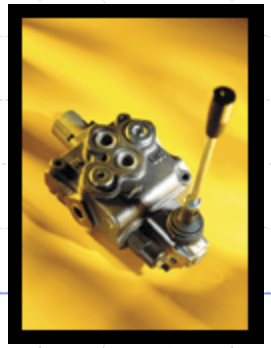
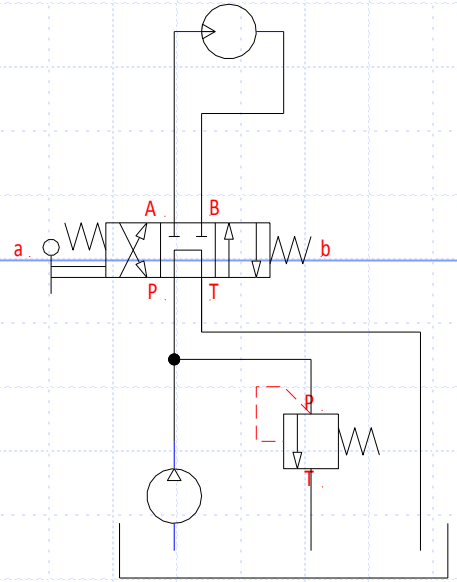
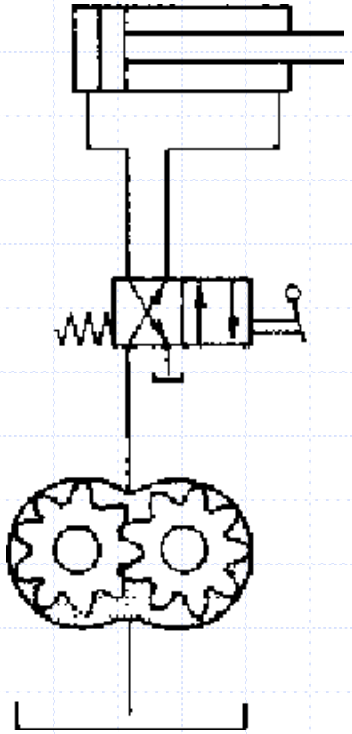
Grundkurs Hydraulik



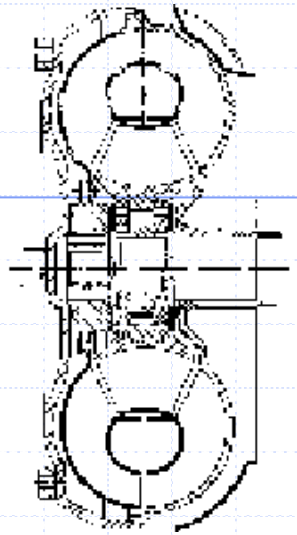
Hydrostatik

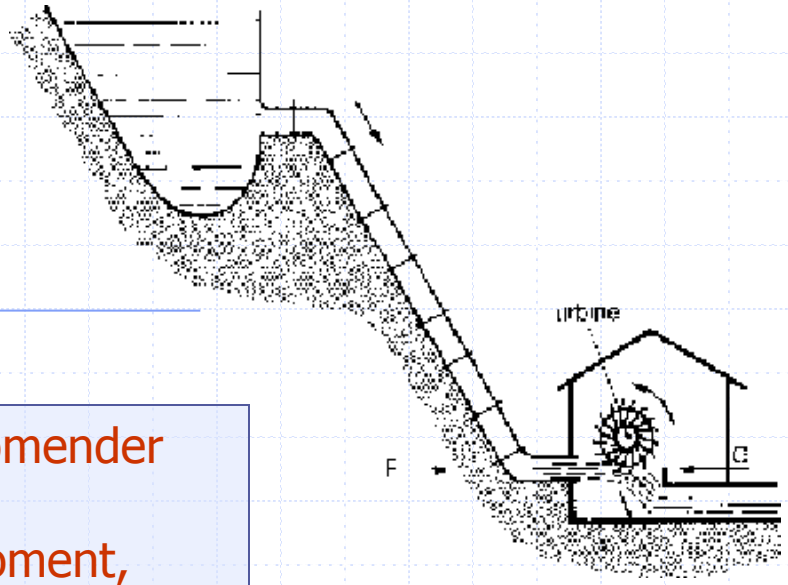


Mechanik ruhender Flüssigkeiten:
Kraft, Drehmoment, Leistung wird über Druck übertragen.



Hydrodynamik





Mechanik strömender Flüssigkeiten:
Kraft, Drehmoment, Leistung wird über die Strömungsenergie übertragen.

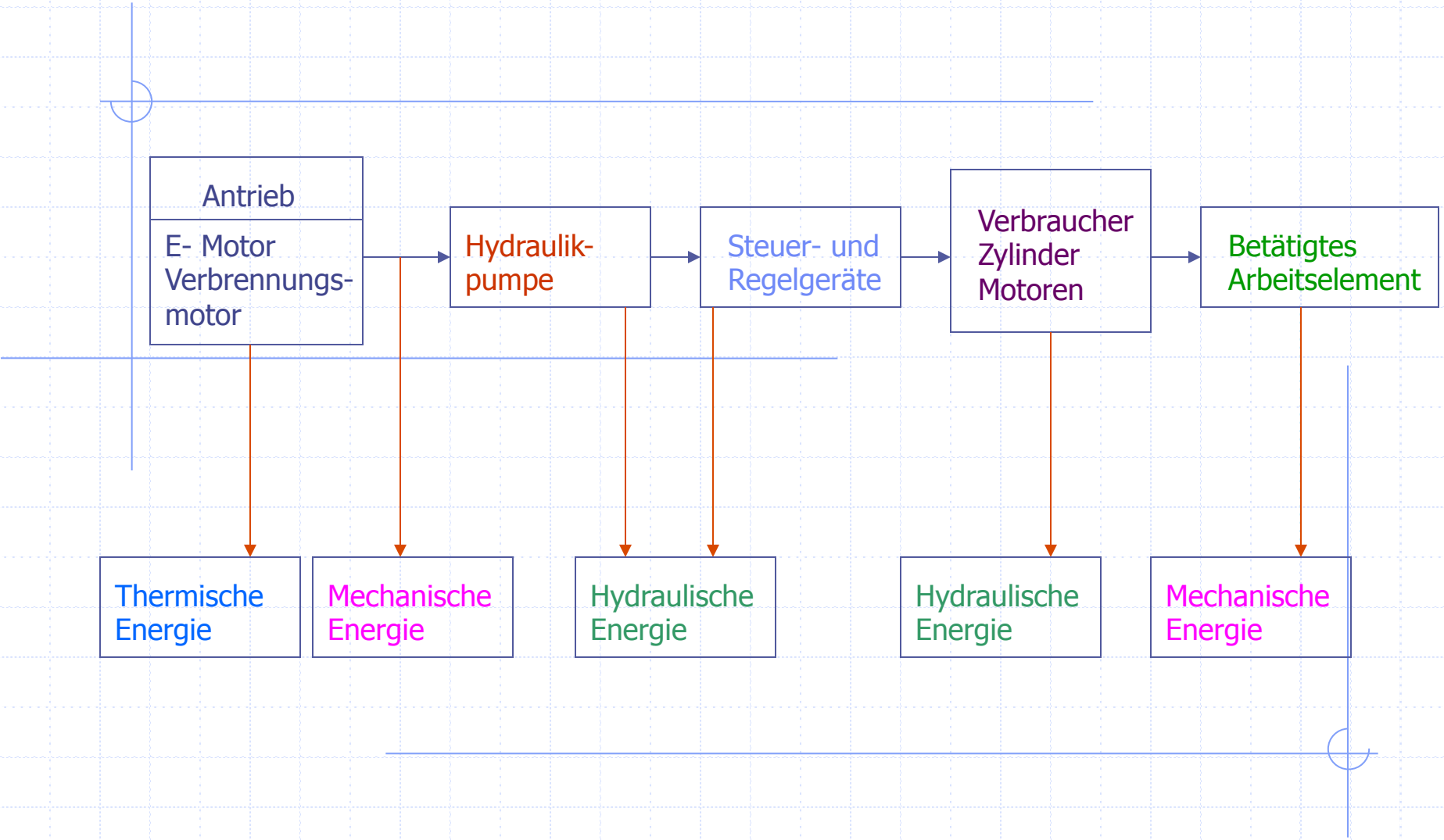
Vorteile der Hydraulik

- ✓ Grössere Kräfte
- ✓ exaktere Bewegungsabläufe
- ✓ Weiches Arbeiten
- ✓ Billigere Arbeitskosten
- ✓ Leichte Kraftumlenkung
- ✓ Geringere Geräuschbildung

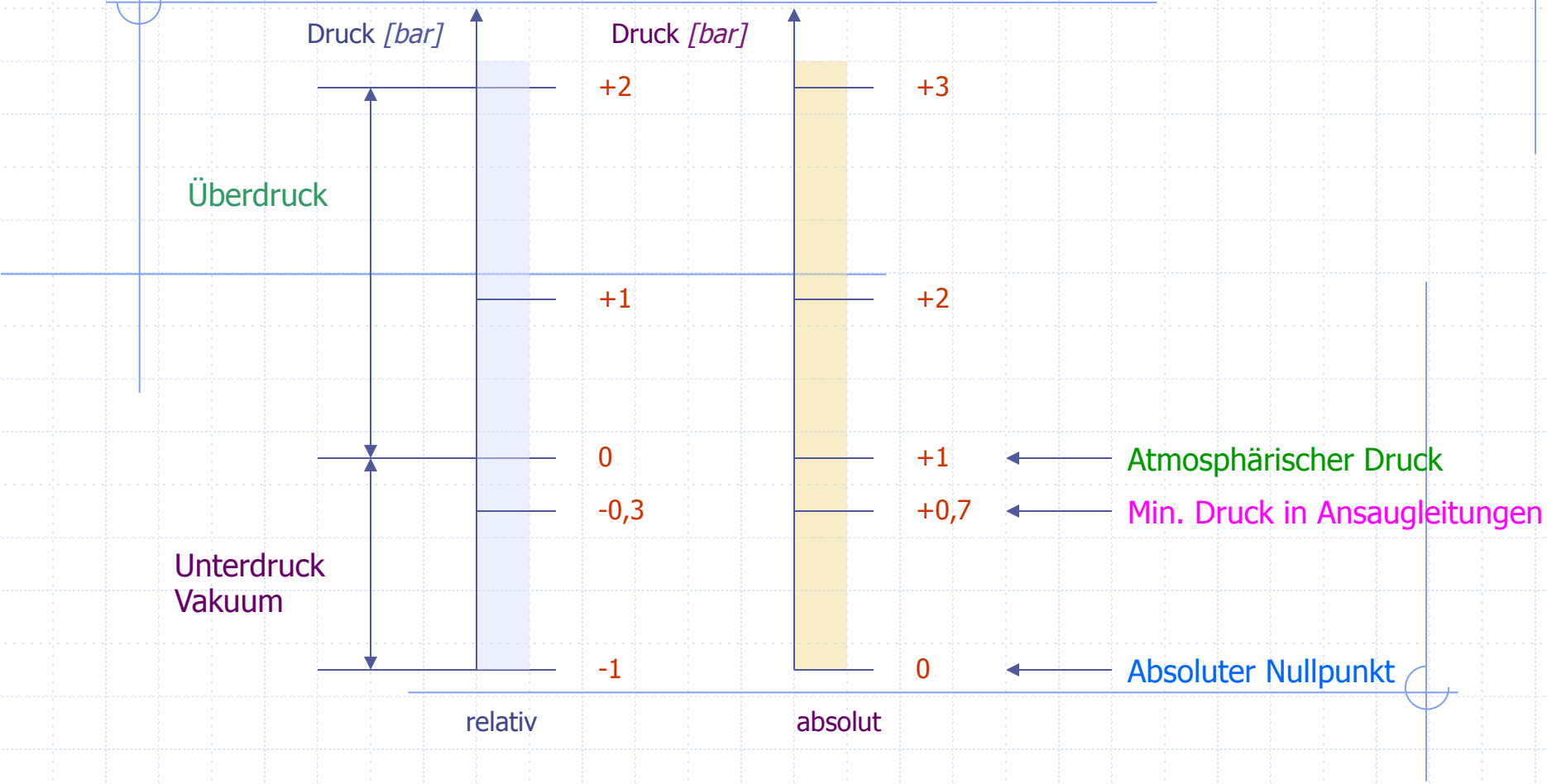
Nachteile der Hydraulik

- ✓ Teuer
- ✓ Gefahr durch hohe Drücke
- ✓ geringe Arbeitsgeschwindigkeit
- ✓ Rückleitungen erforderlich
- ✓ Bei Undichtheiten Verschmutzung

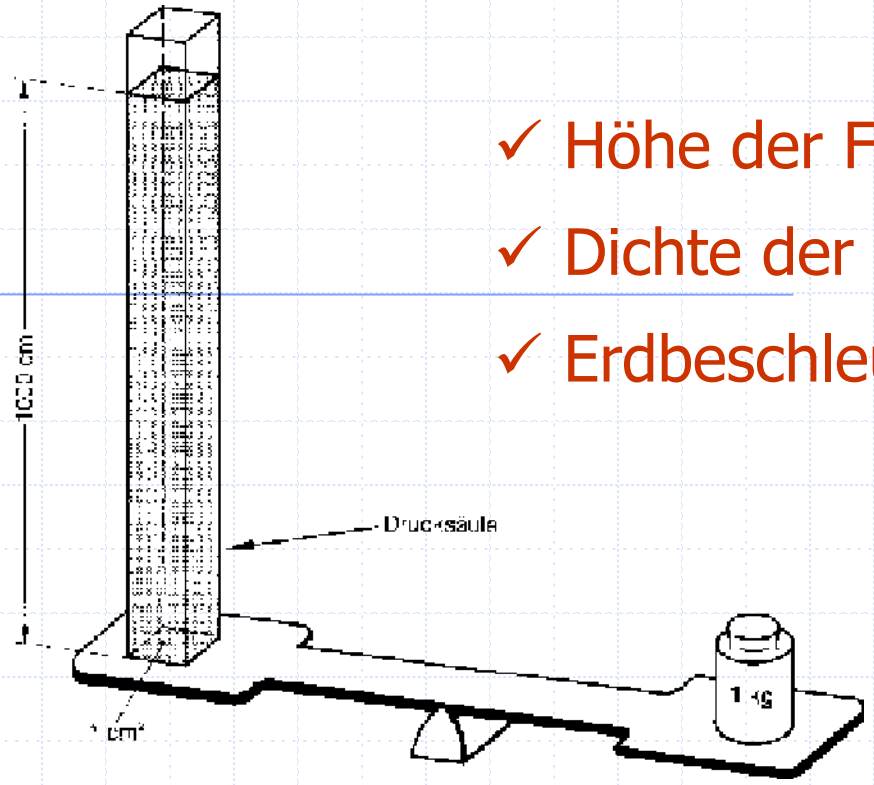
Aufbau einer Hydraulikanlage



Druckmassstäbe

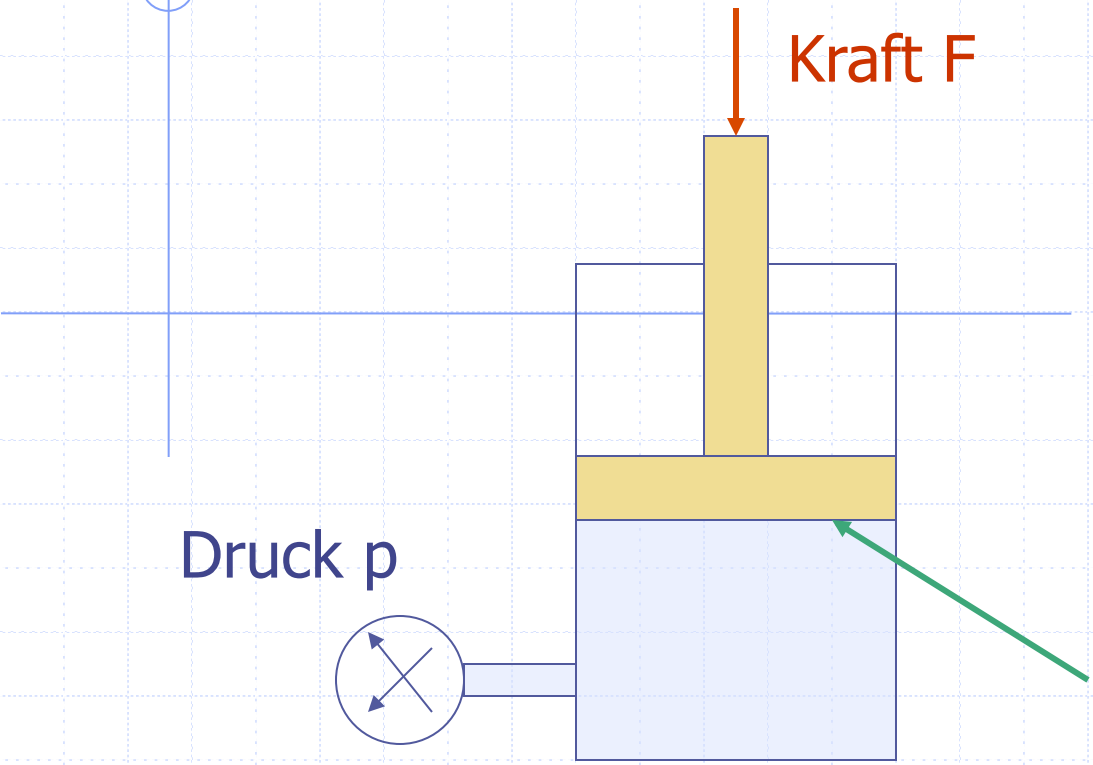


Hydrostatischer Druck



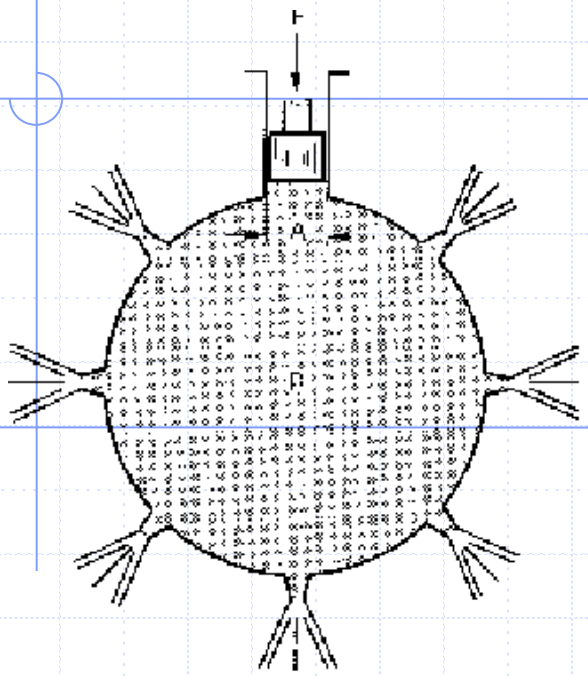
- ✓ Höhe der Flüssigkeitssäule
- ✓ Dichte der Flüssigkeit
- ✓ Erdbeschleunigung

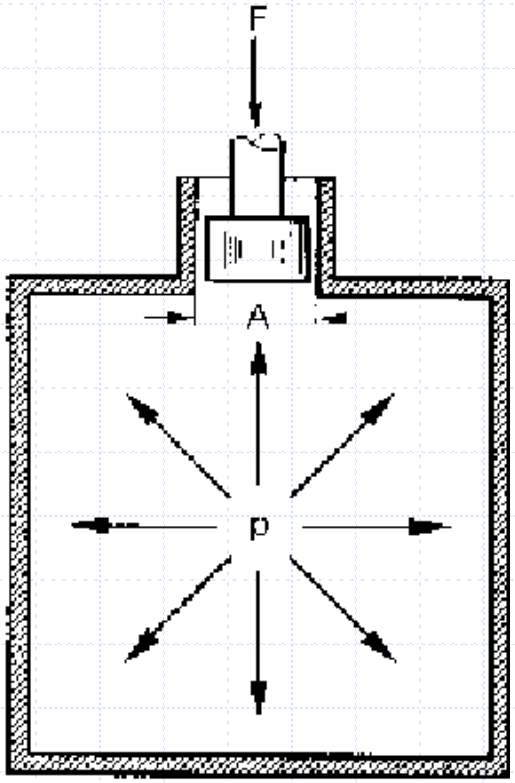
Flüssigkeitsdruck



$$p = \frac{F}{A}$$

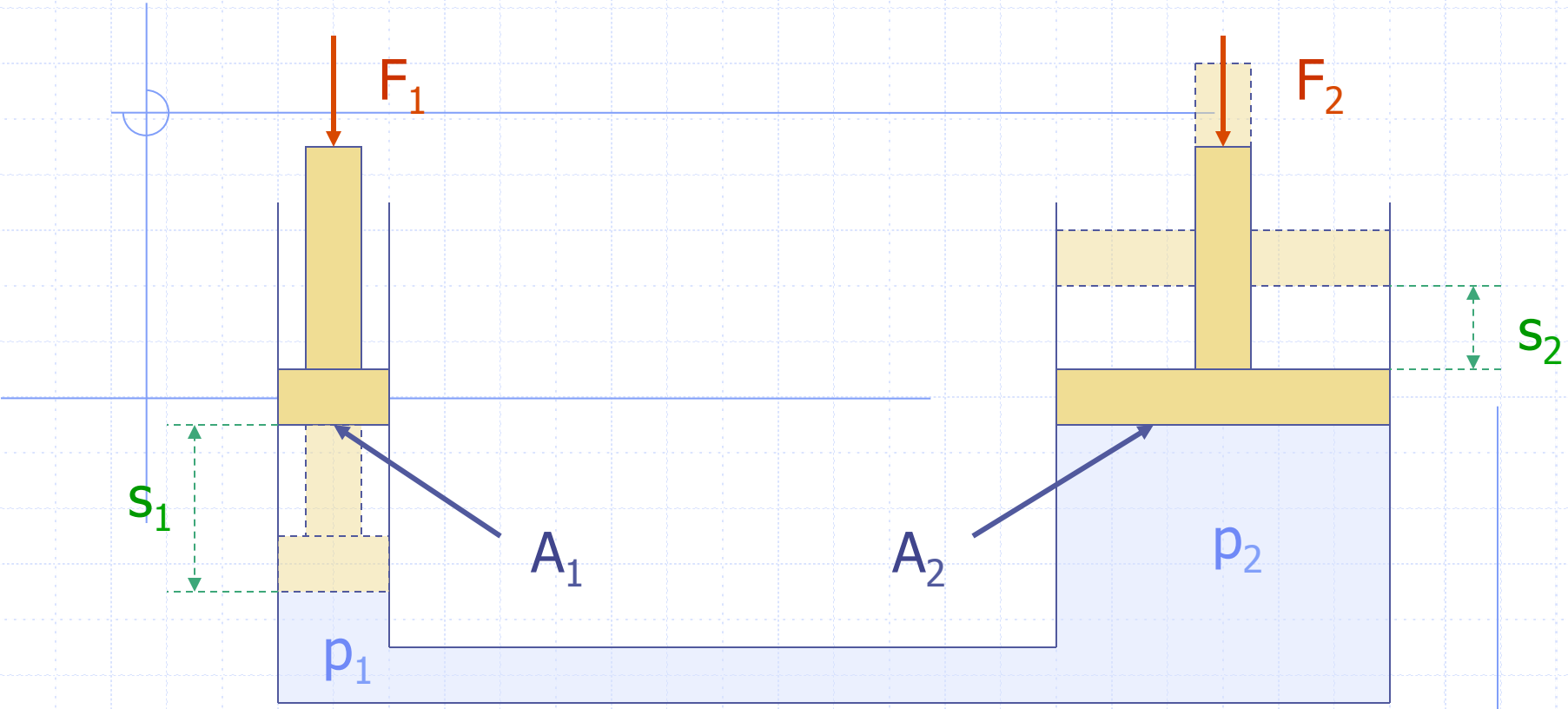
Gesetz von Pascal





Wirkt eine Kraft F über einer Fläche A auf eine eingeschlossene Flüssigkeit, so entsteht ein Druck p, der sich über die gesamte Flüssigkeit gleichmässig ausbreitet.

Kraftübersetzung



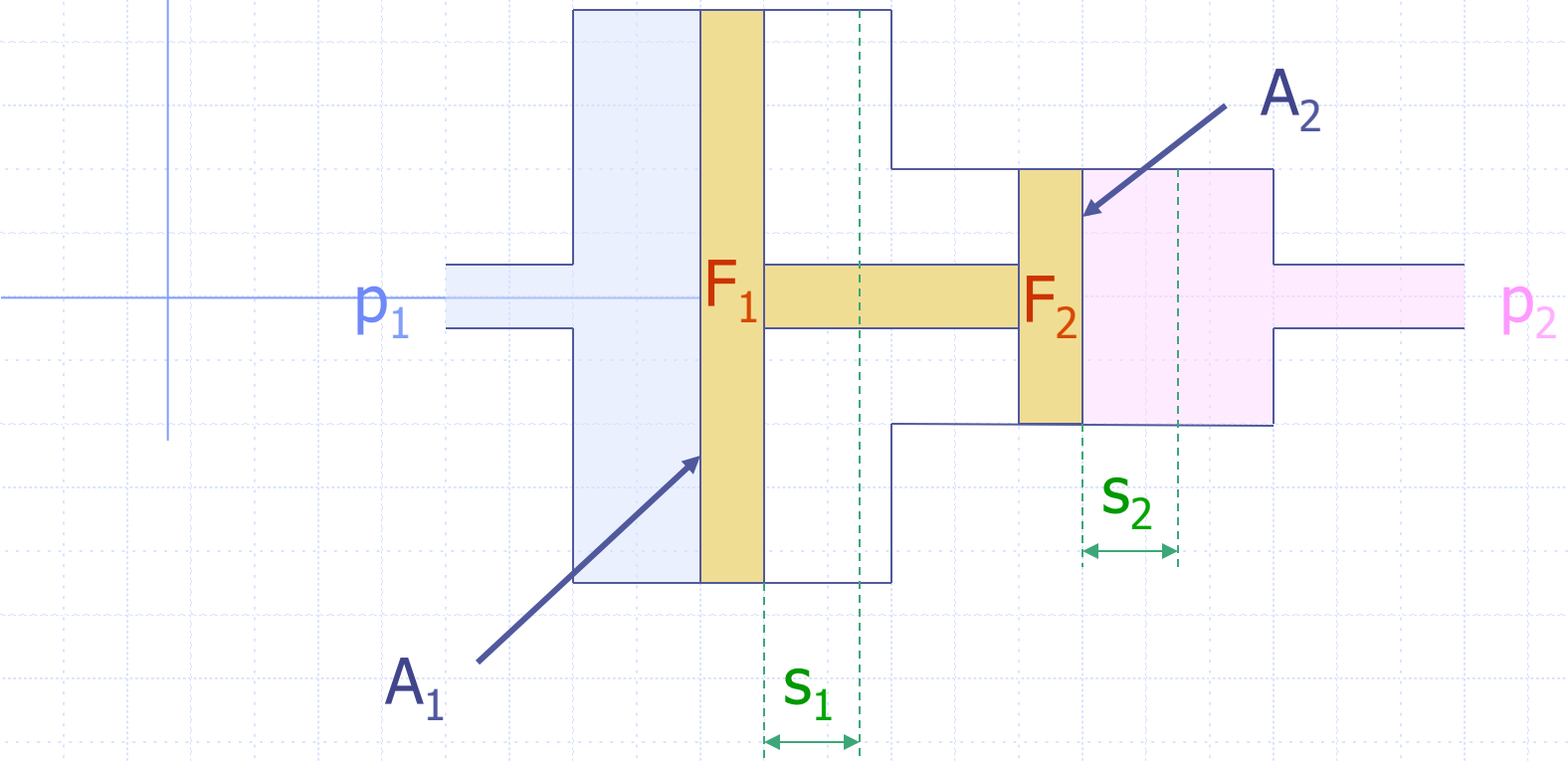
$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$p_1 = p_2$$

$$\frac{F_1}{F_2} = \frac{A_1}{A_2} = \frac{s_2}{s_1}$$

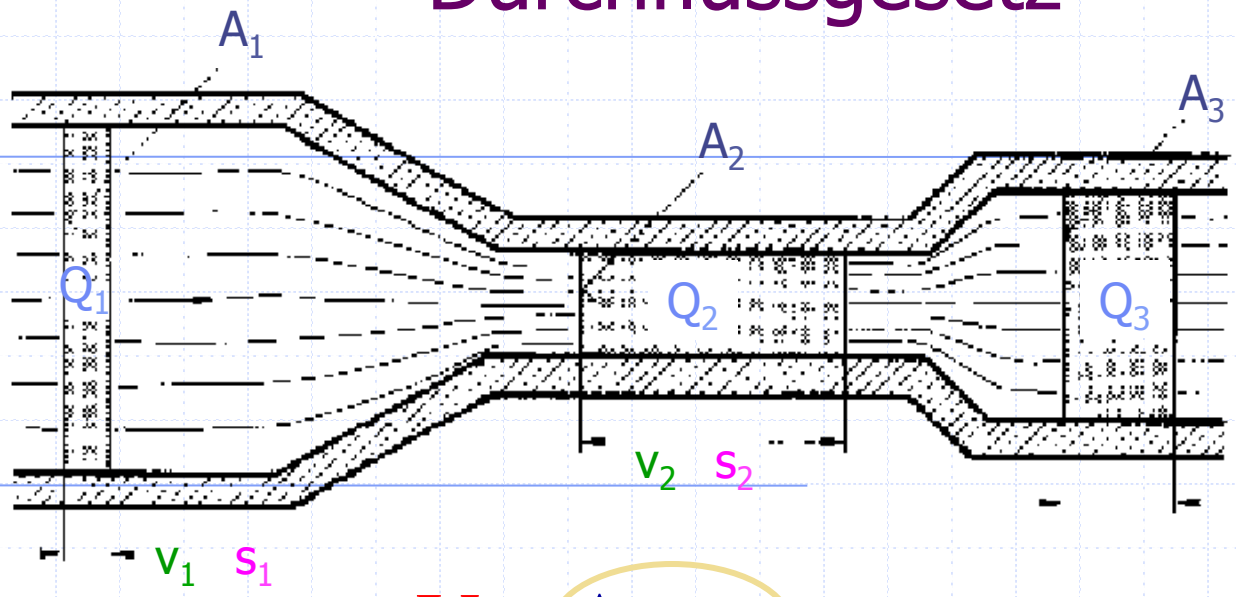
$$F_1 \cdot A_2 = F_2 \cdot A_1$$

Druckübersetzung



$$p_1 \cdot A_1 = p_2 \cdot A_2 \quad \rightarrow \quad F_1 = F_2 \quad \rightarrow \quad \frac{p_1}{p_2} = \frac{A_2}{A_1}$$

