Introduction to Proportional Valve Technology

Arno Schmitt

Proportional Valve Technology

Acting as the linking element between switching and closed-loop technology, proportional valve technology has today become an established component part of hydraulic systems. Industry has been quick to implement the advantages offered by this technology.

What exactly does proportional valve technology mean in hydraulic systems?

Fig. 1 is intended to illustrate the signal sequence:

- An electrical input signal in the form of a voltage (mostly between 0 and ±9 V) is converted into an electrical current in an electronic amplifier corresponding to the voltage level, e. g. 1 mV = 1 mA.
- Proportionally to this electrical current as the input variable, the proportional solenoid produces the output variable - force or travel.
- These variables, i. e. force or travel, acting as the input signal for the hydraulic valve, signify proportionally a certain flow or pressure.
- For the actuator and therefore also for the working element of the machine this means, in addition to variable direction, infinitely variable control of speed and force.
- Simultaneously, acceleration or deceleration can be infinitely varied, e. g. change in flow with respect to time.

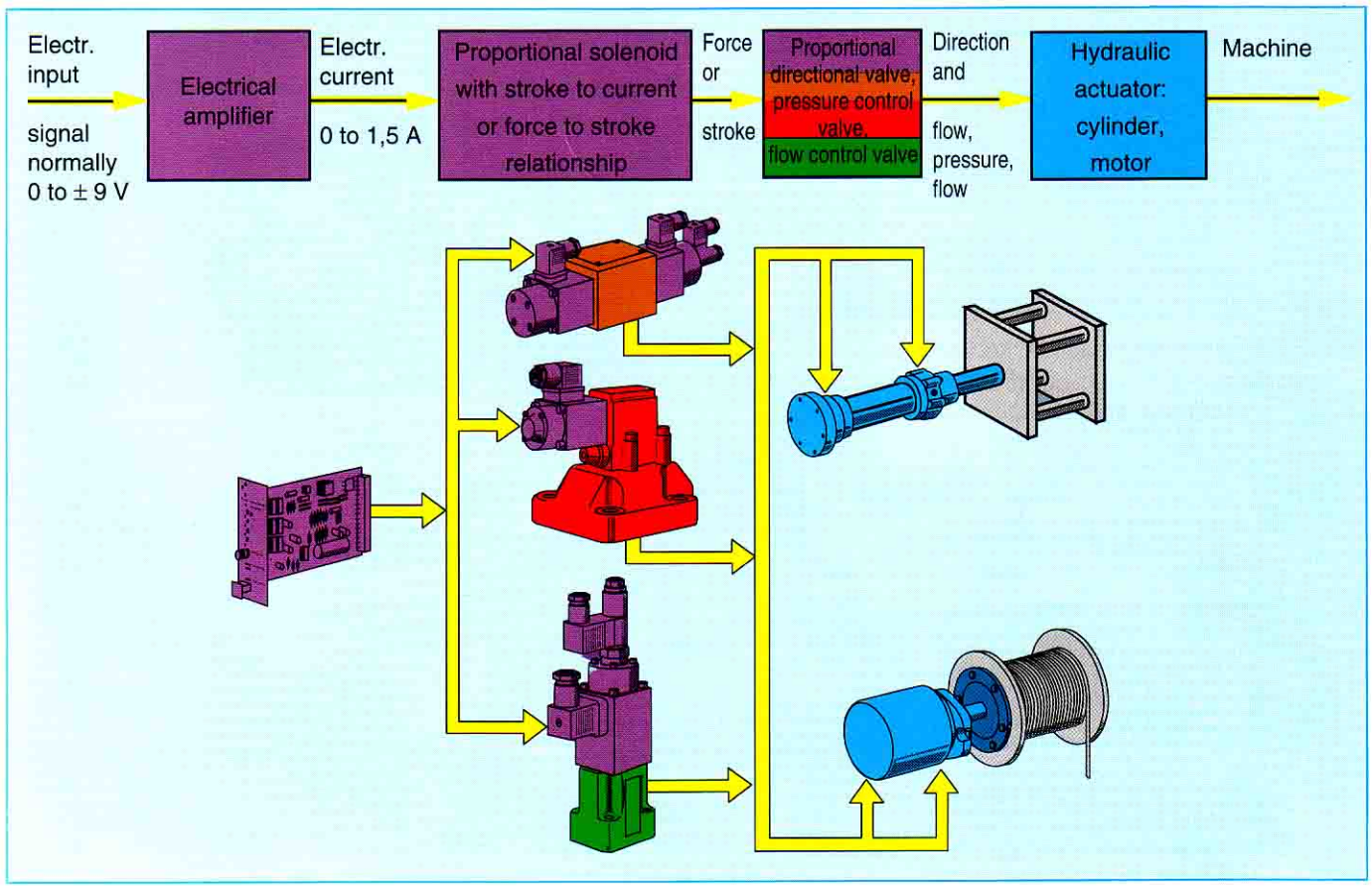


Fig. 1 *Signal sequence*

An example to illustrate the possibilities offered by proportional technology.

