# A Look at Cranking Motors:
## Part and Principles
## Part I

Courtesy Electrical Rebuilder's Assoc.

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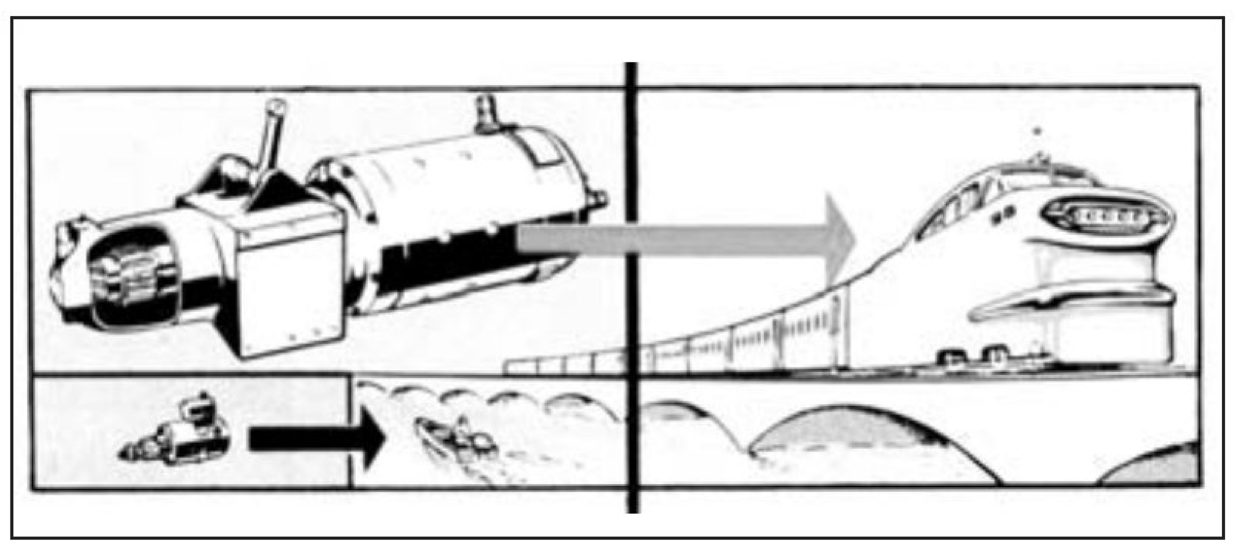
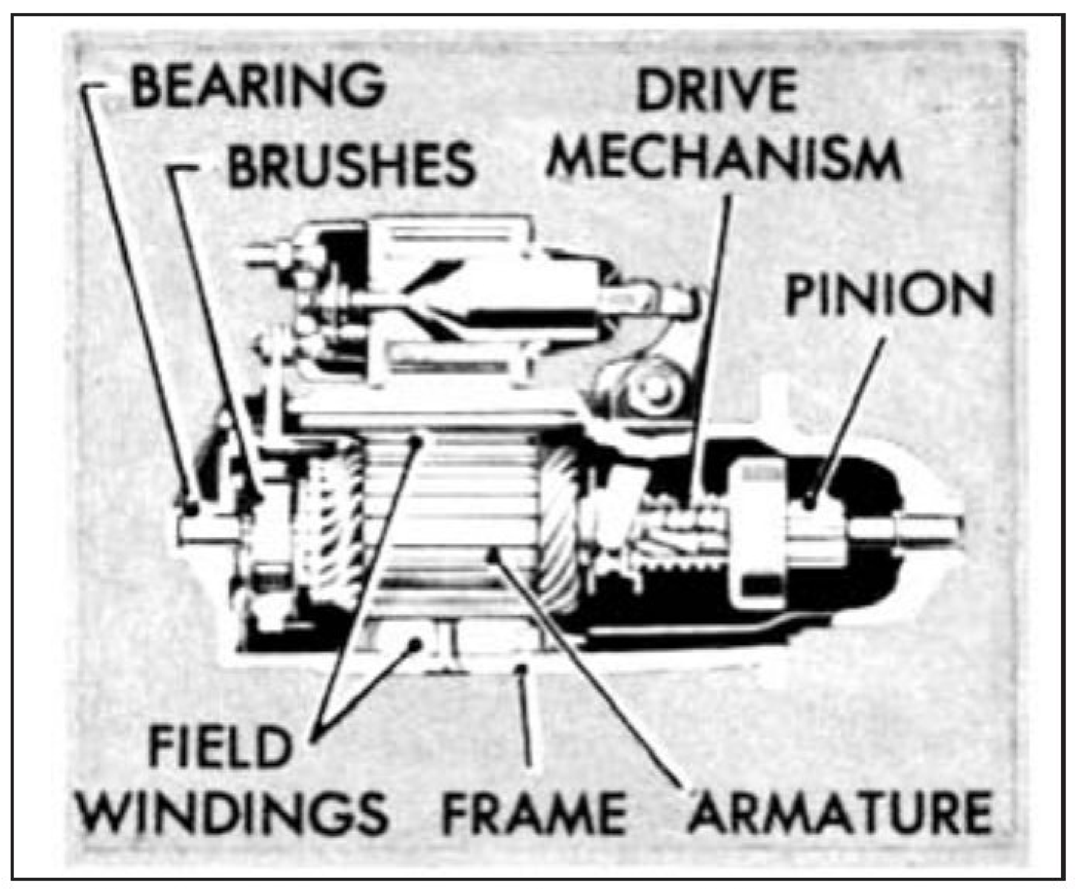
Cranking motors are manufactured in many types and sizes ranging from fractional horsepower units used to crank small engines up to large cranking motors for cranking diesel engines that propel streamline trains, marine engines, or large stationary power installations.

