STARTING SYSTEM AND STARTER MOTORS

ELECTROMAGNETIC ENERGY

Starters use electromagnetic energy to create the powerful torque needed to start an engine. Electromagnetic energy can be explained more clearly by comparing how energy is produced by an alternator, in contrast to how energy is produced in a starter.

An alternator uses motion to create the electrical current needed to recharge the battery. A rotor with magnets spins close beside the copper coils of a stator, and electrical current is induced into the stator coils. This is called magnetic induction.

A starter does not use motion to generate the electrical power needed to start an engine. A starter uses battery current to create a more powerful magnetic force – the force of electromagnetism.

In electrical theory, powerful magnetic forces can be created when a copper wire, (a conductor), is coiled around a core of soft iron, and electrical current is passed through the copper wire. A powerful magnetic field is created in the iron core that now possesses a north and south pole. An electromagnet is created.

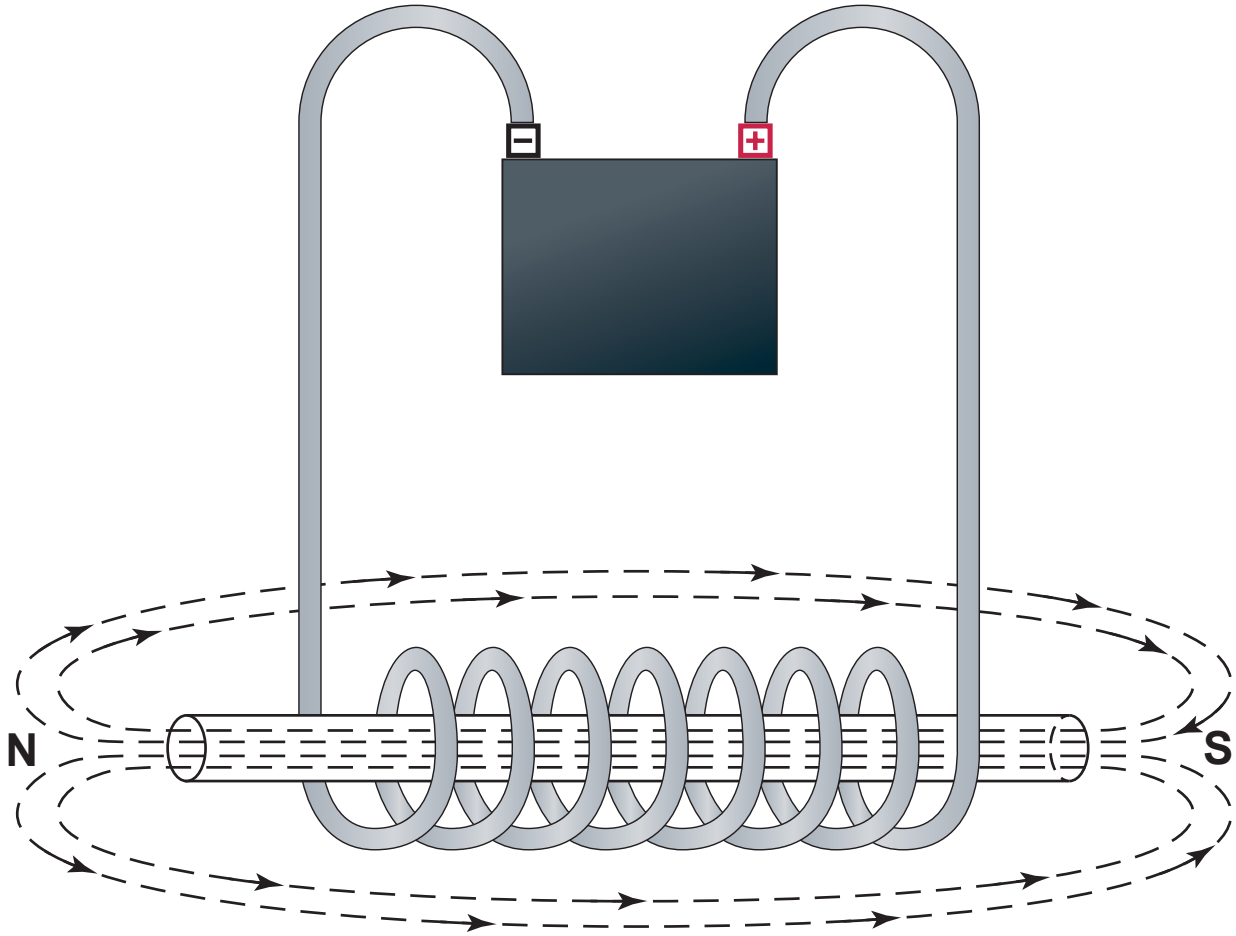
Starters use battery current to transform the starter armature and field coils into electromagnets. Starters use battery current to electrify an armature (conductor). Next, this “electrified conductor” is then placed into the middle of a magnetic field of field coils that are also electrified. Electrical current also transforms the field coils into powerful electromagnets. In other words, the armature is sandwiched between strong magnets.