Durchflussgesetz



$$V = A \cdot s$$

$$Q = \frac{V}{t}$$

$$Q = \frac{A \cdot s}{t}$$

$$v = \frac{s}{t}$$

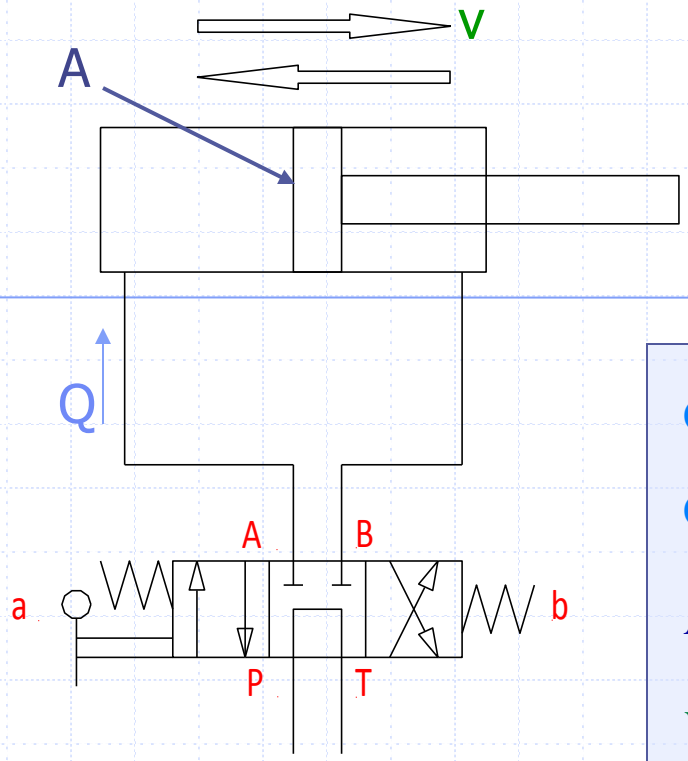
$$Q = A \cdot v$$

Kontinuitätsgleichung:

$$A_1 \cdot v_1 = A_2 \cdot v_2 = A_3 \cdot v_3$$

$$Q_1 = Q_2 = Q_3$$

Volumenstrom / Zylinder



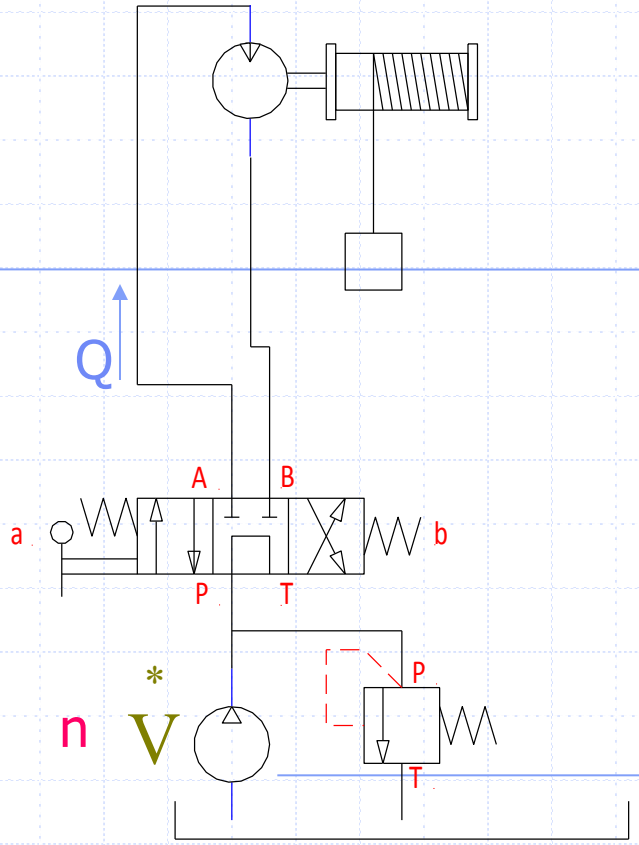
$Q = A \cdot v$

Q = Volumenstrom $\left[dm^3 / min \right]$

A = Kolbenfläche $\left[dm^3 \right]$

v = Ausfahrgeschwindigkeit $\left[dm / min \right]$

Volumenstrom / Hydraulikpumpe



$$Q = n \cdot \overset{*}{V}$$

Q = Volumenstrom $\left[{}^{dm^3}/_{min} \right]$

n = Drehzahl $\left[{}^{1}/_{min} \right]$

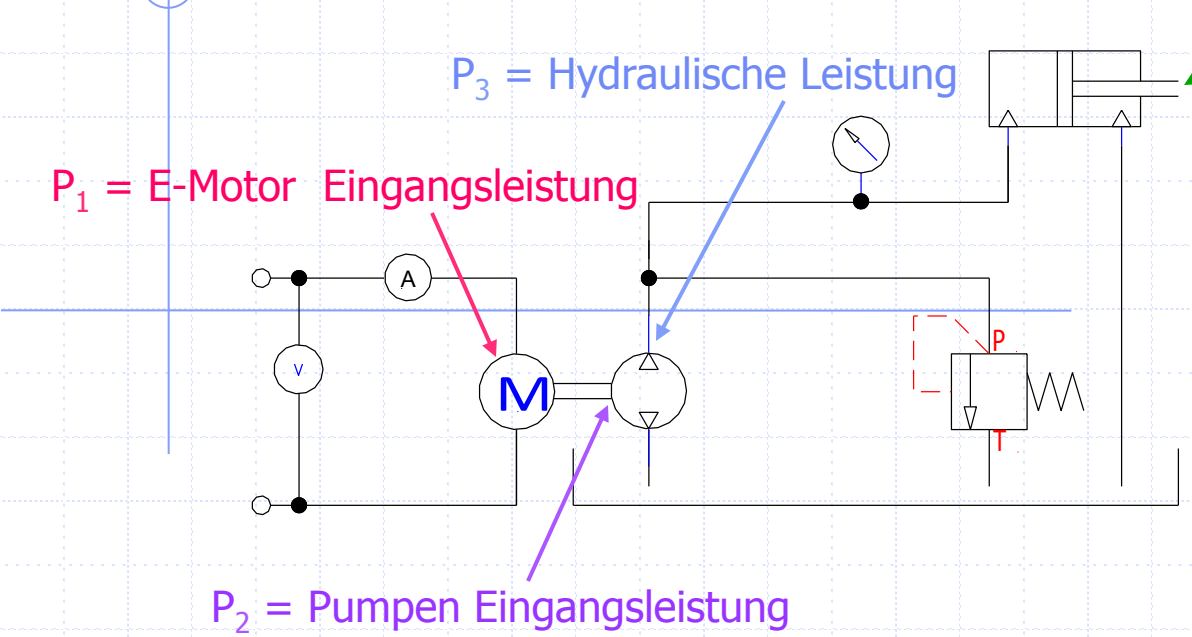
$\overset{*}{V}$ = Fördervolumen $\left[{}^{dm^3}/_{U} \right]$

mit Wirkungsgrad

$$Q = n \cdot \overset{*}{V} \cdot \eta$$

η = Wirkungsgrad

Hydraulische Leistung I



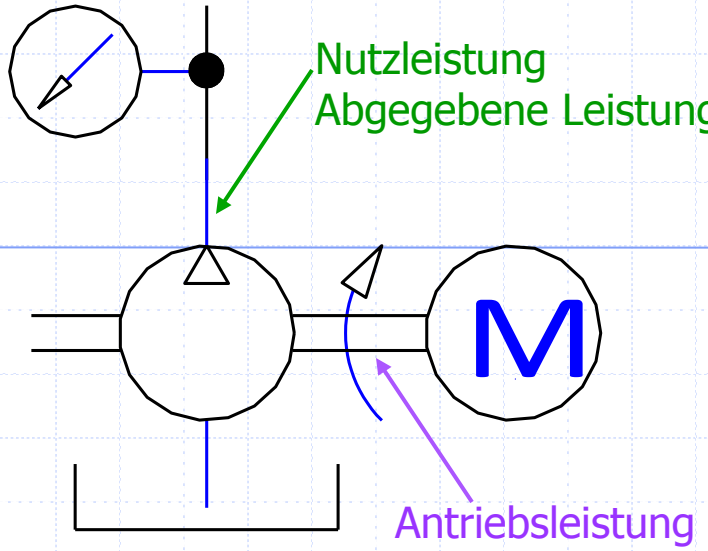
$$P_1 = U \cdot I$$

$$P_2 = \frac{M \cdot n}{9550}$$

$$P_3 = \frac{p \cdot Q}{600}$$

$$P_4 = F \cdot v$$

Hydraulische Leistung II



Antriebsleistung Pumpe:

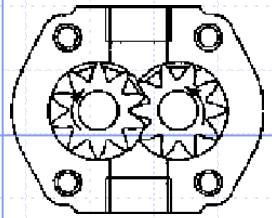
$$P_{An} = \frac{p \cdot Q}{600 \cdot \eta}$$

Nutzleistung Hydromotor:

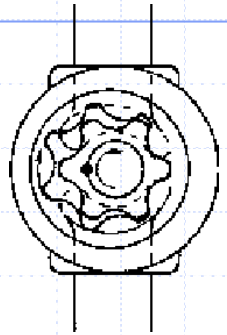
$$P_{Nutz} = \frac{p \cdot Q \cdot \eta}{600}$$

Hydraulikpumpen

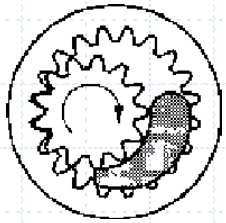
Konstantpumpen



Aussenzahnradpumpe

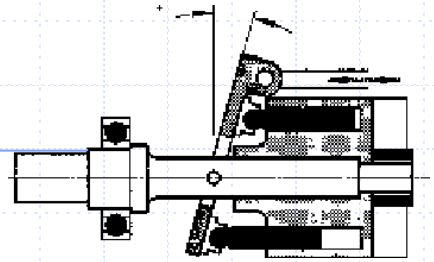


Zahnringpumpe

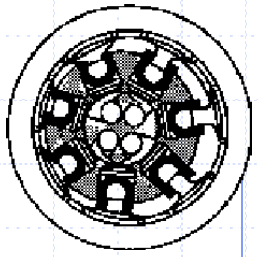


Innenzahnradpumpe

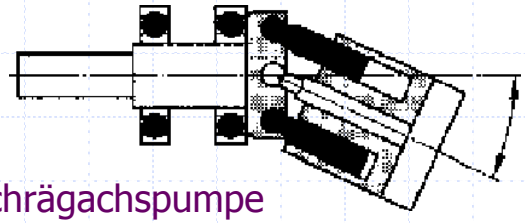
Verstellpumpen



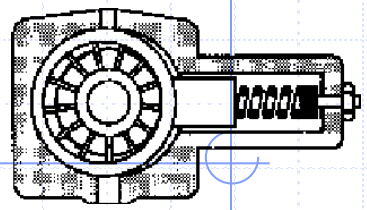
Schrägscheibenpumpe



Radialkolbenpumpe



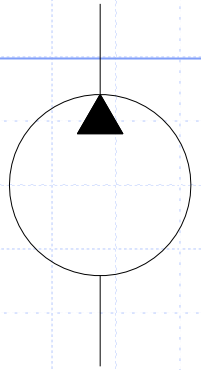
Schrägachspumpe



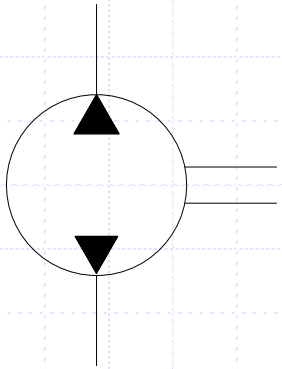
Flügelzellenpumpe

Hydraulikpumpen-Symbole I

Konstantpumpen



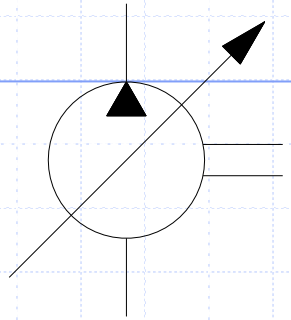
Eine Förderrichtung



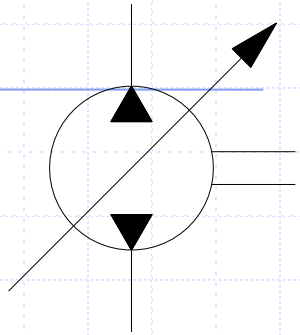
Zwei Förderichtungen

Hydraulikpumpen-Symbole II

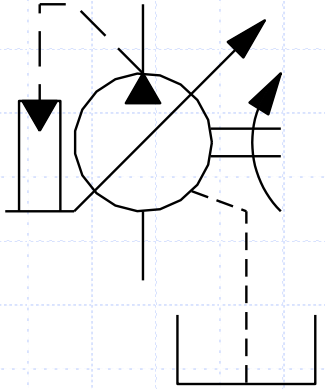
Verstellpumpen



Eine Förderrichtung

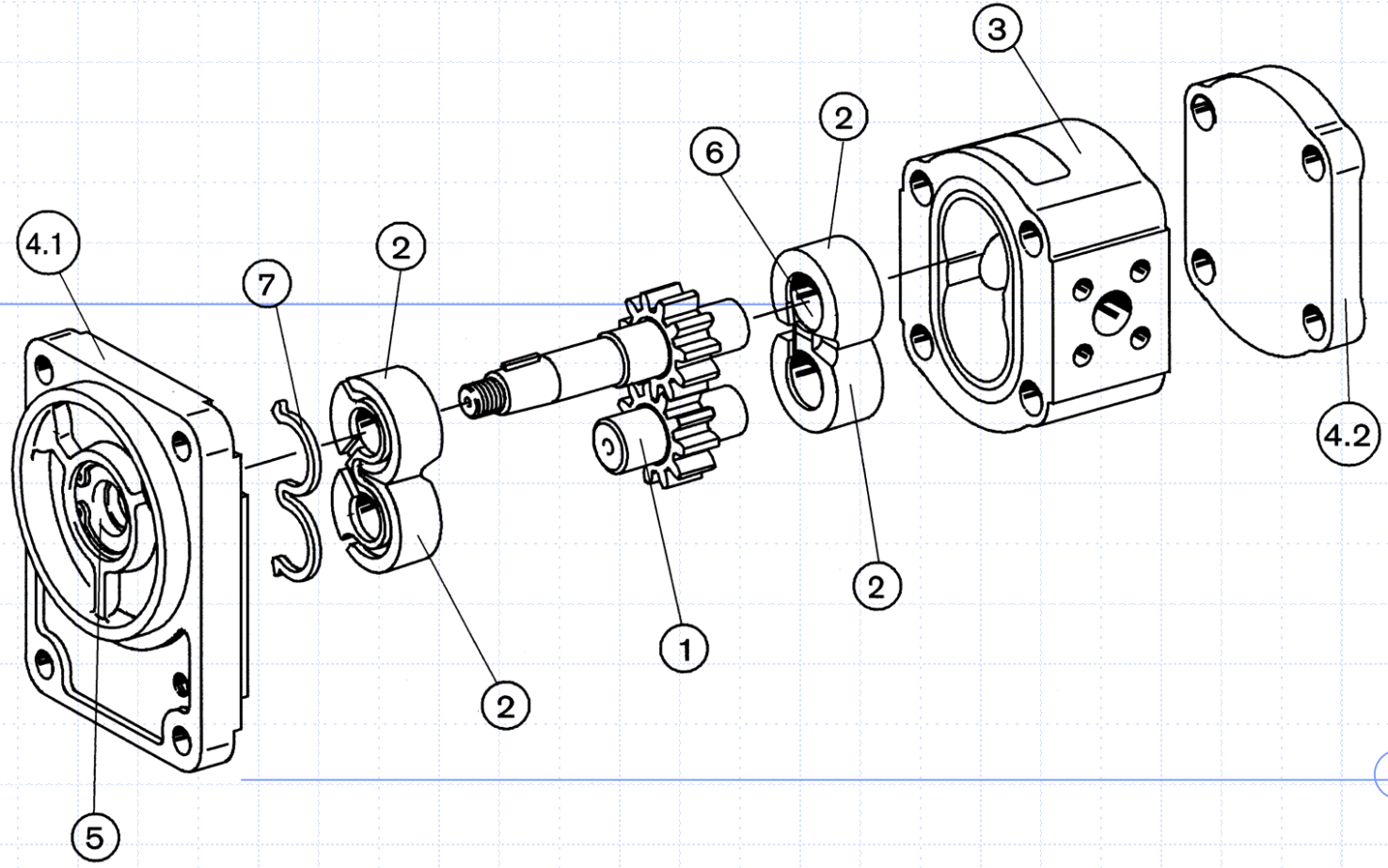


Zwei Förderichtungen



Regelpumpe

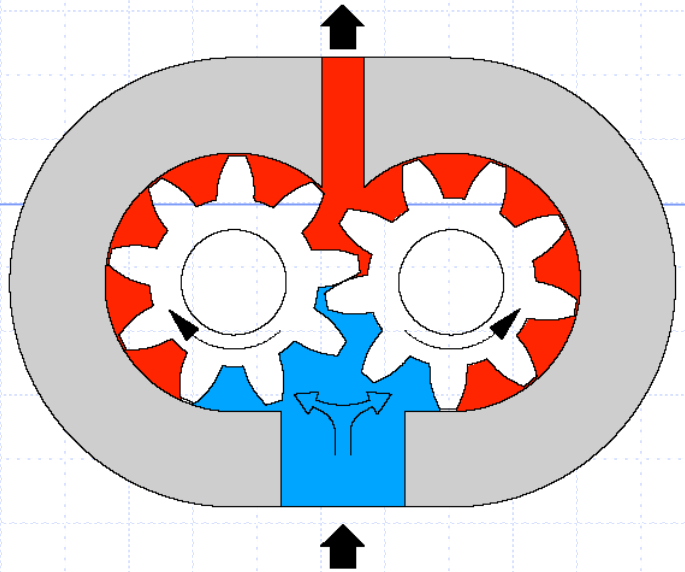
Zahnradpumpe Buchsenpumpe I

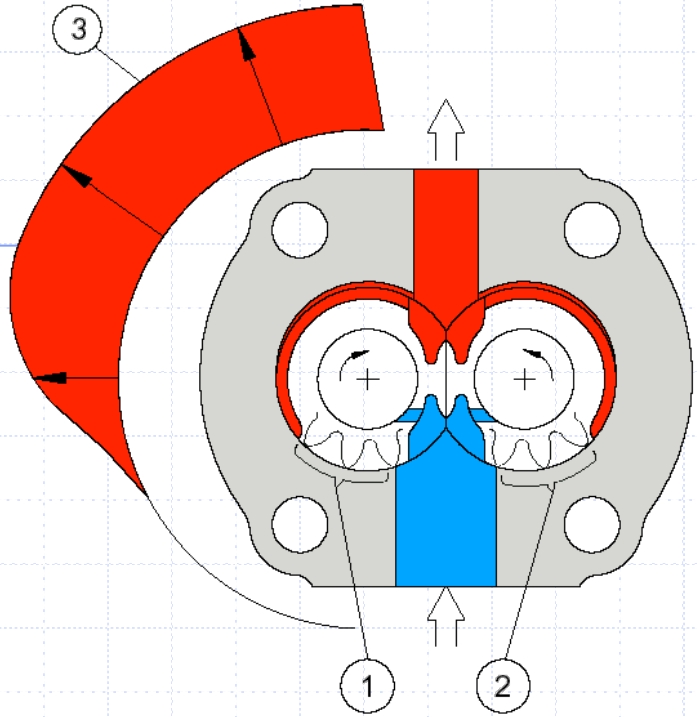


Zahnradpumpe Buchsenpumpe II

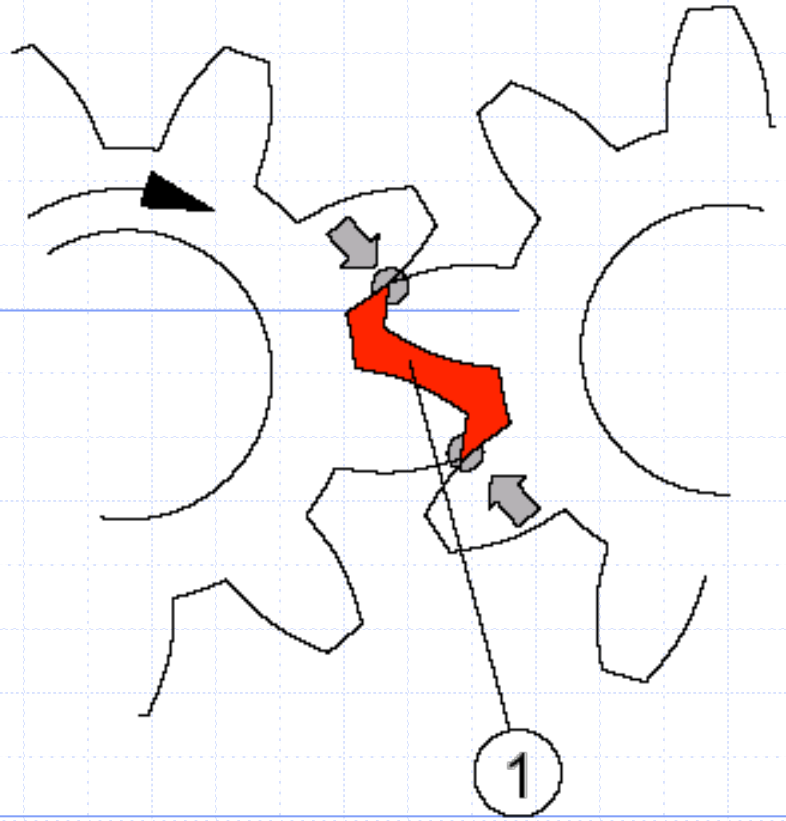
- ✓ Druck bis 300 bar
- ✓ Wirkungsgrad bis 90%
- ✓ Drehzahl bis 3500 1/min
- ✓ Volumenstrom bis 300 l/min

Zahnradpumpe Buchsenpumpe III

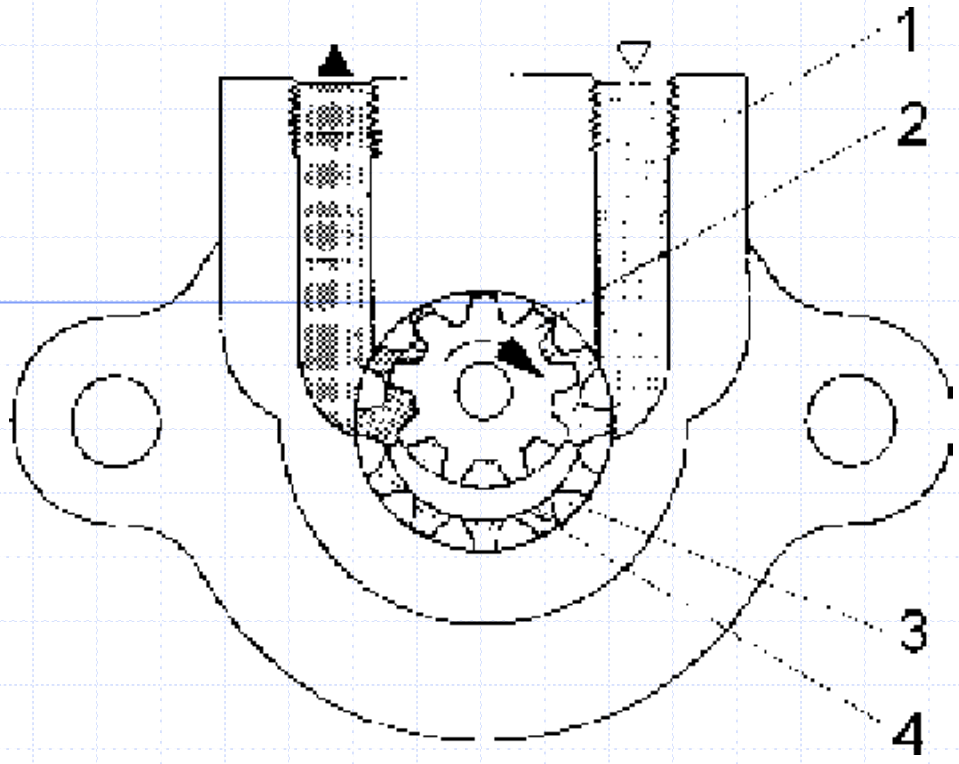




Zahnradpumpe Buchsenpumpe IV



Innenzahnradpumpe I



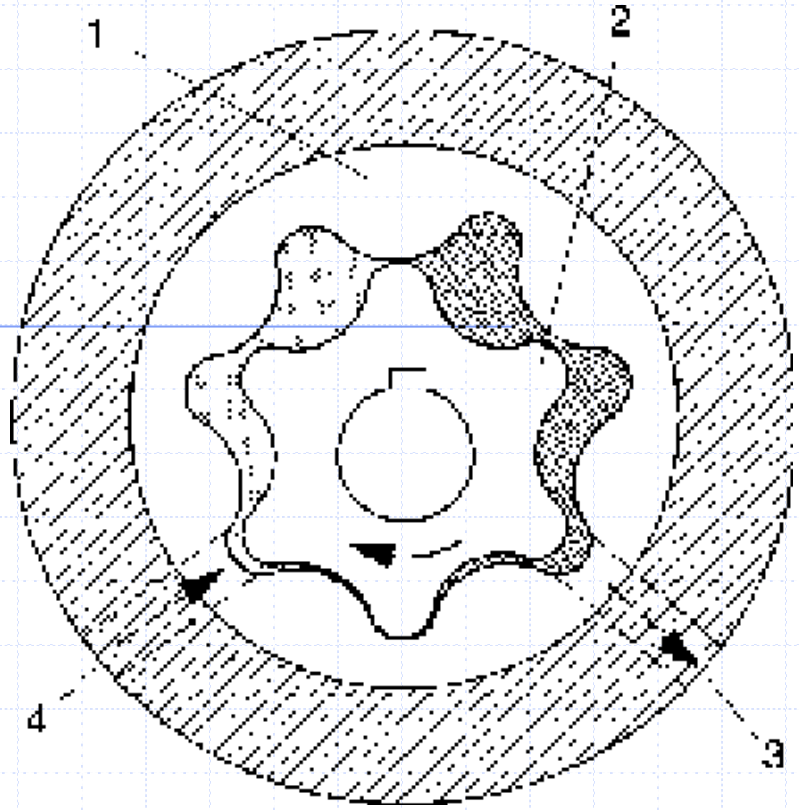
Innenzahnradpumpe II

- ✓ Geräuscharm
- ✓ Geringe Druckpulsation
- ✓ Verwendung als:
  - ✓ Fülllpumpe Motorschmierpumpe

Innenzahnradpumpe III

- ✓ Druck bis 300 bar
- ✓ Wirkungsgrad 60 – 90%
- ✓ Drehzahl bis 3000 1/min
- ✓ Volumenstrom bis 100 l/min

Zahnringpumpe I



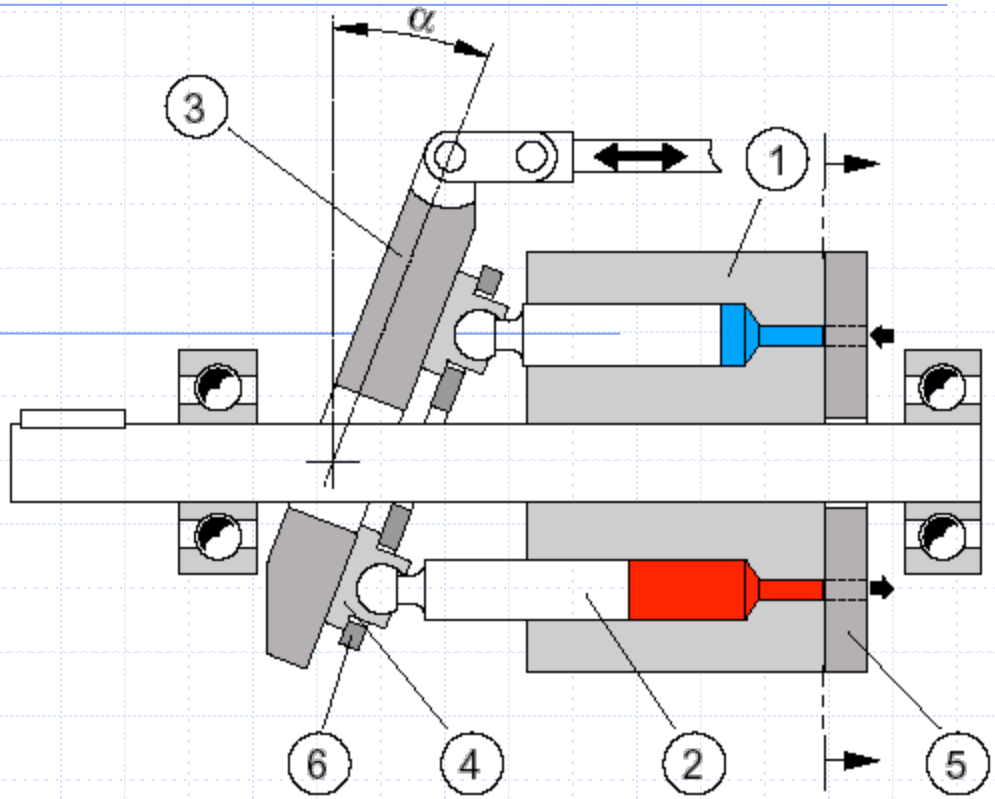
Zahnringpumpe I

- ✓ Geräuscharm
- ✓ Geringe Druckpulsation
- ✓ Verwendung als:
  - ✓ Dosierpumpe Lenkeinheit

Zahnringpumpe III

- ✓ Druck bis 300 bar
- ✓ Wirkungsgrad 60 – 90%
- ✓ Drehzahl bis 3000 1/min
- ✓ Volumenstrom bis 100 l/min

