

Hitachi / Mando Motor-Generators

A motor-generator is simply an electrical device designed to fill the dual role of cranking the engine and providing charging current to maintain the electrical system. The job of both cranking and charging is accomplished using a single armature, one set of four brushes and two different pairs of field coils. One pair of coils is used for cranking (*cranking-coils* in this article). A distinctly different pair of coils is used to generate output current (*generator-coils* in this article). In most cases, the coils can be easily identified by the size of the wire. The cranking-coils have heavier wire with only a few turns. The generator-coils have much smaller gauge wire with many more turns, making them physically larger than the cranking coils. It is a very simple circuit.

Motor-generators were once common back when electrical loads were light. For example, the Dodge Brothers used chain-driven motor-generators to crank their trucks in the 1920's. But as electrical accessories were added to vehicles, the use of motor-generators became impractical, and they were replaced with separate starters and generators.

that came in sailboats manufactured in the US during the 60's and early 70's, came with motor-generators. A compression release allowed the motor to spin the diesel engine fast enough to get it through several compression strokes. The generator easily kept the battery charged and ran a few navigation and cabin lamps. But when boaters began demanding more accessories, the motor-generators had to be replaced with conventional starters and alternators.



Figure 2—1970s Cub Cadet Delco-Remy Str-Gen

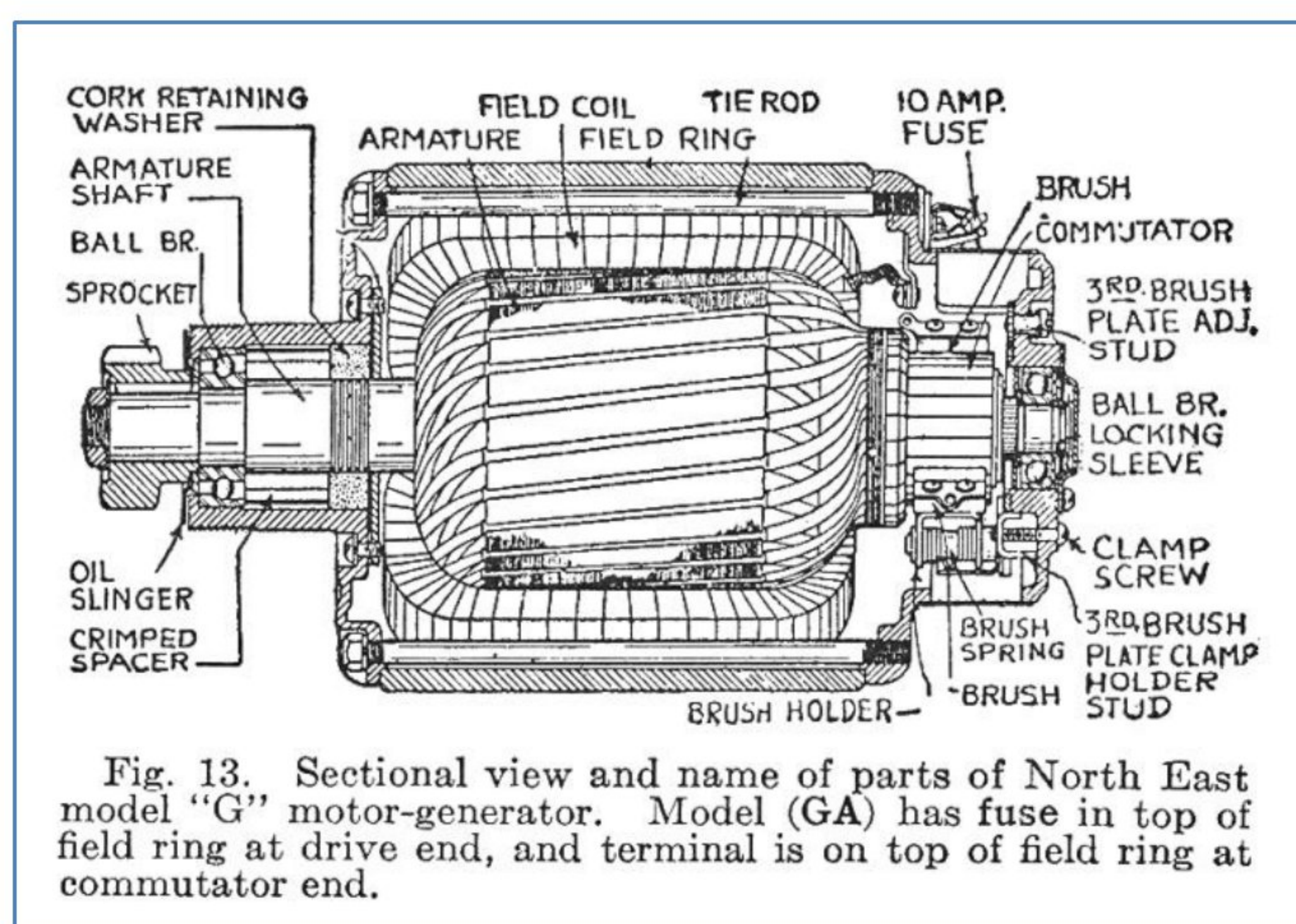


Fig. 13. Sectional view and name of parts of North East model "G" motor-generator. Model (GA) has fuse in top of field ring at drive end, and terminal is on top of field ring at commutator end.

Figure 1—1928 North East Motor-Generator

In the 1960's, motor-generators made a small comeback when belt-driven Robert Bosch units were used on small European-made diesel engines. Most Volvo and Renault diesel engines

In the 1970's motor-generators were used on small garden tractors. Sears, Cub Cadet, Gravely and others brands, used Delco Remy belt-driven motor-generators to crank the small gas engines. The generator side kept the cranking battery charged and provided enough current for the ignition system and headlights. The Delco units used only two coils, one each for cranking and charging. By the late 1980's, motor-generators had been replaced on most garden tractors by lightweight permanent-magnet starters and electronically-controlled internal engine charging systems.

Then in the late 1980's, gasoline-powered golf carts brought back the motor-generator yet again, with a belt-driven Hitachi unit. By the 1990's these carts had found their way off the fairways as consumers discovered all kinds of uses for them. It wasn't long before they started showing up in rebuilding shops for repair, where they caused some confusion, because they have two armature terminals and three field terminals. Today, Mando manufactures a motor-generator that is identical to the Hitachi unit. This article will deal specifically with the most common Hitachi/Mando unit. *But remember, all motor-generators operate basically the same way.*

