Electric Motors

References

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Practical references

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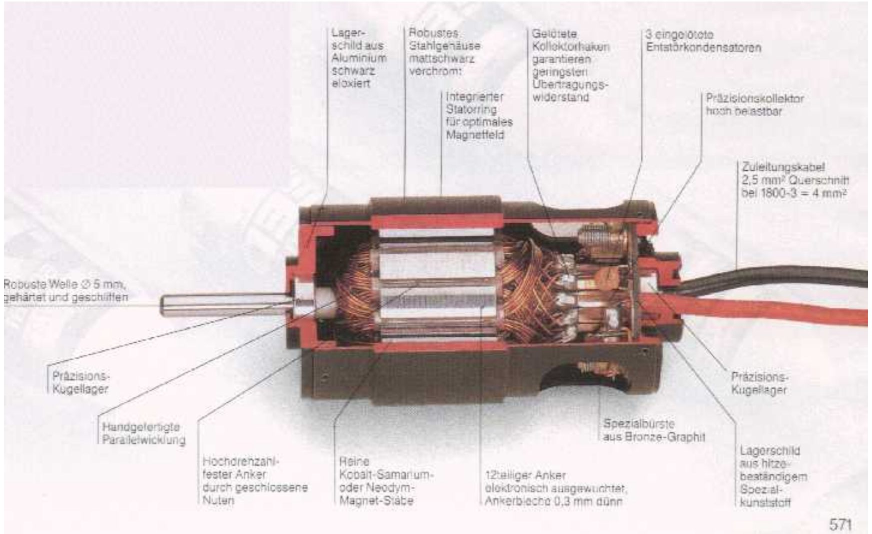
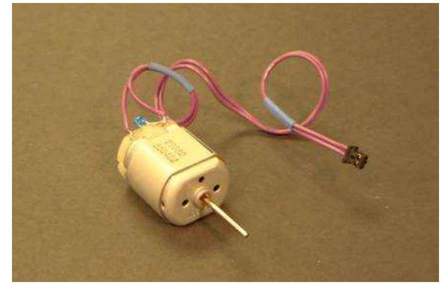
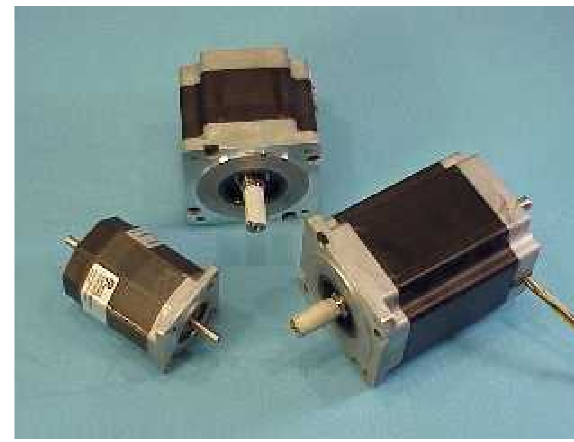
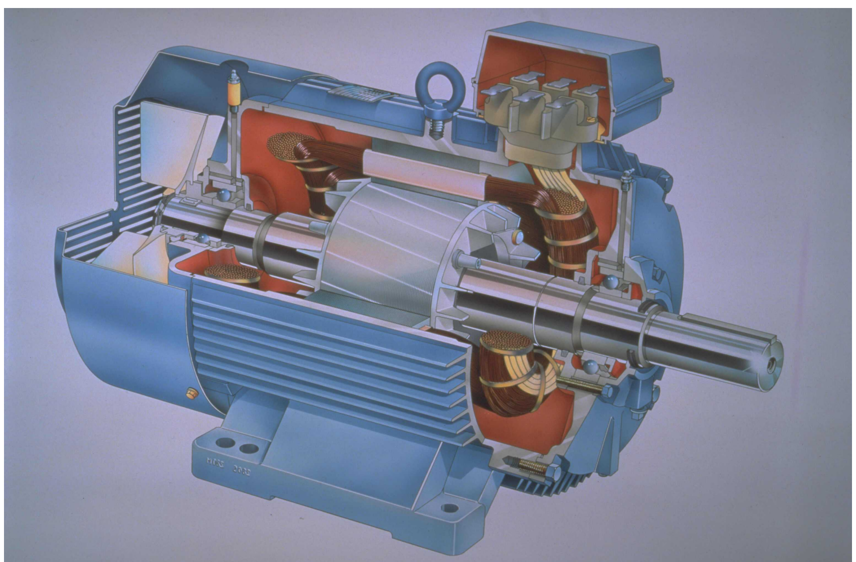
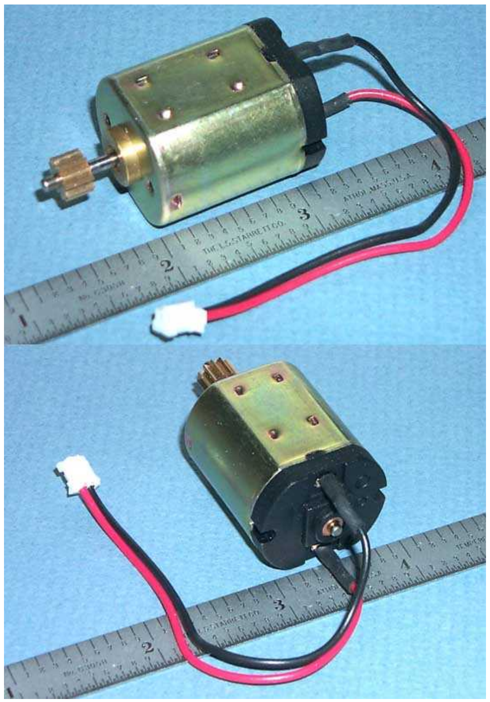

Lagerschild aus Aluminium schwarz eloxiert
Robustes Stahlgehäuse mattschwarz verchromt
Integrierter Statorring für optimales Magnetfeld
Gelötete Kollektorhaken garantieren geringsten Übertragungswiderstand
3 eingelötete Entstörkondensatoren
Präzisionskollektor hoch belastbar
Zuleitungskabel 2,5 mm² Querschnitt bei 1800-3 = 4 mm²
Robuste Welle ∅ 5 mm, gehärtet und geschliffen
Präzisions-Kugellager
Handgefertigte Parallelwicklung
Hochdrehzahlfester Anker durch geschlossene Nuten
Reine Kobalt-Samarium- oder Neodym-Magnet-Stäbe
12teiliger Anker elektronisch ausgewuchtet, Ankerbleche 0,3 mm dünn
Spezialbürste aus Bronze-Graphit
Präzisions-Kugellager
Lagerschild aus hitzebeständigem Spezialkunststoff
571



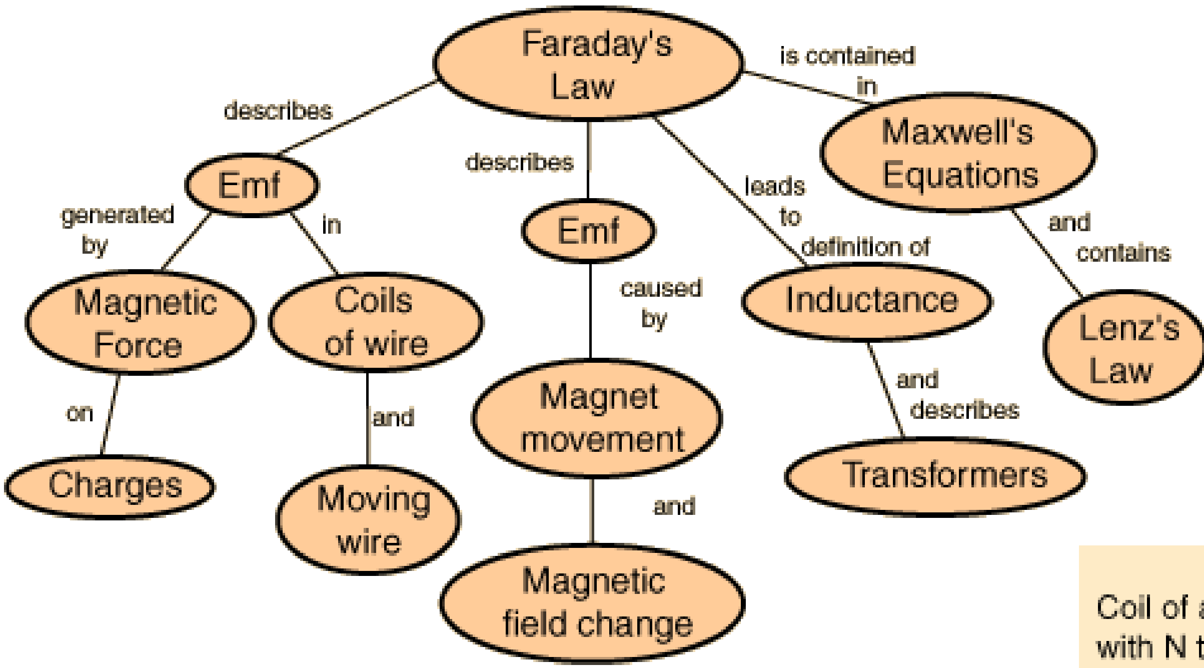


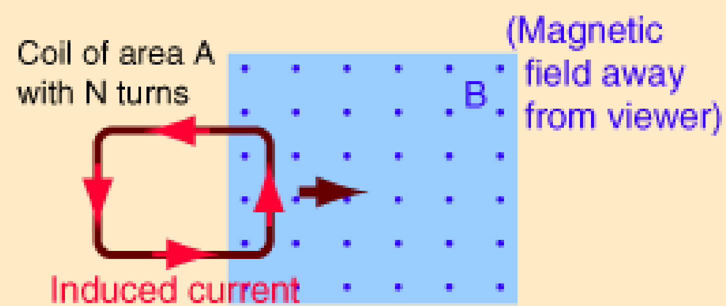




60’000 horsepower

DC Motors – Michael Faraday's legacy





A coil of wire moving into a magnetic field is one example of an emf generated according to Faraday's Law. The current induced will create a magnetic field which opposes the buildup of magnetic field in the coil.

AC MOTORS

- basic parts: axle, inside rotor, outside stator with coils, (commutator and brushes)
- basic types: single and three phase, synchronous and induction type

- **three phase induction (electric trains)**

  high power applications

  phase differences between the three phases of the polyphase electrical supply create a rotating electromagnetic field in the motor; speed a function of the frequency of AC supply and number of poles of the stator

