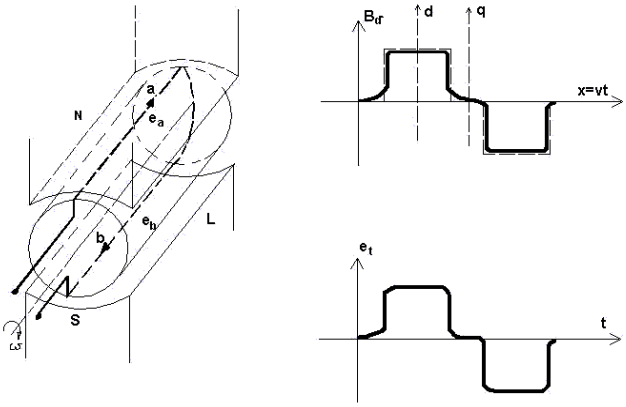
DIRECT CURRENT MACHINES 1

PRINCIPLES OF OPERATION

a) Electromotive forces



$$e_a = e_b = BLv$$

$$e_t = 2BLv$$

Two N & S magnetic poles are created due to:
- permanent magnets, or
- DC electromagnet.

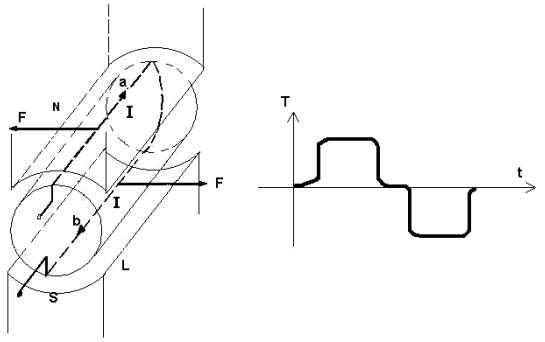
Space distribution of radial flux density B=f(x)

L – length of active part of coil conductor (rotor – armature)
v=ωr=ωD/2 – linear speed of the coil side due to rotation of the rotor with angular speed ω

Electromotive force e_t is of alternating course!

Directions of emfs and forces: three fingers of right hand rule!

b) Electromagnetic forces and torque



$$F = BIL$$

$$T = FD = BILD$$

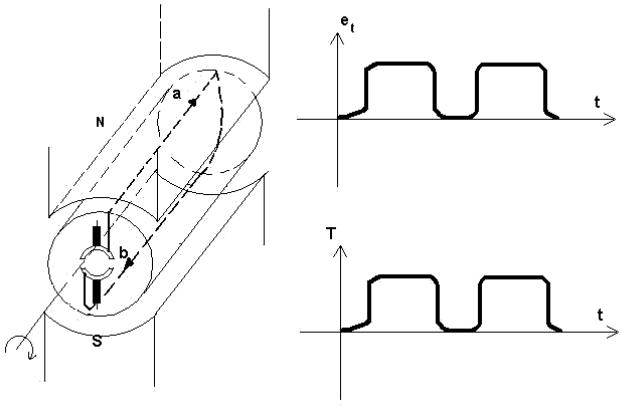
D – diameter of the rotor

I – rotor current

The torque is also of alternating course!

The need of emf rectifying to get DC voltage source or inverting the rotor current to get unidirectional torque is obvious!

c) Electromechanical rectifying (inverting) - commutating



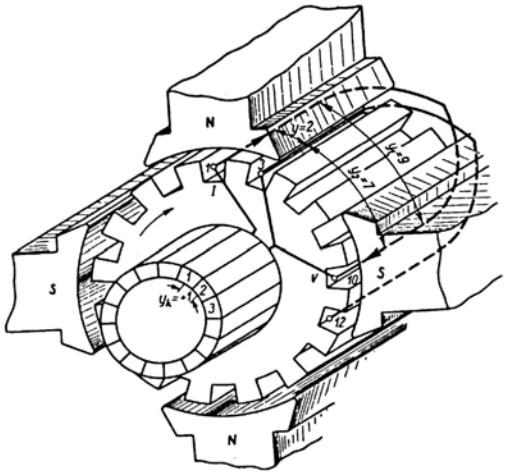
Rectified emf (collected at brush terminals).

