ERA EXCHANGE

YOUR GUIDE TO ELECTRICAL REBUILDING

June 2017 $12.95

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Electrical Rebuilder's ERA Association Founded 2001

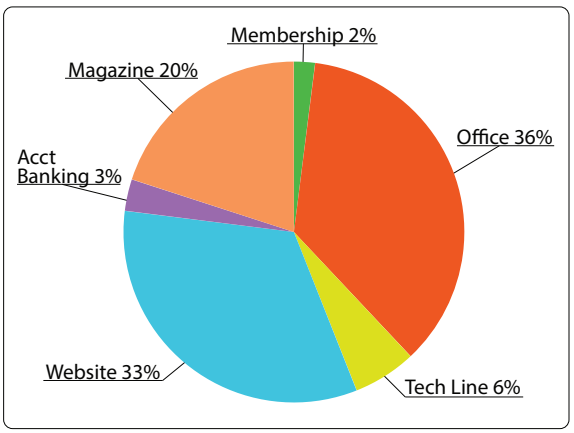
A WORD FROM THE TREASURER
$ Where Does the Money Go? $

As the treasurer of the ERA I am sometimes asked, "Where do the dues that I pay each year go?" I thought this would be a good time and place to refresh every one as to the answer to this question.

The Association's finances are kept on Quickbooks which enables me to pull financial info with a few key strokes. The following percentages I am sharing with you only reflect the percentages as they relate to membership dues and not the percentage of the annual budget.

Starting on the top of the pie chart is the Membership Drive Expense (2%) which this year included the production of the YouTube video highlighting the Tradeshow and its events.

Second, clockwise around the chart is the largest single category but includes many line items which are grouped together under Office Expense (36%). This category includes office rent, electric, cable internet, contract part-time labor, postage, office supplies, telephone, computer equipment and software.



Next is Technical Help Line Service (6%). This is a small percentage for such a large service to our membership. The ERA has been fortunate to have had several individuals with extensive rebuilding backgrounds to field questions and help solve rebuilding and troubleshooting problems.

Our Website, *www.electricalrebuilders.org* costs you merely (33%) of your dues check. Our website not only stores and archives all technical data produced and acquired, but has every detail about the association from the membership bylaws to a directory of all you members. It showcases all the products offered to you for sale by the association as well as other business aids in the form of commonly used office forms, documents and logos. It holds the largest library of wiring diagrams, alternator hookup diagrams and electrical technical service bulletins of anywhere on the internet. Not to forget the Forums section that will assist you in finding hard-to-find parts or maybe a tech tip from a fellow rebuilder as well as other feature sections like the latest on the Tradeshow or other events.

We all have the pleasure of paying for bank account fees, credit card fees and of course an accountant to keep us all legal! The ERA is able to hold that cost to just (3%) for all of these fees annually.

Lastly is the "Exchange Magazine", the industry's Crown Jewel of Rotating Electrical Publications. Twenty percent (20%) of your dues helps offset the cost of producing the monthly magazine. Although the magazine relies on its advertisers to produce each issue the revenues still fall short of being self -sufficient each month. The advertising staff is working diligently with our advertisers to keep this magazine, now 24 pages, growing.

Each December the Board of Directors put on the hat for the Budget Committee. We mull over all the financial info for the past several years and develop the annual budget which helps steer the association for the next financial year. The largest $ line item is the income from annual member dues; it by the way is the also most important number. Each board member takes your commitment to membership to heart; we strive to provide the greatest number and most valuable benefits to you our fellow rebuilders, our members!

Mike Schroeder

ABOUT THE COVER

A close look at the contacts inside a typical SPDT relay.

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NEW ERA MEMBERS

Kocab Auto Electric
Kinsman, Ohio

Curtis Morton Industries
Molalla, Oregon

Newton Electric, Inc.
Brampton, Ontario, Canada

ERA NEWS — Mohammad Samii Joins ERA Team

Noted industry educator and writer, Mohammad Samii, has joined the ERA team in an official capacity as Technical Advisor effective May 1. In addition to writing his monthly column, "Auto Electric Corner" for the ERA Exchange, his new duties include answering the association's Tech Help Line, suggesting topics for technical training and presenting seminars at future events.

Known throughout the automotive repair industry by the nickname "Sammy", he has been involved in electrical rebuilding since 1973 and opened his own business, Sammy's Auto Electric Service, Inc, in Champaign, IL in 1979. He started teaching seminars for the APRA in 1992, the same year he began writing Auto Electric Corner for the APRA's then Electrical Connection. His column ran continuously through three publication name changes for nearly 25 years. He previously held the position of Coordinator of Electrical Training for the APRA.

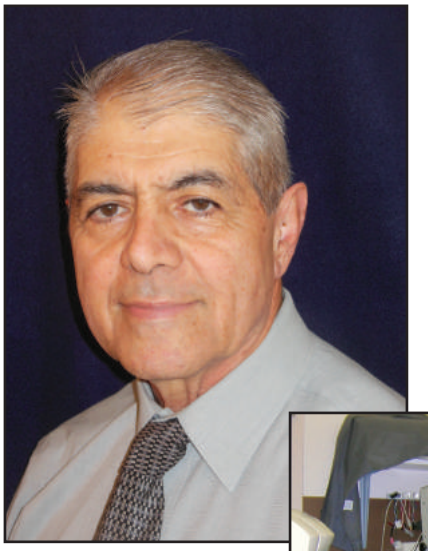
Samii currently conducts automotive technician training classes in advanced charging/starting systems troubleshooting and repair for numerous regional and national venues such as the Automotive Service Association, Vision Hi-Tech Training, Automotive Training Expo, Auto-Value and others. He has spend untold hours on iATN, an internet forum for automotive repair technicians, addressing charging and starting problems and questions in an attempt to improve the reputation of our industry.

He is also a member of a select training group called The Driveabilty Guys that consists of five trainers, proving nearly 45 courses in advanced automotive electronics and scope usage. They cover a variety of subjects such as diagnostic, driveability issues, module programming, PCM flash, security and immobilizer systems, fuel trim and misfire diagnostics. For this group, he teaches charging/starting courses (intermediate and advanced) as well as specialized classes on import electrical and an Electricity for Technicians course at different levels.

"We are very excited to have him aboard, providing technical help and advice to our members," stated ERA President Mike Dietrich. "Sammy has been actively working to enhance training in our industry for over 25 years. He has been an ERA member and a regular contributor on our website's Forums for several years.

"Our bylaws state that the ERA's purpose is to provide information and training to our members while promoting professionalism and public awareness of our industry. I view this as taking another big step toward fulfilling that commitment."

"I am looking forward to serving the ERA as Technical Advisor and writing Auto Electric Corner for the Exchange", Samii explained. "I have come to know many ERA's members over the years and hope to now meet many more by answering the help line. While I may not always have an immediate answer to all questions, I will try my best to find answers. For that, I will be using the ERA's online Tech Library and Archives, All-Data, MotoLogic and other resources that I have access to."



PLAIN TALK — BRIDGE THE GAP
By Educating and Relating

BY ROB BUKSAR

Back in another life, I was having a conversation with Ronnie Holcombe's (Holcombe Armature) number one guy. I believe his name was Doug. I caught him on his way out the door to visit some targeted customers whose business had dwindled dramatically.

Of course, his mission was to stimulate sales and try to recoup business. That was foregone. What I was interested in was how he intended to approach it. What was his plan or strategy? He just wasn't going into the customer's office with his hands in his pocket, stare and grin!

Doug told me as their customer base aged, folks they formally had long-term relationships with either *retired,* died or moved on. They were replaced with folks much younger, better educated yet lacked the understanding, depth and overall big picture view of what they were doing. (Similar to taking a vacation by paging through a National Geographic yet never leaving the confines of the living room.)

Doug felt his mission was to reintroduce himself and the company. To remind his client of the long history Holcombe had and the value to continue the relationship. This usually took a little time and more than one visit. Why? Because a lot of educating had to take place for the younger purchasing guys who seldom even knew that their parts could be rebuilt at a great bargain compared to buying new. Most weren't even aware that there was a rebuilding industry out there!

"Most weren't even aware that there was a rebuilding industry."

That all seemed to occur eons ago. Since NAFTA was signed, the U.S. has lost over 60,000 manufacturing companies. The rebuilding industry was not immune to the effects of modernization and globalization either. We are only a shadow of our former self. Furthermore, I think the ignorance level of many of our customers are higher than ever, especially the larger customers. At very best, they are real different than we are!

For those of us who are going on 30 to 40 years in this business, we have seen purchasing and management folks come and go. They continually get replaced by a 24 year old with a MBA in some sort of business discipline. The problem is that MBA wouldn't have gotten them out of the high school that most of us graduated from! Any of you dealing with this type of customer is well aware of what I'm talking about. They're pretty good with the spread sheets and multiple operating systems yet they're 10 cents short of understanding the big picture as to why they are there and what they're doing!

These are usually difficult folks to sell or maintain good business relations with. Wondering why? In the room you're both in, there is two distinctly different levels of understanding and maybe even two different languages being used. Under those circumstances, it's unlikely that you're going to sell squat and/or continue doing business until you can really begin communicating successfully.

If you want to see a great movie that dramatizes this issue better than I ever could, get your hands on a Clint Eastwood film called "Space Cowboys". Clint stars in it along with Tommy Lee Jones, Donald Sutherland and James Garner.

The four principles in the movie ushered in the space age with the breaking of the sound barrier, supersonic aircraft, etc. They were called into work with NASA astronauts, engineers and current technology 30-plus years later. You see, NASA needed to retrieve a satellite put up into space with Clint's guidance system which was now 30 years old, obsolete and written in an engineering language that none of the current PHDs, astronauts or anyone else could understand. Clint and all his old buddies had to be sent up on a space shuttle to fix the satellite because no one else could understand it. I highly recommend that you see this movie. It's not only widely entertaining, it's educational and packs a real punch clearing up the reason why we fail more than we should.

