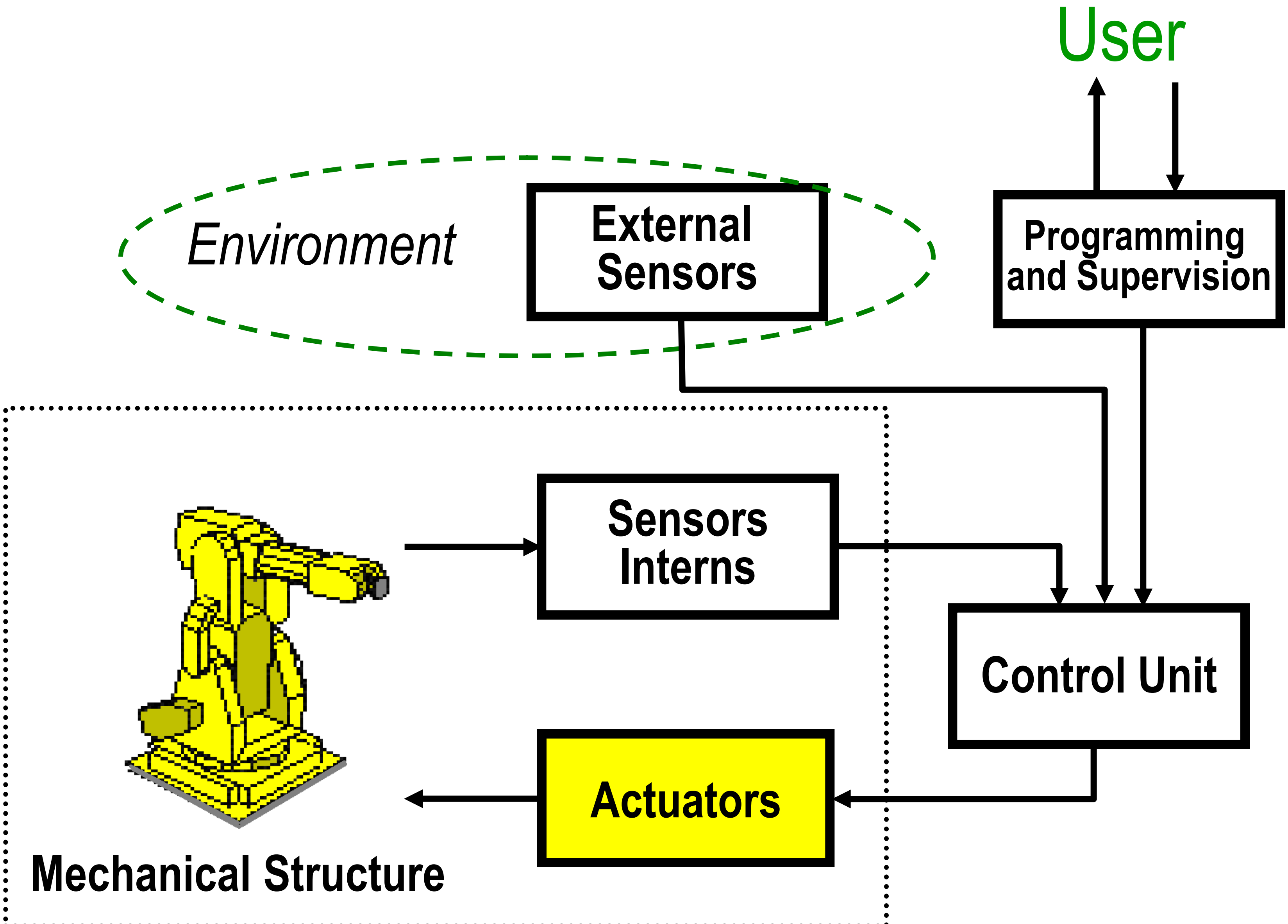
ROBOT TEKNOLOJISI

Ege Üniversitesi Ege MYO
Mekatronik Programı

BÖLÜM 5

Robotlarda Kullanılan Aktuatörler (Eyleyiciler)


User
Environment
External Sensors
Programming and Supervision
Sensors Interns
Control Unit
Actuators
Mechanical Structure

ACTUATORS

1 – Pneumatic actuators

Cylinders

2 – Hydraulic actuadors

Cylinders

Motors

3 – Electrical actuators

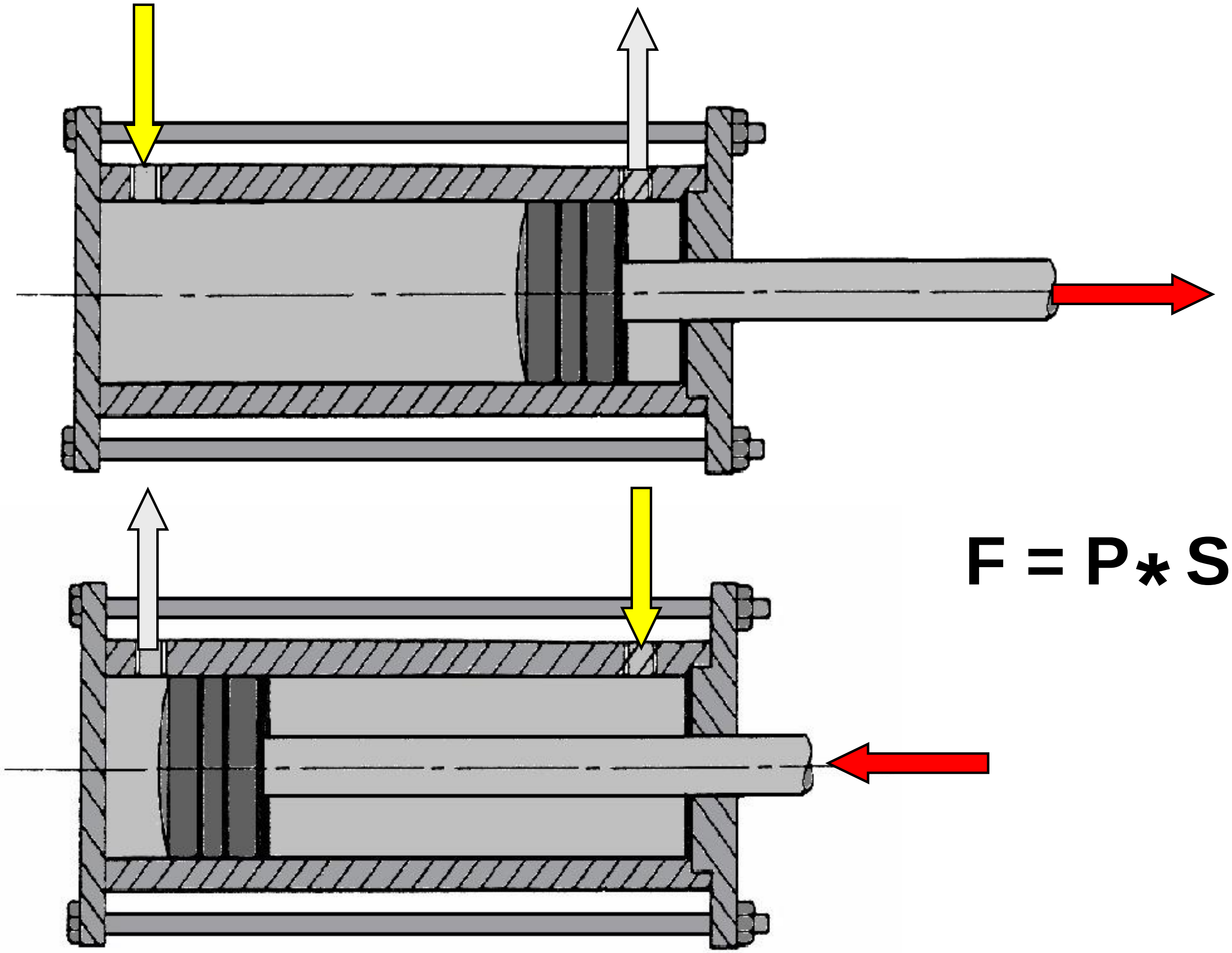
Dc motors.

Ac motors

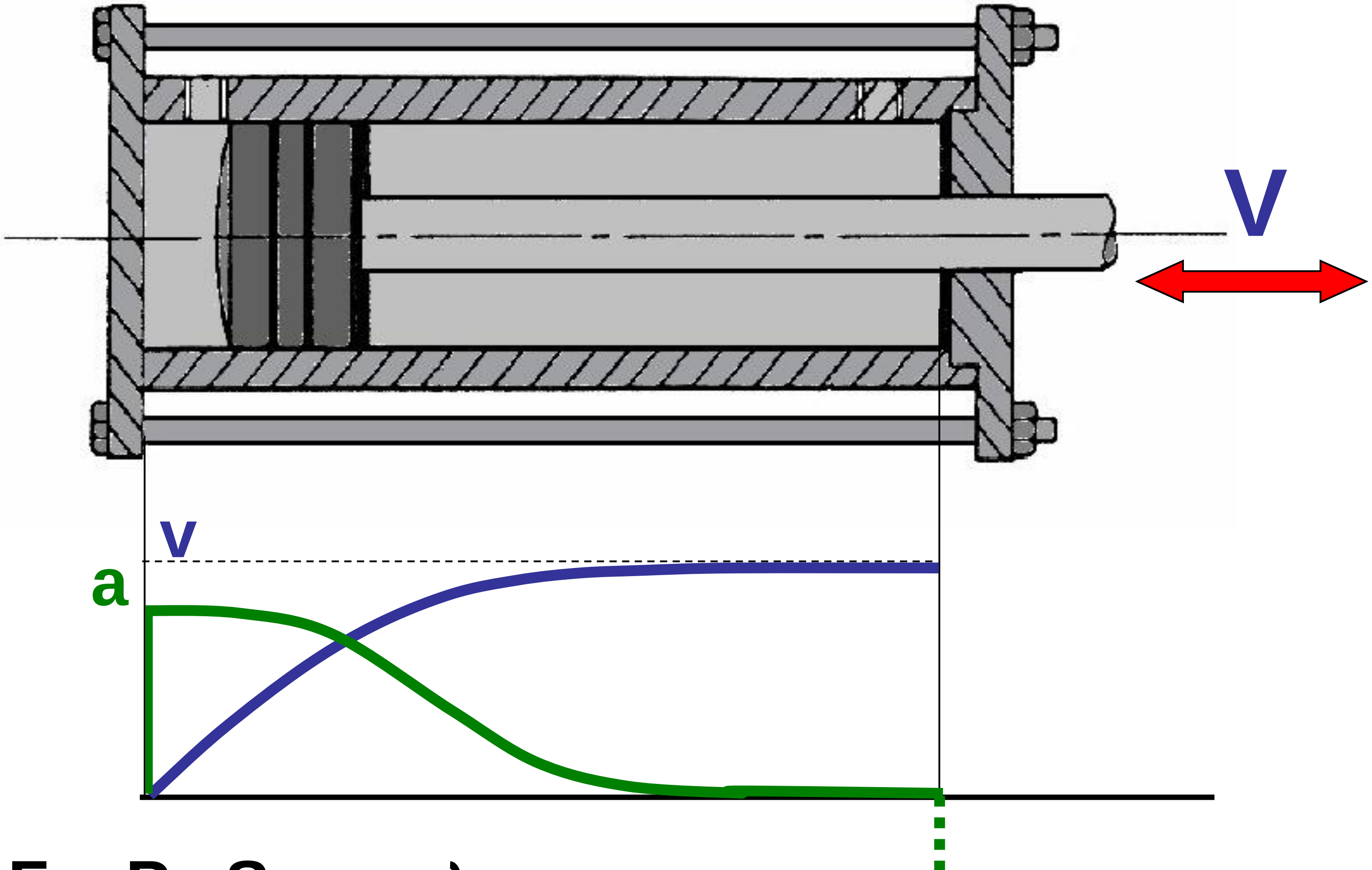
Steeper motors.

1 – Pneumatic actuators (cylinders)

Double effect pneumatic cylinders



$$F = P * S$$



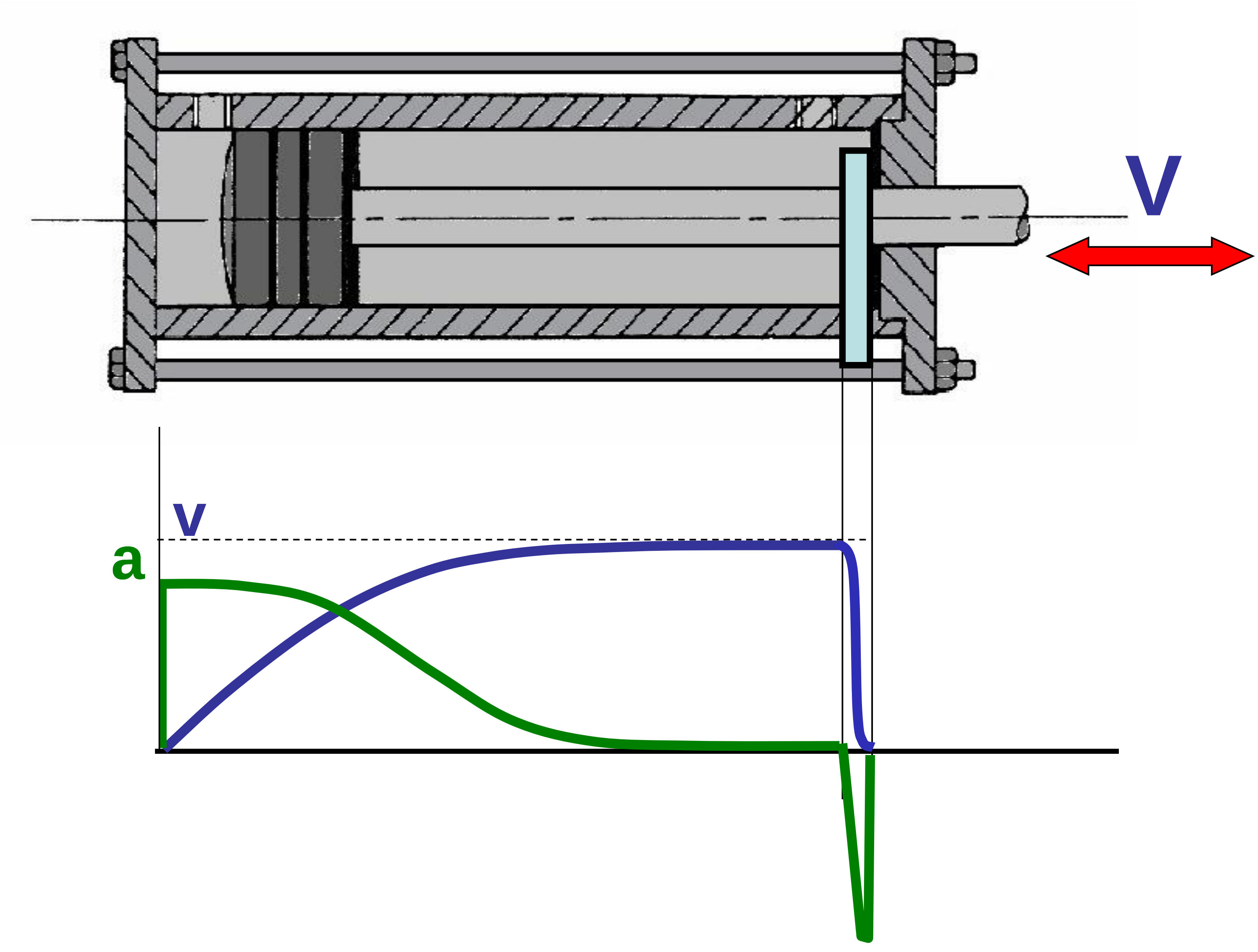
$$F = P * S$$

$$F - F_f = M * a$$

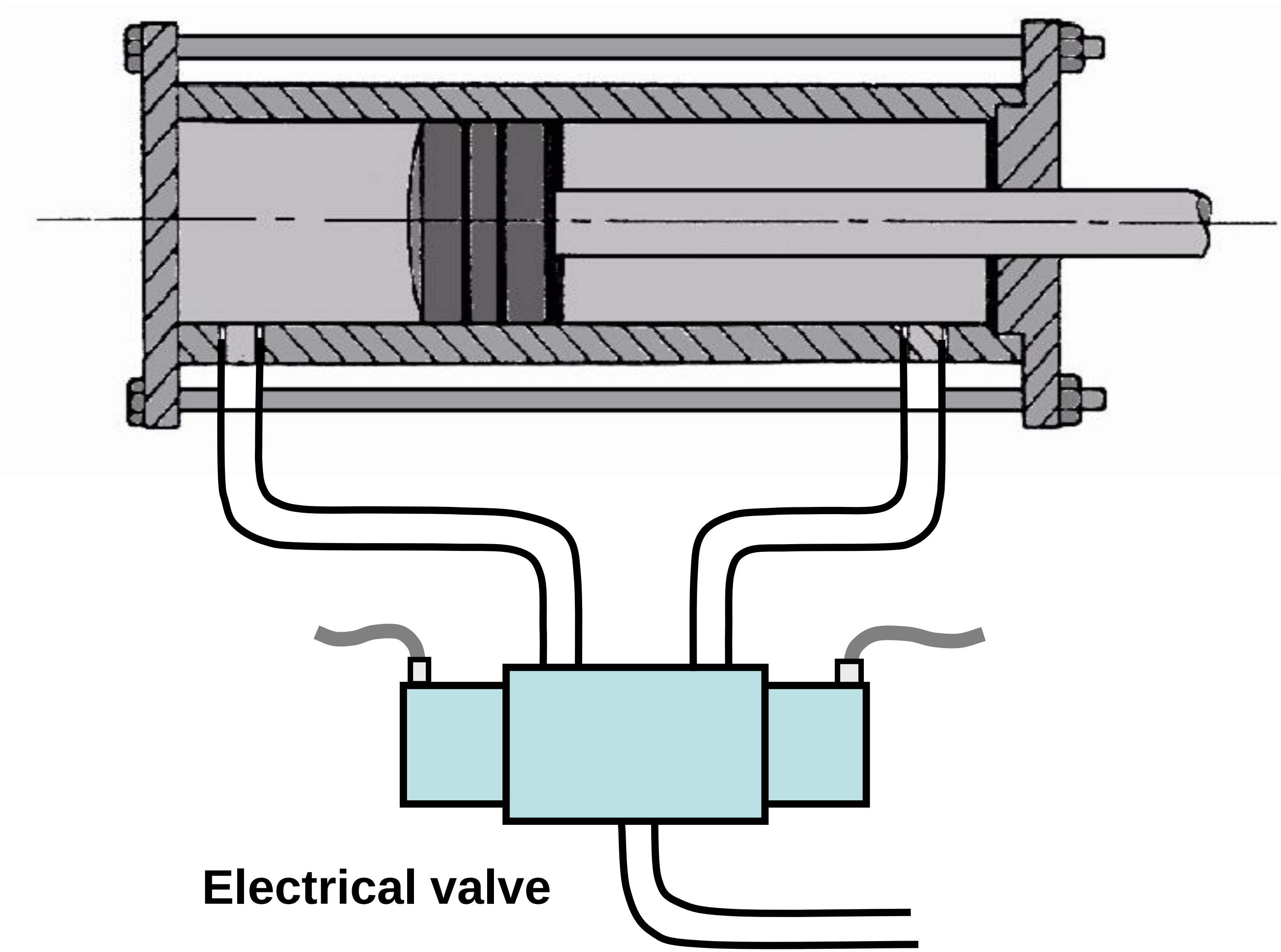
$$F_f = k * v^2$$

$$\Rightarrow \quad a = \frac{P * S - k * v^2}{M}$$

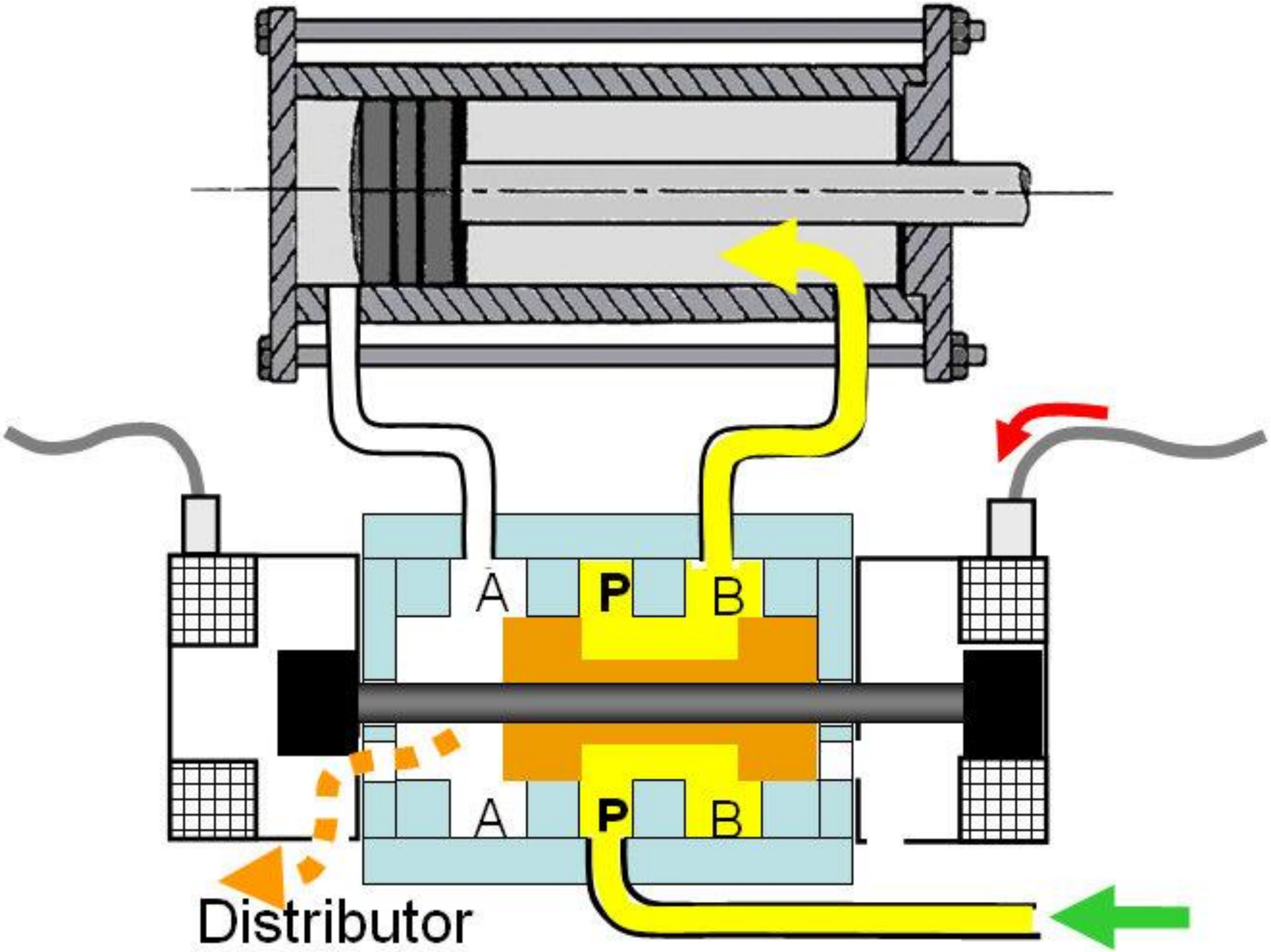
Speed is not controllable. The cylinder maximum speed is achieved when friction forces (kv^2) equal those that produce the advancing movement (F = P.S), and a = 0.

