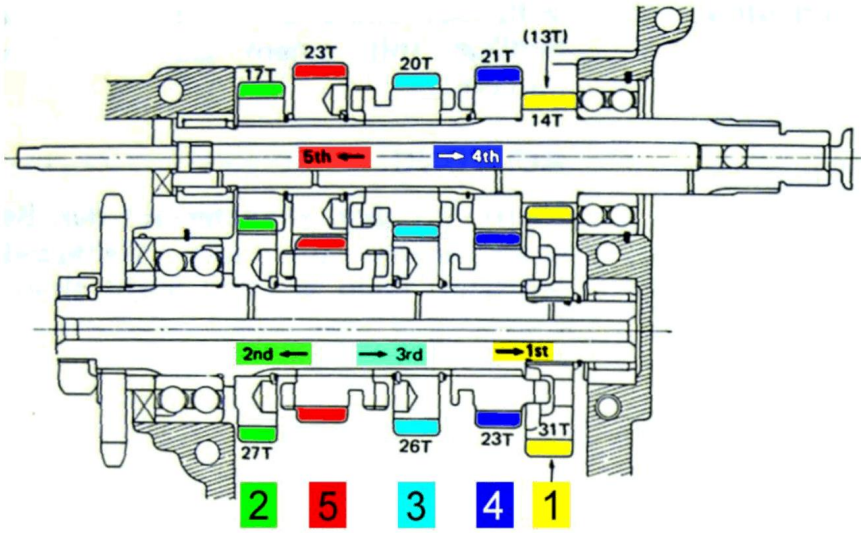


Figure 2-30



Schematic figure: speeds and belonging gear pairs, shifting operations
Figure 2-33

Funktion, drive train

In principle, the power train is established in such a way that one of the gearswheels, which is rotatably mounted on one of the two shafts of the transmission is positively engaged with a gearwheel of a different gear, which is moveable but non-rotatably mounted on the same shaft. The gears are shifted as shown in figure 2-34 on the next page.

1st gear:
The gearwheel of the 4th speed on the transmission output shaft is moved in the direction of the yellow arrow on the figure 34 and engages with its cams in recesses of the gearwheel for the 1st gear.

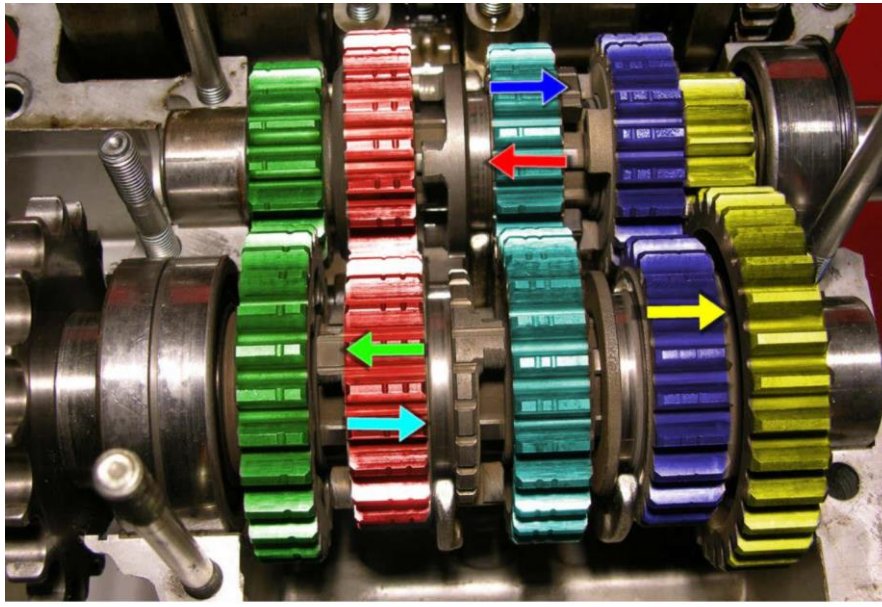
2nd gear:
The gearwheel of the 5th speed on the transmission output shaft is moved in the direction of the green arrow on the figure 34 and engages with its cams in recesses of the gearwheel for the 2nd gear.

3rd gear:
The gearwheel of the speed on the transmission output shaft is shifted in the direction of the turquoise arrow on the figure 34 and engages with its cams in recesses of the gear wheel for the 3rd gear.

4th gear:
The gearwheel of the 3rd gear on the transmission input shaft is shifted in

the direction of the blue arrow on the figure 34 and engages with its cams in recesses of the gear wheel for the 3rd gear.

5th gear:
The gearwheel of the 3rd gear on the transmission input shaft is shifted in the direction of the red arrow on the figure and engages with its cams in recesses of the gear wheel for the 5th gear.



Speeds and belonging gear pairs, shifting operations
Figure 2-34

For shifting the gears, a total of three shifting forks are required. Two of the shift forks engage in the circumferential grooves of the fourth and fifth speed gearswheels on the transmission input shaft, and a third shift fork engages in a circumferential groove of the third speed gearwheel on the transmission output shaft .

Figures 2-35 and 2-36 on the next page show the gearshift forks in a position on the transmission shafts (figure 2-35) and in the built-in position in the upper half of the engine housing (figure 2-36).

The shifting forks move the gearwheels in axial direction of the respective shafts and establish the torque connection by the engaging cams in corresponding recesses of the gearwheel of the gear to be shifted. The arrows on the shiftforks indicate the direction of the movement of the shiftforks and the marking colors of the arrows indicate the individual gears.

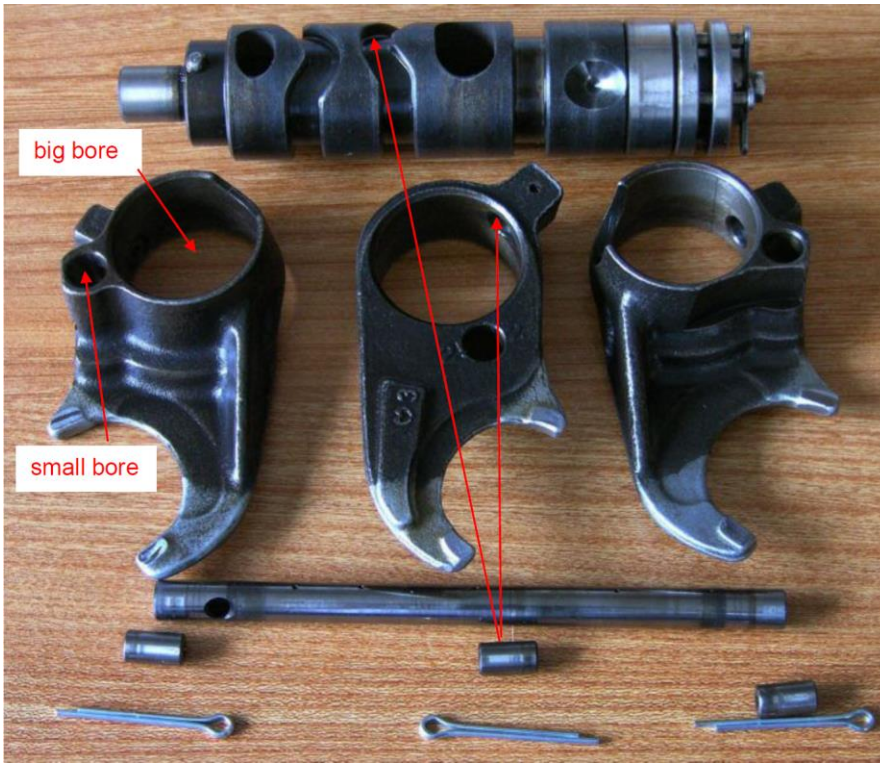


Figure 2-39

In the guide grooves of the shift cam, guide pins (item 12 in figure 2-38) are engaged with one end, while the other end is engaged in bores of the shift forks as shown in figure 2-40.

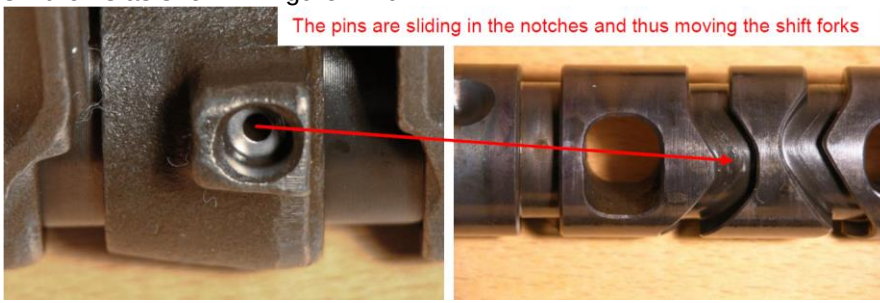


Figure 2-40

A shift fork is moved in the axial direction and a gear is thereby sfifted when a guide pin is engaged within the arcuate course of the guide grooves.

The shift shaft serves to transmit the up-and-down movement of the foot shift lever to the shift cam. By actuating the foot shift lever, the arm welded to the shift shaft is pivoted so that the fork attached to the upper end of the arm is moved for upshifting and downshifting as shown in figures 2-41 and 2-42. The arm, which is welded to the shift shaft, is held in the middle position by a spring, so that the same fork travel is available for upshifting and downshifting.

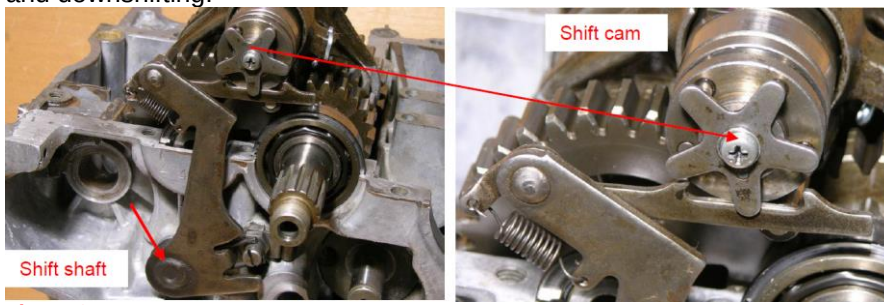


Figure 2-41

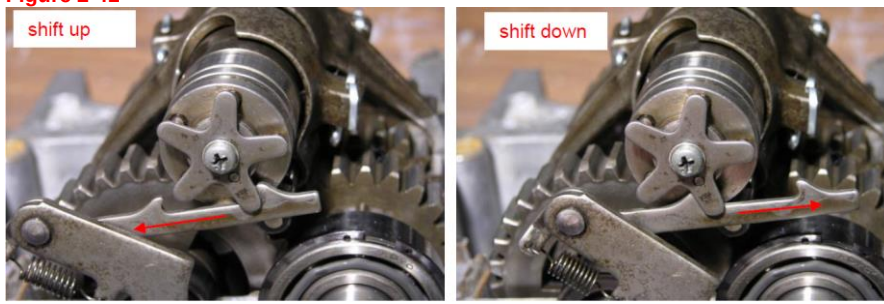
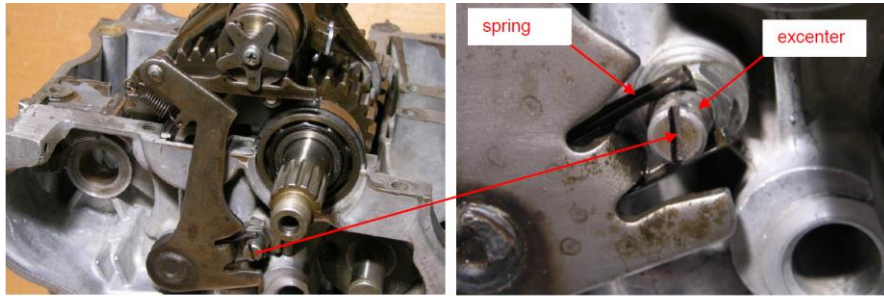


Figure 2-42

The adjusting screw with an eccentric shank indicated by an arrow in figure 2-43 is used to adjust the center position of the arm welded to the shift shaft.