So, the moral of the story is simply this. Our customer base, which used to be a lot of small operations, is being replaced by fewer yet much larger corporations. Management and purchasing have probably never been hands-on or even remotely familiar with what they're presently doing till they've answered a help wanted ad and were hired on. Further, their education and life-level experience is so different than yours; one of you might as well be from another planet. Your first assignment is to begin bridging the gap so both of you can end up on the same page. How else can you possibly do any business if you can't successfully communicate?

Falling short of being a nag or intrusive, I suggest that you find reasons to stay in regular contact with them. Frequent phone calls, a note, or a card will do. You don't need a holiday or birthday to be friendly and giving, build a relationship or a friendship. So this client will always take your call and never hesitate calling you even to get help with an unrelated problem. While this is occurring in a very subtle way you need to be educating so at the end of the day, you're both closer to being in the same place.

Is this hypocritical? Of course not, this is similar to what we all did while child-rearing, or should have and we did that out of love and concern.

My departed dad was one of the greatest salesmen that I've ever known. He always claimed that the best customers are well-informed and well-educated. It was the salesman's job to get the customer to that high level of competence. Dad said, "If you can educate, you can move to the top of the ladder and always get the first call." As business people, that's the best of all worlds, to get the first call from someone looking for help or products.

So, "Bridge the Gap", educate and relate then move to the front of the line. God Bless America and our little industry!

Rob can be reached at IWI 1-800-323-7521 or rob@iwico.com

AUTO ELECTRIC CORNER — Something Old and Something New

BY MOHAMMAD SAMII

I have written a few articles for the Exchange in the past. However this is my first official Auto Electric Corner column, now a regular monthly feature for the ERA Exchange.

For those who are not familiar with my column, Auto Electric Corner appeared monthly in the APRA's newspaper called Electrical Connection which later changed its name to Global Connection and lately Reman Connection. I started writing it in 1992, for a period of nearly 25 years, 12 issues per year. Now my column will appear in the ERA Exchange magazine and will go on as long as the members (hopefully) want it and I am able to write. But given my age, I cannot promise you another 25 years!

The purpose was, and still is, to share my work experience with my fellow rebuilders and discuss a variety of subjects, ranging from rebuilding, diagnostics, shop management issues, and updates on the trends of industry in general and automotive electronics in particular. From time to time I may hint toward an upcoming event, updates on newer units or technology and industry trends as I learn more about them myself.

Another subject that I may discuss at times is the problem of incompatibility and/or interface between an alternator and the vehicle that it goes on. The fact is in today's advanced designs, just because an alternator works on the test bench is no guarantee that it will function flawlessly on the vehicle. I will share some special cases as my work has turned more into diagnostics, fixing vehicles that had multiple units installed by different technicians, or have strange wiring problems preventing them from starting, charging, or running properly.

Since many ERA members are not APRA members and perhaps were not on the recipient list of their paper, I assume there are many who have not seen my column before. So from time to time I may review, repeat or revive a subject that I feel may be of interest or worth updating due to more recent changes.

And finally I would like to mention that I am completely open to any suggestions by readers, regarding special cases they have seen or feel would be of interest to fellow rebuilders. If there are any particular cases or units that you feel you need to know more about, as far as performance, specifications, power curve…etc., I will be very much interested to hear form you, and do as much as I am able to provide answers to the request. Your suggestions will always be welcomed.

Having said so, let's see what's going on…!

Old Technology…but Interesting!

We had this 1946 Chevrolet starter, 1107061 (*see Figure 1*) to rebuild. I noticed that it had a special switch attached to the field case. It toggled and clicked anytime the starter was operated. Since the starter had a foot operated switch, could this have been a neutral safety switch of sort…or if not, what was it?

Looking back at some old books and scratching my head to remember things from the bygone years, it came to me that this was a sort of novelty, designed by GM and used during most of the 40's. It was called a *Polarity Reversing Switch* (*see Figure 2*).

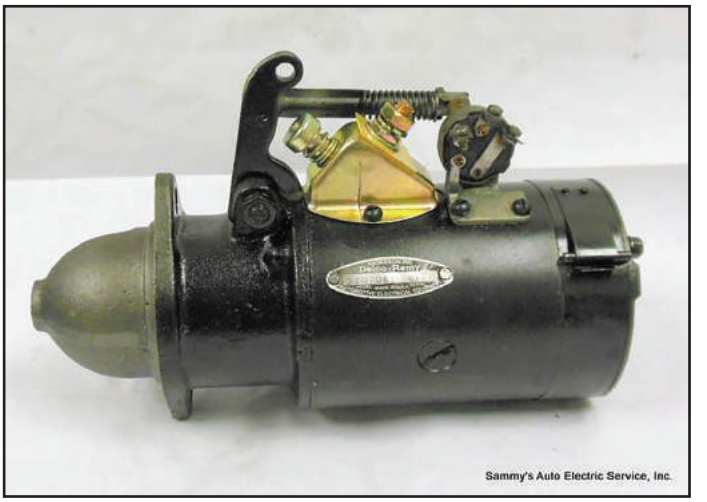


Figure 1 – 1107061 Starter

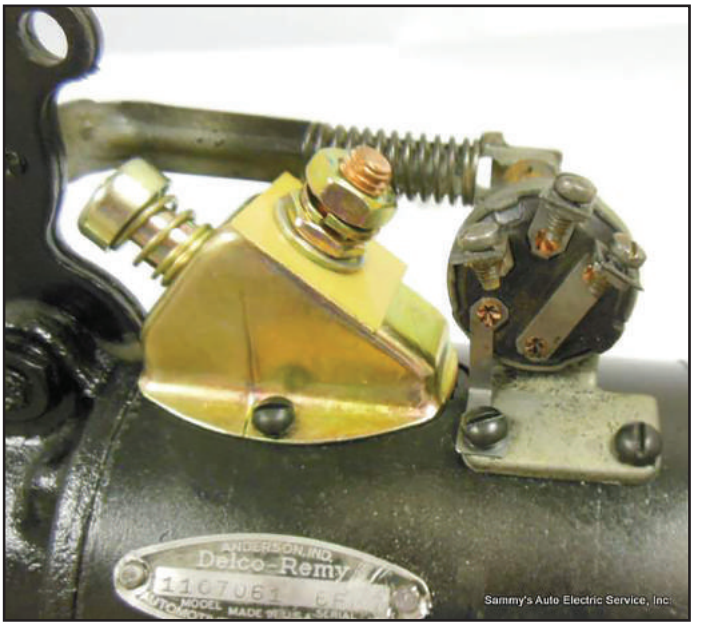


Figure 2 – Polarity Reversing Switch

In those days, pitting of the contact points in the distributor was an issue that affected the longevity of the points, not lasting long. To partially overcome the problem, they invented this polarity-reversing switch, which at every start reversed the direction of the current to the contact points. The distributor's plate was insulated from the ground, and the ground was routed through the switch. At every start attempt, the current path would reverse going through the points to cause even wear on both sides of the contacts, minimizing and sort of evening out the pitting, to make the points last longer!

I suppose that the added complexity to the system was the reason they stopped using it in 1948. But I guess using harder metals such as Tungsten alloys in the design of the points helped them to extend point life without this switch.

It is interesting to see how far we have come since old point and condenser system to electronic ignition, DIS with no

moving parts, and the latest coil-on plug (COP), and exotic plasma ignition. They all need dedicated processors and modules of their own to control and fire the plugs.

And the New…but equally interesting…!

Changes in technology and the way it affects our business is not only interesting to see and experience, but at times it looks like we are being witness to a roving display of technological development going right through our hands, our workbenches, and through our business every day. Here is an example:

A Neutral Safety Switch used to be a simple device attached to the bottom of the steering column or bolted to the transmission with the purpose to only allow cranking when the transmission shift lever was in the "Park" or "Neutral" position. To a very small degree they still exist, particularly in older vehicles but now they have almost all gone by the wayside.

A step above the simple switch was the type used mainly by Chrysler which was bolted to the transmission. A mechanism in the transmission would touch the tip of a plunger in the switch, contacting it to ground, thus make a ground path for the starter relay's coil.

In 2002 Chrysler changed the design of their control modules and introduced a new type call Next Generation Controller or NGC. It was first introduced on the LH series cars but it gradually proliferated into their entire line. NGC uses high-side drivers, meaning rather than grounding a relay or device to make it work, they apply +B to the device. It combined the ECM and TCM into one unit, thus became a Powertrain Control Module or PCM, controlling both engine and transmission (*see Figure 3*).

The alternator field control was a good example of NGC, where one alternator brush is internally or externally grounded, and the controller applies and toggles +B to control field current, thus controlling the charging rate in a B-circuit fashion. This is a total departure from when Chrysler used A-circuit operation to control alternator field via modules or their electronic regulator.

Figure 3 – Next Generation Controller (NGC). Note: Four 38-pin Connectors

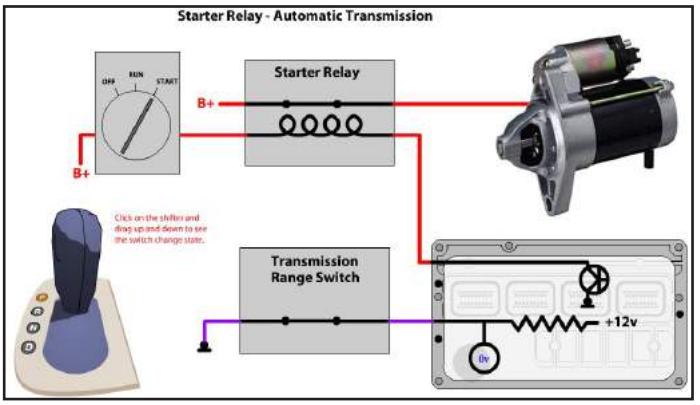


Figure 4 – NGC Starting Sequence-Cranking (Source: DCA)

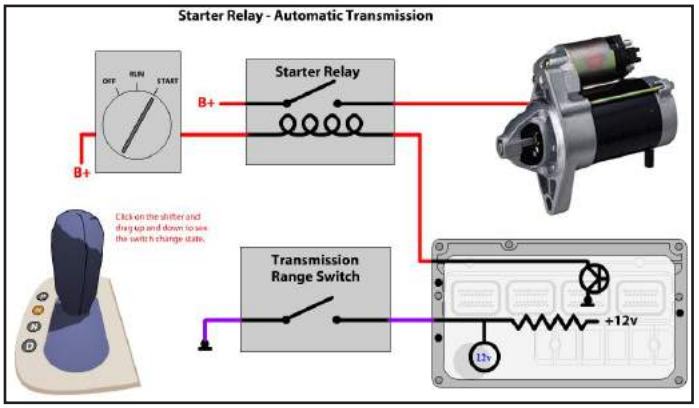


Figure 5 – NGC Starting Sequence-Not Cranking (Source: DCA)

The function of the Neutral Safety switch is now part of the NGC operation and this is how it functions:

When the driver turns the switch to the start position, a 12 volt internal power is applied to a dropdown resistor which completes the circuit to ground via the Park/Neutral switch built inside of the transmission. The NGC monitors the voltage across the resistor. If the voltages drops low after the resistor (going to ground via the switch in the transmission) it considers it as "YES" signal, and allows a power transistor to turn on, completing the starter relay's control circuit, energizing it, and allowing the engine to crank (*see Figure 4*).

