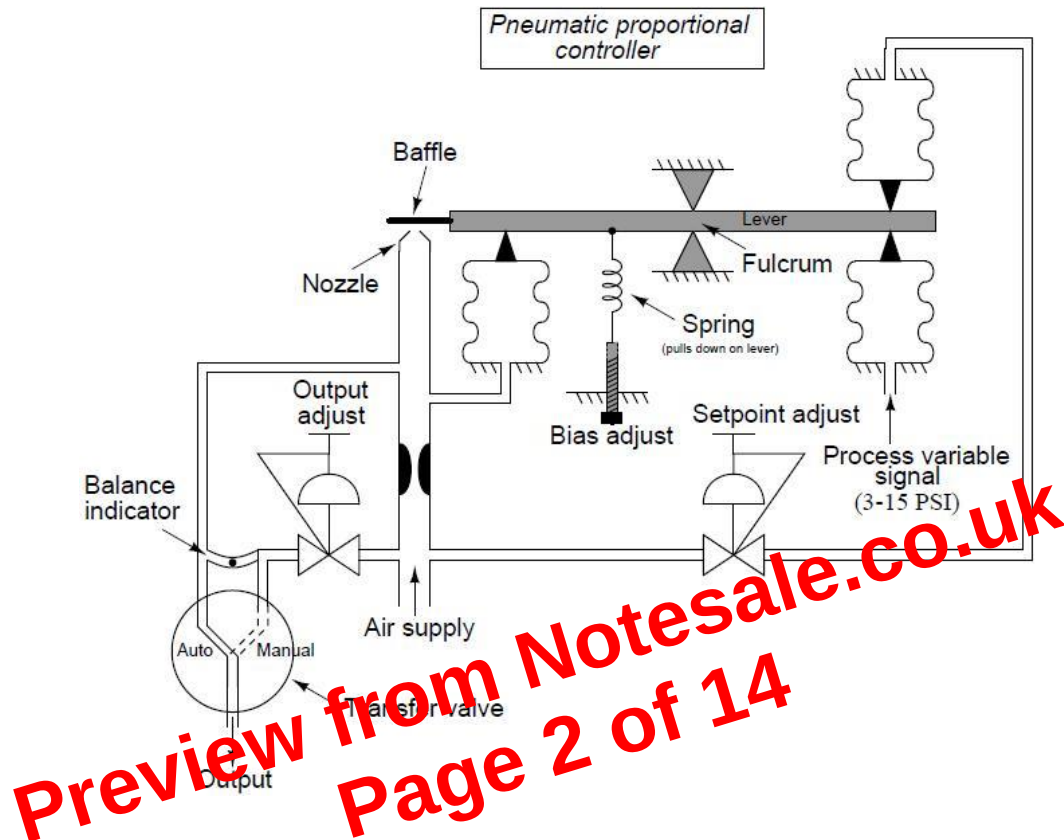


Automatic and manual modes

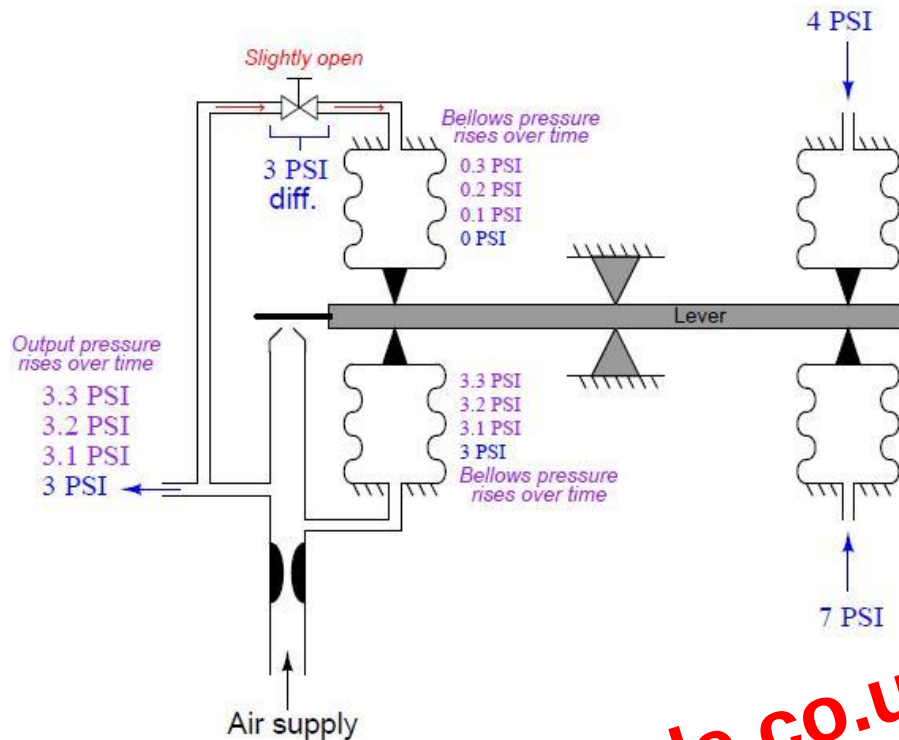
A more practical pneumatic proportional controller mechanism is shown in the next illustration, complete with setpoint and bias adjustments, and a manual control mode:



"Bumpless" transfer between automatic and manual modes is accomplished by the human operator paying attention to the balance indicator revealing any air pressure difference between the output bellows and the output adjust pressure regulator. When in automatic mode, a switch to manual mode involves adjusting the regulator until the balance indicator registers zero pressure difference, then switching the transfer valve to the "manual" position. The controller output is then at the direct command of the output adjust pressure regulator, and will not respond to changes in either PV or SP. "Bumplessly" switching back to automatic mode requires that either the output or the setpoint pressure regulators be adjusted until the balance indicator once again registers zero pressure difference, then switching the transfer valve to the "auto" position. The controller output will once again respond to changes in PV and SP.

Derivative and integral actions

Interestingly enough, derivative (rate) and integral (reset) control modes are relatively easy to add to this pneumatic controller mechanism. To add derivative control action, all we need to do is place a restrictor valve between the nozzle tube and the output feedback bellows, causing the bellows to delay filling or emptying its air pressure over time:



The greater the difference in pressures between PV and SP (i.e. the greater the error), the more pressure drop will develop across the reset restriction valve, causing the reset bellows to fill or empty, depending on the sign of the error) with compressed air at a faster rate², causing the output pressure to change at a faster rate. Thus, we see in this mechanism the defining nature of integral control action (that the magnitude of the error determines the velocity of the output signal with rate of change or velocity, or $\frac{dP}{dt}$). The rate of integration may be finely adjusted by changing the opening of the restrictor valve, or adjusted in large steps by connecting capacity tanks to the reset bellows to greatly increase its effective volume.

Fisher MultiTrol

Front (left) and rear (right) photographs of a real pneumatic controller (a Fisher “MultiTrol” unit) appear here:



The mechanism is remarkably similar to the one used throughout the explanatory discussion, with the important distinction of being motion-balance instead of force balance. Proportional and integral control modes are implemented through the actions of four brass bellows pushing as opposing pairs at either end of a beam: