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September 2023 $12.95

AUTO ELECTRIC CORNER
Stranded Subaru, 6449N Starter, Over-Charging Toyota, IMI to Rescue

DIODES: IDENTIFICATION, TESTING, INSTALLING



A WORD FROM THE EXECUTIVE DIRECTOR
ERA Tradeshow Seminar Topics!



The ERA Tradeshow committee is in full swing planning the show for next spring in St. Louis. One of the tasks the committee tackles is coming up with topics and speakers for the show. This year we are looking for input from you, the attendees of the show, to tell us what you would like to learn about or even be refreshed on.

The industry has many good speakers to choose from so we need to contact them early to get them reserved for the show. One of the speakers we have on staff, Mohammad Sammi our technical director, always promises an interesting seminar, most of which he bases on real life experiences in his shop and his continuing education from various seminars he attends. We are extremely lucky to have him working for us!

So, as you are taking the time to read this magazine, take a few more minutes to call the ERA office (636-584-7400) or email (office@electricalrebuilders.org) to give us some ideas on the topics that you would enjoy learning about, so we can line up the speaker!

Here are some of the speakers from some of the recent past shows!

Mike Schroeder



NEW ERA MEMBERS

Shenandoah Valley Diesel
Staunton, Virginia

Twin Oak Repair
Elkton, Kentucky

ABOUT THE COVER

Enlarged view of 44010 Mitsubishi Alternator
Photo Credit: Mohammad Samii (WAI Photo)

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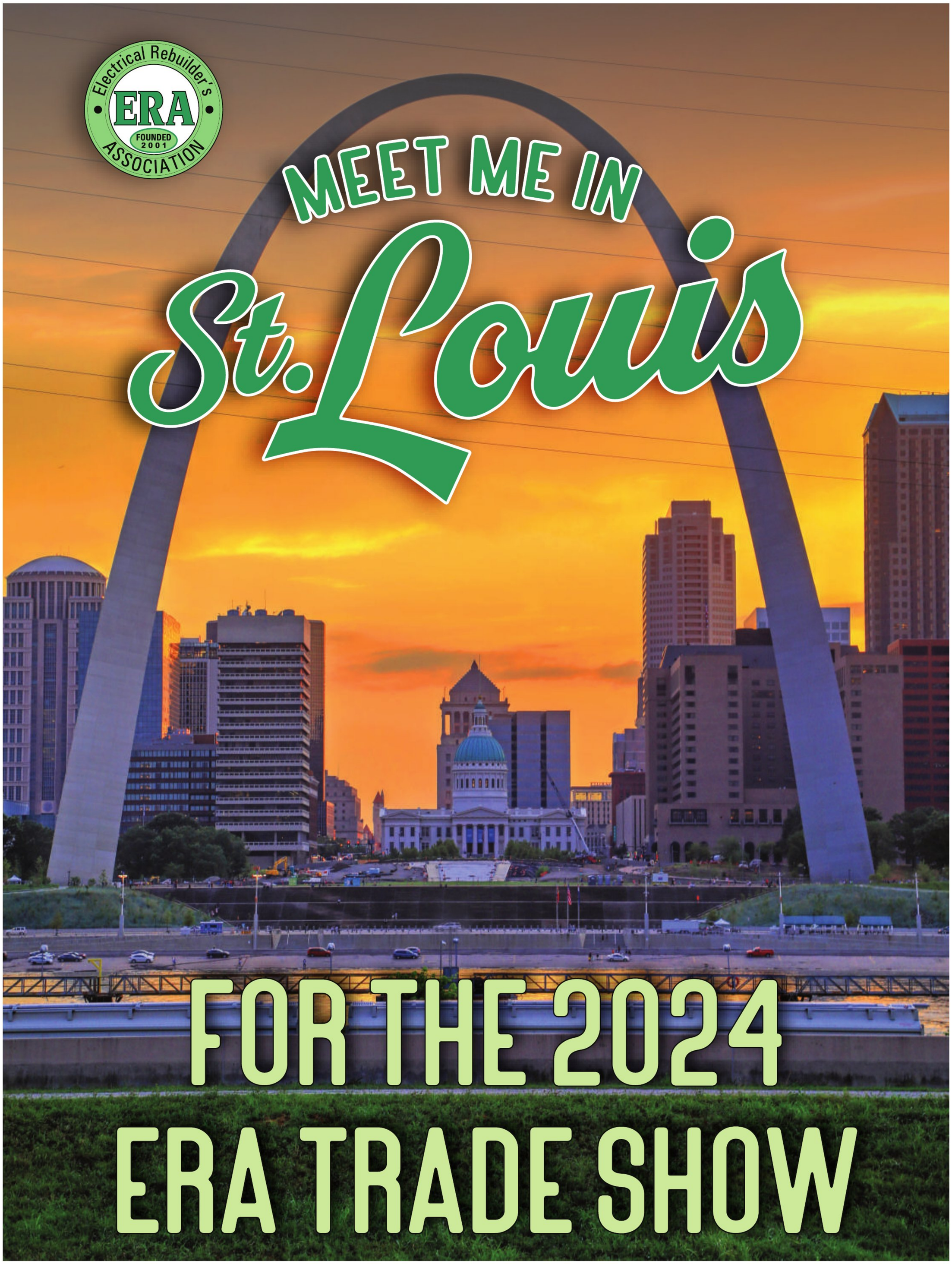
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AUTO ELECTRIC CORNER — Stranded Subaru, 6449N Starter, Over-charging Toyota, IMI to Rescue



BY MOHAMMAD SAMII

One of my faults that I do not have any regrets about is my soft spot to help stranded motorists who are traveling, mostly with family on-board having a vehicle that is broken down due to discharged battery or starting problem. This of course does not happen in the most convenient hour of the day or the day of the week, but an example of it happened a while ago that its unusual cause is perhaps worth sharing.

Early on a Friday morning I got the call from a person who was traveling with his wife and their dog while the second part of the family or relatives was driving a U-HAUL truck, heading from Minneapolis to some city in Mississippi. They sent the truck on their way but asked for help to fix their car. They were on I-57 heading south, about a mile and a half from my shop and were recommended by the tow truck driver who was called in, and now waiting to decide where to take the car to.

I found out the vehicle was a 2015 Subaru Legacy with a 2.5L engine that requires a 44010 alternator, which is a Mitsubishi 130-Amp alternator equipped with a Litens IDP clutch pulley. It was a unit I had not seen before and neither Lester, Partref, nor Apptrak show any pictures of it. WAI showed it on their website but were out of stock. (*Figure-1*)

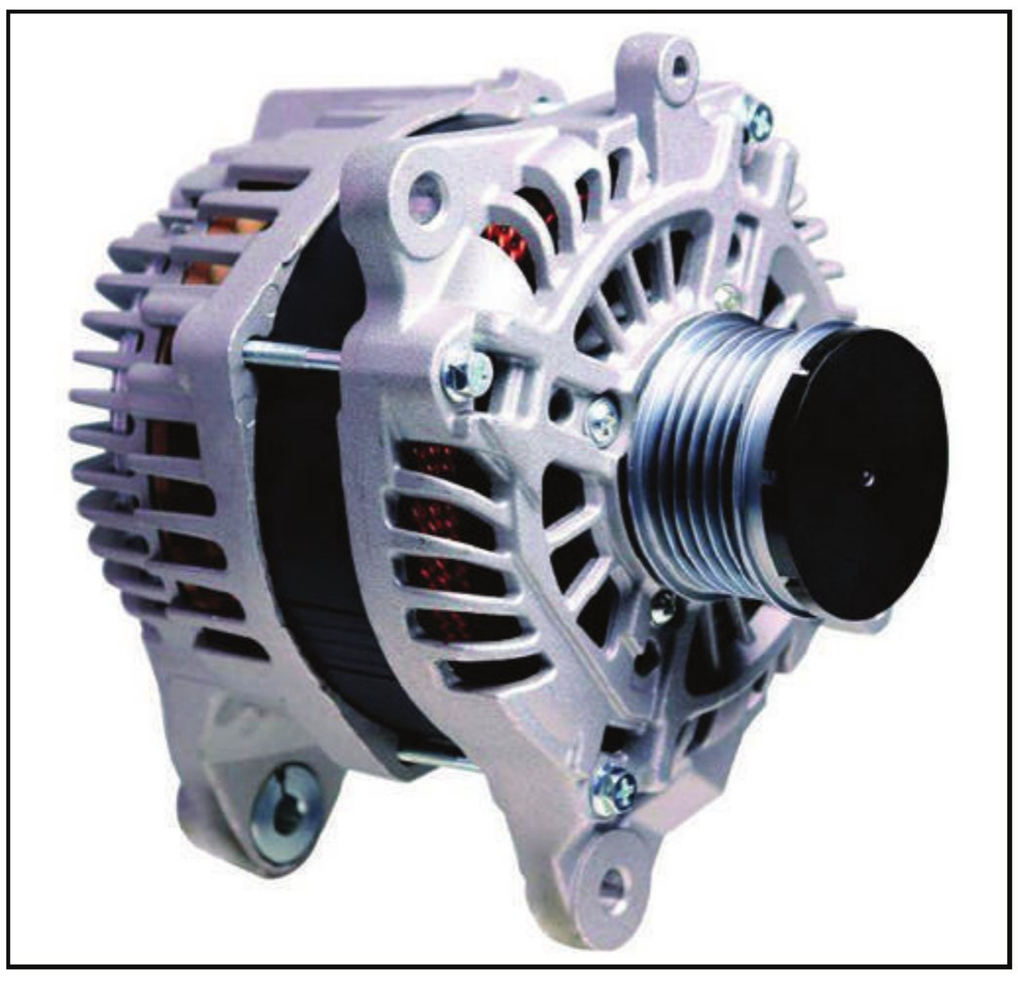

Figure 1 – 44010 Mitsubishi Alternator for Subaru (WAI photo)

Albeit it was an uncommon alternator and the chances of being able to fix it was not great if it needed any electronic parts but it seemed the only option was taking it in as they have been rejected by the dealer due to workload and unavailability of the part well into next week, in addition to a couple of other shops they had called.