Once the gearshift lever is moved from the park position to "Drive", the switch opens the resistor circuit, and the applied voltage stays high. It does not drop since it has nowhere to go! At this point the NGC sees the voltage as being "High". It interprets this as a "NO" and will not allow the starter relay to energize, thus no cranking is possible (*see Figure 5*).

As you see, a simple function of an old-style Neutral Safety Switch is now incorporated into the PCM that monitors it via its internal logic circuit and determines to allow cranking or not. A faraway departure from the function of a simple switch that was used for ages and we were all familiar with.

Well…I hope you liked my first official Auto Electric Corner Column for ERA Exchange, and please do not forget to comment on it. Until I see you again, keep up the good work.

SWITCHES, RELAYS, AND SOLENOIDS
Controlling Current: What, When & Where

BY BOB THOMAS &
WES GRUENINGER, SR

The words switch, relay and solenoid are sometimes used interchangeably by people throughout our industry, and this has caused some confusion. It happens, in part, because all three devices are used to control current flow, and the definitions employed to describe them "overlap". A case in point is the Integrated Magnetic Switch, or IMS, found on Delco-Remy 39MT starters (*see Figure 1*). It is often referred to as a relay. So, is it really a switch, a relay, or a solenoid? Read on and decide for yourself.

A switch is any electrical component that is used to open, close or otherwise alter current flow within a circuit (*see Figure 2*). While we may immediately think of a common on-off toggle switch when we hear that word, a switch does not necessarily have to be controlled by a lever, button or knob. A switch may also be activated by any sensing mechanism that uses temperature, pressure, or other dynamic force capable of creating movement. This includes being electrically controlled. Therefore, the word switch is used generally to describe a wide array of devices that can be utilized in different situations to control current flow. By this definition, the IMS is a switch, as are all relays and solenoids.

A relay is a device that is activated electrically by a low current or signal in one circuit to open or close a higher current in another circuit (*see Figure 3*). Most of us picture a Bosch cube relay, which uses electromagnetism created by current passing through a coil on the low current side to close or open mechanical contacts on the high current side. But in today's world, there is a growing movement toward using a solid-state relay or SSR. An SSR has no coil or contacts. Instead, it is a semi-conductor device which can be activated by a very low current. It contains a thyristor or transistor which controls the high current side.

A solenoid is an electromechanical device, that uses a coil of wire wound around a movable iron core to do work (*see Figure 4*). The solenoid behaves like a relay when a low current passes through the coil and creates a magnetic force, causing the iron core to move and accomplish specific tasks. The task could be: moving a starter drive into cranking position, opening a fuel valve or closing a set of contacts. Most starter solenoids today perform more than one function, and most of those have two coils.

Having defined these devices in a technical sense, we will explain each in further detail and cover some of their more common malfunction symptoms and their causes.

Switches

Electrical switches have evolved considerably since their inception. Today, some switches only signal "intent" to an electronic module, which in turn activates the circuit. These switches seldom need to carry more than a few thousandths of an amp. In the past, headlight switches on passenger vehicles commonly handled 20 amps or more for extended periods of time. The headlight switch of today merely signals a module which activates internal SSRs that power exterior lamps.

When replacing or installing a switch, your primary concern should be its load-carrying capacity, expressed as an

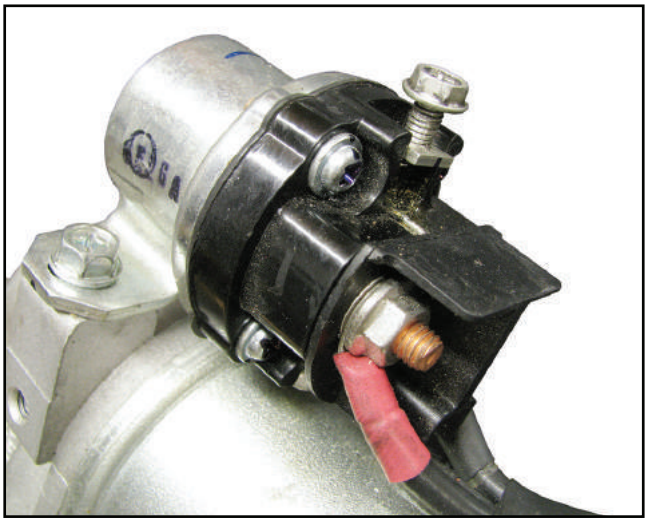


Figure 1 – Delco 39MT IMS. Is it a switch, a relay or a solenoid?

Figure 2 – Switches come in many shapes and sizes. All are used to control current flow.

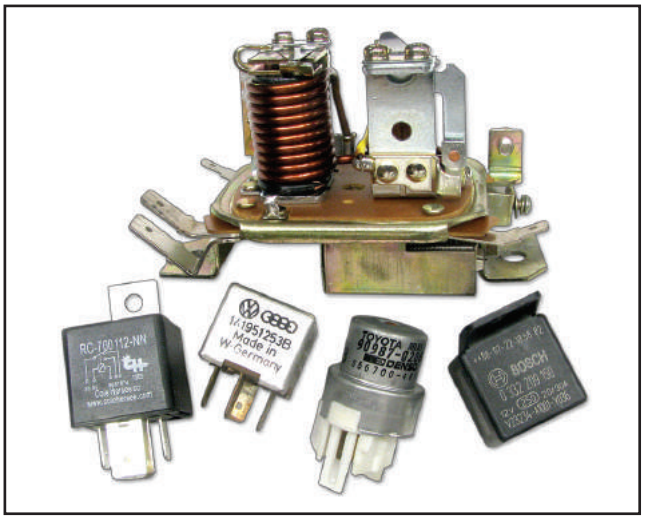


Figure 3 – Relays can be found inside voltage regulators or as stand alone control devices for high current requirements.

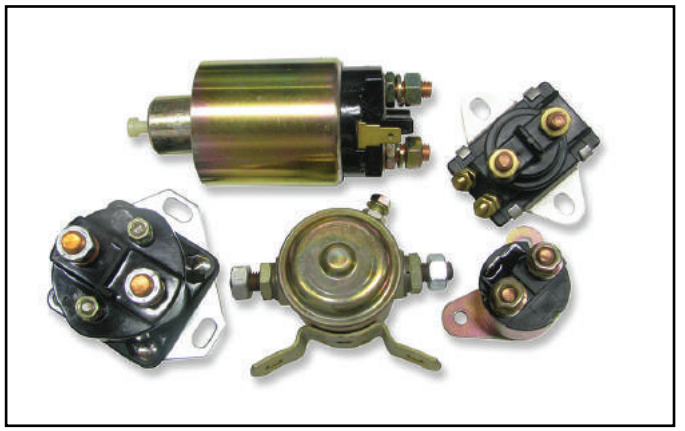


Figure 4 – Solenoids may be used to control current, complete mechanical tasks like shifting a starter drive or both.

Figure 5 – The voltage drop shown here was made while passing 75 amps through the contacts.

amperage rating. This is assigned by the switch's manufacturer, based on the size, composition and construction of the current-carrying surfaces, and the spring tension holding the contacts closed. Keep in mind that current flow will change dramatically, both when the contacts are closed and when they are opened. It is at these times where arcing occurs and most contact wear takes place.

When purchasing switches, remember that the rating is only as reliable as the manufacturer. Each switch also has a voltage limit, which has more to do with contact separation, arcing and safety. This normally is not a concern in the low-voltage applications found in most vehicles. Of course, electric cars using high-voltage battery packs are a whole different story and require unique solutions.

Like all other components of electrical circuits, every switch introduces some resistance into the circuit. While switches are seldom replaced until they fail completely, a suspect switch can be tested for voltage loss by applying a controlled load through its contacts and measuring the voltage drop across the terminals. If the switch is good, the reading should always be less than one tenth of one volt.

As the load is increased, the voltage loss increases, as you can see in Figures 5 and 6. To control the load, we tested a 75-amp switch by wiring it in series with the output terminal of an alternator on our test bench. Most switches can be overloaded briefly without damage. Remember that all lost voltage creates heat. It may be normal for a switch to feel slightly warm during constant-duty use. But if it feels hot, there is either too much resistance in the contacts, or they are being heavily overloaded.

Relays

Relays have been in use for more than 150 years. A relay was one of the two main components of the telegraph that Samuel Morris patented in 1840. (The other part was a momentary switch that he named the "key".) All relays employ a stationary iron core with a coil of wire wound tightly around it. The most basic relay consists of five primary parts (*see Figure 7*):

1. a wire coil wound around an iron core
2. a steel yoke attached to the iron core
3. a hinged steel armature attached to the other end of the yoke
4. a spring attached to the armature that applies force to hold it away from the iron core
5. a set of contacts, one moving (attached to the armature) and the other stationary.

Figure 6 – The voltage drop here was made while momentarily overloading the switch by flowing110 amps through it.