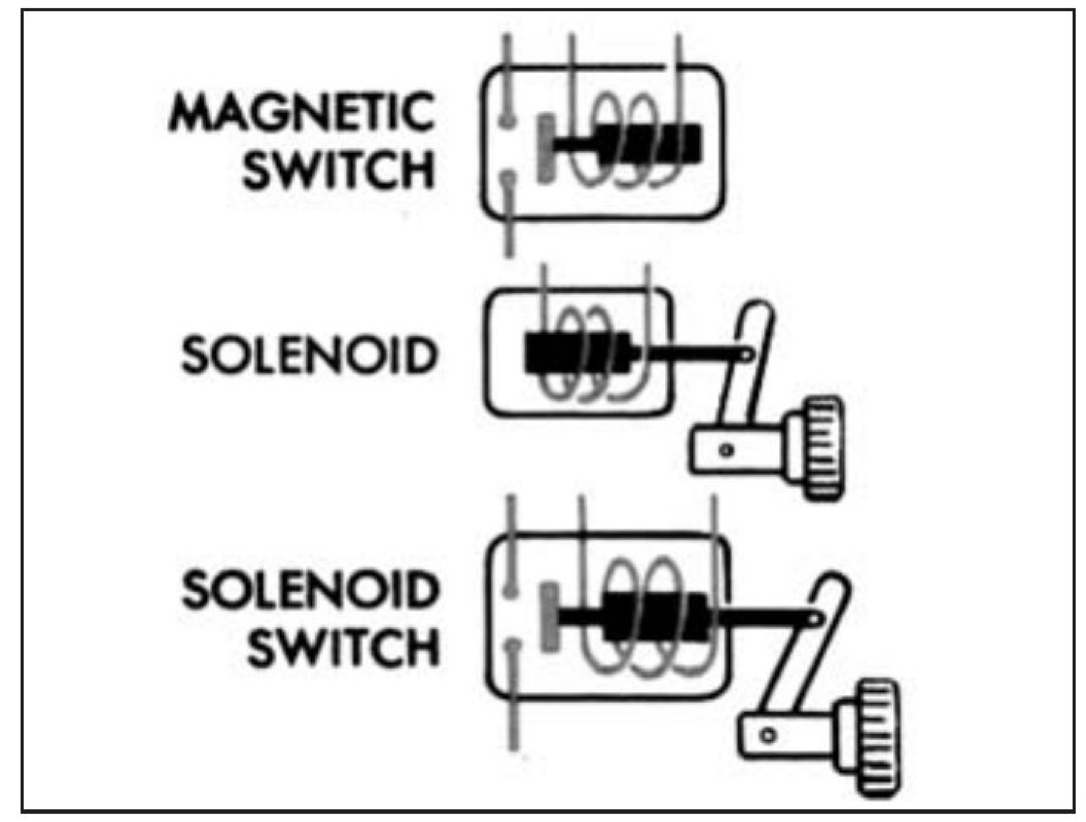


All cranking motors are much the same in general design and operation, differing mainly in the type of drive used. Basically, they consist of the drive mechanism, frame, field windings, armature and brushes. The armature is supported on bearings to permit it to rotate freely. All the current that passes through the field coils also travels through the armature. This type of cranking motor is known as a SERIES wound motor and is capable of developing great torque.

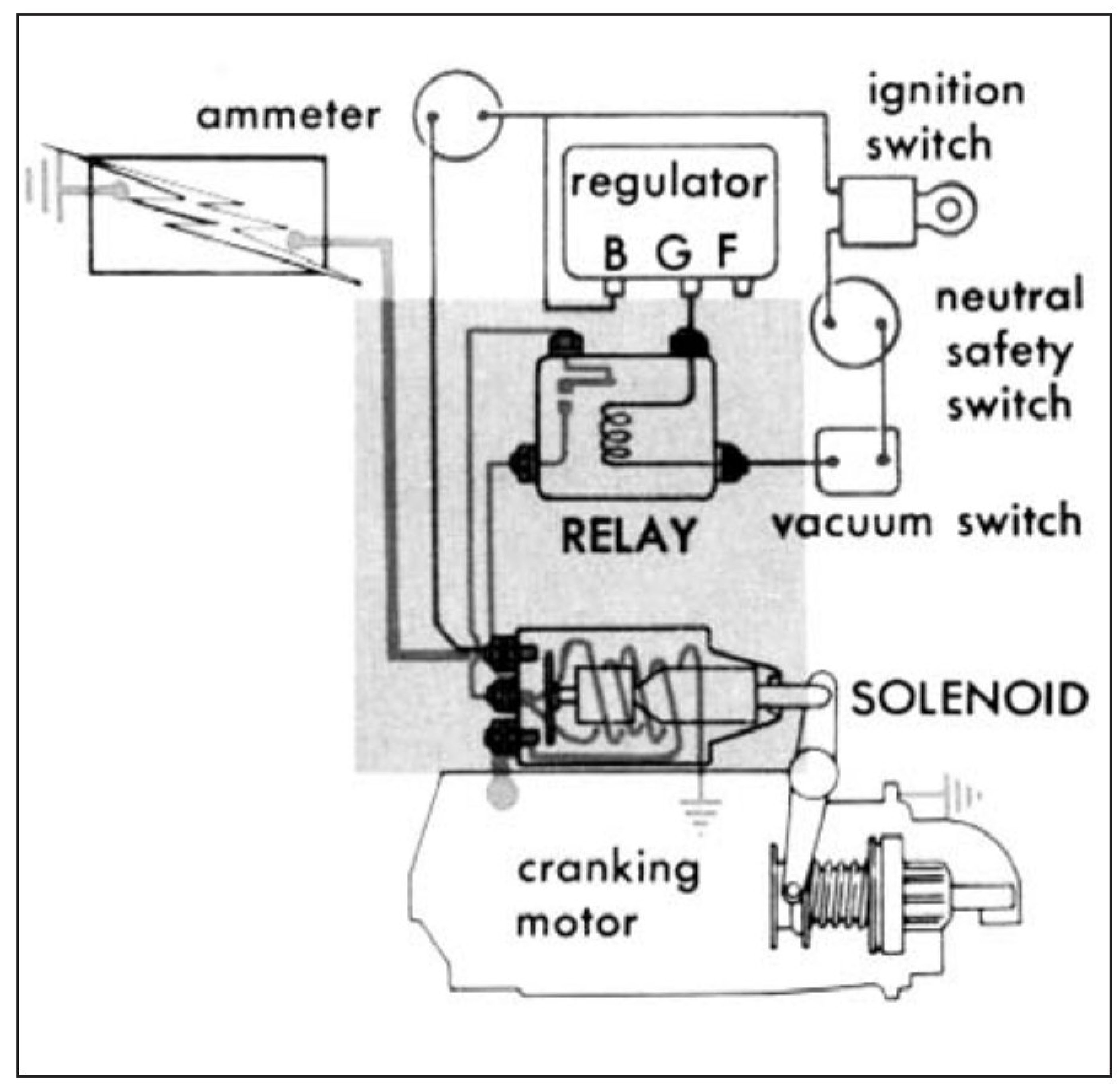
On cranking motors where high voltage is required, auxiliary shunt-connected coils are added to the circuit to slow down the top free running speed which would otherwise be destructive to the motor. As current enters the motor it passes through the field windings creating a magnetic field, then into the brushes which ride on the commutator, and through the armature windings, thus creating a second magnetic field. The two strong magnetic fields oppose each other in such a way that the armature is forced to rotate.