Adjusting the shifting mecanism
Figure 2-43

Neutral position of the transmission

On the left side of the upper engine housing half there is an electrical switch, which is closed by the pressure of a pin on the shift cam. On the

right hand side of the upper engine housing half there is a spring loaded

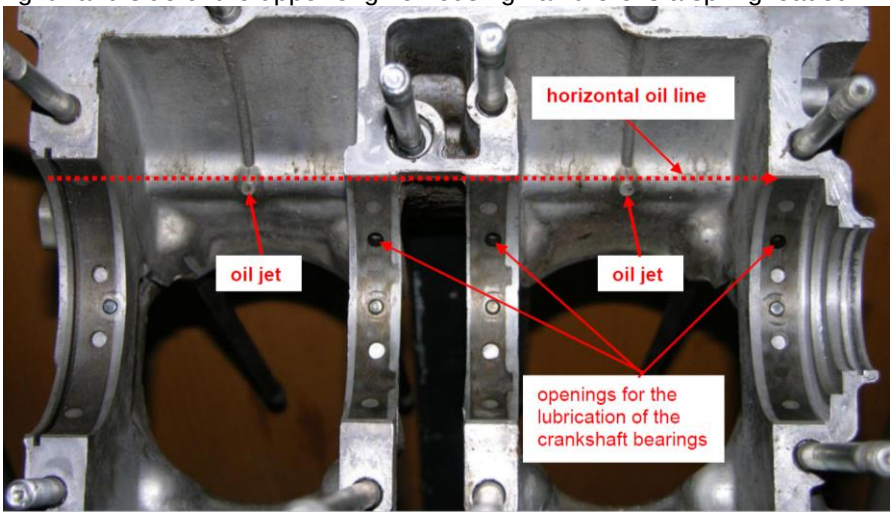


Figure 2-65

Crankshaft, conrod bearings

The oil nozzles and the connecting rod bearings lubricated by these are shown in figures 2-66 and 2-67.

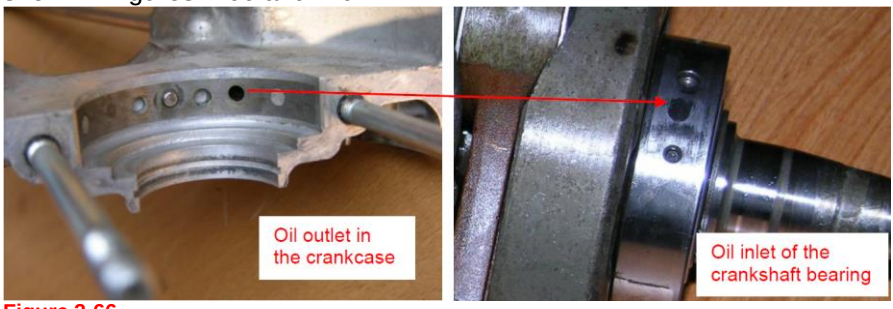


Figure 2-66

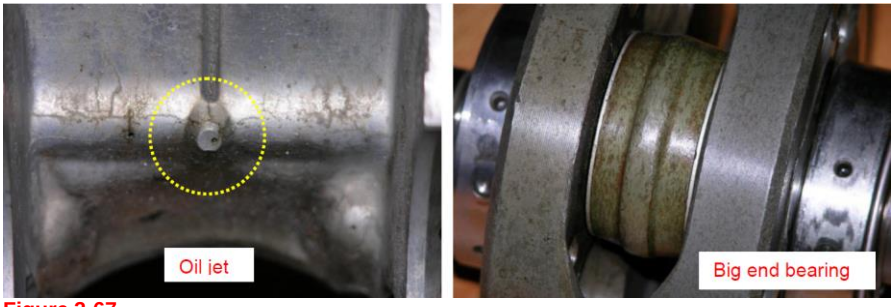


Figure 2-67

Rocker levers, valves

The oil rising pipe in the middle of the oil passage, which extends horizontally in front of the engine housing is the connection to the oil supply

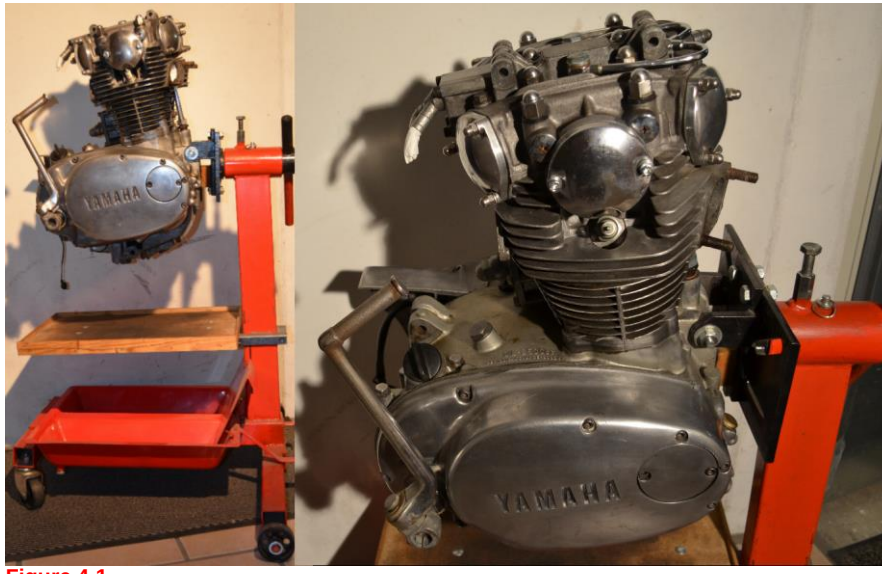


Figure 4-1

If the engine housing is not to be opened and it should be only worked on the cylinder head or the clutch - so that it is not necessary to turn the engine to the side or to turn it completely - a simple self made engine stand as shown in figures 4-2 and 4-3 is sufficient.


Figure 4-2

The XS 650 engine is quite heavy and it can be handled only with difficulty by one person without suitable devices. The device shown in figure 4-4 can be used as an aid to lift the engine with the aid of a hoist and attach it to the engine stand. The device is bolted to the upper mounting points of the

engine with the long M8 bolts. However, there is still a more suitable
Figure 4-5
In principle, apart from the puller on figure 4-5, you do not need any special tools to disassemble the engine and then assemble it again, if you don't intend work that can only be carried out in engine repair workshops anyway.

However, the task can be made much easier, and there is less risk of damaging something if you build some of the tools described in the following. The tools are deliberately not described by means of technical drawings, but by means of photographs. You should improvise here and use material that is currently available. As a matter of experience, the time, which is required for the preparation of aids is saved later in the actual work.

A self-made tool as shown in figure 4-6, can be used to hold the sprocket to loosen the nut. The distance between the bolts was originally designed for a 17 sprocket. After grinding the bolts it also fits to an 18 sprocket.

Figure 4-6

Figure 4-7 shows a self-made tool for holding the clutch boss when the central nut is loosened. The relevant dimensions are shown in the figure.

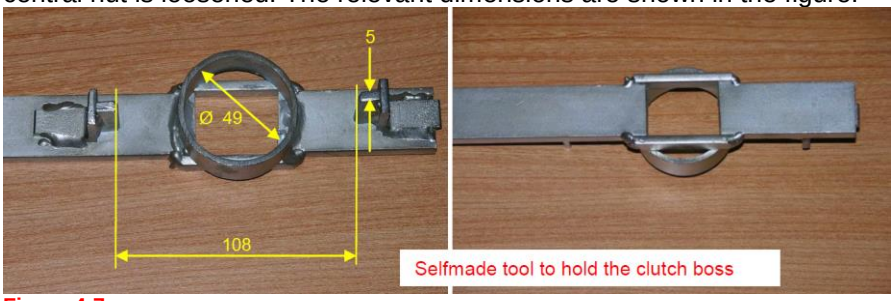


Figure 4-7

If the transmission shafts are also to be disassembled, one needs Seegerring pliers (figure 4-8). If you need such pliers only rarely, universal pliers with exchangeable tips, like the two shown on the left side of the picture are sufficient.

First of all, the engine is lifted by means of the chain hoist (while pressing the handles of the device simultaneously down) so that the lower bolt can be pulled out easily.

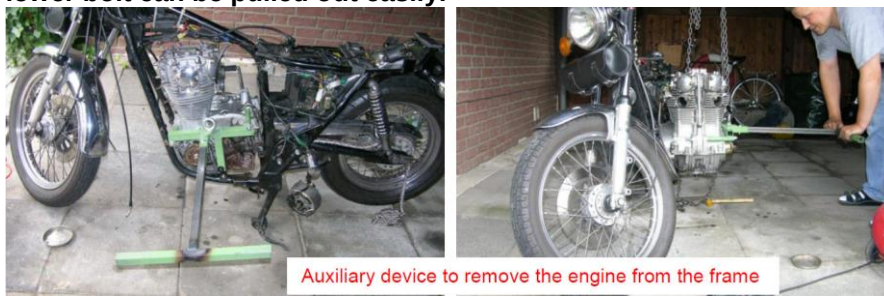


Figure 5-2

Figure 5-3

Figure 5-4 shows a simple engine stand on which the engine should be lowered. This can also serve as an engine stand if it is only planned to work on the cylinder head or the cylinders and the pistons. If the crankshaft is also to be removed or repair-work on the transmission is necessary, this engine stand is not suitable**.**

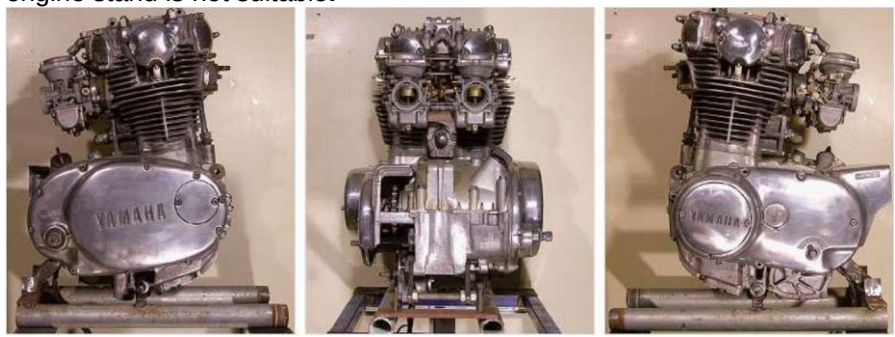
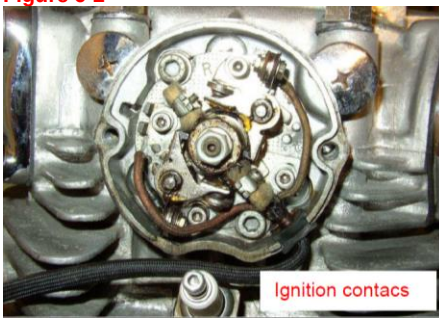


Figure 5-4

If the engine is now lifted further and tipped slightly forward using the handgrips of the device, the engine will automatically swing out of the frame when the suspension point of the hoist has been selected outside the center of the frame.

The sequence of dismantling - starting with the cylinder head - is described by means of photographs, which represent the individual steps. First, the governor assembly and the contact breakers are dismantled:

Figure 6-2



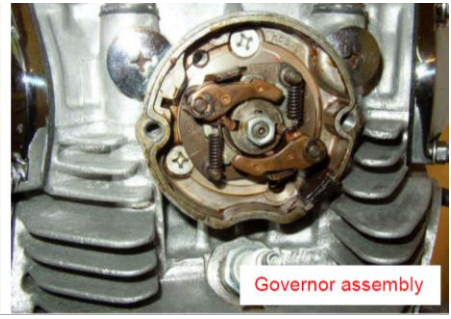


Figure 6-3

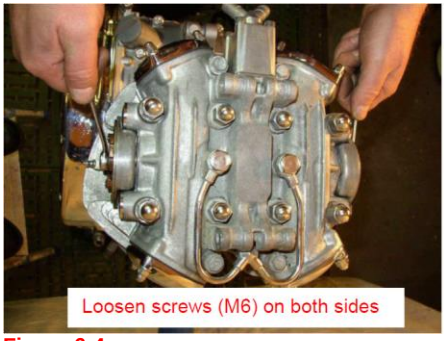


Figure 6-4

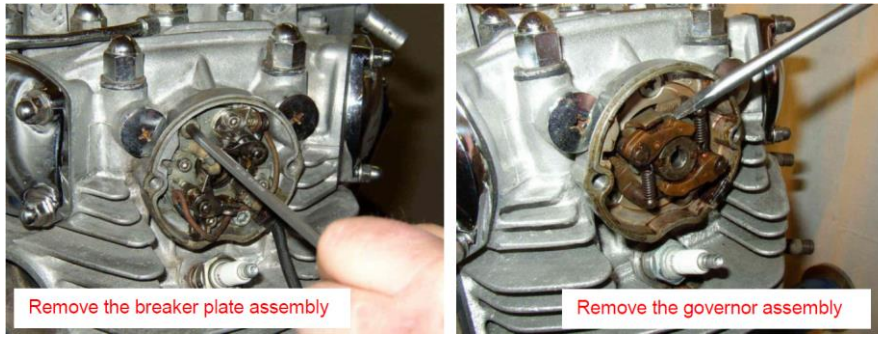


Figure 6-5

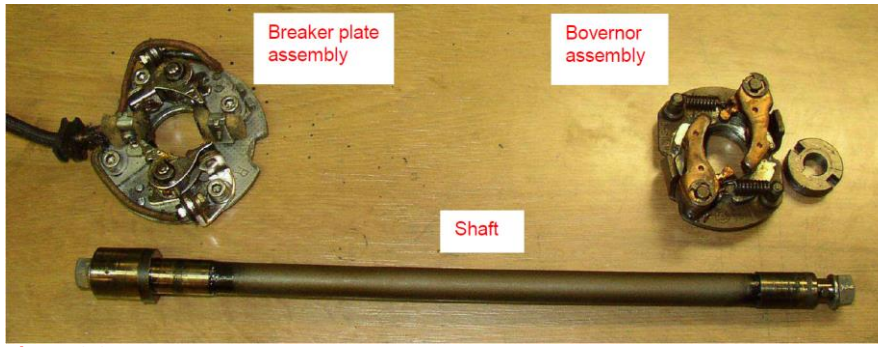


Figure 6-6

Then remove the oil delivery pipe and loosen the cylinder head screws. When removing the oil delivery pipe, first remove the upper banjo bolts so that the oil delivery pipe can not be twisted and damaged when the lower screw connection (Figure 6-8, right side) is released.