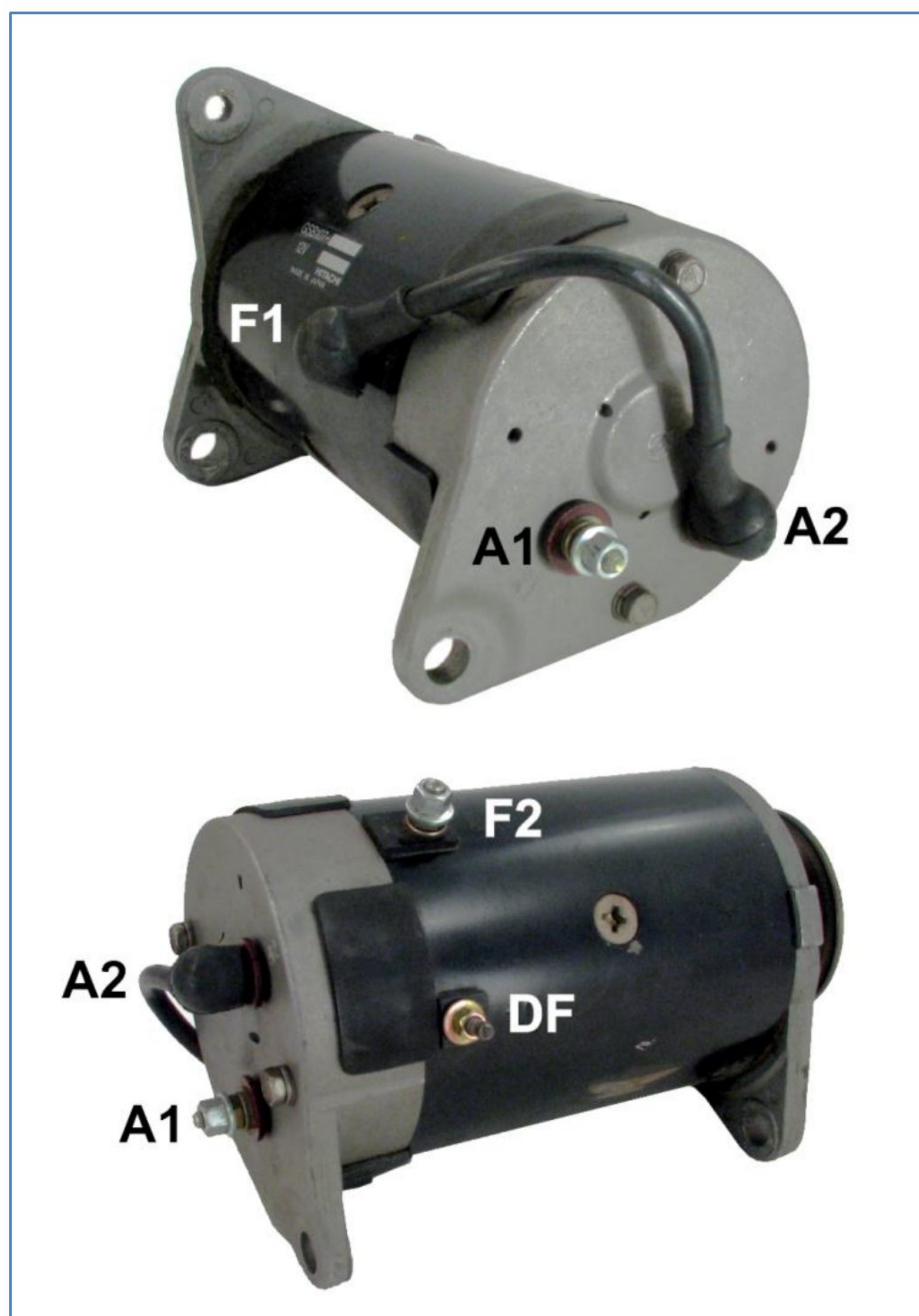


Figure 3—Hitachi Motor-Generator GSB107-01

Terminals Explained (Figure 3)

What Hitachi has done is **isolate both the armature and the field circuits from each other and from ground.**

- Terminals **A1** and **A2** are connected to the **armature** via two pairs of brushes.
- Terminals **F1** and **F2** are connected to each end of the **cranking-coils**.
- Terminal **DF** is connected to one end of the **generator-coils**.
- The other end of the **generator-coils** is connected to **F1** internally.
- On most applications, **F1** and **A2** are **connected externally** using a 6 or 8-gauge jumper cable, as shown in the diagrams and photo.