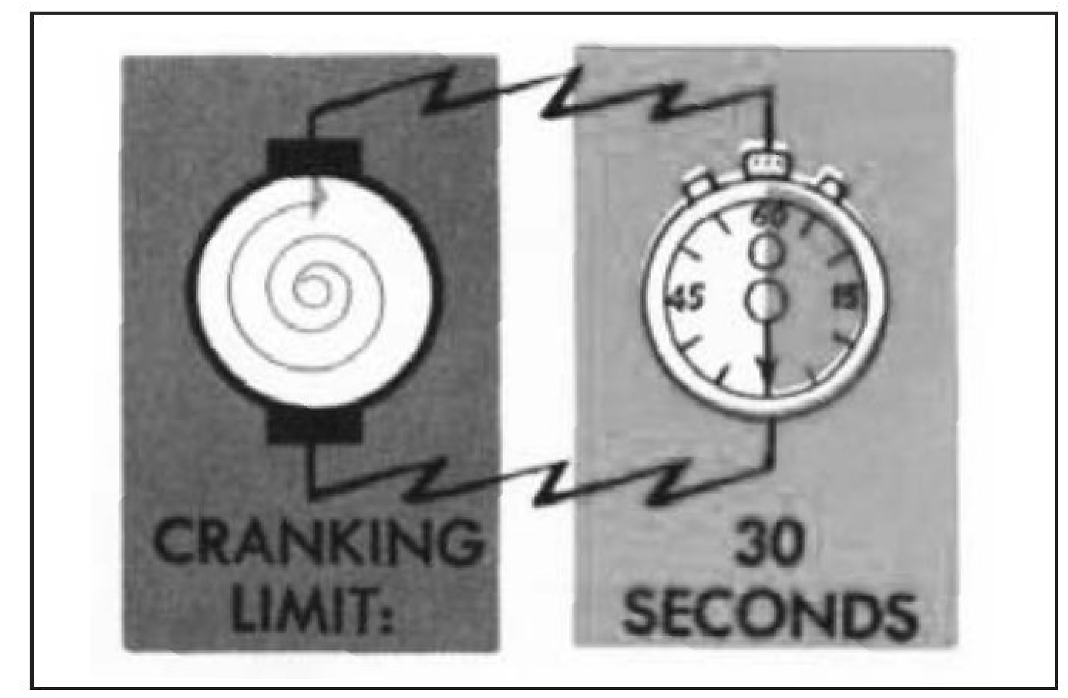

Some types of cranking motors incorporate a magnetically-operated switch which closes and opens the circuit between the battery and the cranking motor. Other motors, designed with an over-running clutch or a Dyer drive, have a solenoid type magnetic switch which not only closes the circuit between the battery and cranking motor causing the armature to rotate, but also shifts the cranking motor pinion into the mesh with the teeth on the flywheel ring gear of the engine. When the drive pinion becomes engaged with the teeth of the ring gear, cranking of the engine takes place.




Some cranking circuits have a RELAY in conjunction with the solenoid switch. The relay type solenoid requires less current to operate in the control circuit, thus allowing the use of lighter switches and smaller wire. It is actuated when connected to the battery by closing the cranking motor control circuit. Energizing the relay winding closes the relay contact points and connects the solenoid directly to the battery. This causes the solenoid to operate, shifting the drive pinion into mesh and closing the cranking motor circuit.