By way of example, we will consider the welding line used in the production of motor vehicle bodies:

Individual components of the car have already been through a fast moving life during the production phase long before certain drivers can test the specified acceleration values of their cars. By analysing the diagram in *Fig. 4* with regard to acceleration of body parts in a welding line, values can be obtained which, when converted, correspond to an acceleration of 0 to 100 km/h in approx. 11 seconds.

The main function of the welding line is to assemble and weld the body parts which are grouped about a platform. This production process involves several stations or better several stages.

All elevating stations are raised or lowered simultaneously in order to reach the working position, i. e. in the area of the welding tongs. The transfer of the prepared sheet metal parts to be added takes place in the middle of the lift travel range at reduced speed. The "transfer speed" must not exceed the value of 0.15 m/s, or otherwise the automatically positioned sheet metal parts would be knocked out of position. On the other hand, the lifting and lowering cycle should be completed efficiently, i. e. as fast as possible.

These requirements are met by proportional hydraulics. In the case of a solution without proportional technology, it would be necessary to, for instance, considerably reduce the maximum speed. This system would also necessitate the use of deceleration valves with corresponding mechanical cams for acceleration and deceleration, as well as flow-control valves for providing the velocity signal and, of course, directional control valves for the direction. Despite reduced acceleration and speed values, a considerably harder, less accurate and less flexible solution would be the result, whilst requiring more expensive and complex equipment requirements.

Despite large moving masses, as well as high acceleration and speed values, proportional hydraulics ensures smooth and reliable operation.

Fig. 2: *One cylinder (at top) - the other one being used as a standby device - moves all stations simultaneously in conjunction with a lifting mechanism.*