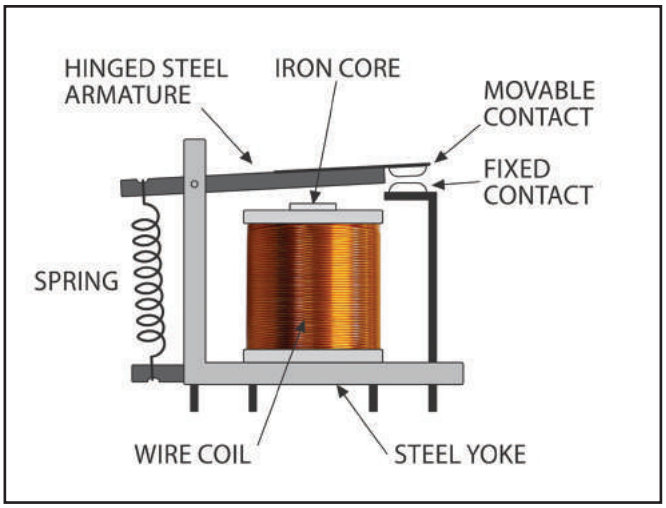


Figure 7 – Parts of a basic SPST NO (single-pole single throw normally open) relay.

The operation of this basic relay is simple. A small amount of current is passed through the coil to magnetize the iron core. That, in turn, pulls the armature down to close the contacts, which can carry a much higher current than the coil requires. If you were to reposition the stationary contact, the same relay could normally be closed, then it would open when activated (*see Figure 8*). The switch nomenclature (NO and NC) refers to normally open and normally closed.

By adding a fifth terminal and a third contact to the same relay, you can switch between two different circuits—one normally closed which opens when activated, and the other normally open which closes when activated (*see Figure 9*). This relay can switch between two circuit paths.

More complex relays are used to accomplish just about any type of switching requirement. For example, vibrating contacts are used to control voltage and limit amperage in a mechanical generator-regulator. Another example is the generator cutout-relay, which is a dual-coil relay—one coil closes the contacts, while the other coil holds them closed.

Relays are rated by amperage, but they are voltage specific because of the coil. While you could safely use a 120-volt switch in a 12-volt application, the same is not true for a relay. Relay contacts are also less forgiving than most switches. They should never be overloaded, not even momentarily, because the contacts could be permanently damaged.

The most vulnerable part of a relay is its contacts, simply because they wear from arcing with use. The resulting uneven contact surfaces increase the inherent resistance, which can

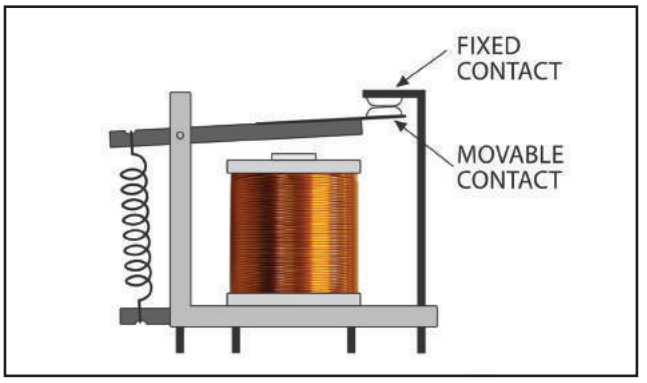


Figure 8 – SPST NC (single-pole single-throw normally closed) relay

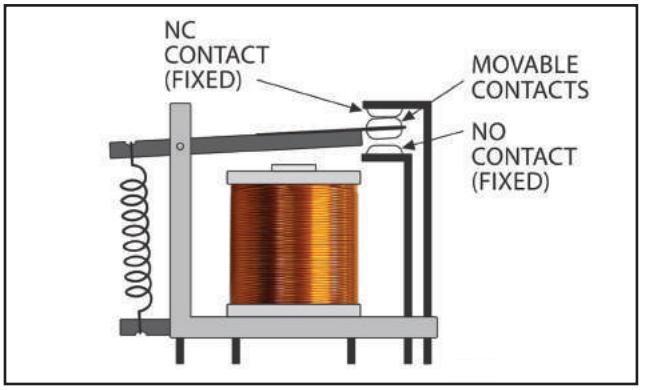


Figure 9 – SPDT (single-pole double-throw) relay

cause them to overheat, stick in the closed position, or fail to close altogether. As with any other switch, you can test relays for voltage drop across the contacts. Since the contacts of most relays cannot be inspected, this is a good indicator of their condition.

We tested a popular 50-amp Bosch relay at both 20 amps and 40 amps (*see Figures 10 and 11*). As you can see, the voltage drop is higher than we found in our mechanical switch. Any relay that loses more than one tenth of one volt should be considered suspect, especially if it is in a continuous-use application.

Figure 10 – The voltage drop shown here was taken with a 20-amp load on the relay.

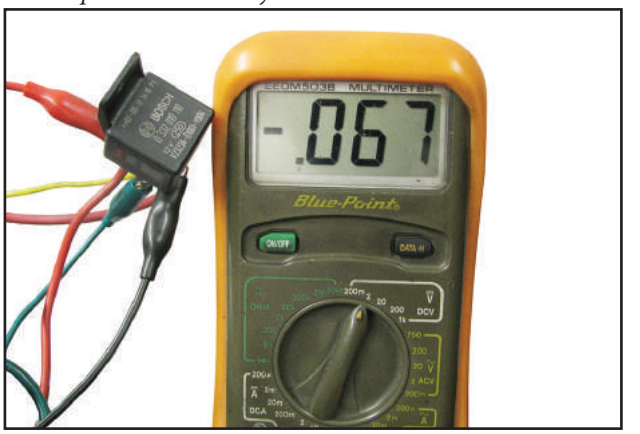


Figure 11 – The voltage drop here was taken with 40-amp load on the relay.

Solid-State Relays

Because of improvements in semi-conductor technology, SSRs are being used more today in many applications. They have no moving parts, and they can now carry loads of up to 100 amps. A solid-state relay has several advantages over an electromagnetic relay, such as: much higher switching speeds, smaller size, longer life and the ability to be controlled by extremely low current.

However, SSRs will probably never completely replace electromechanical relays on vehicles for several reasons. The first is the voltage drop that is inherent in all semi-conductors. While contacts in conventional relays have some resistance that causes a small voltage loss, each SSR has a specific voltage drop on the load side, which can be as high as one full volt. That loss in electrical energy is converted into thermal energy—heat that must be dissipated.

That heat (which increases with the load being carried) is a bigger problem than the voltage drop. High amperage SSRs require a heat sink or air circulation to survive. There are ways to compensate for the voltage drop in most SSR applications, because it does not change with load. As such, it can be dealt with more easily than a voltage drop in a set of contacts (which changes with wear).

SSRs are also more vulnerable to short-term overloading failure. When they do fail, they have a tendency to do so in their "closed" state. Failing to open could create safety concerns in some applications. This failure mode is the exact opposite of a mechanical relay, which would most likely not close when it fails, resulting in an open circuit.

Solenoids

The defining characteristic that differentiates a solenoid from a relay is its moving core. If a movable iron plunger is present in a device, it is a solenoid—even if it only closes a set of contacts. Typically, a solenoid's coil is wound on a bobbin that has a brass or stainless steel sleeve inside the bobbin. This allows the plunger to be near the coil to gain maximum magnetic influence, while the plunger can slide freely inside the sleeve without harming the wire's insulation.

Solenoids come in many different configurations. Some are designed to perform specific mechanical functions. Solenoids can be used to actuate valves, move levers or close electrical contacts. The most common solenoids in our industry perform two functions: shifting a starter drive into cranking position and closing a set of contacts. Any solenoid that closes contacts is also considered a switch.

Solenoids that perform a single task typically require only one coil. They are energized by current flow through that coil,

which creates a magnetic field to pull the plunger. When current is removed, the magnetic field collapses, and a spring returns the plunger. If the solenoid has contacts, a second spring is used to break the connection.

However, dual-purpose solenoids, the most common type found on starters since the 1970s, have two coils that are dependent on one another. These are sometimes called "dual-stage" solenoids, and the coils must be balanced, with an identical number of turns in each (*see Figure 12*). The stronger coil, wound of a larger gauge wire, is called the "pull-in coil". It draws high current to pull the plunger inside the coil. This action engages the starter drive and ultimately closes the contacts. One end of that coil is connected to the solenoid's switch terminal, and the ground side of that coil is connected to the starter's motor terminal. Simultaneously, current also flows through the "hold-in" coil, which is also powered by the switch terminal but grounded directly to the solenoid's case or a dedicated ground terminal. That coil is wound with a smaller gauge wire, resulting in a lower current draw.

This arrangement allows current to flow initially through the pull-in coil and the starter motor in series. The resistance of the pull-in coil limits amperage to the motor, causing it to rotate slowly as the pinion moves toward the ring gear. This gradual