Schrägscheibenpumpe



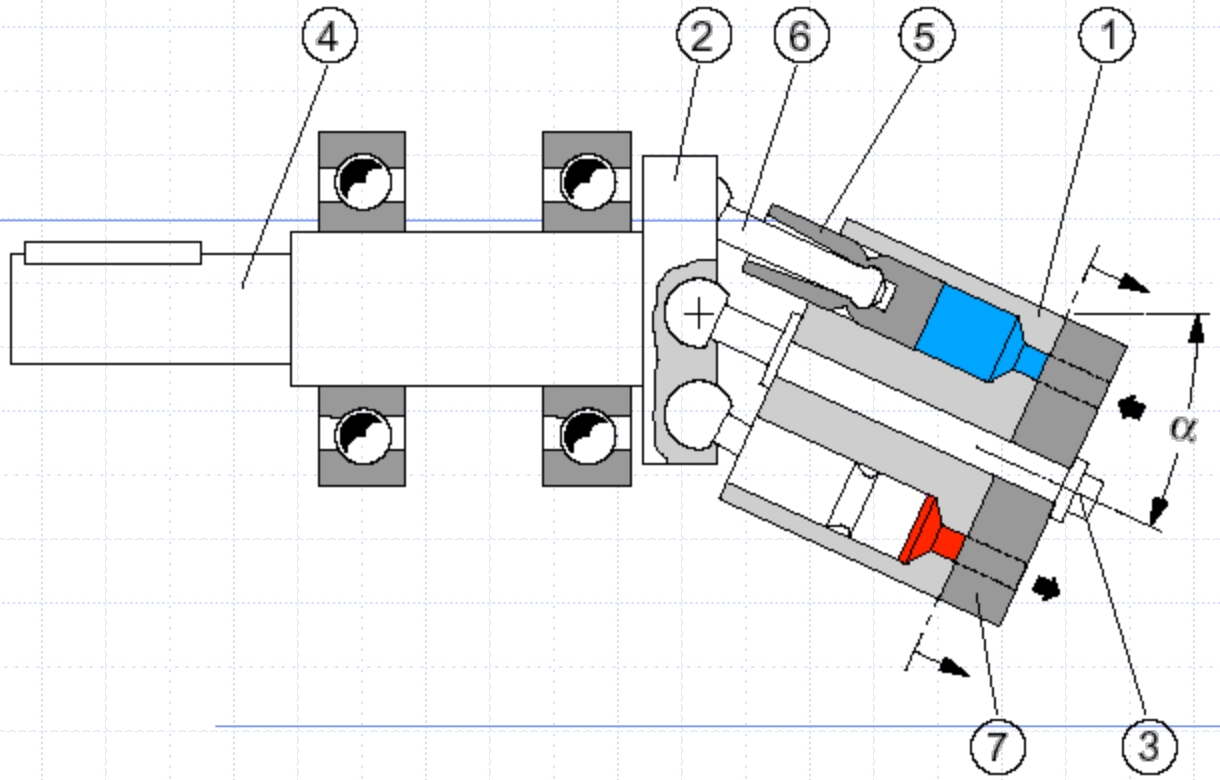
Schrägscheibenpumpe II

- ✓ Geräuscharm
- ✓ Lange Lebensdauer
- ✓ Verwendung:
  - ✓ Hydrostatische Antriebe
  - ✓ Verstellpumpen Traktorhydraulik

Schrägscheibenpumpe III

- ✓ Druck bis 400 bar
- ✓ Wirkungsgrad bis 90%
- ✓ Drehzahl bis 2500 1/min
- ✓ Volumenstrom bis 500 l/min

Schrägachspumpe I



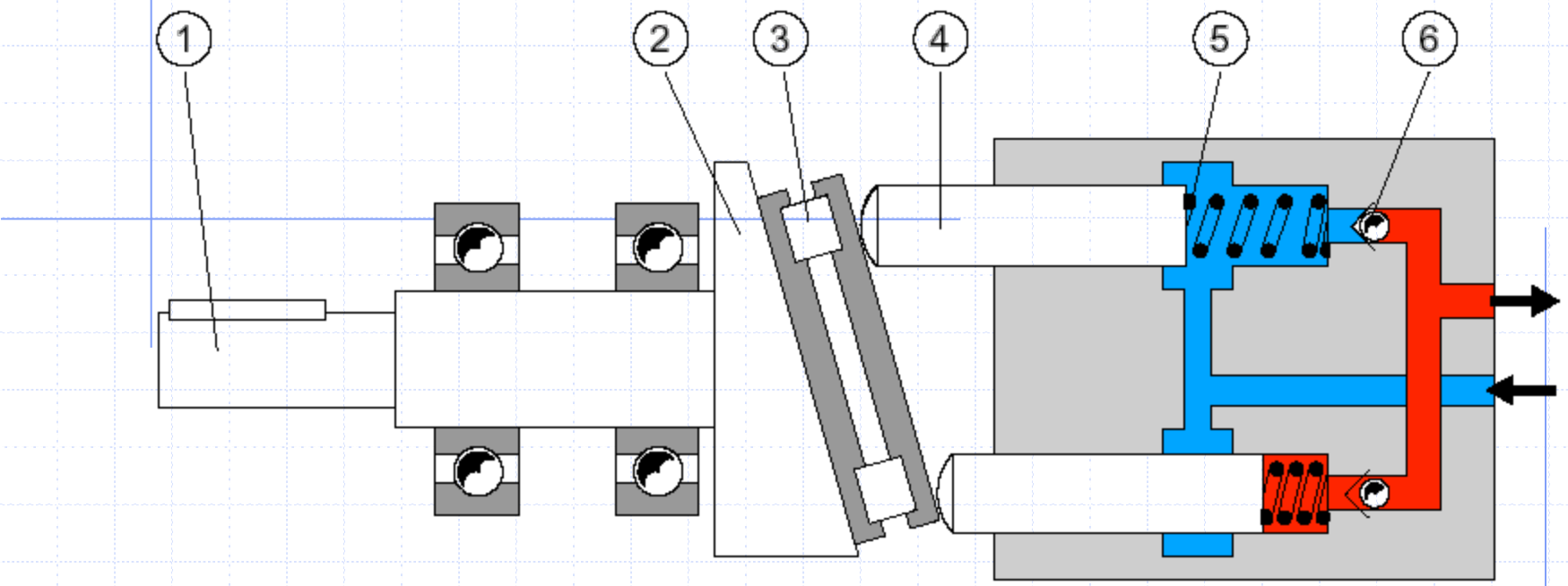
Schrägachspumpe II

- ✓ Geräuscharm
- ✓ Lange Lebensdauer
- ✓ Verwendung:
  - ✓ Hydrostatische Antriebe

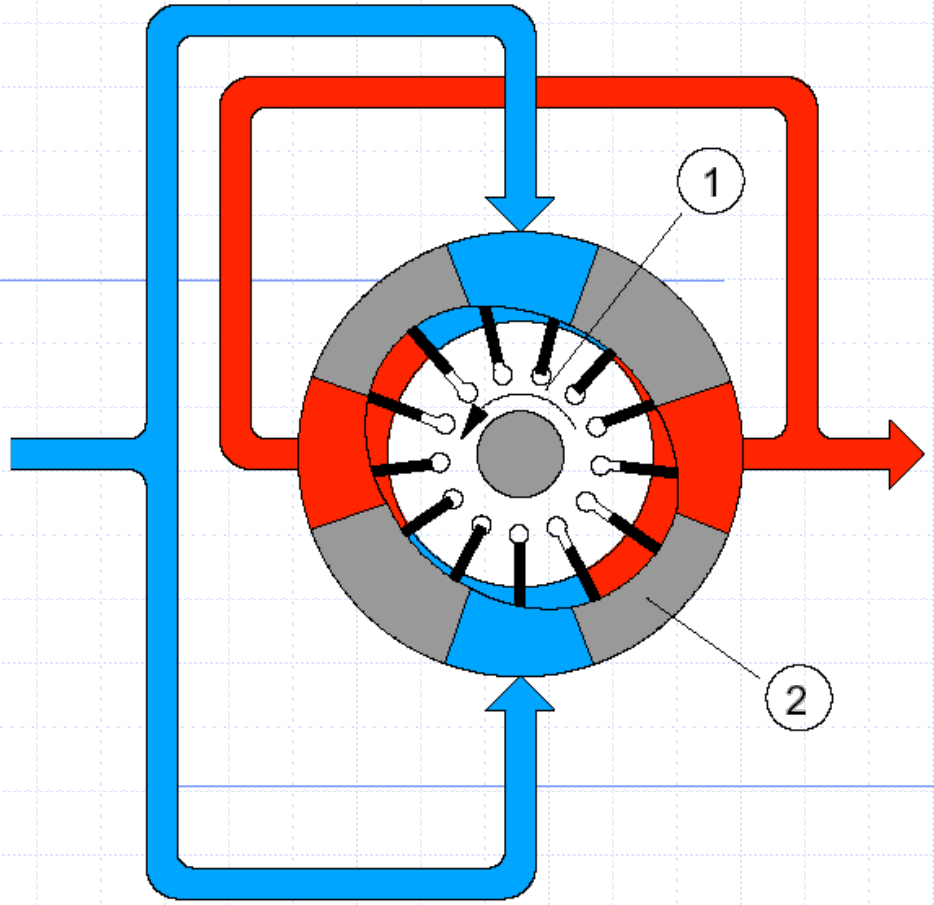
Schrägachspumpe III

- ✓ Druck bis 400 bar
- ✓ Wirkungsgrad bis 90%
- ✓ Drehzahl bis 3400 1/min
- ✓ Volumenstrom bis 300 l/min

Taumelscheibenpumpe



Ausgeglichene Flügelzellenpumpe I



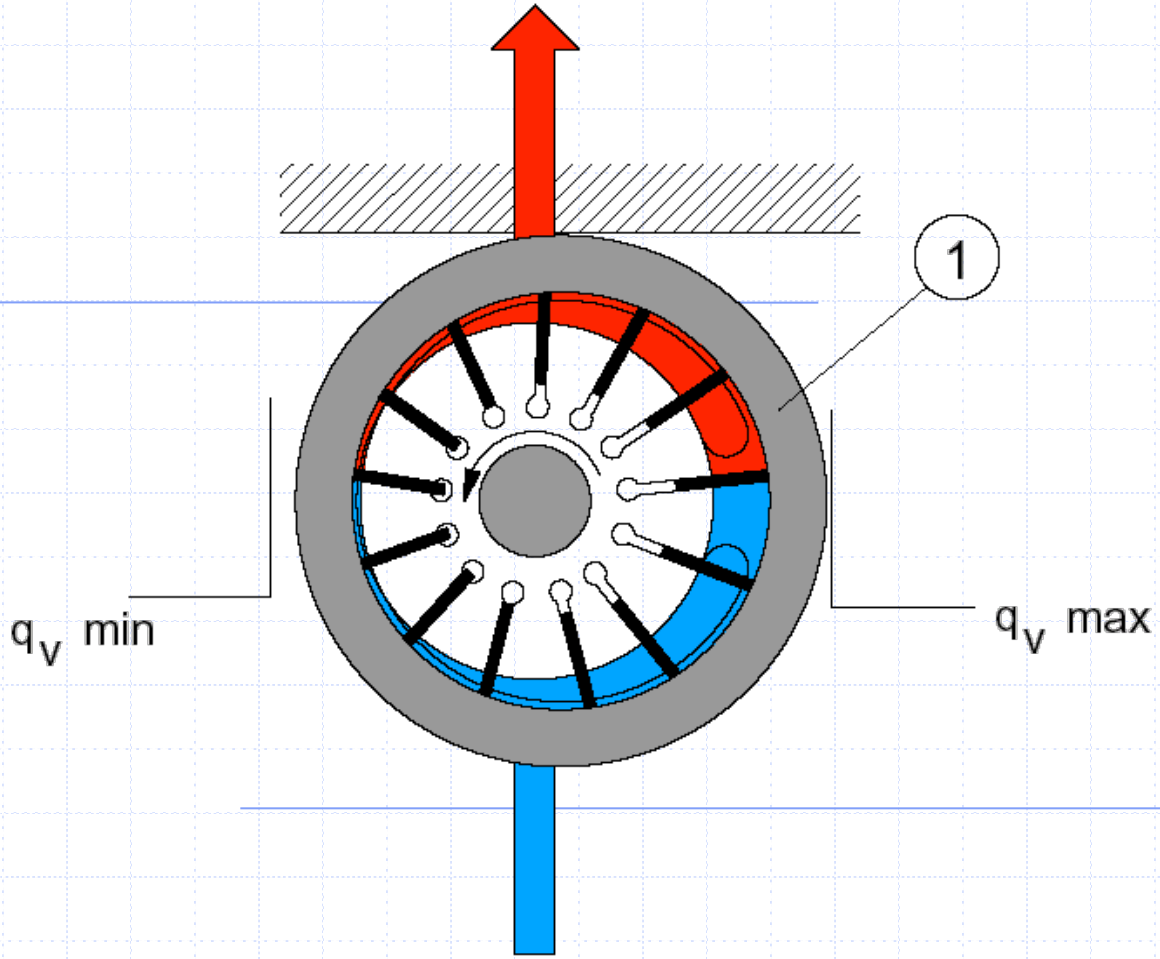
Ausgeglichene Flügelzellenpumpe II

- ✓ Geräuscharm
- ✓ Konstantes Fördervolumen
- ✓ Hohe Lagerlebensdauer durch hydraulische Entlastung
- ✓ Geringer Verschleiss

Ausgeglichene Flügelzellenpumpe III

- ✓ Druck bis 210 bar
- ✓ Wirkungsgrad bis 90%
- ✓ Drehzahl bis 2700 1/min
- ✓ Volumenstrom bis 280 l/min

Unausgeglichene Flügelzellenpumpe I



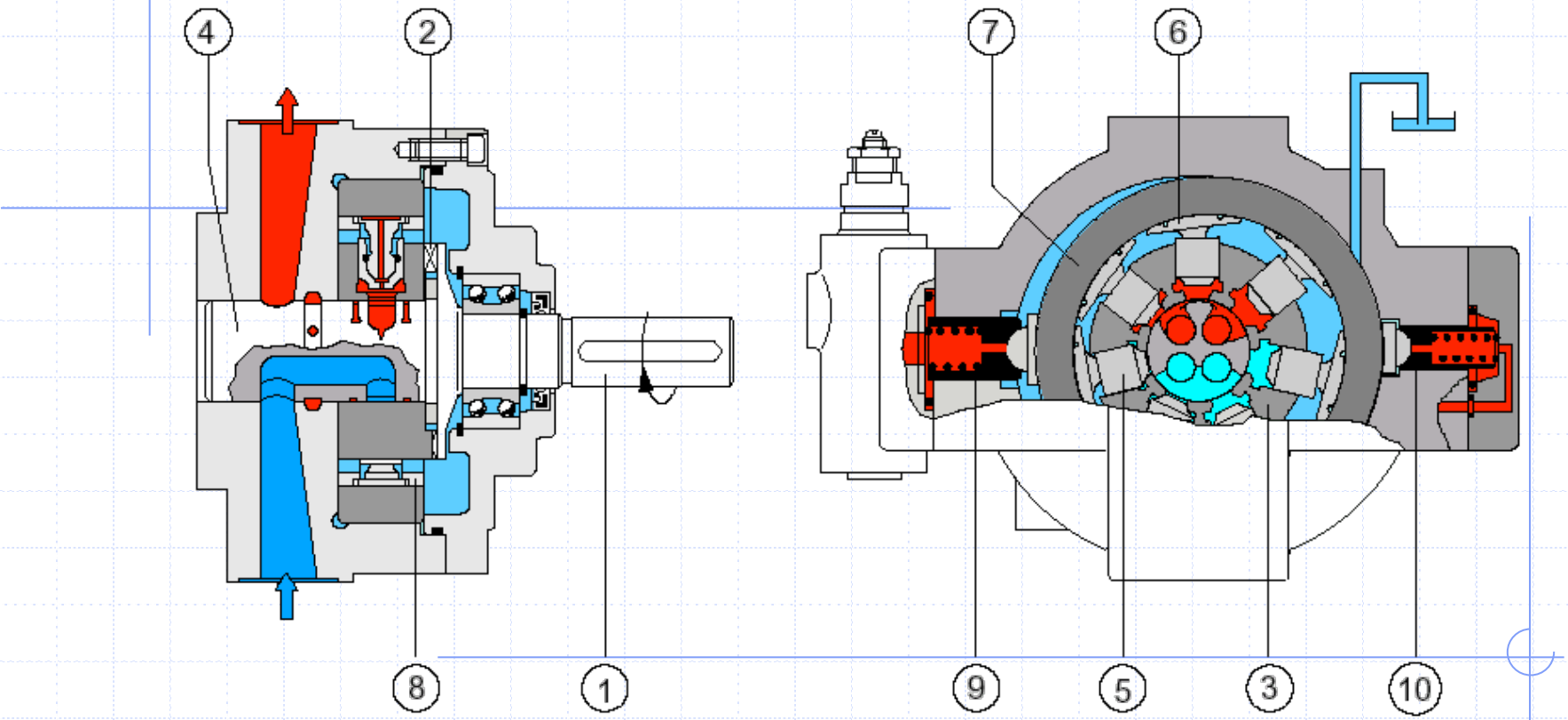
Unausgeglichene Flügelzellenpumpe II

- ✓ Kleiner Einbauraum
- ✓ Verstellbares Fördervolumen
- ✓ Geräuscharm
- ✓ Geringer Verschleiss

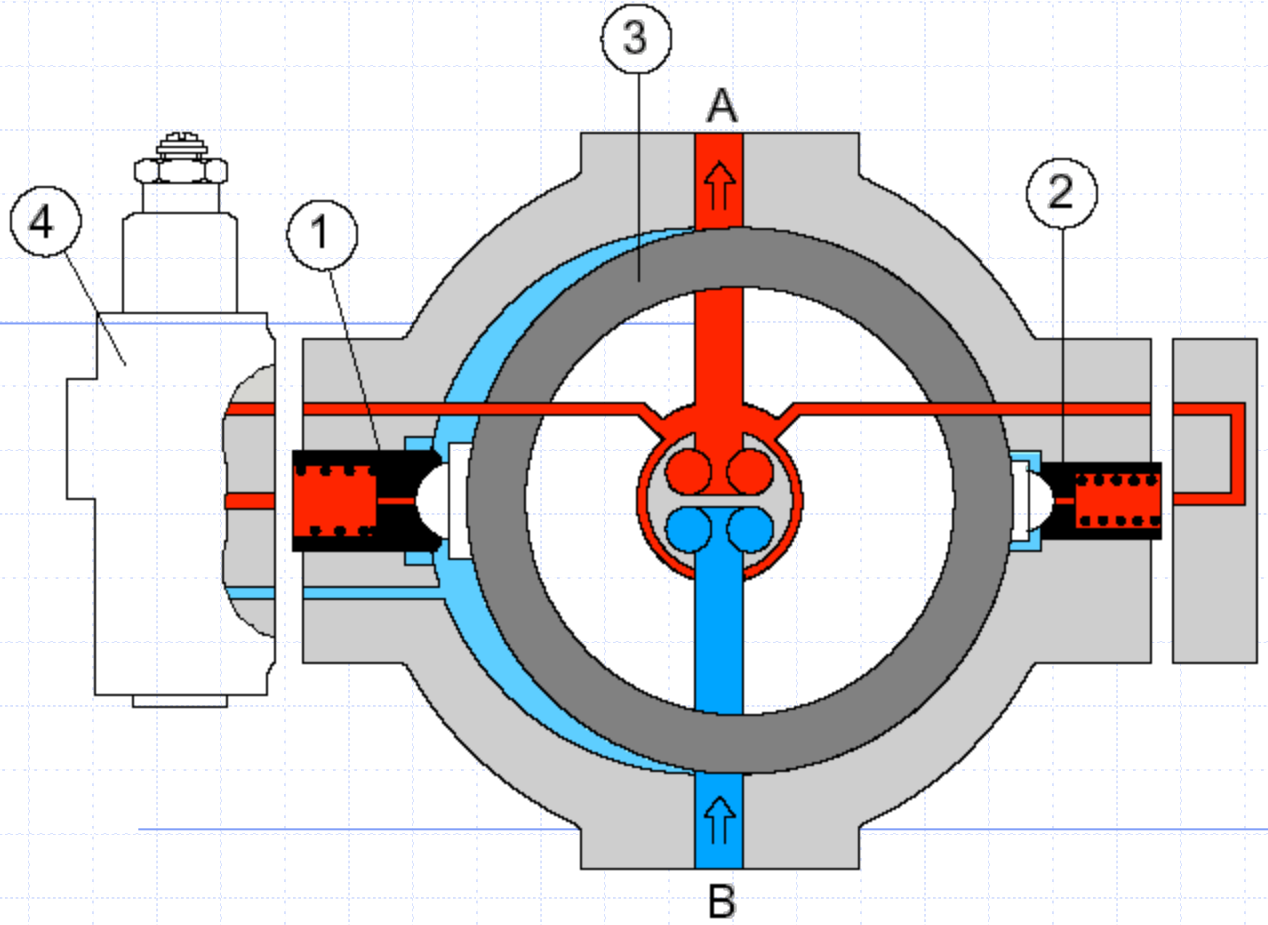
Unausgeglichene Flügelzellenpumpe III

- ✓ Druck bis 150 bar
- ✓ Wirkungsgrad bis 90%
- ✓ Drehzahl bis 2000 1/min
- ✓ Volumenstrom bis 200 l/min

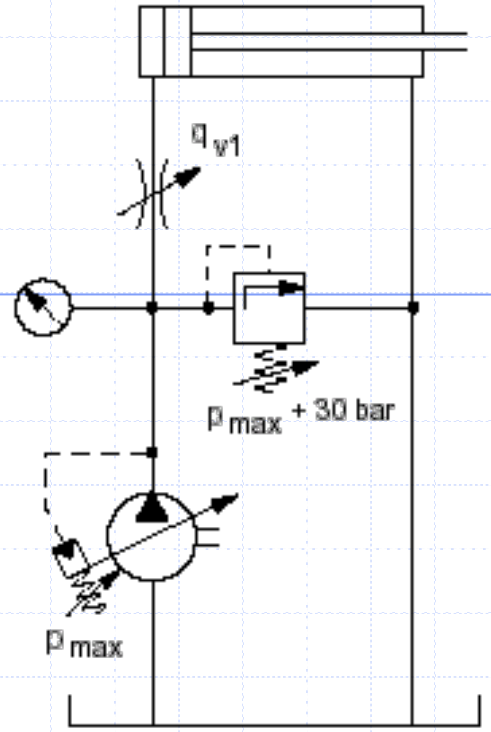
Radialkolbenpumpe I

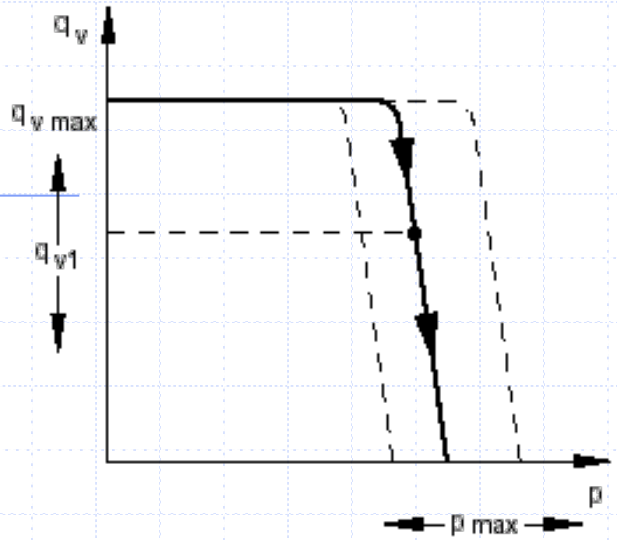


Radialkolbenpumpe II



Radialkolbenpumpe III

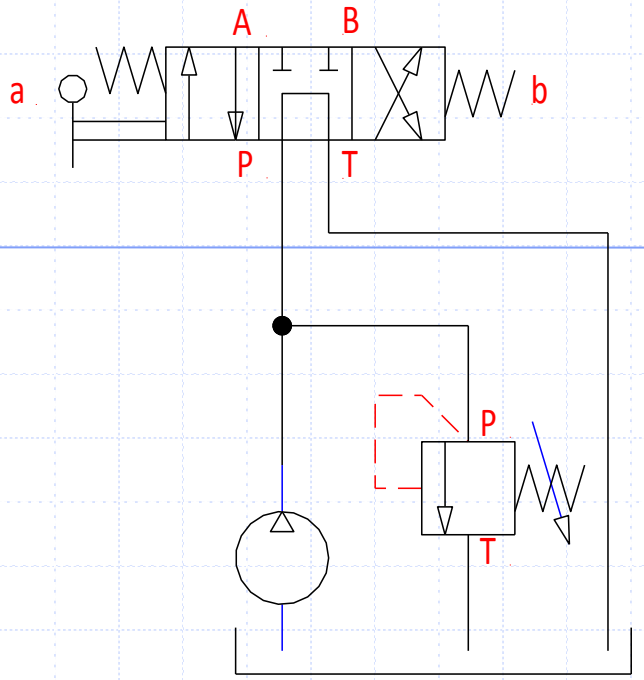




Radialkolbenpumpe IV

- ✓ Druck bis 700 bar
- ✓ Wirkungsgrad bis 90%
- ✓ Drehzahl bis 2000 1/min
- ✓ Volumenstrom bis 200 l/min

Open Center


A
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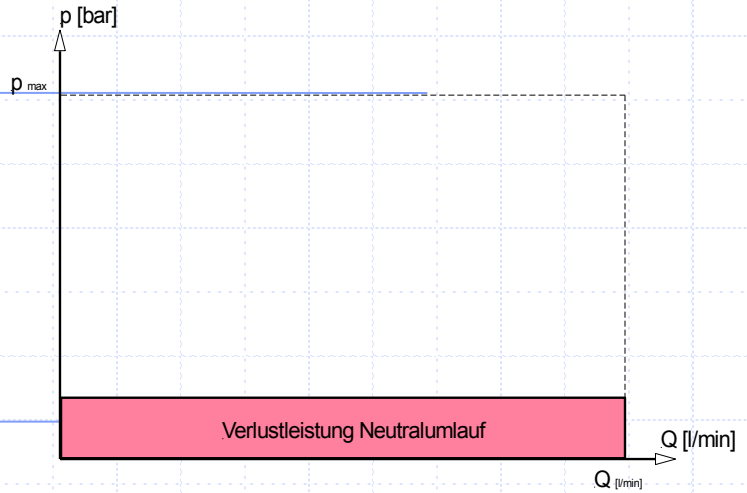
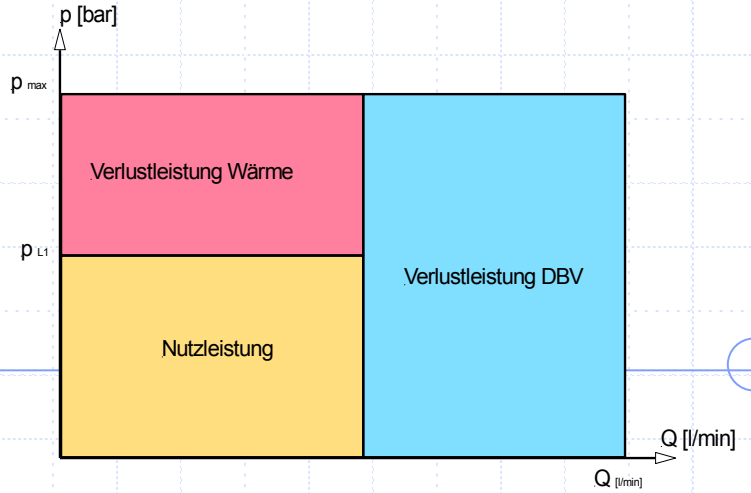
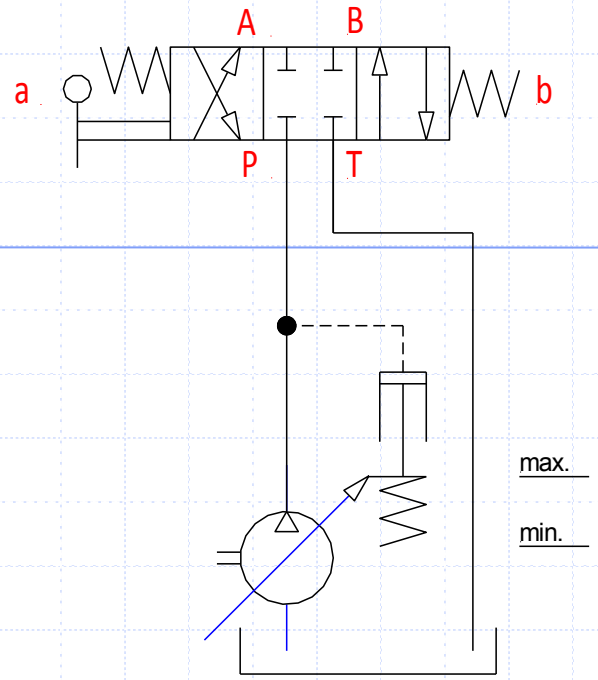
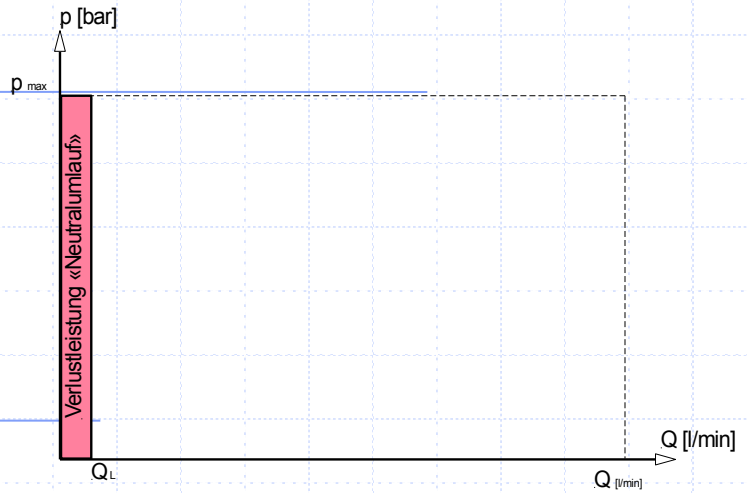
P
T

