Water beds for thin telescope mirrors, without the water

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Mirror Support

How will we support the newer, thinner meniscus mirrors ?

L/D ratios now being contemplated at 1:80, from the 'traditional' 1:8 of the Hale telescope

Is the beloved wiffle tree, applied to ultra-thin mirrors

- Practical
- Cost Effective
- Actually Any good ?

The Wiffle tree

- Many parts, many joints.
- Inevitably „uneven” on some scale, and, by the time 1:80 mirrors are reached
- Kinematically ill-defined

The perfect support

- High degree of consistency, at all elevations
- Simple
- Few mechanical parts
- Provide CLEAR access to the rear of the mirror
- Relatively low cost.

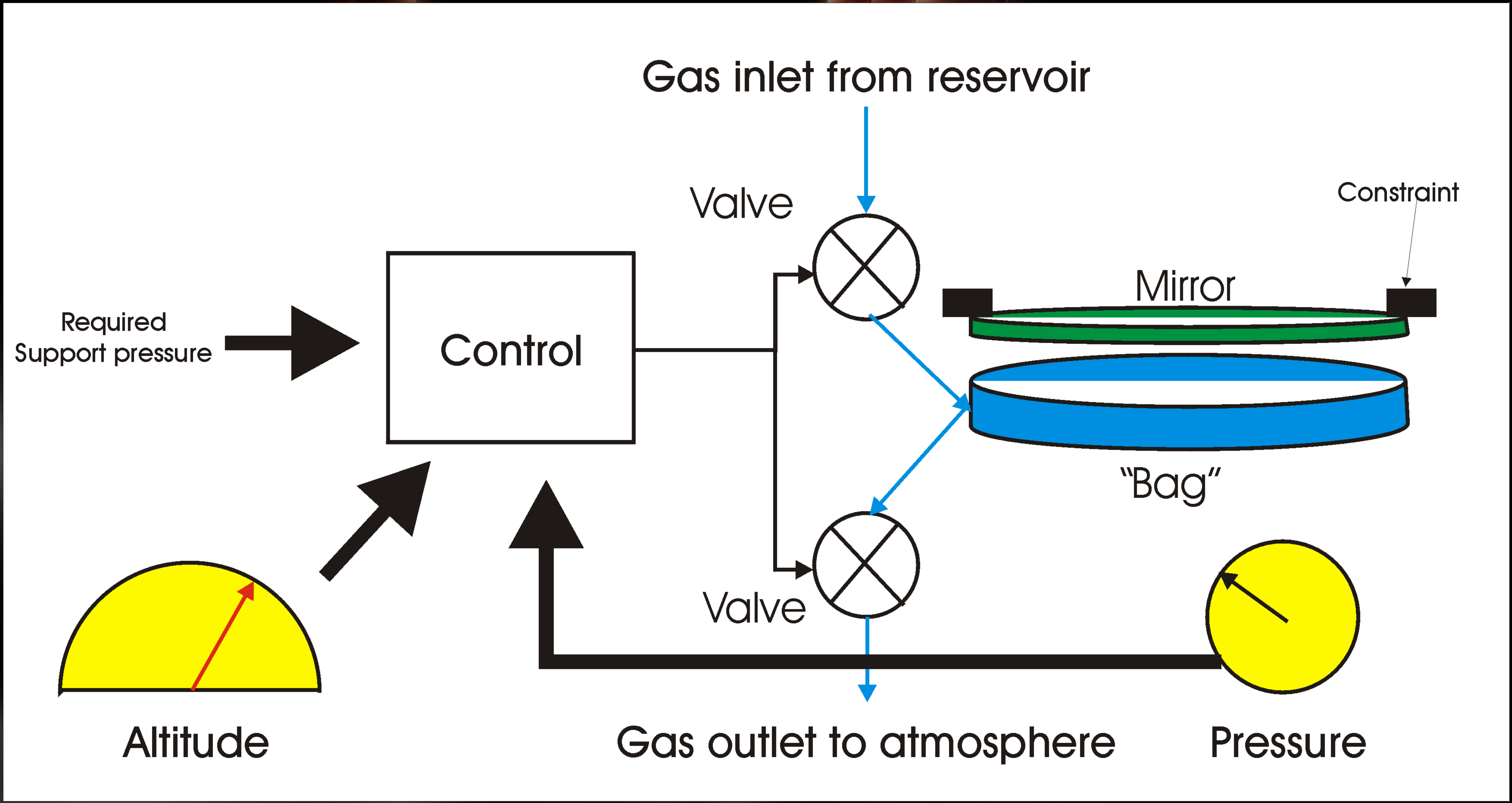
HOW ?

- Air bag support shown below

Elements of the system

1.) Gas bag.
2.) Gas reservoir.
3.) Valving.
4.) Pressure sensing.
5.) Attitude sensing.
6.) Support controller.
7.) User Interface.

Block Diagram of single channel



Gas Bag pressure.