So, I reluctantly agreed to take it in. The car arrived, battery got charged enough to crank and start when I noticed it was actually charging with plenty of output. Since the battery was completely dead upon arrival, and the chances of the alternator had quit charging at some point was certain, I guessed maybe worn-out brushes or dirty slip ring could possibly be the cause. Luckily this alternator is not difficult to remove, so once taken off, I run it on the test bench that showed it was charging fine but with occasional drop-off, suddenly jumping back into charging properly.

Upon teardown, I saw to my great surprise that the brushes were a little worn but not to a point that would lose contact with the rather functional and clean slip-ring. I replaced the bearing and brushes regardless, but decided to pay more attention to the clutch pulley. After holding its hub steady in the vise, using the appropriate tool, I notified that I can rather easily spin the pulley on direction that it supposed to lock with the rotor shaft. Obviously, its internal mechanism was worn enough to release under load and at times spin without turning the rotor or turning it fast enough.

Now came the problem of finding the right clutch pulley on a Friday for a customer that needs to get on the



road. A call to dealer was a waste of time and replacing it with a solid pulley was out of question. I have seen too many shattered belt tensioners and broken belts that flown apart and tangled into the engine compartments to try that. But then I recalled this clutch pulley (J&N's 206-48025) is almost identical to another Mitsubishi alternator, namely 11231 which uses a 206-48003 Litens clutch pulley that I always have a couple them in the stock. The issue regarding their internal design for different applications did not concern me as much as I thought a pulley that is made to withstand the horrible vibration of a 2.4L used on a variety of Jeeps which is notorious for running the 11231 alternators should be sufficient to handle the vibration of a much smoother running Subaru 2.5L Boxer engines. (*Figure-2*)

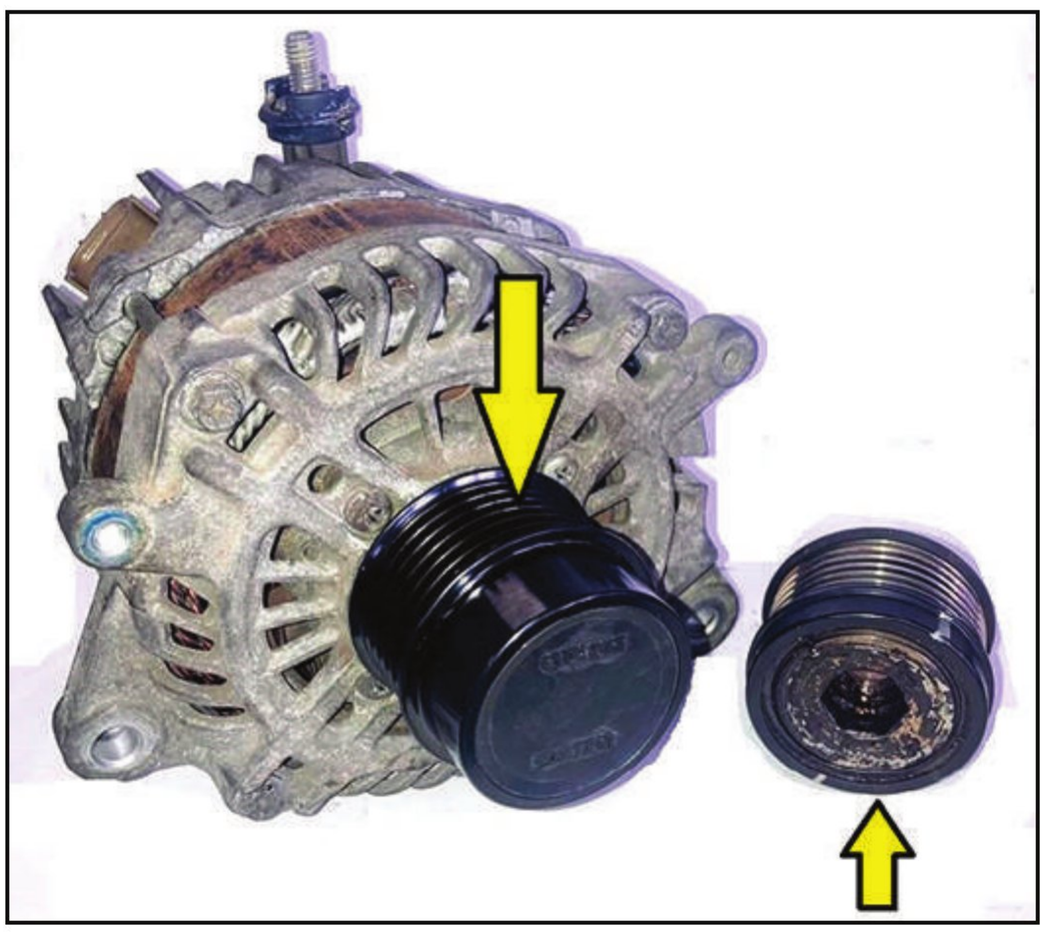

Figure 2 – The Pulley Replaced by a Litens 920810

So, the unit was assembled and installed while the battery was being charged all along. The customer was happy we managed to get him back on the road, and I learned a lesson to pay more attention to checking the clutch pulley in the cases that there seems to be not much wrong with the alternator.

6449N Starters

We sell a good number of these starters (*Figure-3*) to a customer of ours—a casting and forging company—for their many forklifts equipped with GM's 4.3L engines. These starters used to fail in a short time which is not uncommon occurrence in noisy factory floor and machines operated by multiple drivers.

What I notice is the occasional failure of the starter drive but mostly the plastic stationary ring gear of the gear reduction mechanism that simply wear in one or more spot, making the unit to fail. (*Figure-4*)

To correct the issue and make the starter slightly more reliable, I found out that the same stationary ring gear available in steel version rather than plastic (*Figure-5*), and using this steel ring gear rather than the