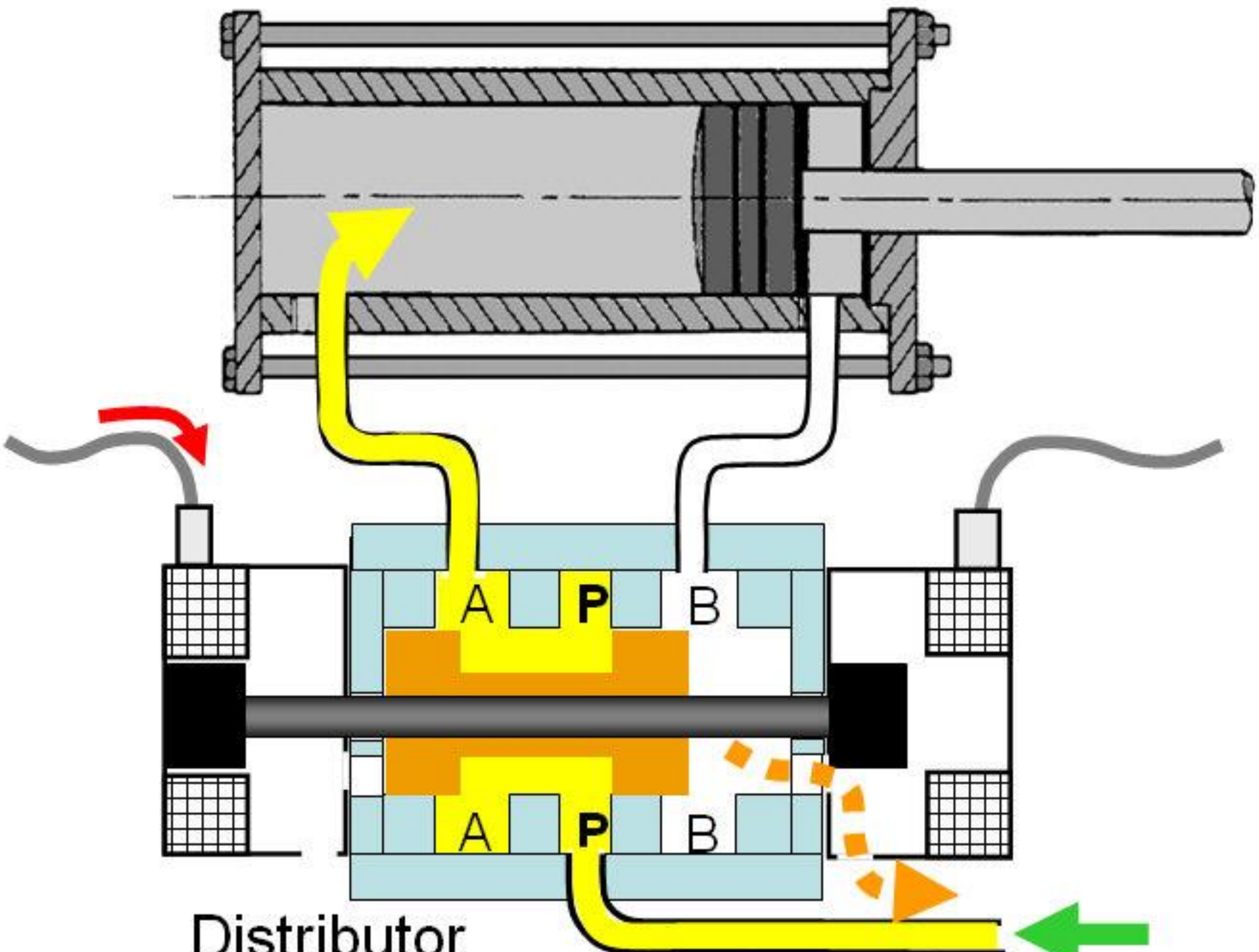


- The impact produced when reaching the end of the run is reduced using a shock absorber.

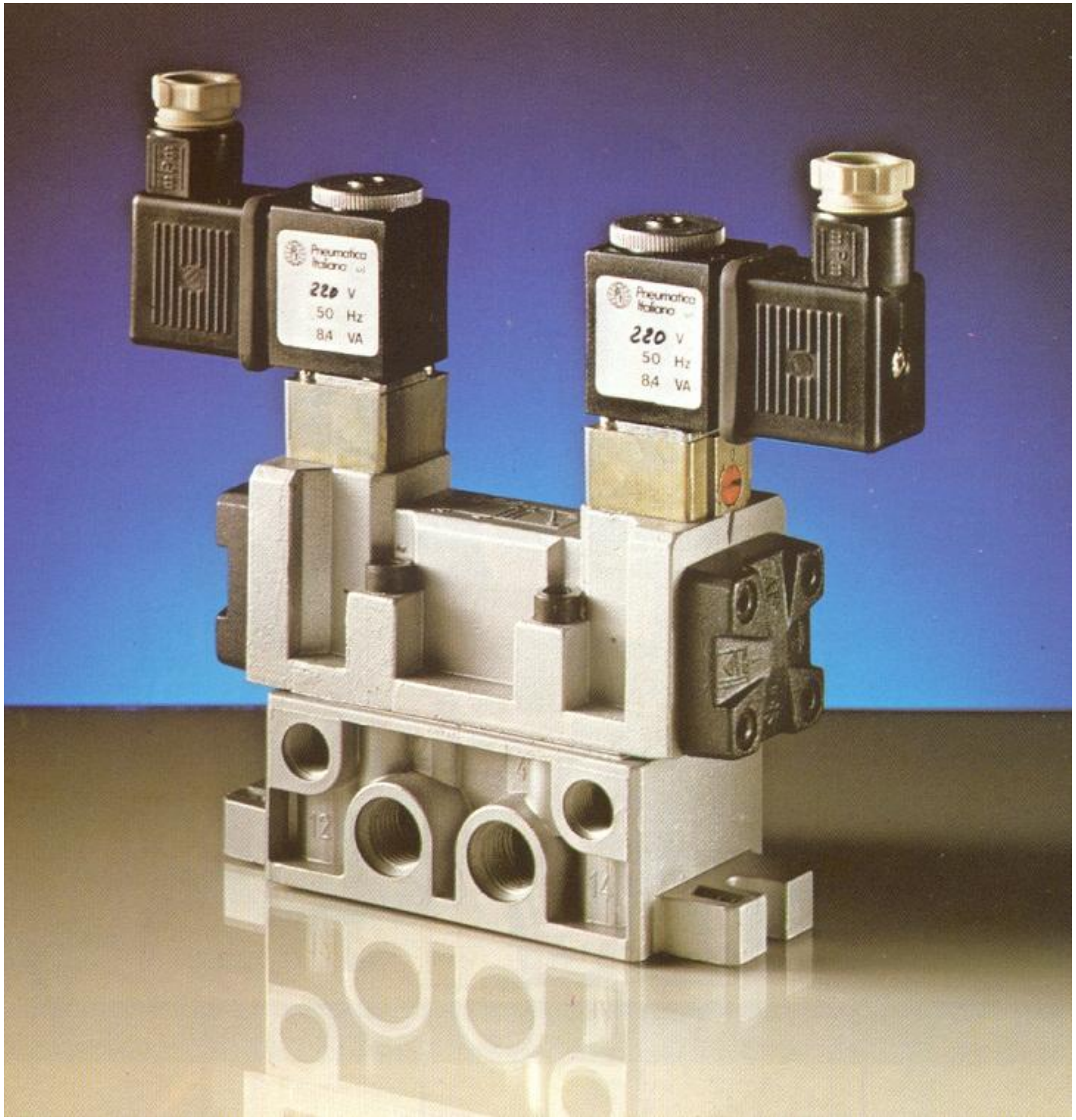


- Electrical valve: the hydraulic-electrical interface

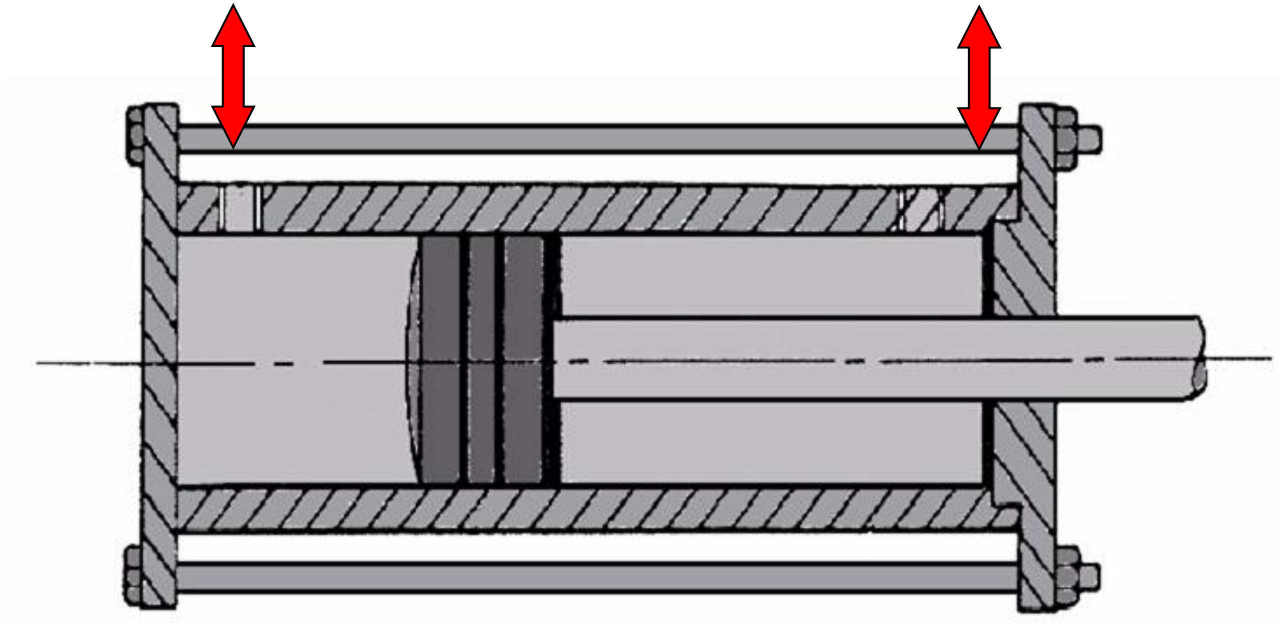

A
P
B
A
P
B
Distributor



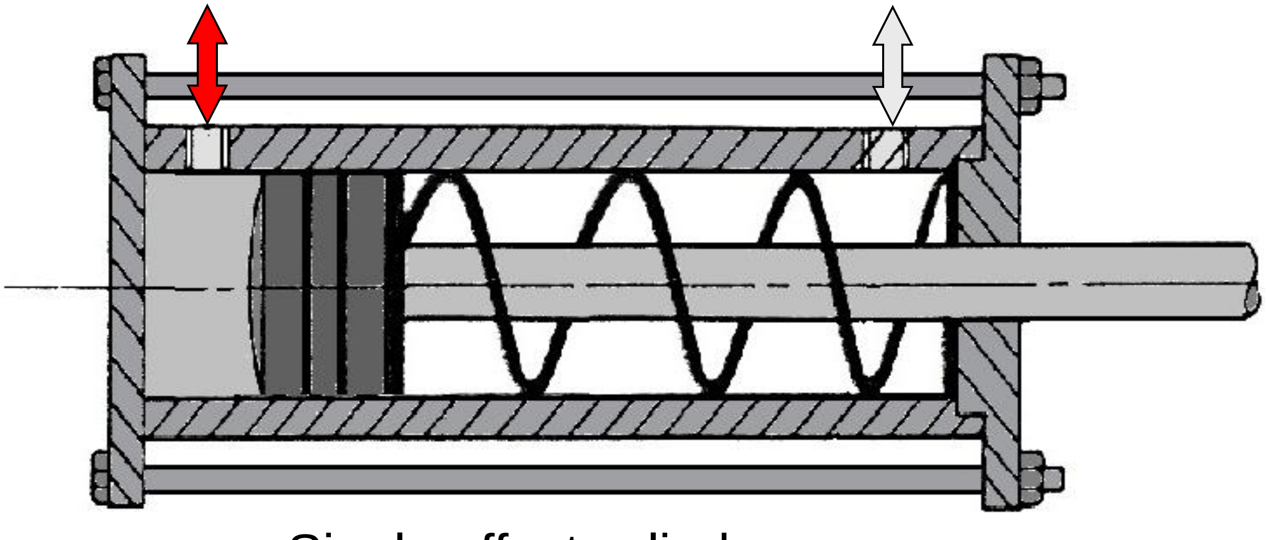
Distributor



Distributor



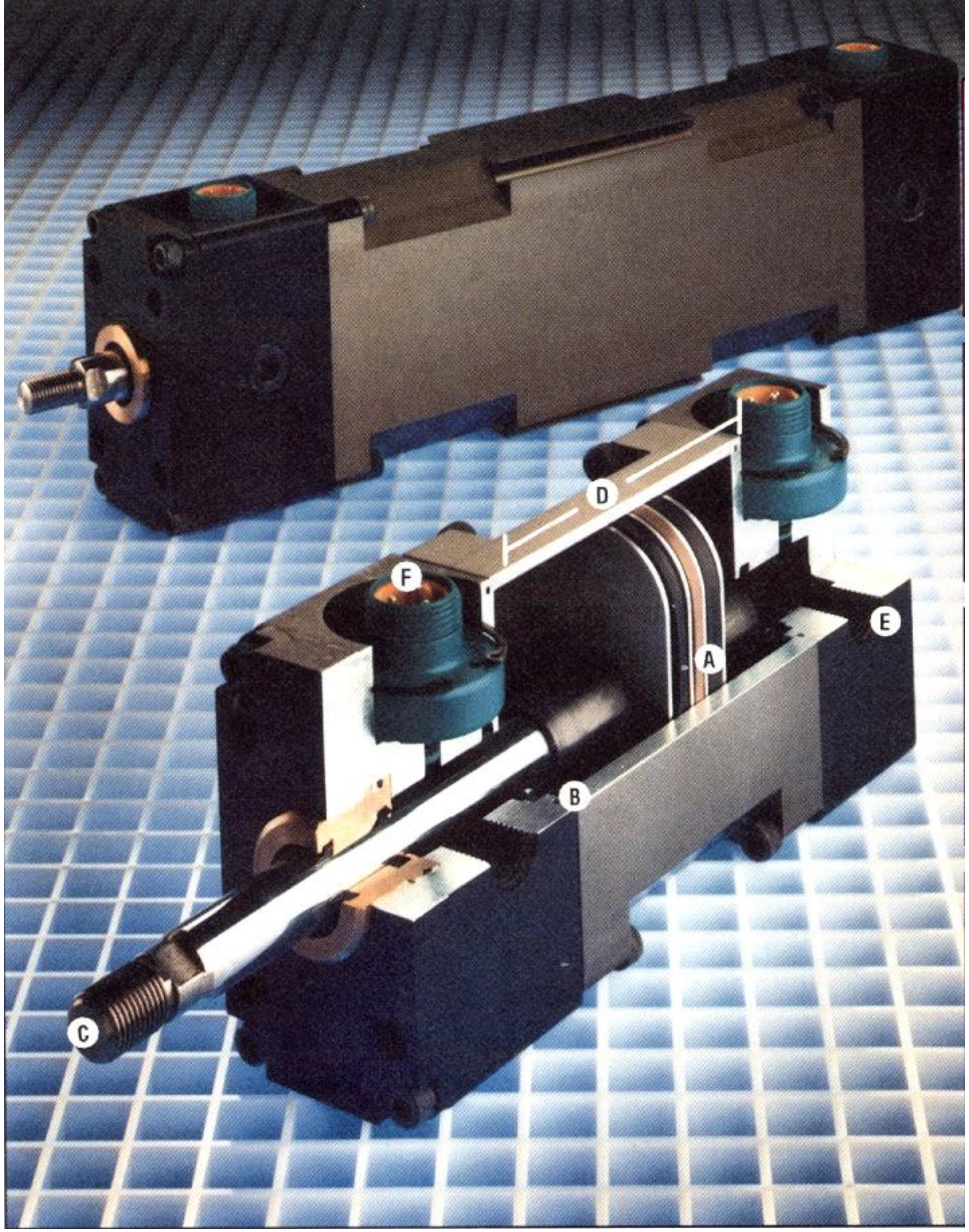
Double effect cylinders



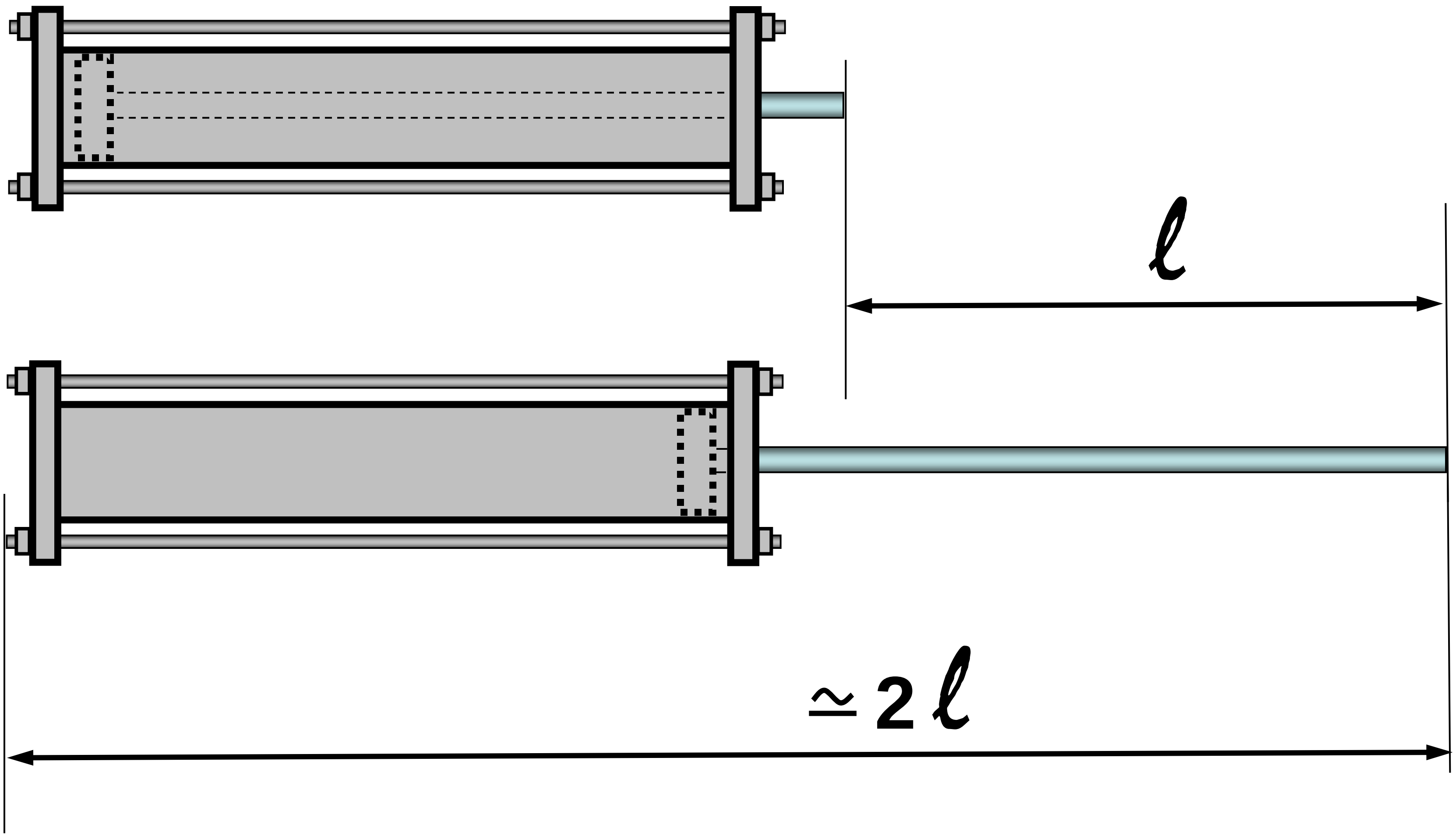
Single effect cylinders

Example of commercial pneumatic cylinders

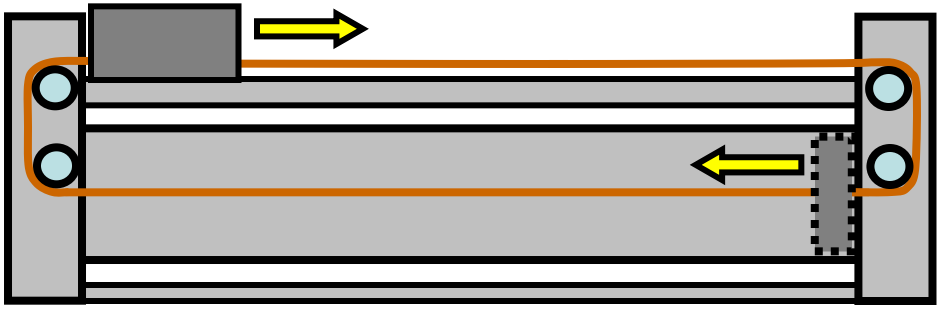
(Lateral guides to prevent axial rotation)

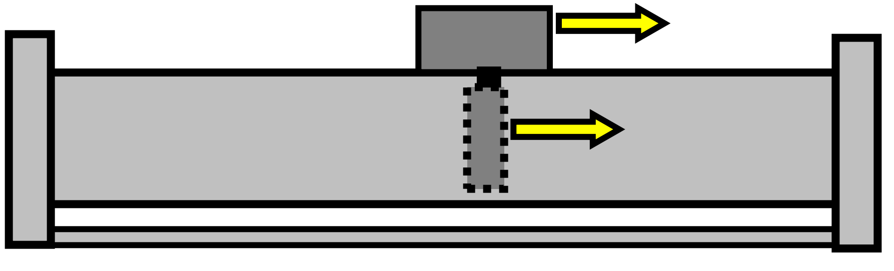


Oval pistons to prevent the rotation of the axis avoiding the need of auxiliary guides