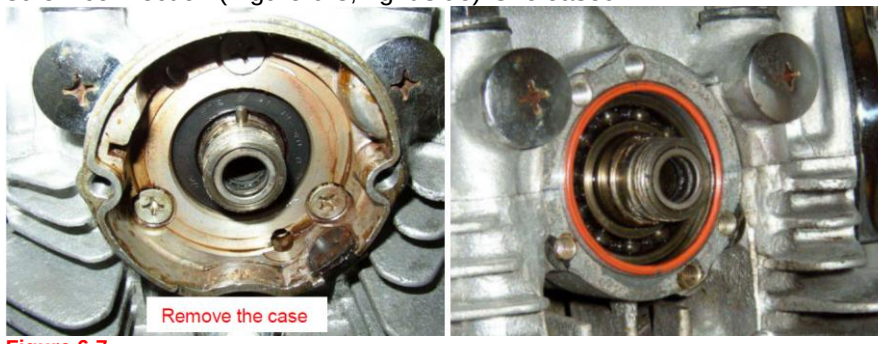


Figure 6-7

The sequence for loosening and tightening the cylinder head screws is shown in figure 6-9. Important: All screws must be loosened evenly, i. e. each screw is first loosened by ½ turns and then the other screws are loosened. In this case, the screw between the carburetor flanges, which can be seen in figure 6-11, must not be forgotten in order to avoid damage to the nut thread.

Figure 6-8

Loosen the bolts of the cylinder head in opposite sequence

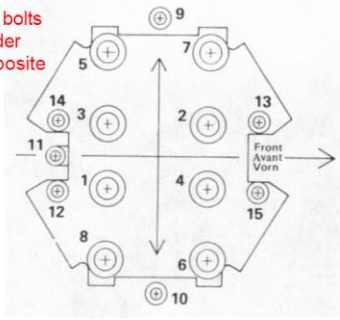


Figure 6-9

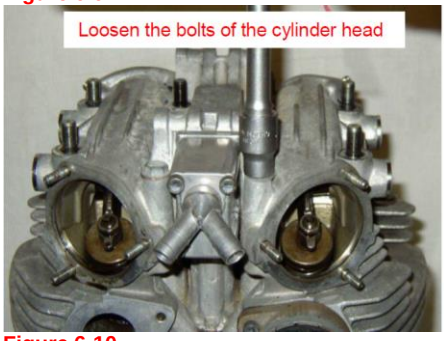
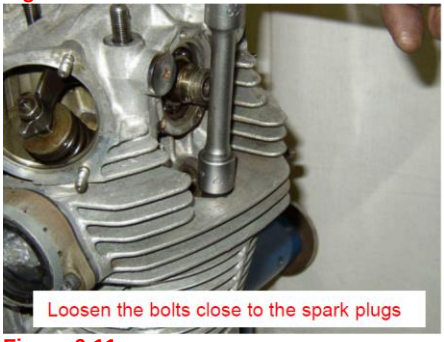


Figure 6-10



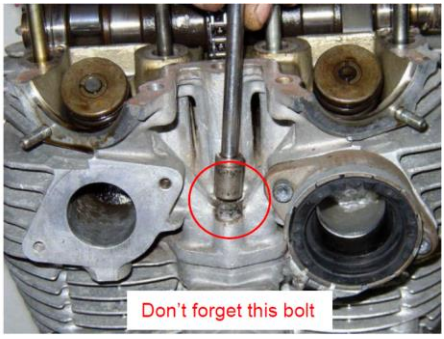
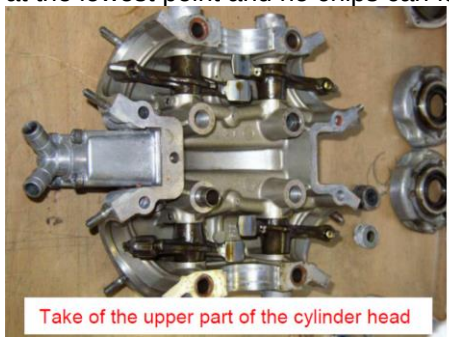


Figure 6-11

Now the cylinder head cover can be removed and the timing chain can be separated by grinding off one bolt. If the engine is not to be completely dismantled, no chips must fall into the crankcase. If the engine is on an engine stand (figure 4-1), it is best to turn it 180° so that the timing chain is at the lowest point and no chips can fall into the crankcase.



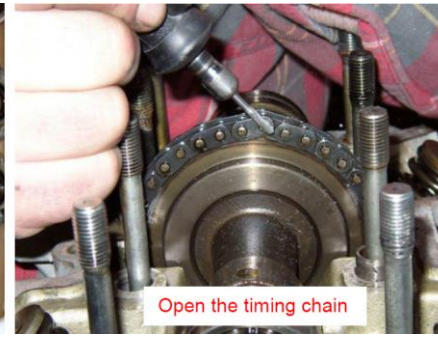


Figure 6-12

Next, the lower part of the cylinder head is dismantled.

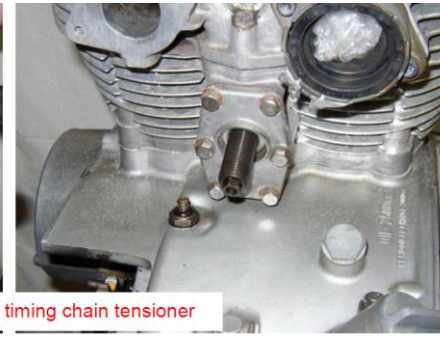
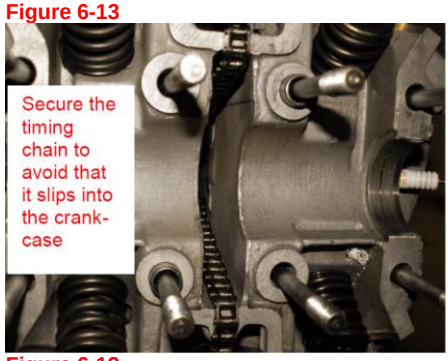


Figure 6-13



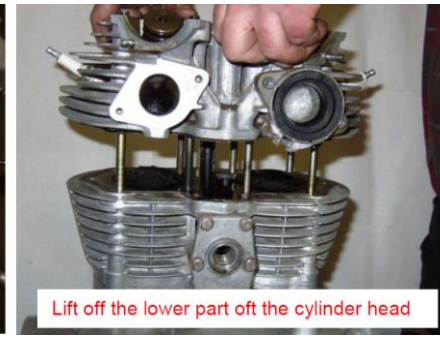


Figure 6-13

Then, the cylinder bank is removed and the pistons are freely accessible so that they can be heated. It is advisable to turn the engine to the side to avoid that the piston pin clips can fall into the crankcase. It is not necessary to dismantle the two piston pin clips of the individual pistons in the middle. If possible, a new piston pin clip should be used per piston.

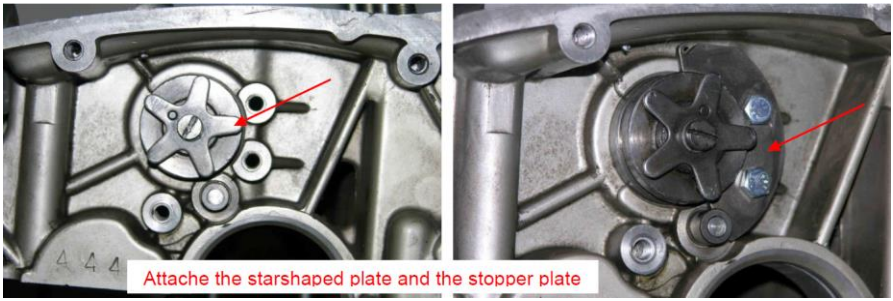


Figure 7-5

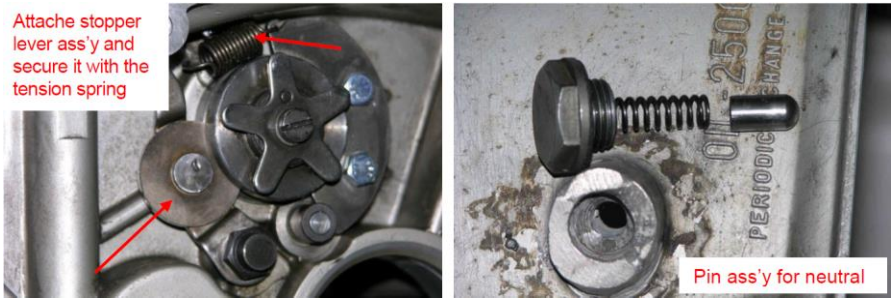


Figure 7-6

Functional check:

Now, you should try to turn the star shaped gear lock wheel to check if the shift cam can be turned freely and whether the shift forks can be moved freely.

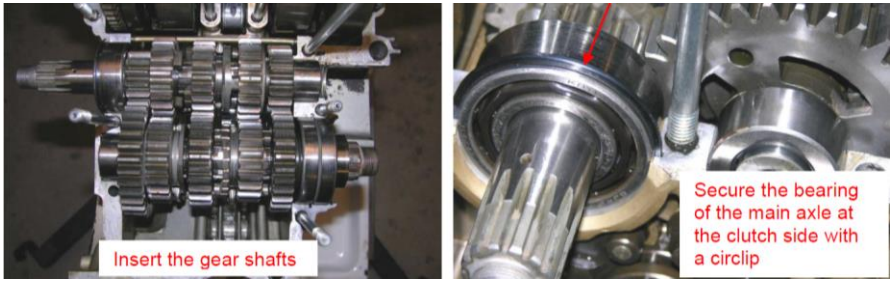


Figure 7-7

Mounting the transmission is easy because the gear shafts are simply inserted (figure 7-7). In this case, ensure the correct positioning of the retaining rings on the clutch side of the transmission input shaft (arrow marking in figures 7-7 and 7-8).

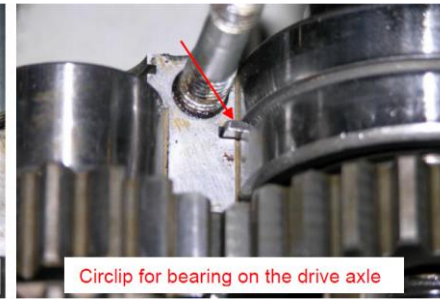


Figure 7-8

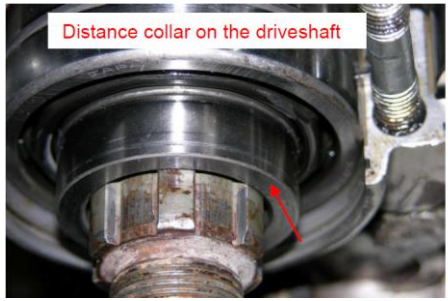
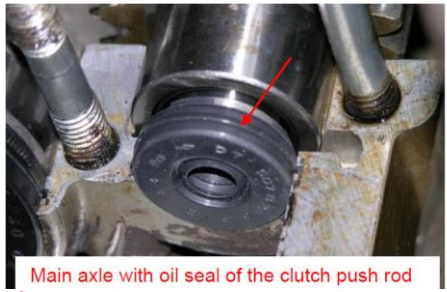


Figure 7-9



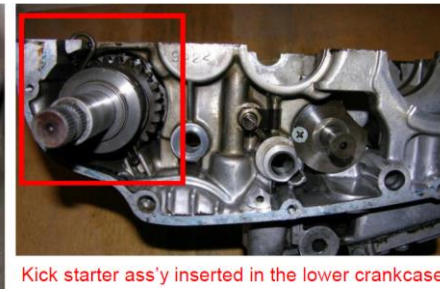
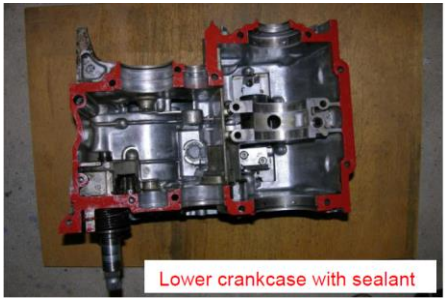


Figure 7-10

Since hardly a new transmission is installed, it should be checked before the installation whether all gear wheels can be turned freely and can be moved freely lateraly on the respective shaft. **Above all, it must be checked whether the shift claws and recesses in the end faces of the counter-gears are not worn out.** An example of how worn-out shift claws look, can be found in chapter "8 Typical damage".

The retaining ring of the fixed bearing (circlip) on the pinion side of the transmission output shaft consists only of one half and must be inserted so that it engages with both housing halves (figure 7-8).

A collar (red arrow mark on figure 7-9) is then pushed onto the toothing of the transmission output shaft. The end faces of the collar and its outer diameter must be absolutely clean and free from scratches in order to



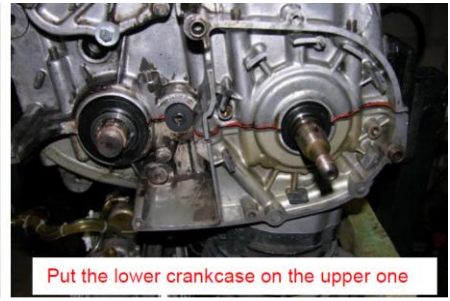
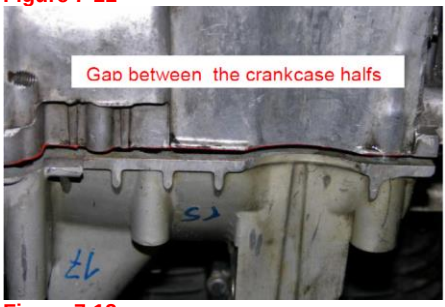


Figure 7-11



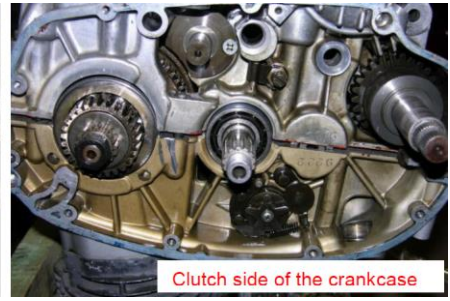


Figure 7-12

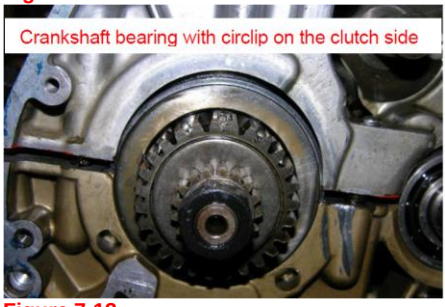


Figure 7-13

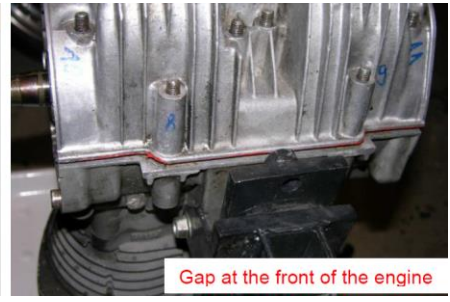


Figure 7-14

Before applying sealing agent to the sealing surfaces, check whether the engine housing halves can be closed easily. If not, check the correct fit of all parts, especially the crankshaft bearings.

Caution: Excessive sealing compound can clog oil channels!

(Simmerrings) should therefore always be replaced. All other shaft seal rings can be replaced when the engine is built-in and can therefore be reused.The screws of the engine housing must be tightened uniformly and in a prescribed order (spirally from the inside outwards).

Installation of the shift shaft and the clutch

The shift shaft

The shift shaft is inserted from the clutch side of the engine (right) into the provided bore in the lower engine housing part.

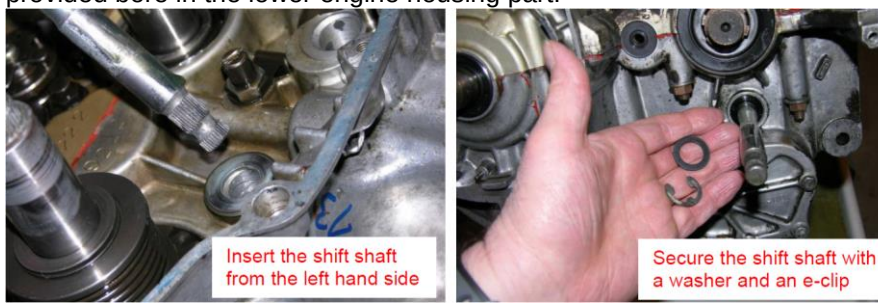


Figure 7-16

The toothing of the shift shaft, with which it is linked to the shift lever, can easily damage the sealing lip of the shaft seal ring. This can be prevented by attaching adhesive strips (e.g., tesafilm) to the toothing. Nevertheless if the shaft seal has been damaged, this is no big problem. The shaft seal ring can be easily replaced when the engine is installed. On the left hand side of the engine the shift shaft is then secured in the axial direction with a disc and an E-clip. Finally, the upper fork of the arm welded to the shift shaft must be connected to the star-shaped disk of the shift cam.

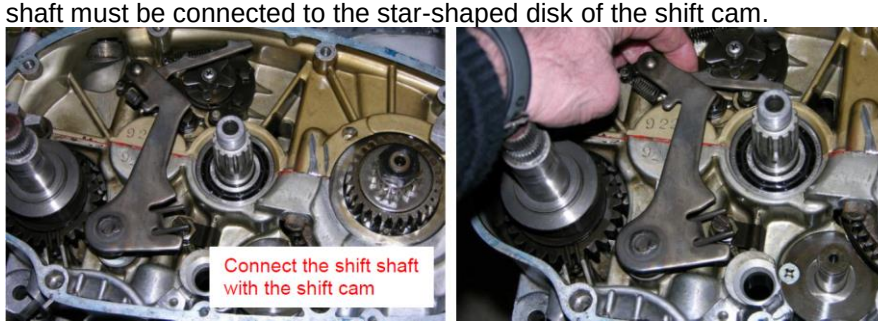


Figure 7-17

The pins of the star-shaped disk must be located between the hooks as shown in figure 7-17. If they are not in the middle, this can be corrected by the eccentric screw.

The clutch

Next, the clutch is mounted as shown in the figures 7-18 - 7-29. Figure 7-18 shows the sequence of the washers and bearings from the inside to the outside by means of characteristic colors.

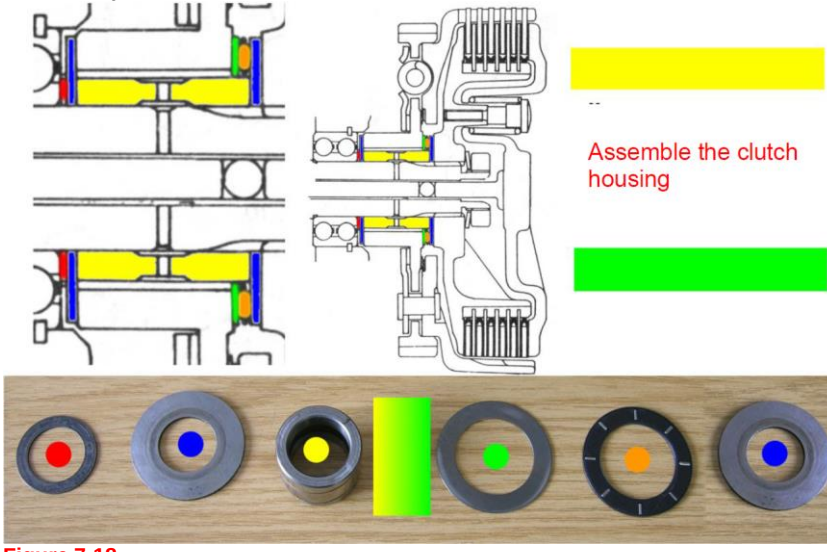


Figure 7-18

The yellow/green colour gradient symbolizes the clutch housing. In the following pictures, the assembly of the individual parts of the clutch is documented in the order of the work steps. The clutch housing and the clutch boss have markings, which must be aligned with each other.

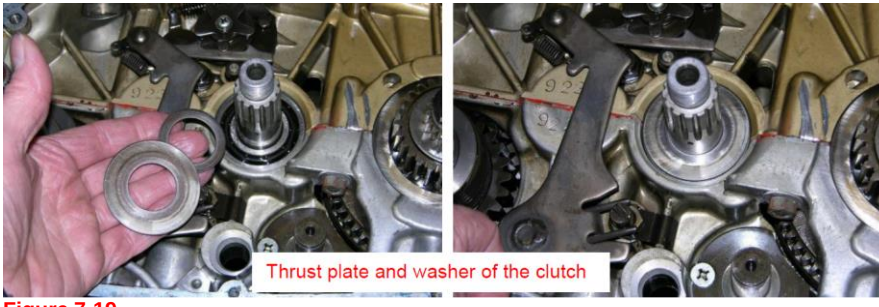


Figure 7-19

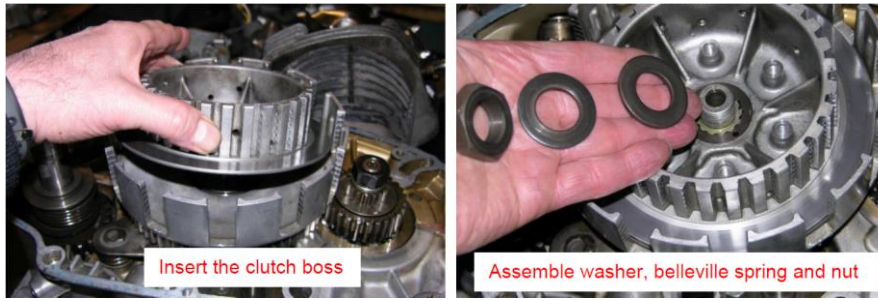


Figure 7-24

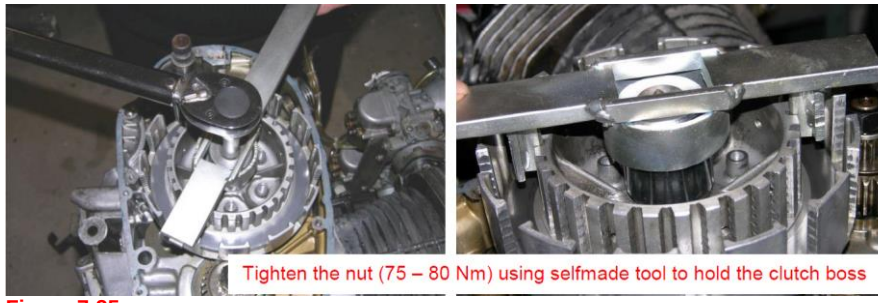


Figure 7-25

Figure 7-26

There are no special features that need to be taken into account when installing the clutch, except for the alignment of the clutch plates (figure 7-26) and how to attach the compression springs (figure 7-27/8). To hold

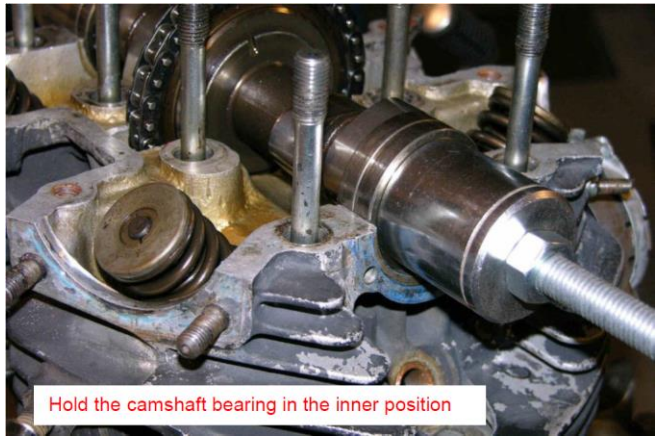
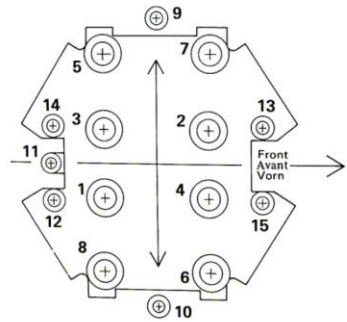


Figure 7-59

The cylinder head bolts must be tightened in the same way as for dismantling in a sequence as shown in figure 7-60. The M 10 x 1.5 nuts are tightened first and then the M 8 bolts.