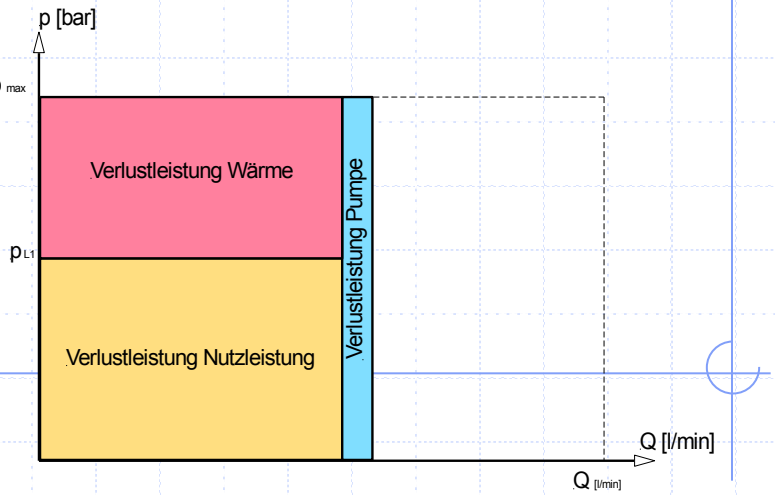

p [bar]
p max
Verlustleistung Neutralumlauf
Q [l/min]
Q [l/min]


p [bar]
p max
Verlustleistung Wärme
p L1
Verlustleistung DBV
Nutzleistung
Q [l/min]
Q [l/min]

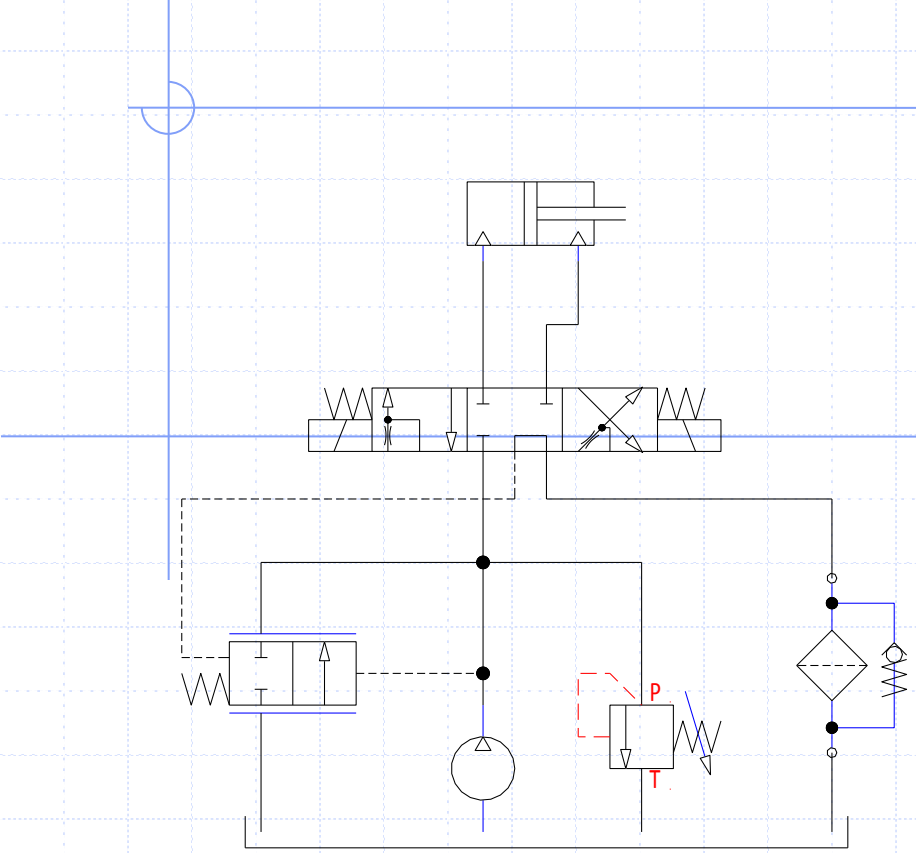
Closed Center

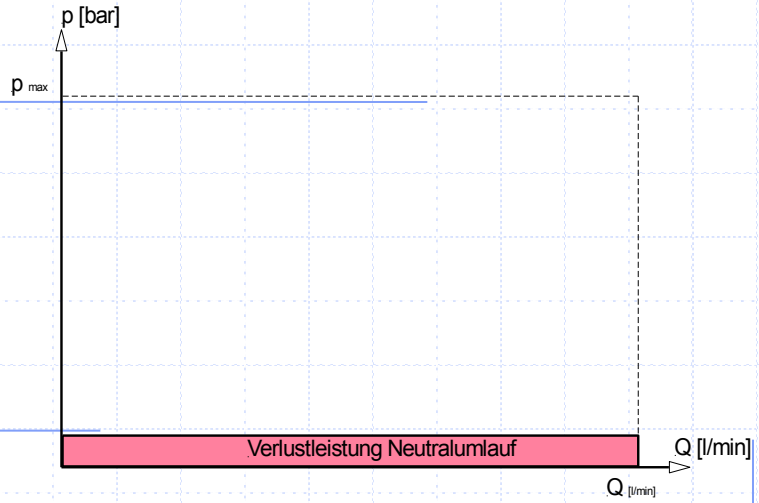


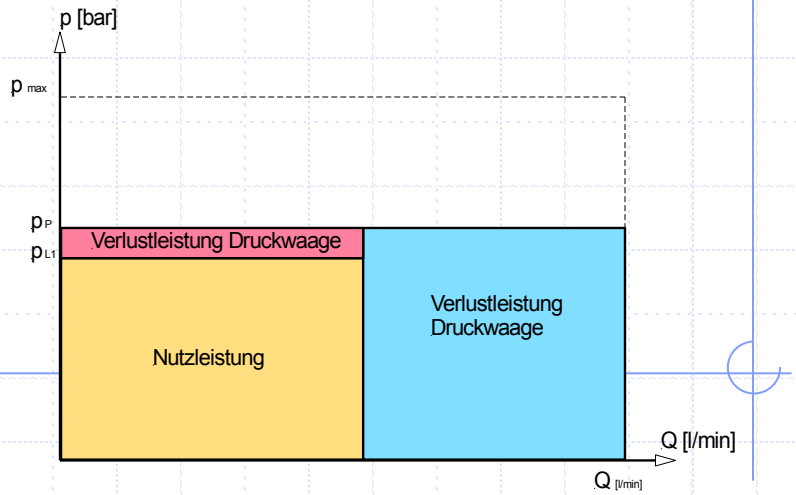




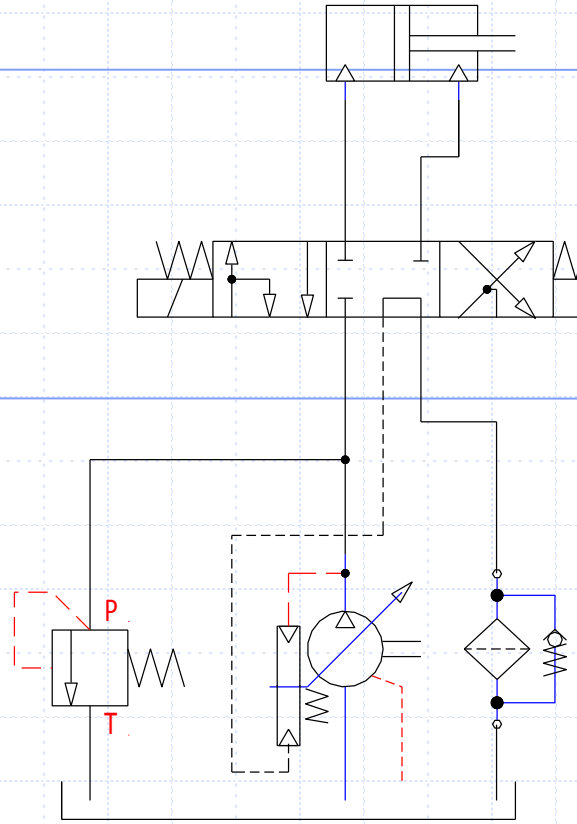
Open Center Load Sensing

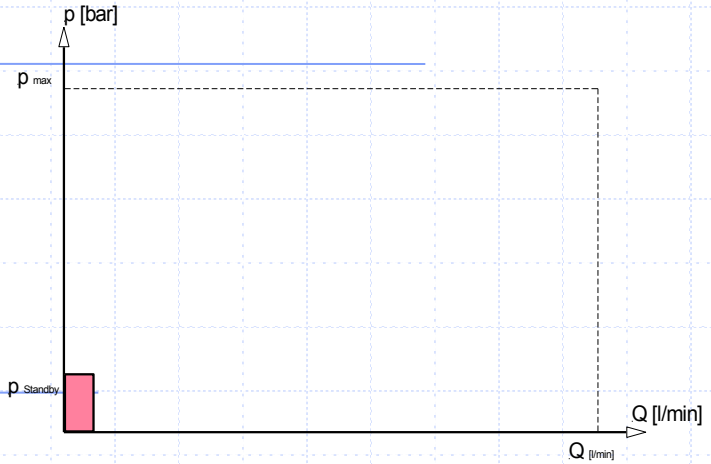


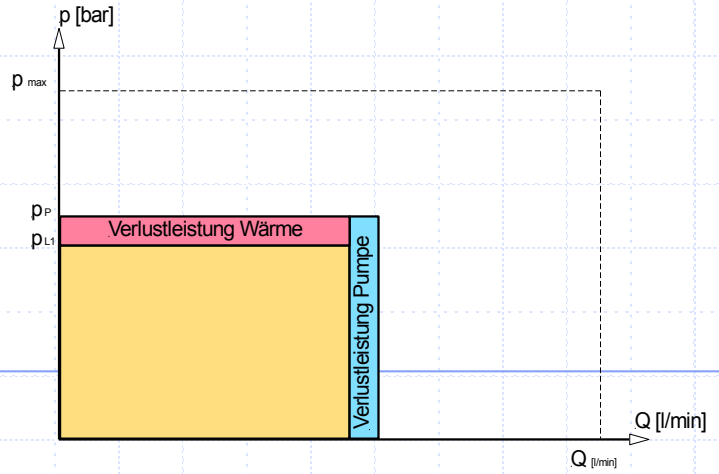




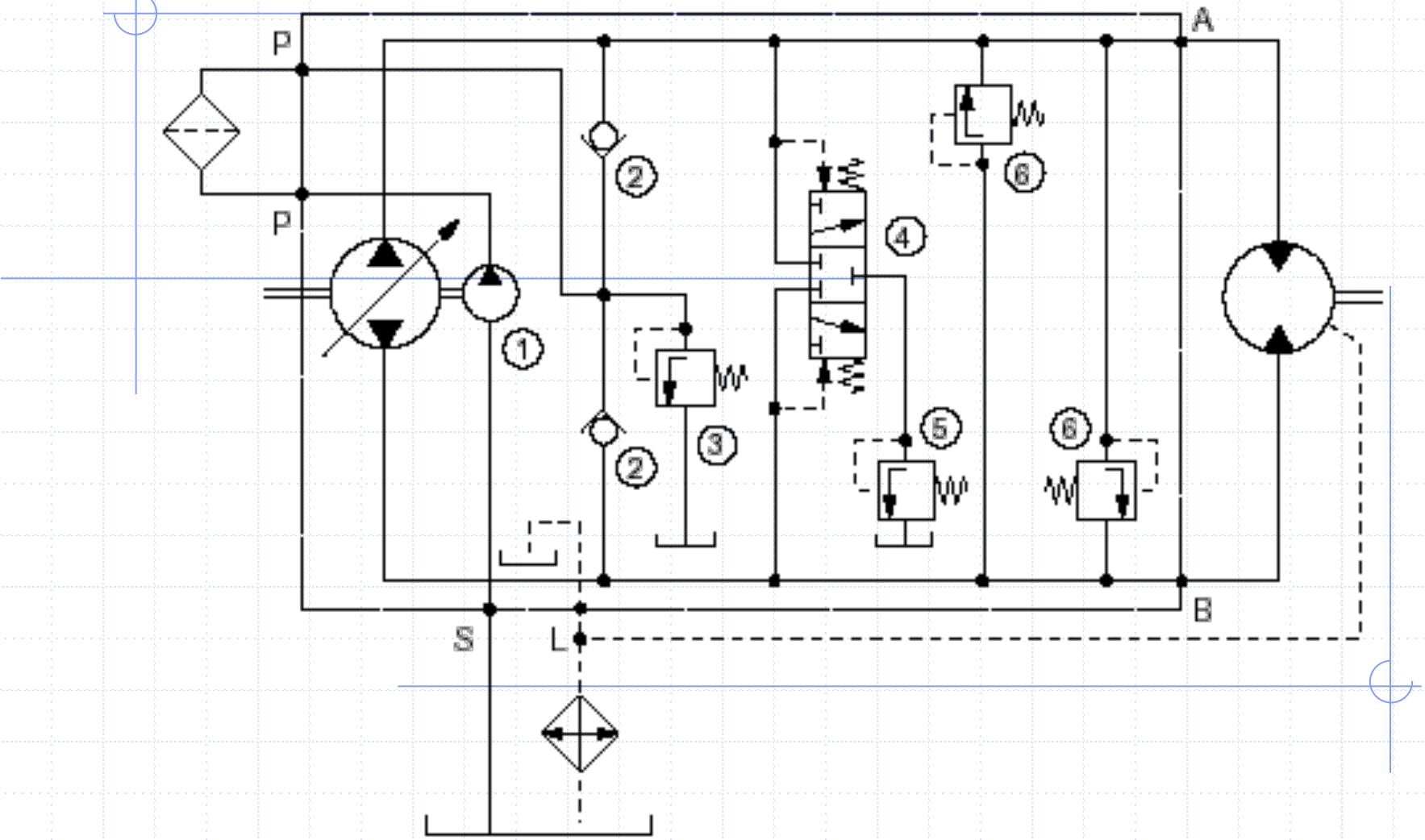
Closed Center Load Sensing



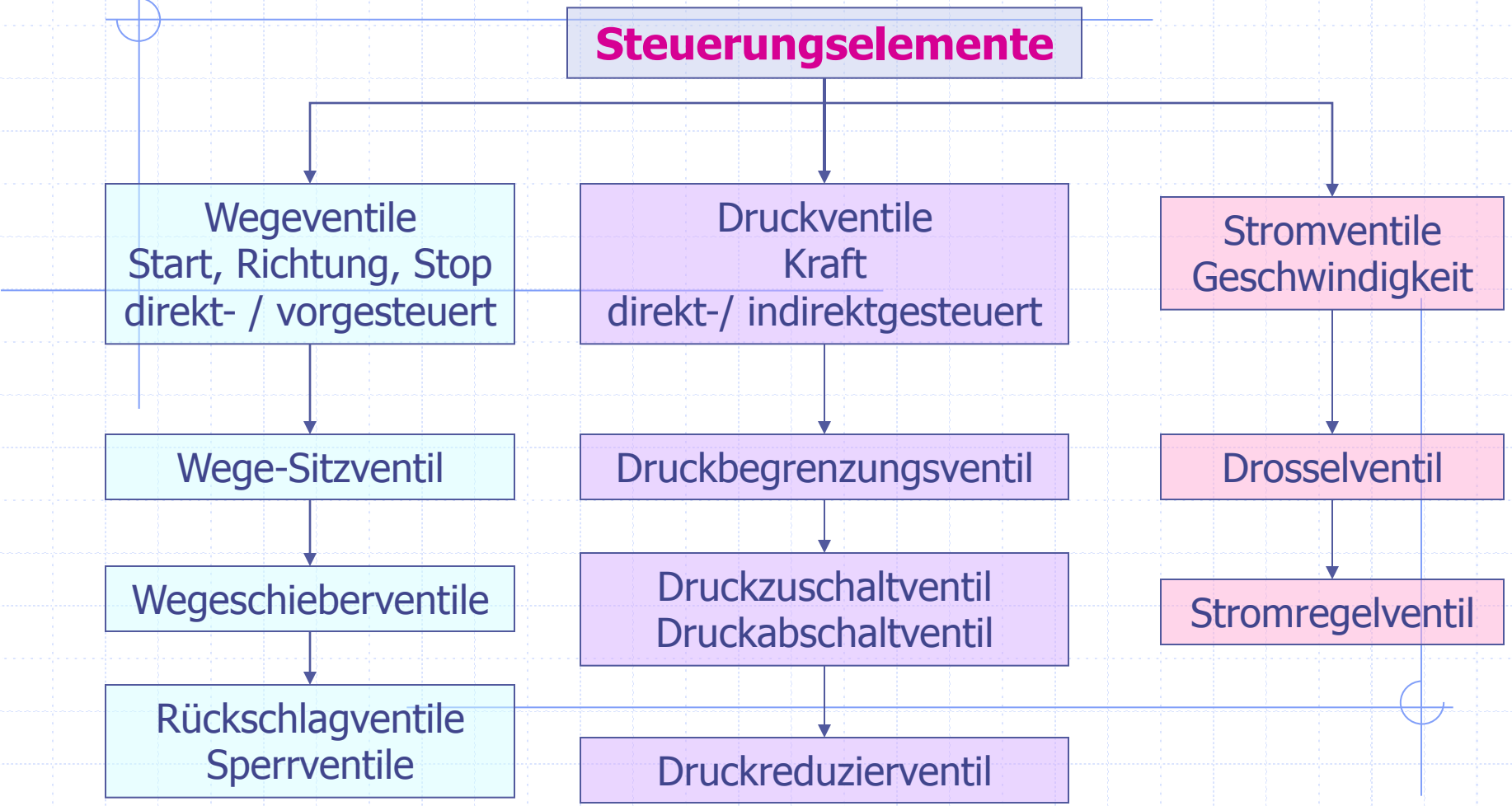




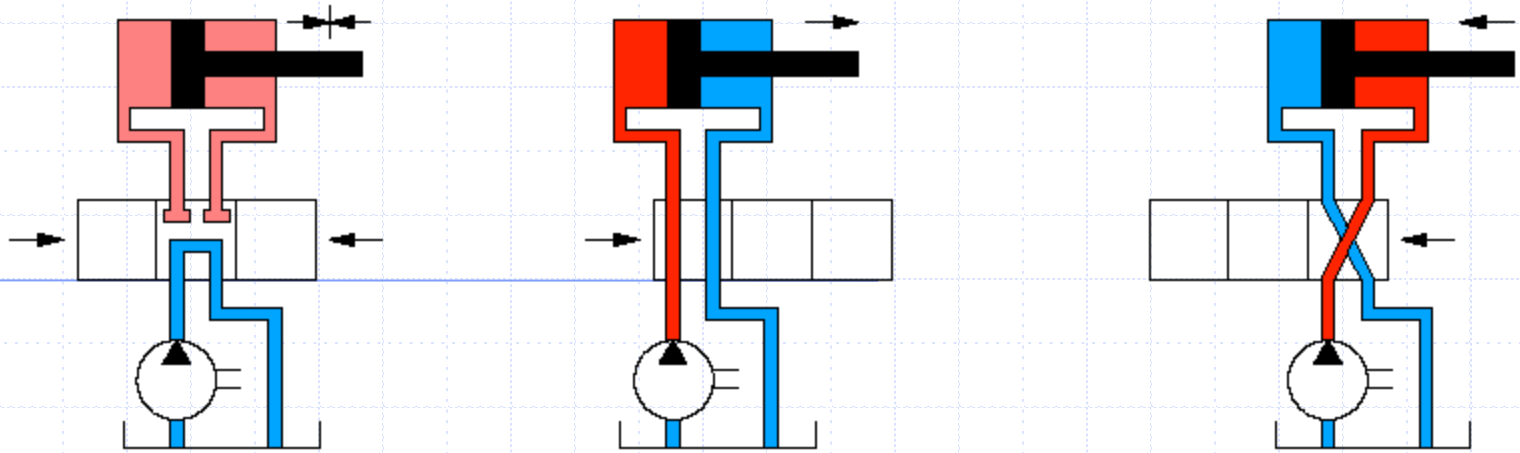
Hydrostatischer Antrieb



Steuerungselemente



Wegeventile



- ✓ Leitungen verbinden
- ✓ Leitungen absperren
- ✓ Ölströme umleiten

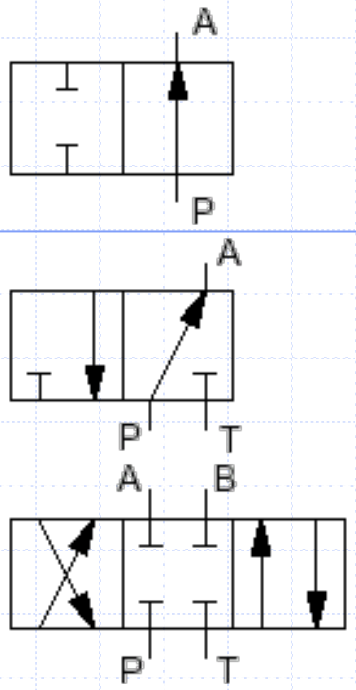
Benennung Sinnbilder

4 / 3 Wegeventil

Anzahl Schaltstellungen

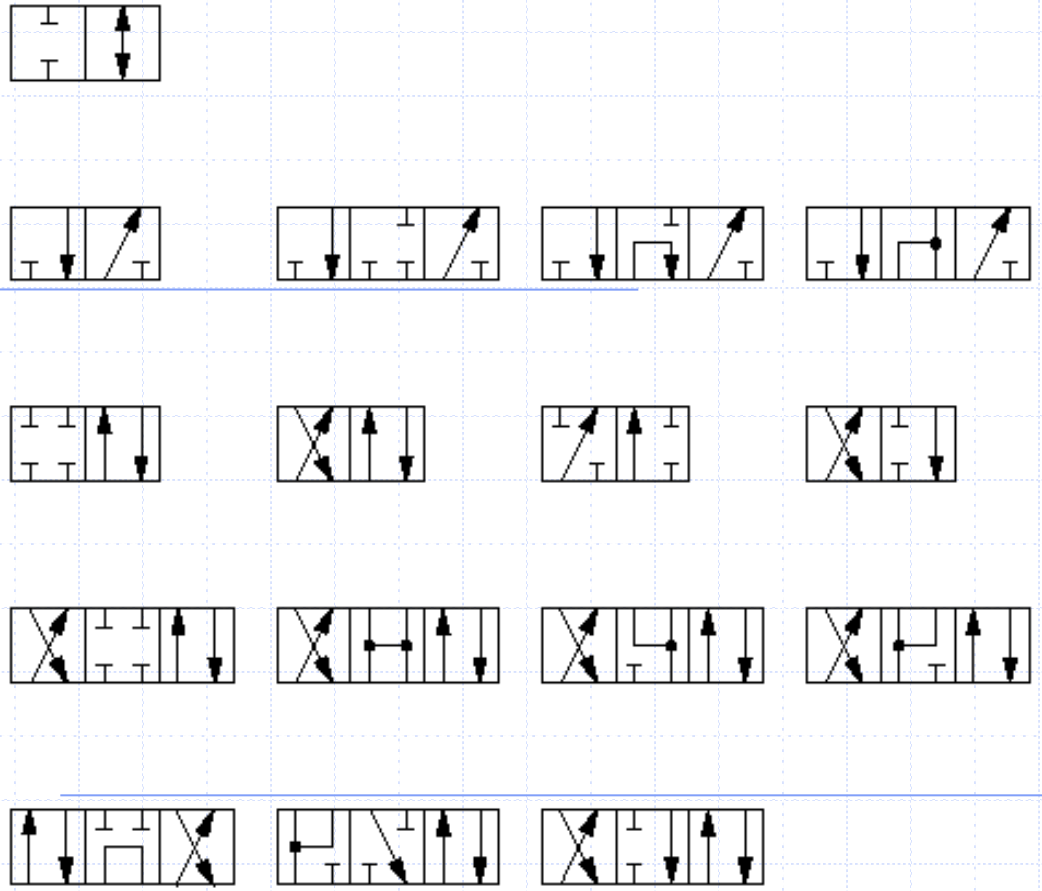
Anzahl Anschlüsse

Anschlussbezeichnungen

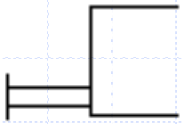


P	Druckanschluss
T	Tankanschluss
A, B	Arbeitsanschlüsse
L	Leckölanschluss
N	Neutralumlauf
x, y	Steueranschlüsse

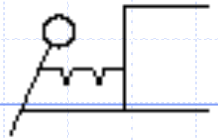
Durchfluss Sinnbilder



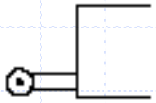
Ventilbetätigung I



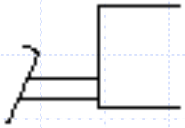
Manuelle allgemein



Handhebel mit Rastung

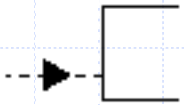


Tastrolle

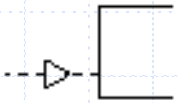


Fusspedal

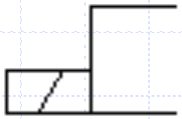
Ventilbetätigung II



Hydraulisch direkt



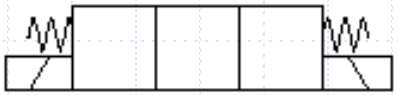
Pneumatisch direkt



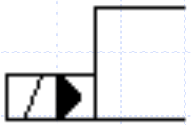
Elektromagnetisch

Ventilbetätigung III

Federrückstellung

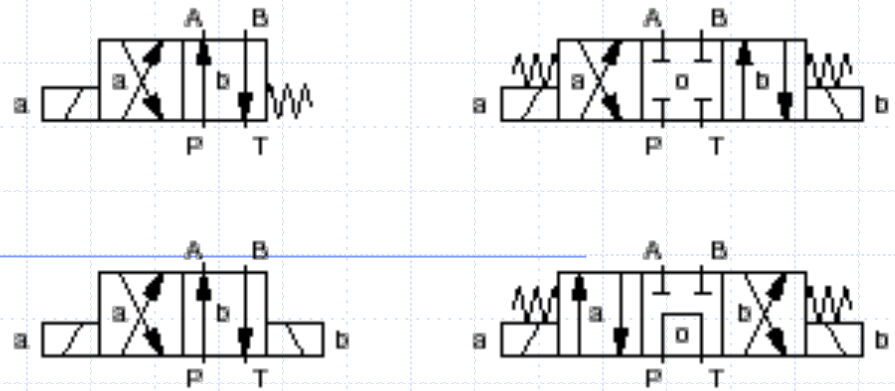


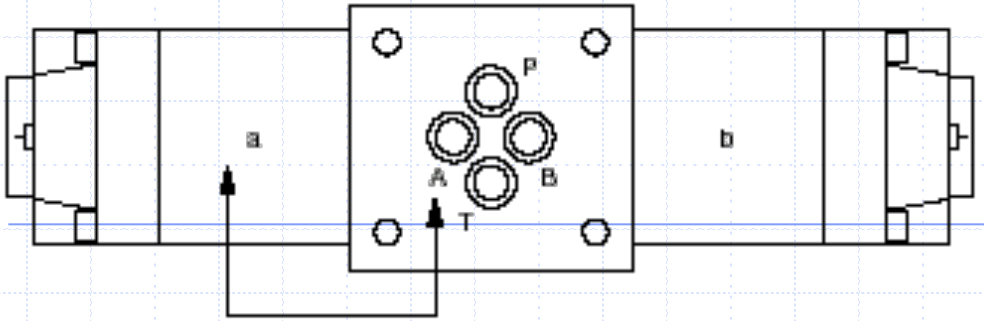
Federzentrierung



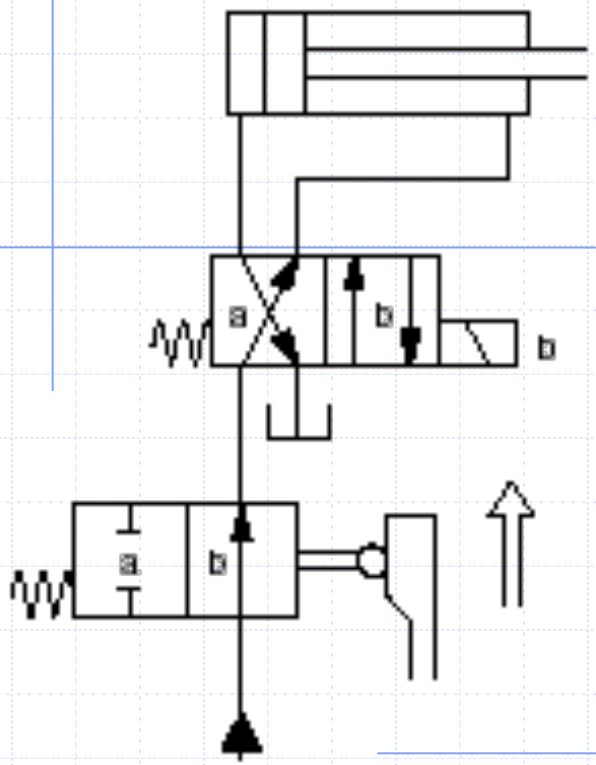
Elektro-hydraulisch vor-gesteuert

Bezeichnung Schaltstellungen I





Bezeichnung Schaltstellungen II



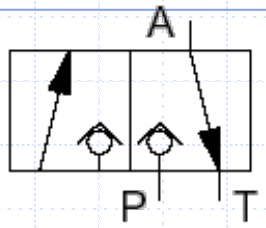
Regel:

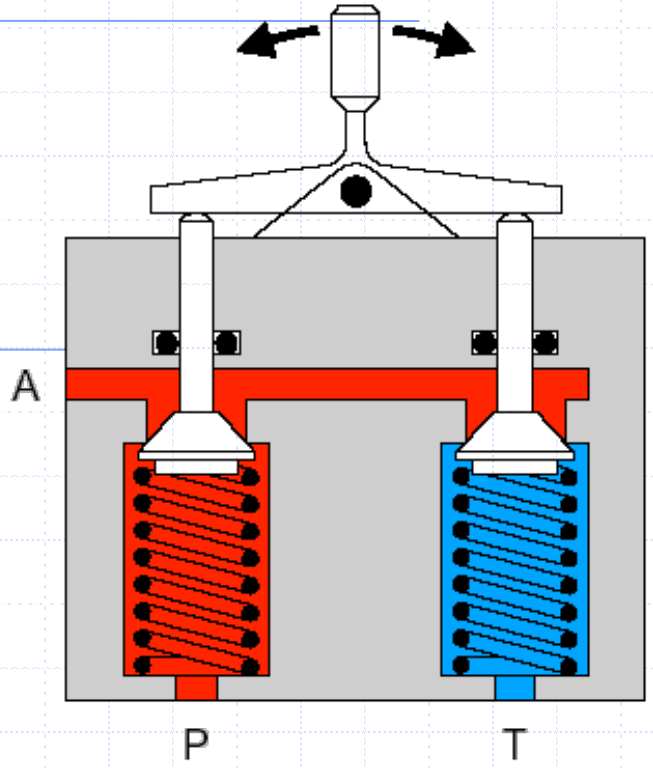
- Ventil nicht betätigt gezeichnet

Ausnahme:

- Ventil betätigt gezeichnet bei Folgesteuerung

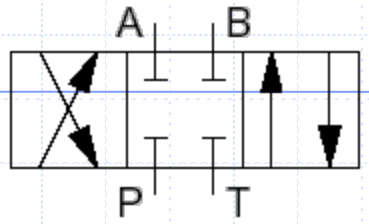
Sperrventile

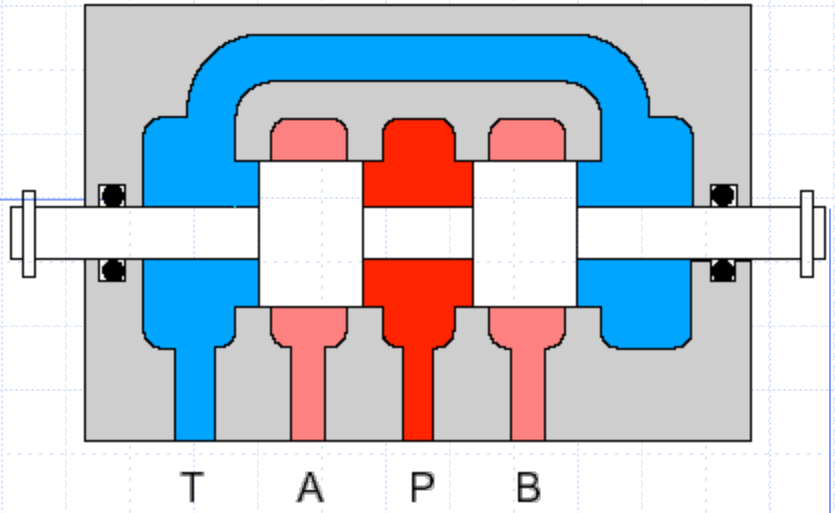




- Sitzventile
  - Kugel
  - Kegel
  - Teller
- Absolut dicht
- Keine Leckagen

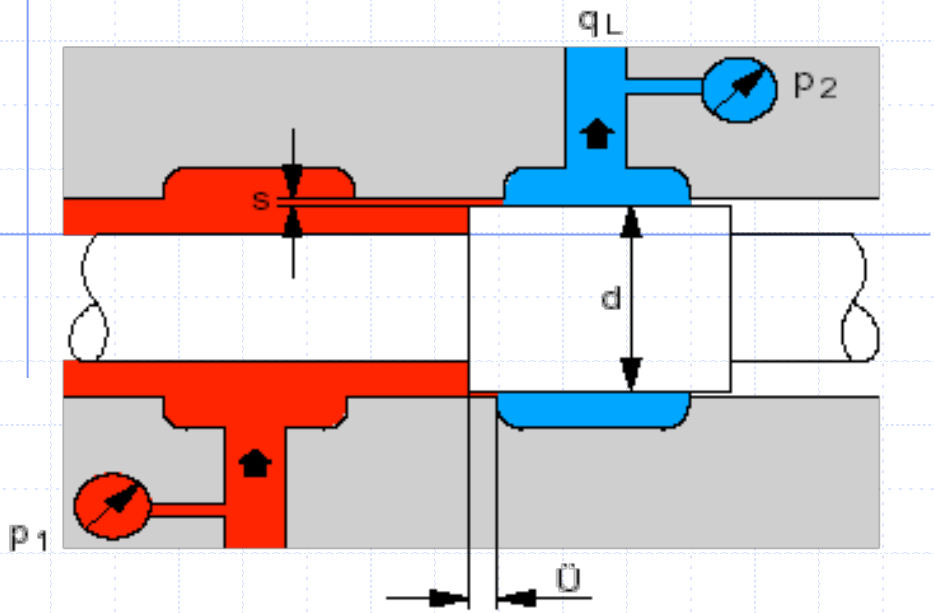
Schieberventile





- Schaltelement Schieber
- Leckagen
  - Schieberspiel

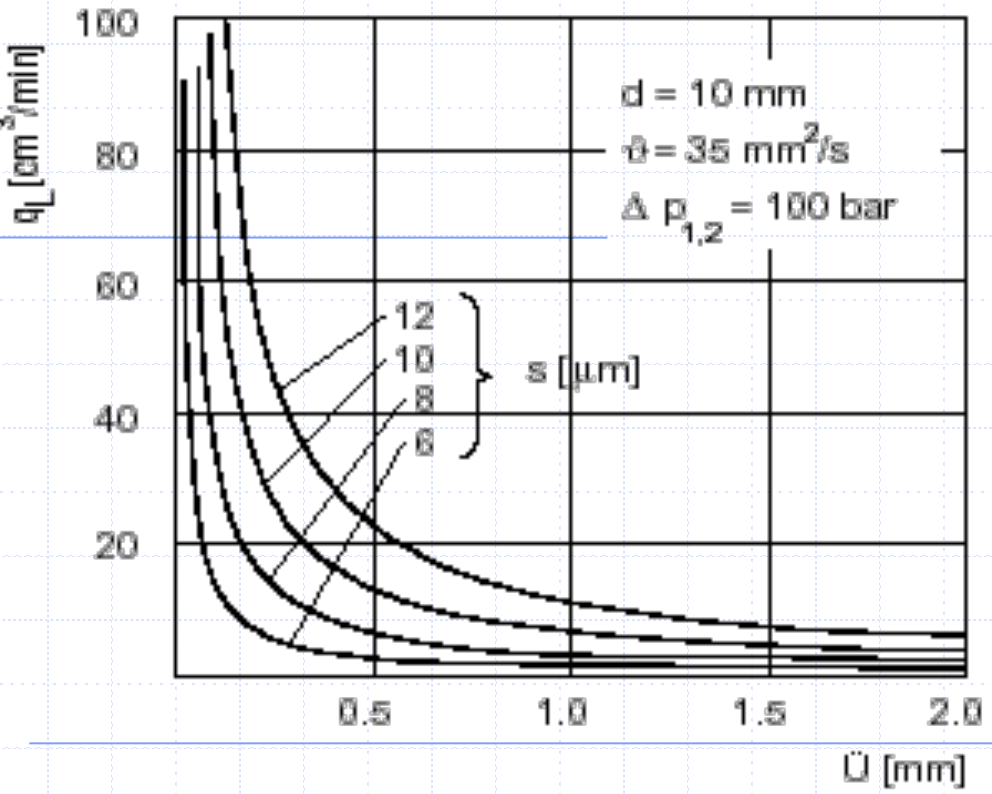
Innere Abdichtung I



Abhängig von:

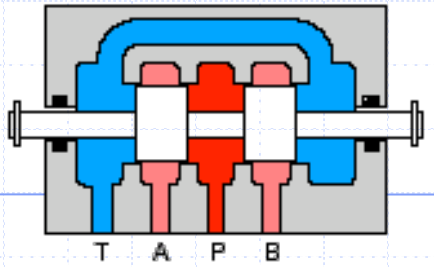
- Schieberspiel
- Überdeckung
- Druck
- Ölviskosität

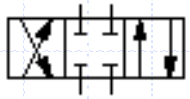
Innere Abdichtung II



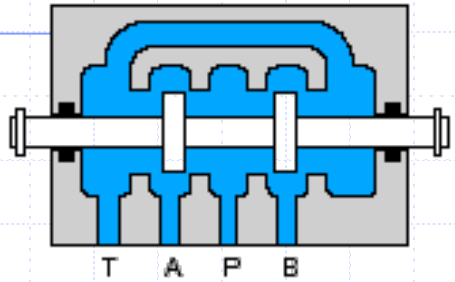
Steuerschieber Sinnbild-Varianten

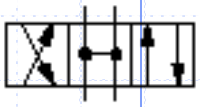
Sperrschaltung



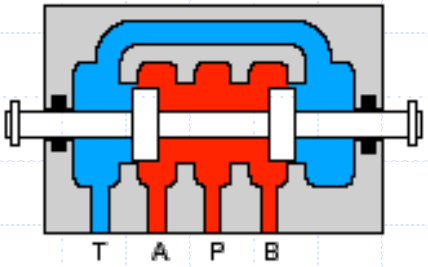


Schwimmstellung

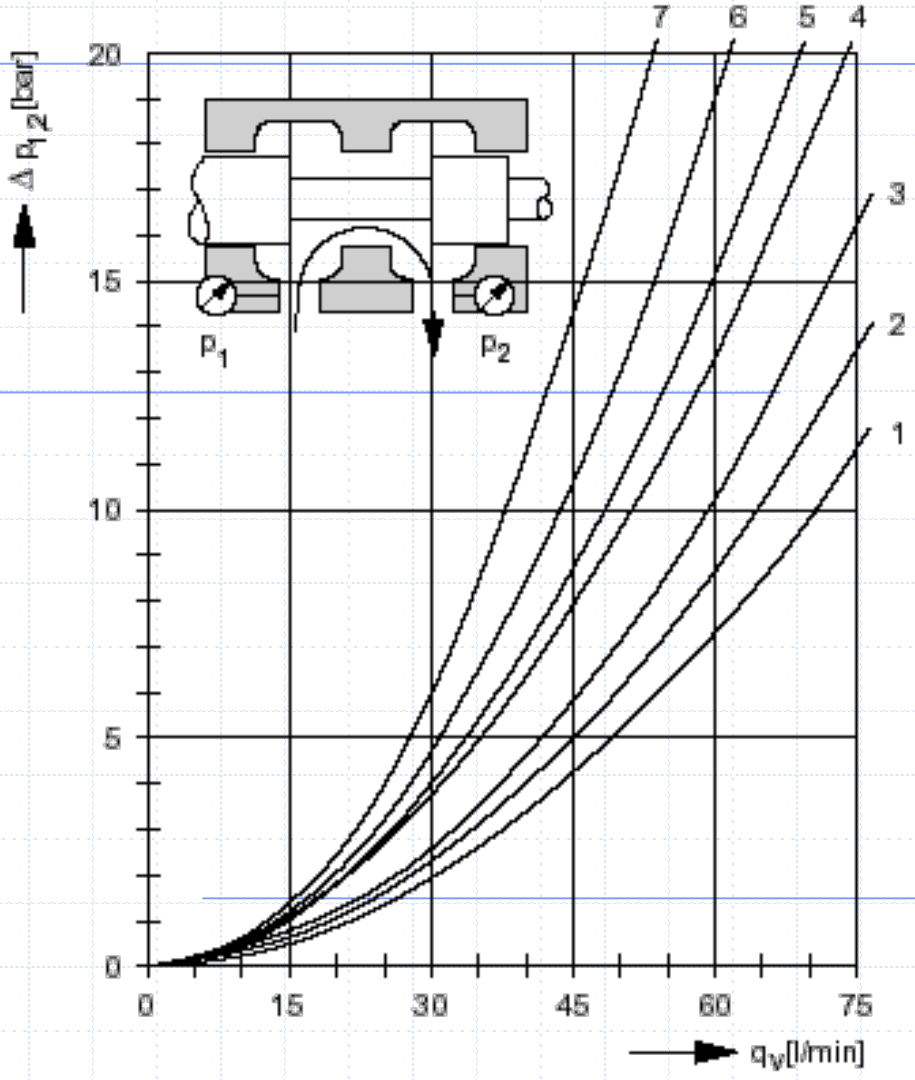




Stuhlschaltung



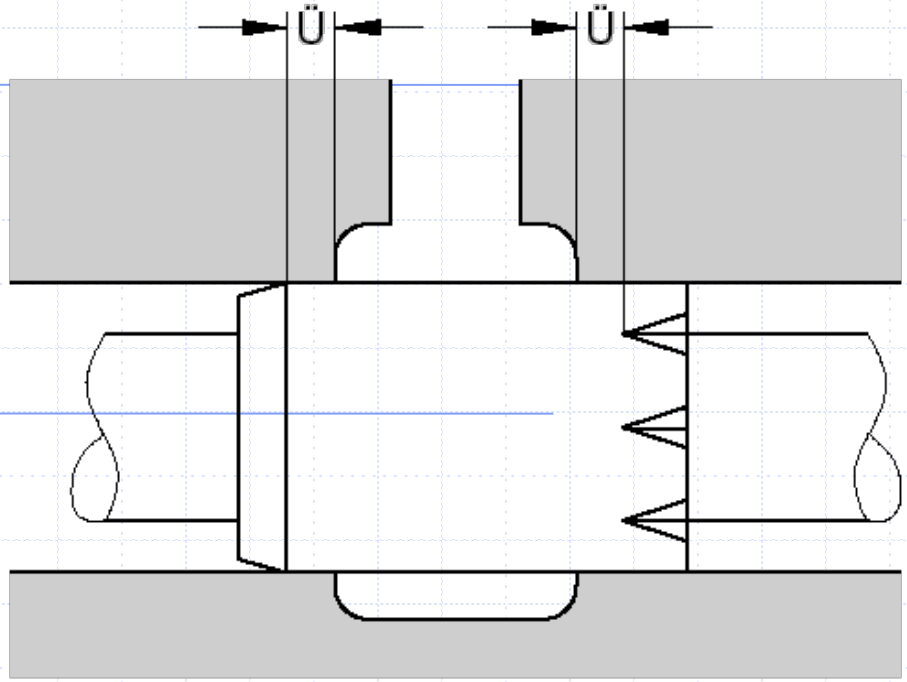
Durchflusswiderstand



Verschiedene Druchflusssinnbilder

Volumenstrom

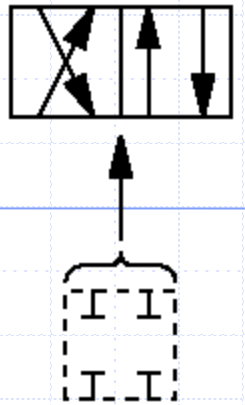
Feinsteuerung



- feinfühlige Steuerung
  - Fase
  - Kerbe

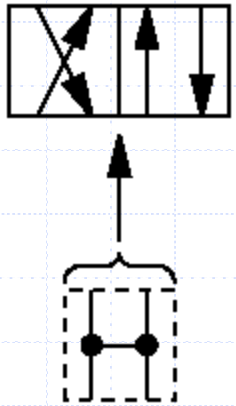
Schaltüberdeckung

Positive



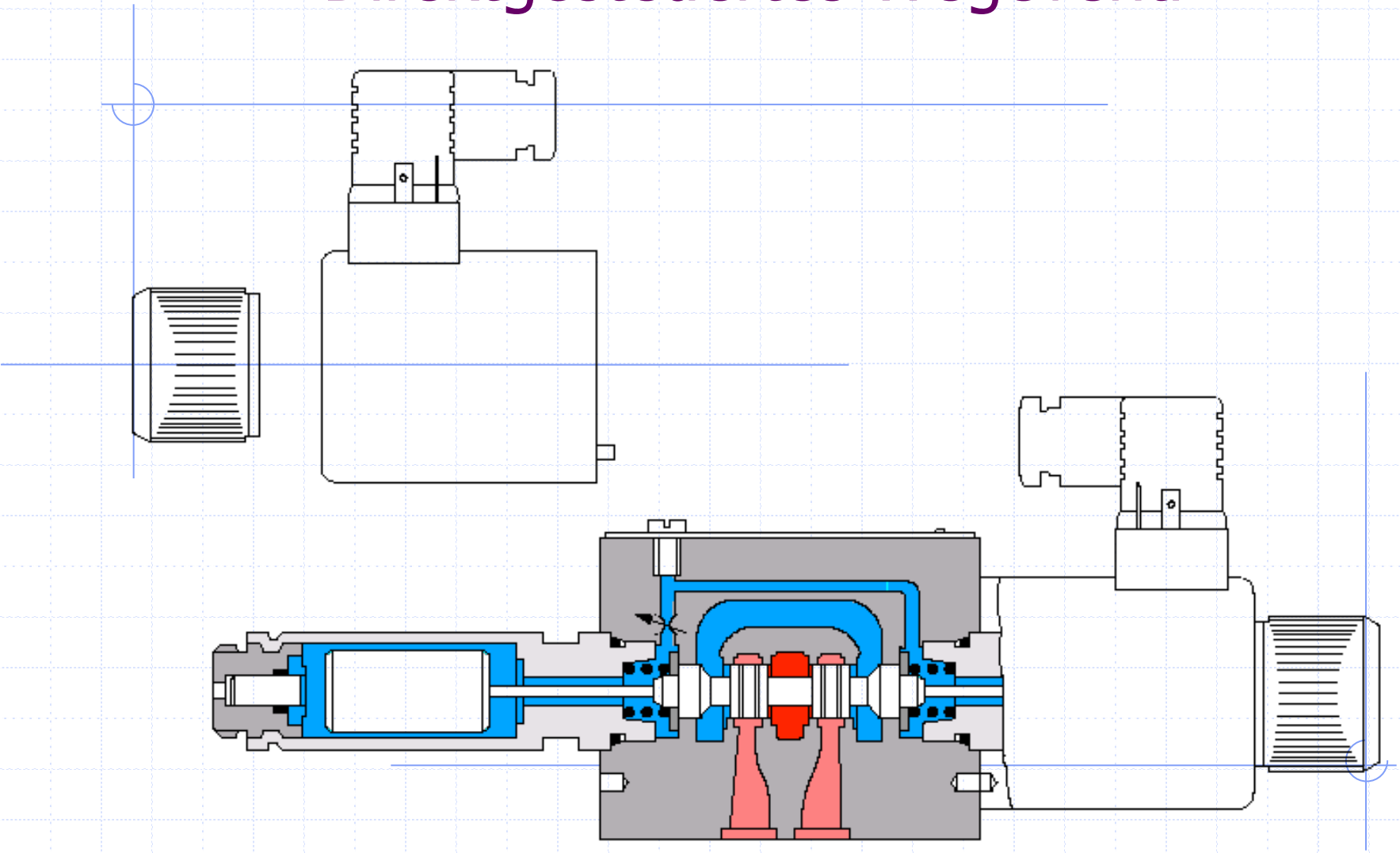
- Anschlüsse abgesperrt
- kein Absinken der Last
- Schaltschläge

Negative

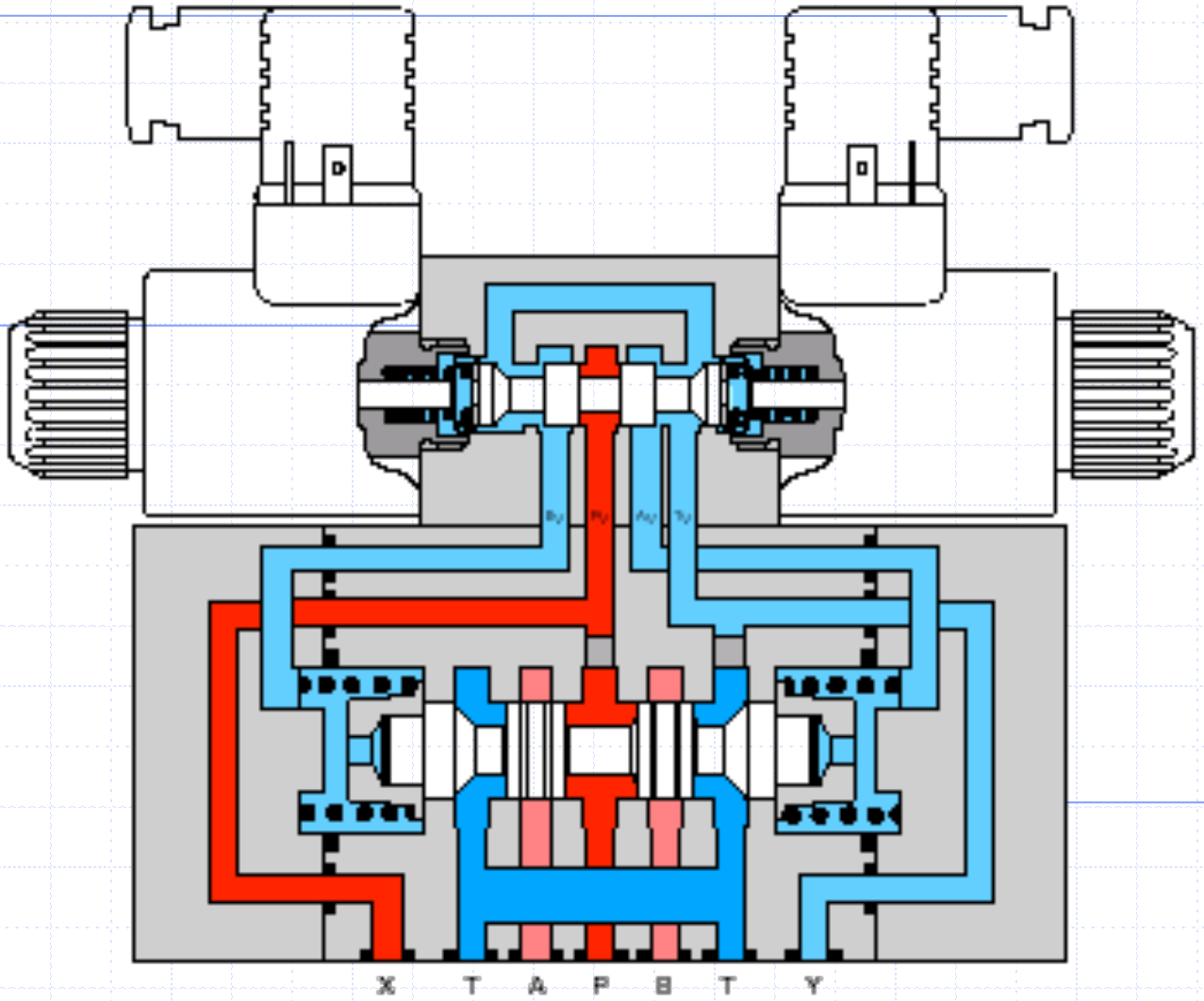


- Anschlüsse verbunden
- keine Schaltschläge
- Absinken der Last

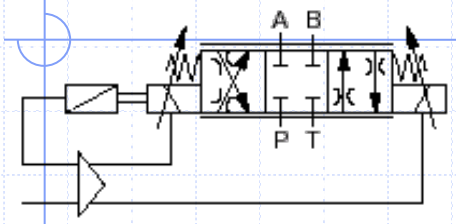
Direktgesteuertes Wegeventil

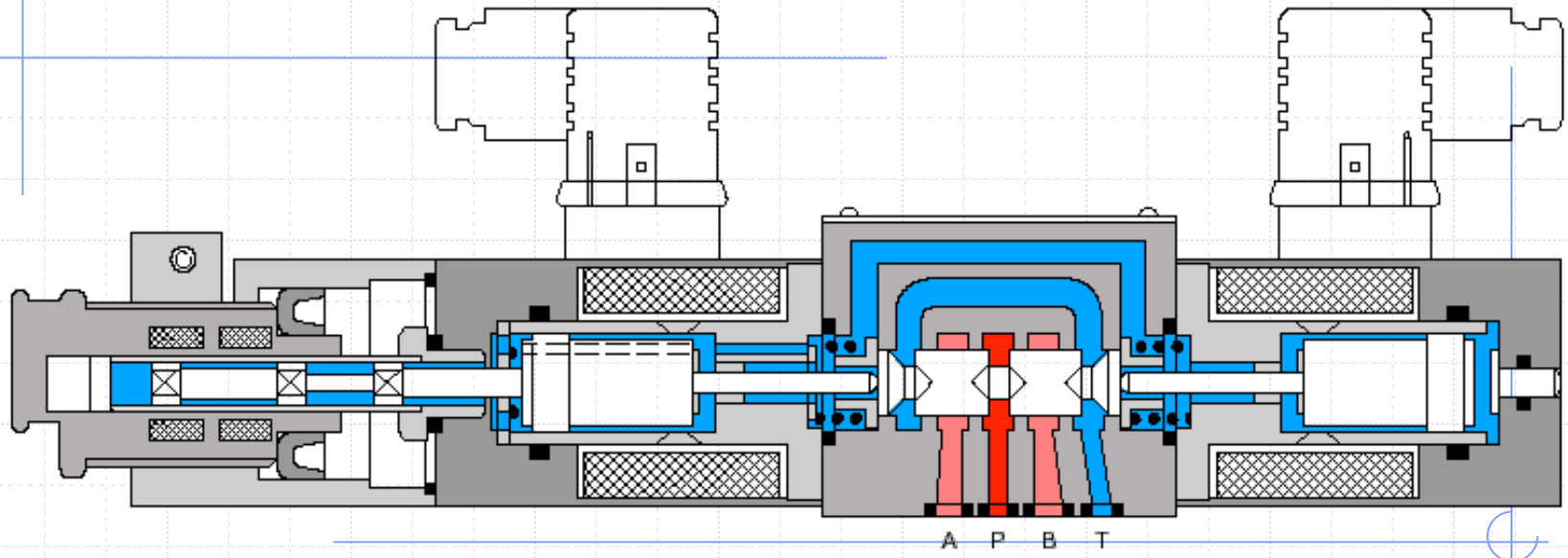


Vorgesteuertes Wegeventil

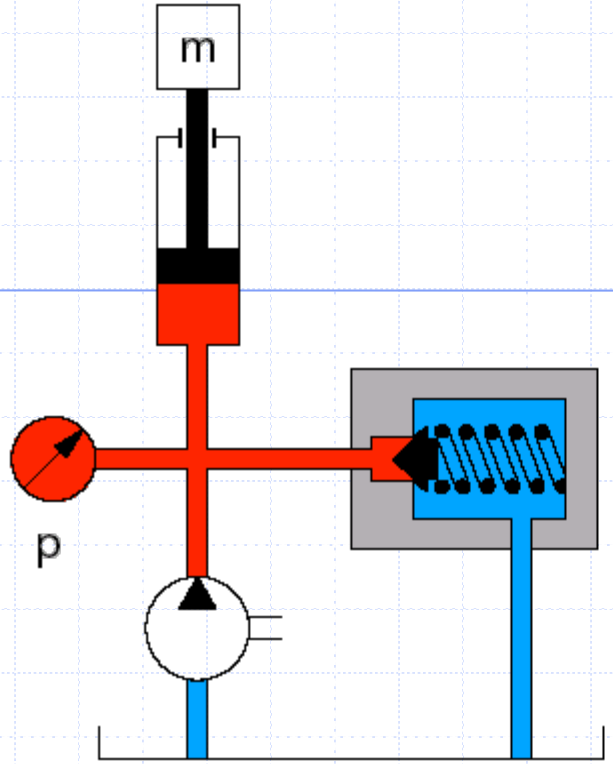


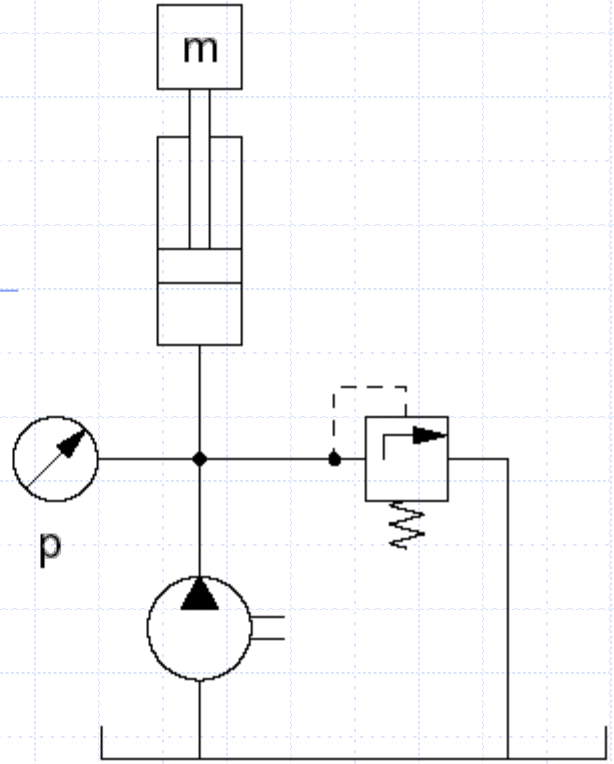
Proportional-Wegeventil





Druckbegrenzungsventil

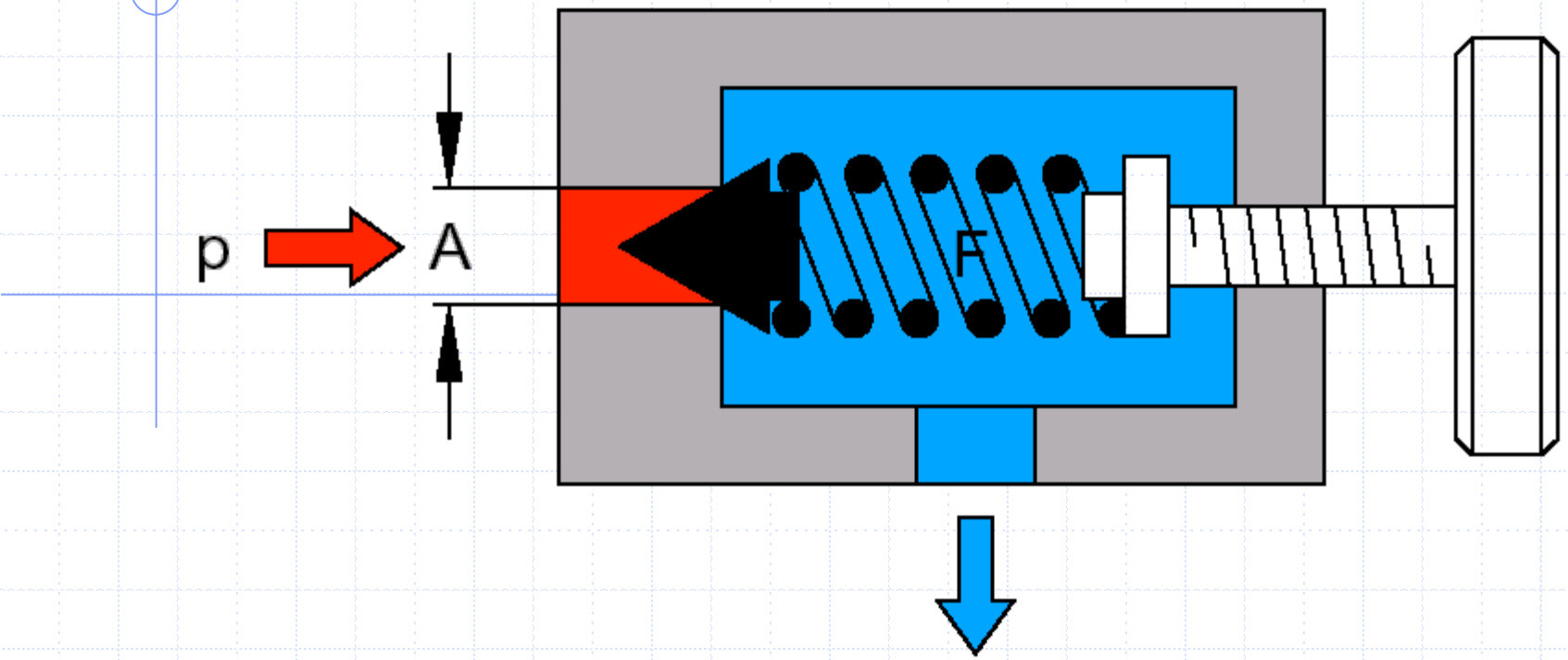




Funktionsdarstellung

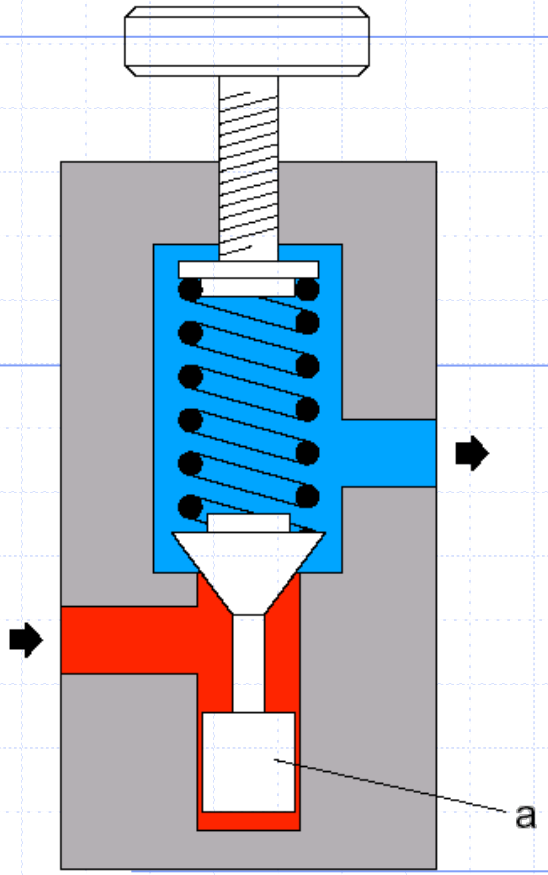
Symboldarstellung

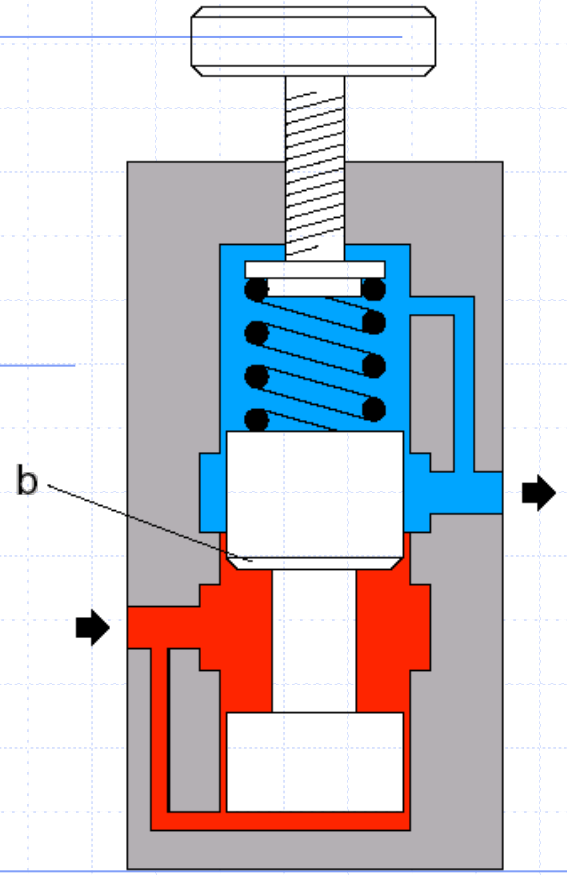
DBV direktgesteuert



- Bei Sitzventile ohne Leckölanschluss
- Bei Schieberventile
  - Externe Abführung
  - Interne Abführung

