

DENSO PA90S STARTER — Completely Different But Strangely Familiar



BY BOB THOMAS

Most of us love to see a Denso offset gear reduction (OSGR) starter show up on the front counter for rebuilding. Aside from their easily accessed solenoid contacts and brushes – most of the component parts in these starters seem to last forever. The drive clutches can be rebuilt without any special tooling and a minimal amount of parts. Denso has a long history of making service and repair components available to the rebuilding industry through their warehouse distributors. The OSGR starters are generally just plain easy to repair or rebuild.

Denso's OSGR platform is a proven design that has withstood the test of time for three and a half decades. It could be argued that pound for pound, they perform as well or better than any other starter ever made. A multitude of vehicle and equipment manufacturers of all types have used them in a wide range of applications. But someone once said that “all good things must come to an end.” In this case, it actually started to change about nine years ago. That is when Denso introduced the PA90S series starter for diesel applications. They are smaller, lighter and stronger than their OSGR predecessors.

The PA90S is a series-wound planetary gear reduction starter for diesel-powered medium duty trucks and equipment. The part number of the one we have here is 428000-6110 (see Figures 1 and 2). It first appeared on Dodge Ram pickups with diesel engines in 2007 and is rated at 3.0kW. As you can see in the third photo (see Figure 3), it is noticeably smaller than its OSGR cousin. Interestingly, this PA90S starter can be used to replace the 228000-2292 in the photo, Lester 17548. Some sources show they will interchange. However, I suspect that may depend upon the amount of room that is available for a bulkier OSGR starter in the post-2007 trucks and the installer's willingness to accept it.

Rebuilding a PA90S is not going to be much more difficult than rebuilding an earlier Denso starter once you gain some experience with them. In fact, other than the gear set, the two starters have more in common than you might think. Sadly, some key component parts like brushes and solenoid contacts are not yet available, most likely due to lack of demand. Hopefully that will change.

To disassemble this starter you must begin by removing the brush holder screws and through bolts. That allows you to remove the commutator end housing, brush holder (see Figure 4), armature (see Figure 5) and field case (see Figure 6). Like many of the small engine Denso starters of the past, the pole shoes are riveted into this case. These coils are quite different too, wound from a heavy flat wire. However, note that the wide side of the flat wire is parallel to the housing (see Figure 7). You can see that there are just three turns per coil.

As a protection feature, Denso has built four fusible connections into these coils, two where the positive brushes attach (see Figure 8) and two where the coils attach to the field case lead (see Figure 9). They are there to prevent a critical failure. But you have to wonder for whom. It obviously cannot benefit of the end user. Once these fuses burn open, the starter is disabled until the fields are replaced or repaired. More about that later. Note that the armature's drive end support bearing is

recessed in such a way that it will be a challenge to remove.

Once the field case and armature are out of the way, you can get to the planetary gear assembly. When you remove the cover plate which also supports the armature's recessed bearing (see Figure 10), there is a good chance that a large strangely-shaped spring washer will stick to its back side. It is very easy to miss it. This is what Denso calls a slip disk shock absorber (see Figures 11 and 12). More about it later as well. But when removing this part, remember to make a note of its orientation, which is easy to forget when it comes out stuck to the bottom of the cover plate. Then remove the planet gears to expose the drive clutch.

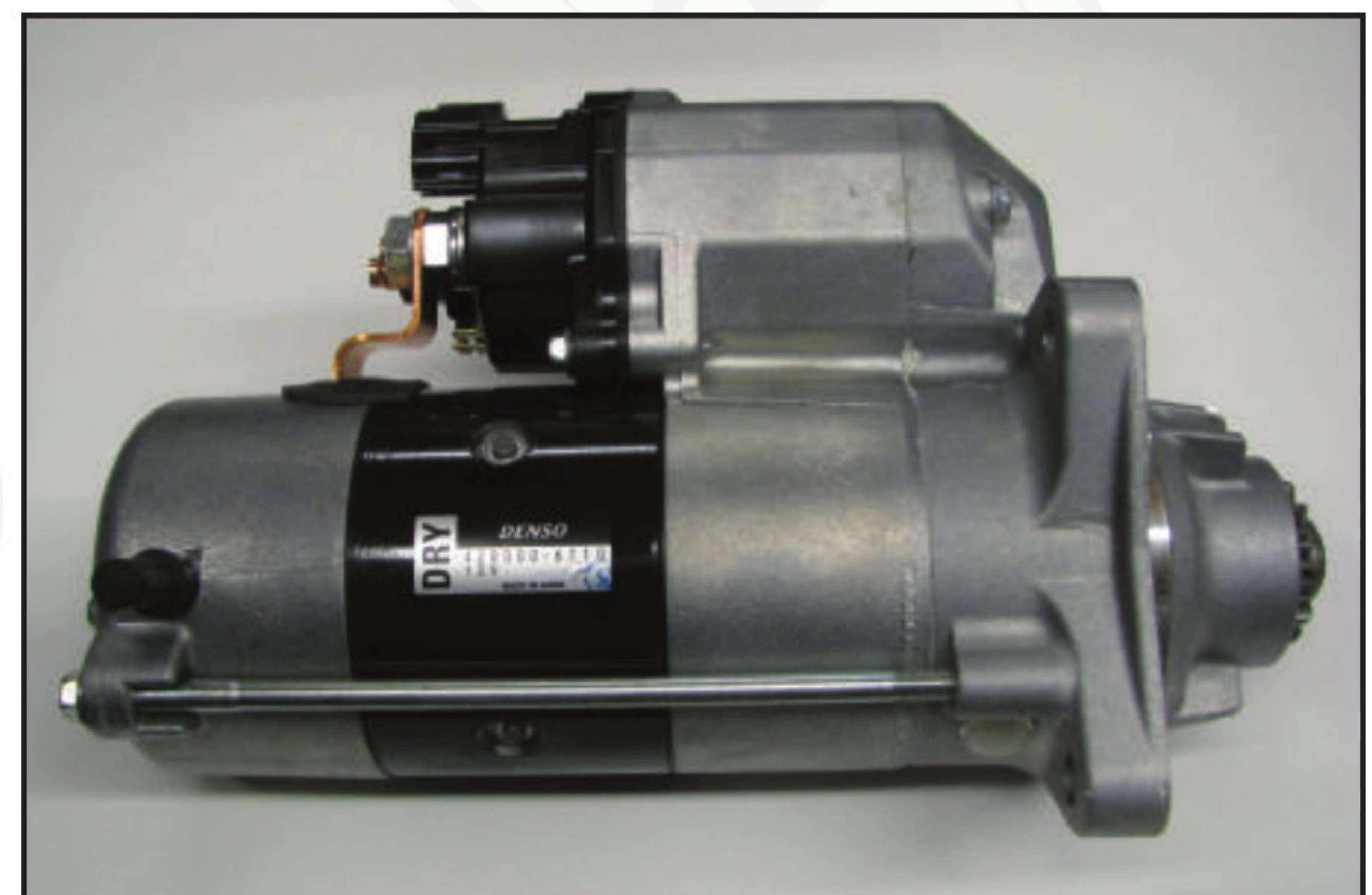


Figure 1 – This Denso PA90S starter has been used on Dodge Ram diesel pickups since 2007.