Install the cylinder head cover and the oil delivery pipe



The cylinder head bolts must be tightened in a sequence as shown

Figure 7-60

Before mounting the covers for the governor and the breaker plate, check whether the camshaft bearings are positioned sufficiently deep in the housing of the cylinder head. To do this, measure the distance between the areas indicated by the red and green arrows on figure 7-61 using a caliper with a depth gauge. The thickness of a paper gasket of about 0.5 mm is added to the measured value.

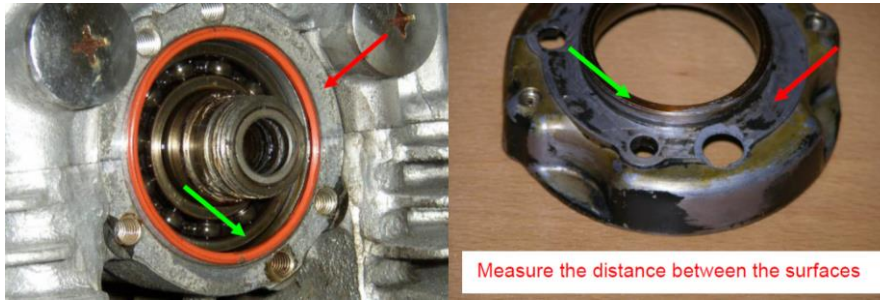


Figure 7-61

The distance to the cylinder head must be larger than the distance on the covers. If the distance on the cover is larger than on the cylinder head, the paper seal is not pressed and a gap remains, which prevents a proper sealing. If the bolts are tightened too much, damage can occur as shown in figure 7-61 above. The region of the cover, which is close to the bolt head, then breaks out. Reassemble governor and the breaker plate in the reverse order as shown in figures 6-2 to 6-5 in chapter “6 Dissassembling the engine”.

It is also possible that e.g. a provided damper disc has not been installed, or the spring force has declined with time. The description in the original workshop manual, according to which the pin is to be flush with the end face of the hexagon within the tensioning mechanism, as shown in figure 7-63, can therefore only be a reference value.

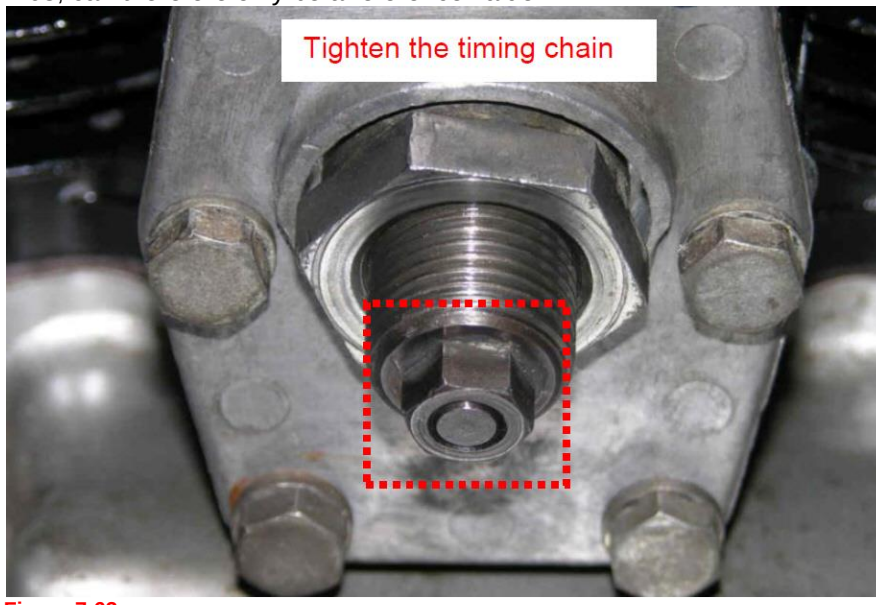


Figure 7-63

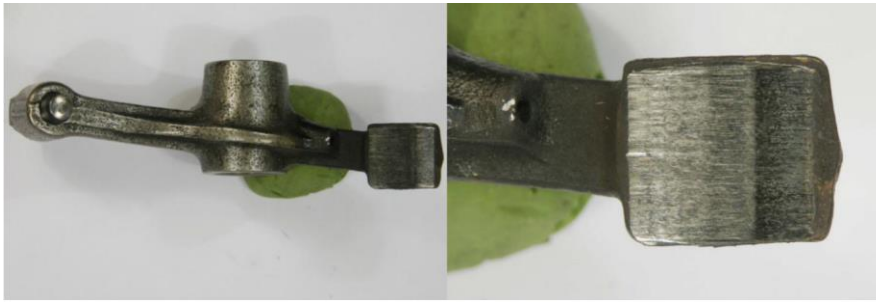


Figure 8-6

Valves

Damage to valves can be caused by too much or too little valve clearance. When the sealing surfaces of the valves and the valve seats wear out, the valve clearance becomes smaller and the valve no longer closes properly. In this case, the valve seat "burns" and the hot combustion gases can flow through the valve, which doesn't close properly. A valve clearance, which is too large is initially less problematic, which is why the valve clearance is often set slightly higher than the predetermined value.

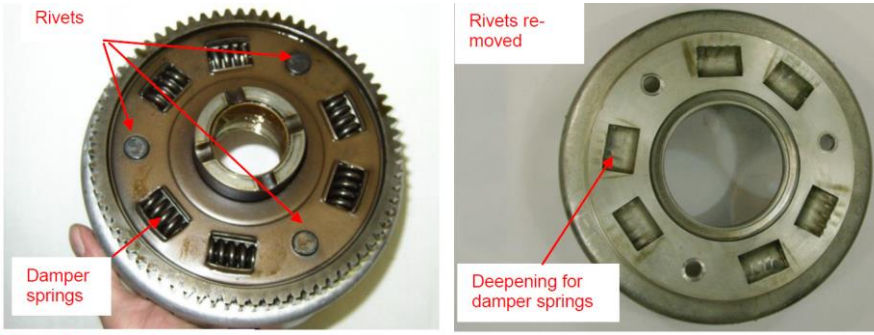
End face of the valve stem and corresponding area of the valve adjusting screw
Figure 8-7

A valve clearance, which is too large, is recognized by noise development, while a too small valve clearance is noticed only when damage has already occurred. However, there is a disadvantage if the valve clearance is to large. There is a low loss of power because the valve no longer opens wide enough. In addition the rocker arm with the adjusting screw strikes later and after a larger idle stroke and thus also faster on the end face of the valve stem. The adjusting screw then damages the end face of the valve stem (figure 8-7).

The clutch

In order to isolate the vibrations of the engine from the tooth flanks of the gear wheels, the torque of the engine is not transmitted by a rigid connection, but by means of six damping springs, which are arranged at the backside of the clutch housing.

This means that these springs are compressed with increasing torque – when accelerating - and they expand again when the torque decreases. Both the springs as well as their counterparts in the clutch housing are designed to be too weak for this permanent load alternation, so that the springs break and their counterparts in the clutch housing gets damaged. Figure 8-8 shows the the clutch housing with the gear wheel of the primary drive in a view from the rear (left). On the right, the riveted plate, which holds the damping springs, is removed. On figure 8-9, a broken damper spring and the damaged corresponding recess in the clutch housing are shown.



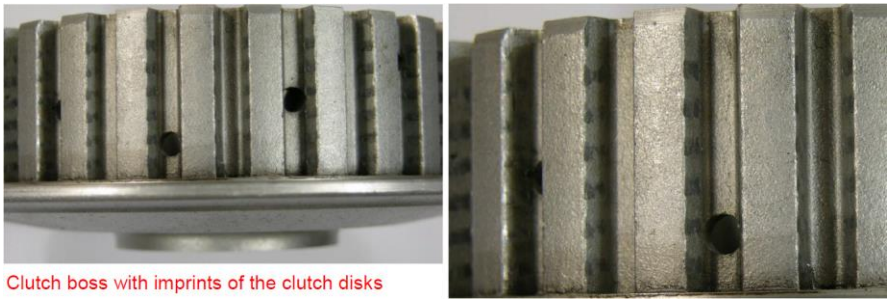
Rear of the clutch housing

Figure 8-8

Broken damper spring and damaged deepening for damper spring

Figure 8-09

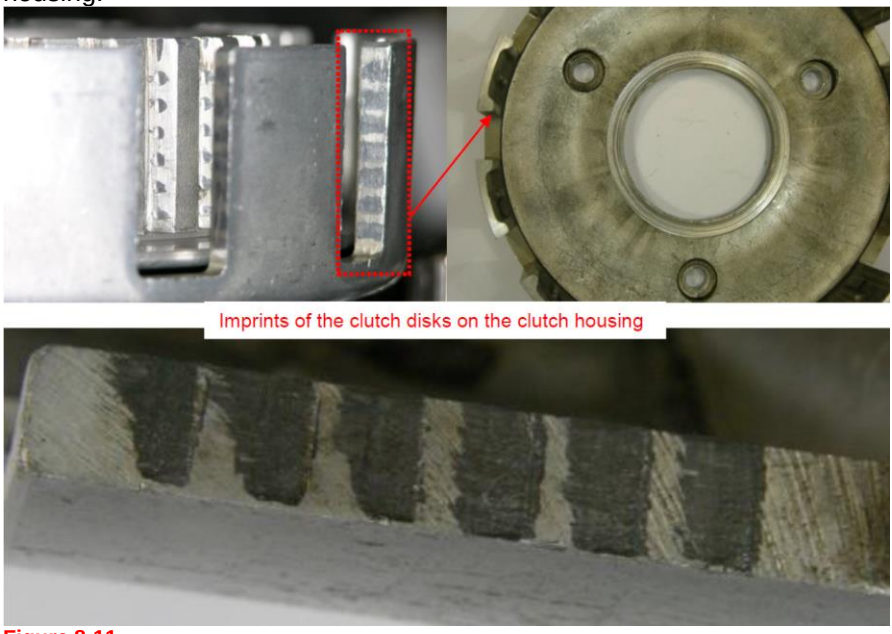
Springs with a larger diameter of the wire may be a remedy, but they also provide less protection for the the tooth flanks of the gear wheels of the transmission.



Clutch boss with imprints of the clutch disks

Figure 8-10

Both the clutch friction plates and the pressure plates work with their edges into the respective grooves of the clutch housing and the clutch boss. Figures 8-10 and 8-11 show the imprints of the edges of the plates in the grooves of the clutch boss and the clutch housing. Figure 8-10 shows the clutch boss with the imprints of the edges of the clutch plates. Figure 8-11 shows an enlargement detail of the imprints in the grooves of the clutch housing.



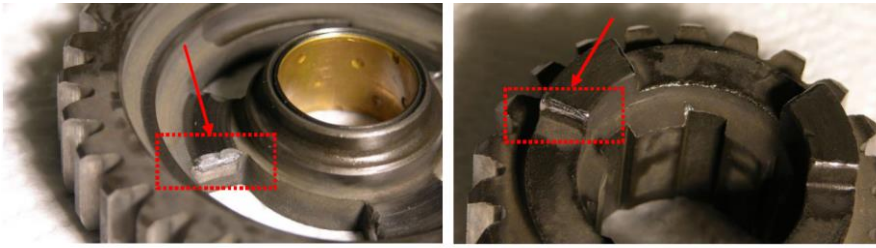
Imprints of the clutch disks on the clutch housing

Figure 8-11

Rework is normally not necessary. Despite the imprints the clutch still separates the crankshaft from the transmission but only slightly slower because the edges of the clutch plates have to slip over the imprints. However, you should consciously shift the gears slower so that the clutch is disengaged during gear change. Otherwise damages to the transmission components will occur.

Shifting claws

The worn edges of the recesses in first speed gear wheel (Figure 8-13, left) and the worn edges of the shift claws of the fourth speed gear wheel (Figure 8-13, right) were the reason that the first speed suddenly disengaged when accelerating. The surfaces on which the shift claws still are engaged are reduced, so that such damage will progress rapidly. If wear is already visible on shift claws of gear wheels or on their counterpart, the recesses, they should no longer be used, since also the shift forks are affected.

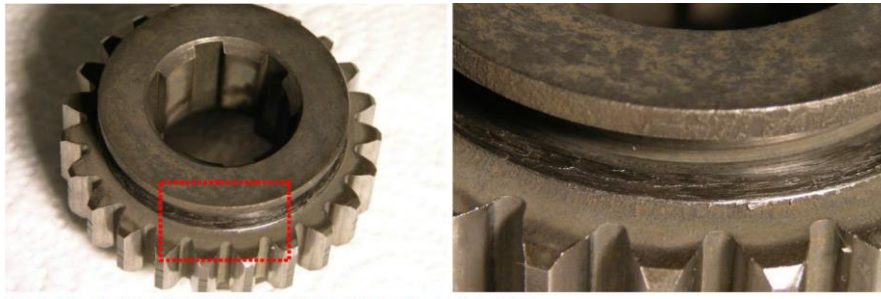


Gearwheel of the first gear on the transmission drive shaft

Gearwheel of the fourth gear on the transmission drive shaft

Figure 8-13

Since the shift claws slip out of the recesses - skip them - a force acts on the shift forks which moves the gear wheels in the axial direction of the transmission shafts.