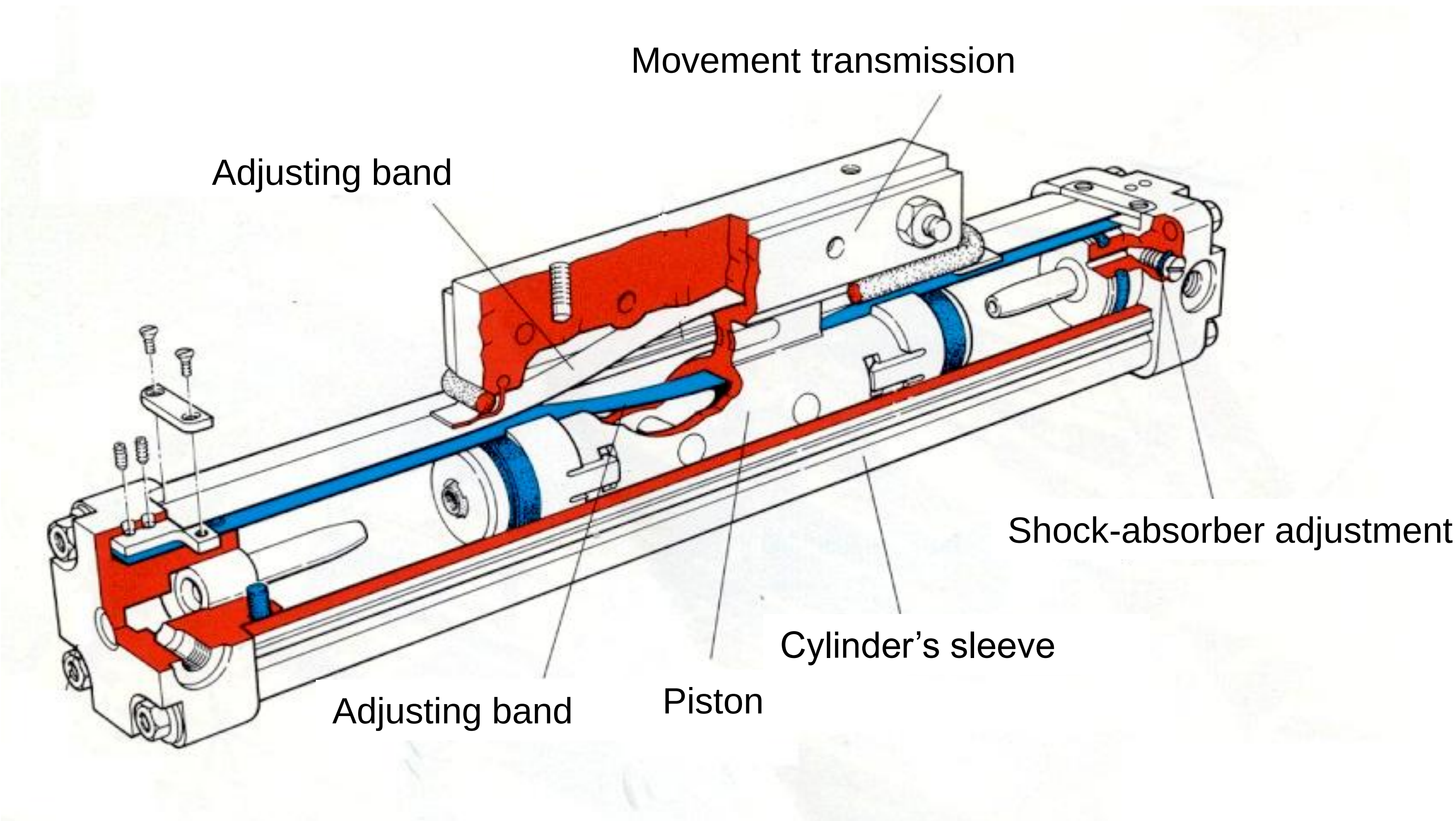
Classical cylinders drawbacks: a displacement of length ℓ requires an additional length ℓ.





$$\Delta \ell \simeq \ell$$

Solutions to reduce the occupied space

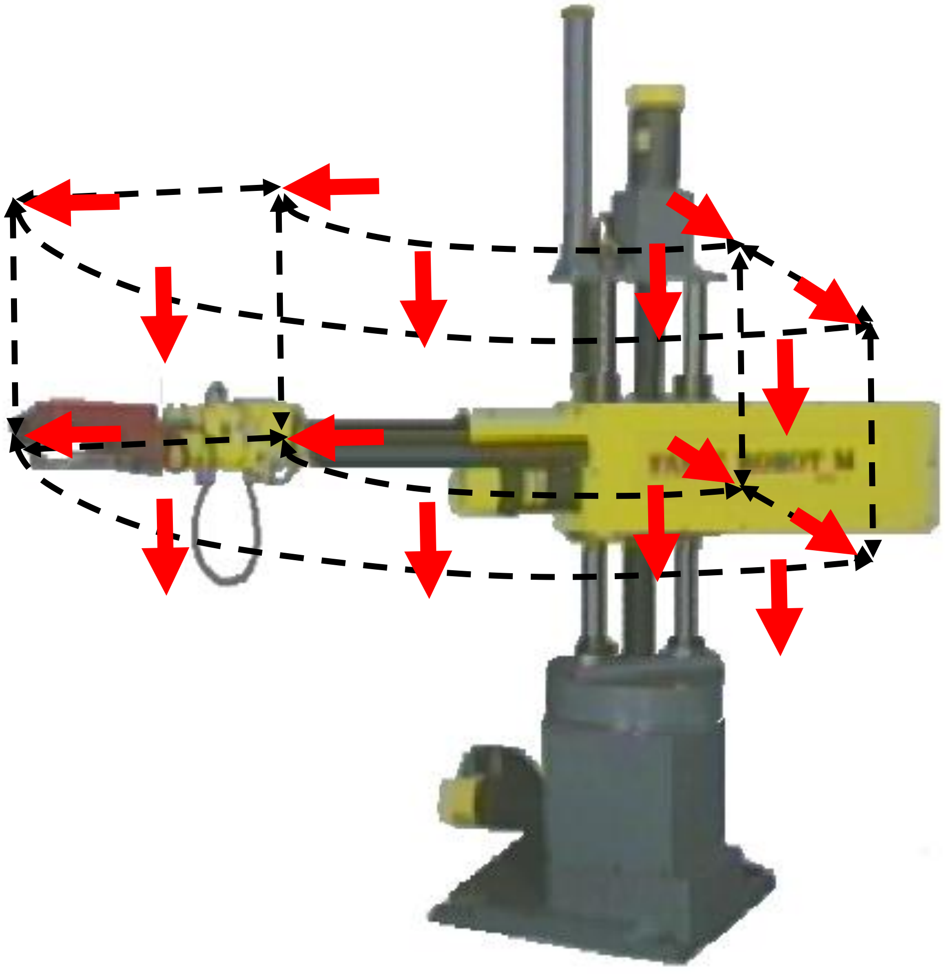

Movement transmission
Adjusting band
Shock-absorber adjustment
Cylinder’s sleeve
Adjusting band
Piston

③
④
⑤
⑧
②
* ⑨
⑦
①
⑥
⑪

Pneumatic actuators (cylinders)

- Economic
- Reliable
- High operation speed
- Operation at constant force
- Resistant to overloads

- No speed control
- Poor position speed
- Noisy operation



Example of pneumatic manipulator, and its mechanical states (End positions of all its cylinders)

ACTUATORS

1 – Pneumatic actuators

- Cylinders
- Motors

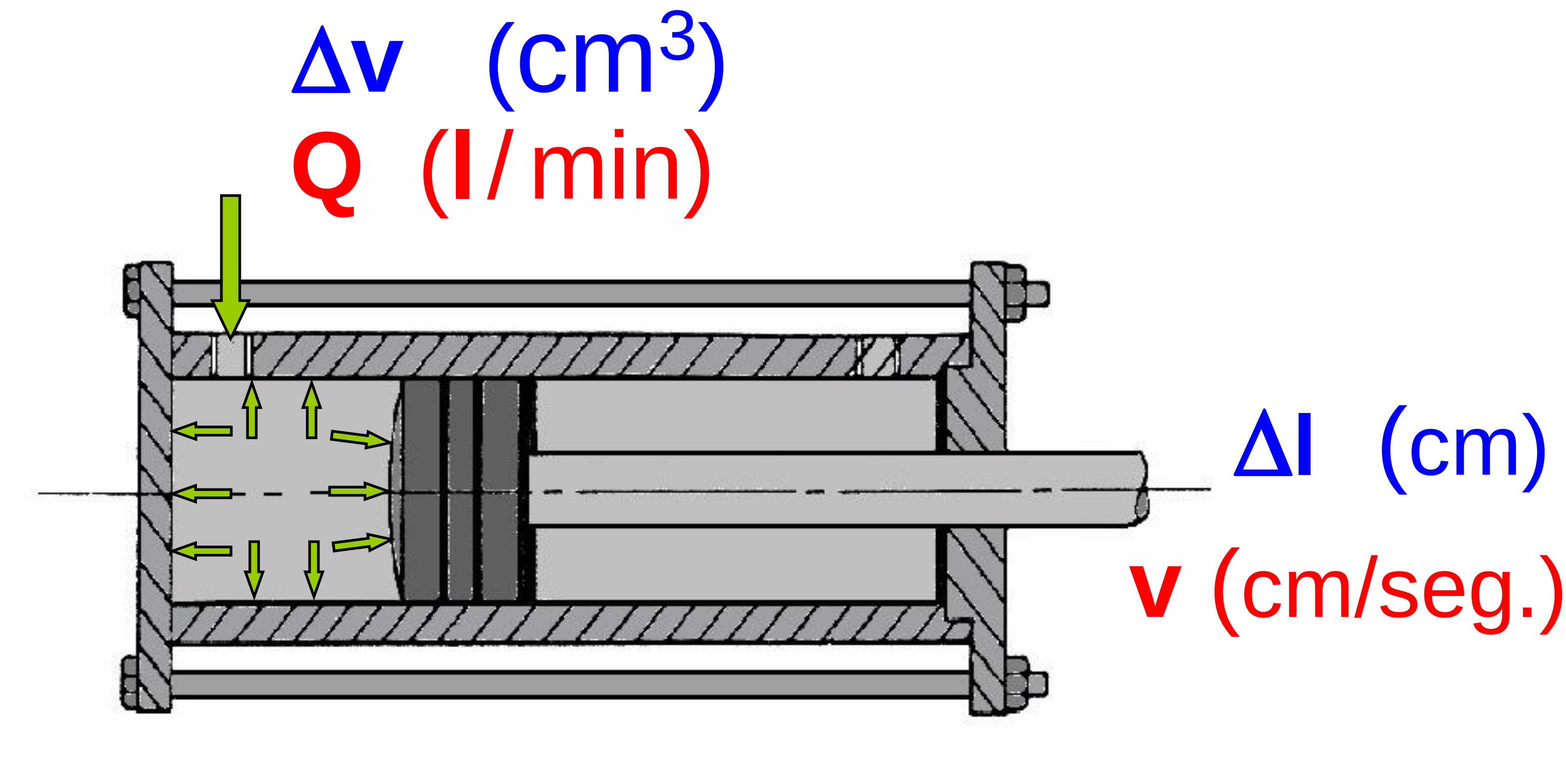
2 – Hydraulic actuadors

- Cylinders
- Motors

3 – Electrical actuators

- Dc motors.
- Ac motors
- Steeper motors.

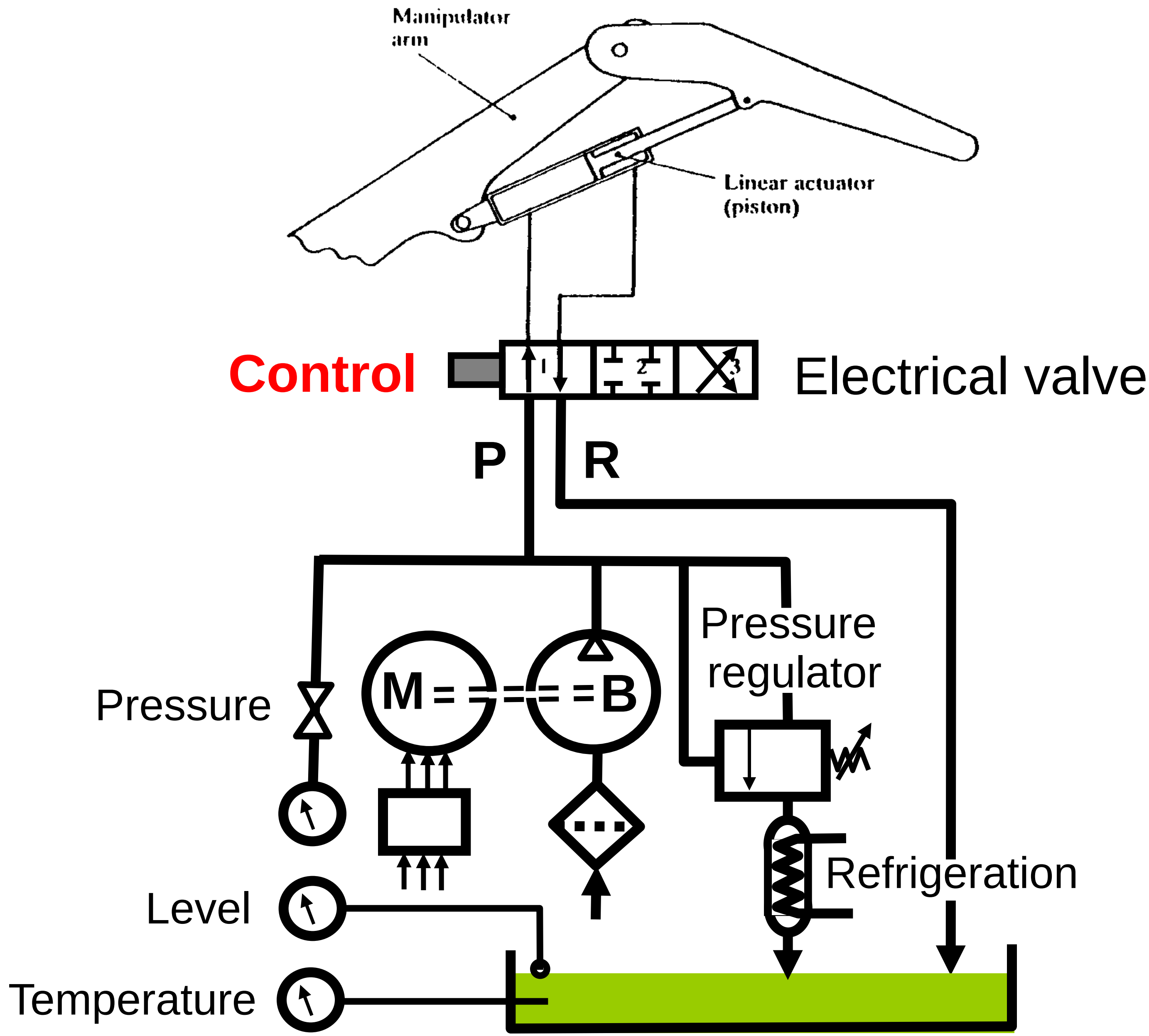
2 – Hydraulic actuators (cylinders)



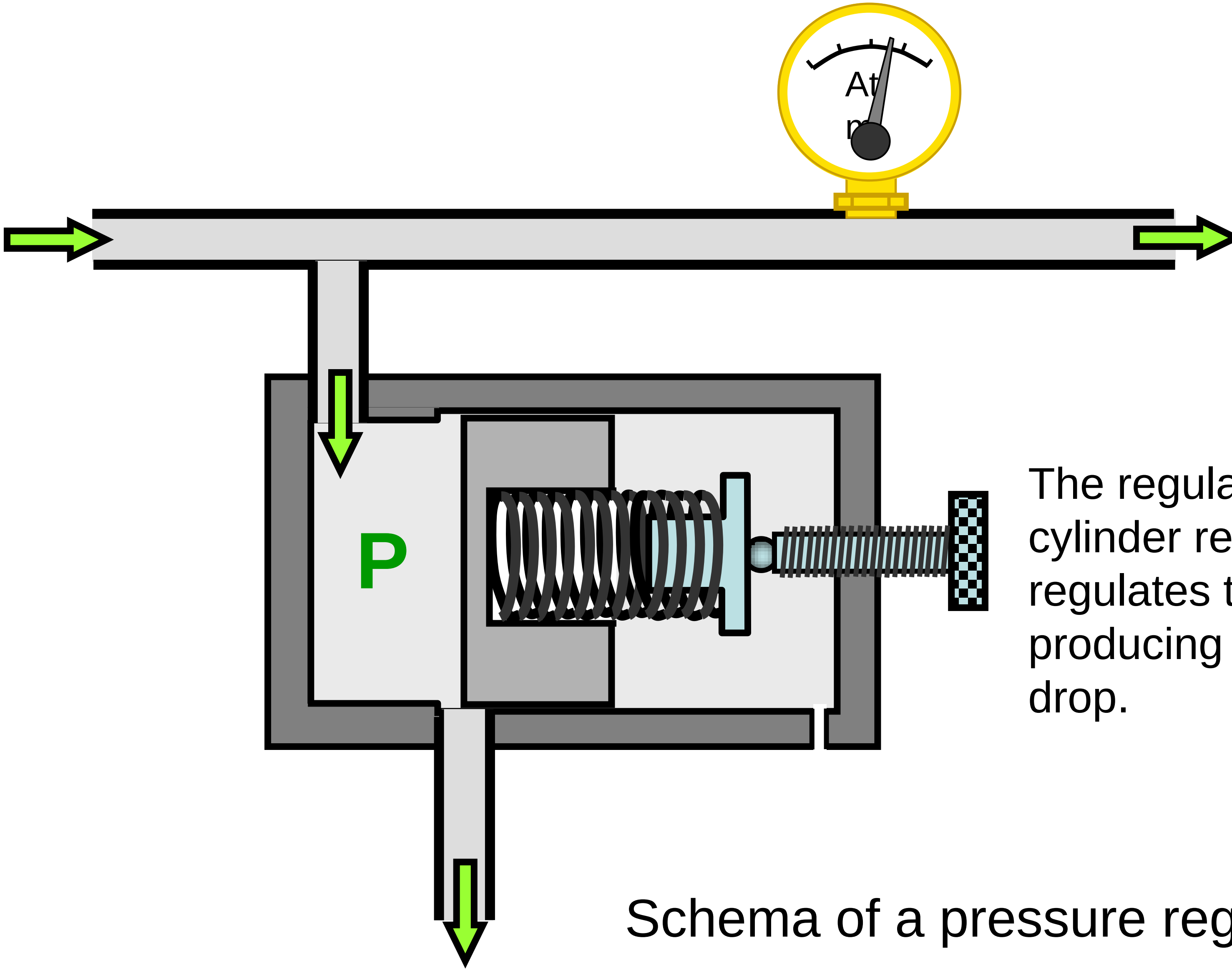
Energy source: oil pressurized between 20 and 300 bars.

$\mathbf{F = P * S}$ If $\mathbf{P} \uparrow\uparrow \;\rightarrow\; \mathbf{F} \rightarrow \infty$

- Controllable position
- Controllable speed

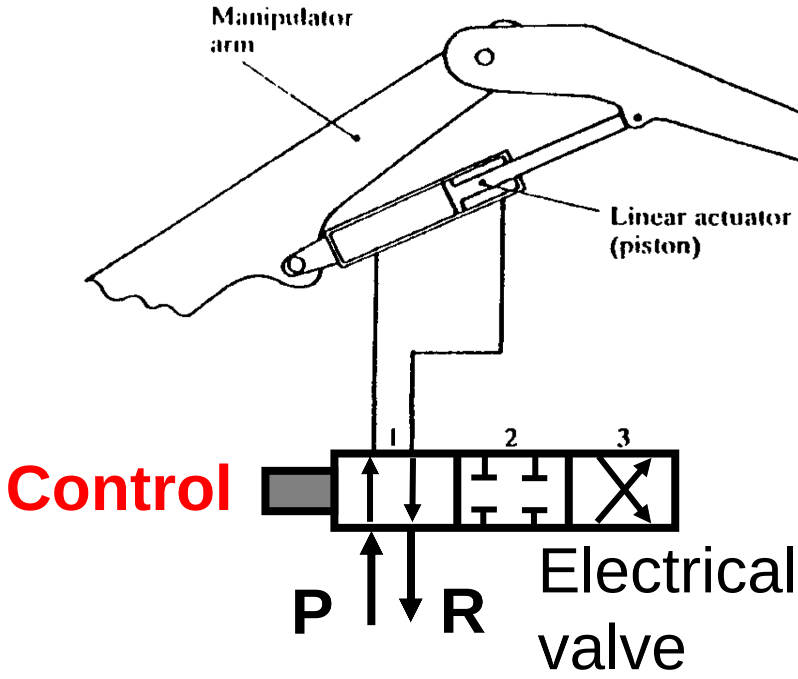


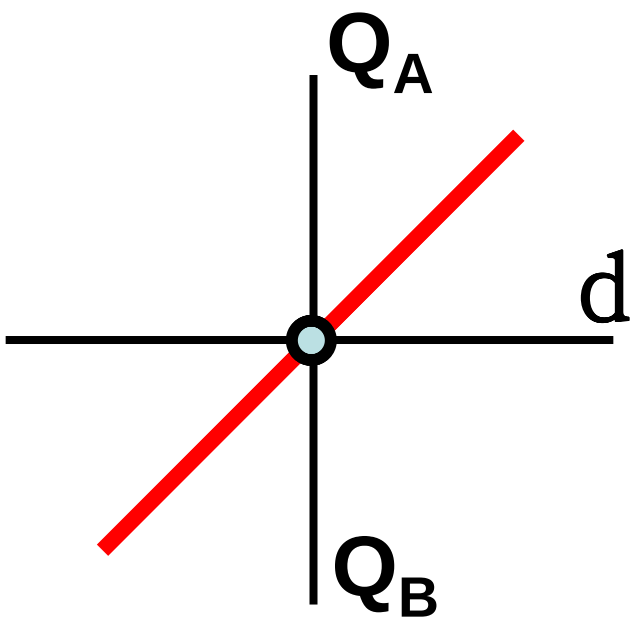
Hydraulic circuit showing its essential elements



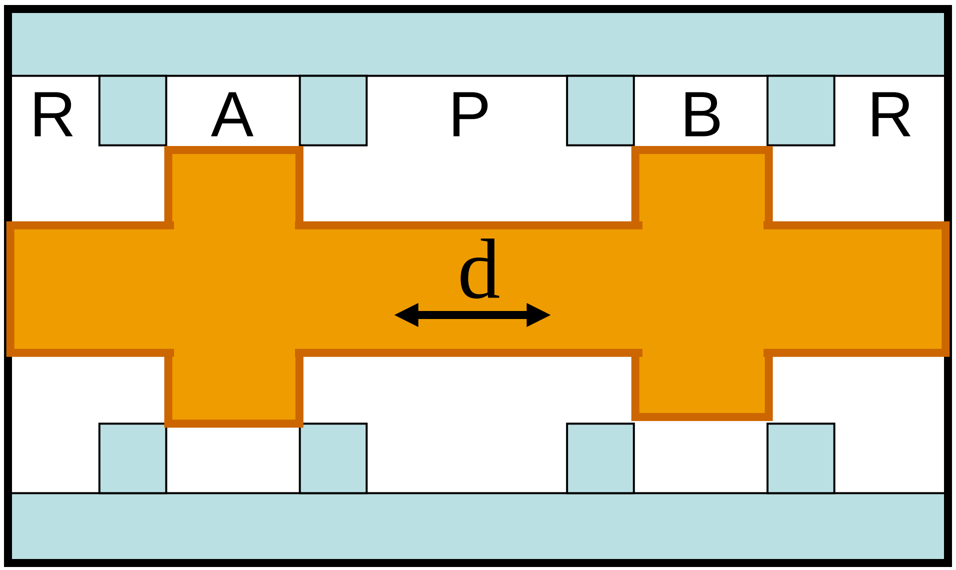
The regulation of the cylinder retention force regulates the oil output producing a pressure drop.

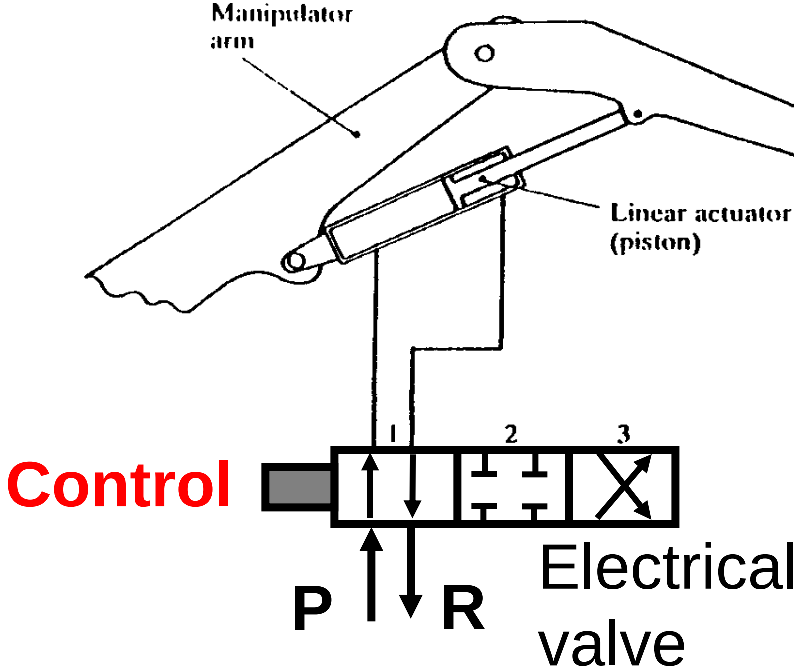
Schema of a pressure regulator

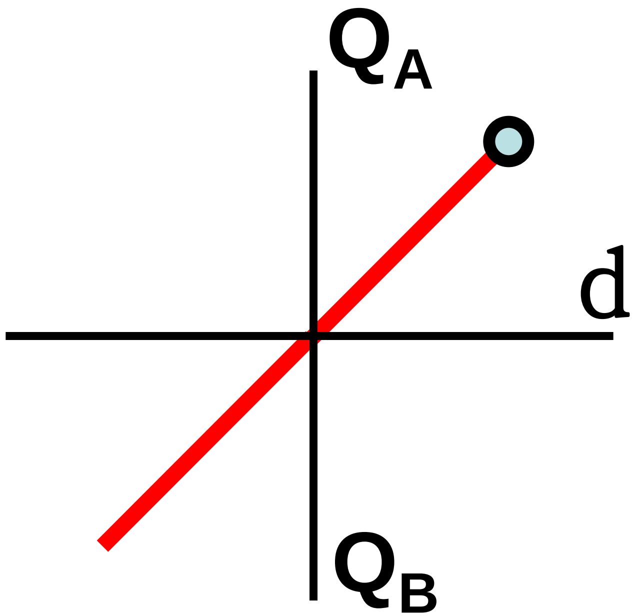


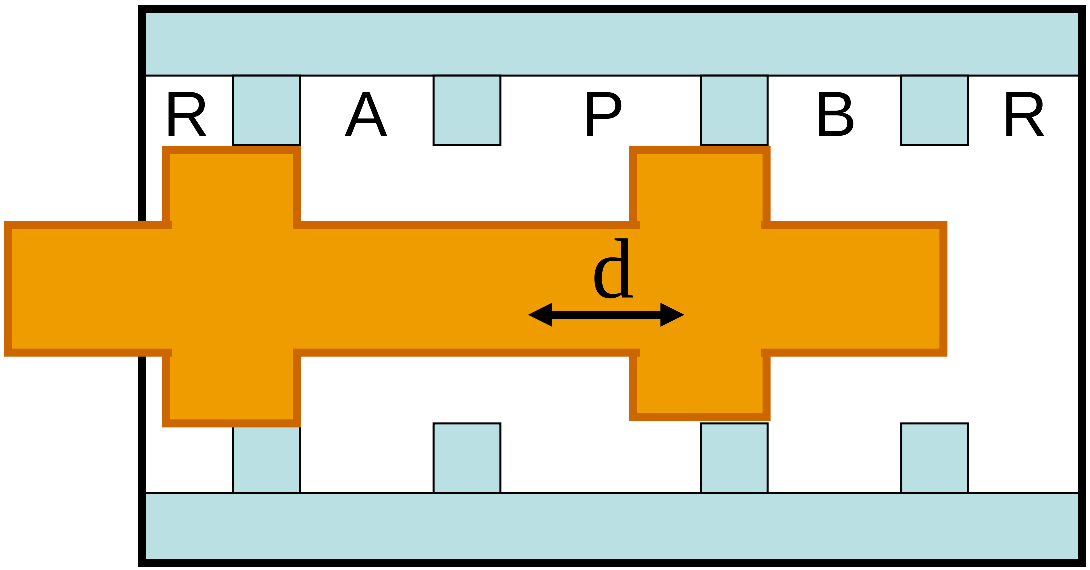


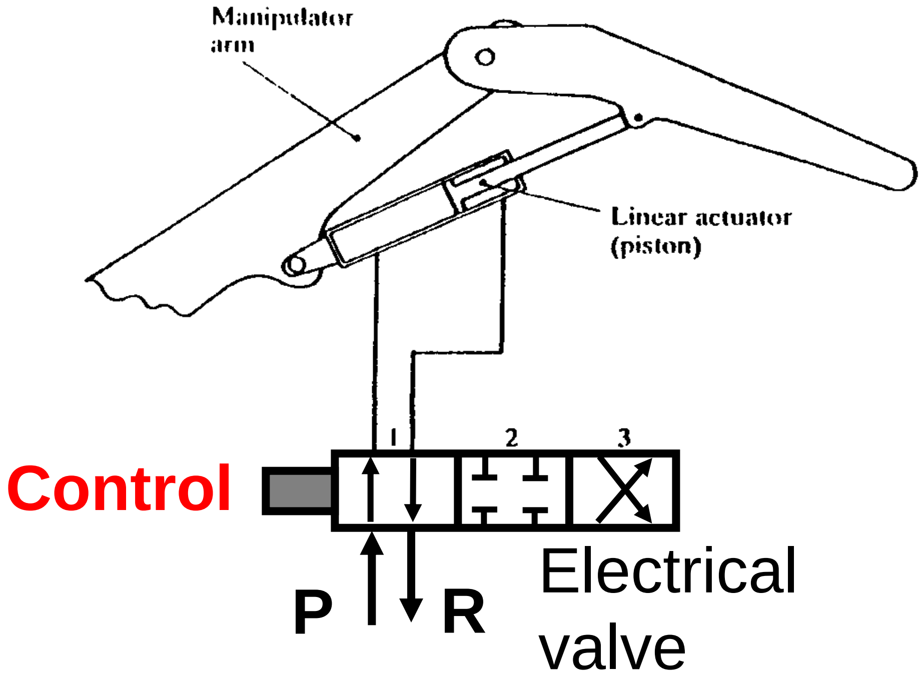
Ideal characteristic



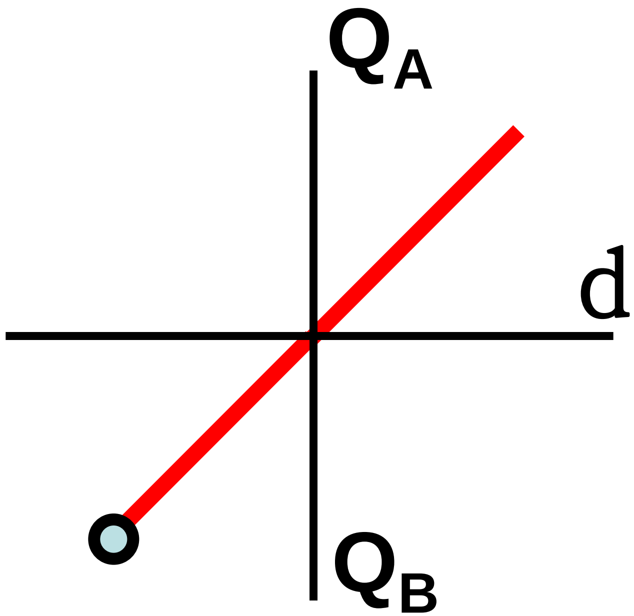

Manipulator arm
Linear actuator (piston)
1
2
3
Control
P
R
Electrical valve


Q_A
d
Q_B

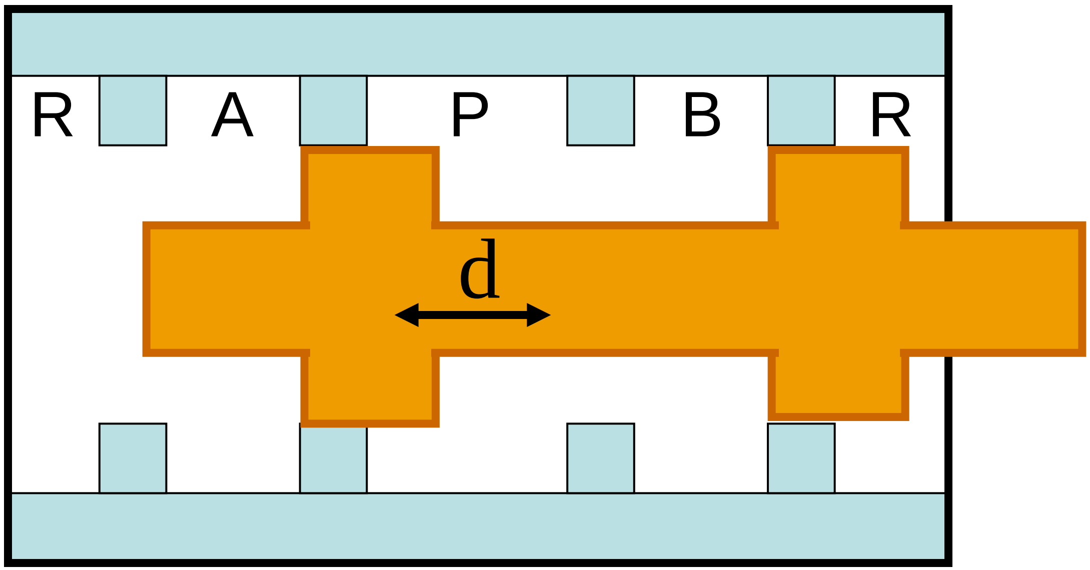

R
A
P
B
R
d



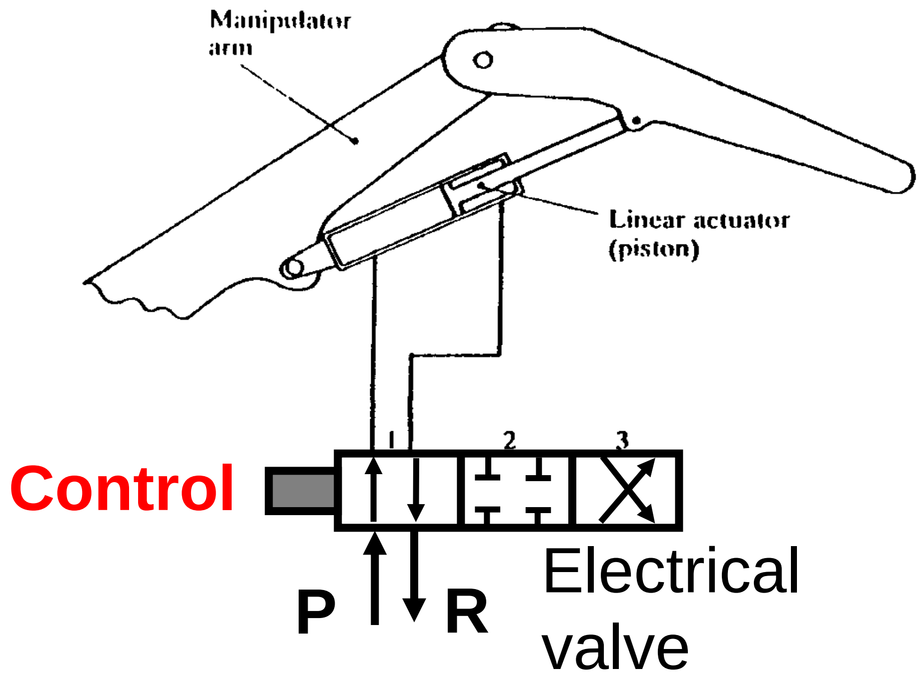
Manipulator arm
Linear actuator (piston)
1
2
3
Control
P
R
Electrical valve

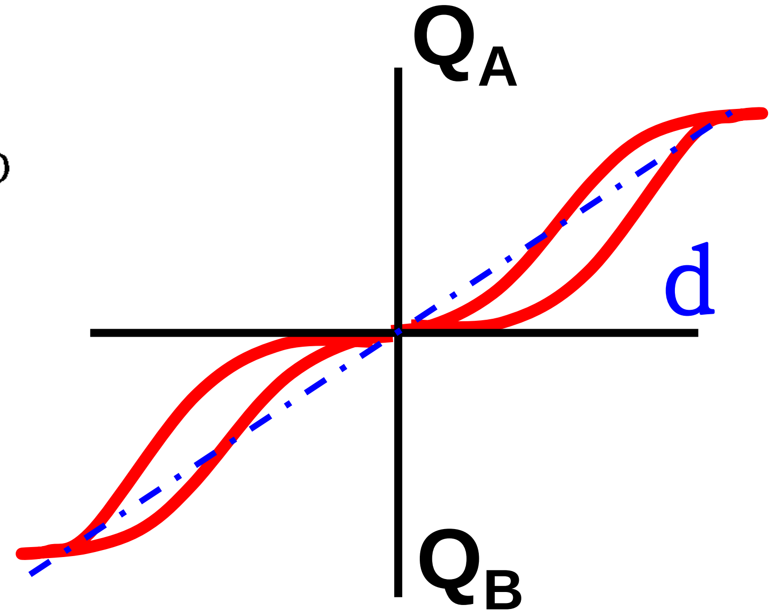


Q_A
d
Q_B

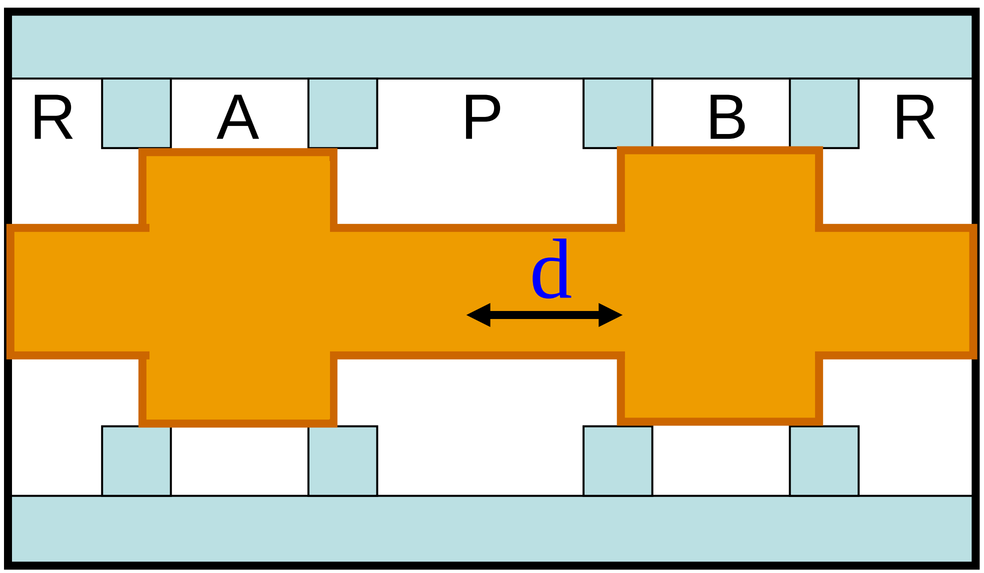


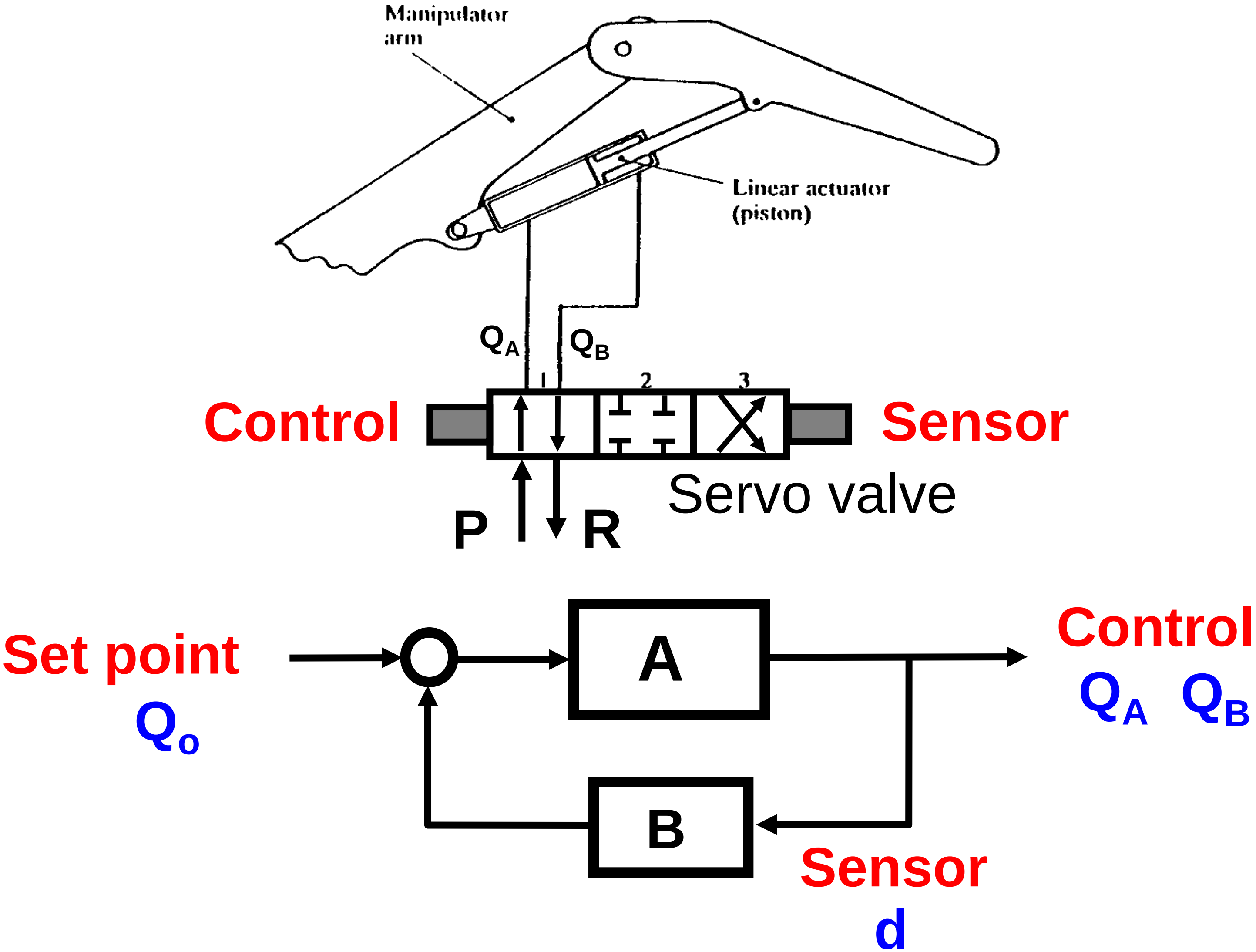
R
A
P
B
R
d





Real characteristic





The use of a position sensor d makes the position servo control possible and thus hysteresis is minimized. The dead zone is minimized as well.

ACTUATORS

1 – Pneumatic actuators

Cylinders

Motors

2 – Hydraulic actuadors

Cylinders

Motors

3 – Electrical actuators

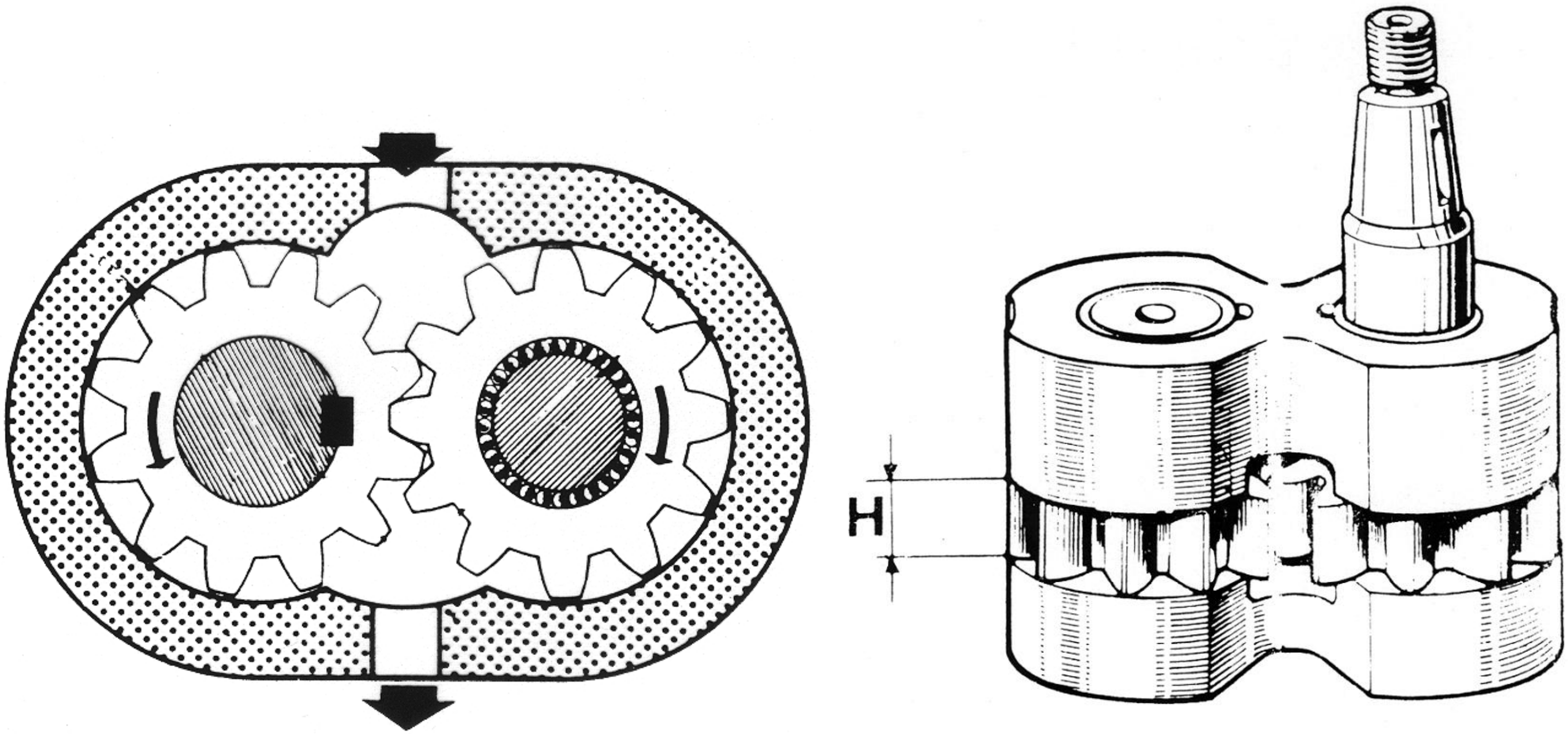
Dc motors.

Ac motors

Steeper motors.