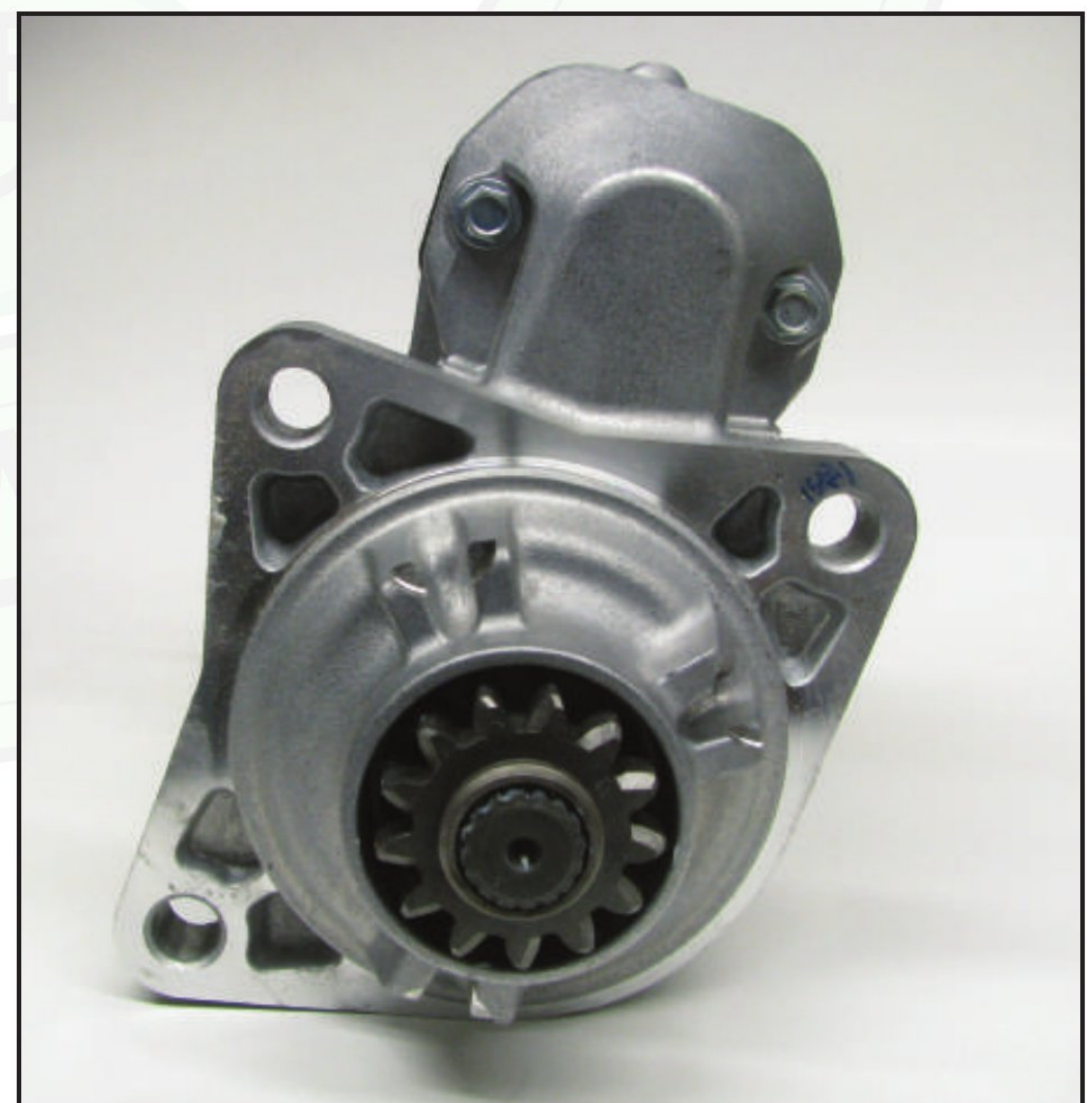


Figure 2 – The 428000-6610 or Lester 19029 as viewed from the drive end.

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Figure 3 – The PA90S (right) is significantly smaller than the OSGR starter.

