ONE ENGINE, TWO STARTERS
Understanding Dual Starter Systems

BY BOB THOMAS

While most of us have encountered a dual alternator system, rarely do we ever see two starters on the same engine. None-the-less, they are used in some specialized applications. In just the last few months, several of our members have run into them.

It is important to realize that there are two different methods in which dual starters might be used. One of the systems involves equipment that must start when needed – most notably in emergency situations where a failed starter could possibly lead to loss of life. The second starter in those applications is merely a back-up should the first starter fail, such as in emergency power generation or pumping water to alleviate flooding. There is nothing special or unique about these starters. There are simply just two of them and a means of selecting which starter to use, the primary or the back-up.

The other type of dual starter systems are found on very large diesel engines that are simply too to big for one starter to crank. Such engines have horsepower ratings in the thousands that are used to power huge pieces of equipment. Two examples are rail locomotives and the mammoth trucks used in mining or heavy earth-moving projects.

When two cranking motors are utilized as a **team**, it is essential that the pinions of both starters be completely engaged in the ring gear prior to sending power to either starter's motor. If one starter were to begin cranking before the other had time to clear an abutment, then the chance of the second starter's pinion ever getting into the ring gear would be marginal.

A number of circuits have been used over the years and each different manufacturer has come up with their own solutions. Almost always, some of the component parts of these starters work differently than their counterparts in single starter applications. It is important that you recognize these starters should a customer show up with one of them or a pair. It is also important that you know how to test them, because the solenoids operate very differently.

Delco 50-MT

The 32 volt 50MT Delco starters used to crank diesel locomotives (*see Figure 1*) employ the use of special solenoids. While they "look" just like the solenoid that you would find on any other 50MT, the internal coil connections are very different. As you can see in the diagrams that compare them both (*see Figure 2*), the dual starter solenoid's coils are connected to the battery terminal. These solenoids only move the pinion into engagement and do not provide power to the starter's motor directly, although they do, in a way, control it.

These starters are cranked using a bank of eight 300 pound, 8 volt batteries connected in series, weighing in at over a ton. If you did the math, you have already caught on that this bank is 64 volts – not 32. The reason it works without damaging the starters is that they are connected together in series through two heavy duty DPST control solenoids (*see Figure 3*). This creative circuit runs power through the second starter in series, but in the opposite direction as the first starter. In essence, one starter is negative ground while the second is operated positive ground! To help you follow the circuits I have used green to show the engagement circuit and blue to show the cranking circuit.

When the #1 control solenoid is activated to start, it applies positive power the #1 starter solenoid's battery terminal. Some of the current flows on through the hold-in coil to the solenoid's ground terminal. But most of it takes a lower path of resistance through the starter's motor via a jumper to the starter's field terminal. That causes the motor to rotate slowly as the pinion moves into the ring gear. This is the same as all other Delco starters. However, note that these starters have no field straps connecting the solenoid to the field terminal!

You will also notice that both of the starter ground studs are connected together with a cable (blue in the diagram) which is obvious in the photo of a pair of these on a locomotive (*see Figure 4*). But do not be confused into thinking that a negative cable is missing in the photo or the diagram. Remember that the second starter is "positive ground". If it were a permanent magnet starter it would turn backwards, but it's not. It will turn in the same direction as starter number 1. The identical circuit is followed in reverse in the second starter, ending up at the solenoid's battery terminal, which is connected to the negative terminal on the #1 control solenoid.

No doubt you have probably noticed that the solenoids' two motor terminals are used to activate control solenoid 2, one supplying positive voltage and the other negative. But this happens only after the contacts in both are closed, which can

Figure 1 – A team of 32v 50MT starters, mounted on a Detroit Diesel engine in a locomotive.