- Axial support Maximum pressure ~10 mBar

ssure=

Pressure=¿

- Radial support

  Maximum pressures typically ~1 Bar

  1 Bar ~ 14PSI = 1MPa

The Maths, Axial case

Let

$\rho =$ **Density of glass** $\quad g =$ **Acceleration due to gravity**

Then

$$Weight = \frac{\rho \times g \times \pi \times Diameter^2 \times Thickness}{4}$$

$$Area = \frac{\pi \times Diameter^2}{4} \qquad Pressure = \frac{Weight}{area}$$

$$Axial\ Pressure = \frac{\rho \times \pi \times Diameter^2 \times Thickness \times g}{Diameter^2 \times \pi}$$

$$\underline{Axial\ Pressure = \rho \times g \times Thickness}$$

Axial pressure is independent of diameter

The Maths, Radial case

, supporting

$$Weight=\frac{\rho\times g\times\pi\times Diameter^{2}\times Thickness}{4}$$

$$Edge\ length=\frac{\pi\times Diameter}{3}$$

$$Edge\ Area=\frac{\pi\times Diameter\times Thickness}{3} \qquad Pressure=\frac{Weight}{area}$$

$$Radial\ Pressure=\frac{\pi\times Diameter^{2}\times Thickness\times\rho\times g\times 3}{4\times\pi\times Diameter\times Thickness}$$

Therefore

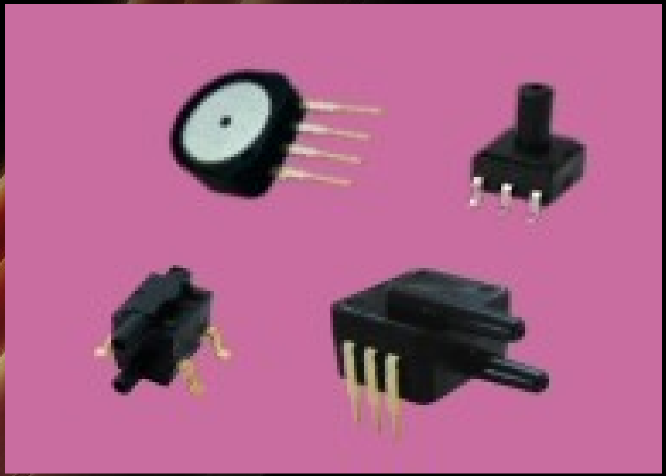
$$Radial\ Pressure=\frac{3\times\rho\times g\times Diameter}{4}$$

¿ **Radial pressure is independent of thickness !**

Pressure Sensing

- Low cost piezo resistive sensors available for

  ~$50 .



- Precision capacitance based sensors for ~$200

Image ©Sensor-technics
BCM-sensor

Elevation sensing

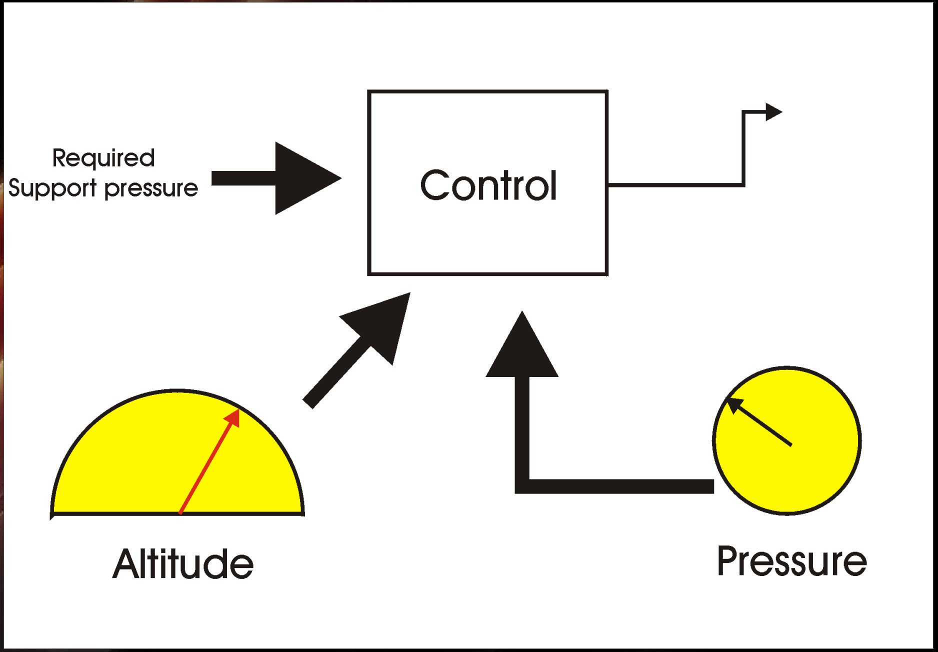
- Low cost 3 axis accelerometers, typically used in smartphones

  < $10

- Precision method, shaft encoder, with suspended weight ~$100

Controller

- Autonomous, embedded microcontroller, whose only function is to monitor the mirror, total cost <100 USD