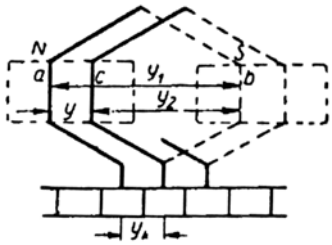
Torque after inverting the current (DC current supplied to brush terminals).

Commutator *– combination of rotating semi-rings and stationary brushes.*
In real machines semi-rings are divided into commutator bars as the number of turns is significantly increased.

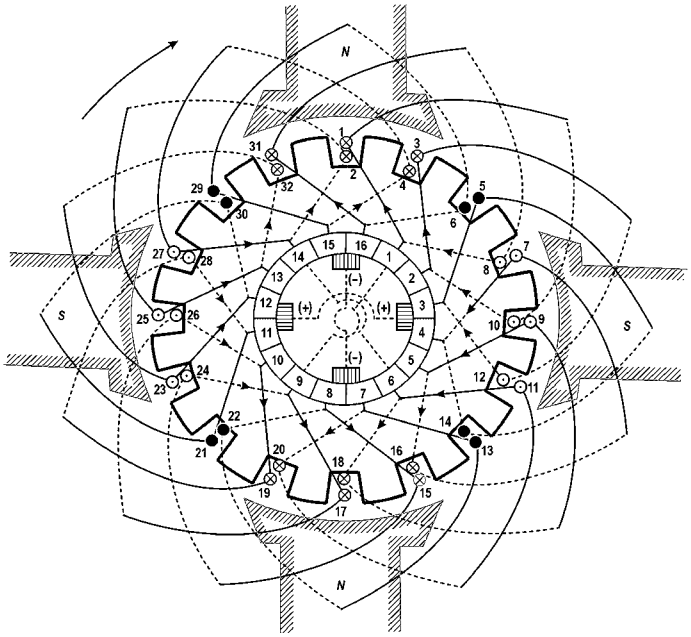
Instead of one turn (one coil) and two commutator half-rings we can apply bigger number of coils located in adjacent slots and connected to next bars (segments) of commutator. These coils can be connected in series or they can form parallel branches. Examples of more advanced armature windings are presented at the next pages.

SIMPLE-LAP ARMATURE WINDING

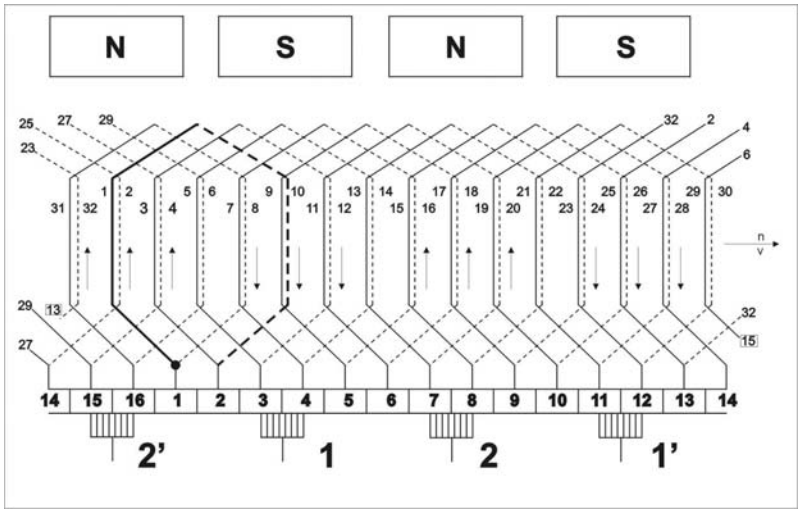




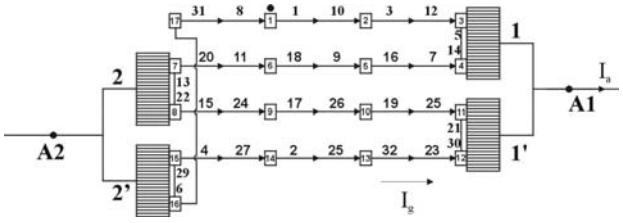
- Number of poles $2p$=4
- Number of slots Q=16
- Number of commutator bars K=16
- Pole pitch $\tau_p=Q/2p$=4 slots
- Width of the coil y_Q=4 slots



See consecutive numbers of coil sides from 1 to 32. There are two coil sides in one slot. Coil sides being at the moment in neutral zone (•) undergo commutation – they are passing from influence of one pole to another pole.
Coil sides under poles are "active" with emf induced depending on the magnetic pole they linked.