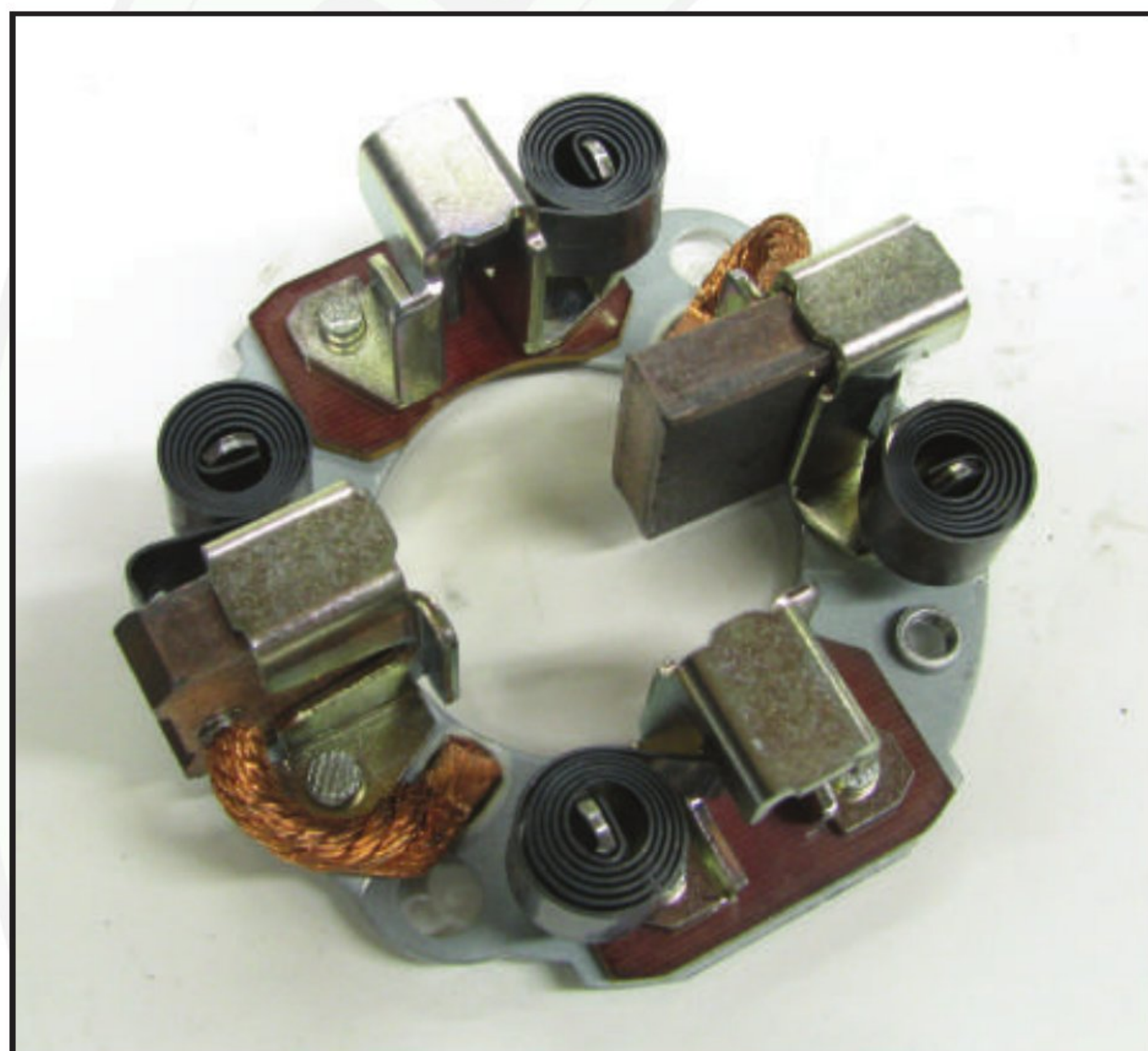


Figure 4 – The PA90S brush holder may look familiar due to similarity to OSGR brush holders.



Figure 5 – The PA90S armature's DE bearing will be a challenge to remove.

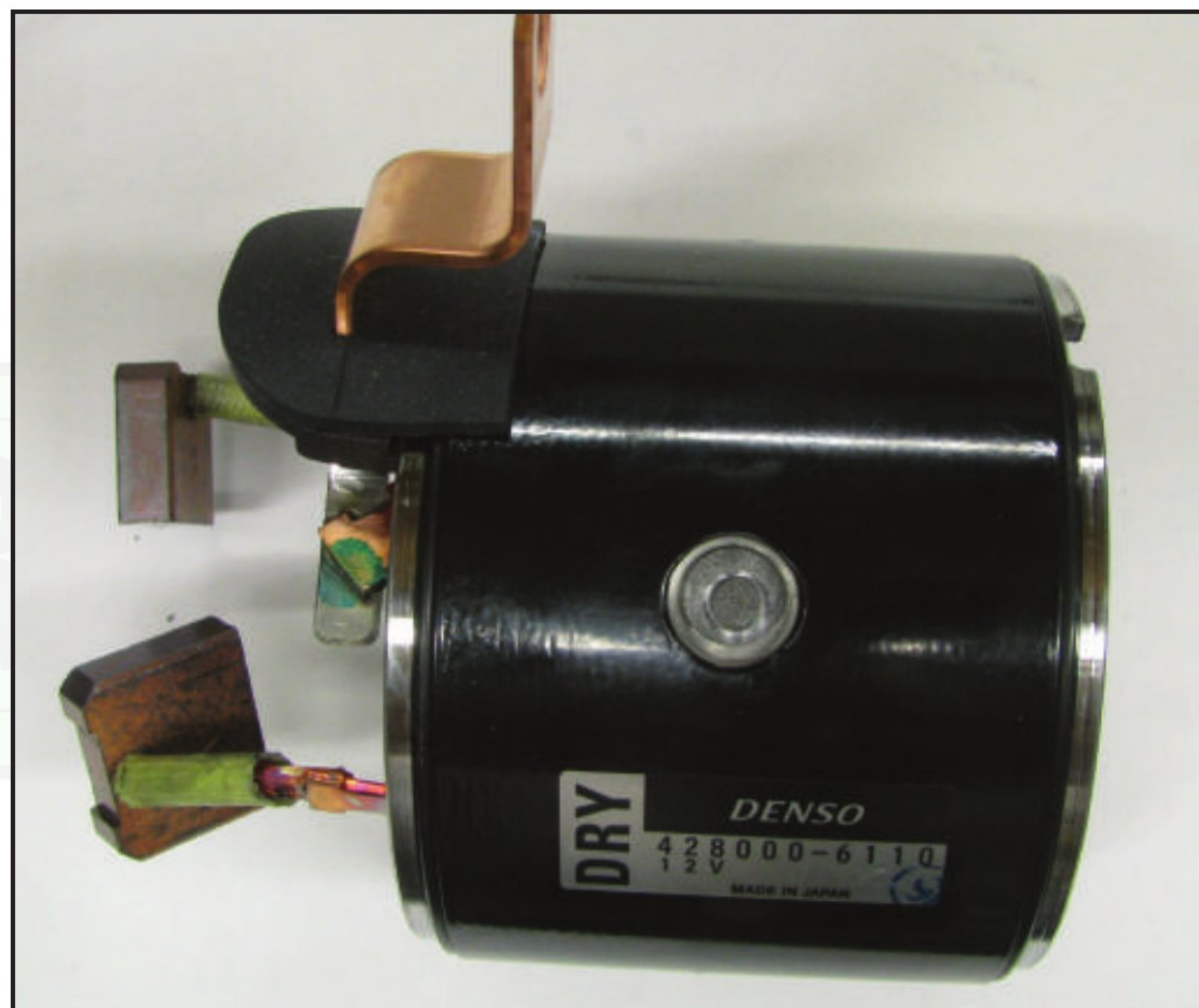


Figure 6 – The pole shoes on the PA90S starter are riveted into the case.



Figure 7 – Note the way that these field coils are wound, the number of turns and the size of the wire.