- **single phase induction (fans – washing machines)**

  shaded pole motor: small household appliances

  requires a rotating magnetic field to produce starting torque (via, for example "shading coils‟. Part of each pole is encircled by a copper coil or strap; the induced current in the strap opposes the change of flux through the coil)

  split-phase induction motor : large household appliances (washing machines)

- **three phase synchronous (electric trains)**

  rotor (with permanent magnet) rotates in synchronism with the rotating magnetic field produced by the polyphase electrical supply

  can be used in the inverse sense as an alternator (produces ac current)

- **single phase synchronous (mechanical clocks, record players)**

  usually have magnetized rotors such that the motor does not require any induced current resulting in synchronous rotation with the mains frequency. Often used where accuracy in motor speed is needed.

DC MOTORS

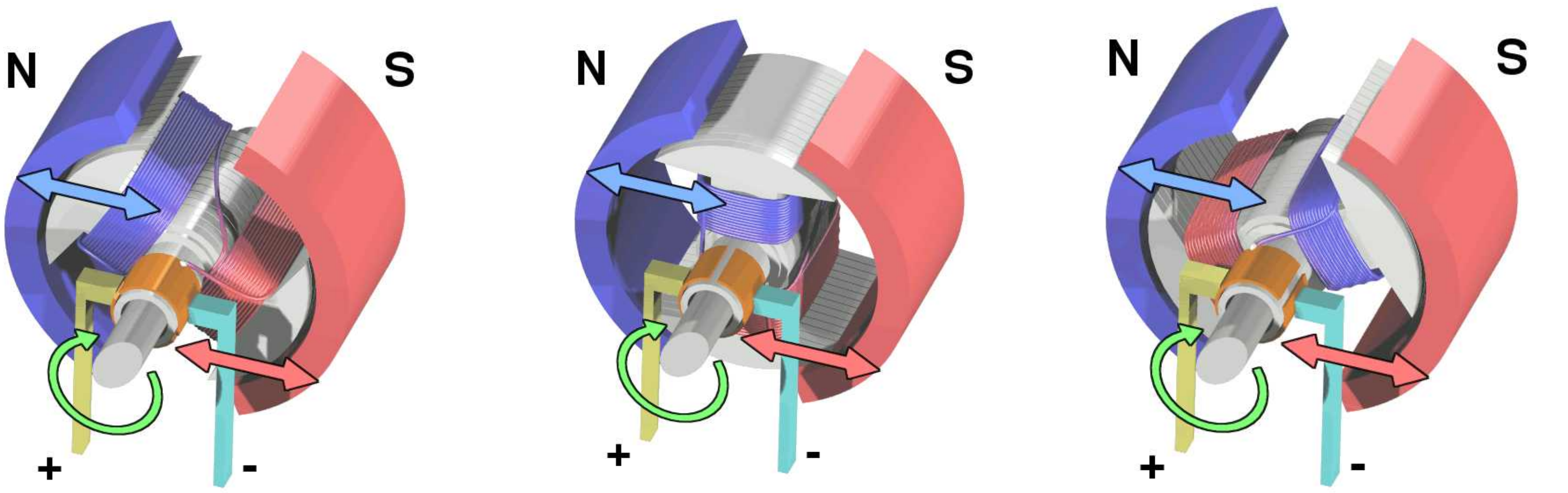
• basic parts -- axle, inside rotor (armature), outside stator, field magnet(s), (commutator and brushes)
• when power is applied, a dc motor turns in one direction at a fixed speed
• torque is highest at the rated speed and lowest at low speeds
• speed can be varied, reversed
• not suitable for positioning unless some kind of position feedback is added -> encoder