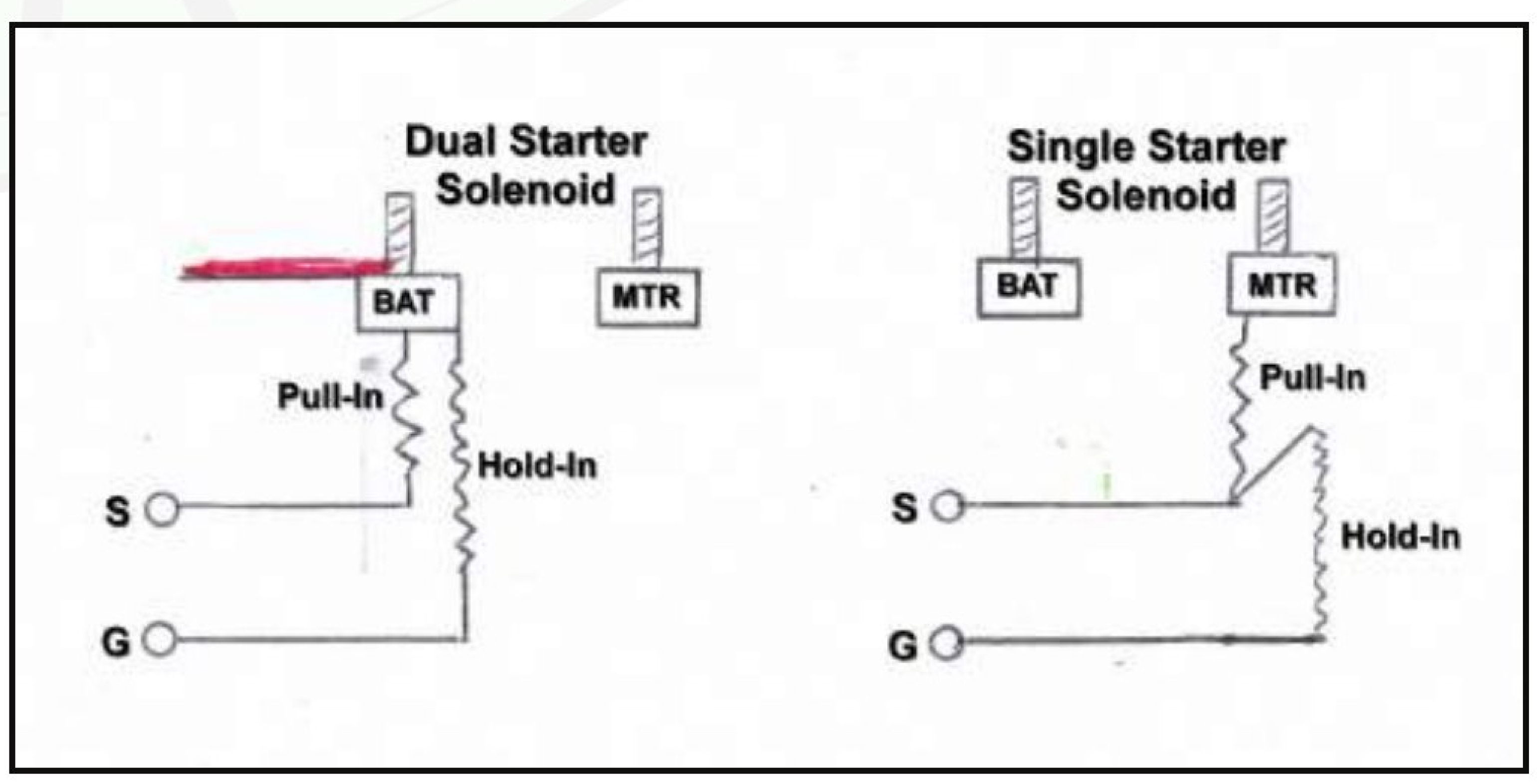

Figure 2 – Here you can see what makes these solenoids special, aside from their 32v coils.

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only happen after both pinions are fully engaged. Of course, control solenoid 2 applies power to the two field terminals, positive to starter 1 and negative to starter 2. Cranking two 32 volt starters in series requires 64 volts.

It has been pointed out that some railroad shops have modified this circuit slightly. They use the motor terminal's output to illuminate a light in the cab to tell the engineer that the pinions are both engaged, and then the engineer pushes a manual switch to activate the number 2 control solenoid that powers the starter motors. Evidently, they were experiencing some pinion milling and wanted to slow down the crank cycle to give the pinions a little extra time to fully seat themselves.

Testing one of these starters on your bench requires simulating the application's wiring. WAI Global has a two-page document on their website showing two different methods that can be used to easily bench test the starter's that use these solenoids. The title of the bulletin is "How To Test 64V 50MT Starters". You can download and print a copy from their website under Publications – Technical Bulletins or at: *http://www.waiglobal.com/technical-bulletins*

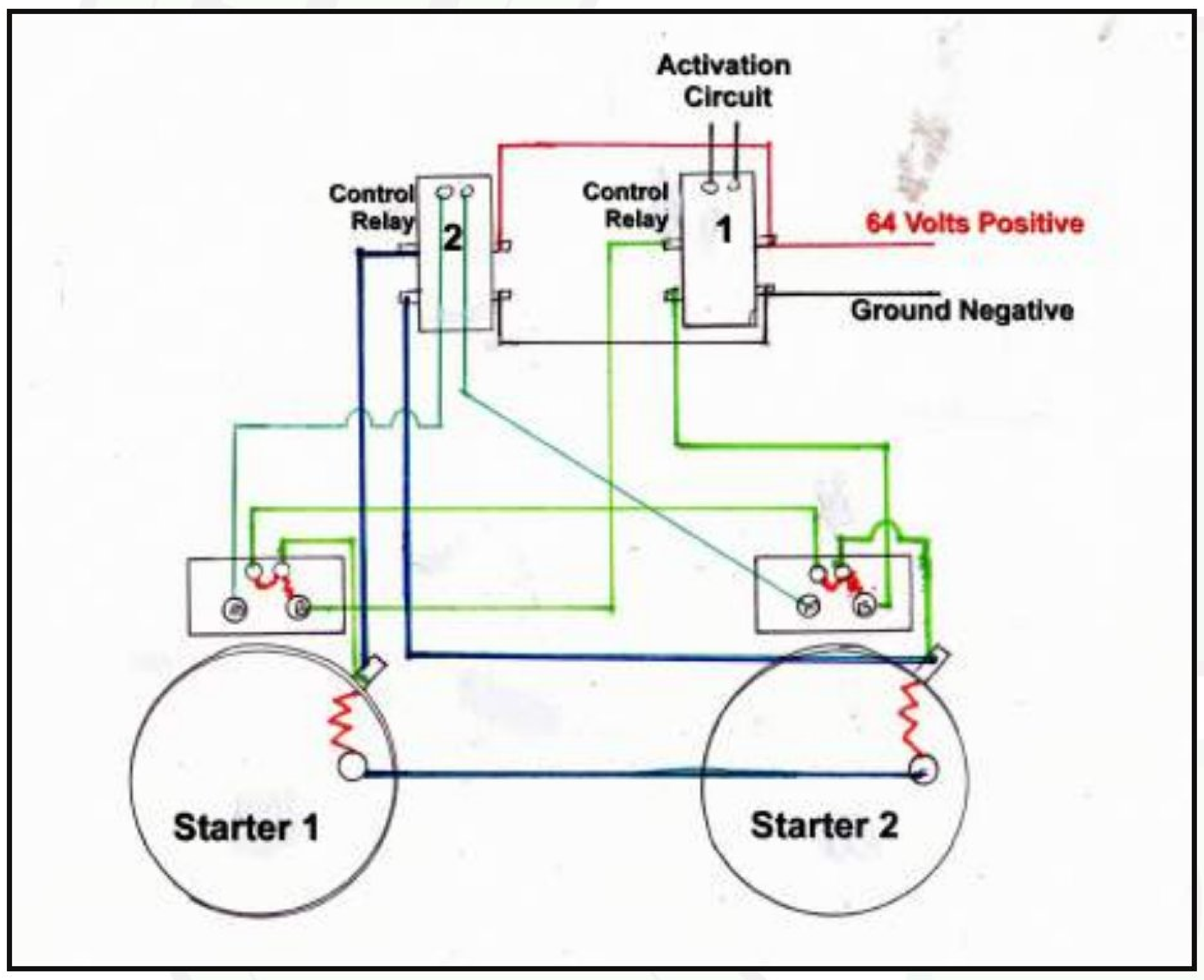

Figure 3 – This diagram shows how the 32v starters are connected in series to a 64v system.