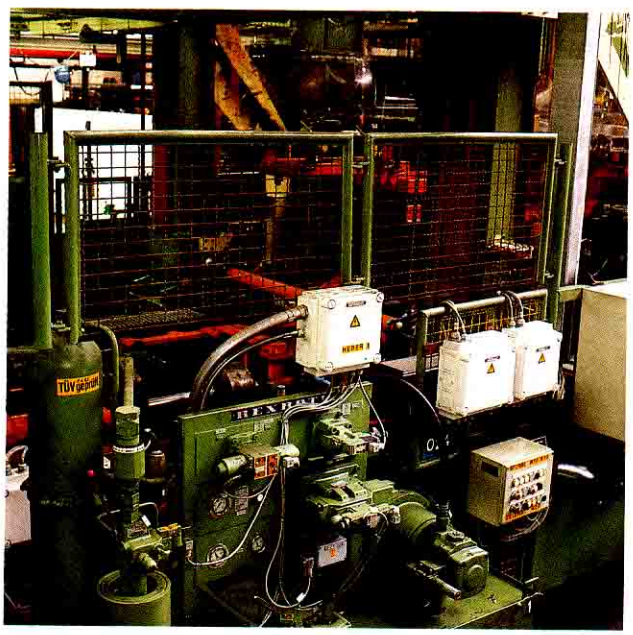
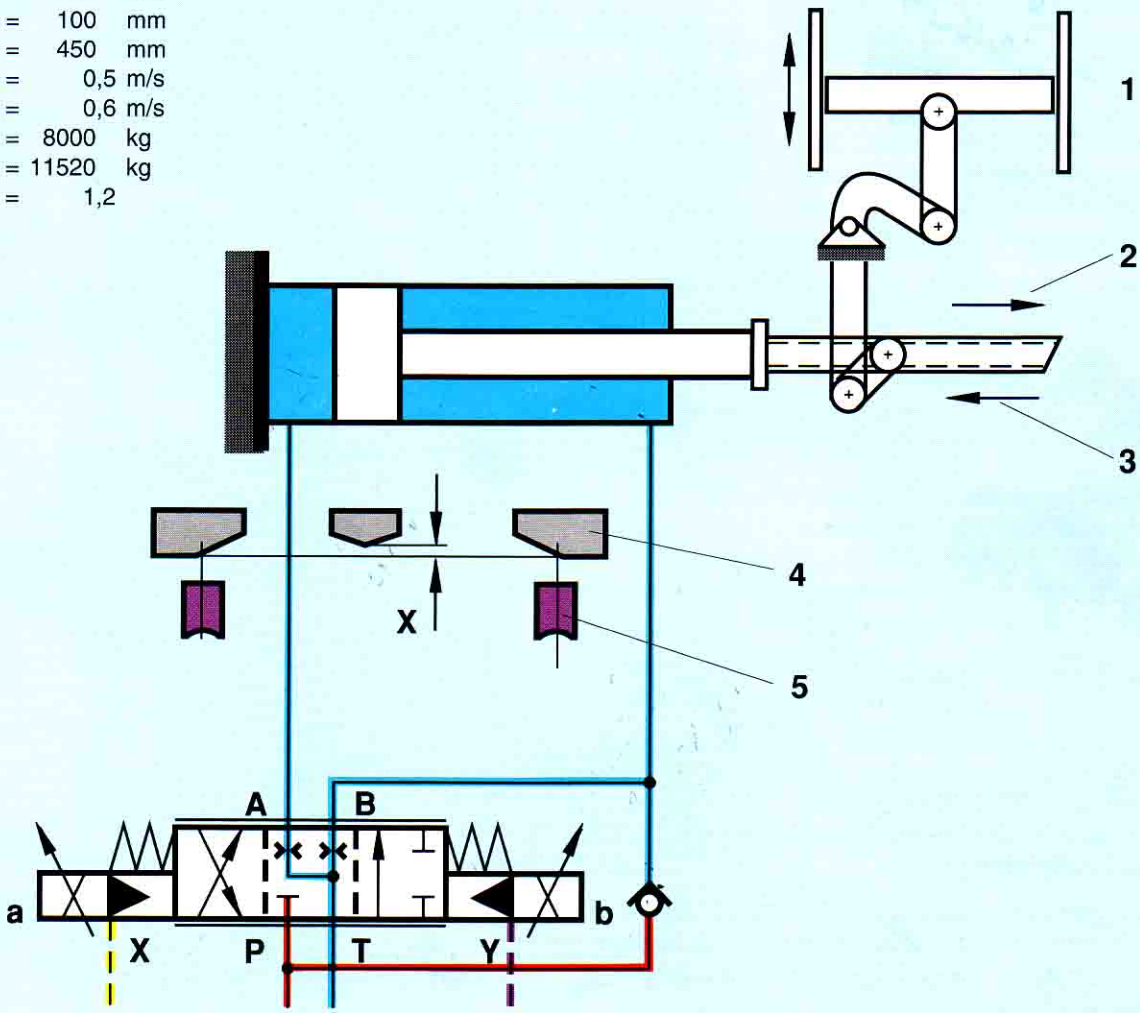
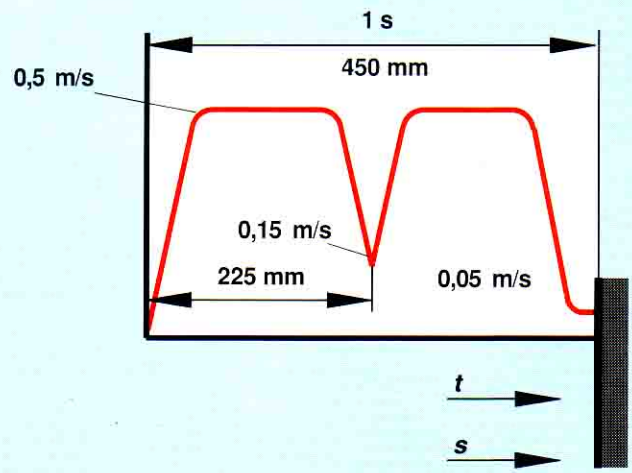


Fig. 3: *The accumulator unit on the left-hand side provides the 460 L/min of hydraulic oil necessary for the high speed operation. The type V4 vane pump to the right fills the accumulator during the "idle periods". The proportional directional valve, type 4 WRZ 25, is in the centre.*

Technical data

D	=	140	mm
d	=	100	mm
H	=	450	mm
$v_{max.\ cyl.}$	=	0,5	m/s
$v_{max.\ stroke}$	=	0,6	m/s
m	=	8000	kg
$m_{ges.}$	=	11520	kg
i	=	1,2	





1 12 elevating stations
2 Lifting
3 Lowering
4 deceleration cam
5 Analog initiator

Fig. 4: *Basic block diagram of a hydromechanical drive for a welding line (top) and its timing diagram (bottom right).*

Proportional valves and pumps with their proportional solenoids provide perfect interface for electronic control, thereby facilitating increased flexibility in the operating cycles of production machines as well as freely programmable control systems and drives.