Gearwheel of the fourth gear on the transmission drive shaft

Figure 8-14

The gear wheels, which are shifted in the axial direction on the transmission shafts by the shift forks, have circumferential grooves into which the shift forks engage as shown in figure 8-14. Figure 8-14 shows the gear wheel of the fourth speed on the transmission output shaft (the shift claws are shown in Figure 8-13). The force caused by the "skipping" of the shift claws has caused abrasion on the shift forks (Figure 8-15) and the circumferential grooves.

Shift forks

A similar material abrasion as at the circumferential grooves also arises at the ends of the shift forks, which engage in the circumferential grooves. The result is that the ends of the shift forks becomes narrower while the circumferential grooves get wider.

Gear shift fork for shifting the first gear with material wear at the ends
Figure 8-15

The shift claws are thus no longer pushed far enough into the corresponding recesses of the mating gear wheel so that the area available for the force transmission becomes smaller. Thus the edges of the shift claws, as shown in figure 8-13 in an advanced state of wear, get rounded.

An condition of the shift fork for shifting the first speed as shown in figure 8-15 is the result. Shift forks that have an initial wear on their ends should not be used any more, even though it will for some time still be possible to ensure proper shifting. However, since the shift claws do no longer engage properly because they protrude no longer far enough into the rececces of the mating gear wheel, so that a sufficiently large area is available for the transmission of force, the damage as documented here will prematurely occur.

Simplified electrical system

To make you familiar with the electrical system, I have described a simplified vehicle electrical system on the following pages, which I have installed in my own motorcycle. There are only the features that are required for driving on public roads. For the sake of clarity, I divided the circuit diagram into two areas, the "charging circuit" and the "consumption circuit" which are shown separately. In the " charging circuit " I kept the cable colors as in the original circuit diagram. In the "consumer circuit" I have chosen the color black according to the original for ground cables and the color brown for switched positive. In the wiring diagram as described here, only very few cables are necessary, so that it is possible to make a wire harness with fewer cable colors than I used it here. In order to be better able to describe the circuit diagrams, I have shown the circuit diagrams in color. So when I speak of a blue cable, a blue line in the circuit diagram is meant.

Consumer circuit

In order to keep the cables as short as possible, I installed the ignition lock under the right side cover. I have used the original ignition lock here, but it may be any other, as long as it has three ports with three key positions. It must be possible, that the key can be removed in position “one” and that there is no connection between the ports. In position “two” the ports “one” and “two” are connected and in position “three” the ports “one”, “two” and “three”.

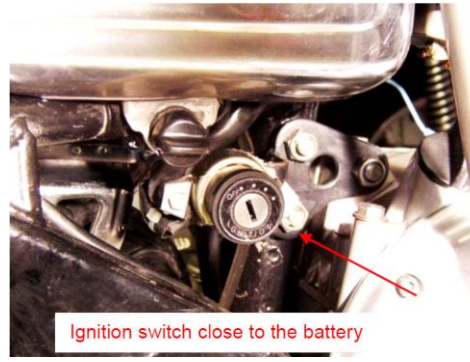


Figure 9-1
The ignition lock is located on a holder below the right side cover. This makes the supply line from the battery and the connection to the fuse box in the right side cover as short as possible.

On the original ignition lock, a red cable (coming from the battery) is located at port 1, two brown cables (switched plus) at port 2, and a blue cable (head light and rear light) at port 3.

A fuse box (Conrad order no. 84 05 64-33, 7.95 €) is installed under the left side cover to prevent that a short circuit in one of the consumer circuits burns the only fuse in the original system. If the only fuse burns, this will mean, that the trip can only be continued after the problem is fixed.

Of the six existing fuses in the fuse box only five are required.

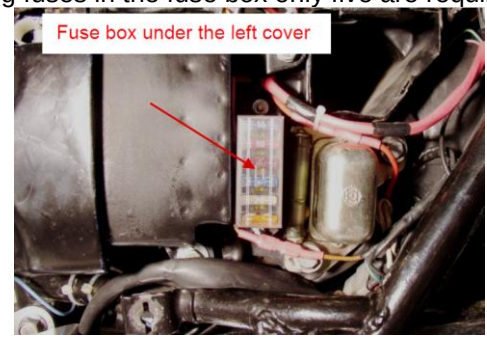


Figure 9-2
Behind the left side cover, there is a fuse box between the voltage regulator and the air filter with slots for 6 fuses. Conrad order no. 84 05 64-33

A brown cable from port 2 of the ignition lock is connected to fuses 2 to 6 in the fuse box. The blue cable from port 1 is connected to fuse 1. In position 1 of the key, all consumers and the ignition are supplied with power.

Headlight: Identification color: blue - Fuse 1

The blue cable from the ignition switch (port 3) is first linked to fuse 1 and then continued to the dimmer switch in the switch unit on the left side of the handlebar. From there a blue / green cable runs to the low beam light lamp and a blue / yellow one to the high beam lamp. Both lamps are connected via diodes (Conrad order no. 15 28 97-33, 0.56 €) to the parking light in the main headlight and to the instrument lighting. Another blue cable leads from the fuse 1 directly to the taillight.

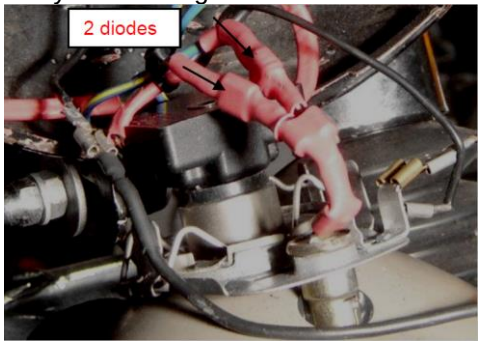


Figure 9-3
The parking light bulb receives its current via two diodes (Conrad order no. 15 28 97-33), which connect them with the leads for high and low beam. The instrument light is connected to the terminal of the parking light (can not be seen in the photograph).

Ignition: Identification color: gray: Fuse 2
The gray cable runs from the fuse 2 directly to one cable of the two ignition coils. It doesn't matter wether to the grey or the orange cable. The other cable of the ignition coil is connected to the respective contact breaker behind the chrome cover on the left camshaft side. The contact breaker located directly on the base plate and marked "R" is responsible for the right ignition coil and for the right cylinder. The contact breaker on the auxiliary base plate marked ("L") is reponsible for the left side.

Brake light: Identification color: yellow: Fuse 3
A yellow cable connects the fuse 3 to the two brake light switches and then to the brake light in the tail light.

Turn signal lights: Identification color: gray / black, red, green: Fuse 4
From the fuse 4, a gray / black cable leads to the flasher relay and from there to the turn signal switch in the switch unit on the left side of the handlebar. From here, a gray / red cable and a gray / green cable lead to the turn signals on the right and left side of the vehicle. There are flasher relays with two and three ports. The original one has two ports as described here. When you buy a relay from a spare parts dealer, it may have three ports. Then one port is connected to the fuse, another one to the switch and a third one to the ground, Usually there are symbols, which indicate the purpose of the ports.

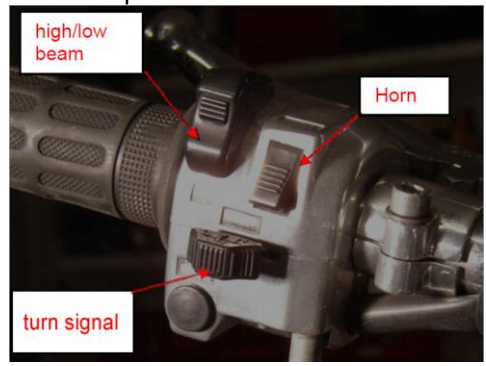


Figure 9-4

Horn: Color code: pink: Fuse 5
A pink cable connects the fuse 5 with the horn switch in the switch unit at the left end of the handlebar. From there it continues to the horn.

Remains free.: Fuse 6
I have connected fuse 6 to a voltmeter, which indicates if the ignition is switched on or off as well as the charge state of the battery.

The switch unit on the right side of the handlebar is no longer required. The switch in the left switch unit, originally intended for the headlight flasher,

now operates the horn. A blind plug closes the hole for the original horn switch.

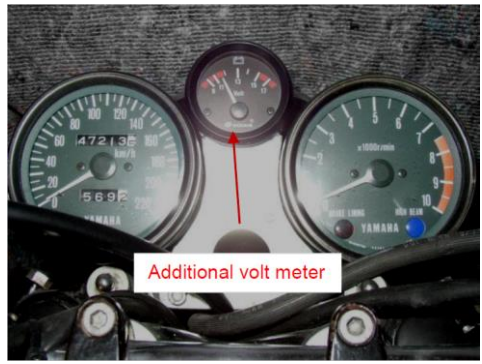


Figure 9-5

For safety reasons, it may also be advisable to secure the parking light separately to remain recognizable for others when the fuse or the bulb of the headlight is burnt. The blue cable from the ignition lock is then connected to the free fuse no. 6 and leads from there to the parking light bulb. It doesn' t matter when in addition a voltmeter is connected to fuse no. 6. Also an indicator lamp for the turn signals, which as well as the parking light bulb can be connected via two diodes to the left and right side, seems to me worthwhile, so that you do not forget to turn off the turn signal.

What I've described so far is the least what is needed. The installation should not cause any problems. It can be helpful if you imagine the cables are water pipes and the switches are stopcocks. Just as the water flows better through a thick pipe, the current also flows better through a thick cable. Everyone who has already installed a ceiling light in the house should also be able to install a simplified wire harness on a XS 650 motorcycle, as shown on figures 9-6 and 9-7 on the next two pages.

When installing the wire harness, lay the cables from the fuse in the fuse box to the switch and from there to the load (light bulb, horn etc). Then connect the load with a black cable to the frame or better directly to battery minus. Lastly, cover all cables with an adhesive ribbon. It does not necessarily look very professional, but is in any case not worse to the bougier pipe used in serial production.

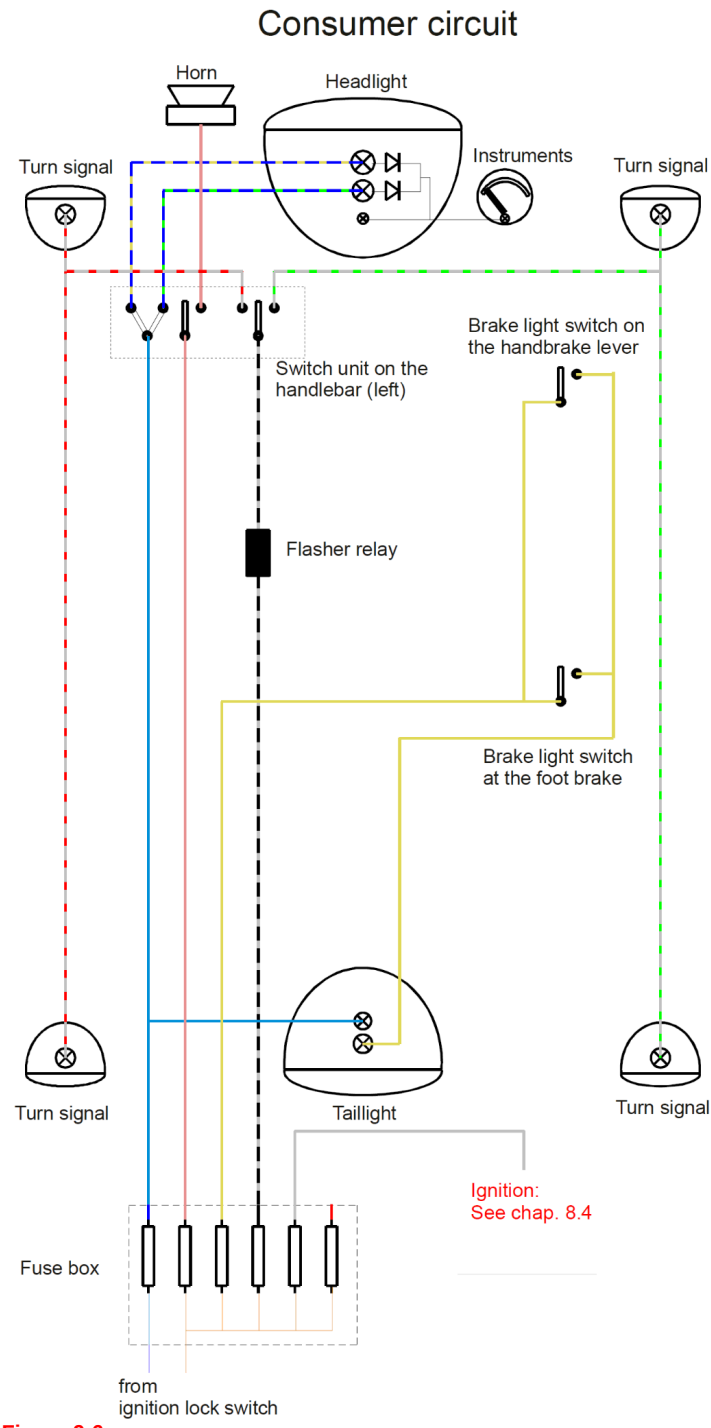

Consumer circuit
Horn
Headlight
Instruments
Turn signal
Turn signal
Switch unit on the handlebar (left)
Brake light switch on the handbrake lever
Flasher relay
Brake light switch at the foot brake
Turn signal
Taillight
Turn signal
Ignition:
See chap. 8.4
Fuse box
from
ignition lock switch