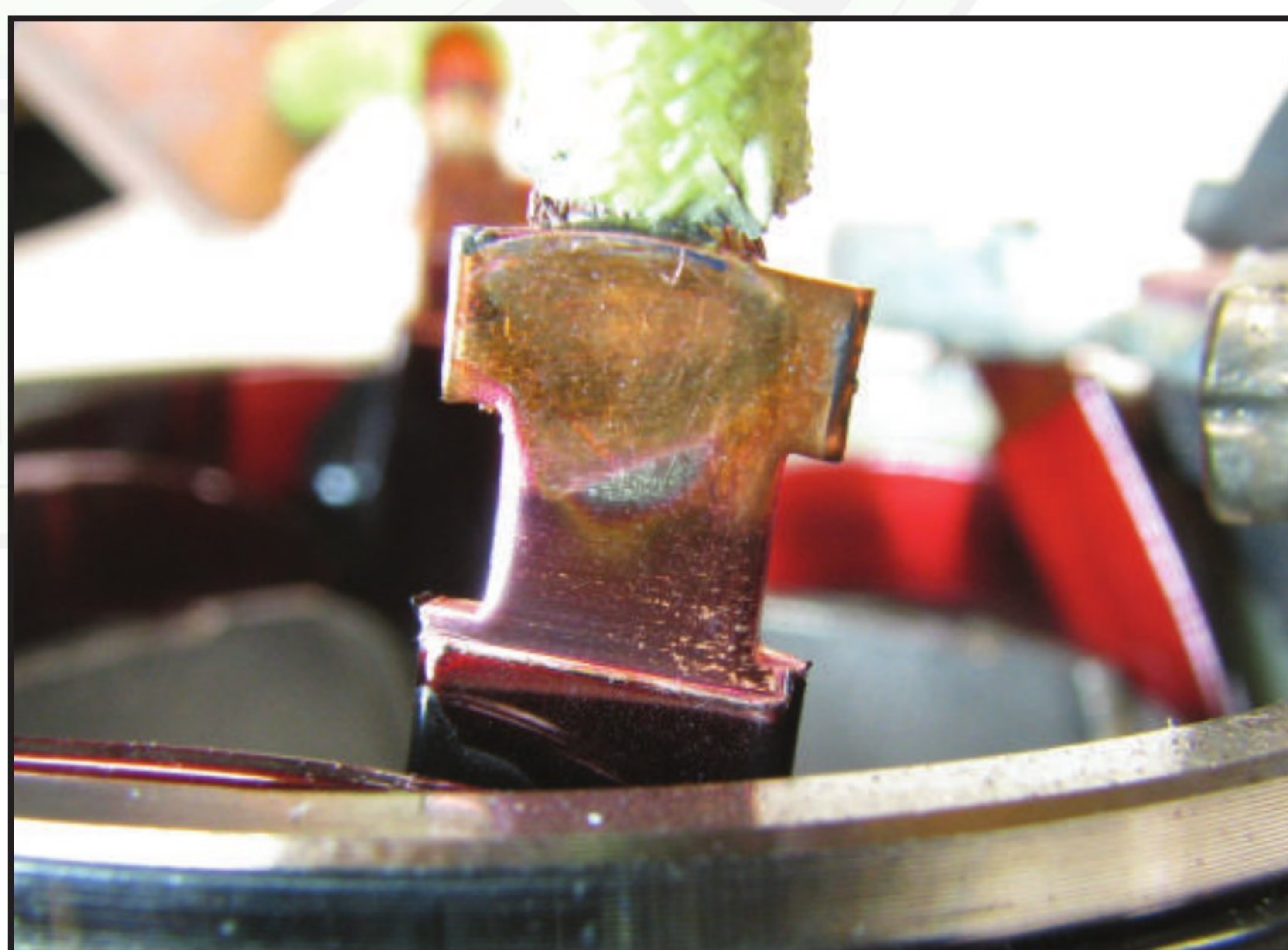


Figure 8 – Here you can see one of the fused field coil connections to a positive brush.

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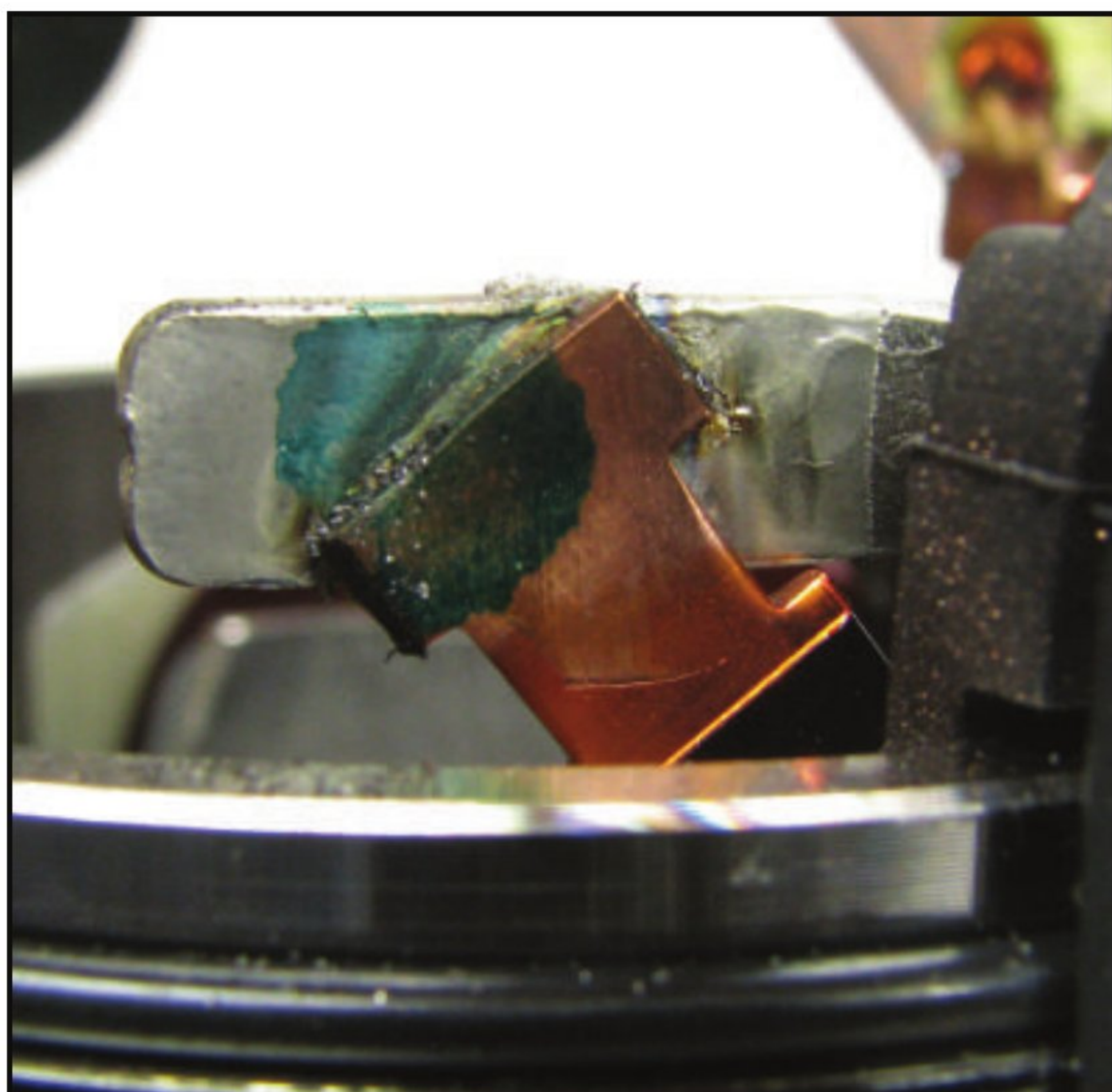