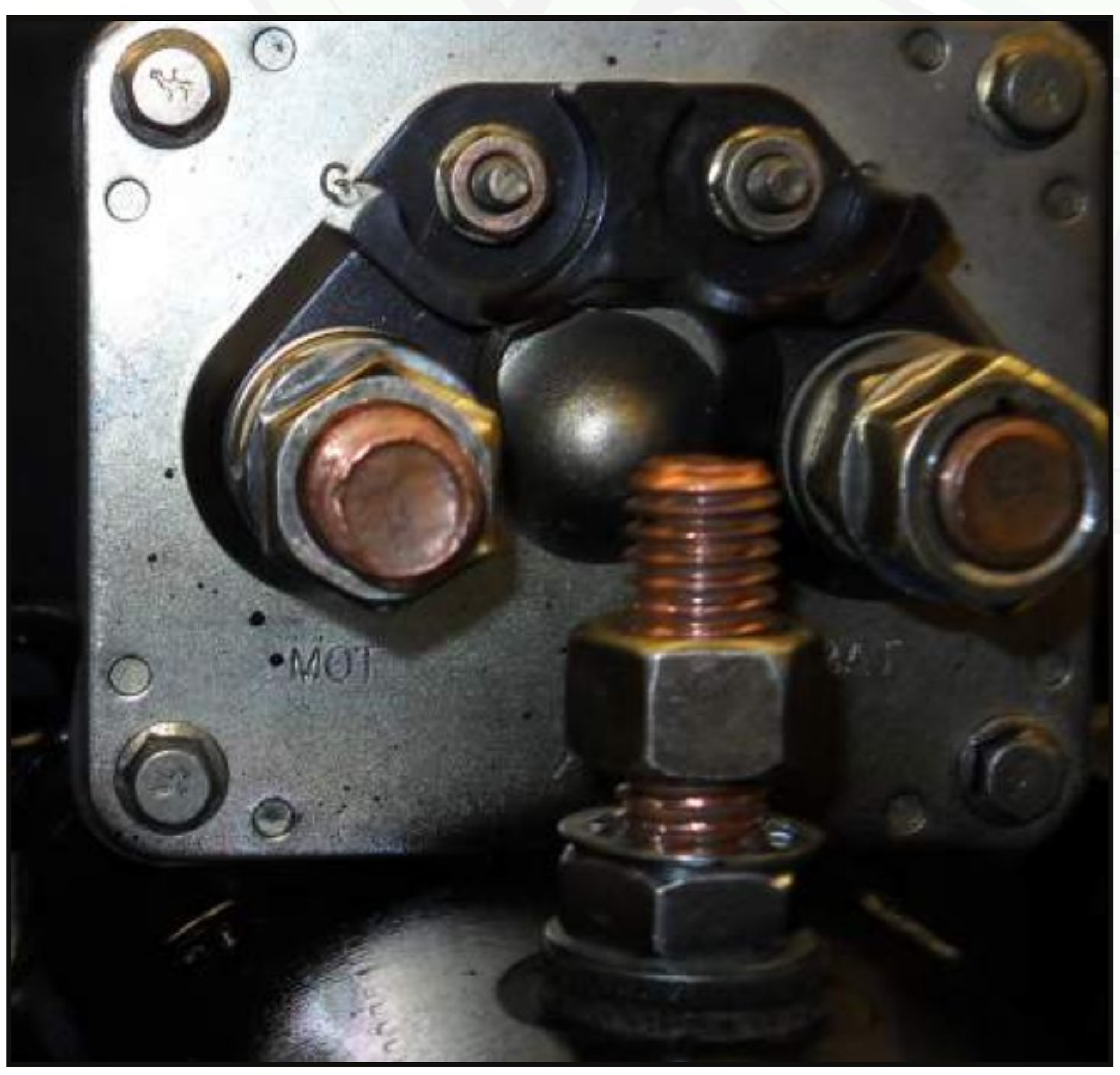

Figure 4 – These field coils have an extra long stud.