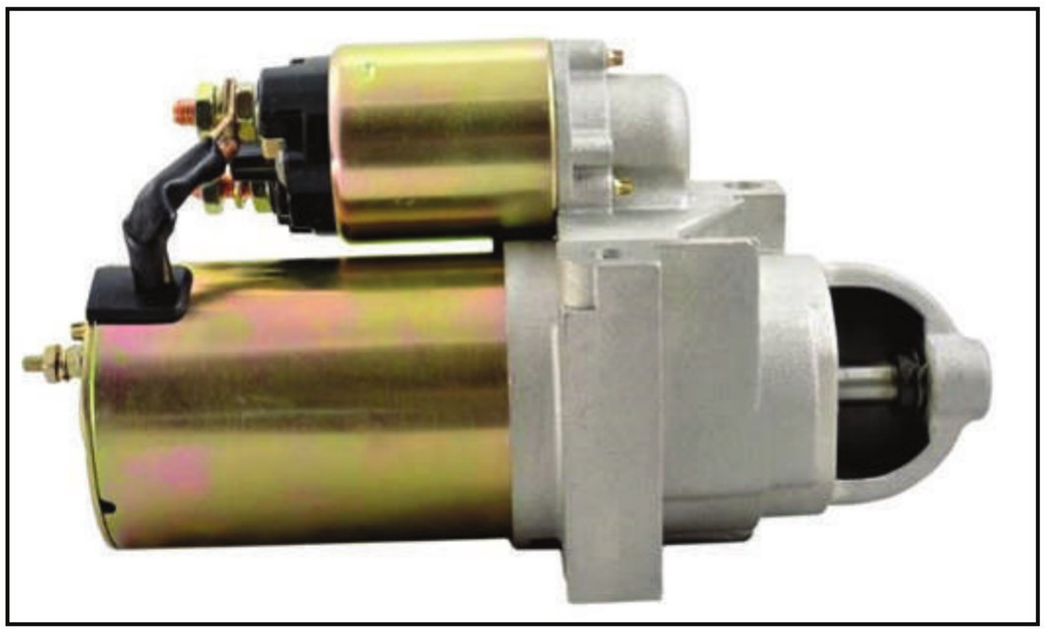

Figure 3 – The New Motor with Conversion Coupling

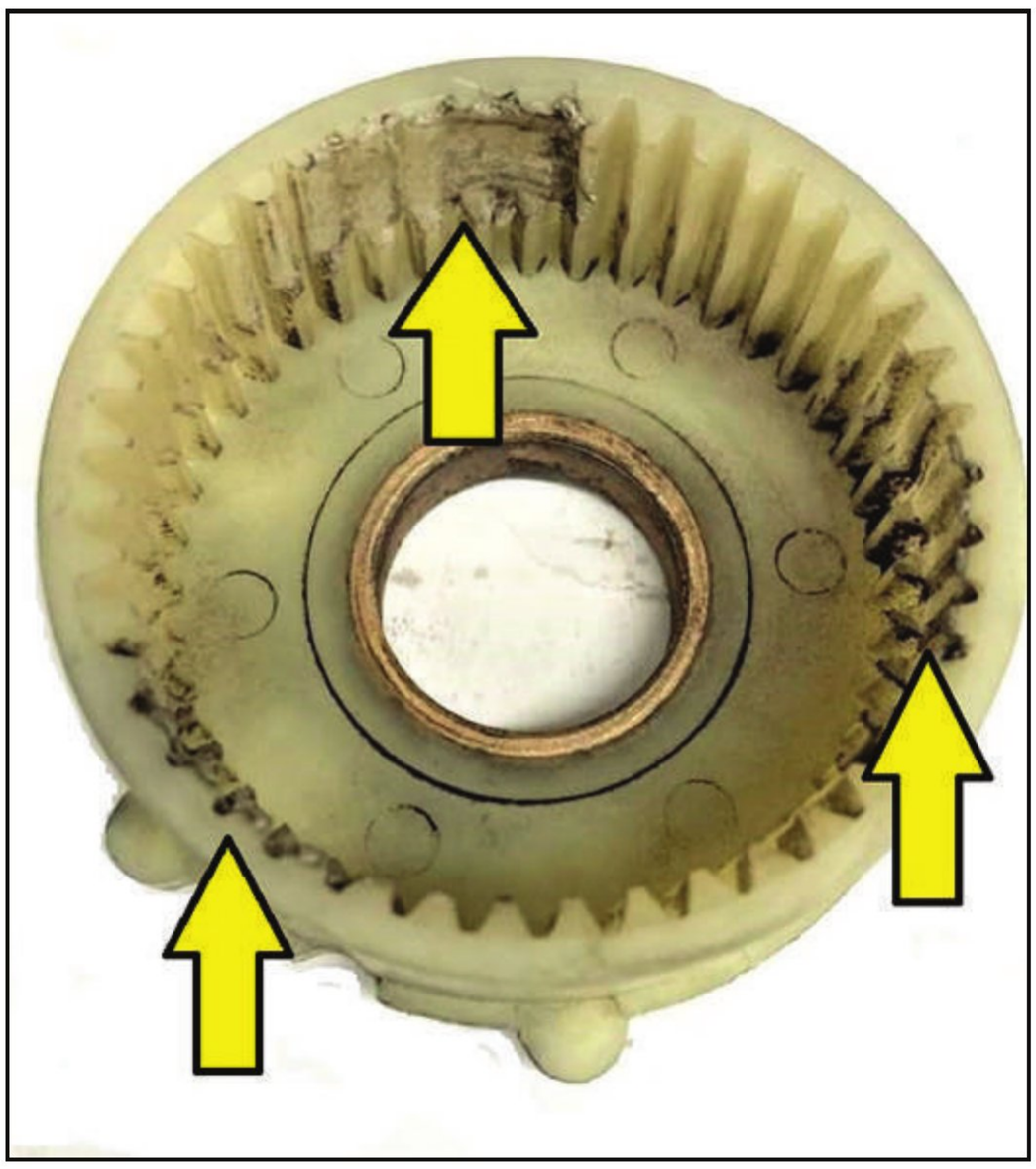

Figure 4 – Worn Spots on Plastic Stationary Ring



Figure 5 – Steel Stationary Ring Kit (J&N 222-12060)

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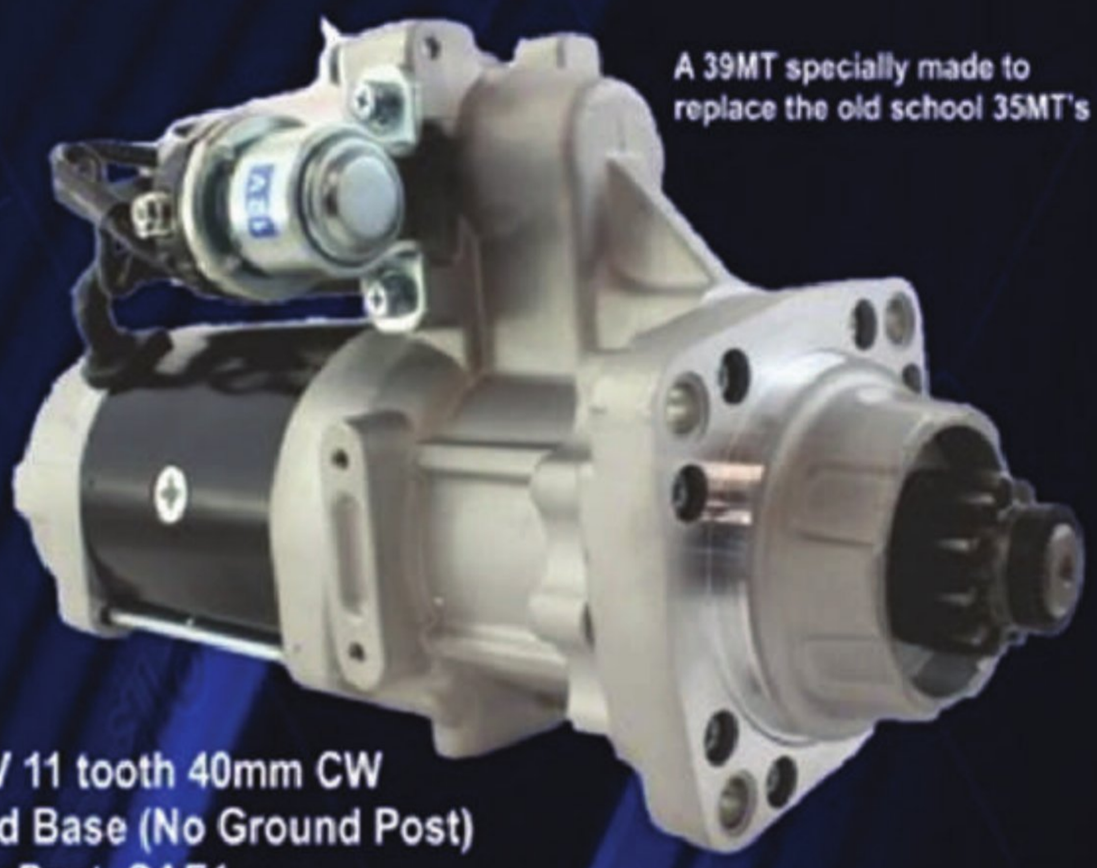

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1113672	DELCO	RE41875	JDEERE
1113692	DELCO	RE501166	JDEERE
12301389	DELCO	SE501414	JDEERE
028000-3290	DENSO	SE502712	JDEERE
028000-3291	DENSO	TY6617	JDEERE
128000-0770	DENSO	TY6667	JDEERE
128000-0771	DENSO	TY6710	JDEERE
128000-0772	DENSO	TY6713	JDEERE
302071	CAT	TY25960	JDEERE
343274	CAT		
394906R91	IHC		
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plastic one does improve the longevity of the starter. *Figures-6 and 7* show the steel ring gear replacing the plastic one which I believe this modification can be used in many such family of this starter as they are used extensively in automotive and light truck applications. The only word of caution is the steel ring gear makes the starter noisier, which is noticeable on the test bench when compared the one with plastic stationary ring gear but not necessarily while cranking the motor.