Figure 9 – This is one of the two fused connections between a field coil and the motor terminal strap.



Figure 12 – This odd shaped spring plate is a key part of the PA90S slip disk shock absorber.



Figure 10 – View of the planetary gear's cover plate once the field case and armature have been removed.



Figure 13 – View of the stationary gear in the housing with drive clutch below it.

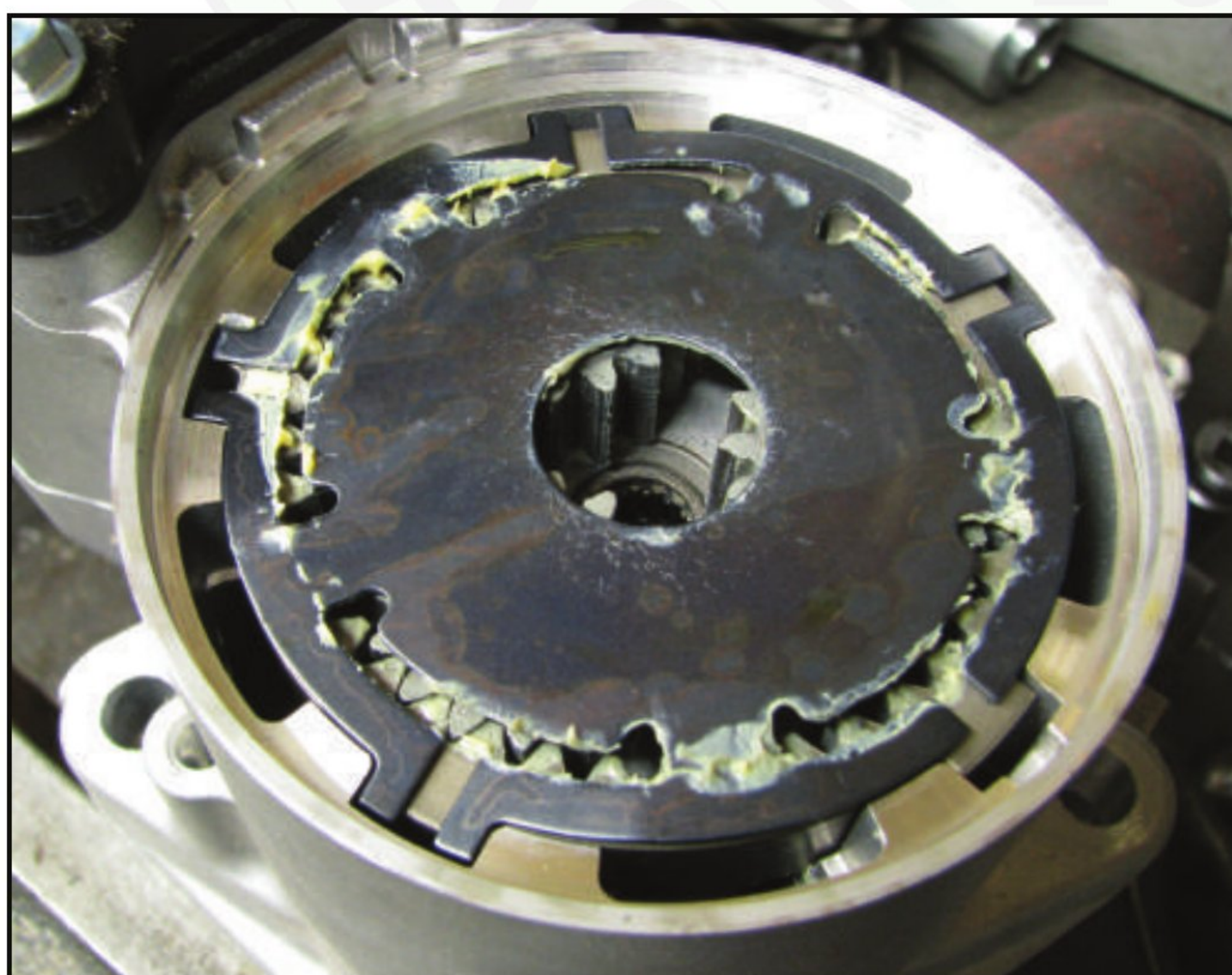


Figure 11 – The spring plate in position here may stick to the back of the cover plate when it is removed.



Figure 14 – Snap ring removal is not difficult once the shaft is held extended by a pin punch.

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The back side of the clutch carries the planet gears. You will note that there is a needle bearing in the clutch housing for the end of the armature's shaft (see Figure 13). That bearing may seem to be redundant given the ball bearing already supporting the armature's shaft, but it is there for a reason. At this point you can remove what will seem like a very loose fitting stationary gear. Do not mistake its sloppy fit in the housing as an indication of excessive wear. It is designed to be loose.

The pinion gear must be removed next. I used a 1/4-inch pin punch, carefully placed through the needle bearing to push the drive shaft to the extended position. It can be held that way by clamping the housing in a vise with the punch supported on the vise's screw box. This starter's snap ring is fairly easy to remove (see Figure 14). Once the pinion and indexing spring are out of the way, remove the two small bolts that are holding the drive end housing to the solenoid housing (see Figure 15) and separate the two housings. That will expose the plunger and shift lever (see Figure 16).

You will need snap ring pliers to get the shift lever off the drive shaft. Once the shaft's retaining ring has been removed, the drive assembly will probably fall out. Be ready for that. Note that two steel washers rest below the retaining ring that holds the shift lever on the shaft. (see Figure 17). This drive clutch itself is nearly identical to the older OSGR drive clutches. The shaft and inner clutch race are two pieces that easily fall apart once they are out of the clutch. Simply rotate the shaft clockwise and pull it to remove the shaft and race from the clutch (see Figure 18 and 19). If you rebuild this clutch, you should use a synthetic drive clutch grease similar to that used by Denso. It is available from Vensel Enterprises in small tubes under their part number P209-0033-OZ.