Figure 9-6

1.1.2 Charging circuit

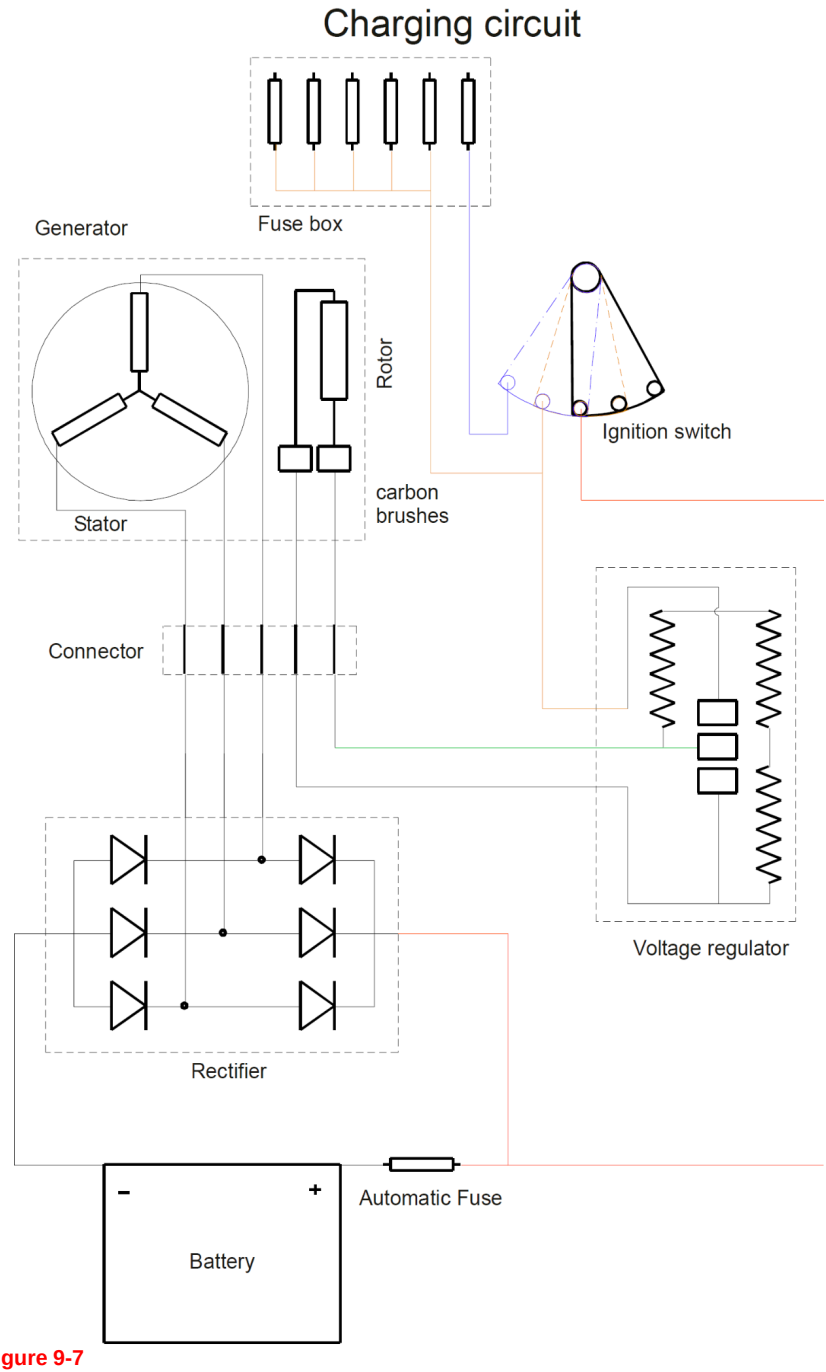


Figure 9-7

brushes.
The following figure shows the generator of the XS 650 with the left engine cover removed.

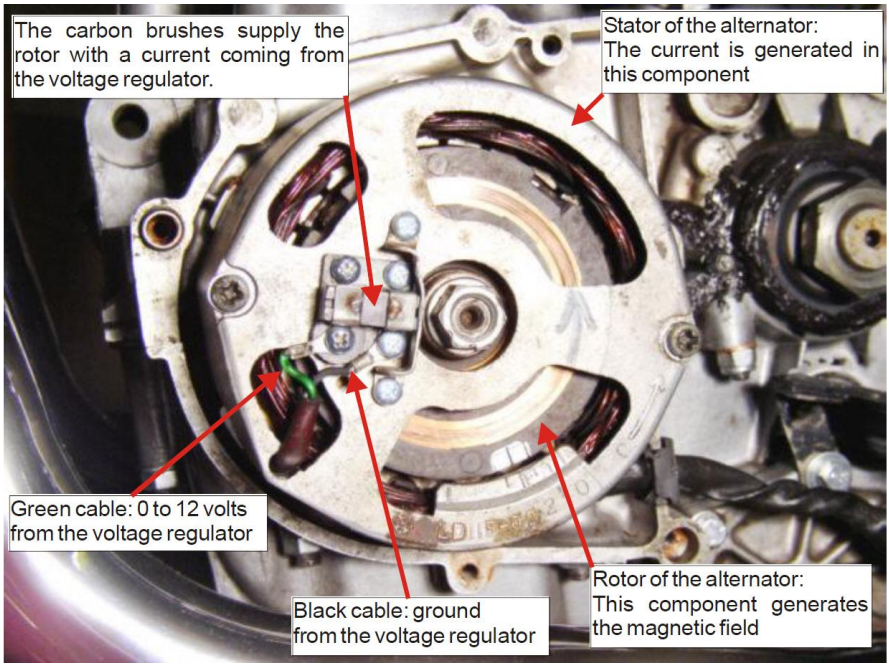


Figure 9-10

In workshop manuals the component of a generator, which is connected to the engine housing and which is stationary in operation, is refered to as the "stator".

The component which rotates is refered to as the "rotor".

From these designations, it is not yet clear which component has which function. Although I do not consider these terms to be very apt, I will use them in the following descriptions to not confuse those who have already read in the original workshop manual on the topic of electrics.

The stator

On the left side of Figure 9-11, the circuit symbol for the stator is shown, as used in the circuit diagrams in the workshop manual. The three rectangles arranged at an angle of 120° symbolize the three coils which produce the three-phase current. On one side, the coils are each connected, while the other side is goes to the outside. These are the three white cables that are found in the connector to the engine.

direction. With alternating current, however, you can not charge a battery. The alternating current must be rectified so that it flows only in one

direction. Just as there are non-return valves for fluids that let the fluid pass only in one direction, there are diodes for the electric current that allow the current only to flow in one direction. Since the alternator has three coils, which are led out with the three white cables, three currents must be rectified.

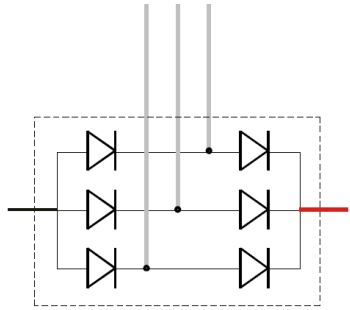


Figure 9-17

In figure 9-17 above, you can see the circuit symbol of the rectifier, as shown in the wiring diagrams. Figure 9-18 shows the original rectifier, as it is installed underneath the battery. Figure 9-19 shows an inexpensive alternative of Conrad Electronics – alone and with an attached heat sink, as it is also to be purchased from Conrad Electronics or others.

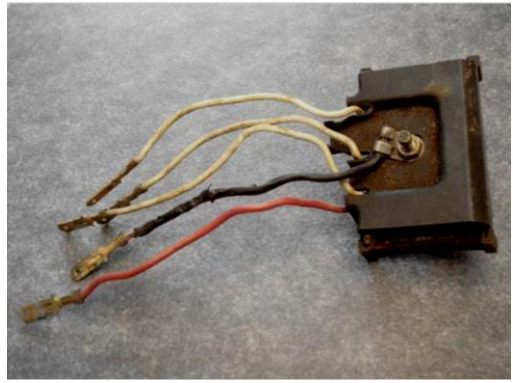


Figure 9-18

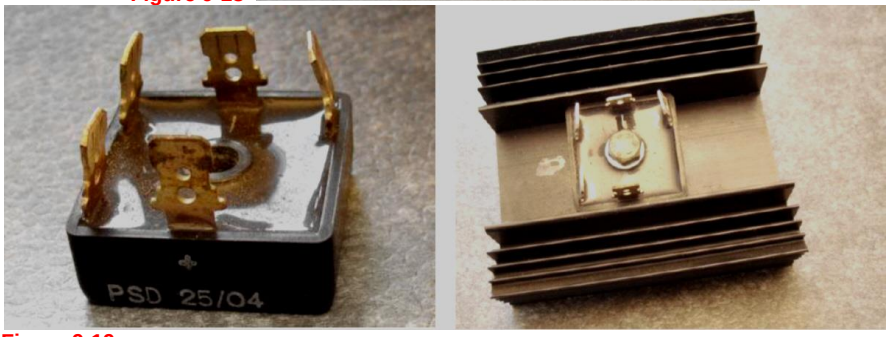


Figure 9-19

The circuit symbol oft the rectifier explains the function quite good. To illustrate it more, I have built a rectifier using six diodes, as I have them the

magnetic field generated by the current flowing through the rotor. The current flowing through the rotor and thus the strength of the magnetic field can easily be influenced by the voltage that is applied to the carbon brushes.

The purpose of the voltage regulator is to adjust the voltage, that is applied to the carbon brushes, so that the voltage induced into the stator coils is about 14 volts. This is the voltage required to charge a 12 volt battery.

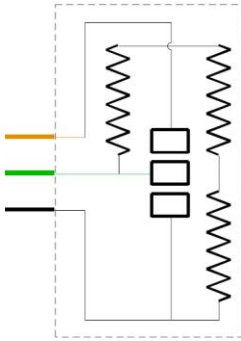


Figure 9-21

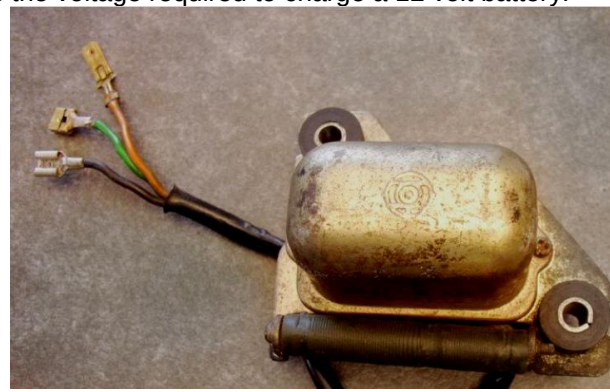


Figure 9-22

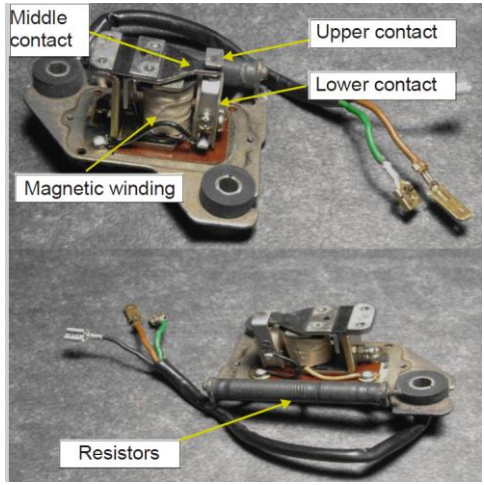


Figure 9-23

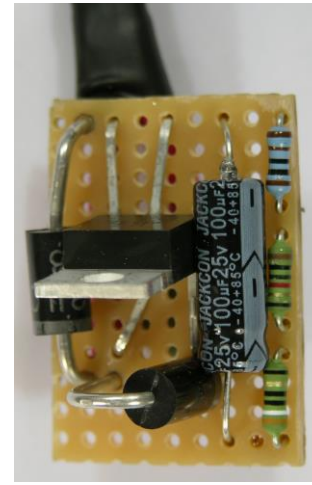


Figure 9-23a

Figure 9-21 shows the voltage regulator as a circuit symbol. Figure 9-22 and 9-23 show the voltage regulator as it is installed under the left side cover and with its cover taken off. As a comparison figure 9-23a shows a selfmade electronic voltage regulator, which works by the principle of pulse width modulation. It is much smaler than the original one, more reliable and there are no resistors, which act as a consumer themselves. Electronic voltage regulators are offered by parts dealers for about 30 $.