The technical benefits of proportional devices can primarily be found in the controlled transfer during valve change-over, i. e. the infinitely variable control of command signals and the reduction of hydraulic equipment requirements for certain control applications. This therefore also represents an effective contribution to reducing material requirements in hydraulic circuits.

Proportional valves permit faster, simpler, and more precise movement cycles while at the same time improving the reversal process. As a result of controlled spool cross-over, pressure peaks are avoided - resulting in a longer service life of the mechanical and hydraulic components.

The fact that the signals for direction and flow or hydraulic pressure are provided by electrical means has made it possible to arrange the proportional devices directly on the loads, thereby greatly improving the dynamic characteristics of the hydraulic control system.

Proportional devices in hydraulic systems found more widespread use when effective devices of simplified design were offered on the hydraulics market. These devices do not greatly differ from those of the standard hydraulic range. It has also been possible to adopt a great number of parts or assemblies from the standard hydraulic range of equipment.

The development of functionally reliable and uncomplicated standard European printed-circuit boards has also greatly contributed to the increased use of proportional technology.

An amplifier, containing the device-specific electronic circuitry, has been designed for each type of proportional unit.

These generally include:

- voltage stabilization stage
- ramp generator
- function generator
- command signal potentiometers
- command signal relay
- pulsed output stage

The overview in *Fig. 8* shows which functions are possible and which devices are available.

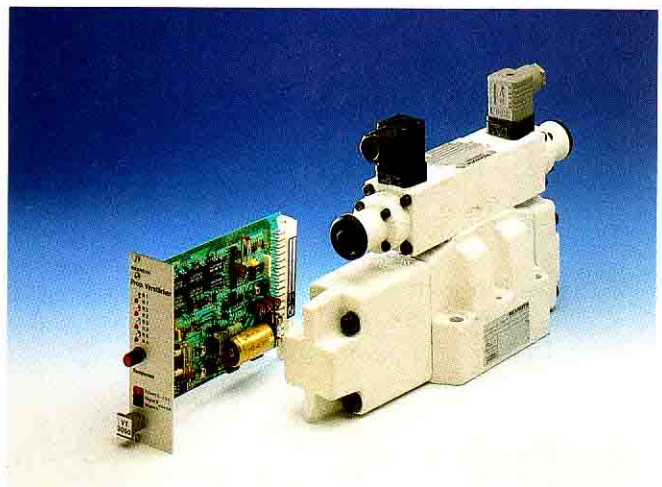


Fig. 5: *Proportional directional valve, type 4 WRZ, electronic controls type VT 3000*

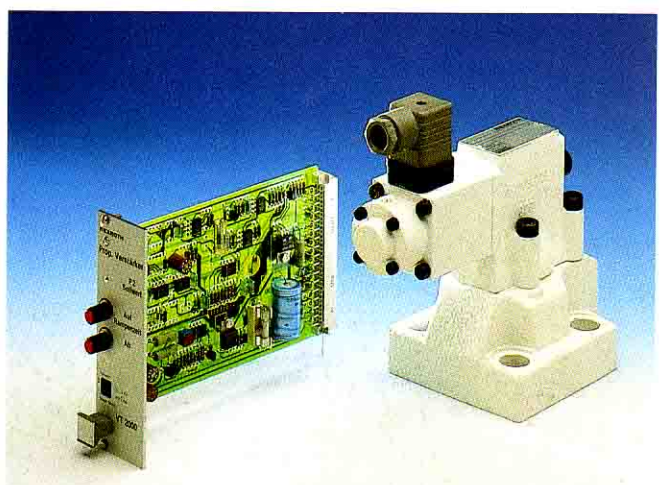


Fig. 6: *Proportional pressure relief valve, type DBE, electronic controls type VT 2000*

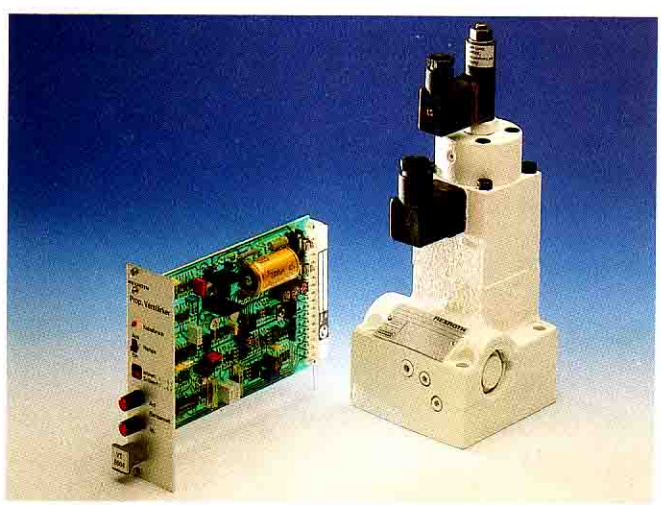


Fig. 7: *Proportional flow control valve, type 2 FRE, electronic controls type VT 5004*