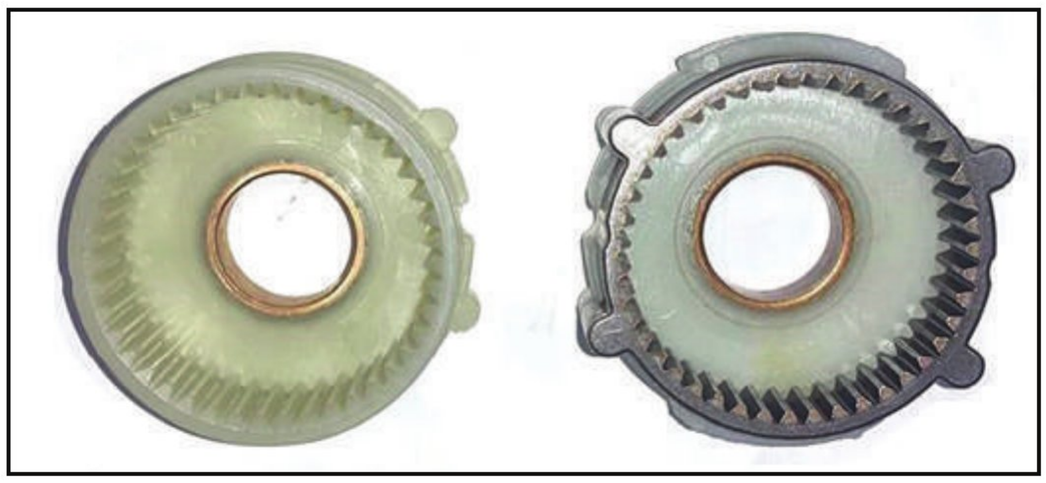

Figure 6 – Plastic vs Steel Ring Comparison

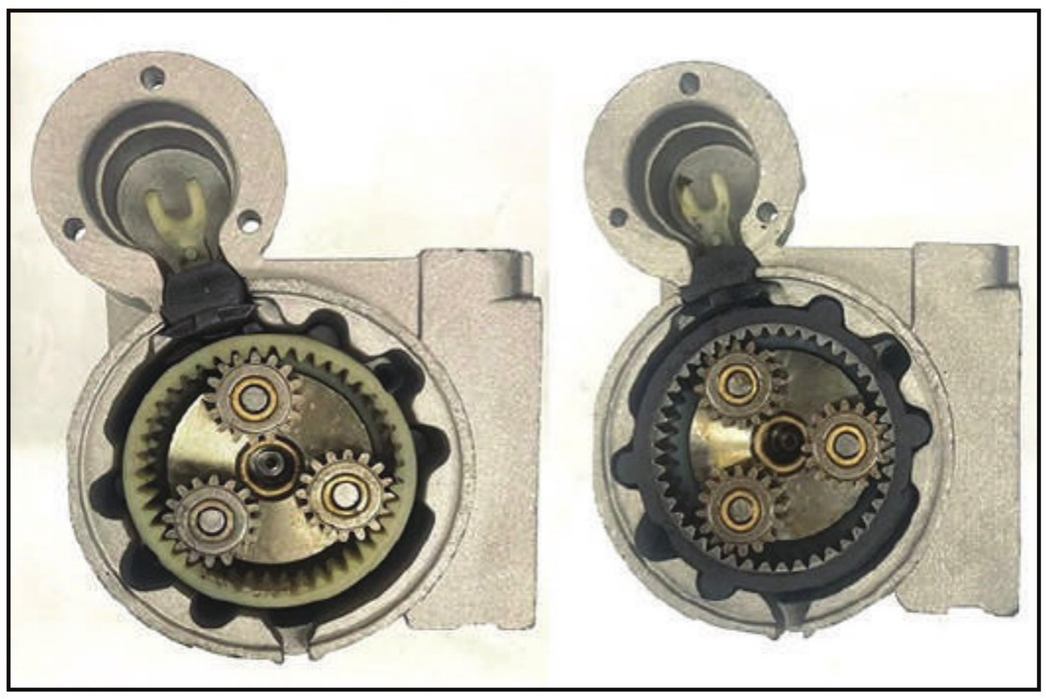

Figure 7 – Plastic vs Steel Ring Gears installation

Overcharging Toyota

The call was for a 13794 alternator that goes on a 2001 Toyota 4Runner with 3.4 V-6 engine (*Figure-8*).

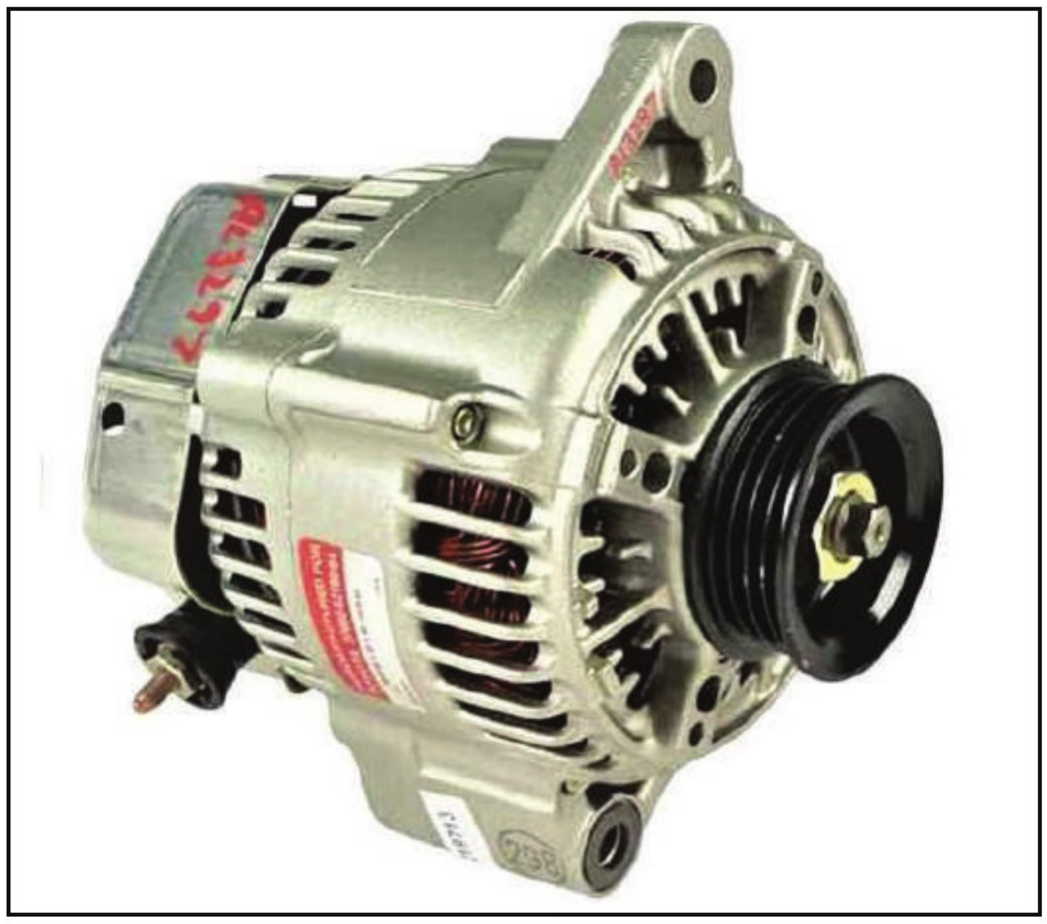

Figure 8 – Toyota 13794 Alternator (Partref Photo)



After the alternator was delivered and the core picked up, I noticed the "S" terminal of the regulator (Plug code 312, *Figure-9*) was burned which had probably affected the plug on the car side too. An immediate call to that shop that is incidentally just across the street to stop the installation was made, and I went there with a new plug, explaining to the technician the issue which he happily understood, and replaced the plug after he confirmed that it was indeed affected as shown in *Figure-10*.

Upon teardown of the core, I noticed nearly all the diodes of the rectifier were burned (*Figure-11*) and the