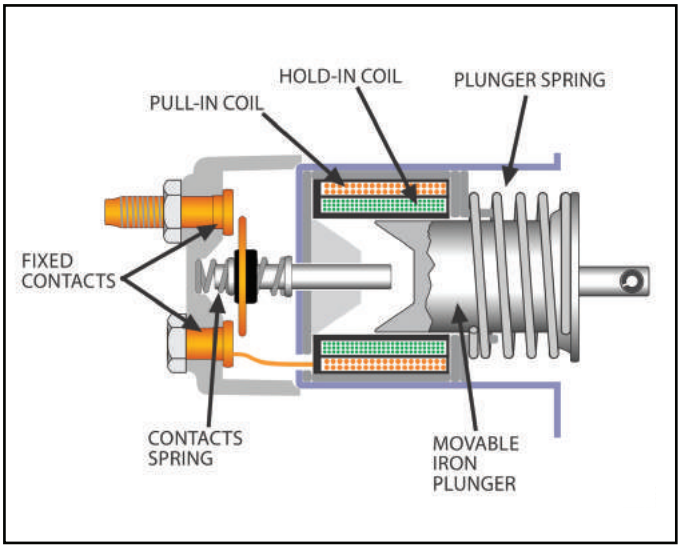


Figure 12 – Typical starter solenoid showing internal parts

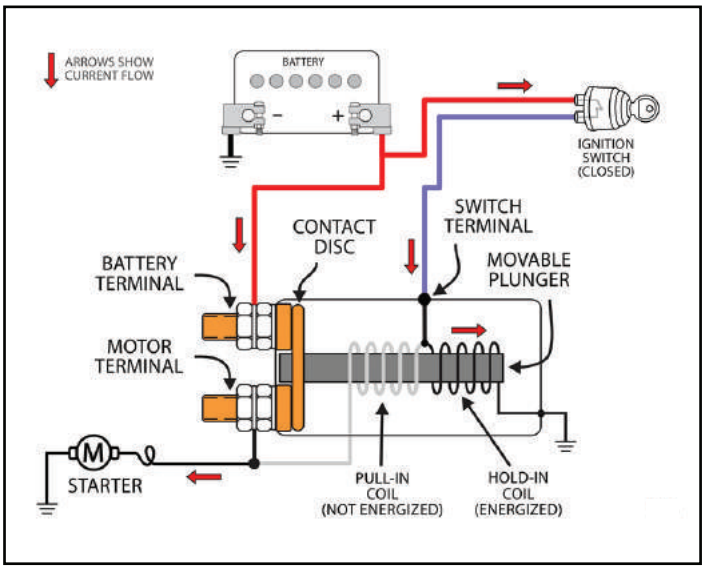


Figure 13 – Typical starter solenoid showing current flow during cranking

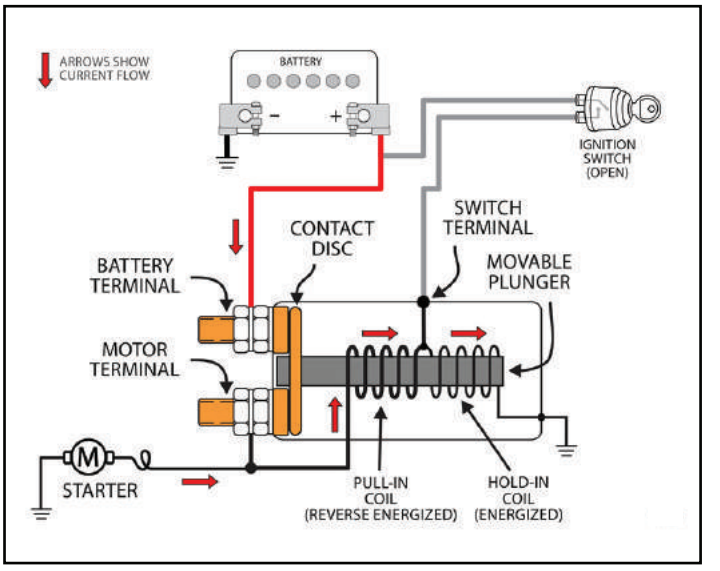


Figure 14 – Typical starter solenoid showing current flow when the key switch is released.

rotation ensures a smooth meshing of the two gears. It also prevents the plunger from closing the solenoid's contacts until the pinion is fully into the ring gear and the engagement is complete. This prevents the pinion from milling against the ring gear.

Once the contacts close (*see Figure 13*), the motor terminal receives full battery voltage to crank the engine, which causes the "pull-in" coil to lose its ground. (With positive voltage at both ends, no current can flow through it.) This leaves only the "hold-in" coil to do the job of keeping the contacts closed during cranking.

Following engine-start, power to the switch terminal is removed. At this point, the solenoid's contacts are still closed and are now applying positive voltage to what previously was the ground side of the "pull-in" coil (*see Figure 14*). This allows current to flow backwards through the "pull-in" coil to the switch terminal, which is no longer powered, but connects to

the "holdin" coil which is grounded on the other end. With the coils now in series, the same current flows through both (but in reverse direction through the pull-in coil). Since the polarity of the pull-in coil has been reversed, its magnetic field has also been reversed. With both coils being balanced with an equal number of wire turns, their magnetic fields are equal in strength. But they are opposing one another, so they cancel each other—releasing the plunger and breaking the contacts with the help of the springs.

The condition of any starter's solenoid contacts can be tested the same way as the contacts in a switch or a relay. We checked a new Delco-Remy PMGR starter in a free-spin test to get a baseline voltage drop (*see Figure 15*). With the starter drawing 100 amps, you can see that the voltage drop was just 0.01 volt.

Starter Solenoid Failure Modes

Understanding exactly how a starter solenoid works will help you to diagnose a problem when one arises. Below are a few common failure modes, along with possible causes for each and the test methods that you can use to identify and isolate them.

No crank and no click – When you get no response from a starter, the first test should always be verifying that you have correct voltage. Attach your meter's ground to the starter's case or the ground post if it has one. Verify that you have a charged battery connected to the solenoid's battery terminal. It should be 12.6 volts (and no lower than 12.5 volts). Otherwise, check and charge the battery before proceeding. Next, test voltage on the solenoid's switch terminal. With the key turned to start, the voltage on the switch terminal should be at least 12.0 volts. Lower voltage readings indicate a problem on the vehicle or with the battery. A remote starter switch can be used to bypass vehicle wiring for test purposes.

If voltage is good at the switch terminal, and the symptom persists, move your meter's ground lead to the solenoid's motor terminal. When you turn the key to start, the meter should read close to battery voltage, because the resistance through the motor's circuit to ground is minimal compared to the solenoid's coil. If the voltage is low or goes away altogether, it indicates a problem inside the starter—an open armature, open field coil or bad brush connections. If it is very close to battery voltage when you turn the key to start, and it still does not pull in the plunger, then you may have a bad solenoid, a binding plunger or a drive stuck on the splines.

Clicks but no crank – When you hear a solid click but get no response from the starter, it usually means that the contacts are not closing. Verify voltage first, to be sure it is sufficient to close the contacts, as described above. If the voltage is good on the solenoid's switch terminal, most likely, the problem is mechanical, not electrical. In other words, something mechanical is limiting the plunger's movement. Double check the plunger and shift lever for damage and ensure they are correct for the starter. Measure the pinion's at-rest location on the shaft in relation to the starter's mounting flange, and compare that to the position of the ring gear in relation to the mounting pad for the starter on the transmission or engine. For example, some starters were made to be mounted using spacers. If the spacer was misplaced or lost, it would put the ring gear too close to the pinion, limiting drive and plunger travel and preventing the contacts from closing.

Chatters rapidly, no crank – When you hear a starter chatter rapidly, it is almost always an open ground connection in the solenoid's hold-in coil or voltage dropping away on the switch terminal. The majority of hold-in coils are wound with fine wire and spot welded to the solenoid's steel case, out of sight. You can easily test for this with the solenoid removed from the starter. Secure a good ground to the solenoid's case, power the switch terminal and push the plunger in by hand, far enough to close the contacts. Once they are closed, slowly remove your hand. The hold-in coil should keep them closed if it is good. At this point, to verify that the weld is secure, lightly tap the solenoid on a hard surface, while being prepared to catch a flying plunger in the event the weld is broken.

Cranks but stays engaged – When the starter cranks the engine, but it fails to disengage, there are several possible causes. Checking for voltage on the solenoid's switch terminal

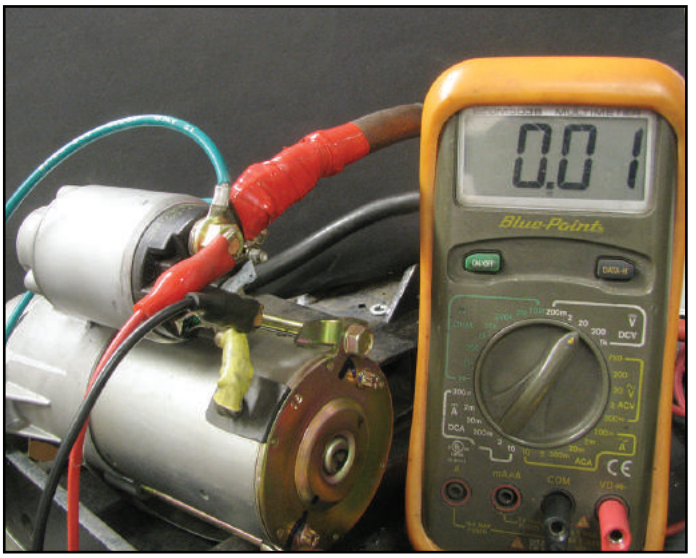


Figure 15 – This voltage drop was taken on a Delco PMGR starter drawing 100 amps during a free spin test.

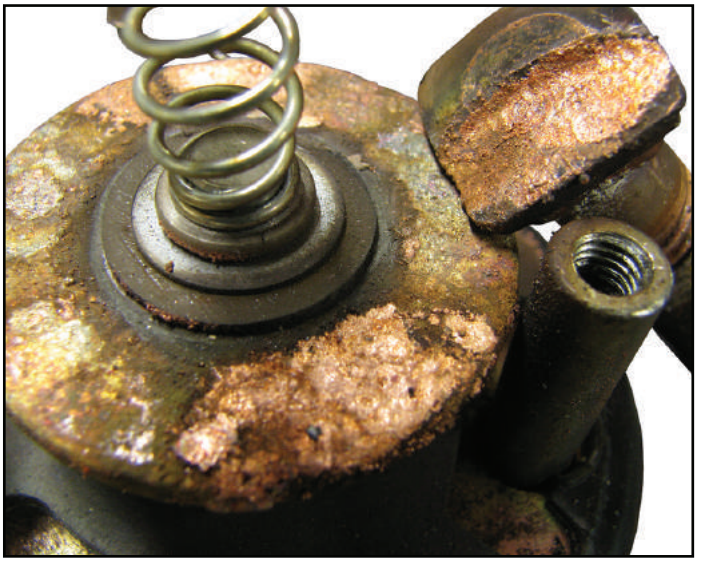


Figure 16 – This solenoid was removed from a 37MT starter that had stayed engaged with the engine running.

after the key is released should be your first test. There should be none. Even a few volts on the switch terminal is sufficient to throw the solenoid's coils out of balance and prevent disengagement. Disconnecting the switch wire and cranking with a remote switch is another test to eliminate that possibility. Of course, a solenoid imbalance is another possible reason, as is welded contacts, caused by extended cranking with low voltage. Solenoids can become imbalanced when coils short internally, which allows current to essentially bypass some coil wire turns. Internal shorts can develop from vibration or overheating from extended use.