Hydraulic pumps and motors

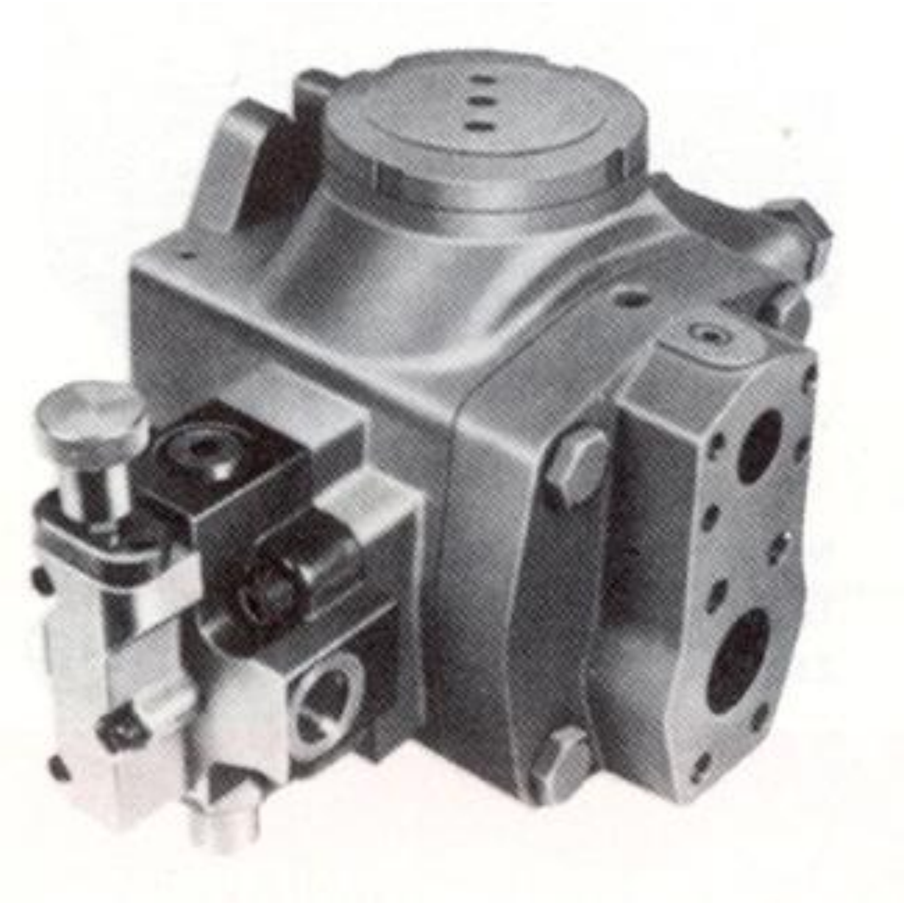
(Kind of gears)



Fix caudal

Hydraulic pumps and motors

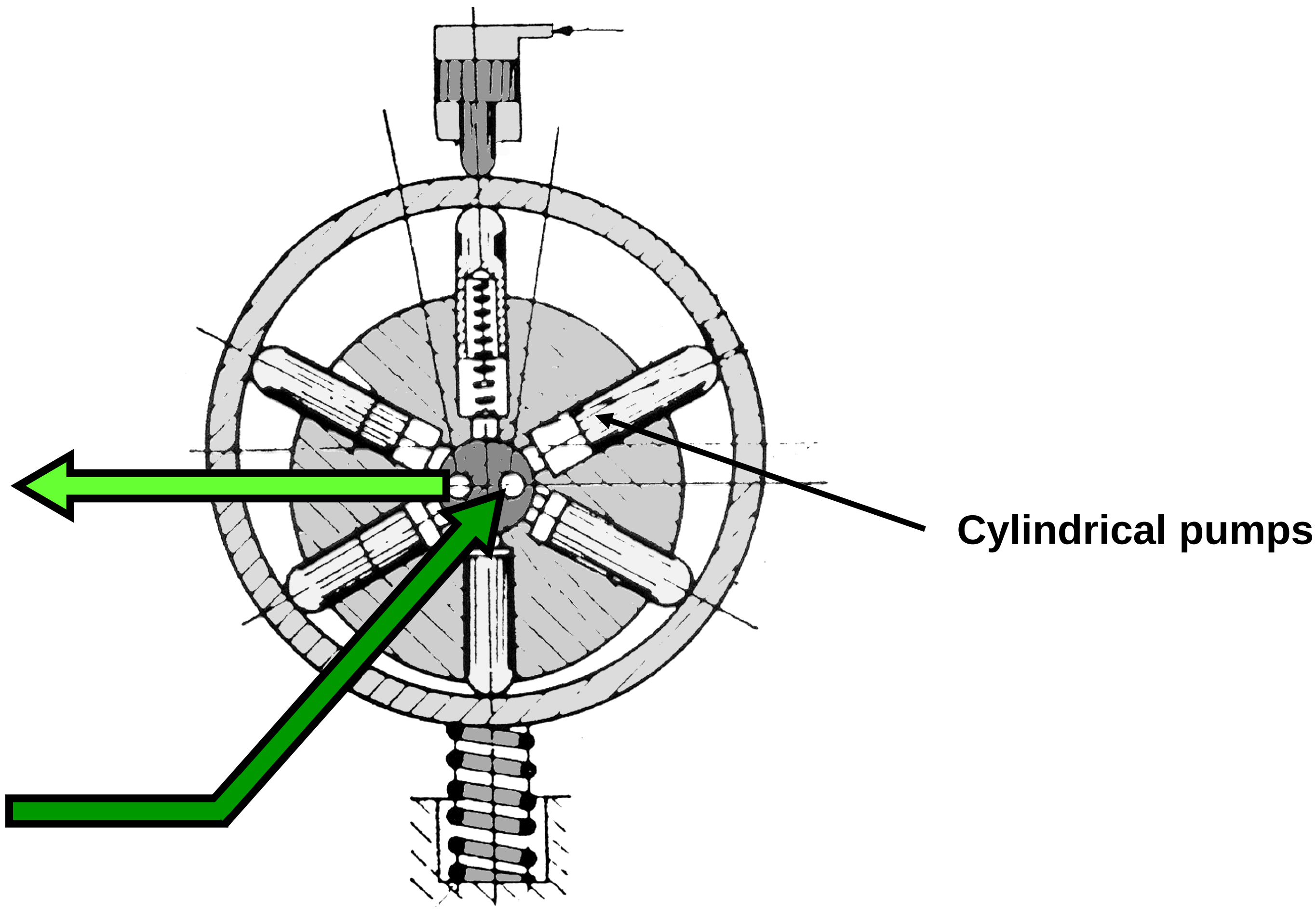
(Kind of gears)



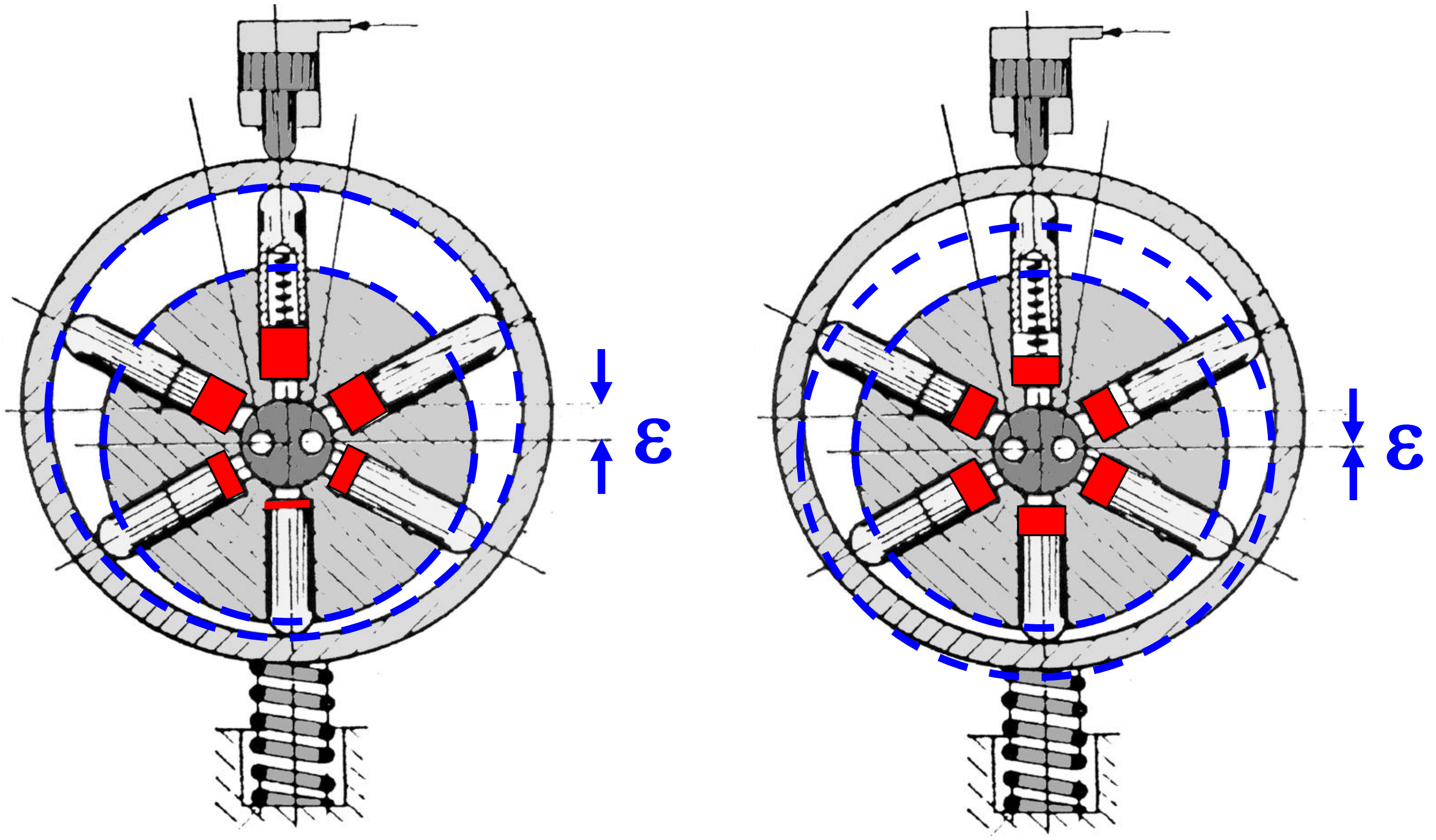
Fix caudal

Hydraulic pumps

(Kind of radial pistons)



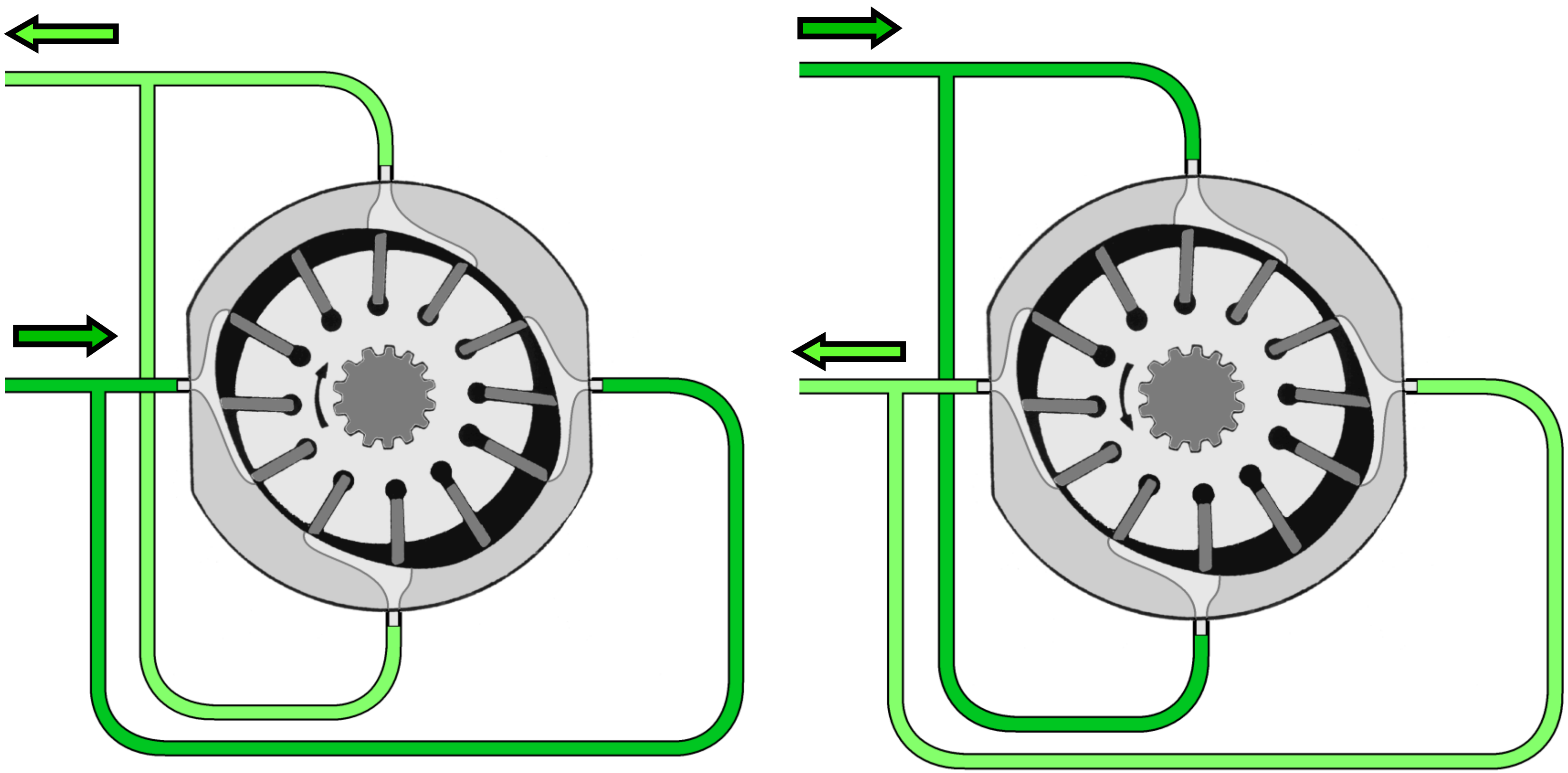
Variable caudal



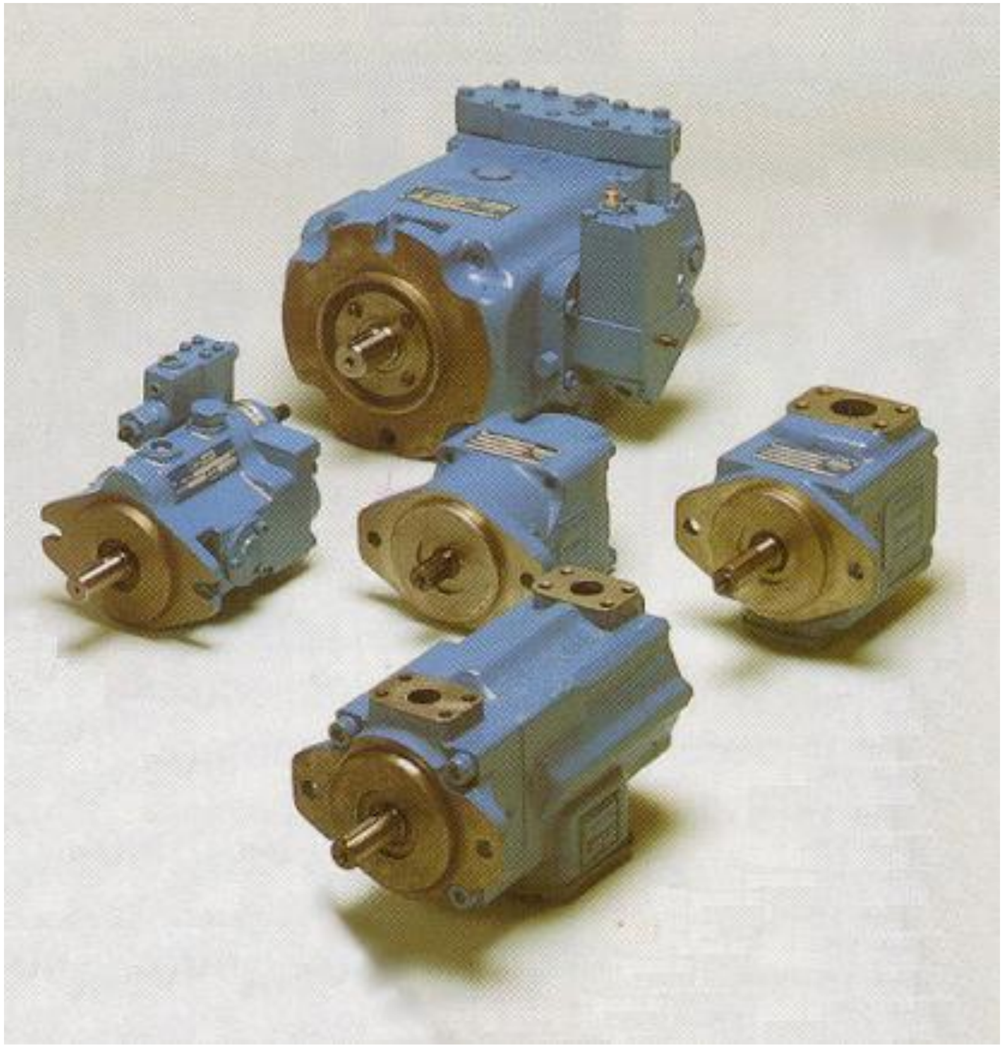
Caudal variation as a function of eccentricity ε

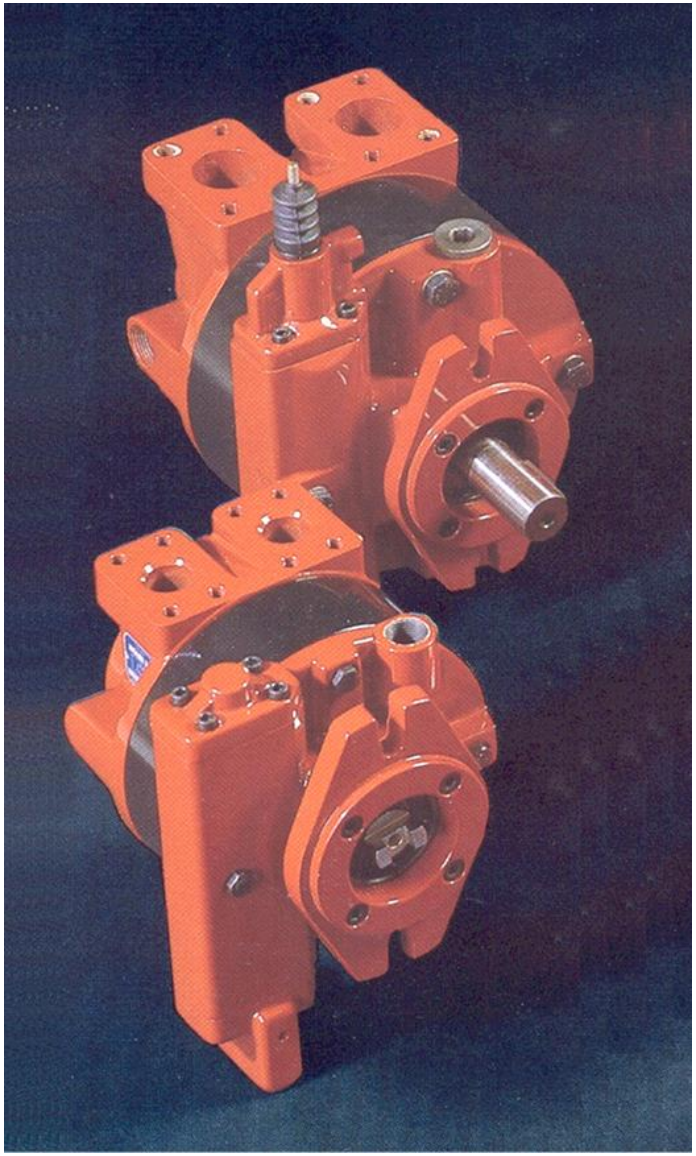
Hydraulic pumps and motors

(Kind of blades)



Hydraulic pumps or motors





Hydraulic actuators

- Economic
- Reliable
- Able to support heavy loads
- Resistant to overloads

- Low working speed
- Hydraulic group noisy in operation
- Possible oil leakage

ACTUATORS

1 – Pneumatic actuators

Cylinders

Motors

2 – Hydraulic actuadors

Cylinders

Motors

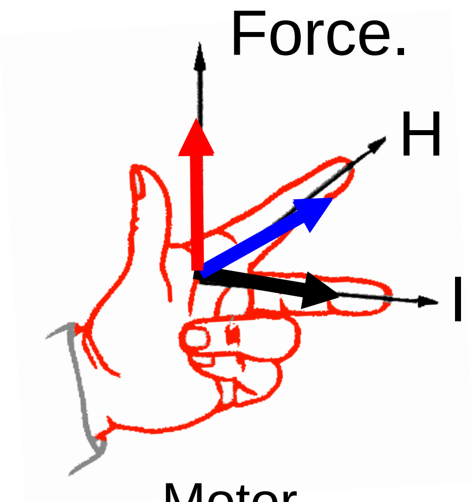
3 – Electrical actuators

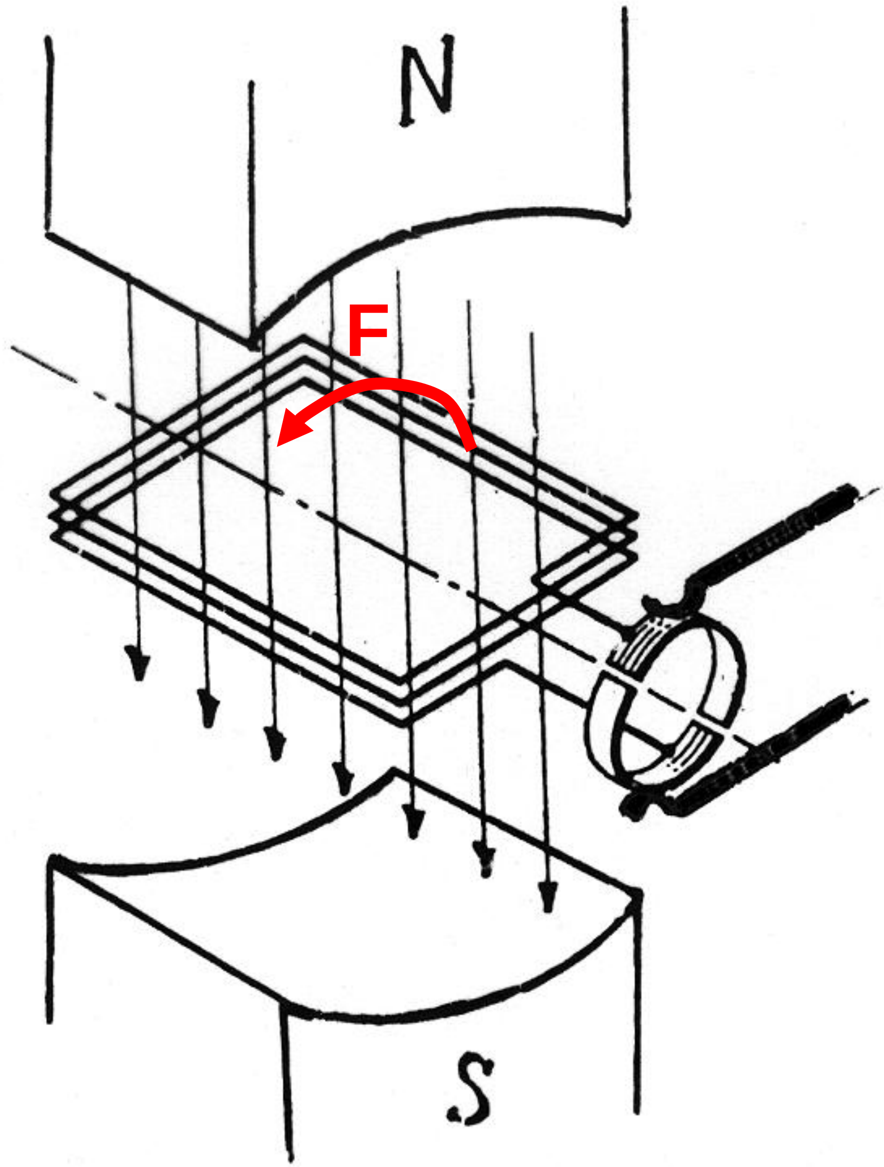
D.C. motors.