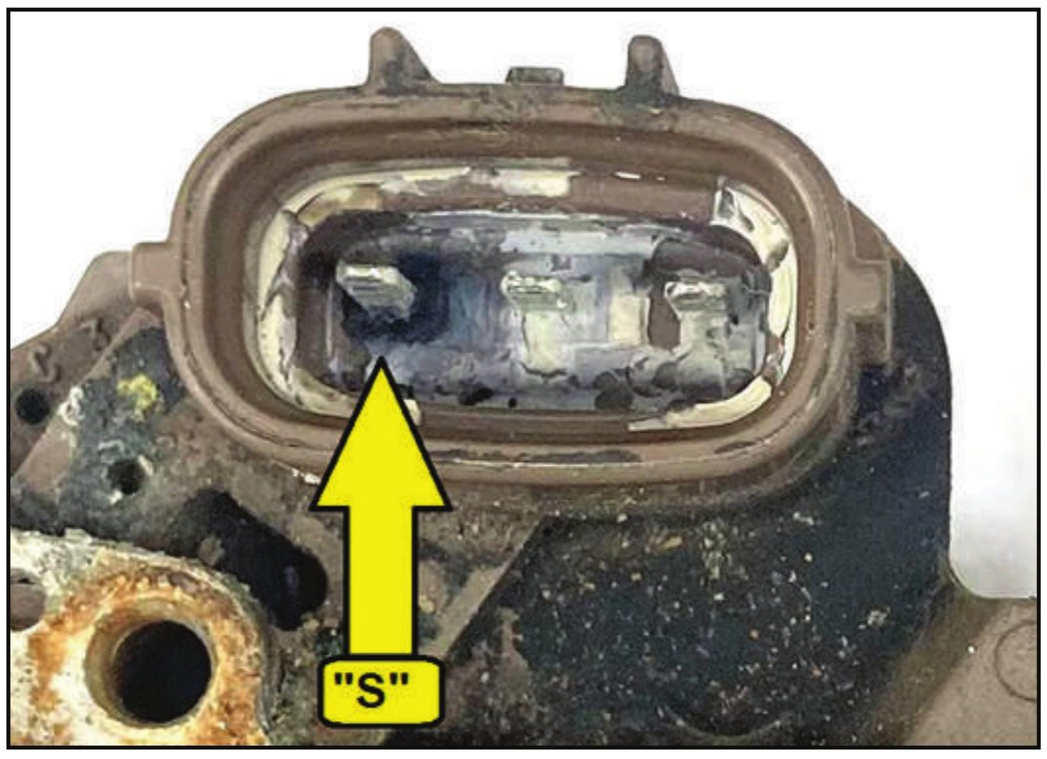

Figure 9 – Plug Code 312 and Burnt "S" Pin

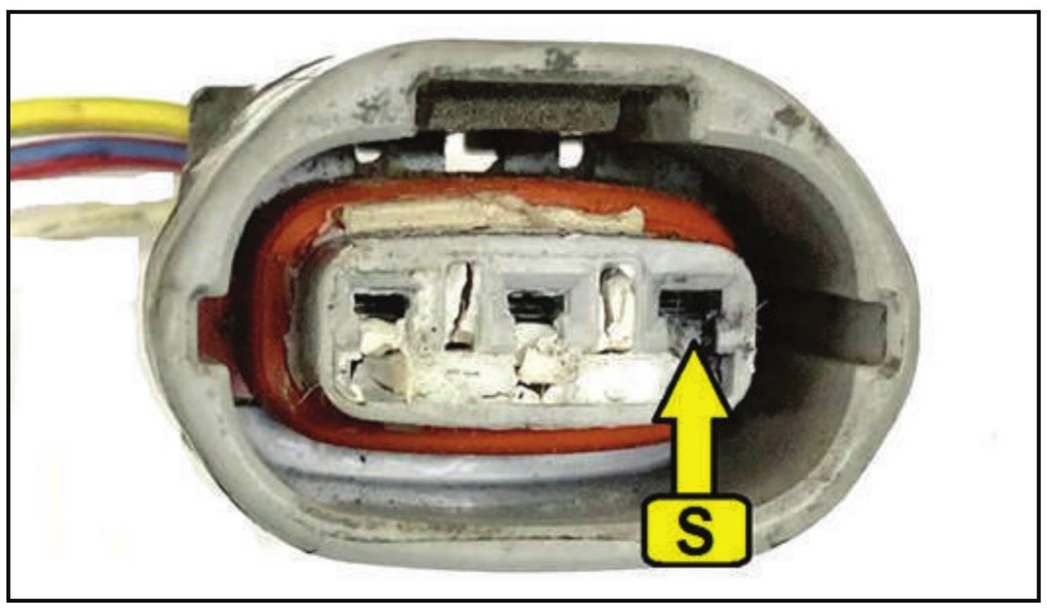

Figure 10 – Burnt Pigtail on the Car Side

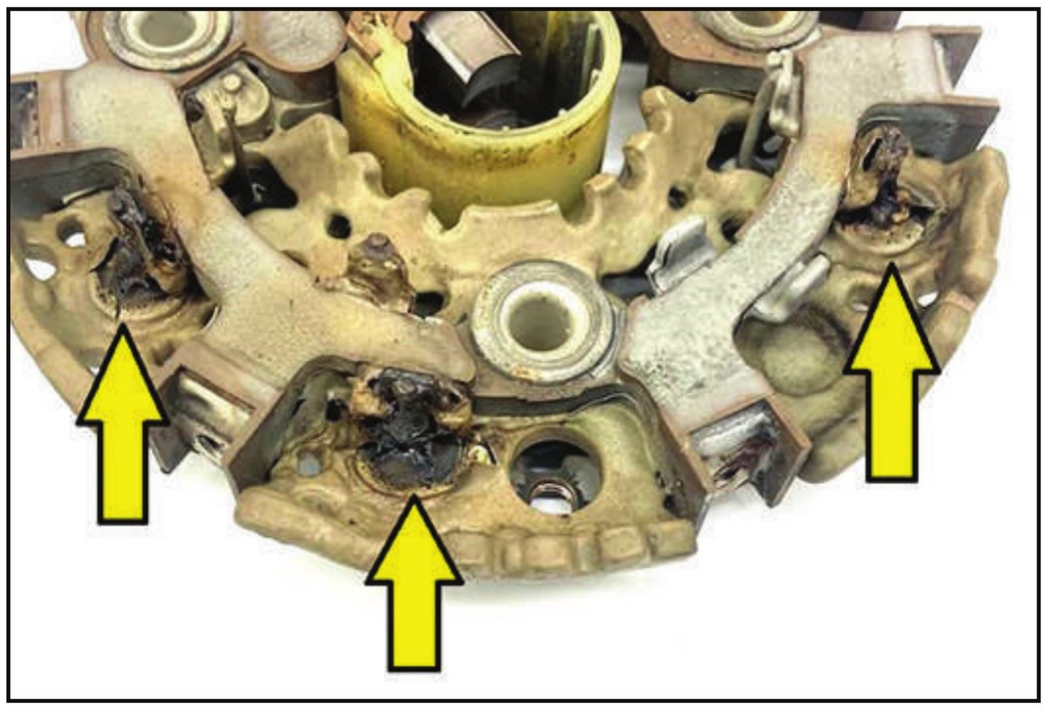

Figure 11 – Melted Rectifier Diodes

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stator overheated, indicating a near wide-open mode until complete failure. Had this alternator been purchased from any auto-part store, I highly doubt this would ever have been brought to the attention of the shop. Meaning in a very short time, the poor connection at the "S" terminal would have turned the new unit wide open, or the alternator would have charged normally but with a warning light staying ON due to lack of "Sense" terminal. Obviously, this customer values the information I can provide them, otherwise they can buy that alternator from any auto part store, perhaps even cheaper, but would have wound up going through the proverbial rabbit hole and repeated alternator replacement.

IMI to Rescue…!

I had this Denso 028000-3930 starter (*Figure-12*) that a contractor brought in. They are a large construction company specializing in bridge repair, and according to them, this starter was used on diesel engine that drives a large air compressor.

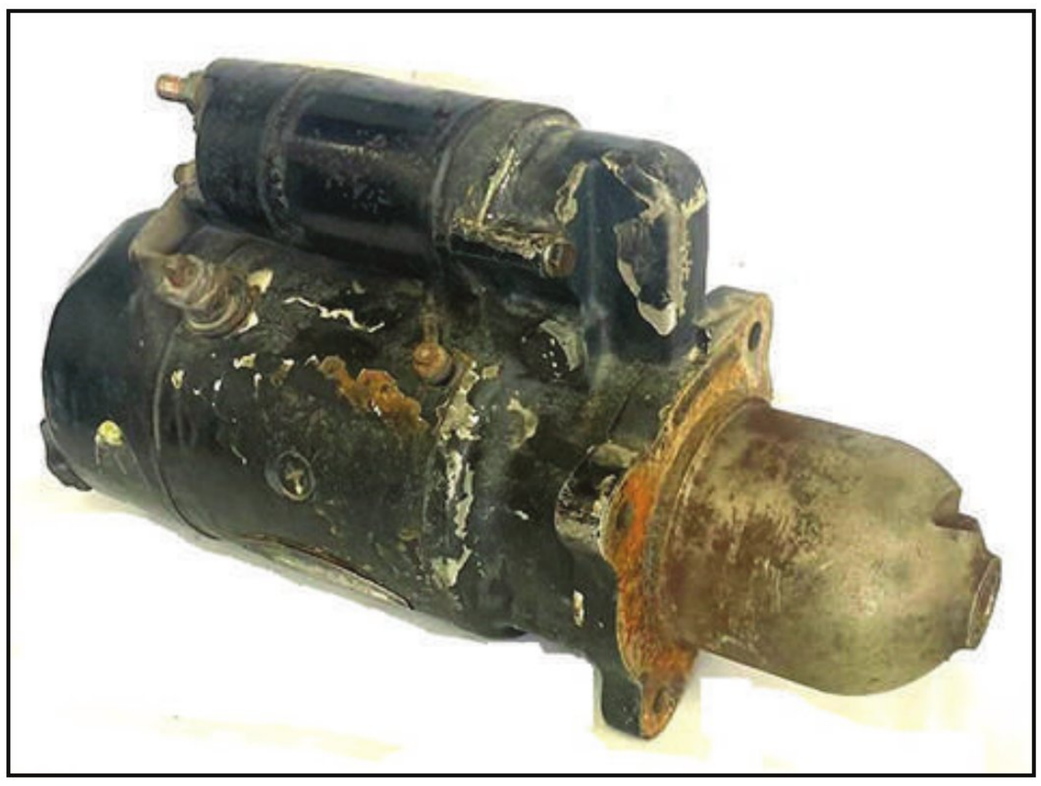

Figure 12 – Denso 228000-3930 Starter (NLA)

The starter was pretty well shot and the owner wanted a new replacement. As much as I tried, I failed to find this starter and major repair part such as field coil and armature were unavailable. The solenoid required knowing the date code of the starter which was nowhere to be found. So the time was right to call Jack Isom (IMI Performance Product, Inc.) and ask for help…!

Most of our members are familiar with IMI products and what a wonderful workhorse they make for just about any hard-to-find applications. Jack, in his typical cheerful and highly polite and helpful manner investigated the starter that I needed and after a few minutes called me back with suggestion to use an IMI-25002-002 starter shown in *Figure-13*.

The starter that has a rotatable DE housing was received without requiring any DE rotation or any changes. It was immediately picked up by the construction crew to be used at the job site. It turned out to be a perfect fit for the application and worked very well to the delight of our customer. I would like to thank Jack Isom and IMI that came through for me and saved the day.

Well, that's all for this issue. Until I see you again, keep up the good work and stay healthy.

You can contact Mohammad Samii by email at: sammyselectric@sbcglobal.net, or by calling the ERA Tech Help Line at 636-584-8324



Figure 13 – IMI-25002-002 Replacement for 028000-3930

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DIODES: IDENTIFICATION, TESTING, INSTALLING



BY NATHAN UNGER

If you stock a few different kinds of diodes, you can rebuild most rectifiers. So don't worry too much if someone brings you an oddball to rebuild.

Axial: I stock these in three sizes. (*See Figure 1*) These axial diodes are used in diode trio configurations, or as an antifeedback device. They have a bar on one end. That is the cathode, or the negative end if it is in conducting mode and not blocking. 6 amp, Cargo #134519. This is used as a rectifier on small engines, plus other applications as needed. 3 amp, Cargo #131294. 2.5 amp, (smallest body) Cargo #231670.