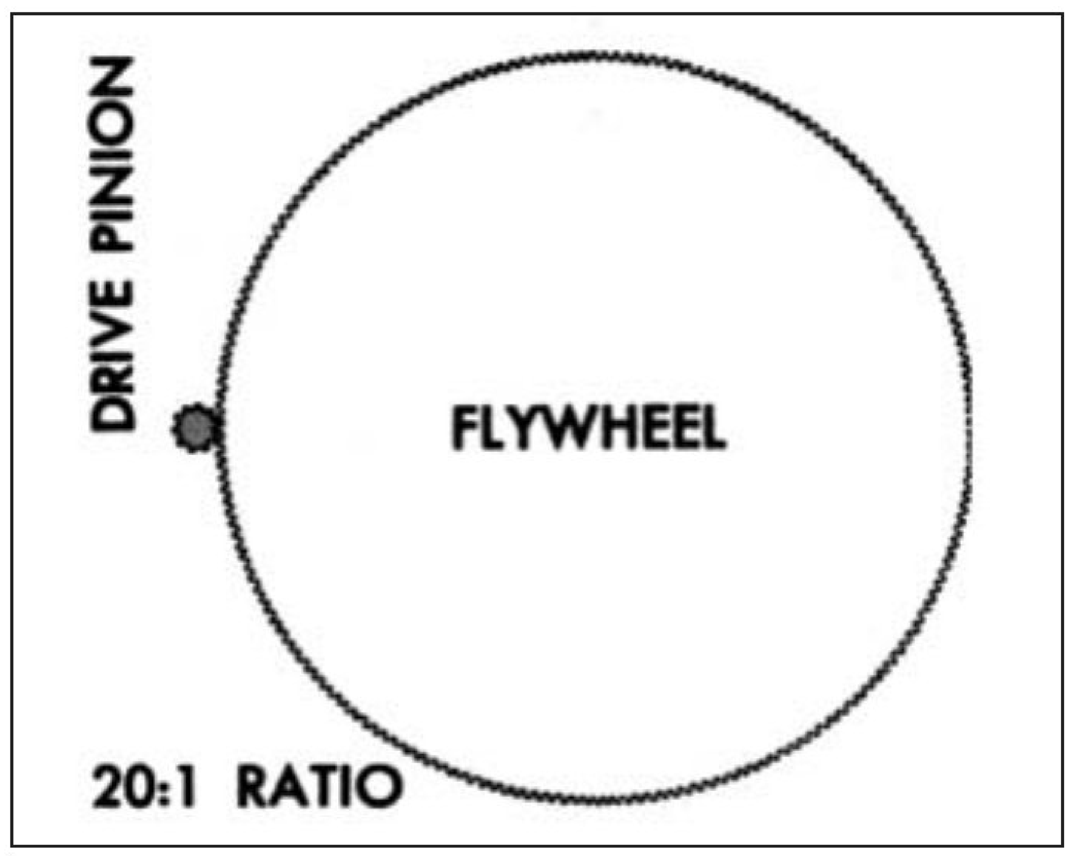



The cranking motor is a special type of electric motor, designed to operate under great overload and to produce a high horsepower for its size. It can do this, however, for only short periods of time, since high current must be used which creates considerable heat. If the cranking motor operation is continued for any length of time, the accumulated heat will cause serious damage. For this reason, the cranking motor must never be used for more than 30 seconds at any one time, and cranking should not be repeated without a pause of at least two minutes to permit the heat to escape.




The drive mechanism is a vital part of the cranking motor, since it is through the drive that power is transmitted to the engine, cranking it as the cranking motor armature rotates. The drive mechanism has two functions. One is to transmit the cranking torque to the engine flywheel when the cranking motor is operated and to disconnect the cranking motor from the flywheel ring gear after the engine has started. The second is to provide a gear reduction between the cranking motor and the engine so there will be sufficient torque to turn the engine over at cranking speed.

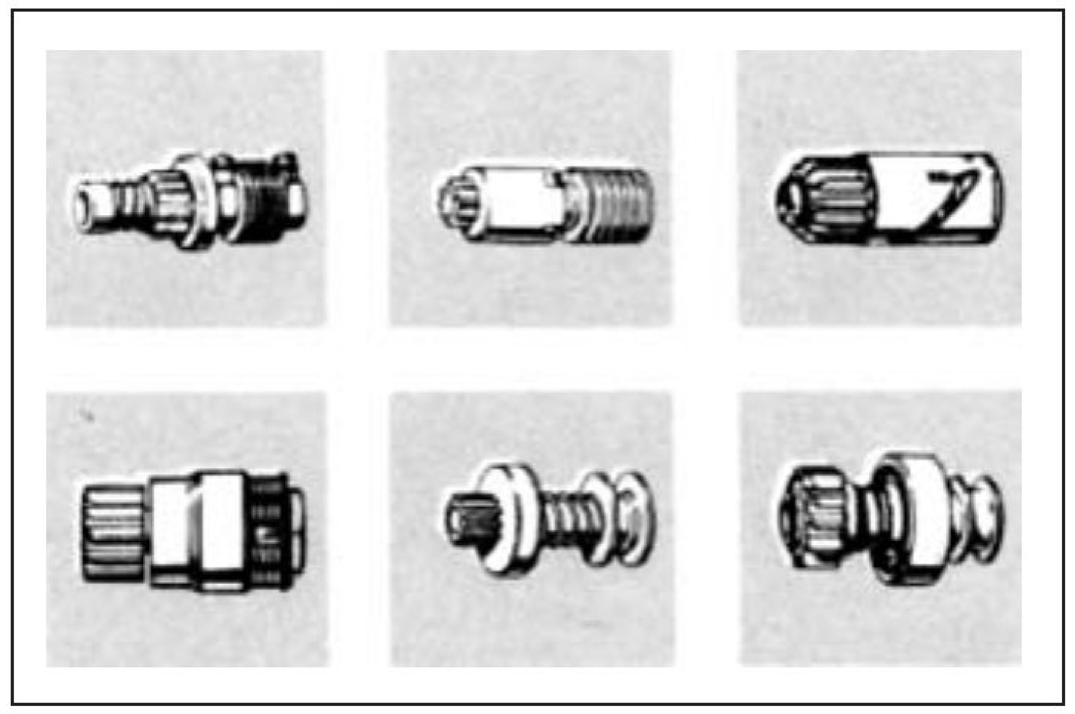
There are approximately 15 to 20 teeth on the flywheel for every tooth on the drive pinion, which means the cranking motor armature will rotate approximately 15 to 20 times for every engine revolution. Thus, to turn the engine over at 100 revolutions per minute the cranking motor armature must rotate at 1,500 to 2,000 rpm.