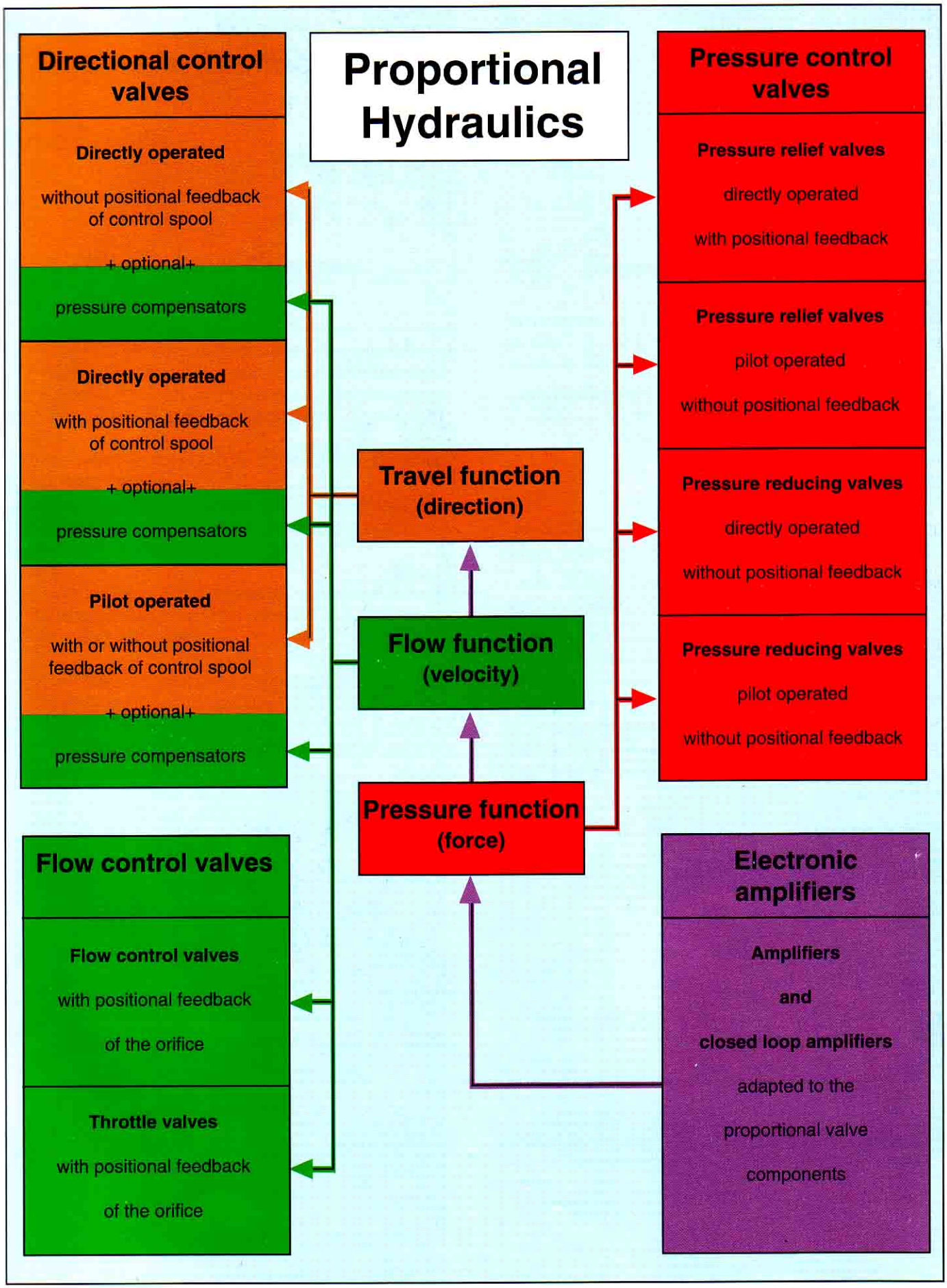


Fig. 8: *Proportional valves and possible functions*