Sitz- Schieberventil DBV

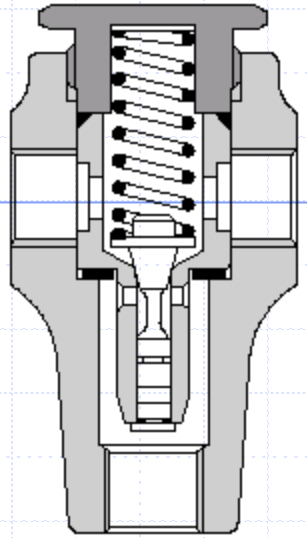


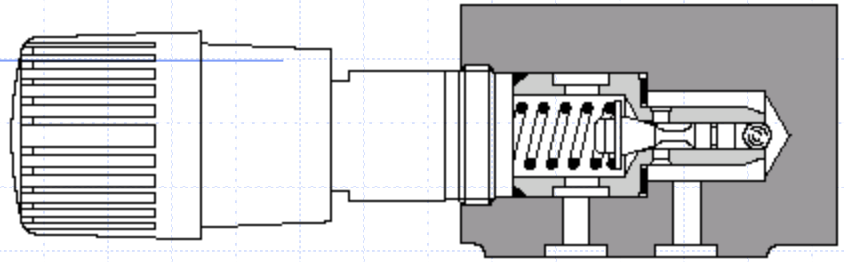


Sitzventil mit Dämpfungskolben

Schieberventil mit Leckölanschluss

DBV Ausführung direktgesteuert

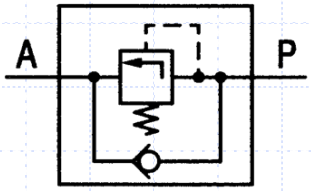


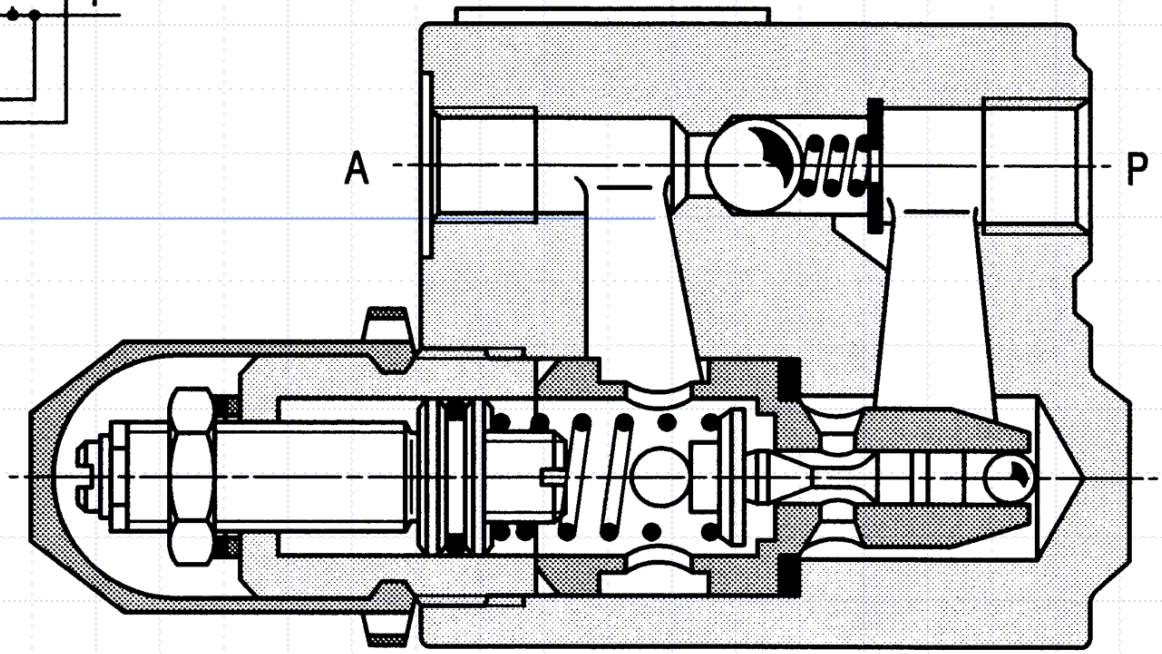


Leitungseinbau

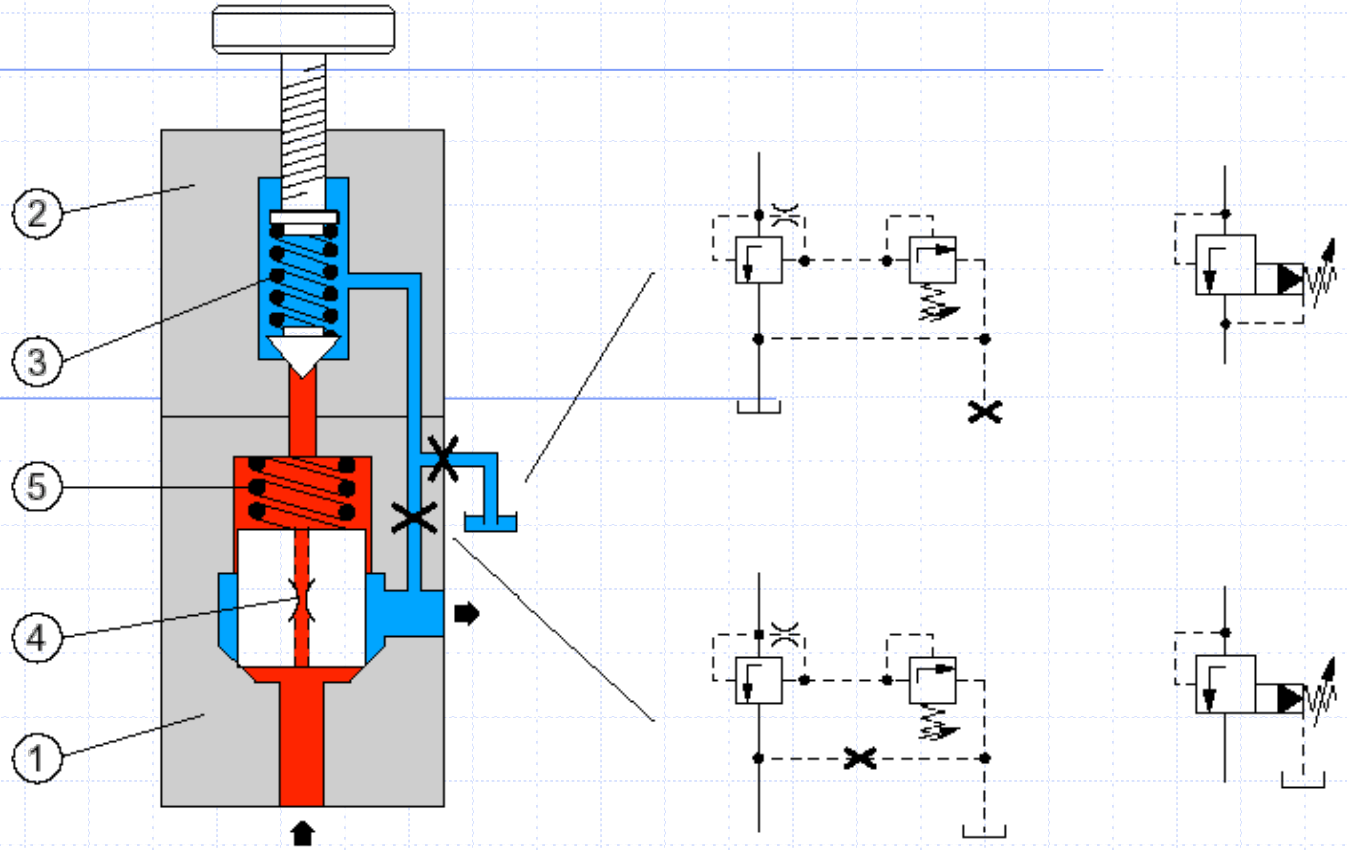
Platteneinbau

DBV mit Umgehungsventil



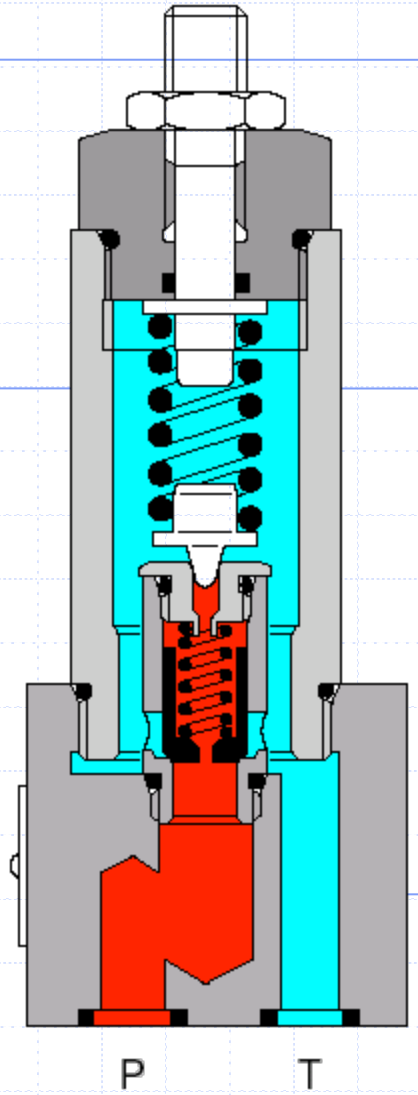


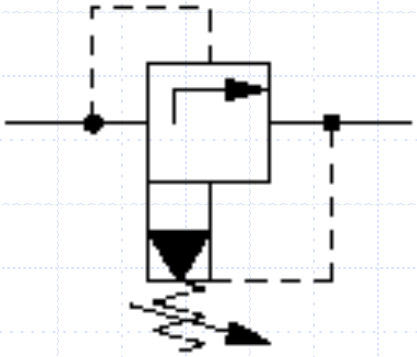
Druckbegrenzungsventil vorgesteuert I



- Durch Stopfen interne oder externe Leckölabführung

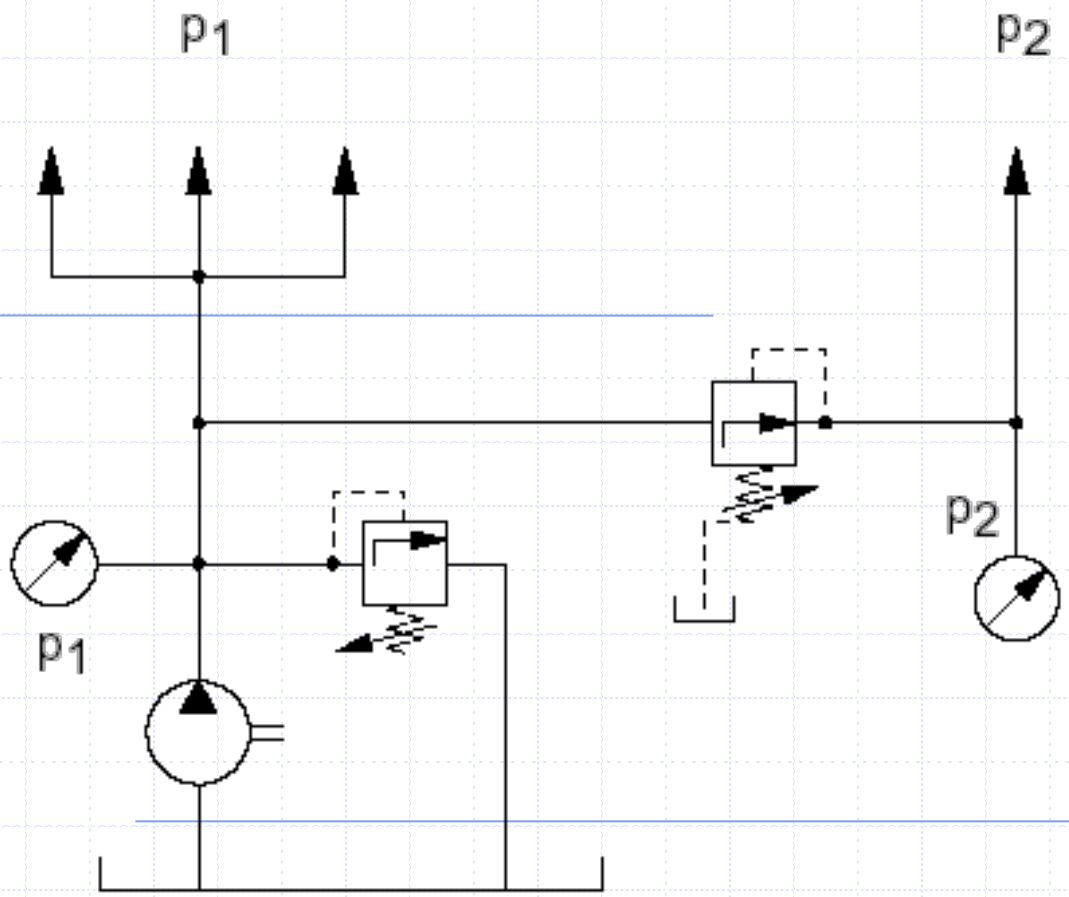
Druckbegrenzungsventil indirektgesteuert II



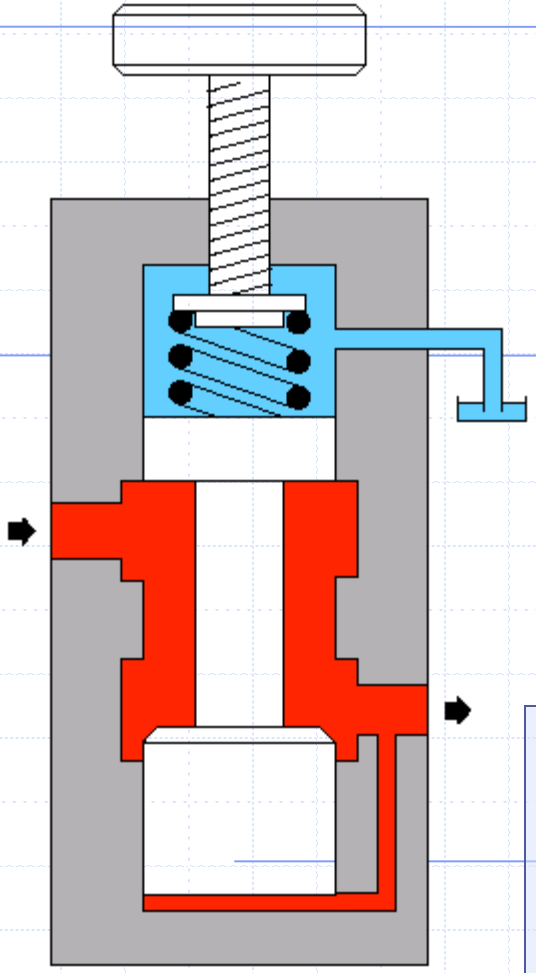


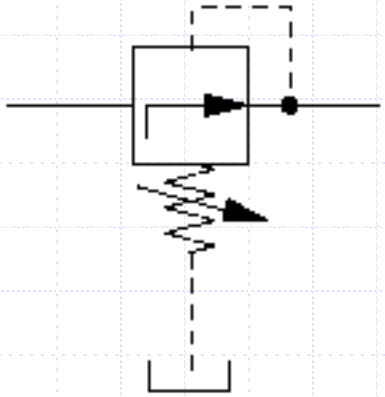
- Vorgesteuert
- Für grössere Durchflussmengen
- Haupt- und Vorsteuerventil

Druckminderventil Schaltung



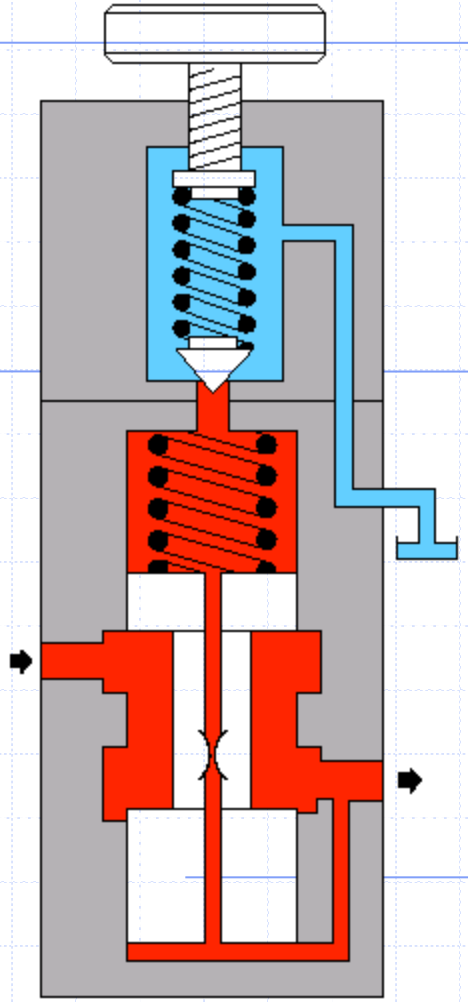
Druckminderventil direktgesteuert

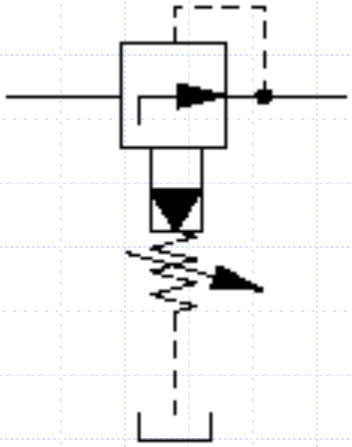




- Ansteuerung Ausgangsdruck
- Unbetätigt offen
- Schieberventil mit Leckölanschluss

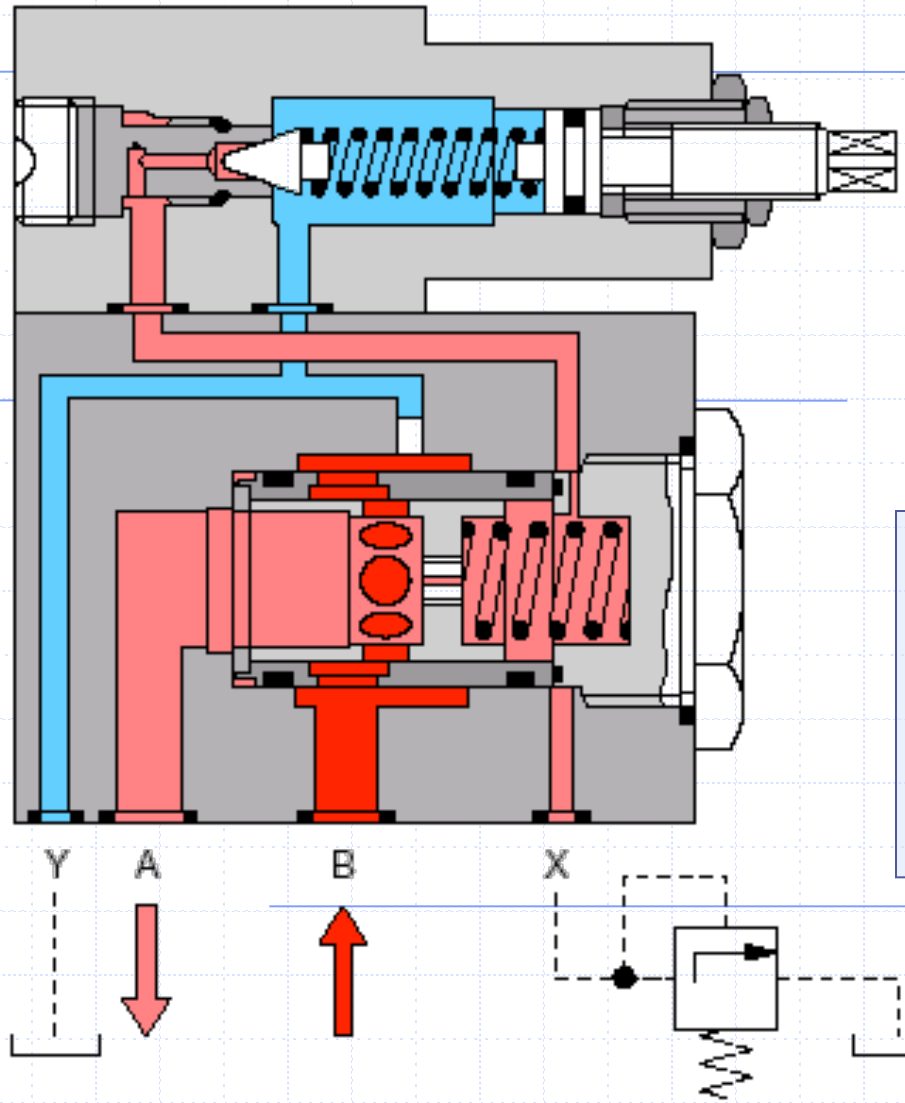
Druckminderventil indirektgesteuert





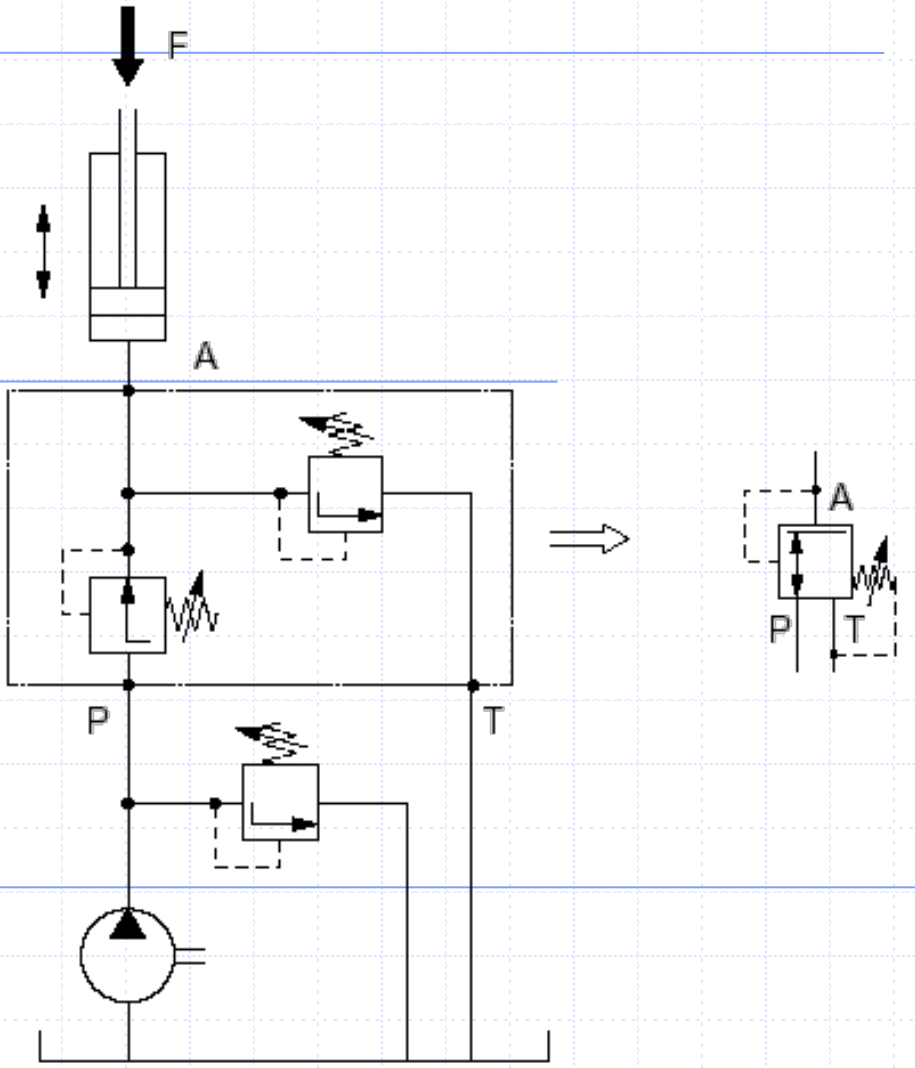
- Vorgesteuert
- Für grössere Durchflussmengen
- Haupt- und Vorsteuerventil