STEPPER MOTORS

• electric motors without commutators
• cross between a DC electric motor and a solenoid; as each coil is energized the rotor aligns itself with the magnetic field produced by the energized field winding. A stepper motor can not operate without a controller.
• precise positioning possible by keeping count of steps -> encoder
• torque is highest at the full stop and decreases as speed is increased
• used in open-loop or closed loop control systems

SERVO MOTORS

• a DC motor combined with feedback for either position or speed
• closed-loop system: constantly adjusts the position or speed in reaction to feedback

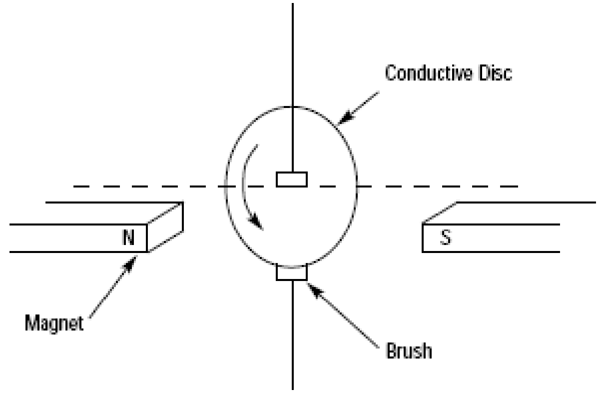


Electricity in coil generates a magnetic field around the armature. The left side is pushed away (blue arrow) and attracted to the right side.

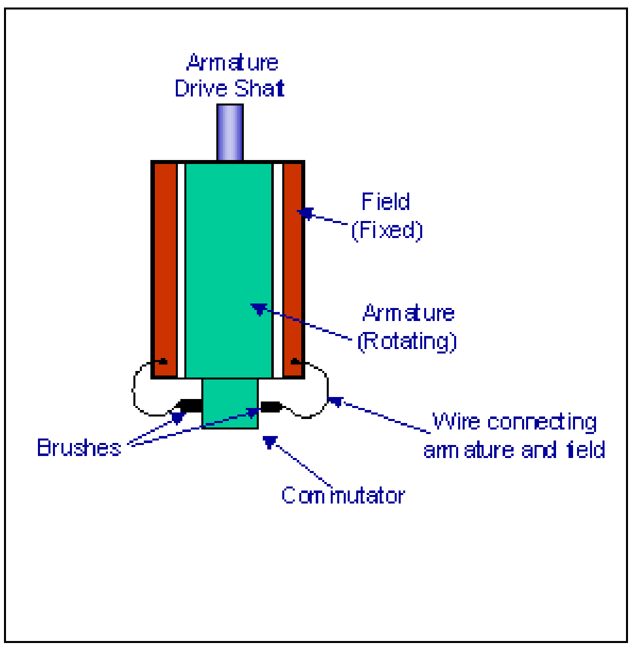
Intermediate state in horizontal position

