

THE GHOST STARTER



BY NATHAN UNGER

As the sultry night air wafted through the open window, the farmer tossed and turned, asleep, and yet awake. Suddenly the sound of a cranking starter sent adrenaline pumping into his heart. *Someone was trying to steal his berry harvester!*

He yanked the covers off and, still in his pajamas, ran out there as fast as his bare feet would go. When he reached the machine parked beside the barn, the starter was still cranking but no one was there...

In the morning I got a call from the local machine dealership asking me to help unravel this mystery. This was already the third starter in a row (please, no puns) on this machine. And each time they had also replaced the auxiliary relay and the ignition switch, just in case the contacts were sticking.

For a long time already I had suspected an issue on these Littau Berry Harvesters (see Figure 1) with the 3.3L B series Cummins diesels, because whenever I would get one of these 228000-9010 or 428000-2650 Denso starters (see Figure 2) to rebuild, they were almost always exploded inside. Since I don't do service calls, I had little opportunity to investigate this.

This time, however, I asked the service technician to bring me not only the starter, but also the auxiliary relay, the ignition switch, and the safety interlock switch.

I took each component apart and did a full "autopsy". The starter had exploded due to excessive centrifugal force (see Figure 3), and also the solenoid coils had been overheated (see Figure 4), indicating that they had been powered up from an external source. There is a condition where the starter can stay engaged because its contacts are welded together, but then the solenoid coils will usually not have been burned up. This damage was not due to sticking contacts.

The auxiliary start relay (one of those Bosch cubes), is used to connect the starter solenoid "S" directly to 12 volts at the B+ when its coil is powered by the ignition switch. I took it apart; the coil and contacts were in good condition. Next I did some testing with a variable DC power supply. Although it draws 0.14 amps at 12 volts, it needs only 0.07 amps to close. I backed the voltage off slowly, and it wouldn't release until the current got below 0.04 amps! Also, it did not have a kickback diode. This means that there will be a spark inside the ignition switch whenever the key is released.

Once I had pried apart the 4PDT safety interlock switch, I found all of the contacts in good condition, so that wasn't the culprit.

Then I got to the ignition switch. Corrosion, signs of electrolysis, and muddy watermarks were in evidence on all of the brass, copper, and aluminum components (see Figure 5).

So to unravel all the evidence, I inquired about anyone washing the machine. It seems this farmer likes to keep his tractors nice and clean. Every day after harvesting, the farmer would have one of his boys pressure-wash the machine. But the ignition switch was not protected nor sealed, and it was cheaply made besides. The muddy water that splashed into it would corrode the copper and aluminum inside, and would begin to become a conductive solution itself. That's why each newly replaced ignition switch would develop the same trouble.



Figure 1 – The Littau Berry Harvester has a Cummins engine and Denso starter.



Figure 2 – 2.2kW Denso starter number 228000-9010.



Figure 3 – Exploded commutator is convincing proof that this starter was engaged with engine running.

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Whenever they would start the machine, the ignition switch would activate the relay, and the relay would activate the starter. But once the muddy water and corrosion would build up inside the ignition switch, there would be enough conduction due to the dissolved minerals in the water to keep the relay closed even after the ignition switch was released. Remember, it only takes 0.04 amps to hold the relay closed. I was actually able to simulate this on the test bench, immersing the contacts in a plastic container of water and then stirring in a little soil from behind the shop.

If the ring gear to starter pinion ratio is, say, 15:1, then the starter could theoretically rev up to a whopping 27,000 RPM. That's why the commutators would always blow up, taking out the brush holder and field coils as well.

Now I have a theory as to what made the starter start cranking at night all by itself. Suppose he had a build-up of residue from the previous time he washed the machine. Maybe it didn't have quite enough electrolyte concentration to cause the run-on condition the next time he started it, but it began the corrosion process. When he turned the machine off at the end of the day, he washed it again, maybe splashing more mud and maybe a bit more berry juice onto the ignition switch. The 12 volts across the open switch contacts accelerated the corrosion problem during the night until the concentration of mineral, copper, brass and aluminum ions, plus a little acid from the berry juice allowed in excess of 0.07 amps to flow, closing the relay contacts and activating the starter.

When the farmer disconnected the battery during the night, he 'saved' the starter, and some of the water in the ignition switch may have gradually leaked out by morning, so that the problem lay dormant until after he started the engine. At that time, since there was still some sludge left in the ignition switch, it could still conduct the 0.04 amps to keep the relay and starter engaged after the engine was started.

Of course, an inexperienced operator might not even hear that sound over the roar of the machine, so the starter would keep trying to crank even though the engine was already running and the operator had released the key. The engine would thus be propelling the starter. With the large ring gear turning at (let's say) 1800 rpm, this would then be why the armature was exploded and the solenoid hold coil was cooked. By the way, the fact that the auxiliary relay coil had no kickback diode means that it would send a high-voltage spark into the leftover sludge, which would definitely not help the situation.

The service technician addressed the problem by installing a separate push button start switch. I hope it was a weather sealed type.

I was not required to cover the warranty on any of the rebuilt starters from that machine because they had burned solenoid hold coils, proving that they had been held engaged because of issues external to the starter.



Figure 4 – The burned solenoid coil indicates the switch terminal was powered for an excessive amount of time.



Figure 5 - Corrosion and conductive sludge inside the ignition switch caused the intermittent self cranking.