If a solenoid's plunger can be rested freely inside the coil's sleeve without a spring, you can do a simple balance test by powering the solenoid's motor terminal with operating voltage and grounding the solenoid's case. The plunger should move freely with absolutely no magnetic attraction. If you suspect that the starter was cranked with low voltage, causing the contacts to stick—look inside. If that happened, the proof can be found there (*see Figure 16*).

Delco-Remy's Integrated Magnetic Switch

What do you think now? Is the Delco-Remy IMS a switch, a relay, or a solenoid? The given name is magnetic switch. But relays and solenoids are both types of magnetic switches, similar but distinctly different in one way—the iron core. If it is fixed, the IMS is a relay. If it moves, it is a solenoid. We dissected one so that you can decide for yourself (*see Figures 17 and 18*).

You may have noticed that we mentioned very little about different types of electrical loads, how each influences arcing differently, how that affects contact wear and the need for suppression devices in modern circuits. Look for more on those subjects in a future issue.

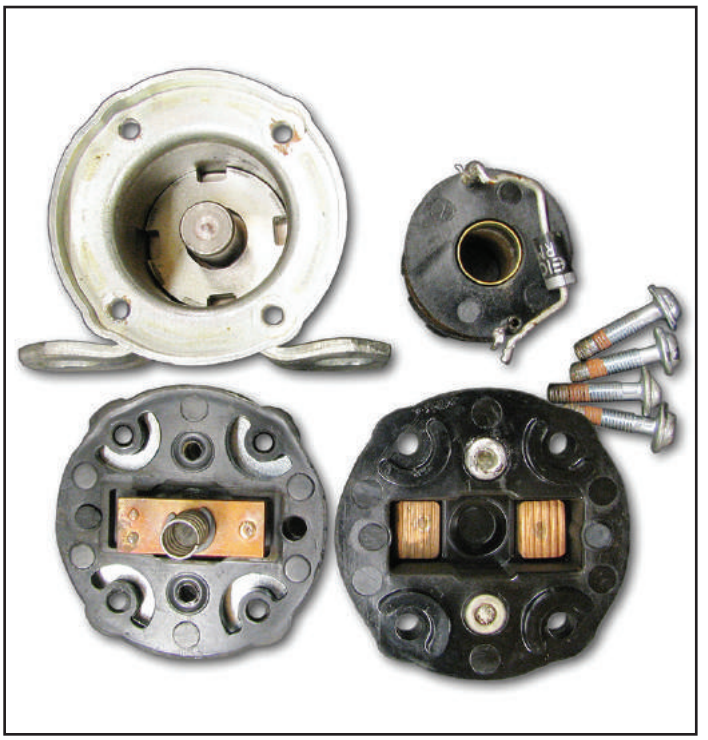


Figure 17 – This is a disassembled Delco-Remy IMS (Integrated Magnetic Switch).

Authors' note: The basis of this article comes from a presentation given by Dan Smith at an APRA training clinic (June 2010). For many years (and for good reason), Dan has been known throughout the electrical rebuilding industry as "Mr. Solenoid". We thank Dan for providing his source material and also for his tireless work promoting education throughout the remanufacturing industry.
Wes Grueninger, Sr. and Bob Thomas
May, 2017

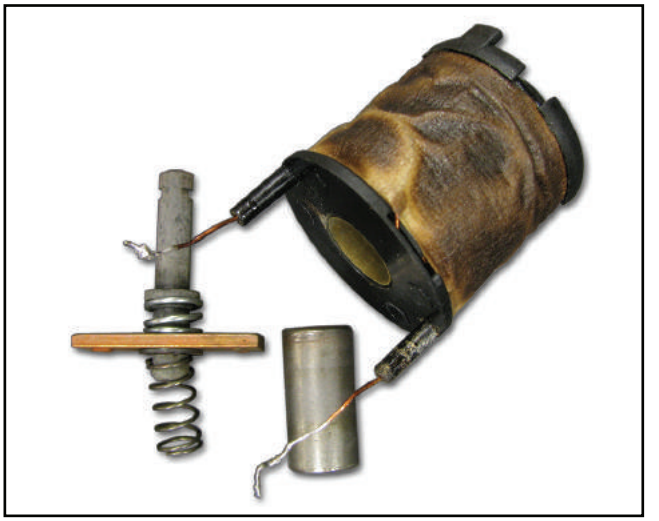


Figure 18 – This is a closer view of the coil, plunger and moving contact.

2017 ERA Honor Roll

The following members were recognized at the 2017 ERA Expo in Dearborn, Michigan for having been added to the ERA Honor Roll for having had at least ten years of continuous membership.

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EXPLORE THE ERA WEBSITE
Using the Forums Part 4: Uploading Photos


BY JESSICA MYERS
& BOB THOMAS

A picture really is worth a thousand words, but adding photos to a Forum post has been a challenge for some of our members. This month we will guide you through the process of attaching photos to your Forum posts. It is quite easy, once you get the hang of it.

Whenever you start a new post, it opens a screen with a text box where you type your question, reply or comment. If you scroll down below that that, a second is labeled **Additional Options**. One option that is offered is **Manage Attachments**. By left clicking it, a pop-up box opens (*see Figure 1*).

At the bottom of the Manage Attachments box, you will find a list of file formats that can be added to your post and the maximum size limit for each one. Most people who have had trouble attaching photos are exceeding those limits. Today's cameras and cell phones produce high resolution photo files that are much larger in size than needed to show detail on your monitor, which has a relatively low resolution. The limit for a JPG file is 803.1 KB and 1024 x 1024 pixels This is necessary to conserve server space and insure fast data transfer speed.

Once you locate the photo file that you want to attach to your post, you need to check its file size. Unless it was taken many years ago, chances are high that the file is too large. There are three solutions. The first is to change your camera or phone's compression setting to it's lowest resolution before you take the photo. That will probably get you within limits, depending on the camera.

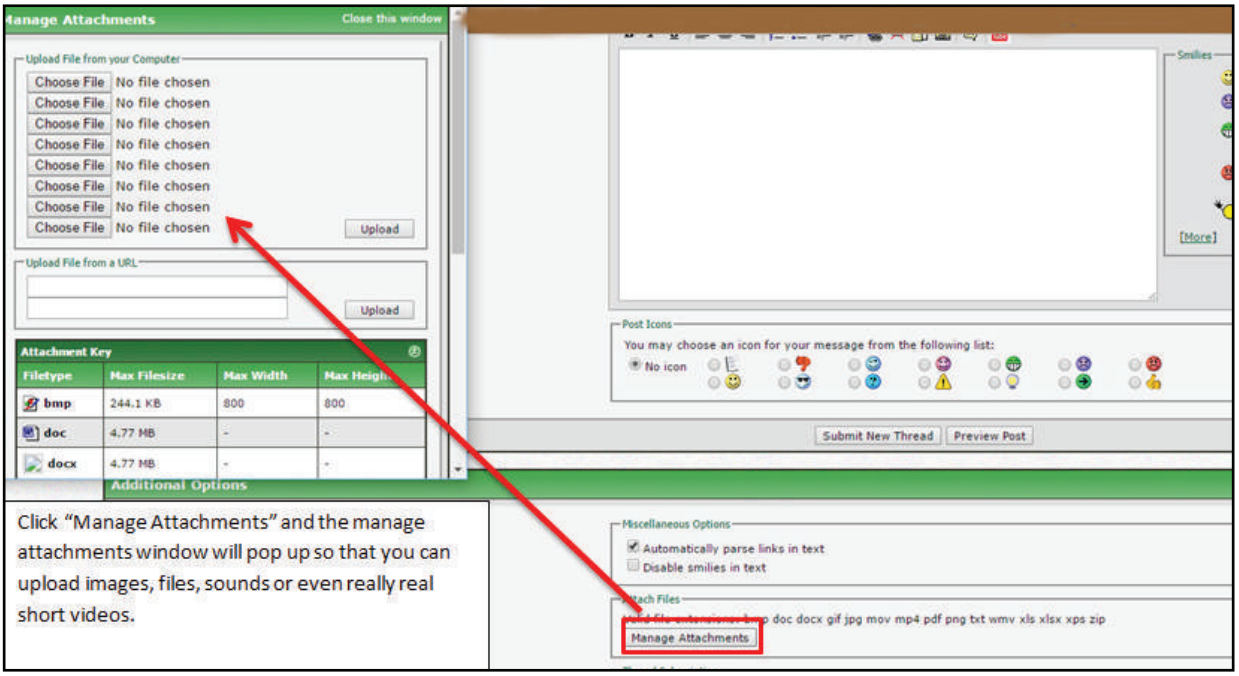


Figure 1 – New Thread page showing Manage Attachments button and Manage Attachments pop-up with JPG limit's circled.