The PA90S solenoid operates differently from the OSGR starters in which the plunger pushed the drive out at one end while pulling the contacts closed on the other. The PA90S uses a shift lever. The plunger pulls the shift lever which in turn pushes the drive to its extended position. As it is pulling the shift left lever the plunger also pushes the moving contact under the solenoid's cap. You can inspect the contacts on a PA90S starter, although it is not as easy as it was for the OSGR starters. Three screws hold the plastic cap in place (see Figure 20). It can be removed once you break the spot weld on the strap that connects the motor terminal to the pull in coil lead (see Figure 21).

With the cap off, you can inspect the contacts (see Figures 22 and 23). As you can see, the moving contact was not designed to be serviceable. It is permanently affixed to the shaft end of the plunger. I suspect that the aftermarket will come up with a plunger kit with a detachable moving contact. Otherwise, the entire solenoid case would have to be replaced over a worn moving contact. Denso's parts list shows the loaded solenoid case as one part with no further breakdown. You can see that the plunger has a plastic pin that pulls the plastic shift lever (see Figure 24). Replacing a PA90S solenoid coil will be a little more difficult than on OSGR units because they are staked in four places (see Figure 25).

What to Watch Out For

The fusible field coils are vulnerable to abuse by operators. This has been confirmed in the field by at least one rebuilder.

While a burned open fuse that is part of the coils makes the starter unusable for the owner, it is a repairable problem. When it burns, the copper at the narrow spot literally melts away leaving the rest of the coils unharmed. It is not too difficult to replace the missing copper with a similar sized section cut from a scrapped set of diesel field coils. The rebuilder who reported this has repaired them by spot welding a new piece of copper to bridge the gap. Silver solder could be used in place of spot

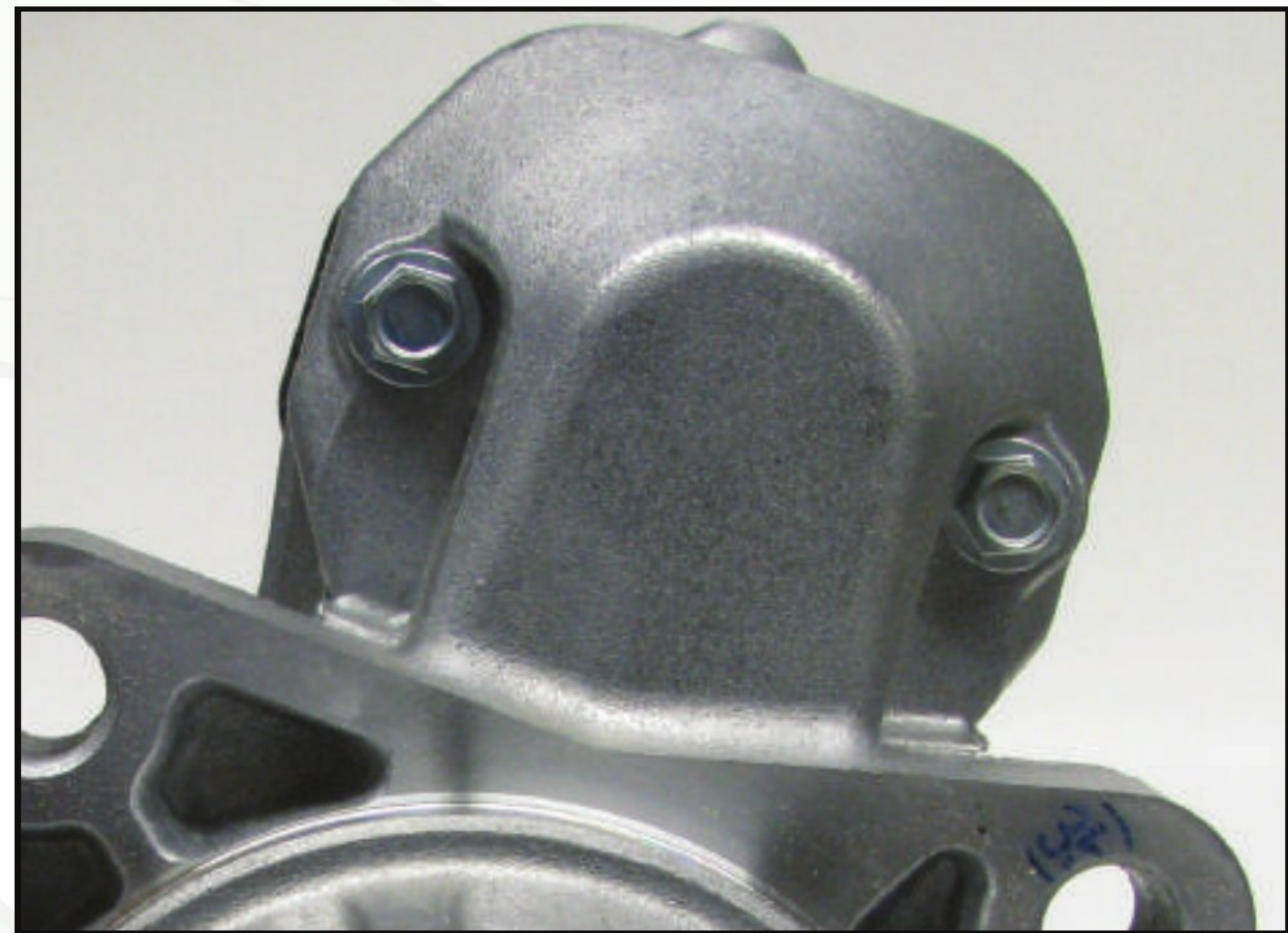


Figure 15 – Remove these two solenoid bolts before attempting to separate the DE housing from the solenoid housing.



Figure 16 – View of plunger, shift lever and pinion shaft once the DE housing has been removed.



Figure 17 – A close view of the shift lever with washers and retaining ring shown in correct order.

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welding. Either way, it is important to insure that your patch is smaller than the field coil wire. Educate the operator about what caused the failure - staying on the starter too long. But you can retain the protection for yourself in case he does not heed the advice.

The odd shaped spring plate, or **slip disk shock absorber** that was mentioned earlier is there to absorb some of the impact that is created at the moment the pinion engages the stationary ring gear. to soften the blow to the pinion that comes with each crank cycle. But it also reduces the strain placed on the other parts of the starter's power train – all the way back to the armature's gear.