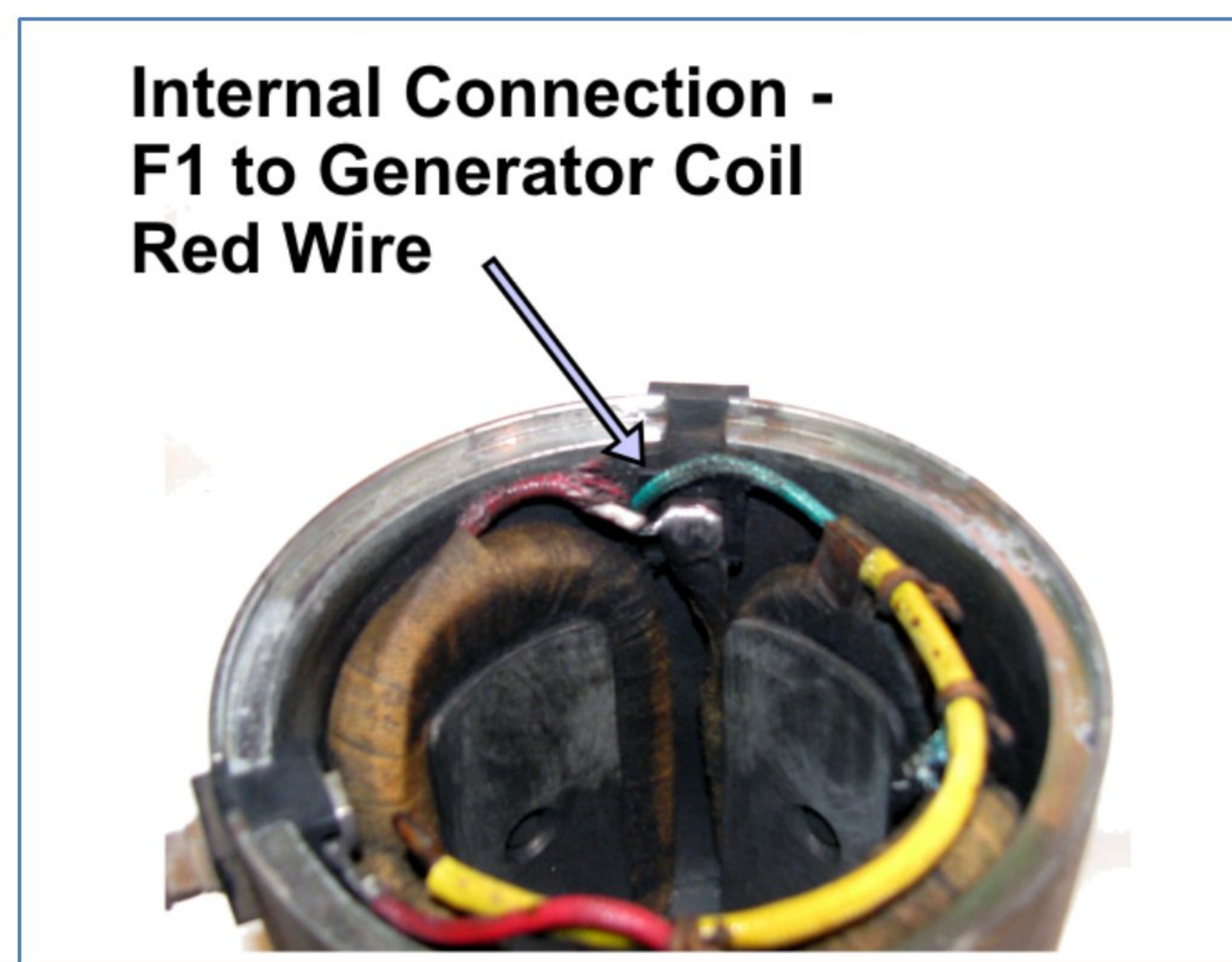


Figure 4—Internal Generator-Coil Connection

Cranking (Figure 5)

When the gas pedal is depressed, an ignition switch on the pedal closes to engage a continuous-duty relay. That relay will supply power from the battery to **F2**, and at the same time, power the positive terminal on the voltage regulator. The current applied to **F2** travels through the cranking-coils to **F1** and through the external jumper cable to **A2**. From there, it continues through the positive brushes, the armature, the negative brushes, to **A1** and to ground. The motor-generator is now cranking the engine.

Note that one end of the generator-coils is also connected to **F1** internally (see Figure 4), so during cranking, current is also flowing through the generator-coils to the **DF** terminal and on to the voltage regulator. Since the regulator is energized during cranking and system voltage is below the set point, the regulator is grounding the **DF** terminal to complete the generator field circuit. While there are insufficient RPM at this point to produce any output, the current flowing through the generator-coils does provide additional torque during cranking.