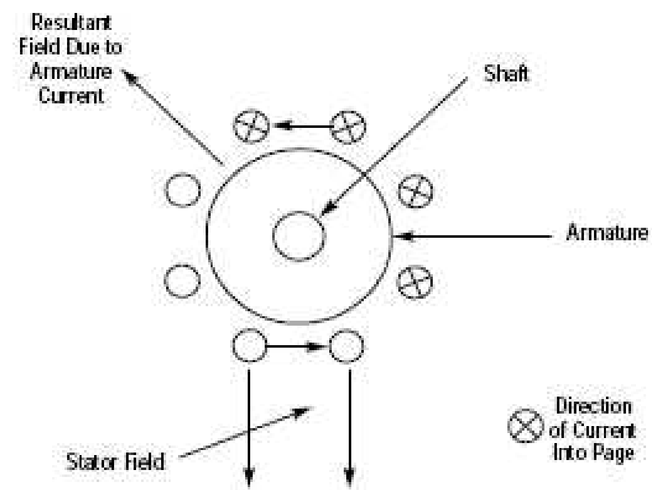
At the horizontal position the commutator reverses the direction of current through the coil, thus reversing the magnetic field. Process repeats…

http://en.wikipedia.org/wiki/Electric_motor



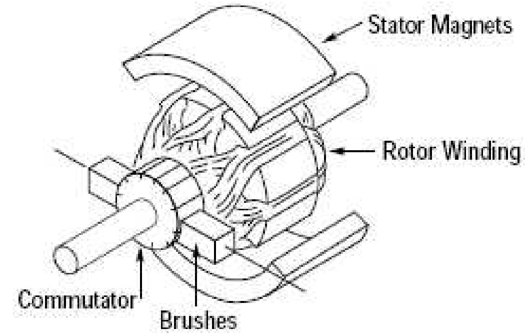
To obtain the greatest force and maximum performance from a motor, the maximum number of conductors must be placed in the magnetic field. In practice, this produces a cylinder of wire, with the windings running parallel to the axis of the cylinder. A shaft is placed down this axis to act as a pivot, and this arrangement is called the **motor armature**





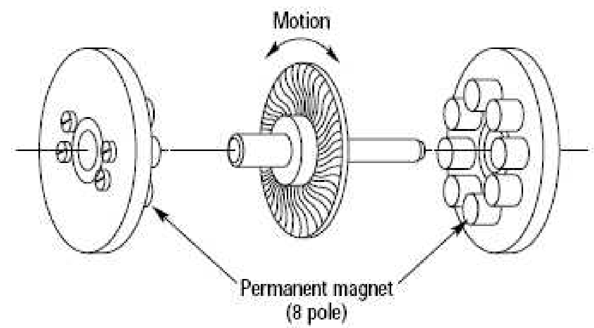
Iron cored

This is the most common type of motor used in DC servo systems. It is made up of two main parts; a housing containing the field magnets and a rotor made up of coils of wire wound in slots in an iron core and connected to a commutator. Brushes, in contact with the commutator, carry current to the coils.



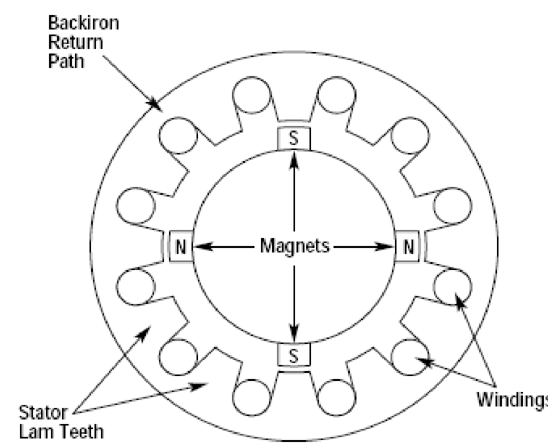
Moving coil

Since these types of motors have no moving iron in their magnetic field, they do not suffer from iron losses. Consequently, higher rotational speeds can be obtained with low power inputs.



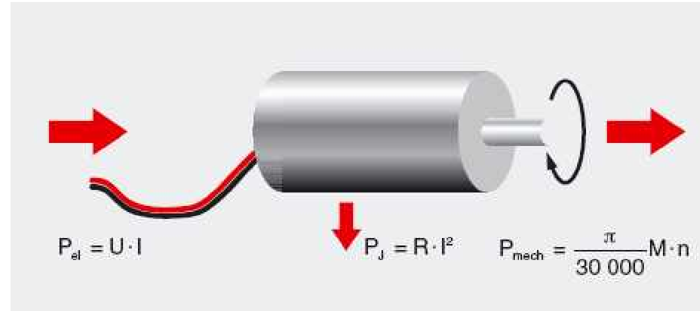
Brushless motor

In the brushless motor, the construction of the iron cored motor is turned inside out, so that the rotor becomes a permanent magnet and the stator becomes a wound iron core. The current-carrying coils are now located in the housing, providing a short, efficient thermal path to the outside air. Ease of cooling the brushless motor allows it to produce higher power in relation to its size. The other advantage of brushless motors is their lack of a conventional commutator and brush gear. By not having these components, the brushless motor is inherently more reliable. Also, they have a high starting torque and good controllability.



Motor losses

$$P_{el} = P_j + P_{mech}$$



Winding losses

Winding losses are caused by the electrical resistance of the motor windings and are equal to I^2R (where I = armature current and R = armature resistance).

Iron losses

Iron losses are the major factor in determining the maximum speed that may be attained by an iron-cored motor. Eddy current losses are common in all conductive cored components experiencing a changing magnetic field. Hysteresis losses are caused by the resistance of the core material to constant changes of magnetic orientation, giving rise to additional heat generation, which increases with speed.

Brush contact losses

Brush contact losses are fairly complex to analyze since they depend upon several factors that will vary with motor operation.

Maxon Motors

Alnico motor with precious metal brushes: no iron losses

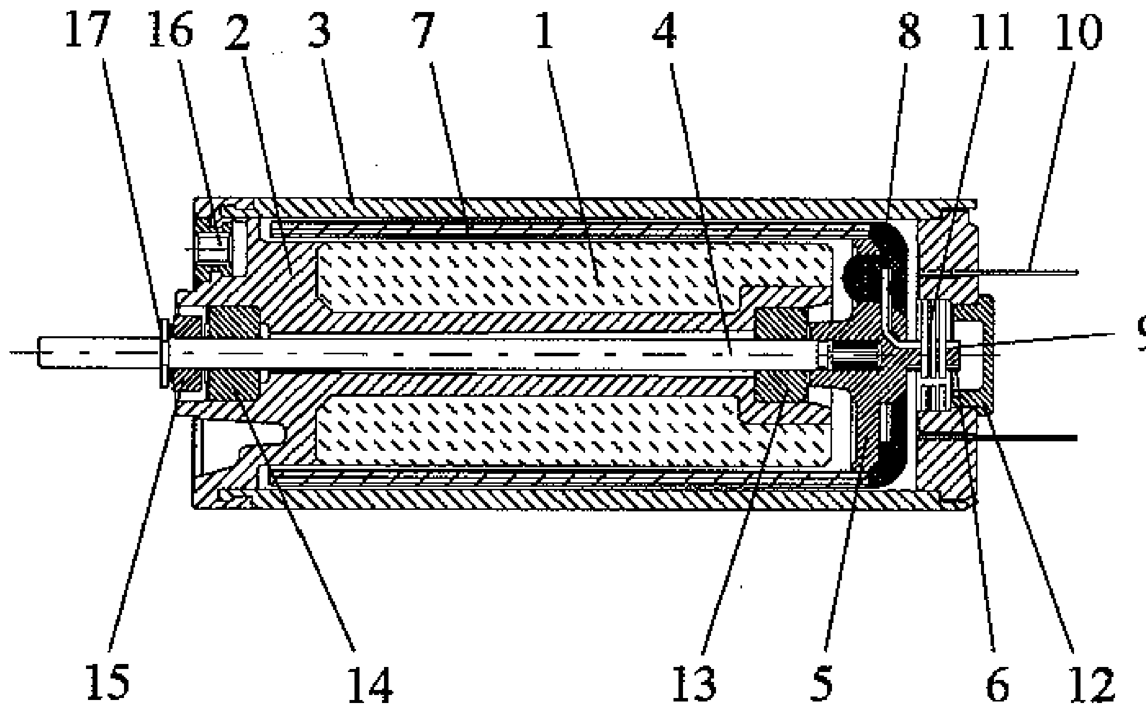


Figure 1.18.

1: **alnico magnet,** 2: plastic, 3: steel return path, 4: **shaft,** 5: collector plate, 6: **commutator**, 7: **winding tube** (rhombic winding), 8: junctions, 9: commutator segments, 10: connector tabs, 11: **metal brushes**, 12: end cap, 13/14: brass bearings, 15: retaining ring, 16: threaded inserts