are labeled A and B. As the coil rotates, the segments slide onto and past the fixed terminals or brushes. With this arrangement, the direction of current in the side of the coil next to the north-seeking pole flows toward the reader, and the force acting on that side of the coil turns it downward. The part of the motor that changes the current from one wire to another is called the commutator.

Position A

When the coil is positioned as shown in *Figure 12-296A*, current flows from the negative terminal of the battery to the negative (–) brush, to segment B of the commutator, through the loop to segment A of the commutator, to the positive (+) brush, and then back to the positive terminal of the battery. By using the right-hand motor rule, it is seen that the coil rotates counterclockwise. The torque at this position of the coil is maximum, since the greatest number of lines of force is being cut by the coil.

Position B

When the coil has rotated 90° to the position shown in *Figure 12-296B*, segments A and B of the commutator no longer make contact with the battery circuit and no current can flow through the coil. At this position, the torque has reached a minimum value, since a minimum number of lines of force are being cut. However, the momentum of the coil carries it beyond this position until the segments again make contact with the brushes, and current again enters the coil; this time, though, it enters through segment A and leaves through segment B. However, since the positions of segments A and B have also been reversed, the effect of the current is as before, the torque acts in the same direction, and the coil continues its counterclockwise rotation.

Position C

On passing through the position shown in *Figure 12-296C*, the torque again reaches maximum.

Position D

Continued rotation carries the coil again to a position of minimum torque as in *Figure 12-296D*. At this position, the brushes no longer carry current, but once more the momentum rotates the coil to the point where current enters through segment B and leaves through A. Further rotation brings the coil to the starting point and, thus, one revolution is completed.

The switching of the coil terminals from the positive to the negative brushes occurs twice per revolution of the coil.

The torque in a motor containing only a single coil is neither continuous nor very effective, for there are two positions where there is actually no torque at all. To overcome this, a practical DC motor contains a large number of coils wound on the armature. These coils are so spaced that, for any position of the armature, there are coils near the poles of the magnet. This makes the torque both continuous and strong. The commutator, likewise, contains a large number of segments instead of only two.

The armature in a practical motor is not placed between the poles of a permanent magnet but between those of an electromagnet, since a much stronger magnetic field can be furnished. The core is usually made of a mild or annealed steel, which can be magnetized strongly by induction. The current magnetizing the electromagnet is from the same source that supplies the current to the armature.

DC Motor Construction

The major parts in a practical motor are the armature assembly, the field assembly, the brush assembly, and the end frame. *[Figure 12-297]*

Armature Assembly

The armature assembly contains a laminated, soft-iron core, coils, and a commutator, all mounted on a rotatable steel shaft. Laminations made of stacks of soft iron, insulated from each other, form the armature core. Solid iron is not used, since a solid iron core revolving in the magnetic field would heat and use energy needlessly. The armature windings are insulated copper wire, which are inserted in slots insulated with fiber paper (fish paper) to protect the windings. The ends of the windings are connected to the commutator segments. Wedges or steel bands hold the windings in place to prevent them from flying out of the slots when the armature is rotating at high speeds. The commutator consists of a large number of copper segments insulated from each other and the armature shaft by pieces of mica. Insulated wedge rings hold the segments in place.

Field Assembly

The field assembly consists of the field frame, the pole pieces, and the field coils. The field frame is located along the inner wall of the motor housing. It contains laminated, soft-steel pole pieces on which the field coils are wound. A coil, consisting of several turns of insulated wire, fits over each pole piece and, together with the pole, constitutes a field pole. Some motors have as few as two poles, others as many as eight.

Brush Assembly

The brush assembly consists of the brushes and their holders. The brushes are usually small blocks of graphitic carbon, since this material has a long service life and also causes minimum wear to the commutator. The holders permit some play in the brushes so they can follow any irregularities in the surface