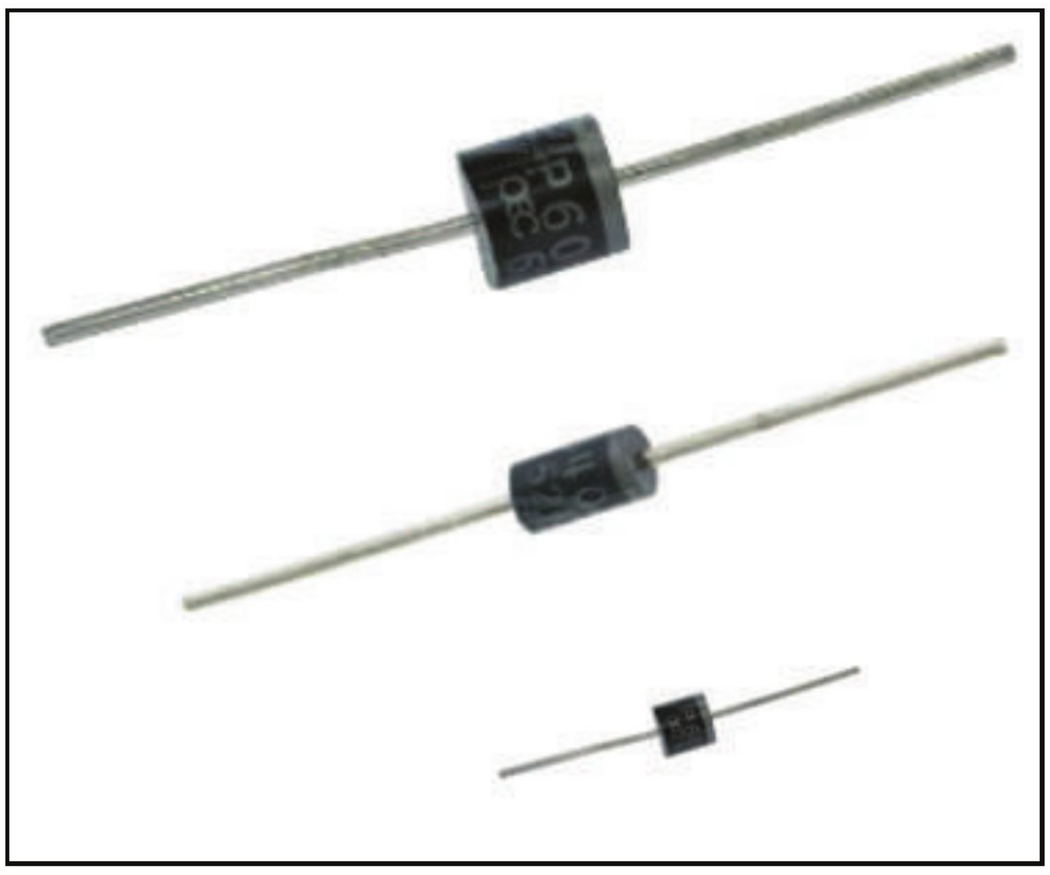

Figure 1

Press Fit: There are three main sizes of press fit diodes.

1) ½" Bosch, Motorola, Delco, Ford, or Leece Neville: The Bosch diodes have a fairly low profile. (*See Figure 2*) These fit into a ½" or 12.7mm opening in the heatsink. To install them, you use a round pusher bar.



Figure 2



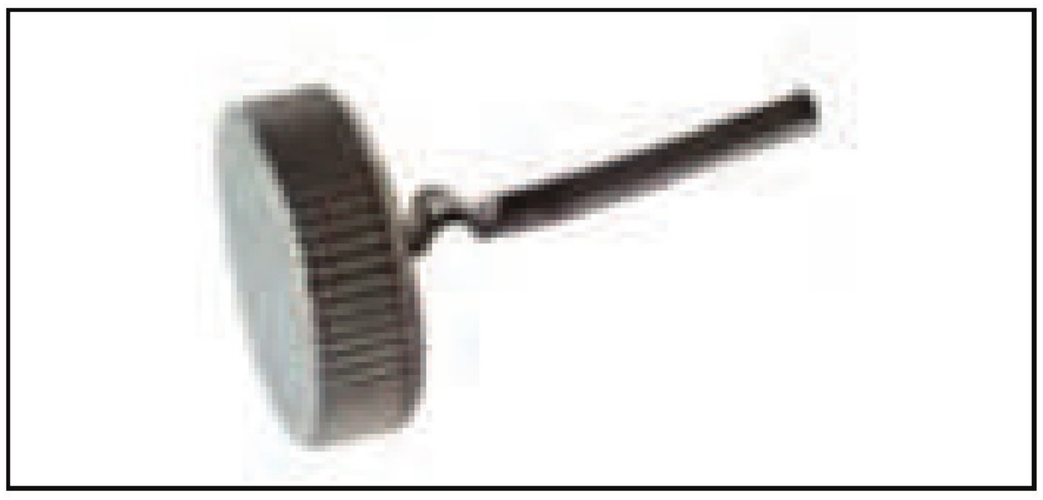

Figure 3

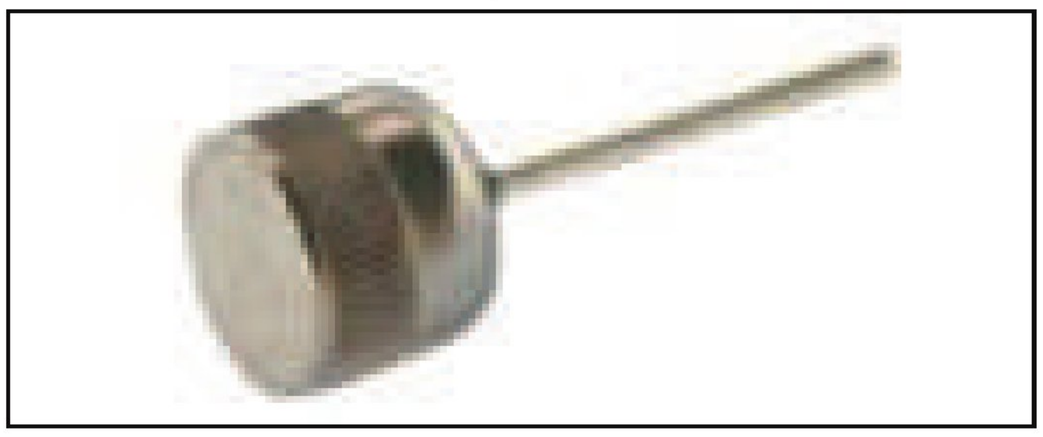

Figure 4



Figure 5



Figure 6

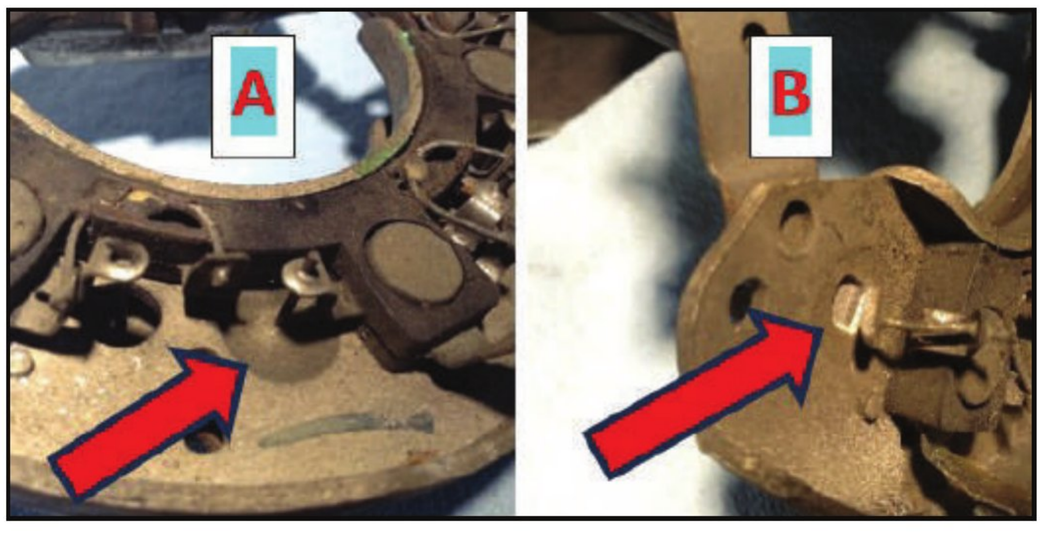

Figure 7A / 7B

The pressure you put on a diode when installing it into a heatsink should not be more than one ton of force and not less than about 350 pounds. One ton seems like a lot but I read about this in a Bosch installation guide, and they also recommend a specific shape and size of a pusher bar. It must have a shoulder and a slightly concave surface. To give you a feel for that minimum pressure, when I use my 3-ton (rack & pinion) arbor press, it's about a 20/1 ratio. Like 400 pounds of pressure is about 20 pounds on the end of the handle.

I believe this much pressure helps to ensure good heat conduction by contacting the heatsink firmly. That's also why the diode is knurled with ridges and valleys– to give relief to the aluminum, so it has somewhere to go when the little ridges are being forced in.

Of course, there are a number of different styles. Some have flag leads, some have really thick leads, some have a slight flange on the bottom, some have a large flange on the top (preventing it from being pushed right through), and then some have different profiles on top.

2) Hitachi: These are very flat. (*See Figure 3*) They fit into a 11.5 mm opening in the heatsink. The knurling will dig into the aluminum. I typically put some white heatsink compound on each diode when pressing it in to make sure it has adequate heatsinking, but also to help it go in a little easier, without galling the aluminum.

3) Lucas: These fit into a 10mm opening in the heatsink. (*See Figure 4*) Then there are the different ratings, but more on that later.