Current Flow While Cranking

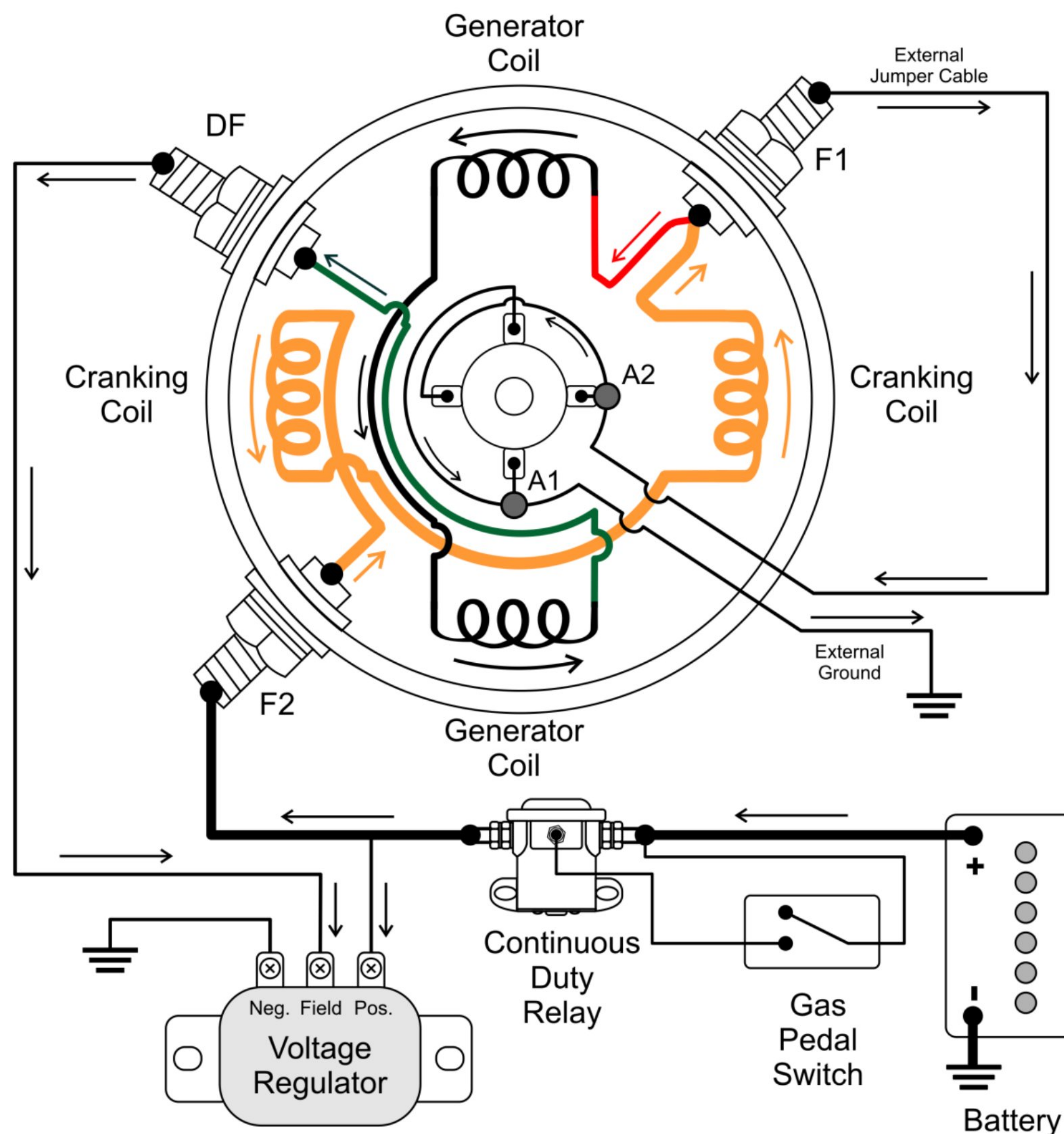


Figure 5—Cranking Current Flow

Charging (Figure 6)

Once the engine starts, and RPM are increased to a point where the unit can begin charging, **A2** becomes the output terminal, just like the **A** terminal on any other DC generator. But unlike other generators, the charging current does not go directly to a cut-out relay. Instead, it must pass through the jumper cable to **F1**. This is important, because the positive side of the generator-coils is also connected here internally. At this point, **A2** is now providing the power for the generator-coils which are also connected to **F1** inside the case. The charging current will now flow through the

low-resistance cranking-coils to **F2**, in the opposite direction that it flowed during cranking. From **F2** it travels back to the battery through the continuous-duty relay, as long as the gas pedal is held down to keep the battery connected. Note that the continuous-duty relay acts as both a cranking relay and a cut-out relay for the generator.

As you can see, this circuit is not nearly as complicated as it looks. Every single part in the circuit is used twice, for both cranking and charging, making for true efficiency.