A.C. motors

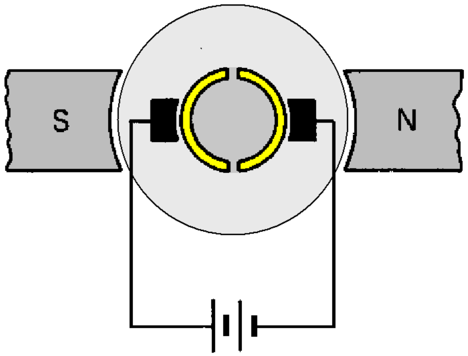
Steeper motors.

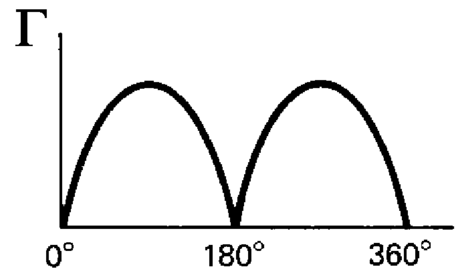
D.C. Motors.





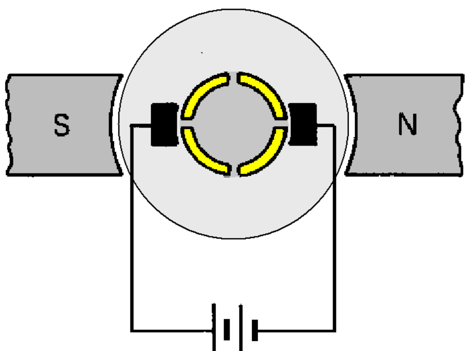
D.C. Motors.

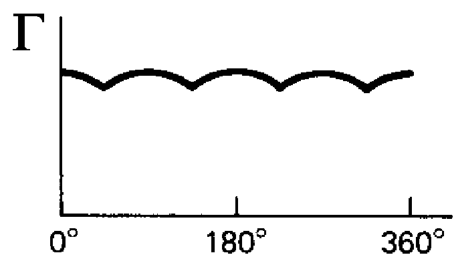




Motor torque with a one turn

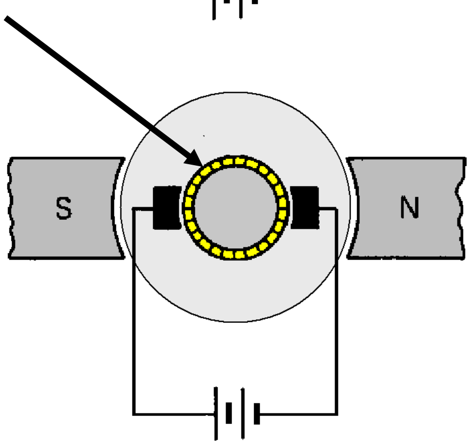
coil

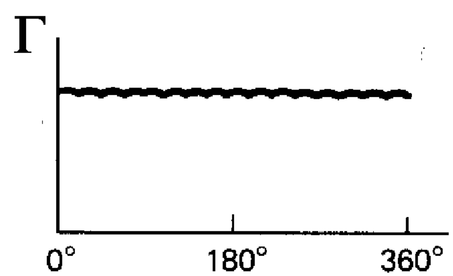




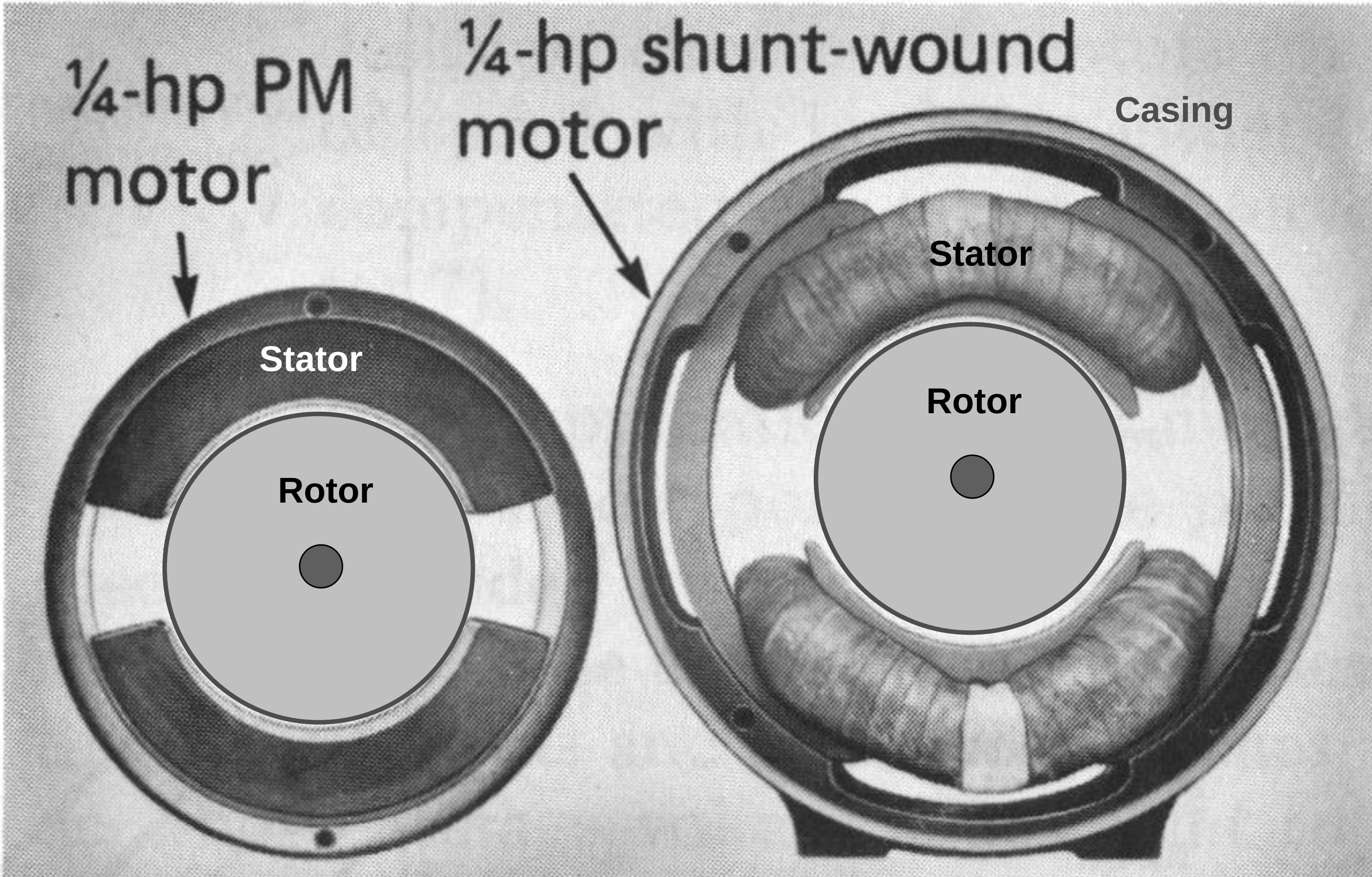
Motor torque with two turns coil

Brushes

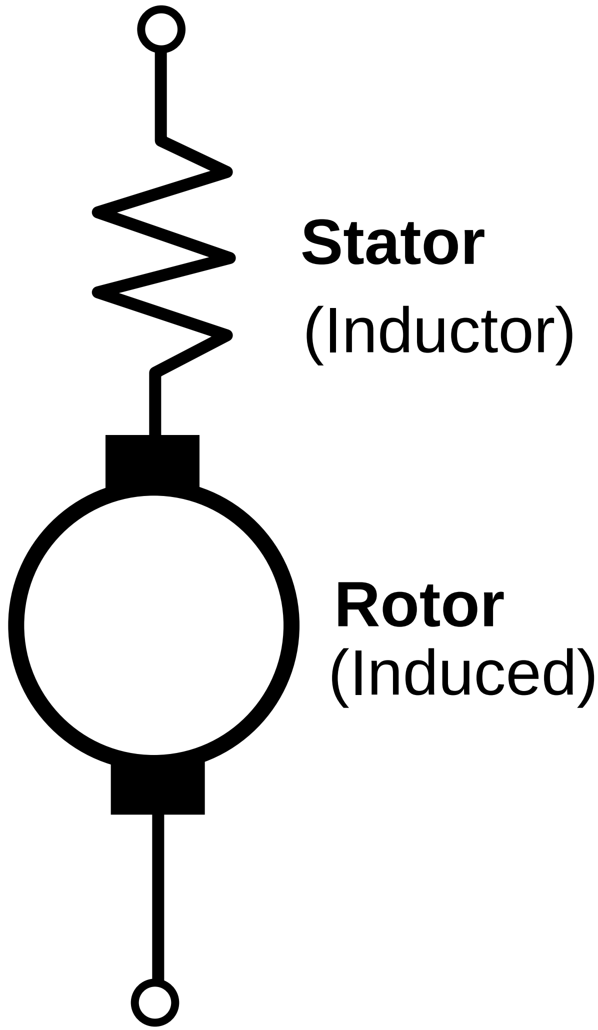




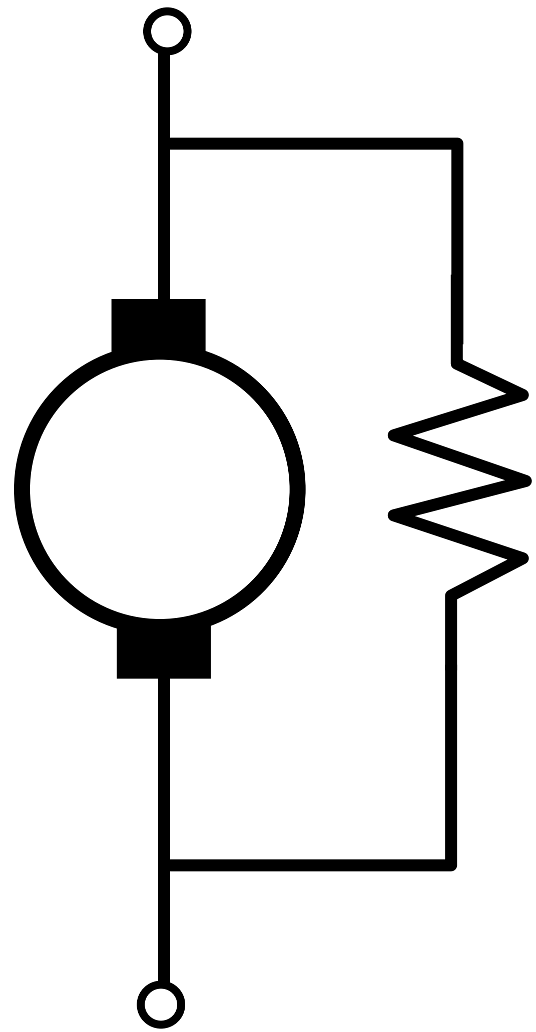
Motor torque with multiple turns coil


¼-hp PM motor
¼-hp shunt-wound motor
Casing
Stator
Rotor
Stator
Rotor

D.C. Motors.

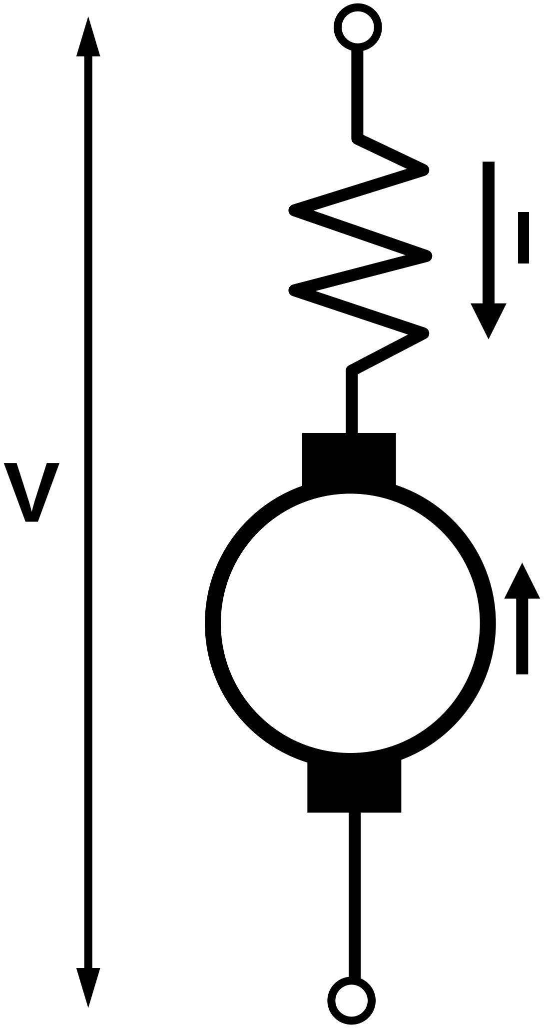


Serial excitation



Parallel excitation

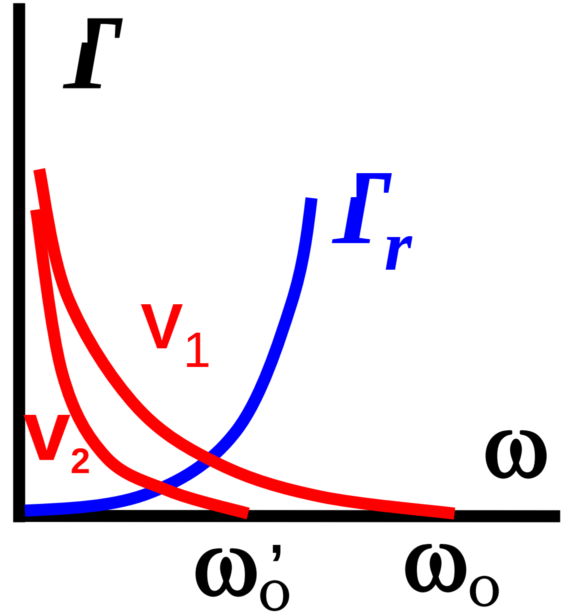
D.C. Motors.



$$V = I \cdot (R_e + R_r) + V_{cem}$$

$$\Gamma = K_I \cdot I \cdot \Phi_I$$

$$V_{cem} = K_V \cdot \omega$$

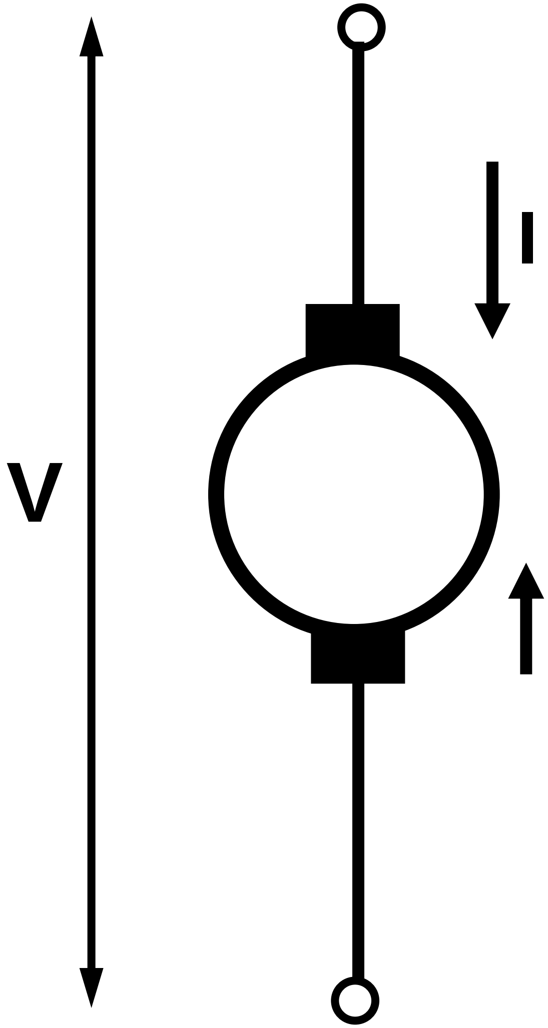


Serial excitation

D.C. Motors.

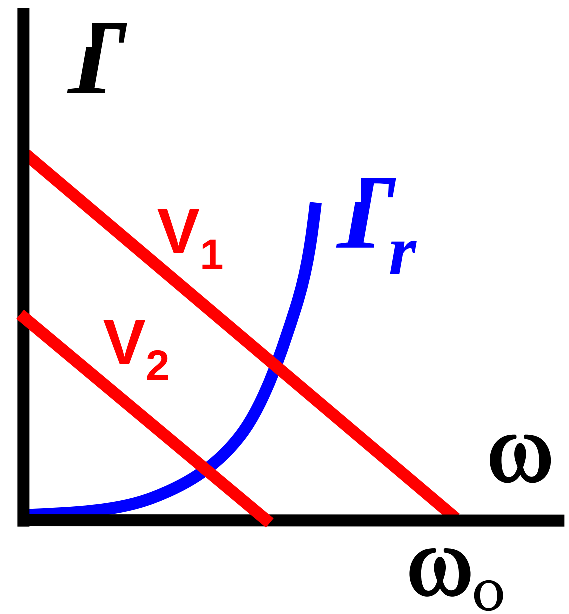
$$V = I \cdot (R_e + R_r) + V_{cem}$$

$$T = K_I \cdot I \cdot \Phi_o$$



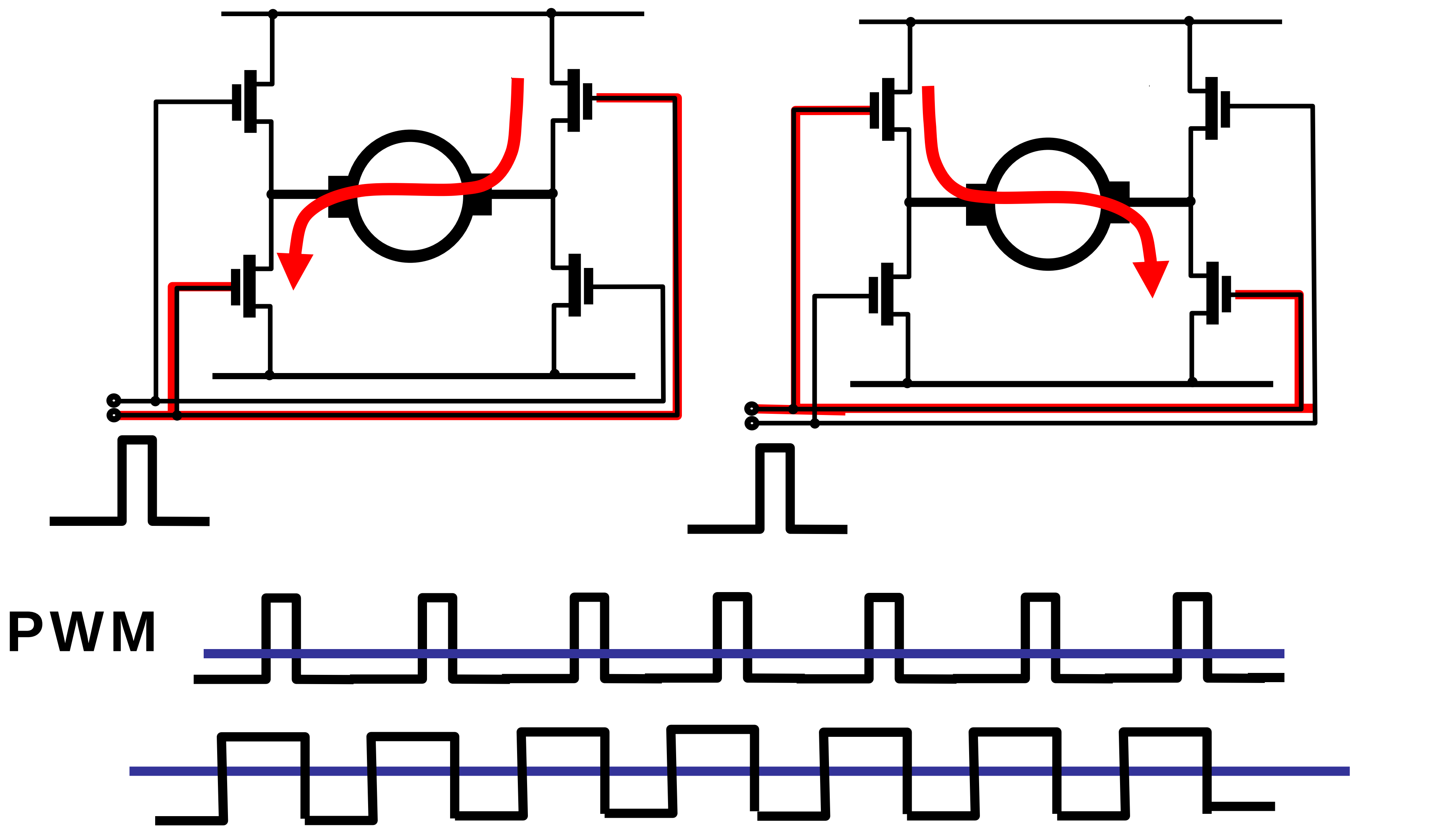
$$V_{cem} = K_v \cdot \omega$$

Permanent magnet dc motor

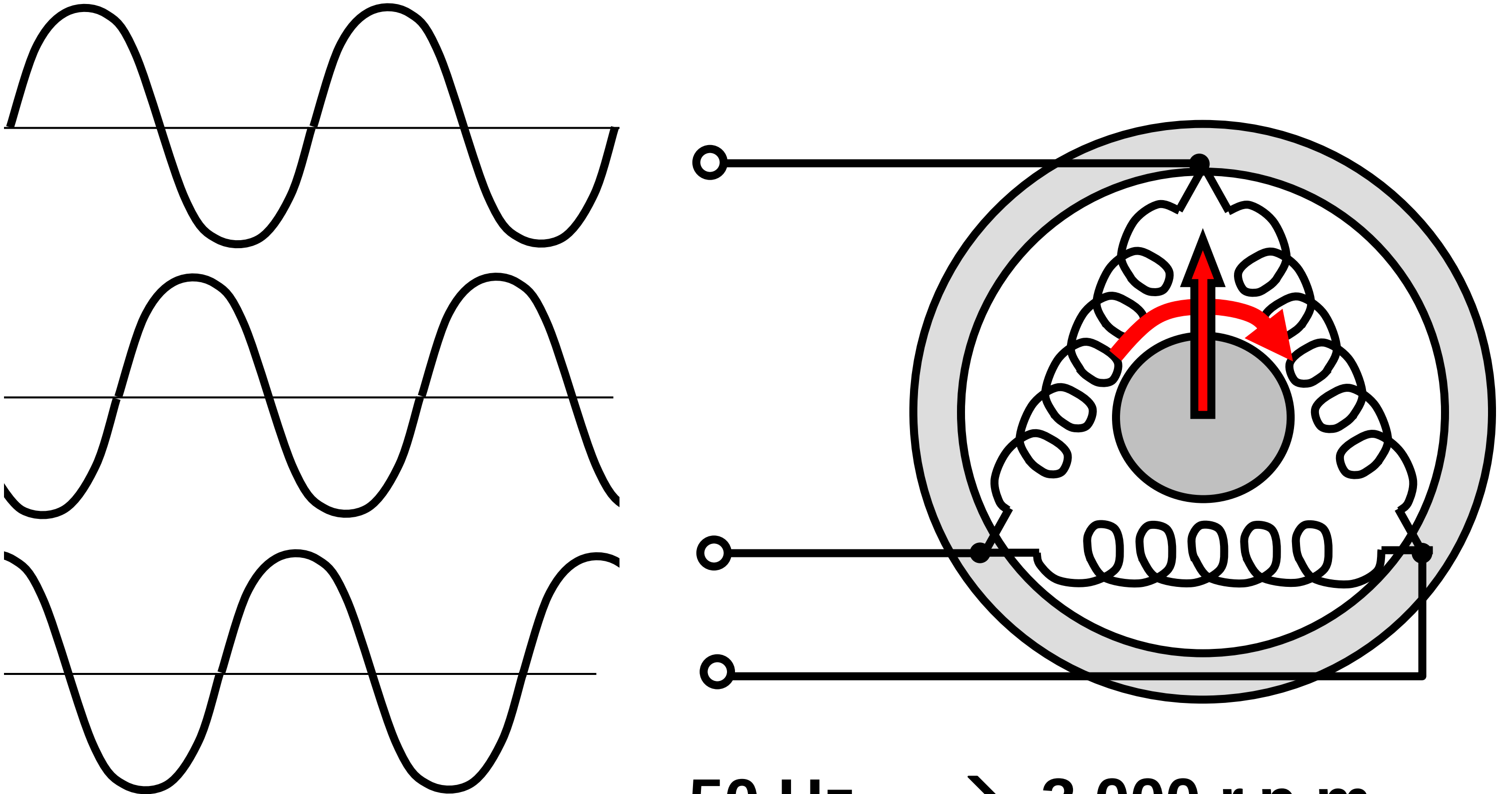


D.C. Motors.