When the pinion grabs the ring gear, the helical splines on the shaft create backwards pressure on the drive clutch, which also holds the planetary gears. You may remember that the stationary gear fits loosely in the drive end housing for a reason. It must be free to move too. The spring plate rests between the loosely fitting stationary gear track and the tightly fixed cover plate. Backward movement is limited to about 1mm. That may not seem like very much, but it is enough to reduce pinion wear over thousands of crank cycles. The needle bearing in the drive clutch which seemed redundant is there to allow the clutch to move toward the armature which does not move back. Remember that it is held in place by its drive end ball bearing. All of these components must work together.



Figure 18 – View of the roller clutch, inner race and shaft.



Figure 19 – The clutch's rollers and springs are similar to those on OSGR Denso starters.

PA90S starters have been used on three known applications. In addition to the Dodge Ram trucks, they will be found on 6.7L Cummins engines used on other applications including Bluebird buses, Freightliner step vans and Freightliner custom chassis. If you have not seen one of these starters yet, it probably will not be too long before you do. Some of them have been in service now for nine years.

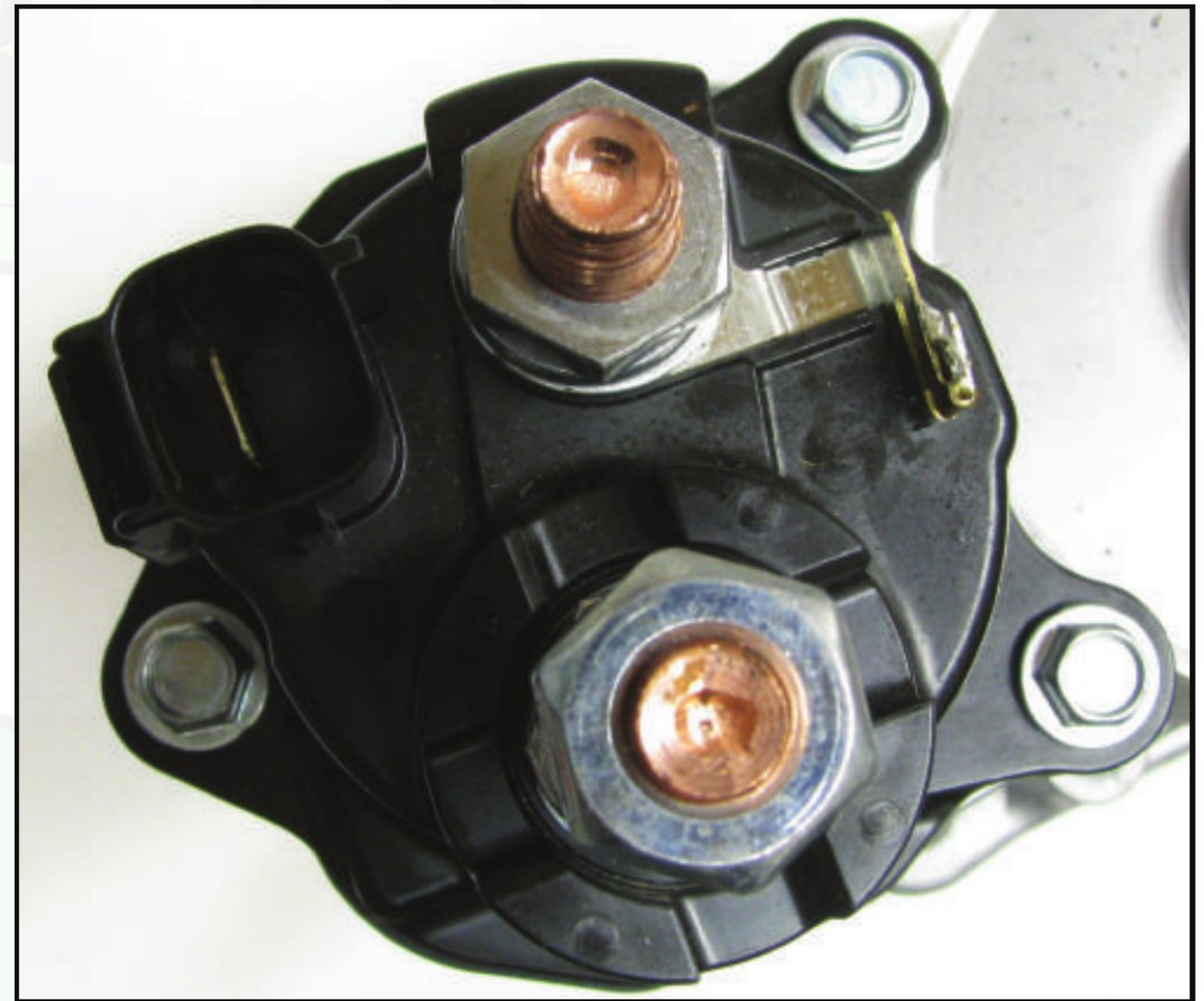


Figure 20 – The PA90S solenoid's cap, held on by three bolts, can be removed easily.