Solder-in: The kinds of solder-in diodes that I stock are the dish, button, block, tin can, and forked tin can. (*See Figure 5*)

Bolt on: These are heavy duty, used on 50DN's and others. (*See Figure 6*) I recommend they be installed with heatsink compound. They are used mostly on heavy duty alternators or under the cap of cutout relays for generators; to substitute the coil and contacts.

Some rectifier manufacturers like Hitachi, (*See Figure 7A*) Lucas, Nikko, and Delco used to solder (or passivate) the chip right onto the heatsink and then cover it with special sealant. The CS130 rectifiers had problems with the sealant and became famous for their failure rates. Now those rectifiers made by aftermarket factories mostly use pressfit diodes.

If it is worth considering re-using one of those kinds of rectifiers, I always pull on the stem with a fingernail and put enough lift as if I were going to bend the stem up. It will easily come apart if the diode has failed. (*See Figure 7B*)

I had put no more than 2 pounds of pull on the stem, and the diode came apart. This diode was already ruined by heat, even though it looked just fine.

Diode Polarity

Simply by which face of the chip they put down inside the case of a diode, the manufacturer makes it into an 'N' or a 'P' diode. In the case of the button diode, you can just turn the button over yourself. Some diodes are marked with a number and/or a "P" or an "N". Other diodes have a red dot or a black dot, or maybe the potting is colored that way. Some diodes have + or – on the bottom. With some diodes, you just have to mark them yourself.

For unmarked diodes, an easy way to tell is with your DVOM on the diode test setting. Put the black lead on the stem. If it conducts, it's an N diode. If it conducts with the red lead on the stem, it's a P diode. It's sort of intuitive.

Diode ratings

Here's where it gets technical. After reading articles and talking to people from Jimco, Vensel Enterprises, Diverse Enterprises (Bill Bowman), D&V electronics, Bob Wagner (Wagner Alternators), Peter Bain at Rand Premium Electronics, and others, it would seem that the most important measurements are the first three, in this order.

1) Forward Voltage Drop. Vf is my abbreviation. If I use a 10 amp limited current, the Vf is between 0.80 and 0.90 volts, depending on the diode rating. If I am testing a Denso rectifier, and one of the diodes is 0.02 volts more than the rest, I look to see if that is the neutral-rectified diode. Some manufacturers use a smaller diode there because the neutral (wye) does not have as much current through it. Otherwise, the diodes should all be pretty much the same, within less than 0.02 volts. This test has to happen quickly because as soon as the diode gets warm, its Vf will drop.

You can also do this test without separating the rectifier from the stator. This is because the if the Vf is too high or even open, then you will read voltage drop from another diode via the stator, but the stator has a voltage drop too, so you will see that the Vf is too high.

Diodes can be sorted by the Vf, which easily determines whether it is a 20 amp or an 80 amp and everything in between. This must be measured with the voltmeter connected to the diode separately from the amperage source. If you piggy-back the leads, then you will be reading the voltage drop of your source connection as well as the diode, and that will skew your readings.

When testing with 10 amps of current, the following approximate voltage drops I measure indicate to me the rating of the diode.

0.81 Vf - 80-amp diode
0.82 Vf - 70-amp diode
0.83 Vf - 60-amp diode
0.85 Vf - 50-amp diode
0.86 Vf - 35-amp diode

- and so on. You see that the cold Vf for a lower amp diode is higher.

2) Reverse leakage in microamps Irl. I read somewhere that up to 50 microamps is fine. More is not necessarily bad, if the Vf is good. I have found that if I am measuring reverse leakage at 12v, the avalanche diodes often have more leakage, as compared to the non-avalanche types, but that is not a problem.

If you are concerned about burning out the fuse in your multimeter when reading such a low current, put a 194 bulb in series with your measurement.

3) Avalanche voltage, Vav, in three ranges: 19-22 Vav, 24-29 Vav, 38-42 Vav. I shared one method of doing this measurement in the Jan 2022 ERE.

4) Reverse breakover voltage, Vbr. Some of the ratings used in automotive applications are 50, 100, 200, and 400 volts Vbr. These are non-avalanche diodes.

5) Forward voltage drop after you have heated the diode in the heatsink for a standardized time. (Vfh) There are also a number of other tests that the big factories do but I have gotten good reliability in my units by doing the first three.

Verify lead frame connections to the terminals of the rectifier. I do this with a 10amp limited supply and separately connected voltmeter leads. (Kelvin clips) If the connections are partly weak, there can be some very strange and baffling problems. The Transpo D200 (Taditel T4622) regulator was re-designed just because of this kind of problem. You can read up on that here.

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DIODES: IDENTIFICATION, TESTING, INSTALLING

Ford 4G, 6G, and some older Mitsubishi rectifiers are notorious for having bad connectivity from the regulator to the B+. Also check the stator and trio connection to the regulator.

Someone might ask, "OK so how do I get this 10 amp limited current?" Purchase two J&N 170-14003 resistors and put them in series with your 12v battery. 0.6 ohms + 0.6 ohms = 1.2 ohms. 12v/1.2ohms = 10 amps!

Sure it's not exact, but at least it will be reasonably consistent. Or go to Amazon and buy yourself a little 30v, 10a power supply for $100, like the TopPower PS3010H.

https://www.amazon.ca/Variable-Adjustable-Switching-Regulated-Adjustments/dp/B0BN1GZP9J/ref=sr_1_1?keywords=ps3010h&qid=1691511648&sr=8-1&th=1

Kelvin clips are also readily available on Amazon. (Kelvin measurement is also called four wire measurement. The brass jaws are isolated from each other.) (*Figure 8*)

A popular diode tester is the SR200 by Jimco. It can test diodes separately but will also test diodes while connected to the stator. It also can test the trio diodes (but at lower current) while connected to the stator. Regitar sells a diode tester VC-010, and Transpo has a DT301. I would include D&V electronics, but then we're talking big bucks. There are also others by MSG and Motoplat. From what I can tell, I think the SR200 would be my recommendation.





Figure 8



Figure 9

When selecting diodes, I use the 1/3rd rule, and round up to the next larger size. If it's a 200-amp alternator, 200/3 = 67 so then I will use a 70a diode. Bill Bowman wrote an article about that in the APRA magazine years ago. Ask me for a copy if you want one. It's quite interesting. If it's a 90-amp alternator, I will use a 30 or higher amp diode.

It happens once in a while that an alternator will come my way that needs diodes, but nobody shows a BOM for that alternator. Or if I can match it up, nobody has it in stock. Or maybe they have it but the freight cost and/or the time for it to arrive is not advantageous. Spending 30-45 minutes adds to the cost of the rebuilt unit, but sometimes it's worth it.

Here are some procedures: Take a picture of the rectifier first and mark the negative and positive heatsinks (N or P) with a letter stamp. Do this on the lead side of the diodes so you know which way the heatsink faces when you reassemble the rectifier. A felt pen or scratched marking might not be legible after it has been cleaned. *Figure 9* is out of an old Toyota Landcruiser 100213-0520, Lester 21079.

DIODES: IDENTIFICATION, TESTING, INSTALLING

As you take it apart, take more pictures to show which way the insulators go, and make sure no insulators or washers get lost.

To drill out rivets, I put an end mill on the head end of the rivet, and then drill it out from the other end. The end mill keeps the rivet from turning when I apply the drill pressure. (*Figure 10 A/B*)