Control techniques



A.C. Motors.

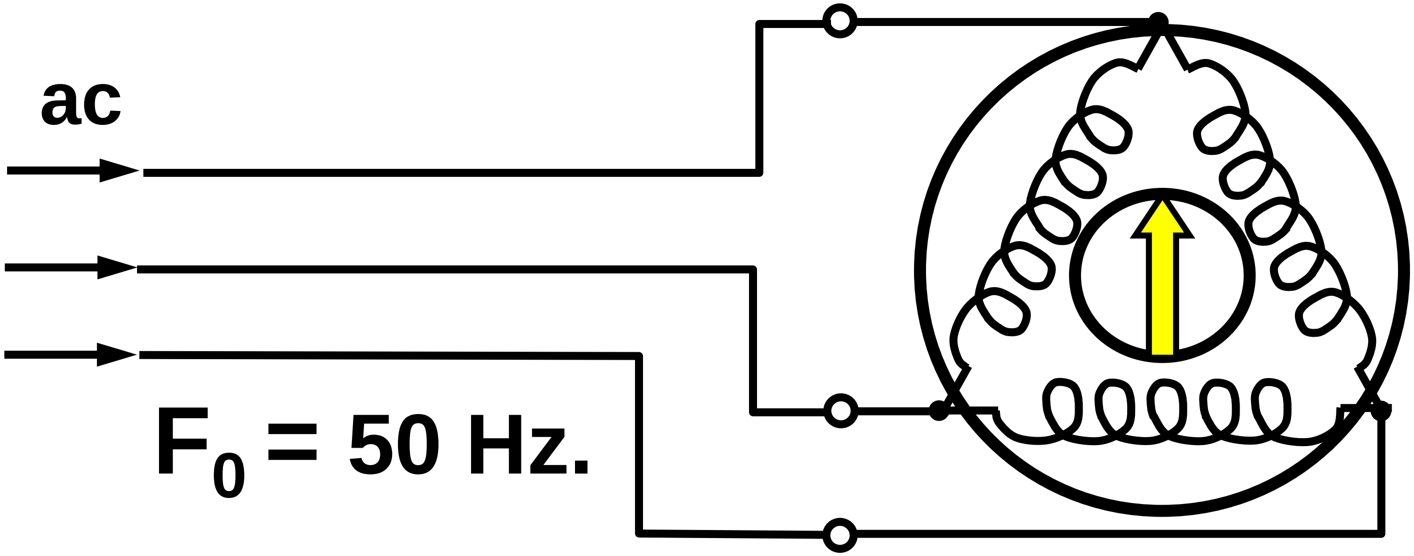


50 Hz. → 3.000 r.p.m.

50 Hz. = 50 r.p.s x 60 = 3.000 r.p.m.

Triphasic voltage produces a rotator magnetic field
that steers the rotor, if it is a magnet

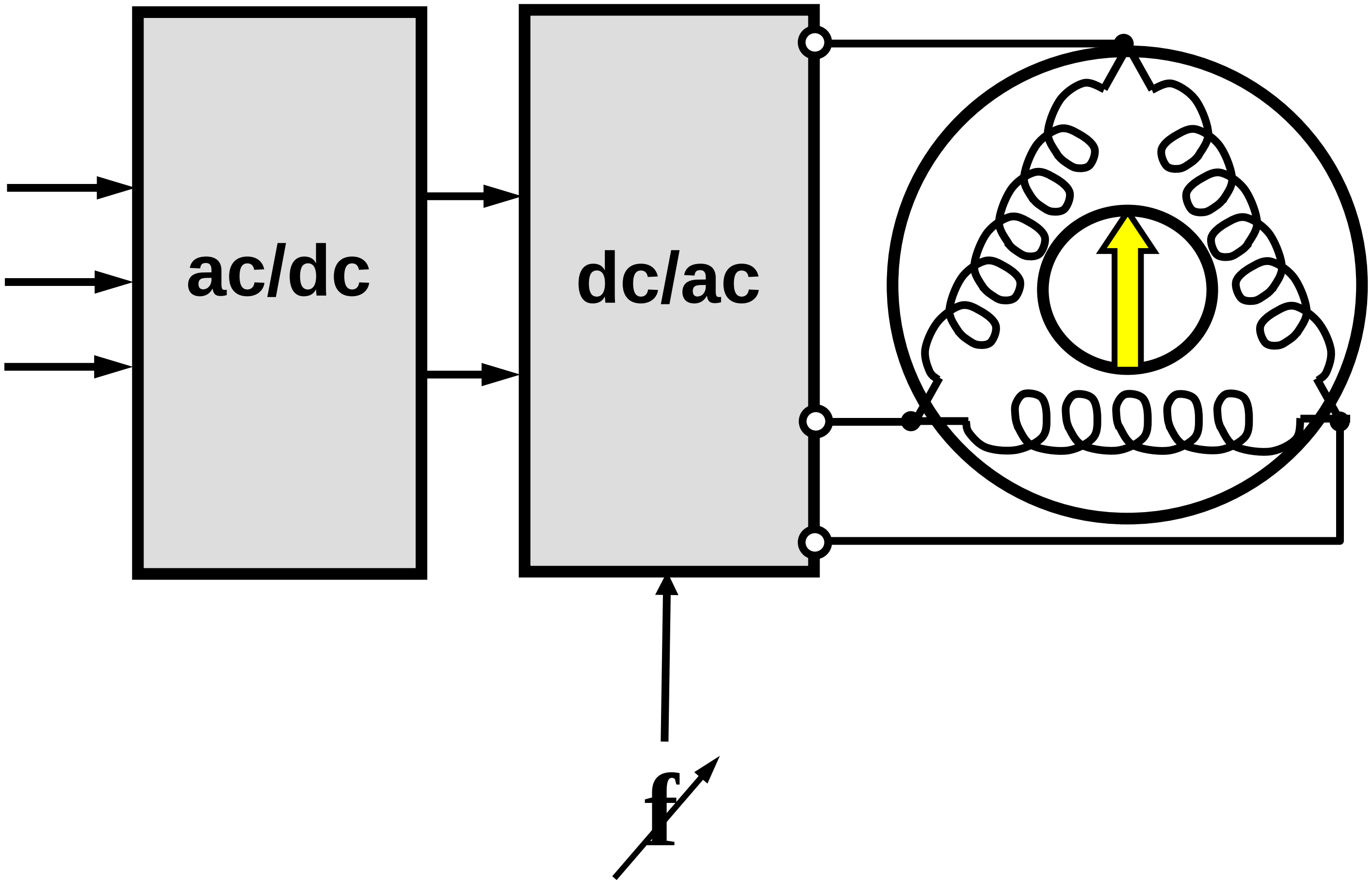
A.C. Motors.



The permanent magnet triphasic motor has a constant speed. Synchronic motor

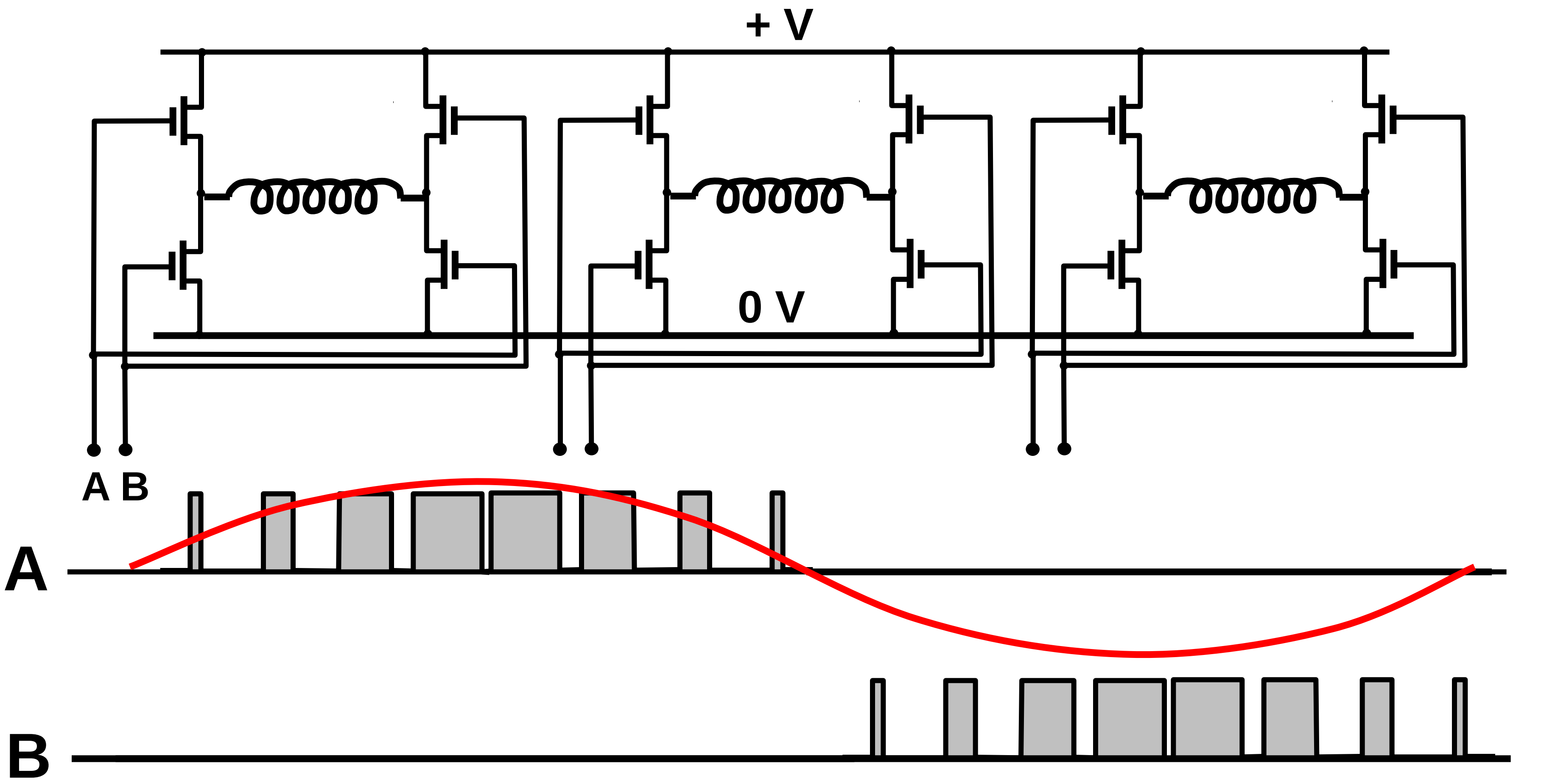
A.C. Motors.

Control techniques



The speed of a triphasic motor with permanent magnet rotor can be controlled by varying the frequency of the feeding signals.

A.C. Motors.



Control technique: using a dc / ac converter

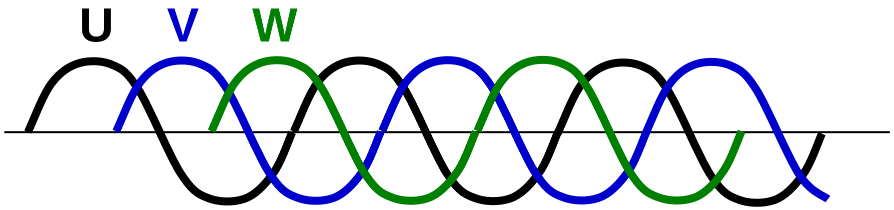
Electrical Actuators

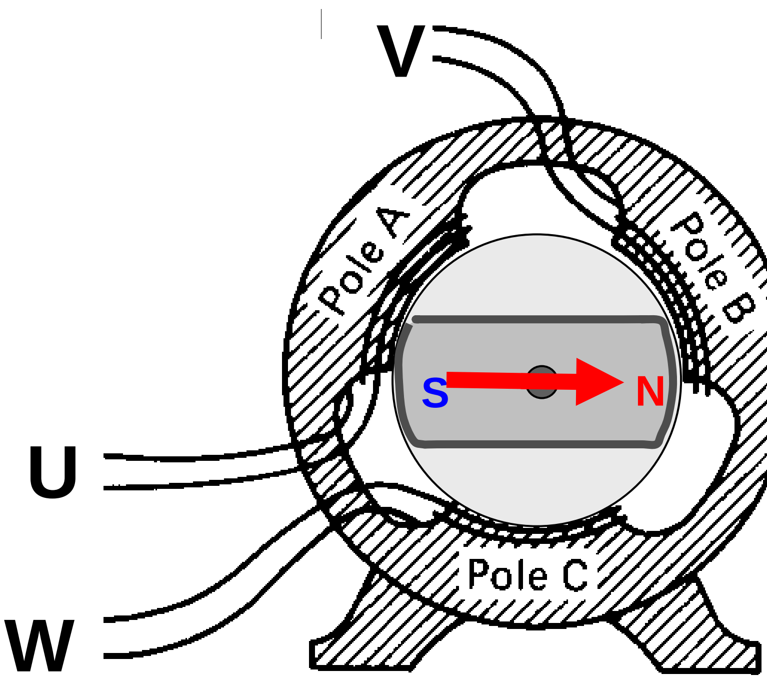
DC Motors.

AC Motors.

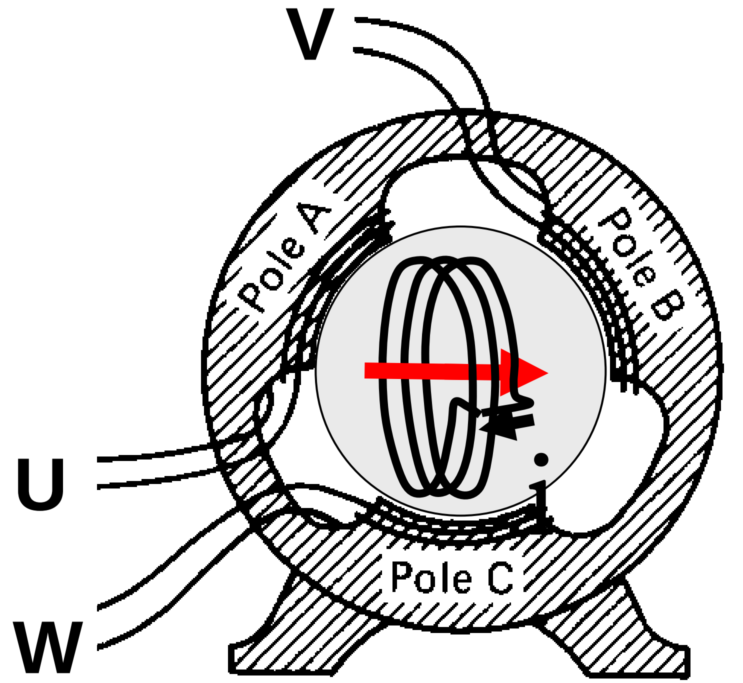
- Synchronous
- Asynchronous (Induction)

Stepper Motors

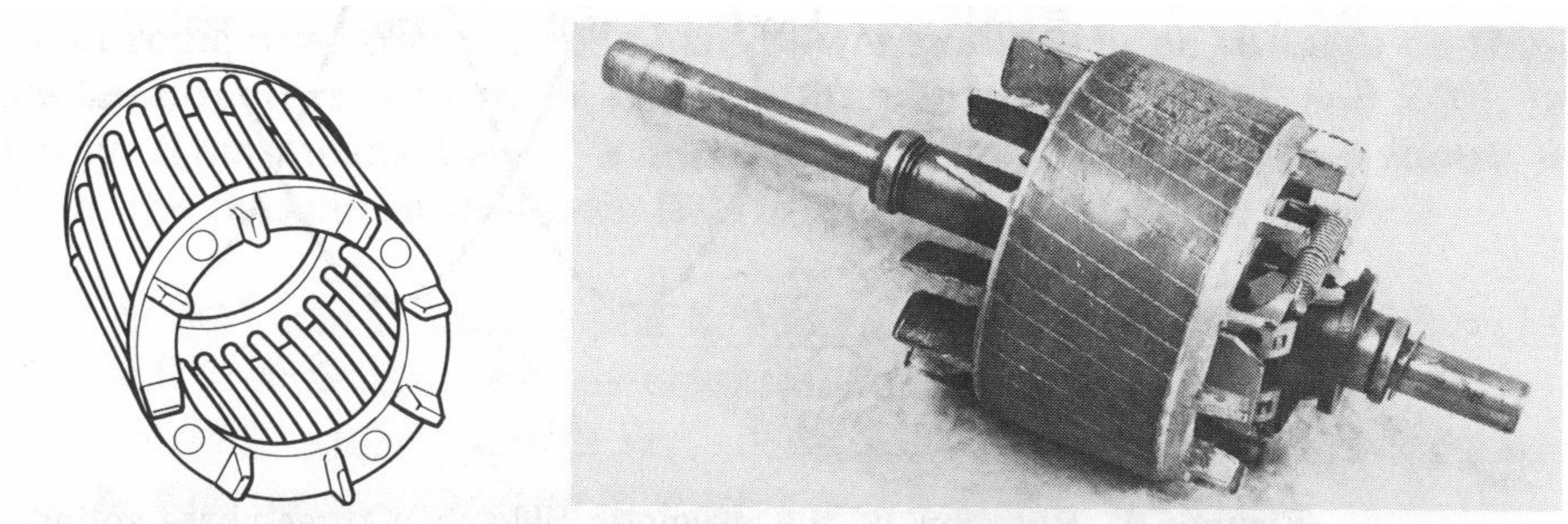




Synchronous A.C. Motor the rotor is a permanent magnet

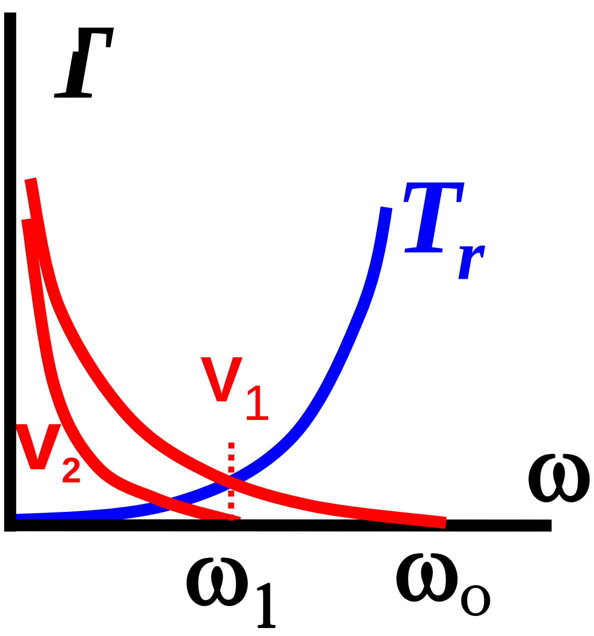


Induction motor (asynchronous), the rotor is composed of one or more windings in short-circuit

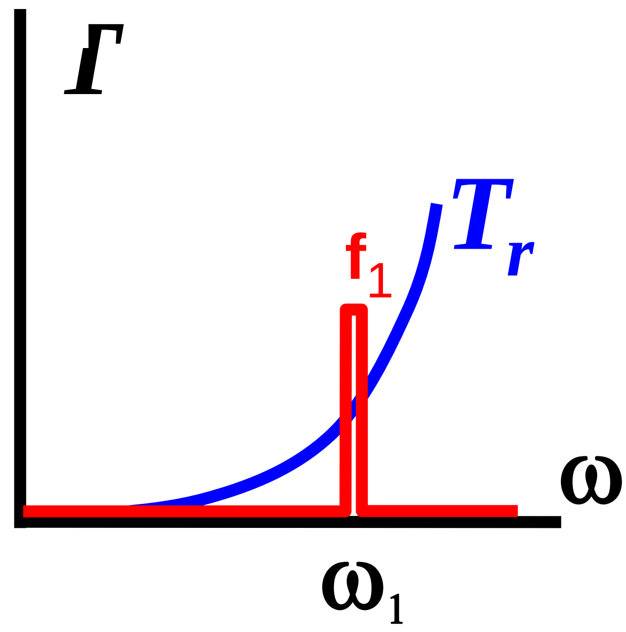


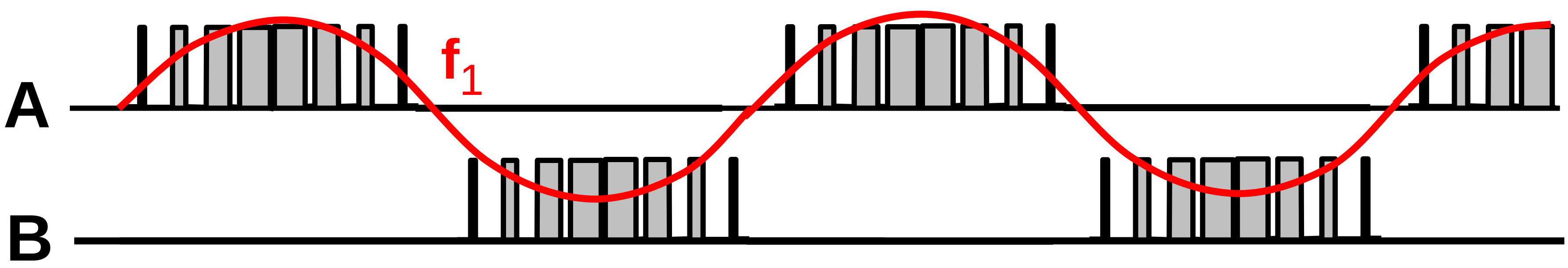
Rotor of an asyncronous a.c.
motor (Rotor as squirrel cage)

D.C. Motor.