First, you should check whether this voltage is also applied to the carbon brushes. In the standard wire harness the current must flow from the battery through the steering head to the ignition lock, the voltage regulator and then to the rotor. On this way a few tenths of a volt can be lost - but it should not be more. So first measure the voltage directly at the battery and then at the carbon brushes as shown in figure 9-27.

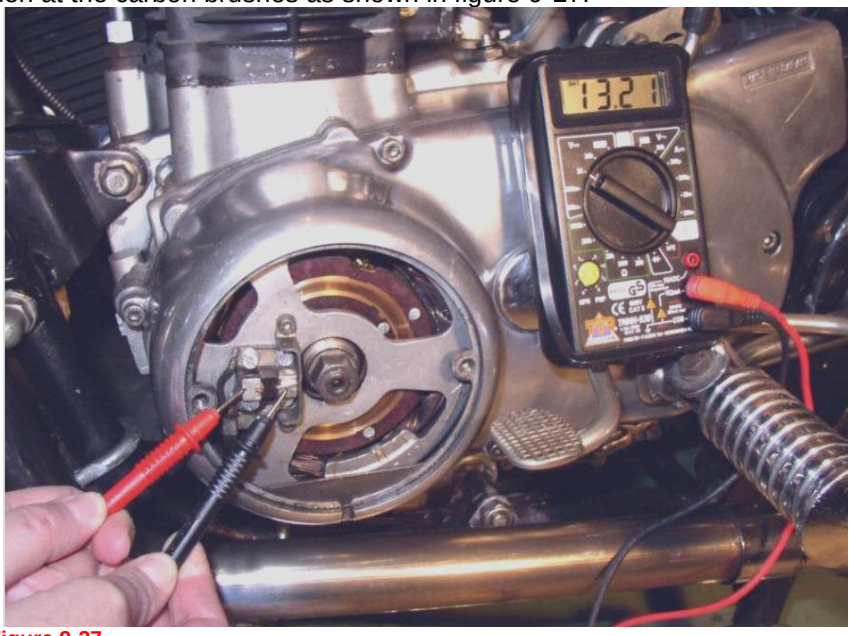


Figure 9-27

The difference between the voltage measured at the battery and the voltage measured at the carbon brushes should not be more than 0.5 volts. Now start the engine. Up to an engine speed of approx. 2000 rpm the battery voltage should be measured at the carbon brushes. If the voltage at the carbon brushes drops earlier, the battery is only charged at higher engine speeds. This may be no major problem for those who ride mostly at higher speeds on country roads and highways. If the voltage drops only at higher engine speeds than 2000 rpm, the generator is overstressed and battery may start to cook. Here, the interaction between the spring and the magnet in the voltage regulator does not work properly. See chapter "9.3.8 Testing the voltage regulator" for more information.

Testing the voltage regulator

To test the voltage regulator, we need an ohm meter. The voltage regulator consists of a changeover switch (three positions), resistors through which the excitation current flows to the rotor as the vehicle voltage increases, and a magnetic coil. Measurements are taken in the three positions of the changeover switch.

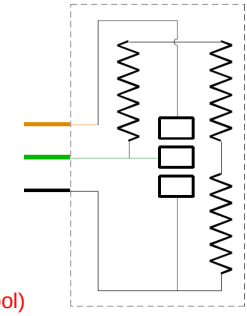


Figure 9-35 (circuit symbol)

Before the measurement, the contacts of the switch should be carefully cleaned as a transition resistor on the contacts distorts the measuring result and, of course, also affects the function of the voltage regulator. For cleaning, abrasive paper with a grain size of 600 can be used

Middle contact in upper position

In this position the coil of the magnet is checked and the passage from the brown cable to the green cable from the electrical system to the rotor.

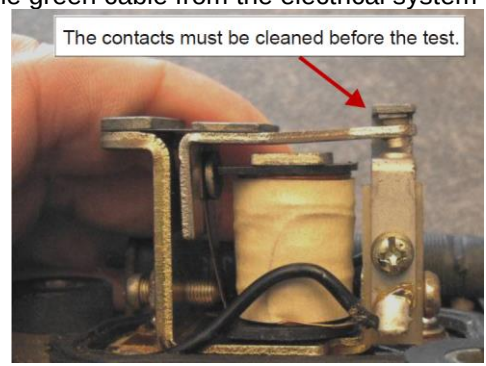


Figure 9-36

The magnet coil should have a resistance of 36 to 38 ohms - measured between the brown and the black cable. Between the brown and the green cable, the resistance should be as small as possible, i.e. 0 ohms

Middle contact in middle position

In this position the resistor is tested through which the current from the vehicle electrical system flows when - with increasing bord voltage - the magnet develops so much force that it pulls the middle contact away from the upper contact.

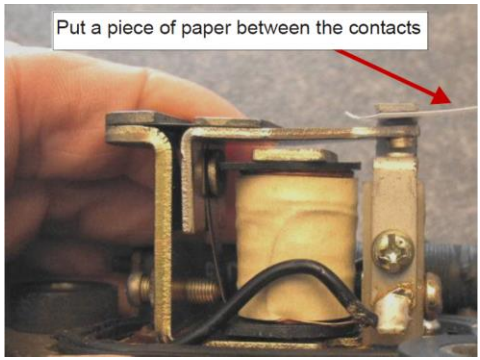


Figure 9-37

A resistance of 10.7 Ohm should now be measured between the brown and the green cable.

Middle contact in lower position

In this position the resistance is tested, through which the current flows at maximum board voltage when the magnet develops so much force that it pulls the middle contact against the lower one.

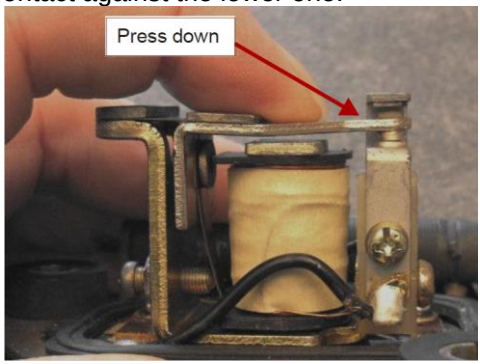


Figure 9-38

A resistance of 8.4 ohms should now be measured between the brown and the green cable

If the measured resistance values correspond to the desired values, the voltage regulator is electrically okay. This does not necessarily mean that the voltage regulator will work properly.

Depending on the demand of the consumers and the engine speed the

middle contact changes its position between the upper contact and lower contact in fractions of a second. The actual position of the middle contact depends on the interplay between the spring, which pulls the middle contact against the upper contact and the force of the magnet which pulls the middle contact against the lower contact. When the spring force is decreased by wear, the magnet pulls the middle contact too early down, that means, when the voltage of the vehicle electrical system is too low. This can be determined by measuring the voltage at the carbon brushes while the engine is running. It should be up to about 2000 rpm equal to the battery voltage and only then get lower, when the engine speed increases over 2000 rpm. The voltage measured at the battery should be about 14.5 to 15 volts at 2500 rpm.

However, you should only change the setting of the pretension of the spring, until you are sure that all other components work properly. Often the reason for a low charging voltage at the battery are oxidized contacts of plug connectors or in the ignition lock.

The "heart" of the ignition is the contact breaker base plate with the ignition contacts for the right and left cylinder, placed under the small chrome-plated cover in the cylinder head on the left side.

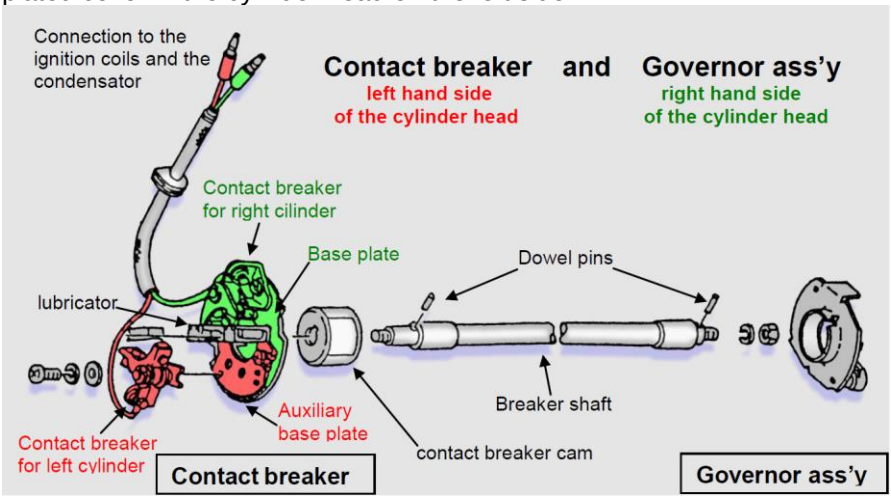


Figure 9-41

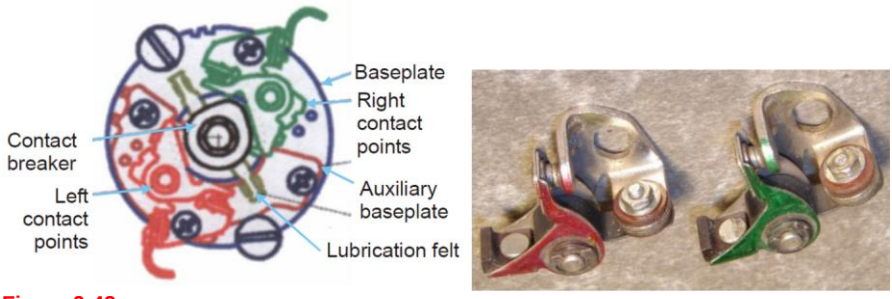


Figure 9-43

How to adjust the ignition timing is explained later. The contact breaker pairs themselves are wear parts, which must be adjusted regularly and replaced after longer intervals. The red and green color markings in figure 9-43 have no meaning, both pairs are the same. However, the cables leading to the contact breaker pairs should also be marked in color, as shown in Fig. 9-42. Both pistons move up and down at the same time, one of which is in the compression stroke and the other in the exhaust stroke. If the connection cables from the contact breaker pairs to the ignition coils are mixed up, the ignition spark fires into the exhaust stroke. Of course the engine doesn't start and there are loud misfires.

For each contact breaker pair, there is one capacitor. The capacitors of the XS 650 are assembled together in one housing (figure 9-44). Here nothing

can be mixed up - the connecting cables are connected to a brown cable of the ignition coils.

1. Set the contact distance to the right

Rotate breaker cam (at crankshaft stump) until maximum distance is reached (highest point of the cam). Loosen the fastening bolt and move the fixed part of the pair of contact breakers so that a distance of 0.3 to 0.4 mm is created between the contacts. Tighten the fastening bolt.

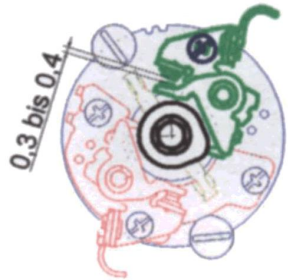


Figure 9-48

2. Set the contact distance to the left

Repeat procedure for left pair of contact breakers.

Figure 9-49

3. Set the ignition timing to the right

Turn the crankshaft until the ignition marking of the rotor is in line with the marking on the housing. Loosen the fastening bolts of the base plate. Turn the base plate until contact breaker pair for right cylinder is just opening (use a test lamp or continuity tester). In this position, tighten the fastening bolts.

Figure 9-50

4. Set ignition timing to the left

Turn the crankshaft by almost 360° until the ignition marking of the rotor is again in line with the marking on the housing. Loosen the fastening bolts of the auxiliary base plate. Turn the auxiliary base plate until the contact breaker pair for left cylinder is just opening (use a test lamp or continuity tester). In this position, tighten the fastening bolts.

Figure 9-51