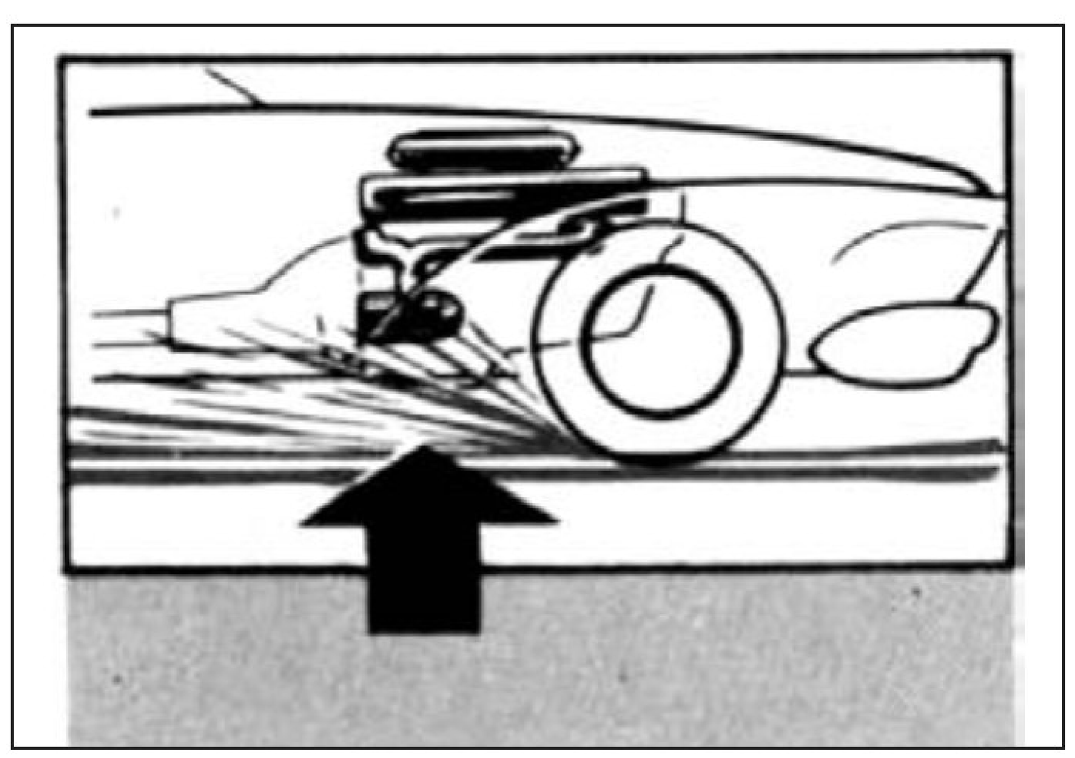

If the cranking motor drive pinion remained in mesh with the flywheel ring gear at engine speeds above 1,000 rpm, and if the pinion transmitted its rotation to the cranking motor armature, the armature would be spun at very high speeds. Such speeds would cause the armature windings to be thrown from the armature slots, and the segments to be thrown from the commutator.

To avoid such a condition, the cranking motor drive mechanism must disengage the pinion from the flywheel ring gear as soon as the engine begins to operate.

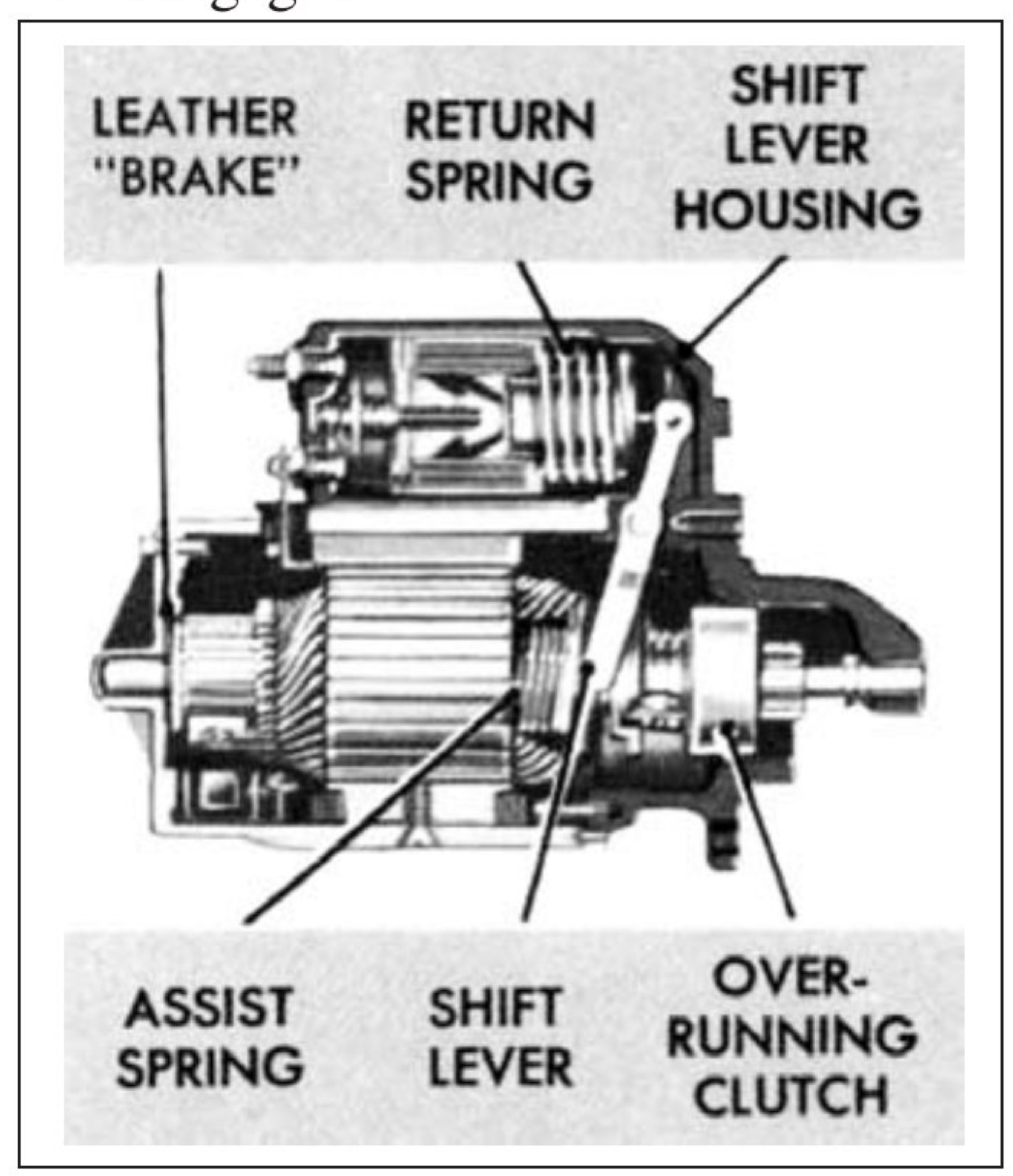
Several types of drive mechanism have been developed for use with cranking motors and are in widespread use. Each provides a means of engaging the drive pinion with the engine flywheel for cranking, and for disengaging the drive pinion from the flywheel ring gear when the engine starts.



Many cranking motors are now located under the engine, subject to road splash, slush and mud. To prevent entrance of moisture and other foreign material detrimental to the operation of electrical equipment, the Enclosed Shift Lever type was produced. The drive housing is extended to enclose the entire shift lever mechanism and solenoid plunger. These parts were formerly subject to icing and freezing which prevented normal operation.