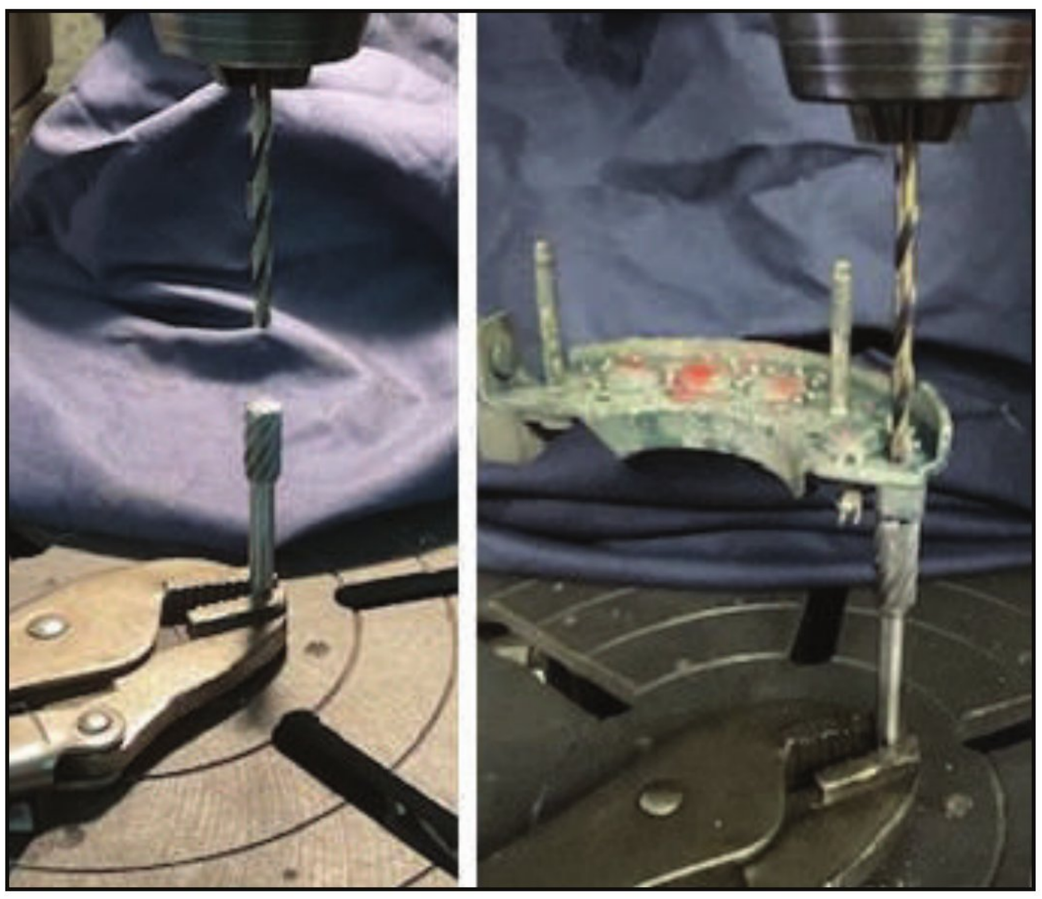

Figure 10A / 10B

Test the conductance of all the lead frame connections. I also check the capacitor after verifying determining that there is no diode leakage. First I short it to discharge it, then I use my capacitance function on my DVOM. Meter polarity is important. If I have the black lead on the side that's connected to B+, then the capacitance meter will be wrong because the diodes are trying to conduct. *Figure 11* shows a 6G rectifier with a 2.2 microfarad capacitor.



Figure 11

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1.2kW

Yanmar Marine Applications
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Soldering Diodes

I use 60% tin/40% lead solder (J&N 900-20010) which melts at 375 degrees. That way, the solder temperature is just a little higher than the maximum operating temperature of the diode junction inside, which is rated at somewhere around 300 degrees maximum. You don't want the solder to melt under normal operating conditions. This is not the maximum rectifier temperature which is much cooler, maybe around 212 degrees, according to what I read somewhere.

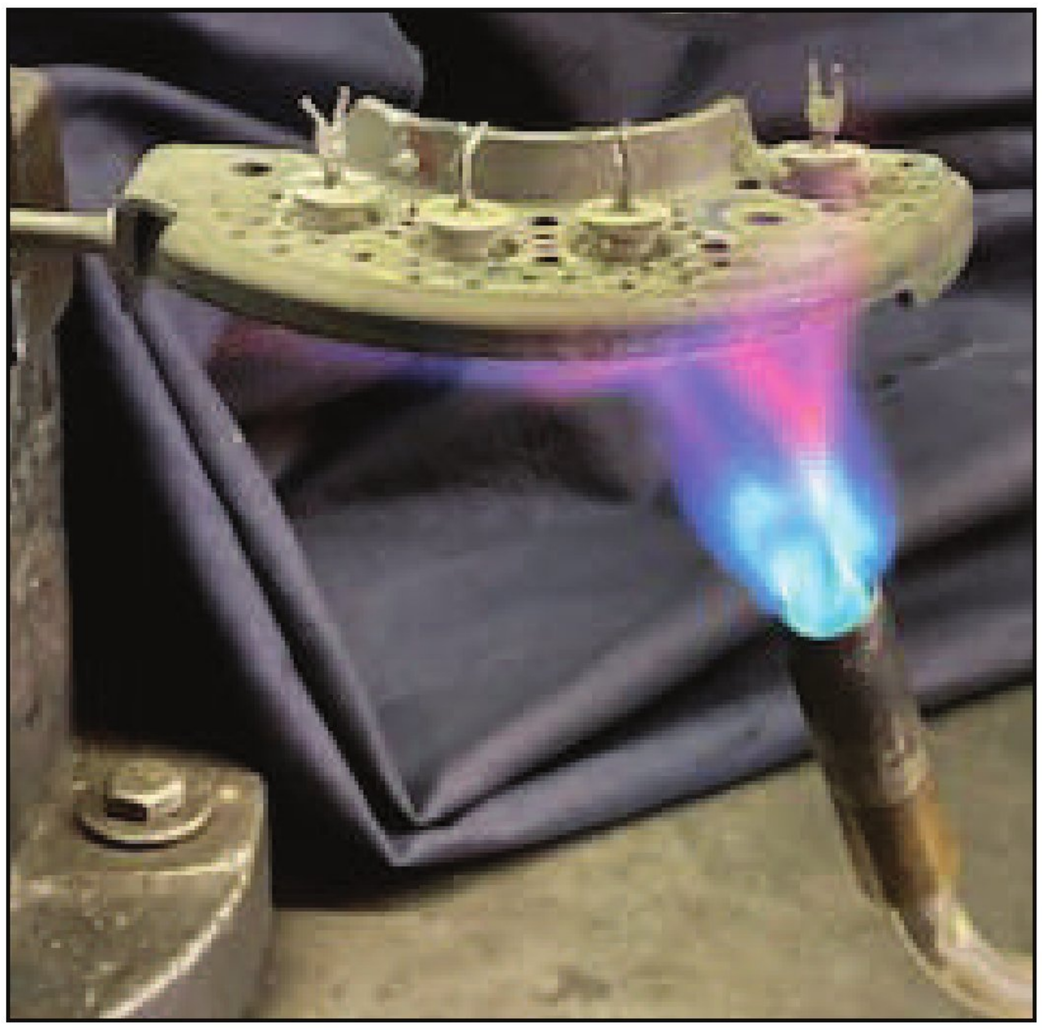

Figure 12

First I remove all the lead frame and plastic parts from the old heatsink. The knurled mounting bolts come out fairly easily by supporting the rectifier however you can, and then give many light taps with a small hammer.

Then I warm it with a propane or mapp gas handheld torch just until the solder melts. Then I use an airgun to blow away all the old diode pieces, solder, and corroded stuff, if there is any. (Figure 12)

Then I take it to my glass bead blaster and clean it thoroughly. (Figure 13)



Figure 13





Figure 14



Figure 15

By the way, if the heat sink is new aluminum, that's ok too. I bought Richard Vensel's DVD on soldering and learned how to do that. It's available from the ERA. (I don't glass-bead an aluminum heatsink before soldering. If the aluminum heatsink has been arc'd out, corroded or has lost its plating, I have not yet figured out how to solder to that, no matter how much I have cleaned, filed, or brass-brushed it. Maybe someone can give input on that?)

Next, I apply flux (J&N 900-20039) and warm the heatsink again, applying enough solder to tin the area where the diode sits plus a little bit to make the solder layer about 1 mm thick. (Figure 14) I keep the process very short to avoid corrupting the solder with excessive heat times. The flame should be waved to the side periodically because it only has to keep the heatsink at temperature, not keep on getting it hotter and hotter.

Now I grind the nickel plating off the back of each diode so that I don't have to heat it so much to get the solder to flow. Brass solders much easier than nickel. (Figure 15)

If the stems are nickel plated, I grind them a wee bit too, so I can solder to the leads later, although I prefer to 'spotweld' the leads to the lead frame if I can, using a little ribbon silver.

I apply flux to the newly bared surface and seat the diode in place on the heat sink. When I have all the diodes in place, then I warm the heat sink again, and watch each diode "settle" as the solder bonds to it, moving the flame from one to the next. I then immediately remove heat. This must be done well, but also quickly so that the heat doesn't have as much chance to damage the diodes. And then - don't budge anything until the solder is solidified. Sometimes I will carefully blow on the heat sink from underneath with an air gun to cool it more quickly. But then I must be careful to not unsettle the diodes or the solder. When everything has cooled, then I test the diodes again, double-checking that I have the correct polarity of diodes.

Many thanks to Mohammad Samii, and Bob Thomas who have mentored me during this season of writing articles for the ERE.



Figure 16

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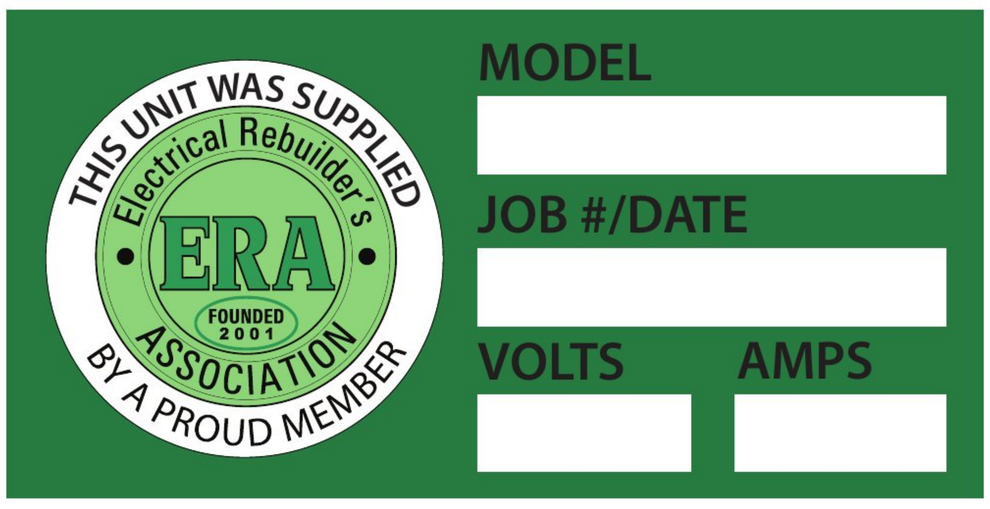

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