Current Flow While Charging

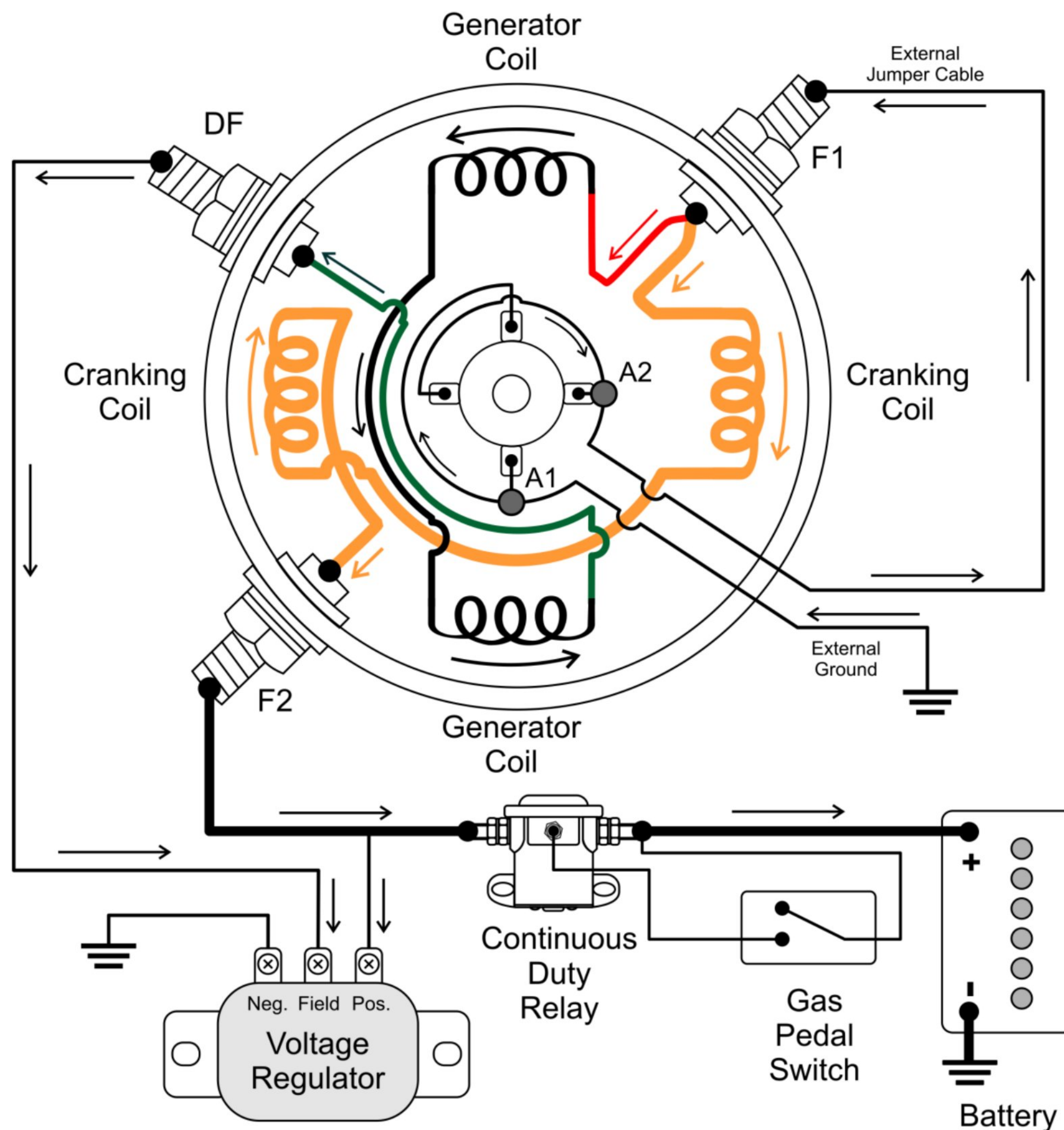


Figure 6—Charging Current Flow

Testing the motor circuit

1. When testing this unit, remember it will both motor and charge **CCW**.
2. Be sure a jumper is connected between **F1** and **A2**.
3. Ground the **A1** with your negative lead.
4. Attach your **B+** lead to **F2**.
5. The unit should motor effortlessly at this point. Watch your fingers!

Testing the generator circuit

1. Follow all of the directions for testing the motor circuit.
2. Connect **DF** to an A-circuit regulator, or you can full-field it by grounding the **DF** terminal.
3. Apply power and spin the generator at sufficient RPM's to see that you have output.



Figure 7—Generator-Coil Bullet Connectors

connector, you'll have to guess. It won't harm anything if you hook it up wrong. It just won't charge. Since this generator is “A” circuit, the **DF** wire is grounded to make it charge.

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Variations

On some early applications, two-stroke engines were cranked in reverse to run backwards in place of a reverse gear. These circuits were more complicated, because switches or two-stage relays were used to reverse polarity of the armature to control direction. However, all Hitachi motor-generators can be connected as shown above for testing purposes.

In addition, some early units had isolated generator coils with no internal connections. Those models can be identified by two small wires coming out of the field case. (see Figure 7). The green field wire is **DF**. The red field wire is **D+** and must be connected to **B+** or **F2** with a jumper wire when testing charging capability. On some generators, male and female bullet connectors were used. On those units the wires may be of the same color. However, the female connector is **DF** and the male connector is **D+**. If by some chance the wires can't be identified by color or type of