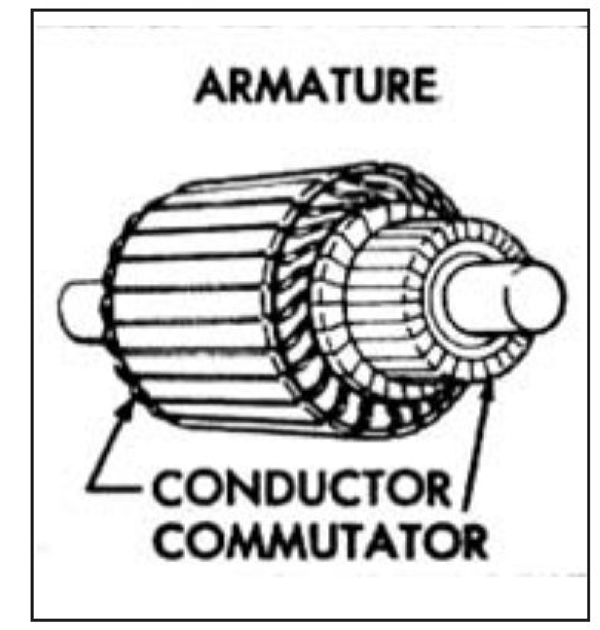


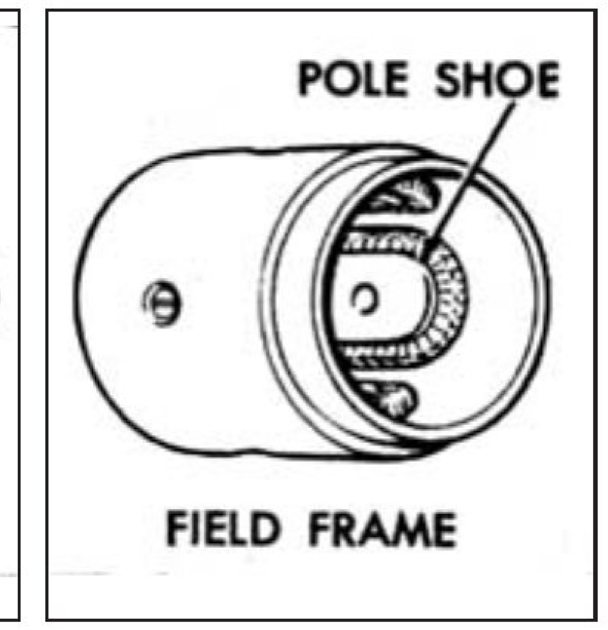
The solenoid is flange mounted and sealed to the drive end housing, completely enclosing all operating parts. When cranking, an "assist" spring aids the solenoid to overcome a return spring force and start the clutch movement toward the flywheel. When the solenoid circuit is broken, the shift lever return spring of a compression type exerts a push on the lever. Through linkage this push is exerted on the armature. The commutator end of the armature is pushed against a leather washer, which acts as a brake to slow down the free speed of the armature when the clutch is disengaged.



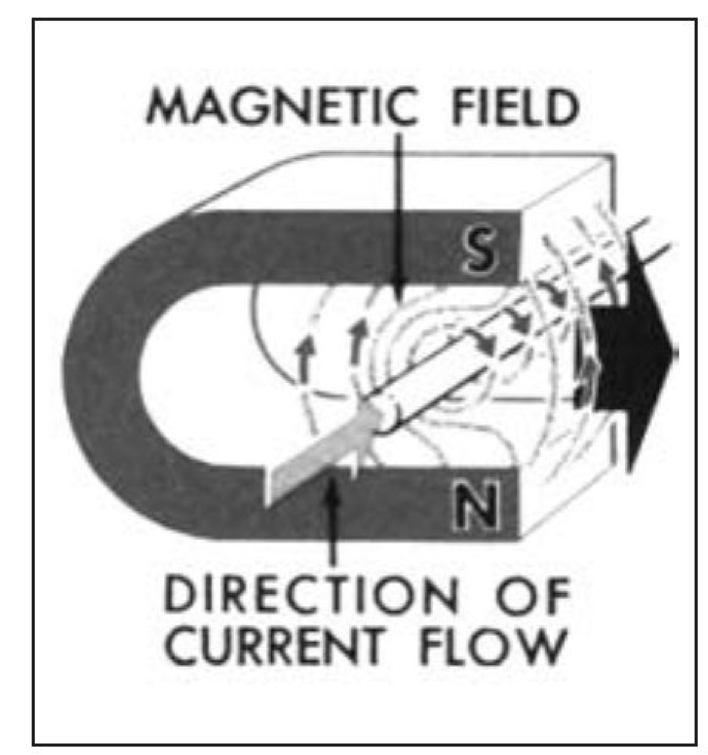

### *Motor Principles*

Magnetically, the cranking motor is made up of two parts, the ARMATURE and the FIELD WINDING ASSEMBLY. The armature contains a number of low resistance CONDUCTORS placed in the insulated slots of a laminated soft iron core assembled onto an armature shaft. The commutator is made up of a number of copper segments assembled together and insulated from each other and from the armature shaft. The conductors are connected to each other and to the commutator in such a way that current flows through all of the armature conductors when brushes are placed on the commutator and a source of current is connected to the brushes. This creates magnetic fields around each conductor. Current also flows through the field windings creating a powerful magnetic field.