Druckminderventil konstruktive Ausführung

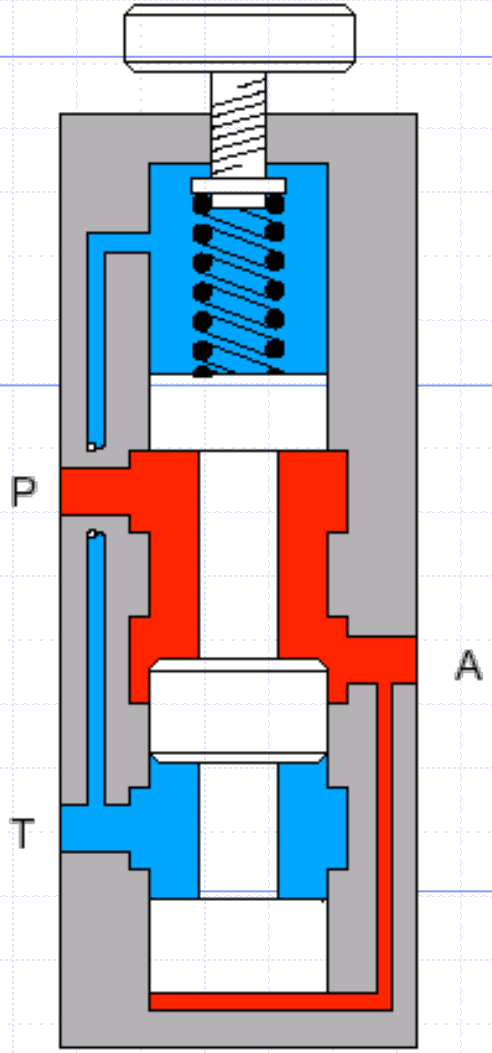


- Vorgesteuert
- Steuerölabfluss über Anschluss y

3-Wege-Druckminderventil I

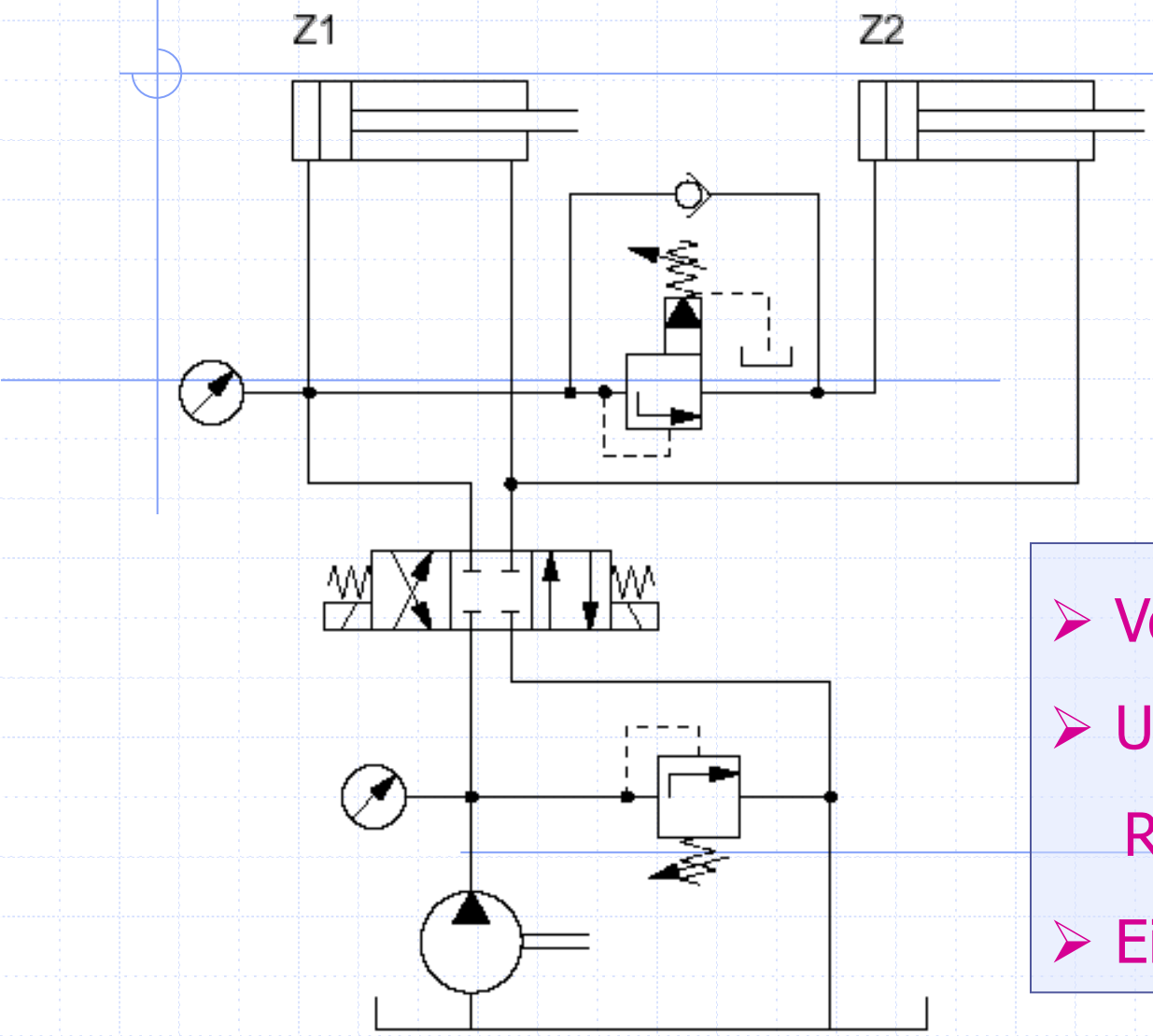


3-Wege-Druckminderventil II



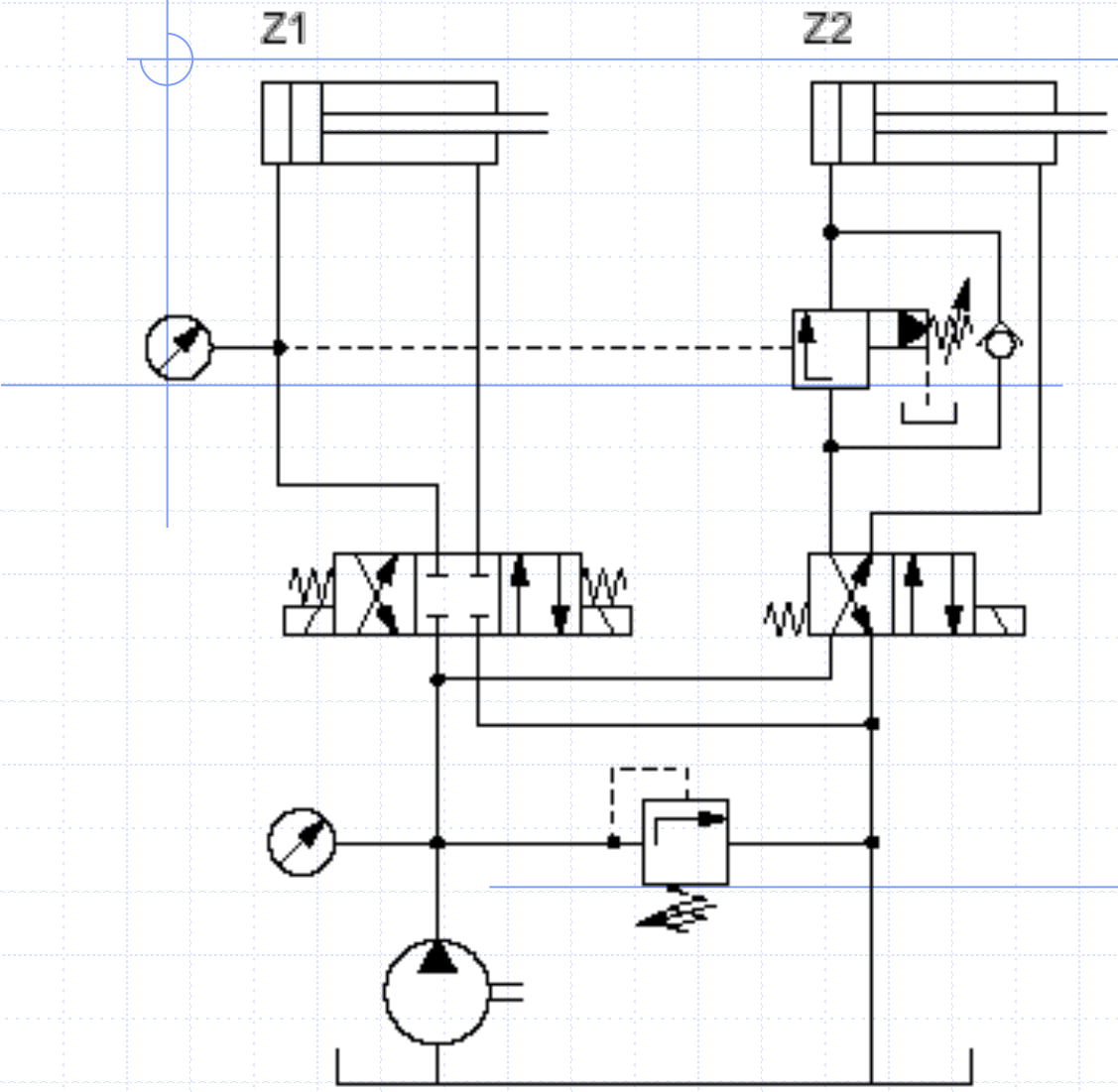
- Kombination Druck-minderventil mit Druck-begrenzungsventil
- DBV höher eingestellt
- Bei äusserer Kraft auf Verbraucher

Druckzuschaltventil eigengesteuert



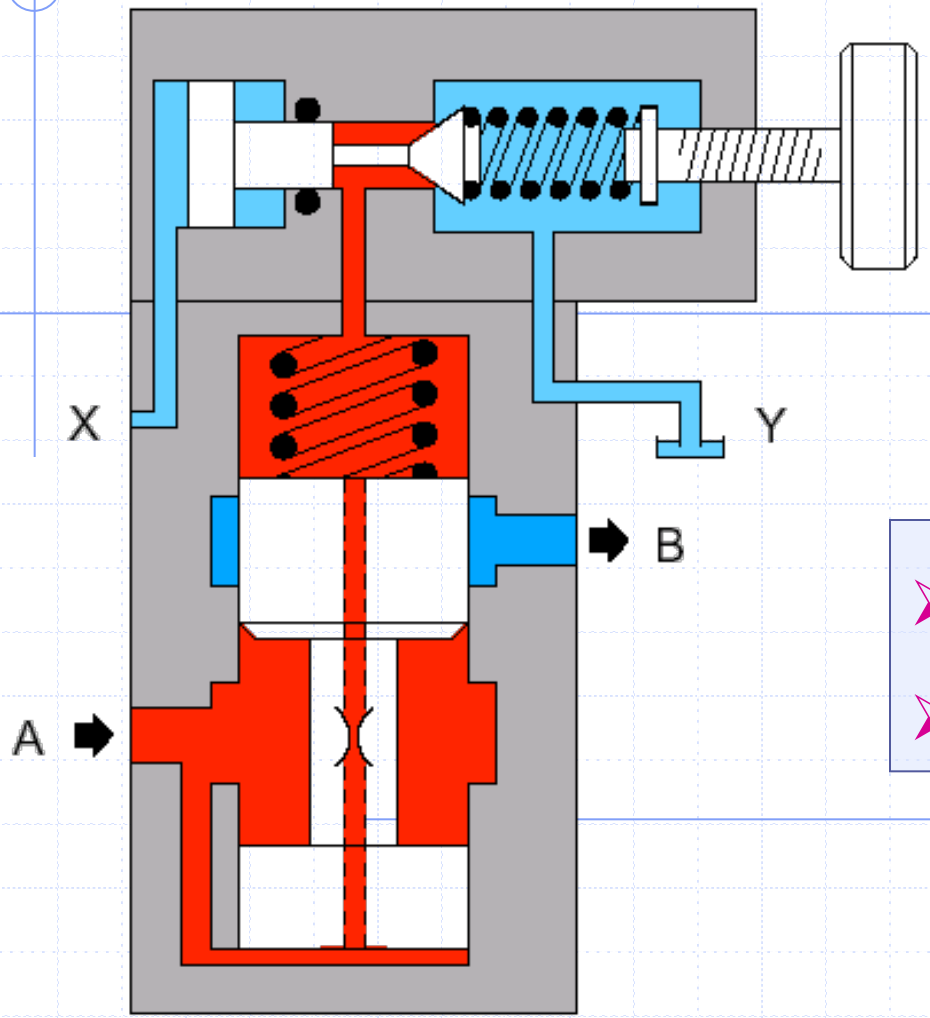
- Vorgesteuert
- Umgehung mit Rückschlagventil
- Eigengesteuert

Druckzuschaltventil fremdgesteuert



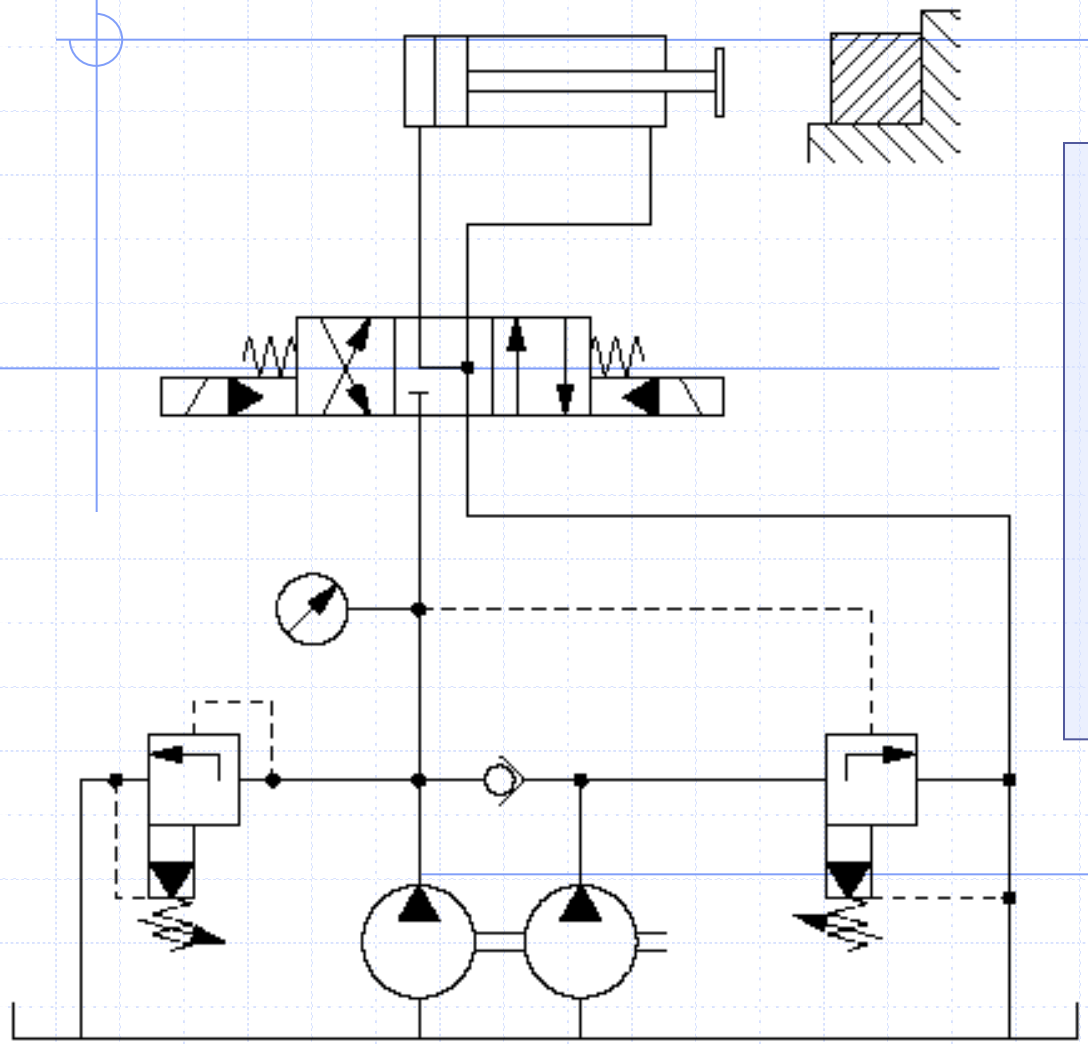
- Vorgesteuert
- Umgehung mit Rückschlagventil
- Fremdgesteuert

Druckzuschaltventil indirektgesteuert



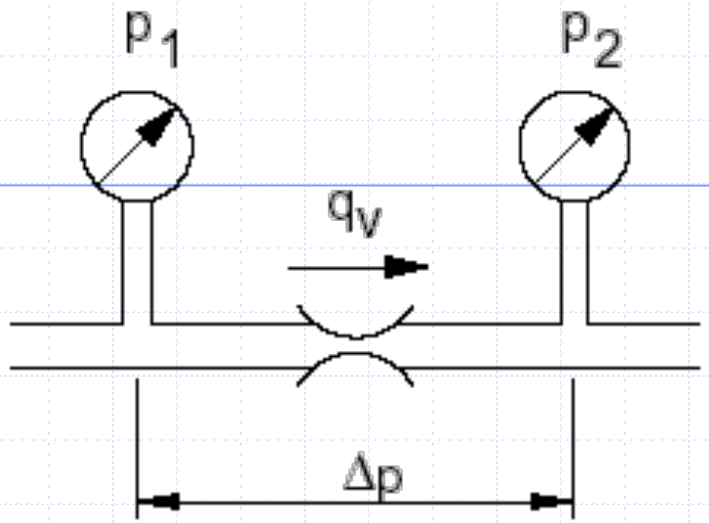
- Vorgesteuert
- Fremdgesteuert

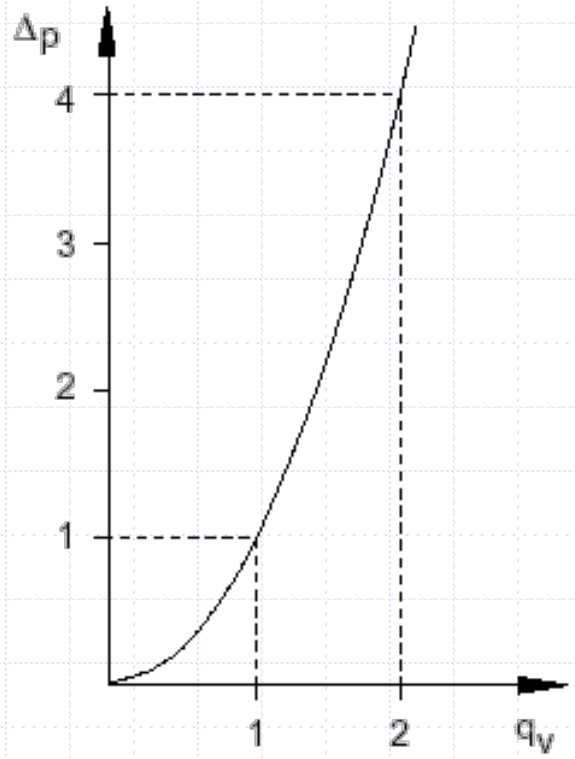
Druckabschaltventil



- Abschaltung einer Pumpe
- Verkürzung Leer-wege
- Fremdgesteuert

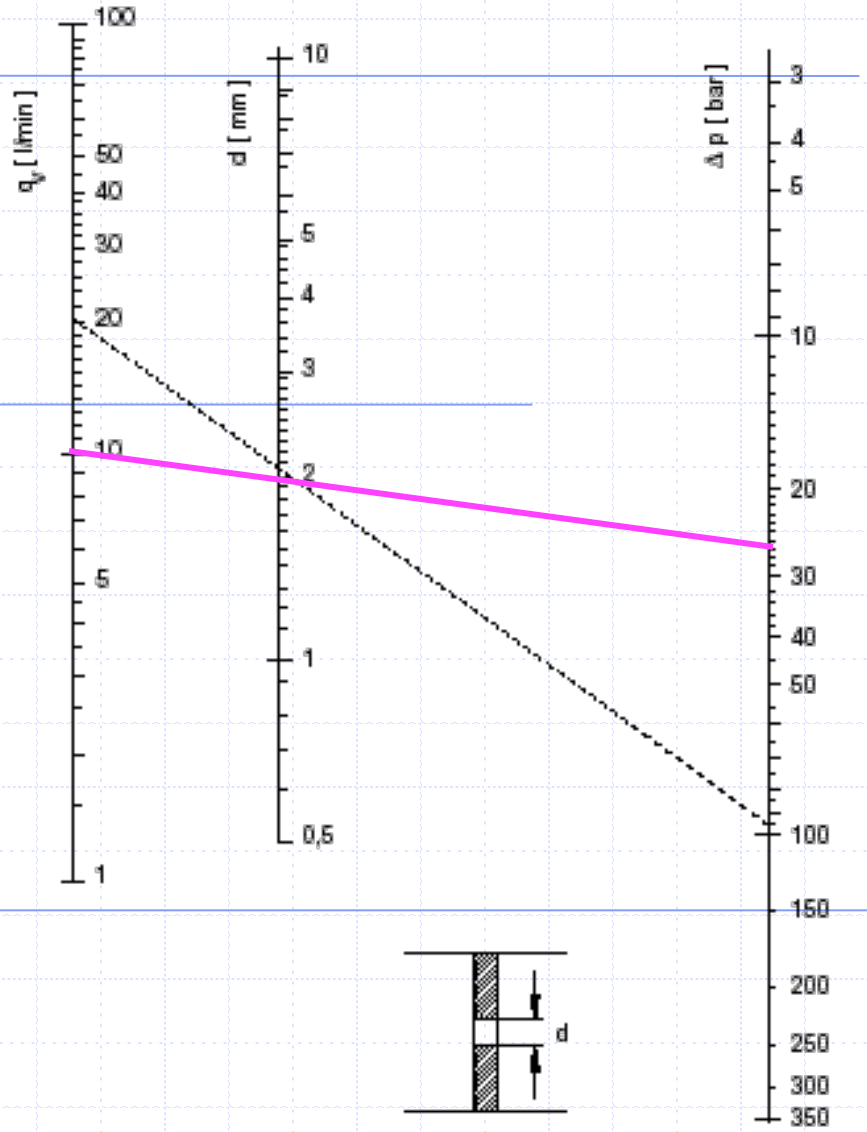
Stromventile Strömungsgesetz





$$\Delta p = Q^2$$

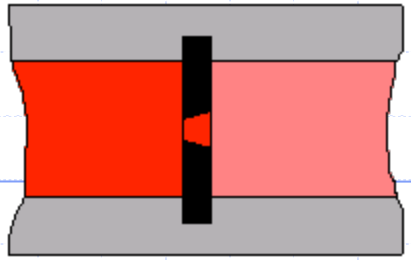
Berechnungsdiagramm Blende



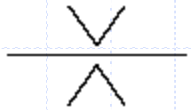
Blende / Drossel

Blende

1

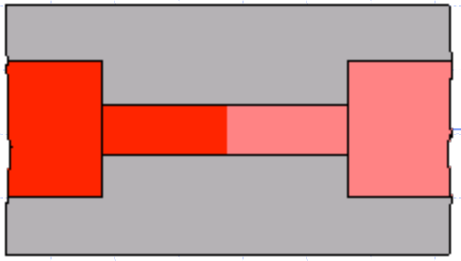


Symbole

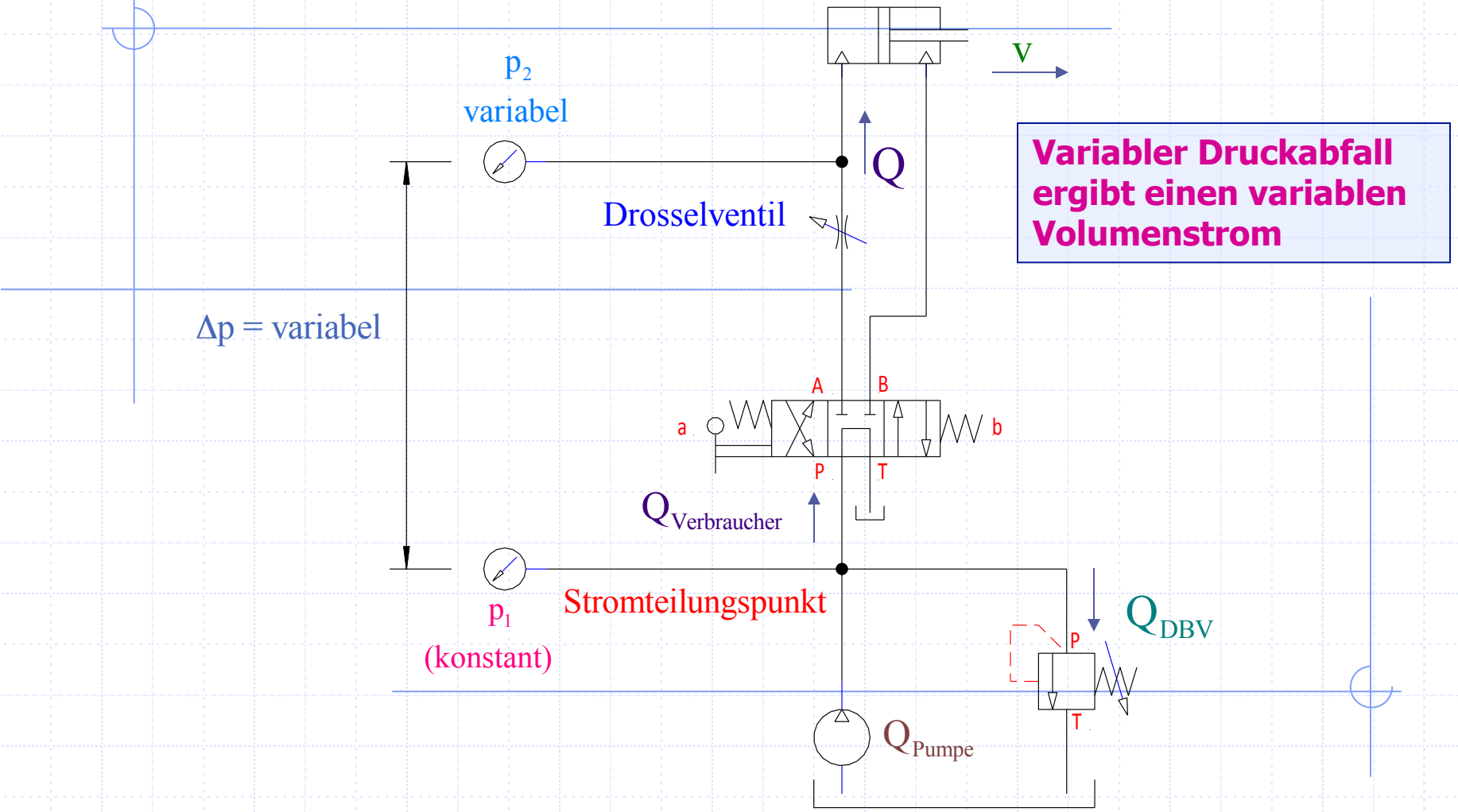


Drossel

2

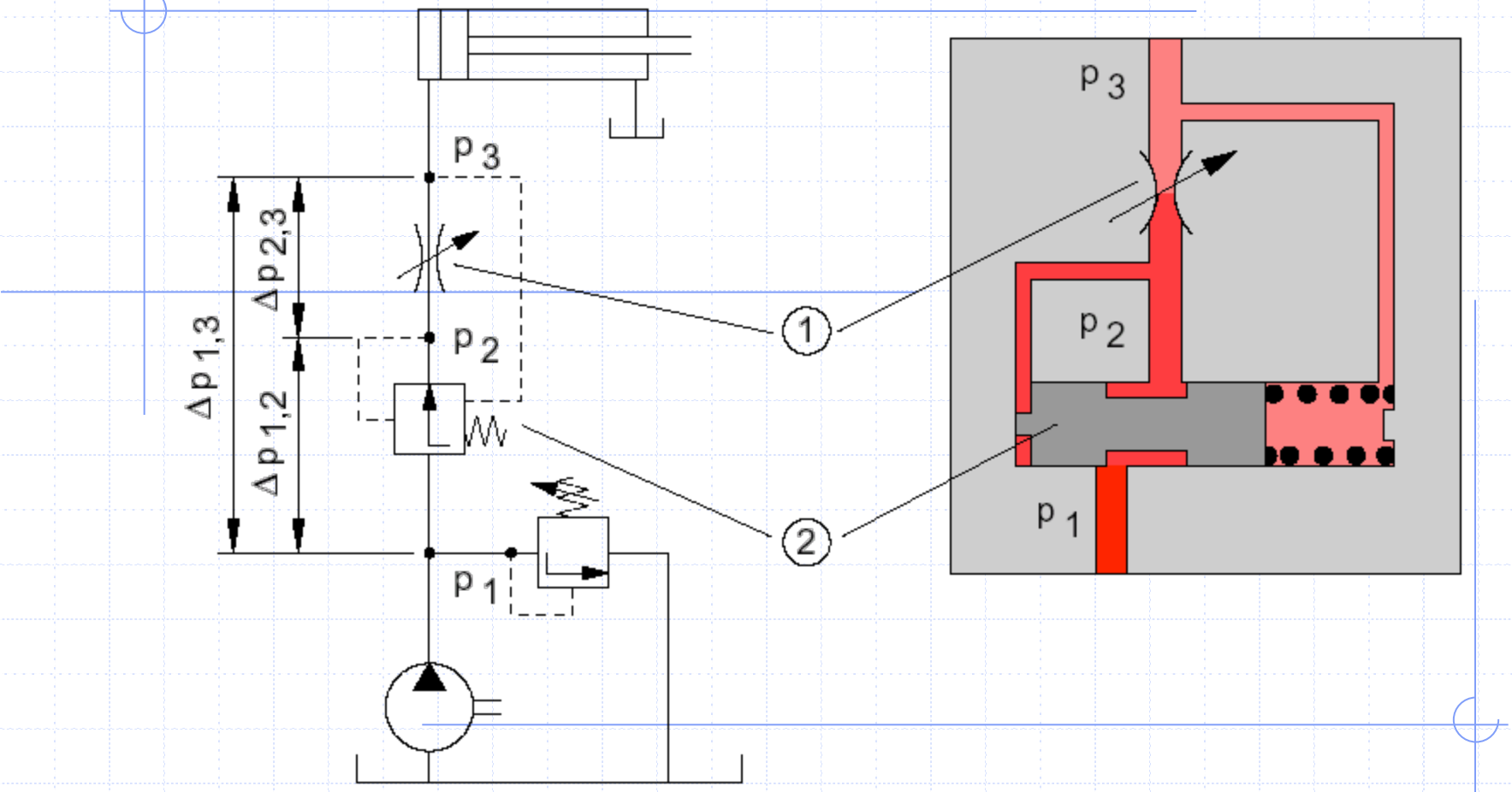


Drosselschaltung



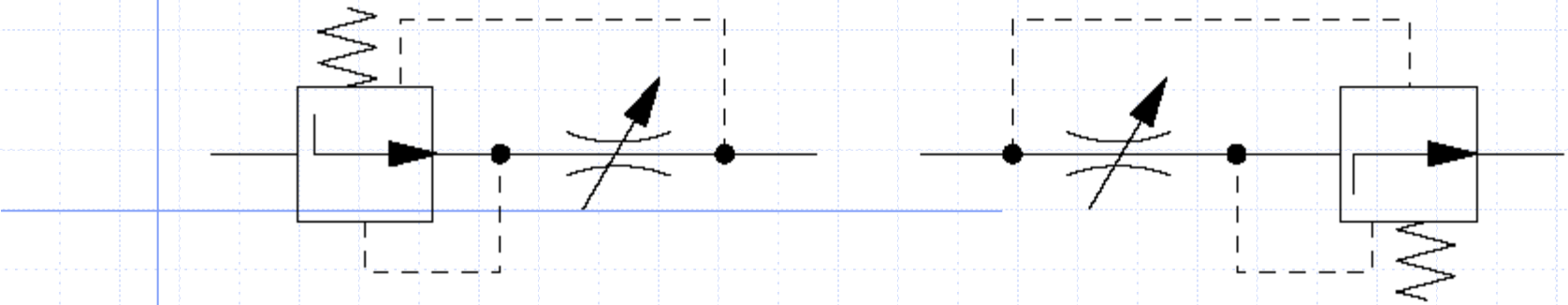
Variabler Druckabfall ergibt einen variablen Volumenstrom