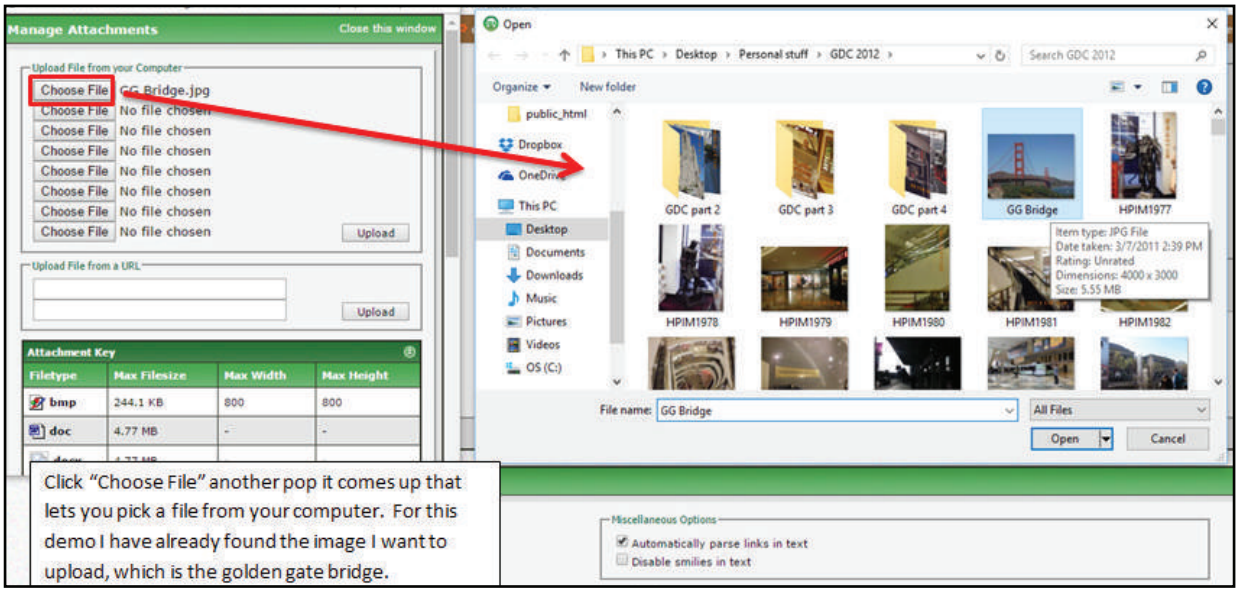


Figure 2 – Pop-up with Browse button circled.

The second is to re-size the photo using a photo managing program, if you have one. These programs also have other tools to help you organize, modify or otherwise alter photos. If you already have a photo program, check to see if it will resize a JPG for you.

A third alternative is to ask either of us for help. If you send us the photo by email, we can downsize it for you and upload it to your post. Just let us know which Forum it is on and the subject name of the thread.

Assuming that you have located the photo and confirmed it is within size, click on the Choose a file or Browse button on the pop-up box (*see Figure 2*). This should open a small File Upload window on your screen. Use it to locate the photo on your computer and click the open button. The photo's file name should then appear next to the Choose a file or Browse button. If you have more than one photo, use the next browser button and so on.

Once you have them all selected, click on the Upload button below and to the right. You will see "Please Wait" until all files are uploaded. Then the file names will appear where it told you to wait. Each file will have a Remove button next to it, in case you decide not to use it. It will also show each file's size (*see Figure 3*). Then you can close the pop-up window to go back to the text box on the post or reply page where your attachment will now be listed under Manage Attachments. Type your message and preview your post using the Preview button. That should load your post with the photo. Make sure that it is OK, then click the Submit button to put in on the Forums.

Once you have done this a few times, it becomes second nature.

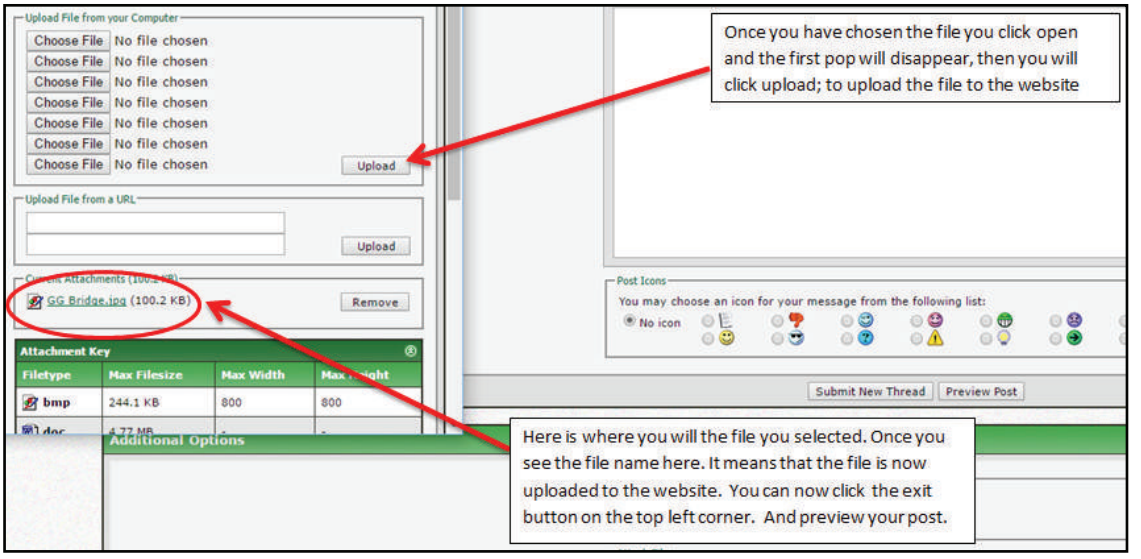
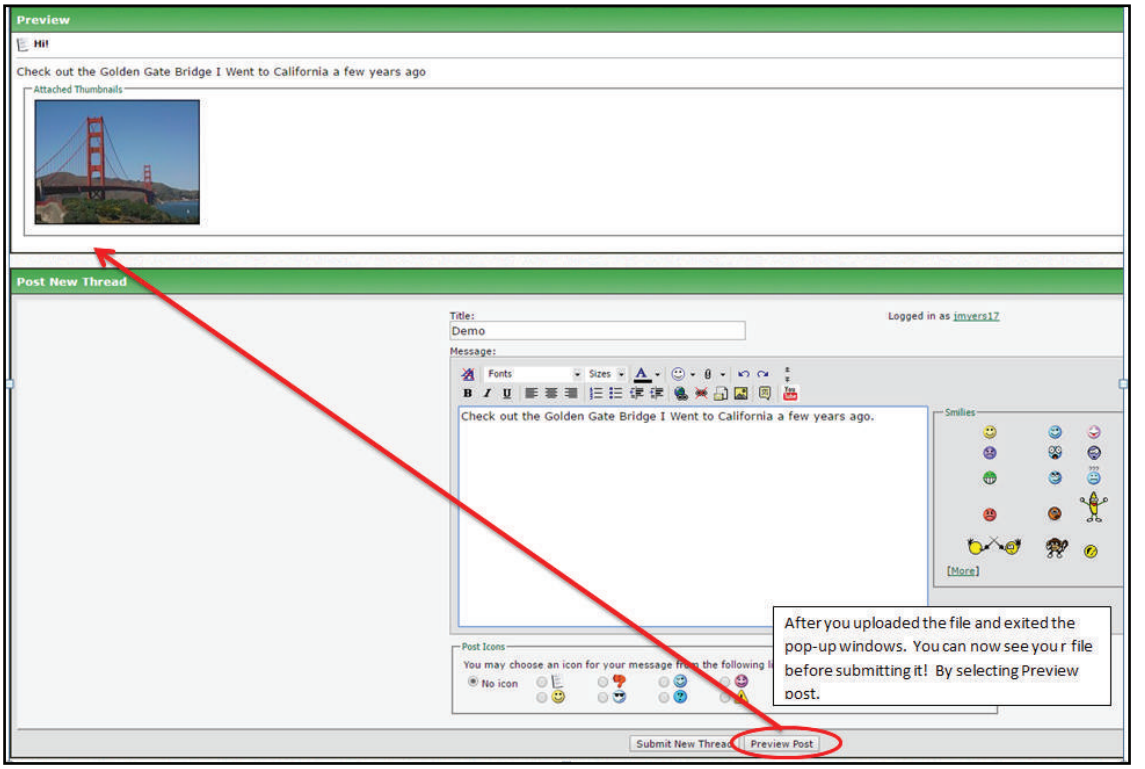


Figure 3 – Pop-up with photo files loaded.



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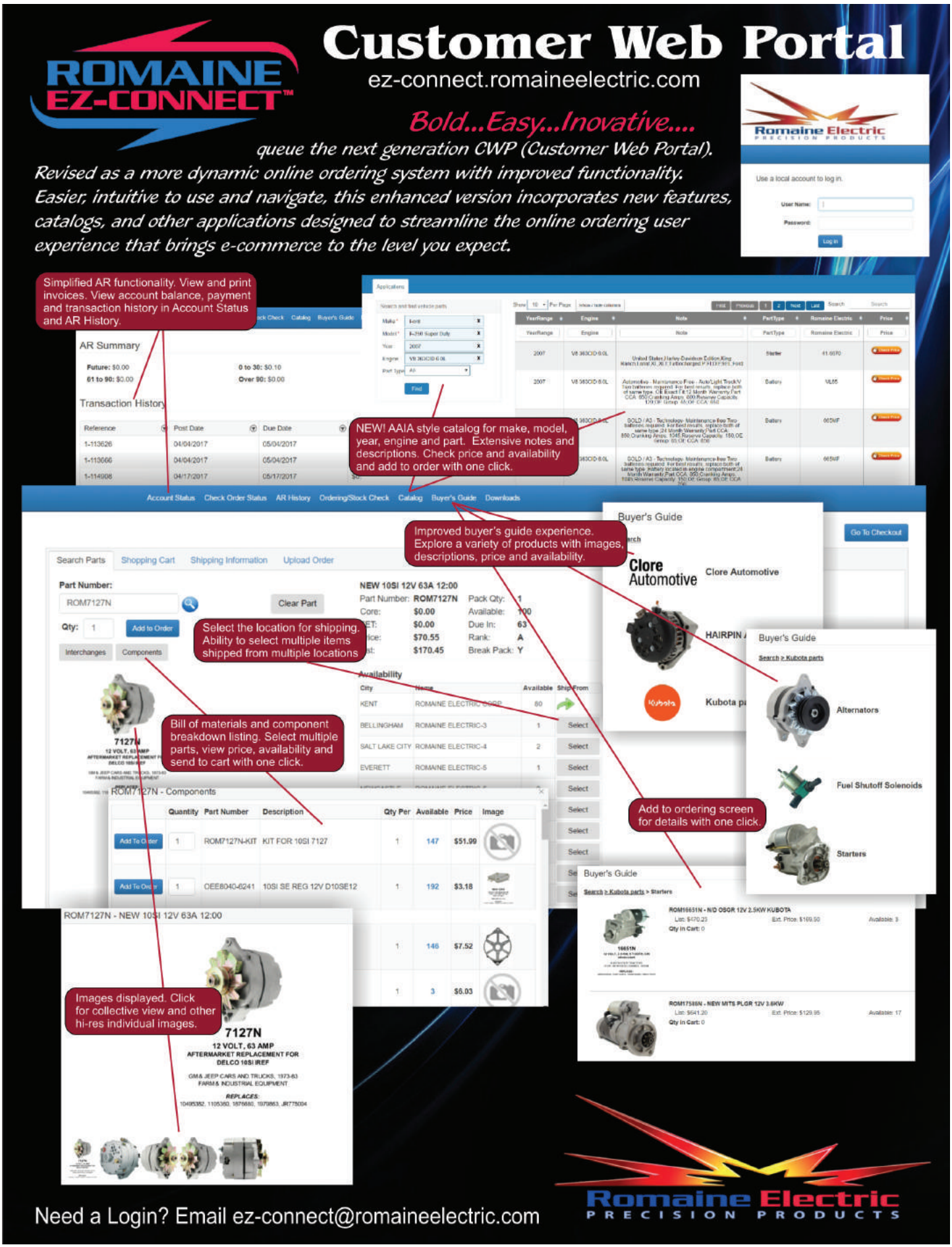
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CAN A SLIPPING BELT HARM AN ALTERNATOR? You Better Believe That It Can