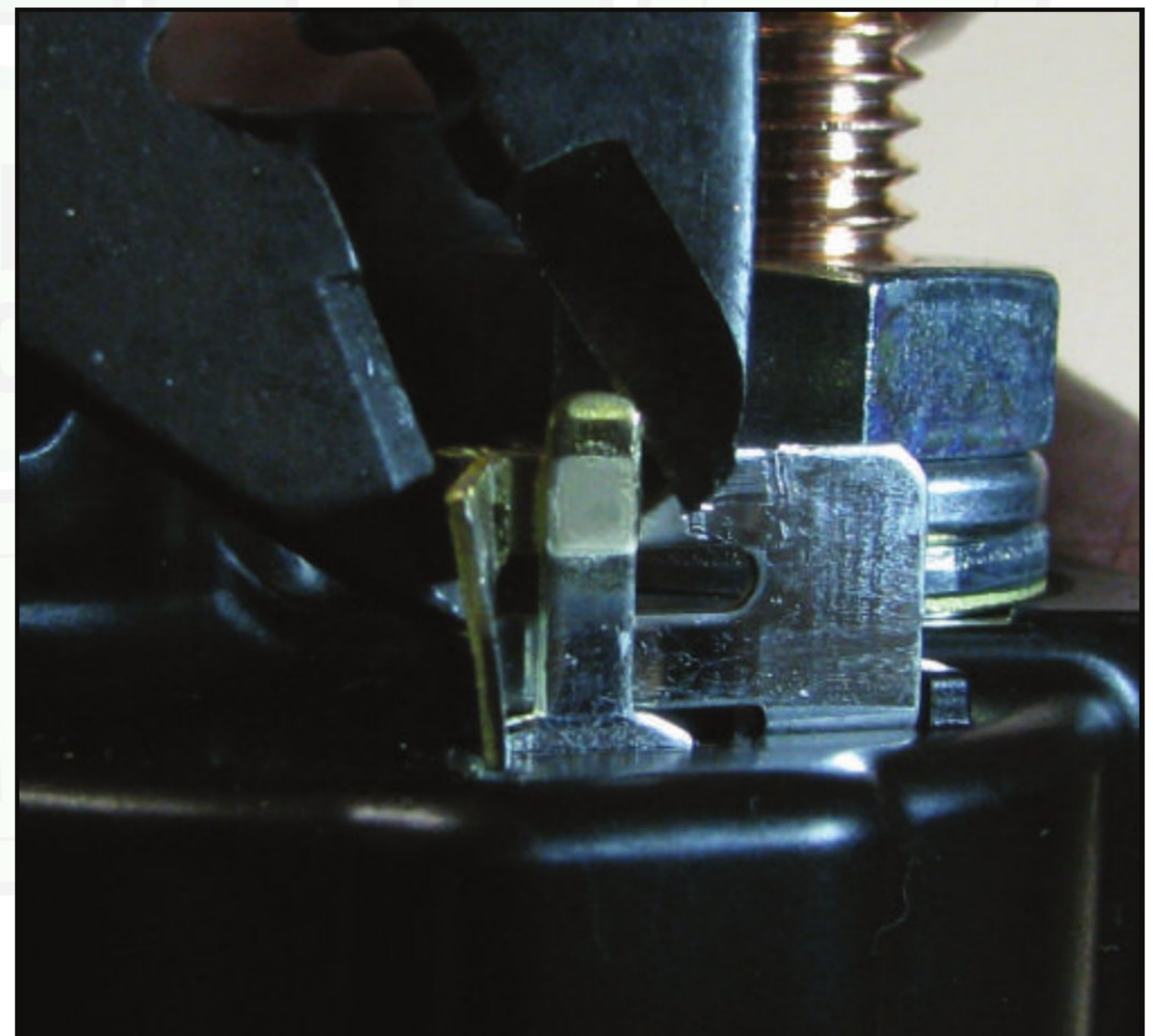


Figure 21 – You must break the welded connection between the pull in coil and motor terminal.

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Figure 22 – A view looking inside the solenoid cap.

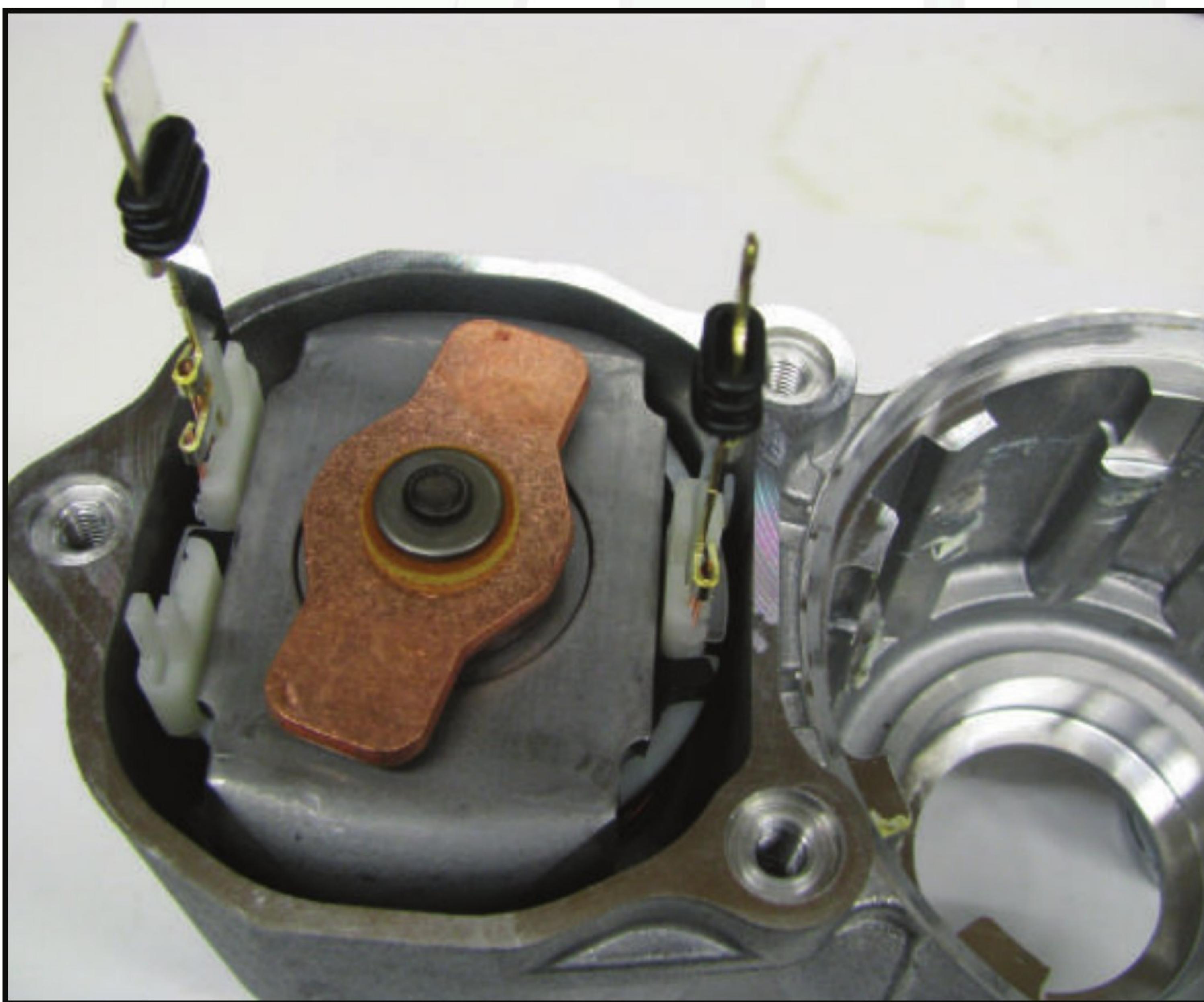


Figure 23 – The solenoid's moving contact resting on the coils – note offset position.



Figure 24 – PA90S plunger in its at rest position.



Figure 25 – PA90S solenoid coils are staked in four places for improved reliability.