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It is also worth mentioning that the field coils and armatures are not what you would normally see in a 50MT. The field coils (Ace ST-810) have an extra long stud (*see Figure 5*) and are often shown as 32/64 volts, CCW. The armature (Lester 1993) has a 35 bar commutator, which will make it turn CW when used with the CCW field coils. When sourcing parts (solenoids, armatures, field coils or brushes) for dual starter applications, always use the original Delco unit number.

Bosch 340 Series

A similar but different dual starter system that an ERA member ran into was a pair of Bosch starters used on the V-16 MTU 4000 diesel engine in a Komatsu 930E haul truck (*see Figure 6*). Interestingly, this truck, like the diesel locomotive, is a hybrid vehicle. The diesel engine runs an AC generator that in turn provides the electrical power for the AC traction motors that move the truck at speeds up to 45 mph while carrying 300 tons of ore, dirt or rocks.

Figure 5 – Note the heavy strap that connects the two starter "ground" terminals in opposing polarity.

Figure 6 – Komatsu 930E haul truck powered by a 4000 HP MTU diesel engine.

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The starters were Bosch part number 0-001-340-501 (*see Figure 7*). They operate on 24 volts and are rated at 8.4kW each. Together a pair of them can deliver 16.8kW of cranking power. The only similarity between the Bosch and Delco circuits is the use of two "extra" solenoids. While Delco mounted theirs near the starters, Bosch incorporated two solenoids on each starter – one to engage the pinion and the other to power the motors (*see Figure 8*). They also mounted an IMS relay on each starter.

While Delco used a series circuit to power their starter motors, the Bosch starters are each powered separately in parallel circuits. The only series circuit in the Bosch system is the one that activates the motor solenoids. The Bosch starters are also both protected by thermal switches, similar to the Delco OCP switches used on 42MT and 39MT starters. Each IMS switch gets its ground through the thermal switch on its starter.

When the IMS relays are powered, they each supply voltage to their respective pinion solenoids. Also note that on the left side starter, a jumper wire also feeds voltage to the top terminal, or what we might normally call the battery terminal. In the diagram it is labeled terminal #1. You may notice that there is no such jumper on the right side starter. We will soon explain why.

Each pinion solenoid has two coils, just like all normal starter solenoids, but neither are grounded internally, making them quite different. Hence the need for two spade terminals on the left side of each one (*see Figure 9*) leading its coils to different ground paths.

The pull-in coil terminal on both starters leads to the motor terminal on the other solenoid, where it supplies just enough current to rotate the armature slowly to assist in engagement. The hold-in coil is grounded at starter's ground terminal.

As each pinion engages, the contacts in its solenoid will close to create a path for current flow. If you follow the numbered terminals in the diagram in order, you will see how these solenoids work together to supply power to both motor solenoids simultaneously. It is only after both pinions are fully engaged and both sets of pinion contacts become closed, that the motors are powered. While the Bosch starters are cranked on 24 volt parallel circuits, a series circuit, through the four pinion solenoid contacts, actually controls the cranking.

Incidentally, an MTU document indicates that on some larger engines, three of these starters have been used.

Very special thanks goes out to ERA members Larry Hagemeister of Hagemeister Enterprises in Lebanon, Oregon; Ken Plourde of Guy's Electric Service in South Windsor, Connecticut; and Clayton Augustine of EK Auto Electric in Cranbrook, British Columbia. They took the time to provided much of the information used to produce this article. Without their own research and photos, this would have not been possible.

Figure 7 – Bosch 0-001-340-501, one of a pair used to crank the mammoth MTU diesel.