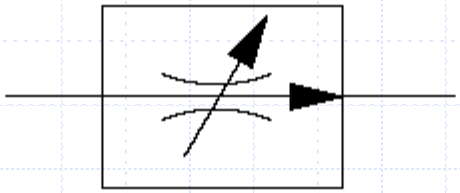
Wirkungsweise Stromregelventil II



Sinnbilder 2-Wege-Stromregler

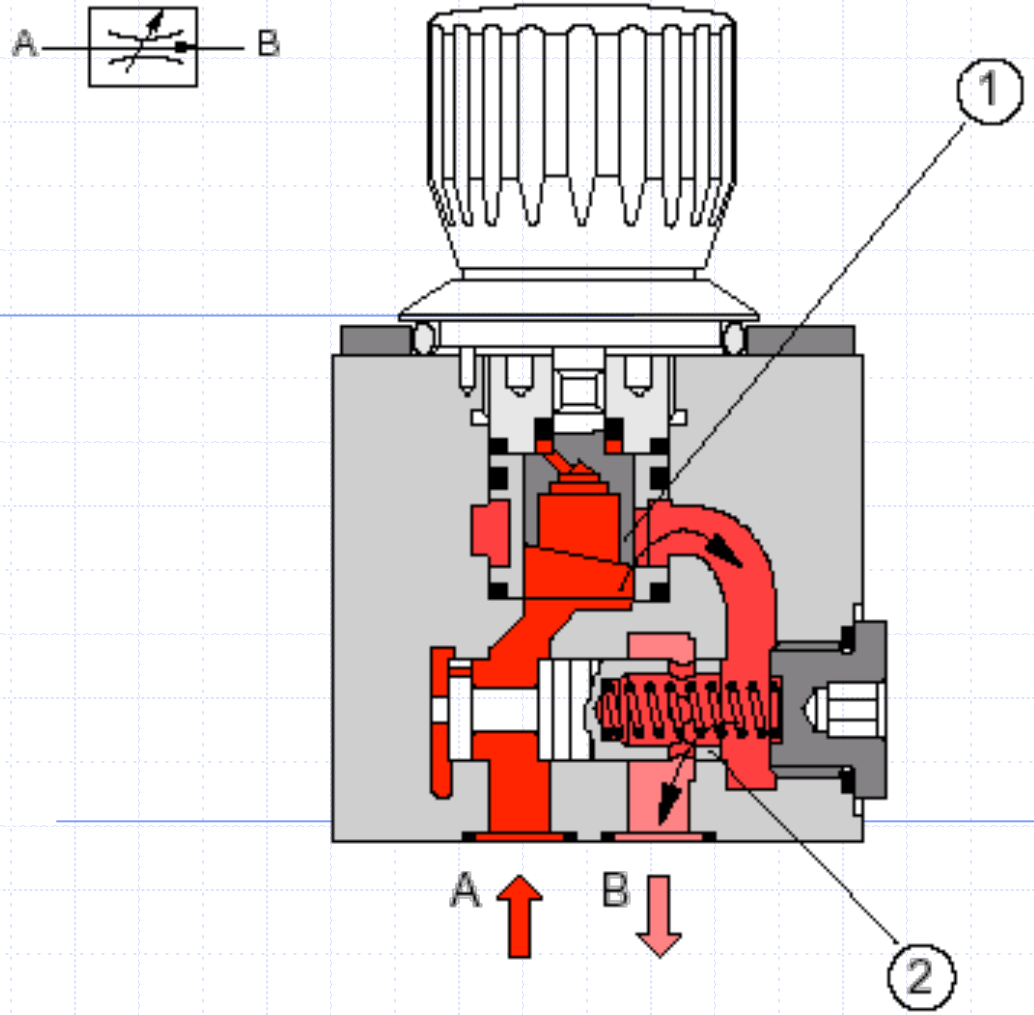
ausführliche Darstellung



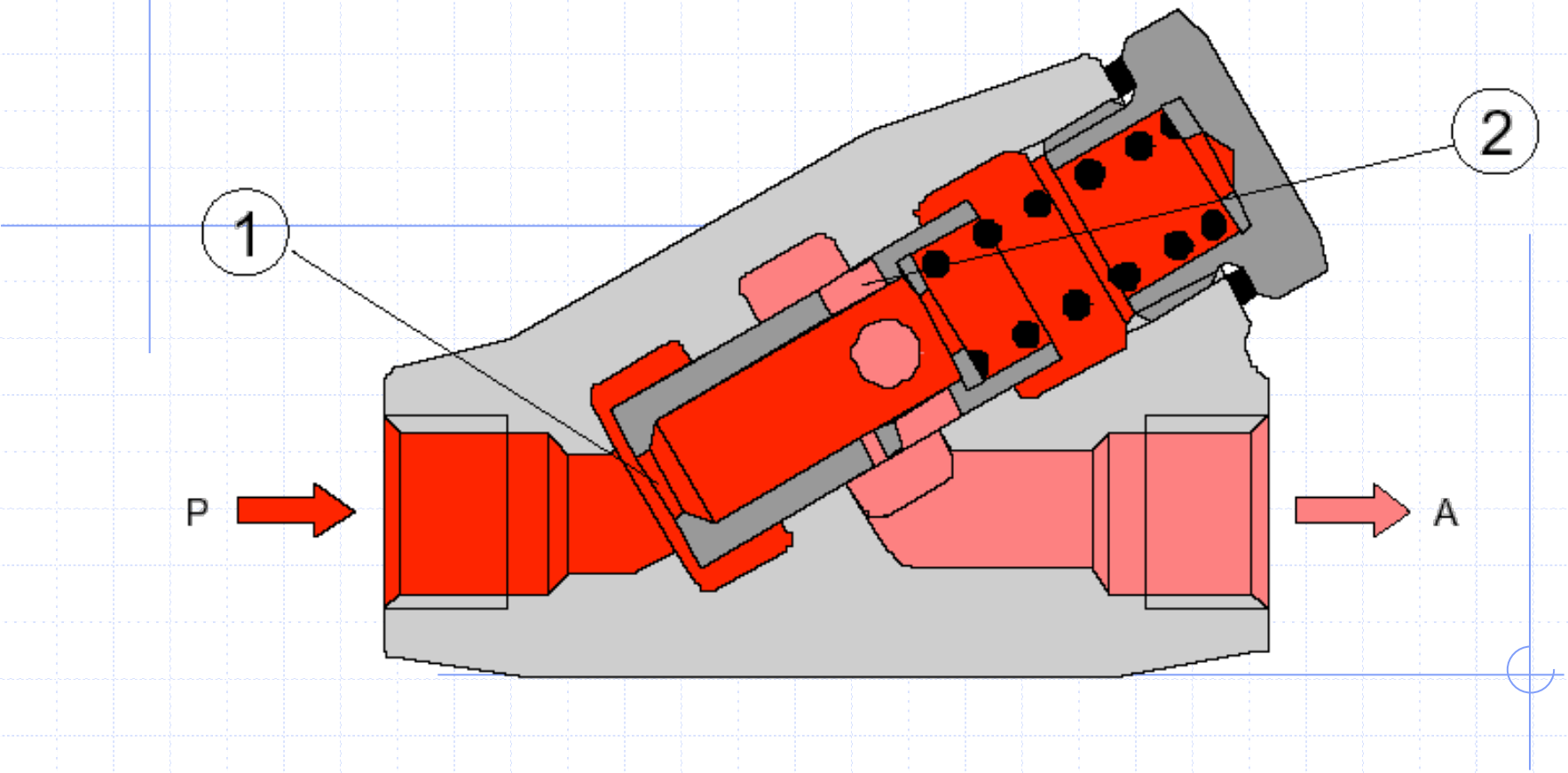


vereinfachte Darstellung

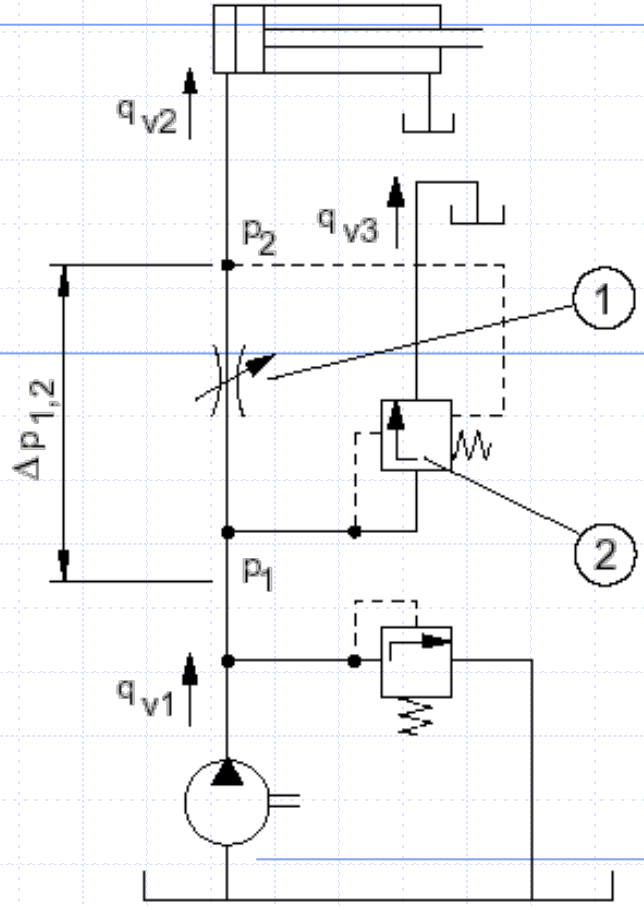
Stromregelventil einstellbar

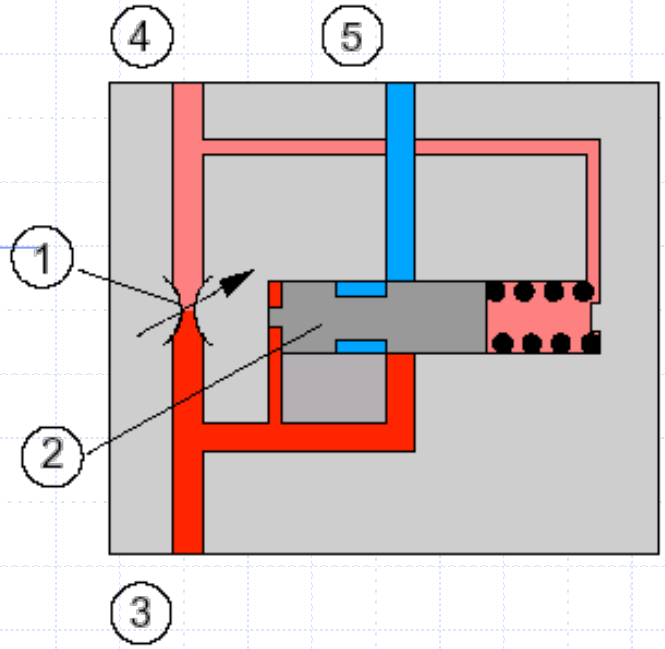


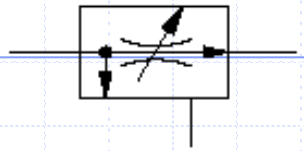
Stromregelventil festeingestellt



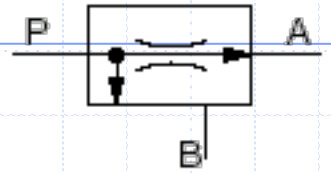
3-Wege-Stromregelventil

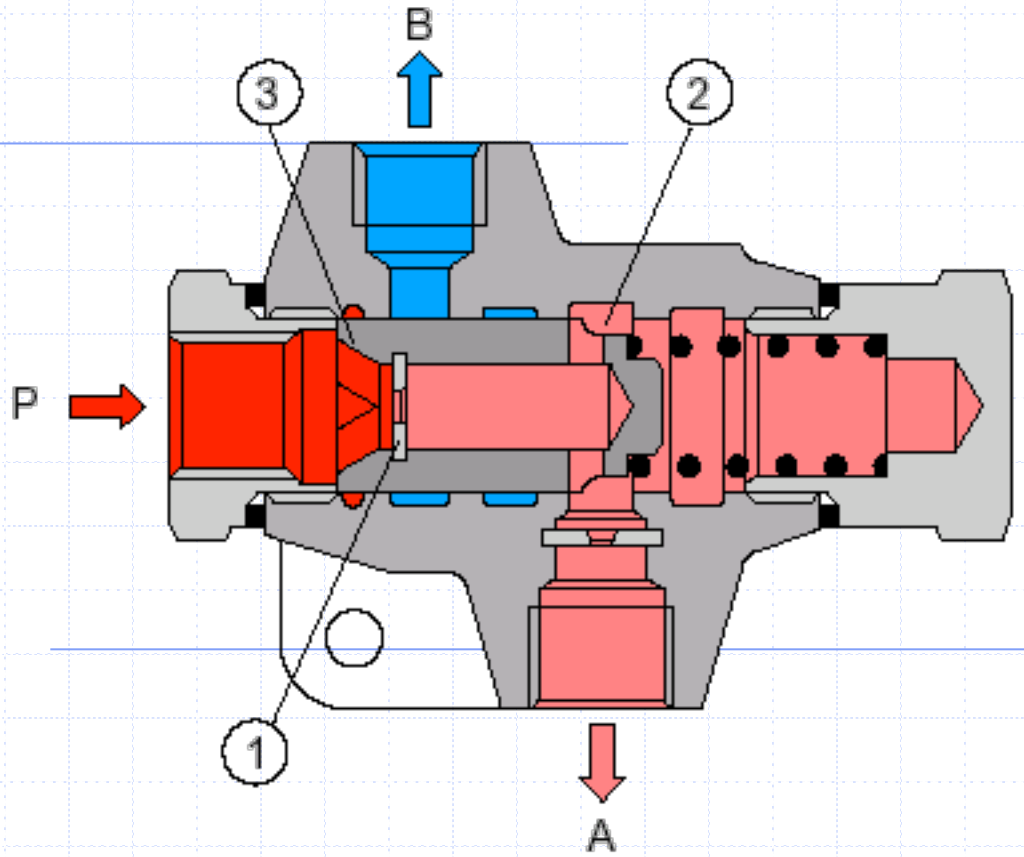




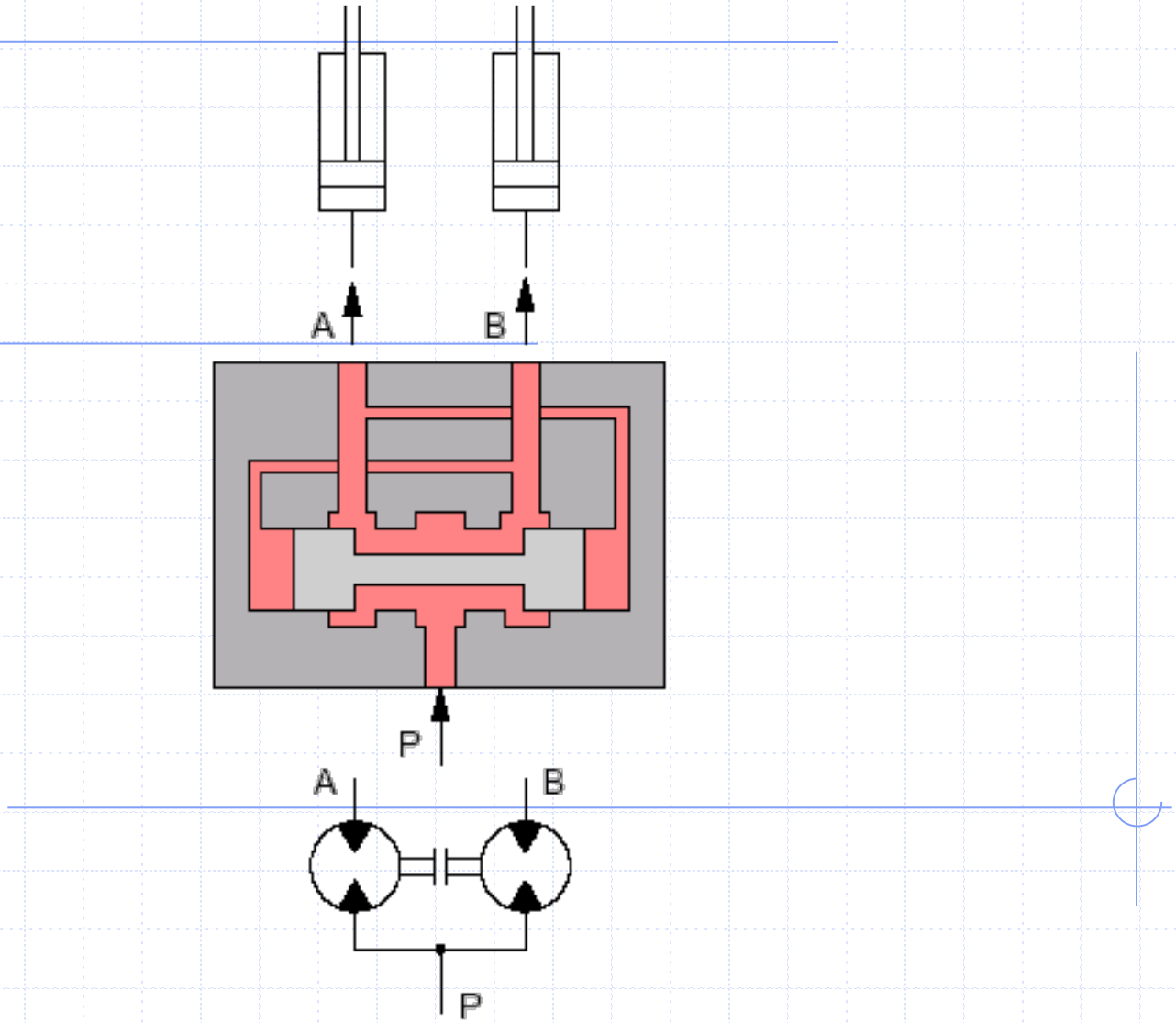


3-Wege-Stromregelventil festeingestellt

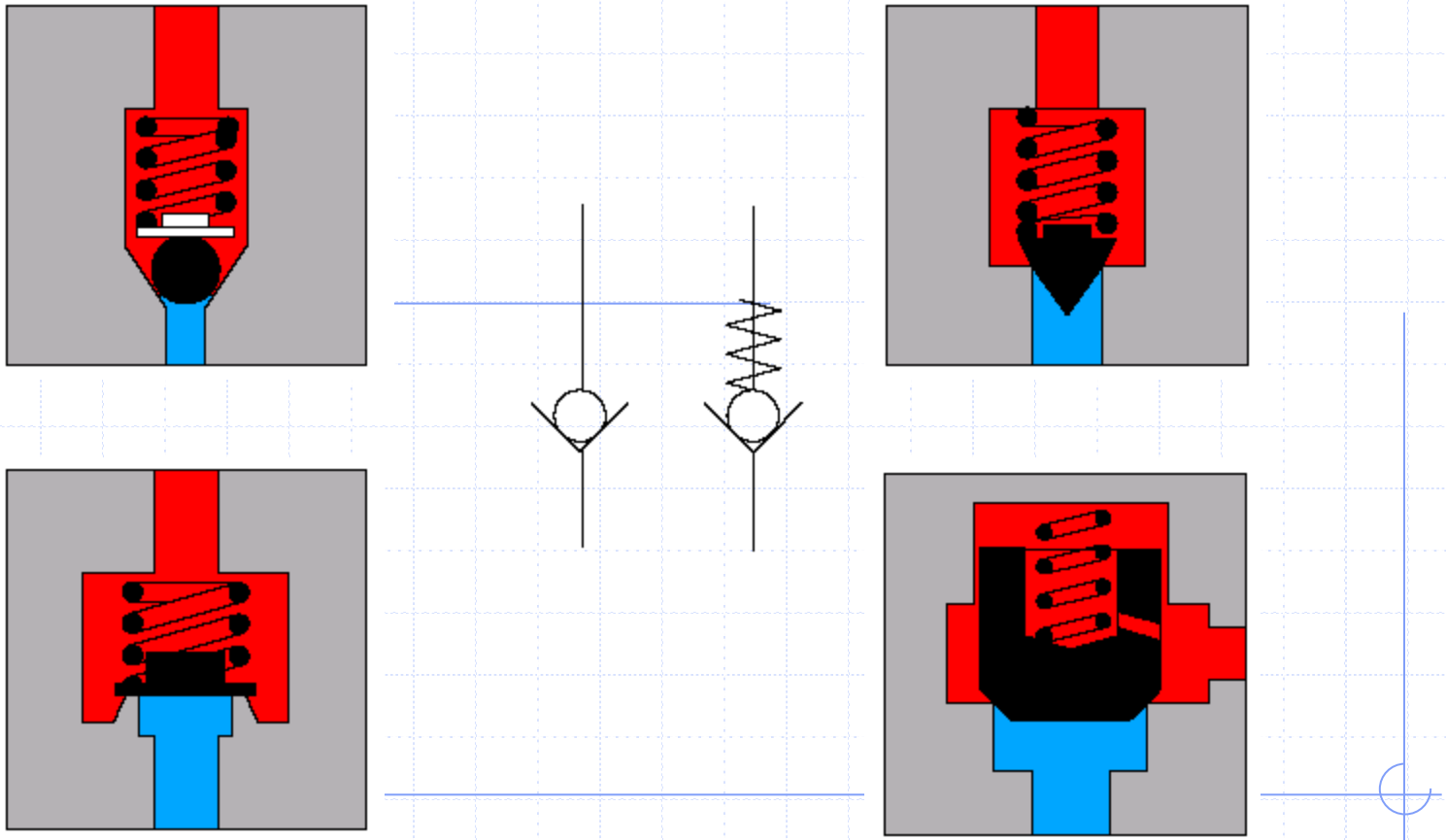




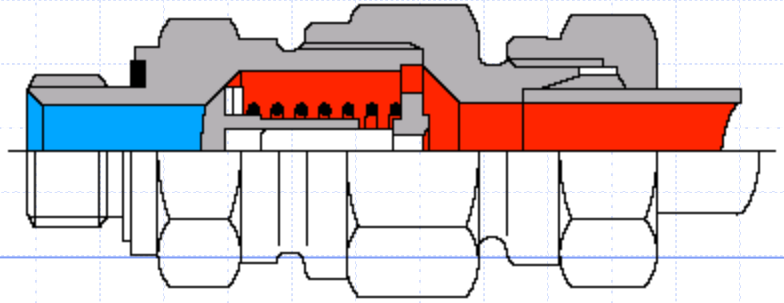
Stromteiler

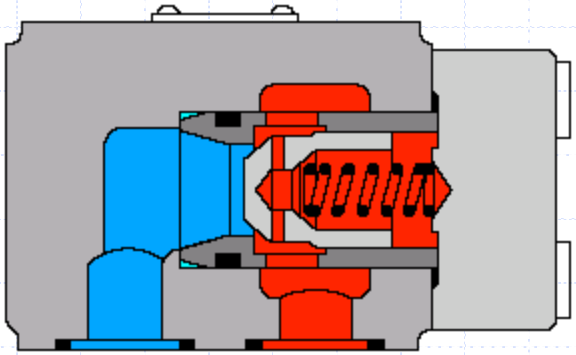


Rückschlagventil I

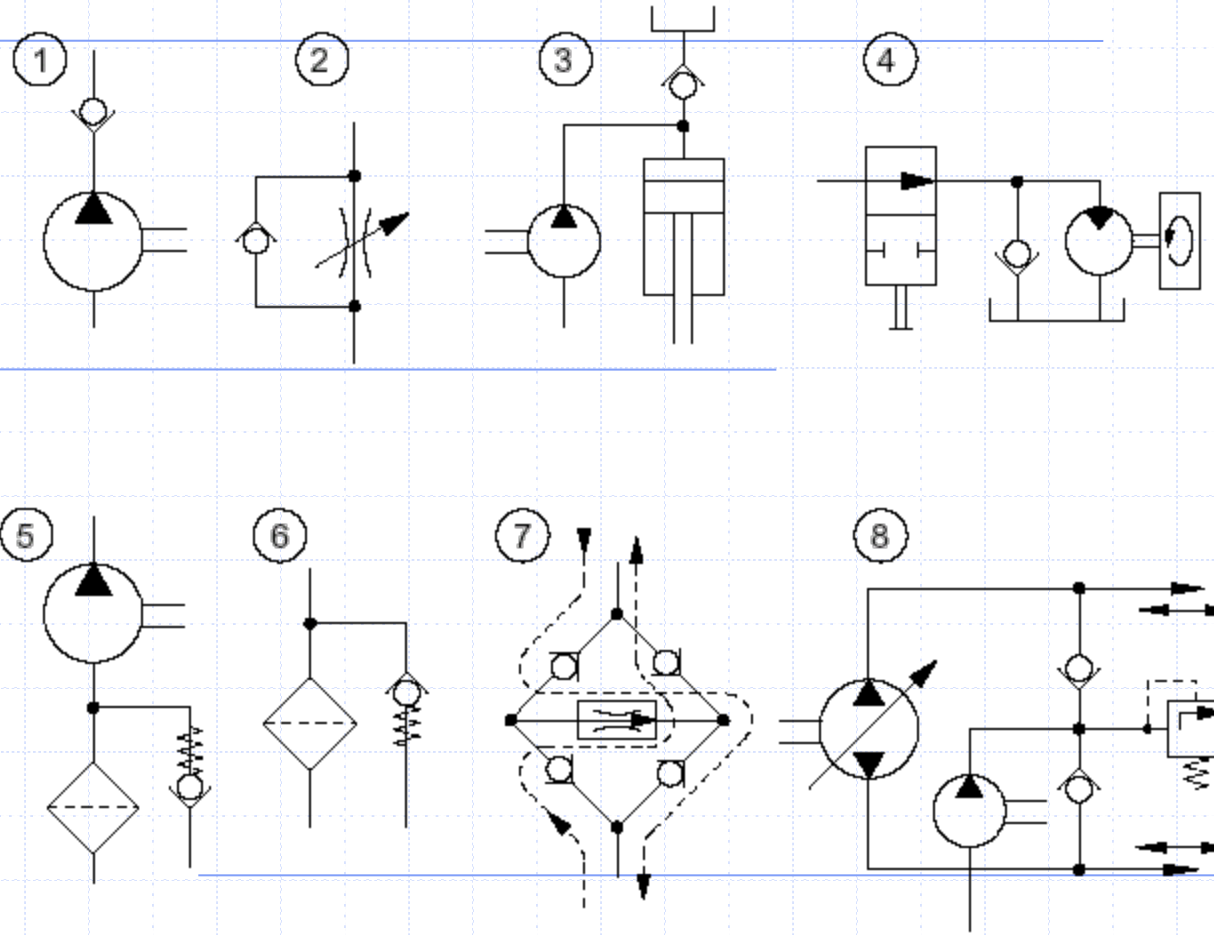


Rückschlagventil II

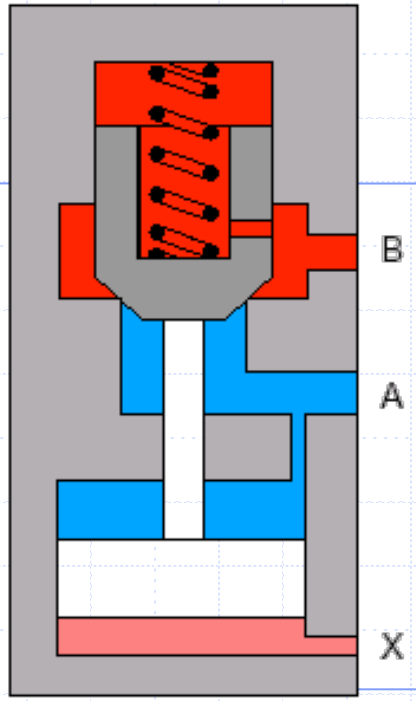


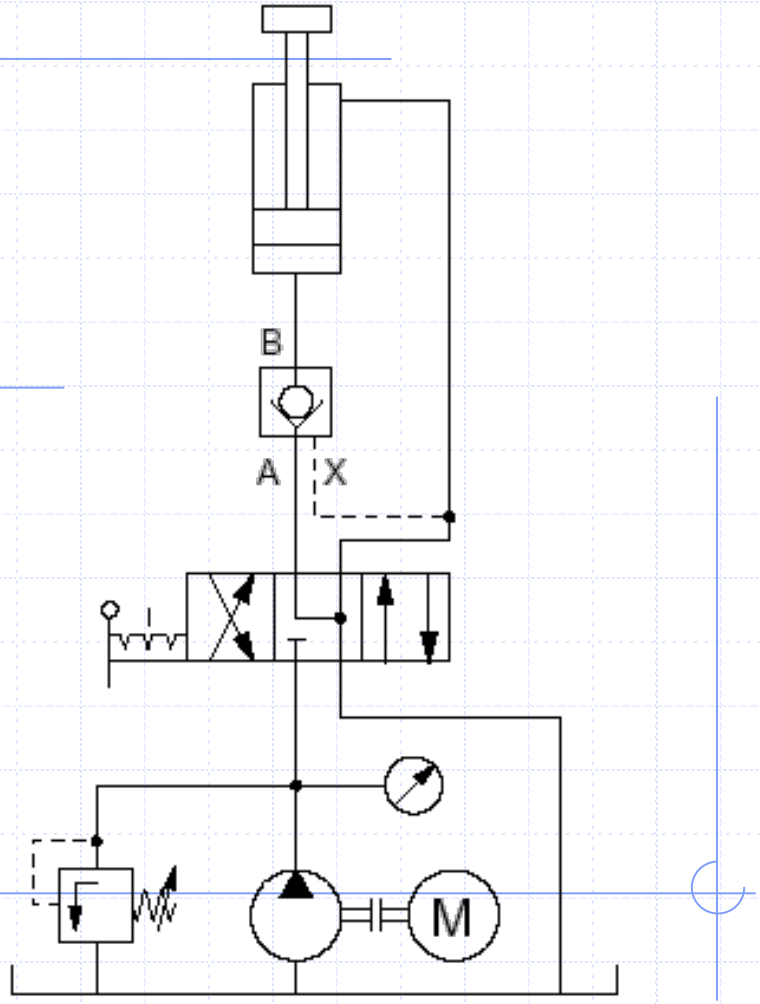


Schaltungs-Varianten



Entsperrbares Rückschlagventil





Schaltung entsperrb. Rückschlagventil