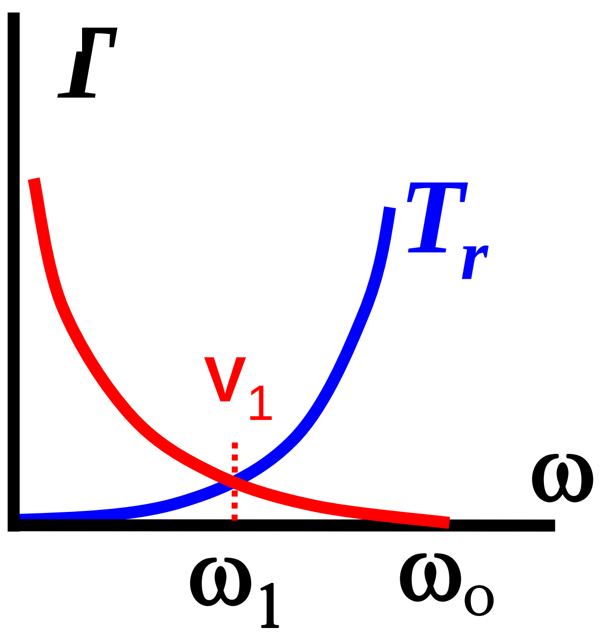


A.C. Motor.
(Synchronous)

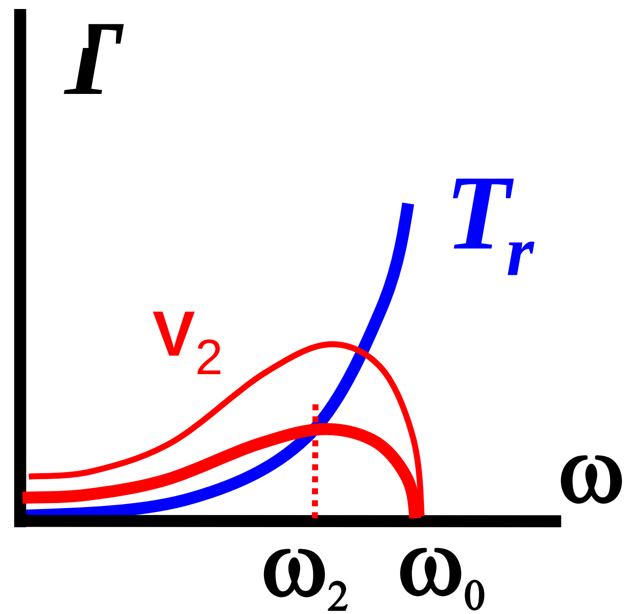


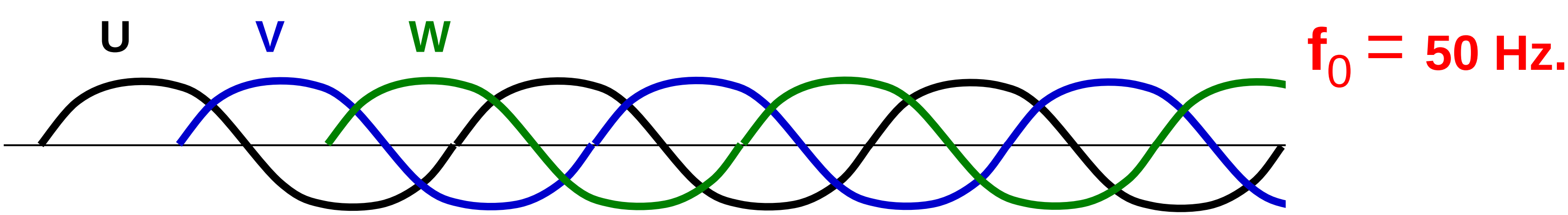


D.C. Motor.

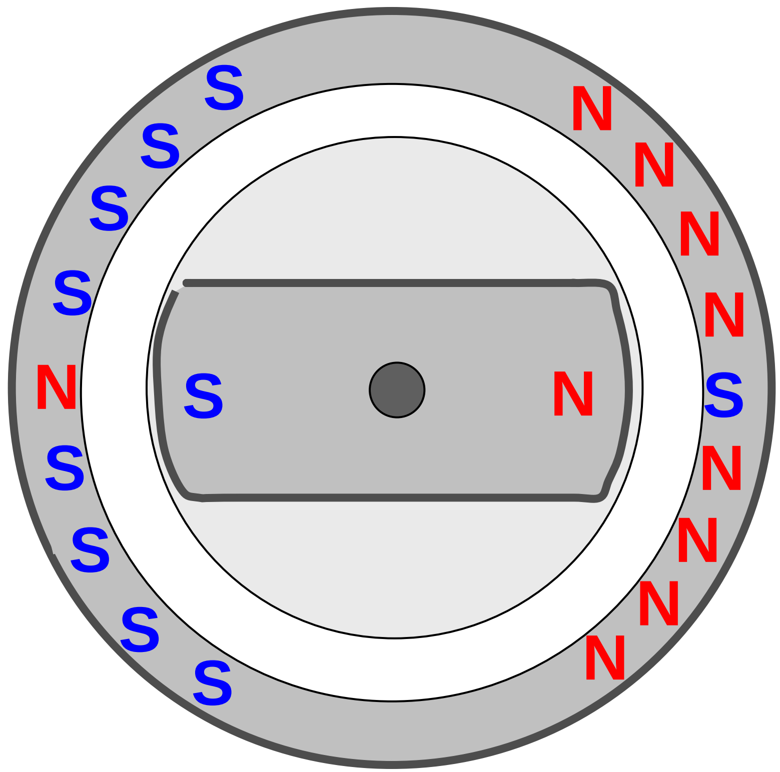


A.C. Motor.
(Synchronous)



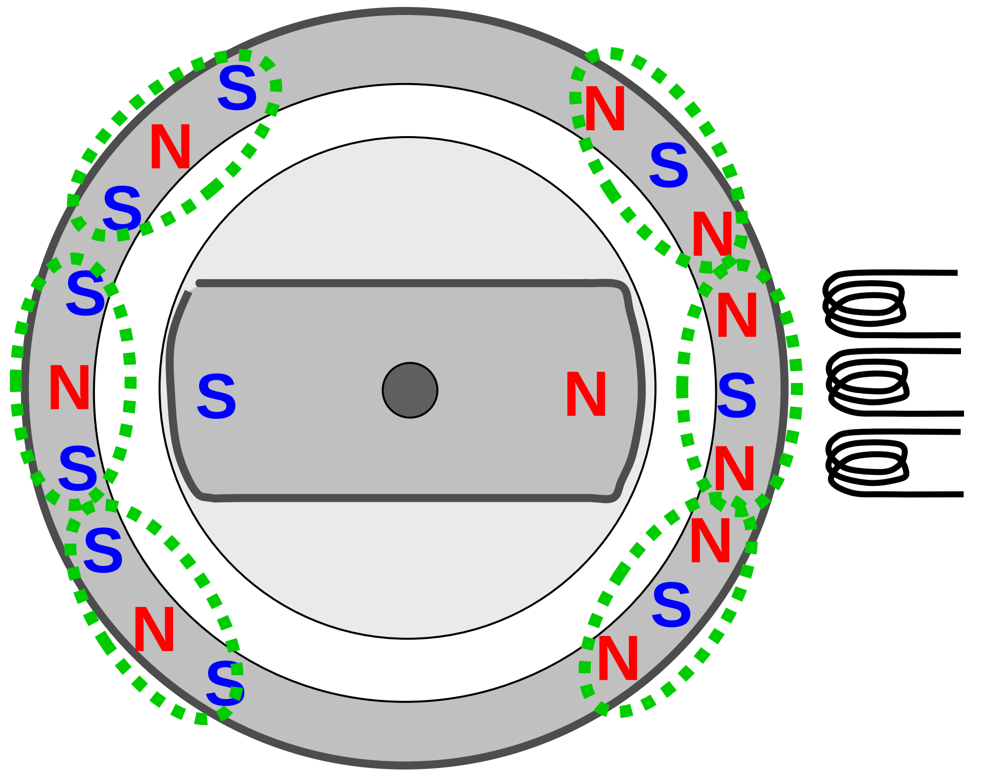


Stepper Motors



Control of the position of the rotor in a stepper motor using multiple pole pairs

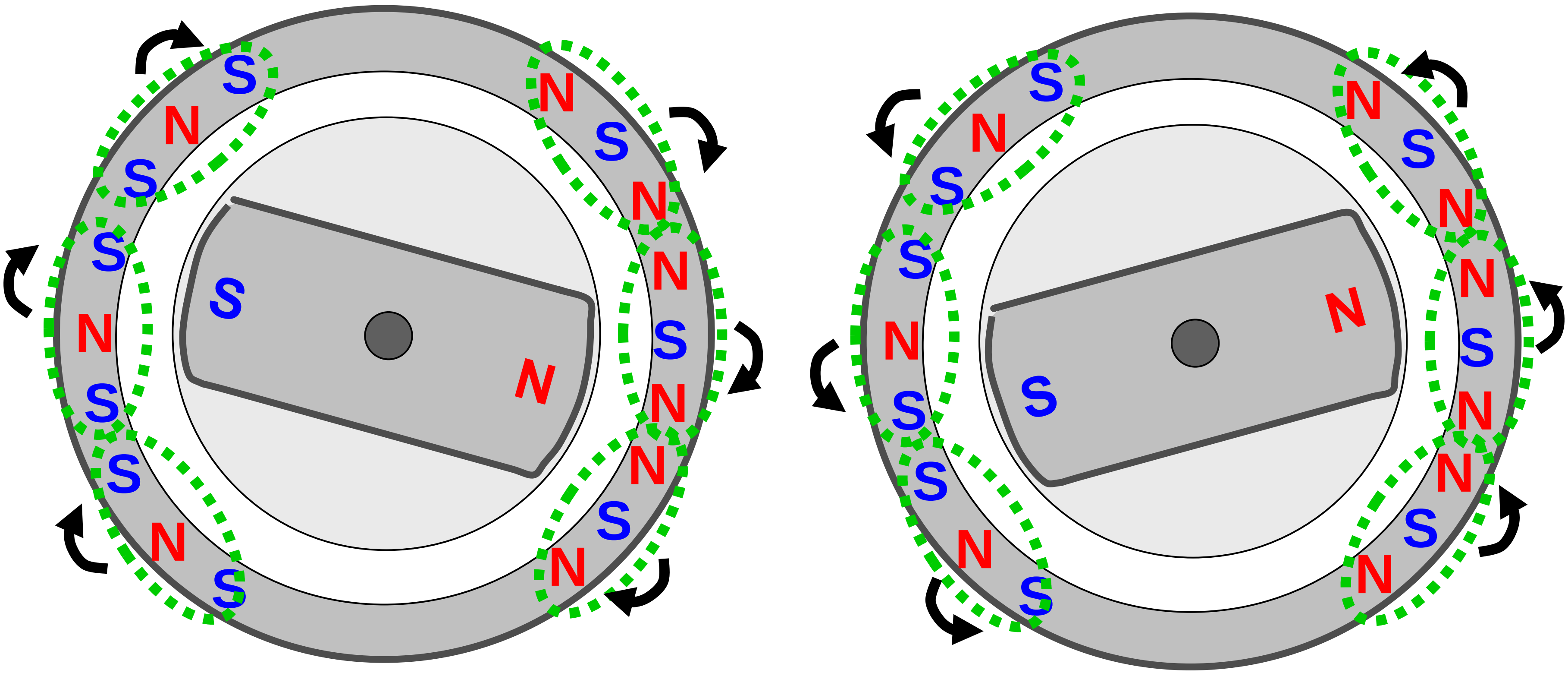
Stepper Motors



Reduction of the number of pole pairs to a minimum, groups of three that share the same coils:

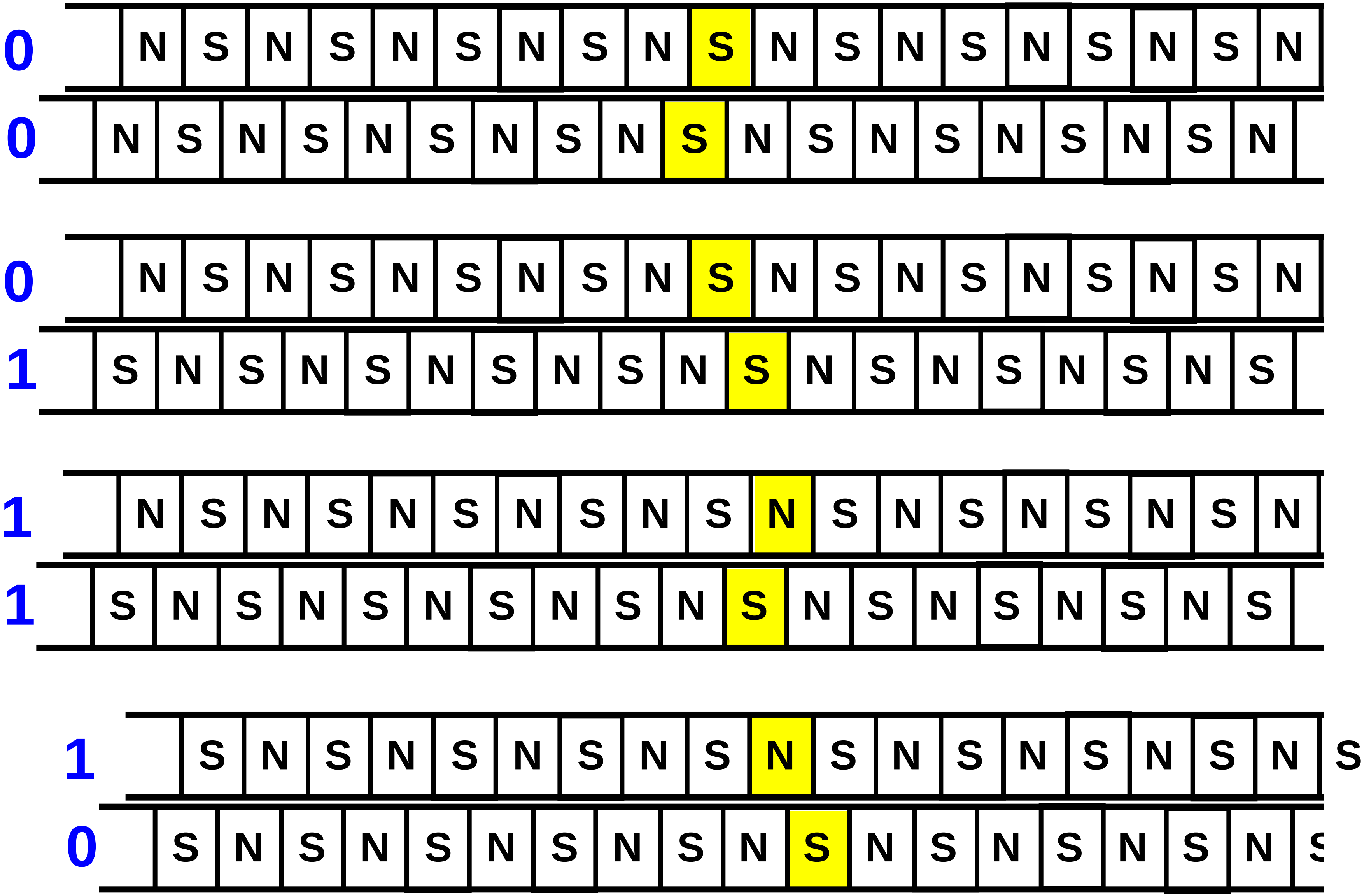
Three phases stepper motor

Stepper Motors

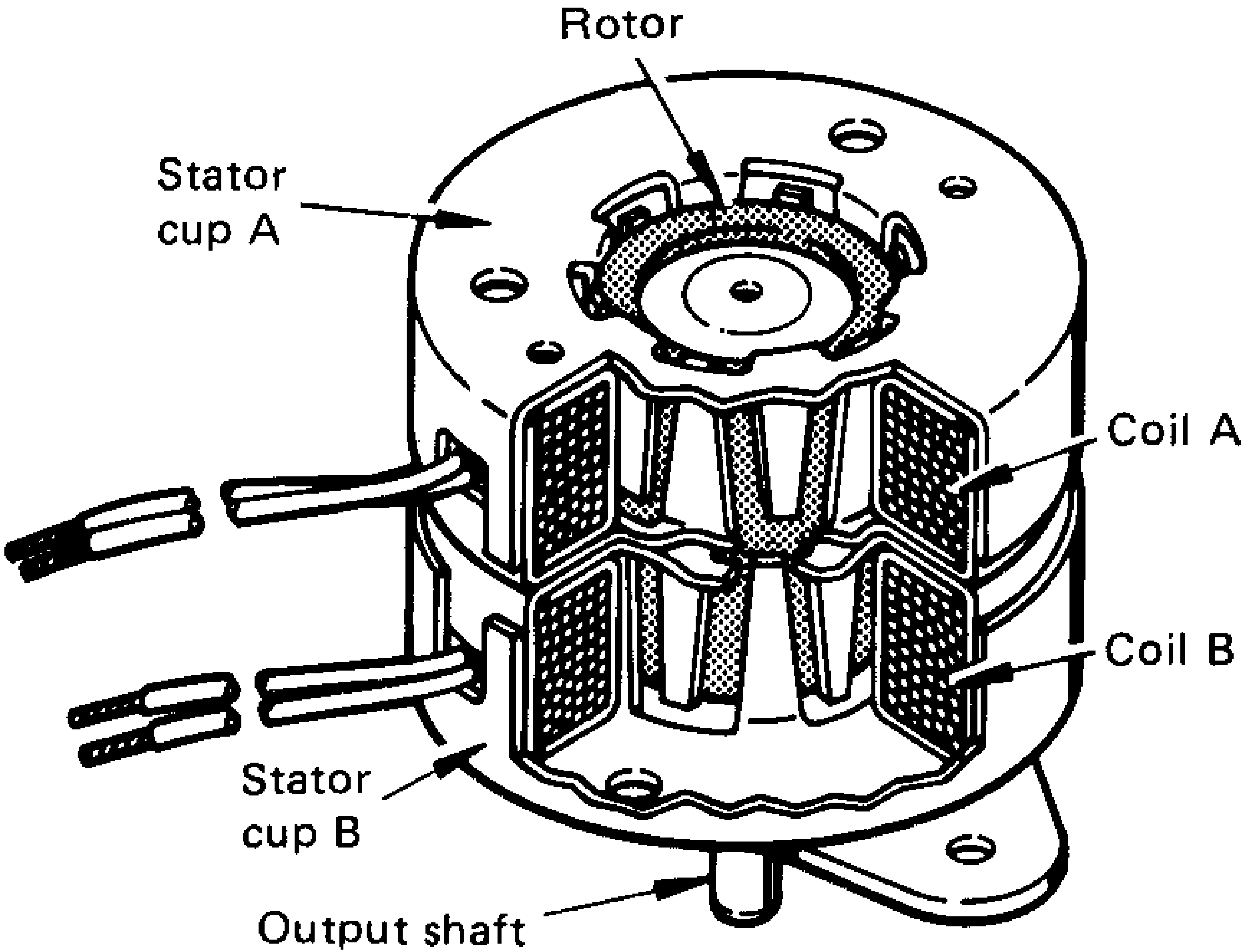


Stepper motor control in three phases

Stepper motors.

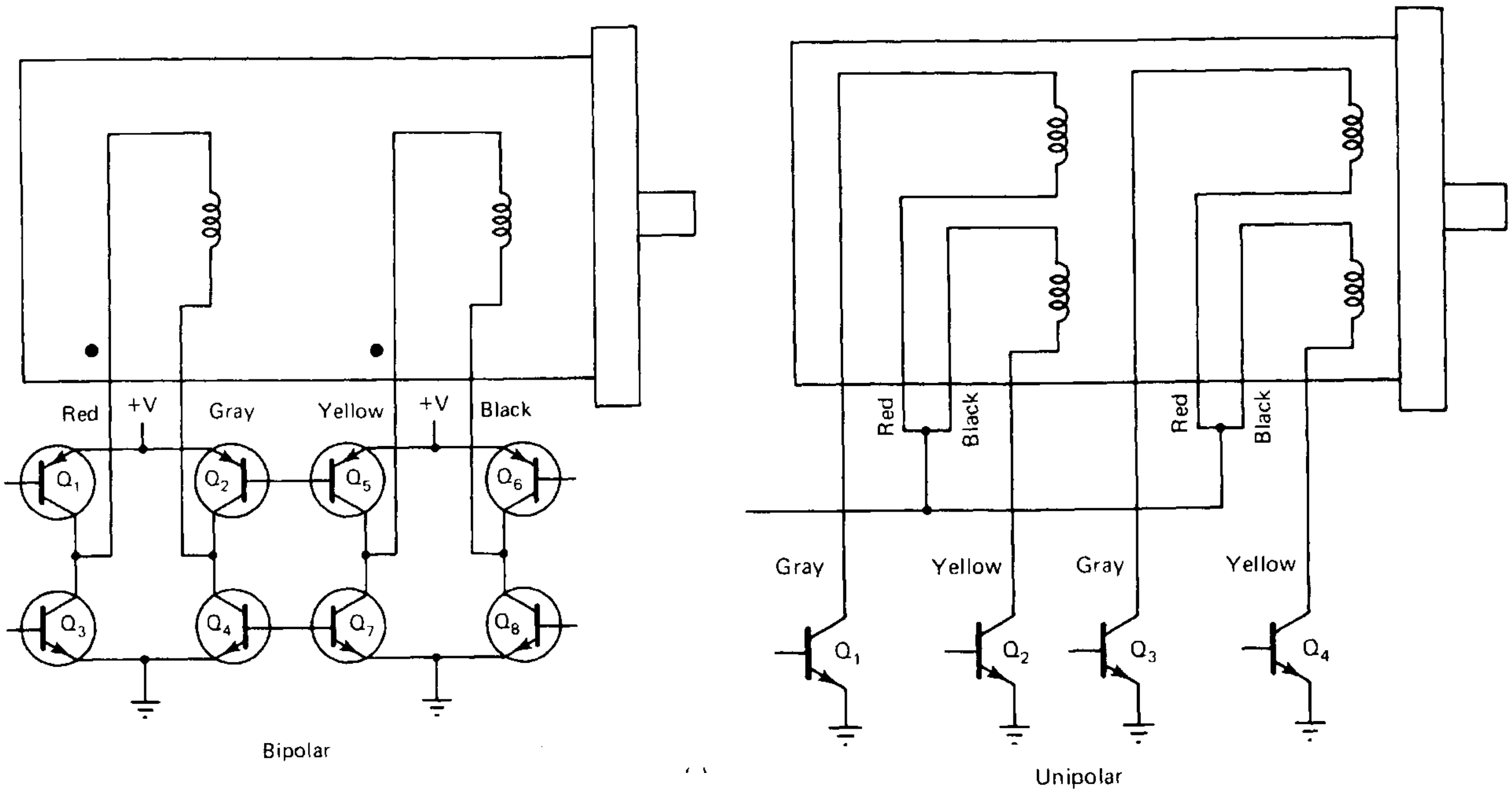


Control of a two bodies stepper motor of two phases



Internal structure of a two bodies stepper motor, of two phases

Stepper Motors.



Control techniques of a two phases stepper motor