BY NATHAN UNGER

When a customer brings me an alternator, the first thing I do is glance at the pulley. It if looks worn or as if it has been hot, I ask the customer if the belt has already been changed, because otherwise it will need to be. If the tips of the ribs on a serpentine pulley are flattened or really shiny, there is probably sand embedded in the belt, causing slippage.

I read somewhere that more than half of the automotive belts out there are slipping somewhat, and that this condition is not usually detected because most slipping belts make very little extra noise. The belt tension may even be fine.

In 1831 Michael Faraday figured out that the faster the magnet (In this case the rotor) moves past a coil (in this case the stator), the more output you get. Which means that the alternator will put out more as it spins faster. This then loads the belt more.

To make matters worse, the load is not constant. Some loads come on and off suddenly. Also the torque on the belt from the engine is not smooth either, due to engine compression and firing.

But consider the following; at a constant load and engine rpm, a loose belt will speed up the alternator until the alternator puts out enough to load the belt to the point where it slips. It will find its own equilibrium. So to look at it, it seems to be turning at a reasonable RPM but you could be fooled, since it may not be squealing.

But then there is the case of the squealing belt... The rubber is actually jumping, sending vibrations down the rotor shaft. The bearings have enough play to allow these vibrations to affect the brushes on the sip rings. The brush spring tension is not adequate to keep the brushes firmly seated against the vibrations, so the brushes jump, causing the rotor current to be interrupted unnecessarily. This causes the magnetic field to collapse, and because it collapses quickly, it creates a voltage spike (Faraday's principle again) which creates excessive arcing between the brush and the slip ring.

This arcing is bad news for the slip rings, brushes and brush-holder, because of the excessive heat - not to mention the high voltage spikes which may damage the regulator.

A rebuilt 130 amp Denso hairpin style alternator came in from a 2004 Cadillac CTS 3.2L V6 - Denso 104210-3280, Remy 12556, Bosch AL8636N or Lester 11003 (*see Figures 1 and 2*). This alternator has terminals F and L. F is the field

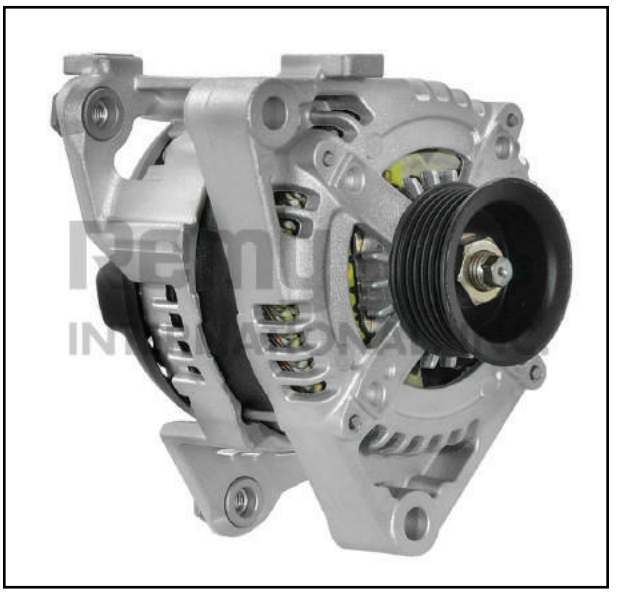

Figure 1 – Denso Alternator 104210-3280, used on 2000-03 Cadillac CTS vehicles with 3.2L engine.

Figure 2 – Side view of the Denso alternator, Lester number 11003.

Figure 3 – A close inspection of the pulley reveals abnormal wear on the center surfaces.

duty cycle signal, and L is the usual warning lamp powered by the ignition.

The first thing I did was look at the 6 groove pulley (*see Figure 3*). It had a strange wear pattern. The middle three or four ribs were much darker than the outer ones, and it wasn't the typical glazed metal look. It sort of looked more like rubber had been deposited. The groove depth looked excessive too. I measured the depth of one of the grooves, and it was about a millimeter deeper than that of an OEM pulley. This would make the belt's rib loose in the groove. Had the belt been squealing? The customer did not know.

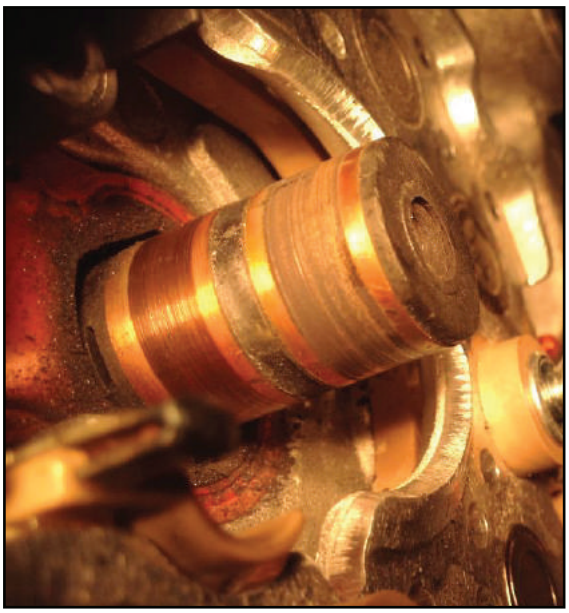

Figure 4 – Notice here that the outer slip ring shows signs of significant arcing.

Figure 5 – Likewise, the outer brush was hot enough to melt the brush holder.

He was fixing his boss's car.

When I pulled the alternator apart, sure enough, one slip ring had been arcing (*see Figure 4*), and the matching brush was stuck in the now partially-melted brush holder (*see Figure 5*).

I decided to test my theory using this alternator on the test bench after I replaced the damaged parts. First I took a picture of the brushes on the rotating slip ring at high load and 4000 RPM (*see Figure 6*). No arcing was visible (although of course there would be a microscopic amount due to the fact that it is a moving connection).

Then at the same high load and RPM, I backed the belt tension off until it started to really squeal. The arcing got so severe and so bright that now my iPad camera did not even want to focus on it (*see Figure 7*).

I shut everything down and pulled the brush-holder out again. I could already see signs of carbonization on the slip ring where it had been arcing, just for that short duration.

Figure 6 – On the test bench, the repaired alternator showed no arcing under heavy load with the belt tight and not slipping.

Figure 7 – Under the same load and RPM but with the belt slipping, the arcing is obvious.

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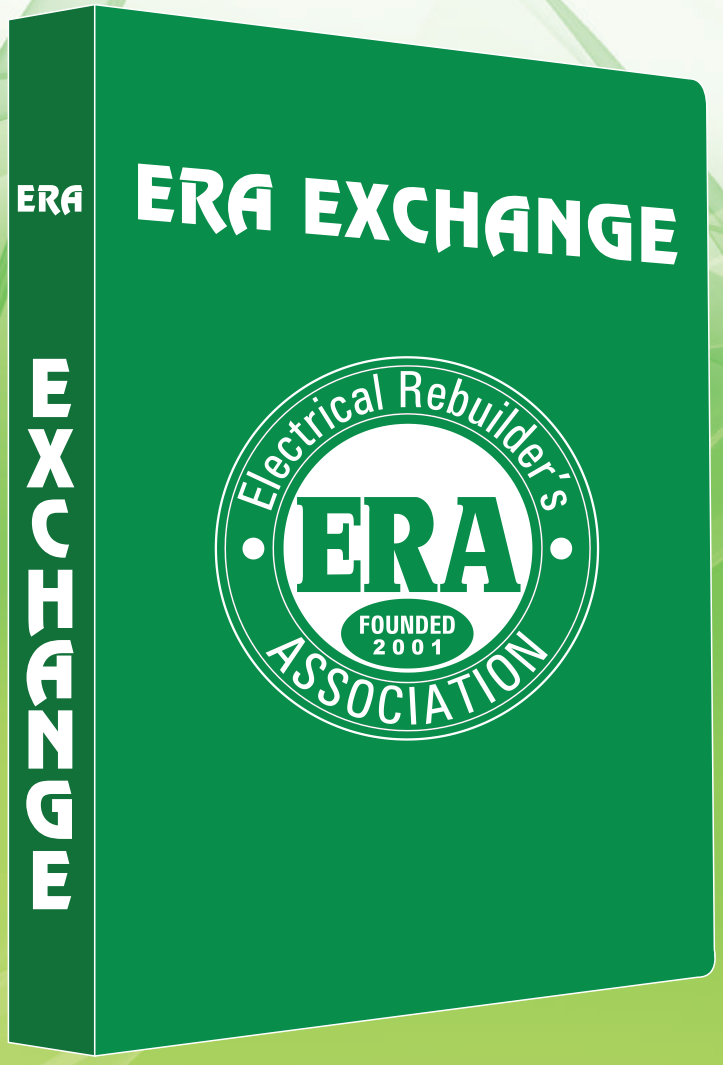

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