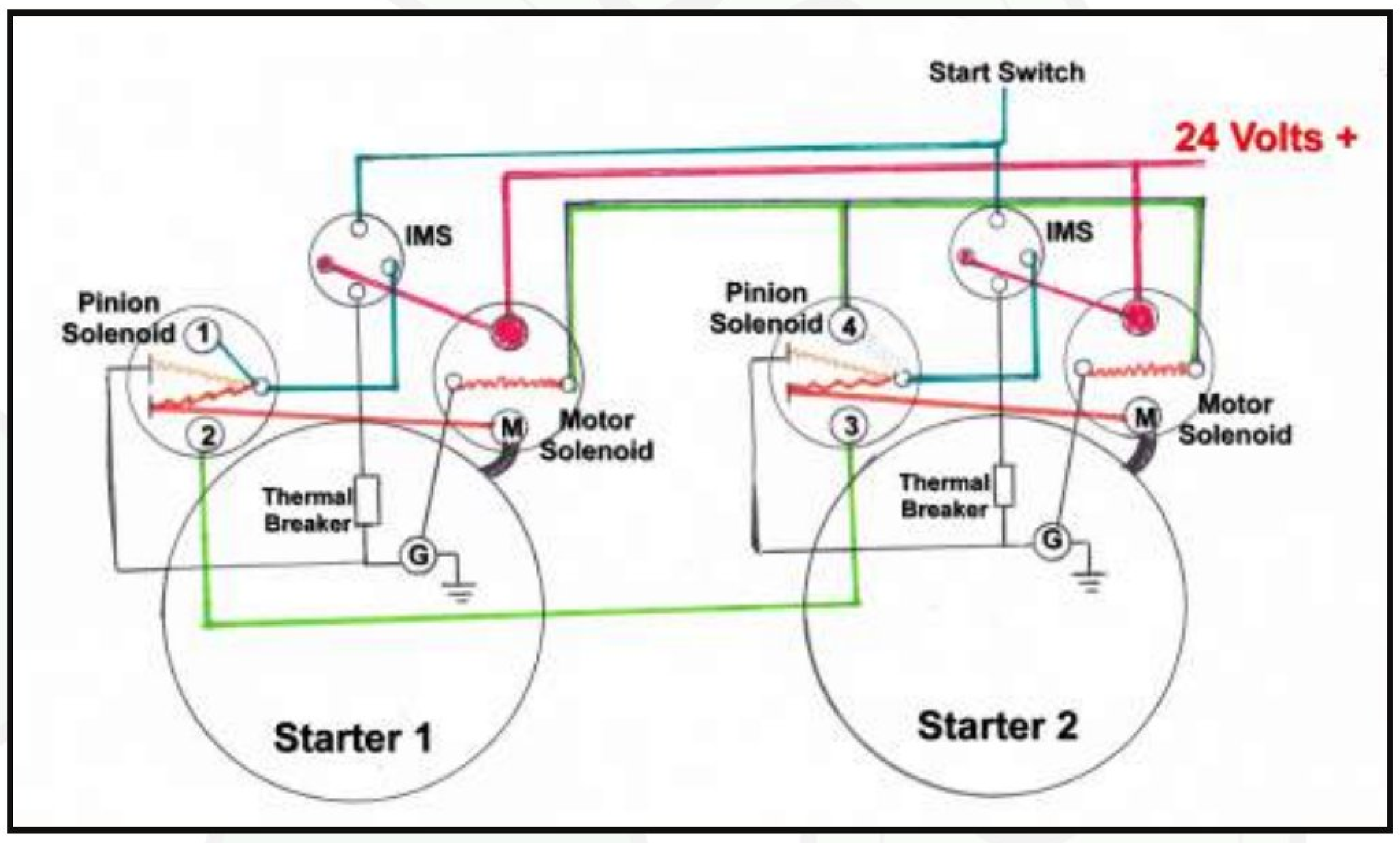

Figure 8 – This diagram shows how they are wired to crank as a team.

Figure 9 – The spade terminals on the left are grounds for the two coils inside.