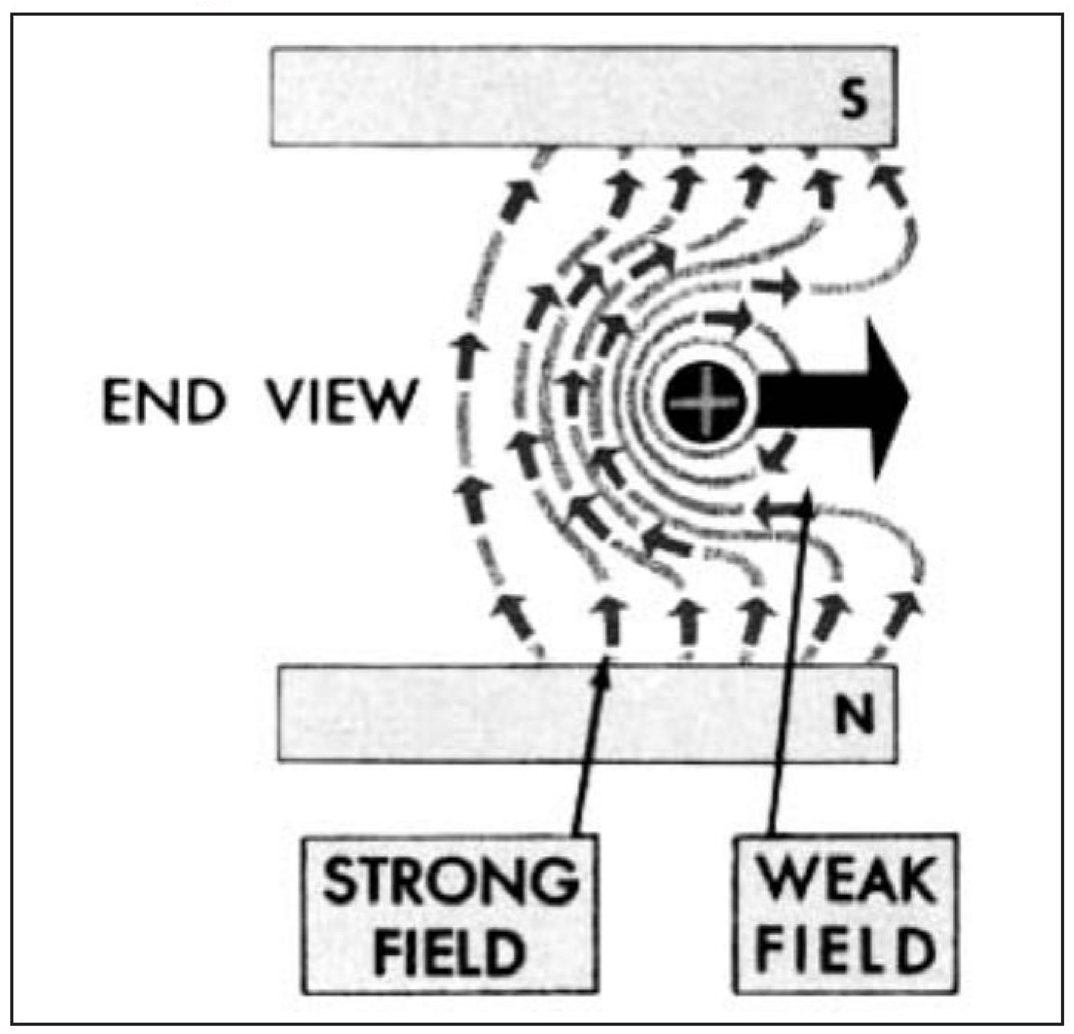



Illustrated is the relationship between the magnetic field of a permanent magnet, a single conductor through which current is flowing, and the direction of the force exerted on the conductor. Magnetic lines of force pass from the north to the south pole as indicated by the arrows. The flow of current through the con-ductor is in the direction shown.

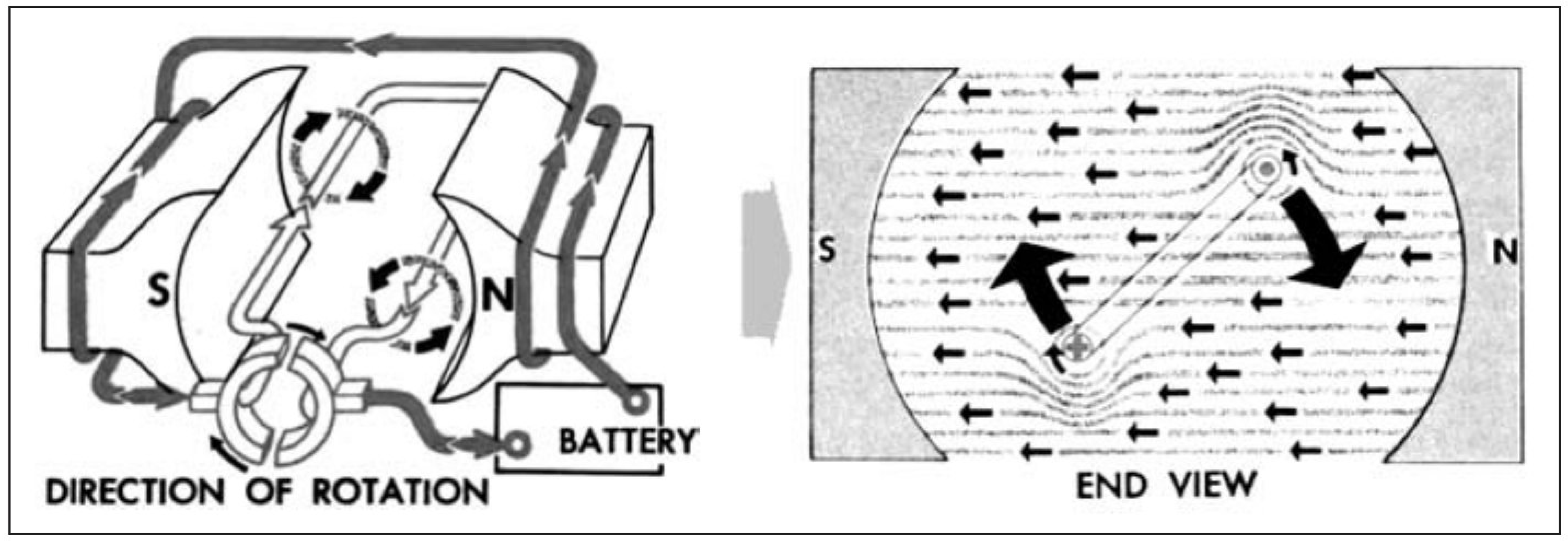



Using the right-hand rule, it can be seen that when the direction of current through the conductor is as shown the magnetic lines of force around the conductor will be in a clockwise direction as indicated by the circular arrow around the conductor. Looking at the end of the conductor, it will be noted that to the right of the conductor the magnetic field from the permanent magnet and the circular magnetic field around the conductor oppose each other. To the left of the conductor they are in the same direction and the field is strengthened.