The attracting and repelling forces of the positive and negative polarities of the magnets, (field coils), are then harnessed to create the powerful turning motion of the armature. On one end of the armature is a gear that will mesh with the starter clutch assembly. Starters also use reduction gears to further leverage the torque generated from the electromagnets.

The starter must have enough torque to push each engine piston through a compression stroke, as well as compress the intake valve springs and the exhaust valve springs in the cylinder head during the intake and exhaust strokes. This requires substantial torque.

Some starters use permanent magnets to surround the armature instead of field coils. However, electrified field coils are more powerful than permanent magnets.

How an Electromagnet Works



An electromagnet is created by wrapping a coil of copper wire around a soft iron core and then running electrical current through the wire. This creates a powerful magnetic field in the iron core.

BASIC STARTER OPERATION

Starter Field Coils and Armature – High Current Circuit

The construction of a starter can be illustrated as follows. Firstly, inside the starter is an armature. In illustrations, the armature looks like a bar that is bent in a "U" shape – it looks like a loop. In reality, the armature is a series of copper wire coils called armature windings.

The magnetic field produced by the coils of wire is increased and becomes highly concentrated when the wire is looped into coils with many turns of wire lying side by side. Each turn of wire adds more strength to the magnetic field.

A commutator is built into one end of the armature. Electrical current from the battery is induced into the commutator by 2 or 4 copper/carbon "brushes". These brushes are held against the commutator under slight spring pressure.

The commutator then transmits this electricity through the armature windings. Each separate armature coil has its own commutator segment.

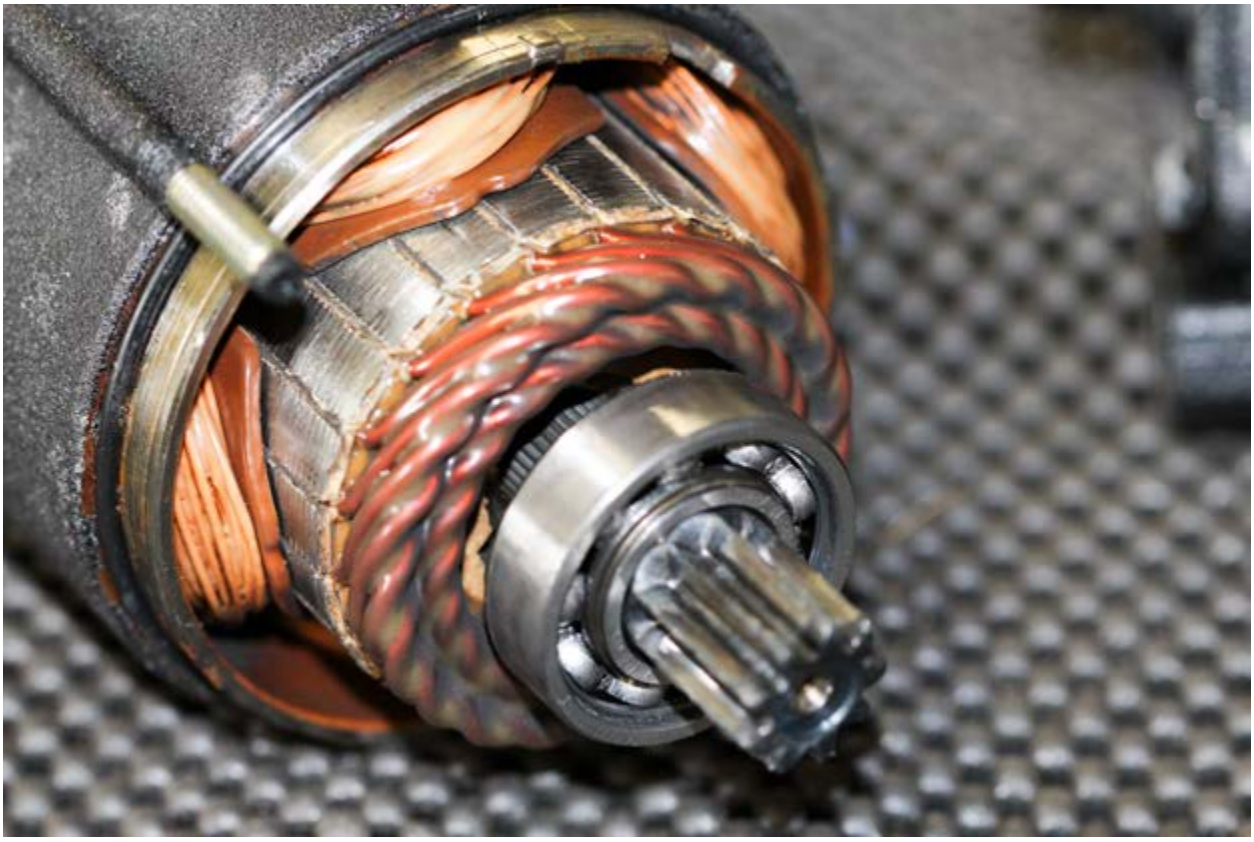
Electrical current starts flowing at one end of the armature, and it comes back out the other end of the armature and then travels to ground.