Starting from the point • (commutator bar 1) we follow coil-side emfs 1 and 10 and come to commutator bar 2, then emfs 3 and 12 … and finally we get "the chain":



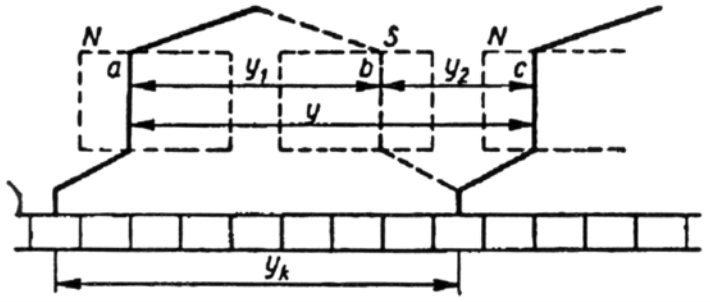
For simple-lap winding number of pairs of parallel branches = number of pole pairs

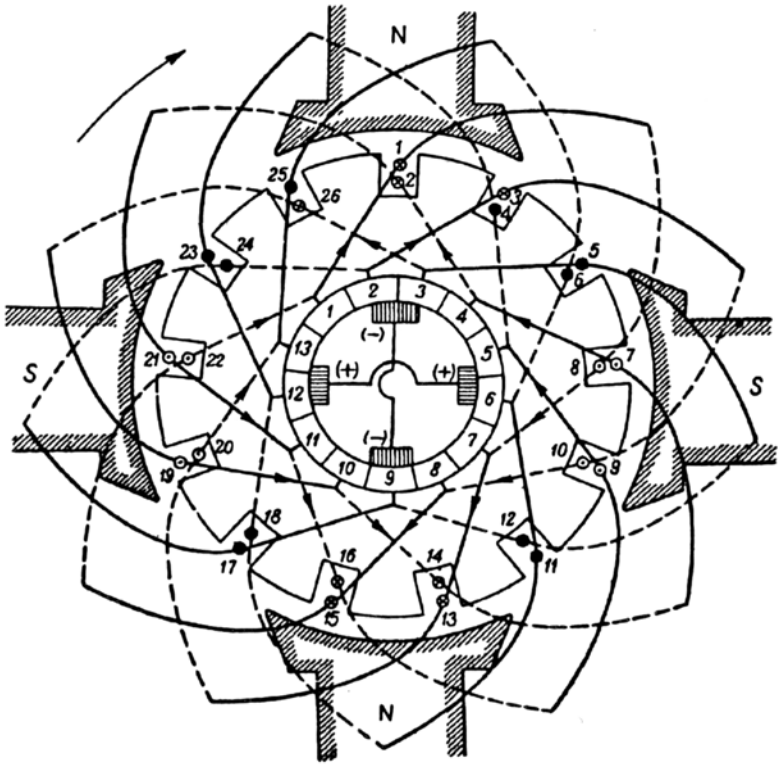
$\boxed{a=p}$

For multiplex-lap winding ($y_k = m$)

$\boxed{a=mp}$

SIMPLE-WAVE ARMATURE WINDING





After drawing “the chain” we find that for simple-wave winding:

$$a = 1$$

For multiplex-wave winding

$$a = m$$

Wave windings are applied in machines of higher voltage and smaller current comparing to machines with lap windings.

[Figures for this part od DC Machines Theory were drawn with the help of 2002/03 academic year students:
At page 1 – Bartosz Duszczyk,
page 2 – Jakub Ściuba,
page 3 – Paweł Gołębiowski]