When a current-carrying conductor is located in a magnetic field the normal field of force is distorted, creating a strong field on one side of the conductor and a weak field on the opposite side. The conductor will be forced to move in the direction of the weak field, therefore, in this instance, it will be pushed to the right. The more current flowing through the conductor the stronger is the force exerted on it.

Application of this principle is illustrated, showing a simple electric motor with a one-turn armature. The magnetic field is created by means of current flowing through the field coil windings

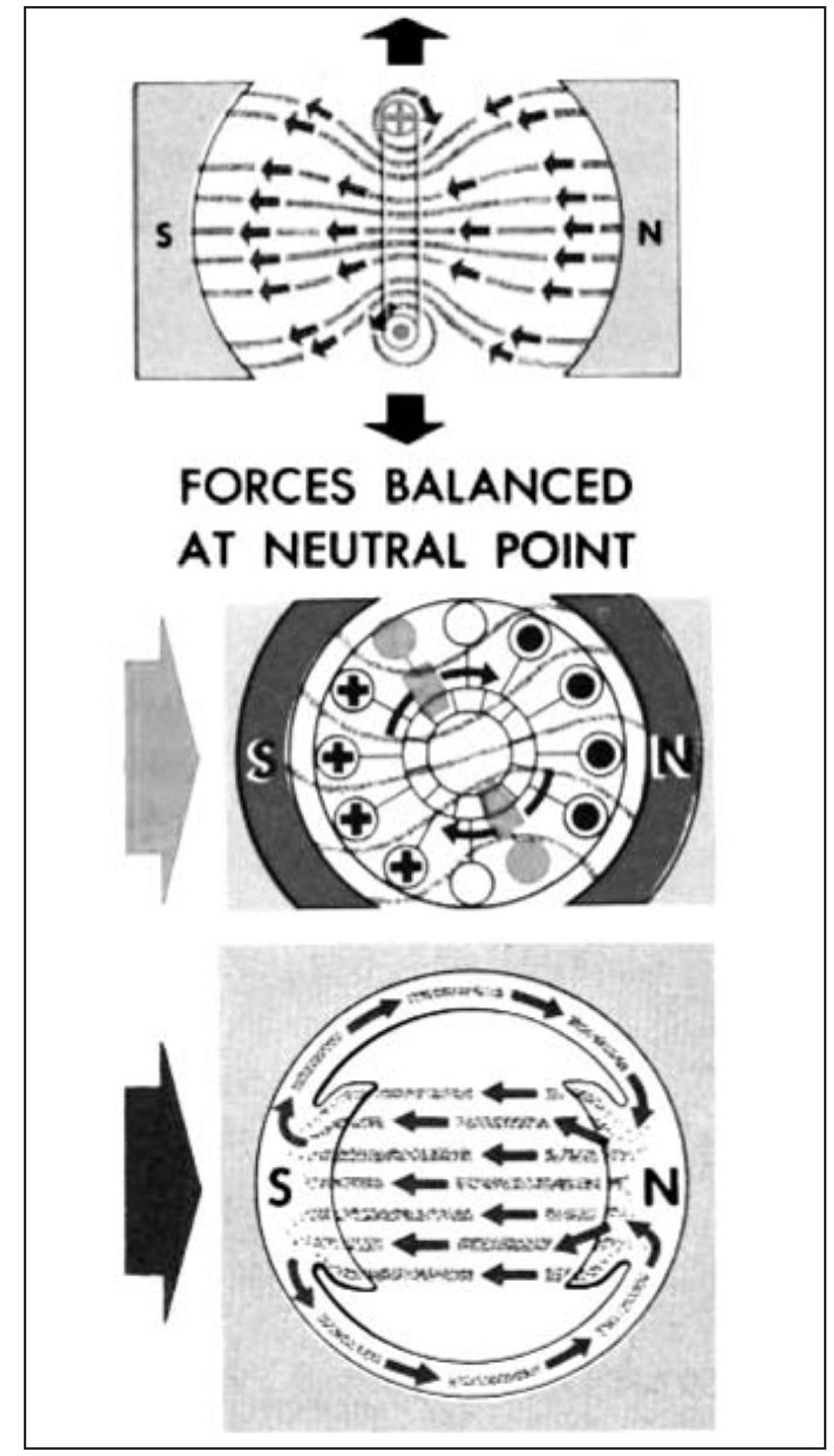



which are assembled around the two poles. By the right-hand rule for coils, it can be seen that the direction of the current tends to increase the magnetic field between the two poles. The “U” shaped armature winding placed between the two poles is connected to a two-segment commutator.

In the position shown, current from the battery flows first into and around the right hand field coil. It then crosses over to the left hand field coil and flows through, coming out at the left hand brush on the left hand commutator segment. From the segment the current flows through the armature winding, entering on the side nearest the south pole and returning on the side nearest the north pole to the right hand segment. From the right hand segment the current returns through the right hand brush to the battery. The magnetic fields around the conductor will be in the directions shown by the circular arrows. The left-hand side of the armature winding will be pushed upward while the right-hand side will be pushed downward, thus imparting a clockwise rotation.

Since the armature winding and commutator are assembled together and must rotate together, movement of the winding causes the commutator to turn also. By the time the left-hand side of the winding has swung around toward the north pole, the commutator segments will have reversed their connections with respect to the brushes. Current will then flow in the opposite direction with respect to the winding, but since the winding has turned 180 degrees the force exerted on it still will tend to rotate it in a clockwise direction.

The static neutral point is always half way between the pole shoes and is the point where the direction of current must be changed to maintain a turning force in the same direction. This is true whether the motor has two, four or six poles. However, when current flows through the armature windings creating another magnetic field, the normal field between the pole shoes is distorted. Since lines of force may be assumed not to cross each other, the neutral point is therefore shifted. Motor brushes are usually located back of the static neutral point (against the direction of rotation) to prevent excessive arcing and to obtain more efficient operation.




The type motor illustrated above is what is known as a series wound motor. The armature windings and the field coil windings are connected in series so that the current which flows through one winding will flow through the other. The current flowing through the field winding produces a powerful magnetic field between the poles. In the complete assembly, the field frame into which the pole pieces are assembled forms the return magnetic circuit for the magnetic lines of force.

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See Part II in the March issue.