For example, if there are just 2 brushes inducing current into the commutator, one brush feeds positive current from the positive terminal of the battery, and the other brush is grounded back to the negative battery terminal to create a completed circuit. The brushes are offset 180 degrees from each other.

After the current goes through the armature, the current then goes to ground. The current that flows through the armature turns the armature into a highly charged electromagnet.

Next, permanent magnets – or electrified field coils - are located on either side of the electrified armature. The north magnetic pole is on one side of the armature, and the south magnetic pole is on the other side.

Note that electromagnets (field coils) are sometimes used instead of permanent magnets to create a more powerful magnetic field. The starter discussed in this example uses field coils instead of permanent magnets.



With starter partially disassembled, notice how the starter armature sits between the field coils. Field coils can be seen on the left and right side, as well as on top. On the end is the gear that will mesh with the starter clutch assembly, and the final starter shaft.

These field coils - in combination with the armature that is already energized with electrical current - create a very powerful reaction of motion because the field coils strongly repel the electrified armature and vice-versa. The armature becomes encircled and wrapped with magnetic forces.

This electromagnetic reaction causes the armature to rotate with great force. The electromagnetic reaction that occurs is that of the magnetic field

in the field coil repelling the magnetic field in the armature. This causes the armature to rotate.

Starter housing is separated. Starter armature sits between the field coils. The gear on the end of the armature will engage the drive assembly/overrunning clutch gears. The solenoid and housing – top right – has been detached from the starter housing and armature.

This forceful motion is harnessed in such a way that it causes the armature to spin in one direction. This is accomplished by reversing the current flow back and forth in the armature loops through the brushes and commutator.

In summary, starters use either field coils or permanent magnets to create the magnetic field around the armature.

Starter field coils are also called field windings, starter fields, coils, or just fields. Service manuals are likely to use any of these terms.

Note that permanent magnets often replace field coils on today's starters. Many starters today have no field coils.

Starter armature pulled out of the starter case. The commutator is located on the far end of the armature (right side). Brushes inside the end cap ride over the commutator and feed battery current into the armature.

If magnets are used instead of field coils, the magnets that surround the armature will also repel the magnetic field in the armature, causing the armature to turn.

Starter force is dependent on the amount of amperage it receives from the battery. If the battery is able to get 170 amps to the starter, it is likely the starter will turn over properly. If the battery is somewhat run down and/or the battery plates are not in good condition, the battery may only be able to deliver perhaps 130 amps. In such case, 130 amps may not be able to turn the starter over fast enough to start the engine.