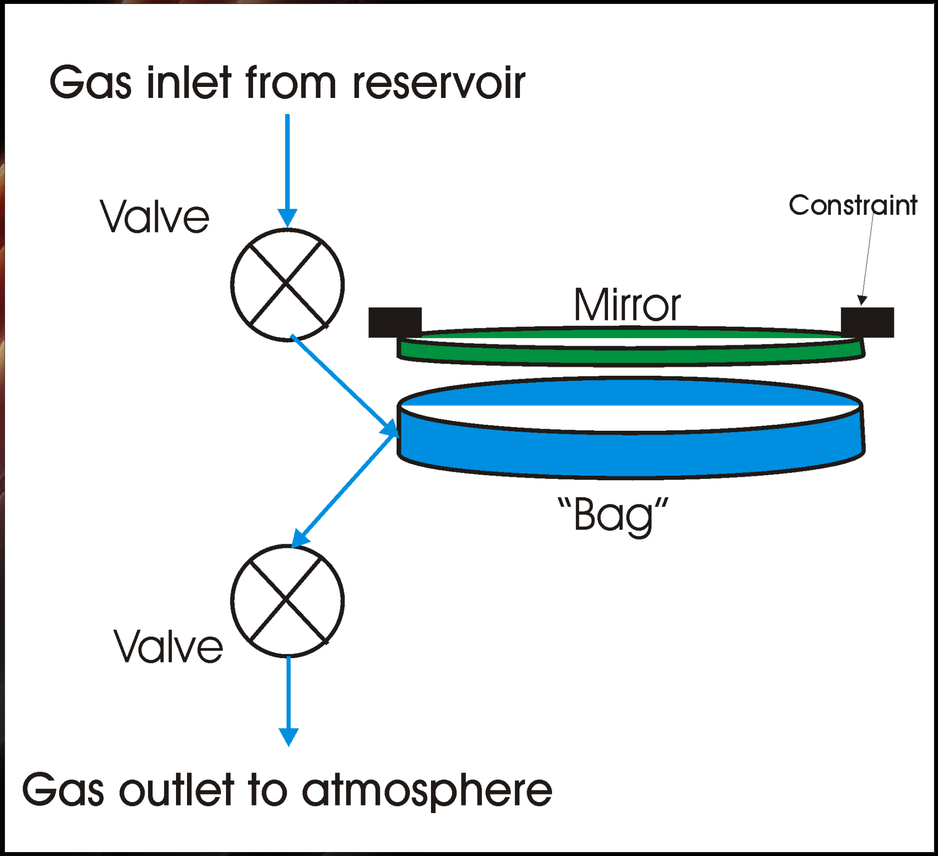


- All input sensors are digital, no need for Analog-Digital conversion and extra noise sources. Output sensors too are digital.

One Controller handles Axial and radial support

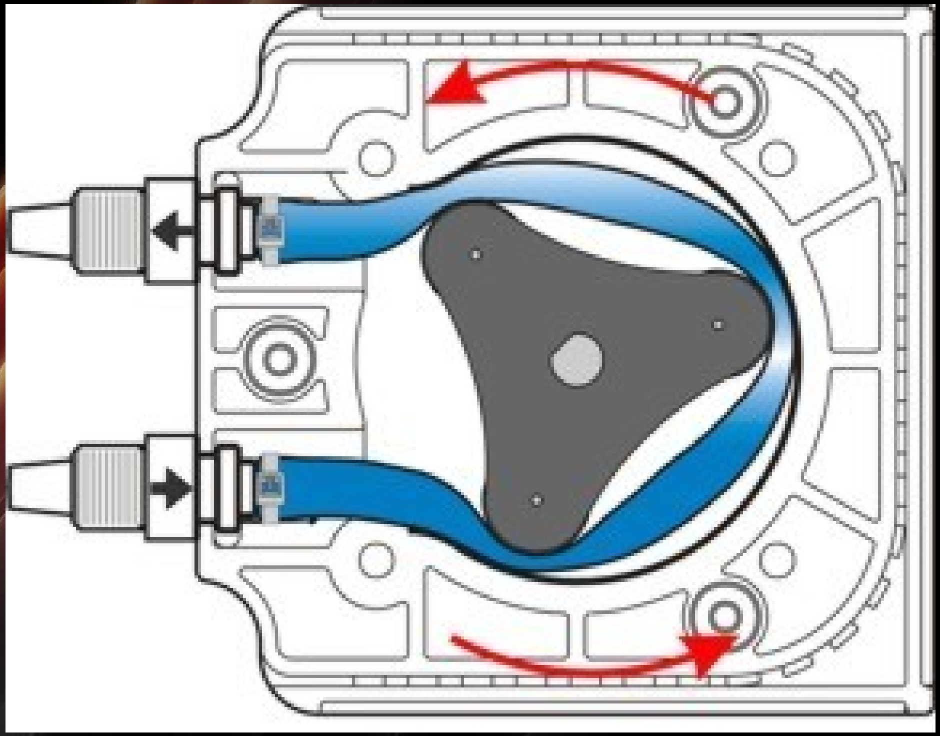
Valving and gas system

- Mechanical assembly is the expensive bit.
- Need two valves, an inlet and an outlet in one embodiment of the idea.
- Need a fast peristaltic pump in another design



Alternative concept

- Another way to do this utilises a peristaltic pump, now we need no valves and no reservoirs, but we need a fast pump for the primary inflation of a big bag



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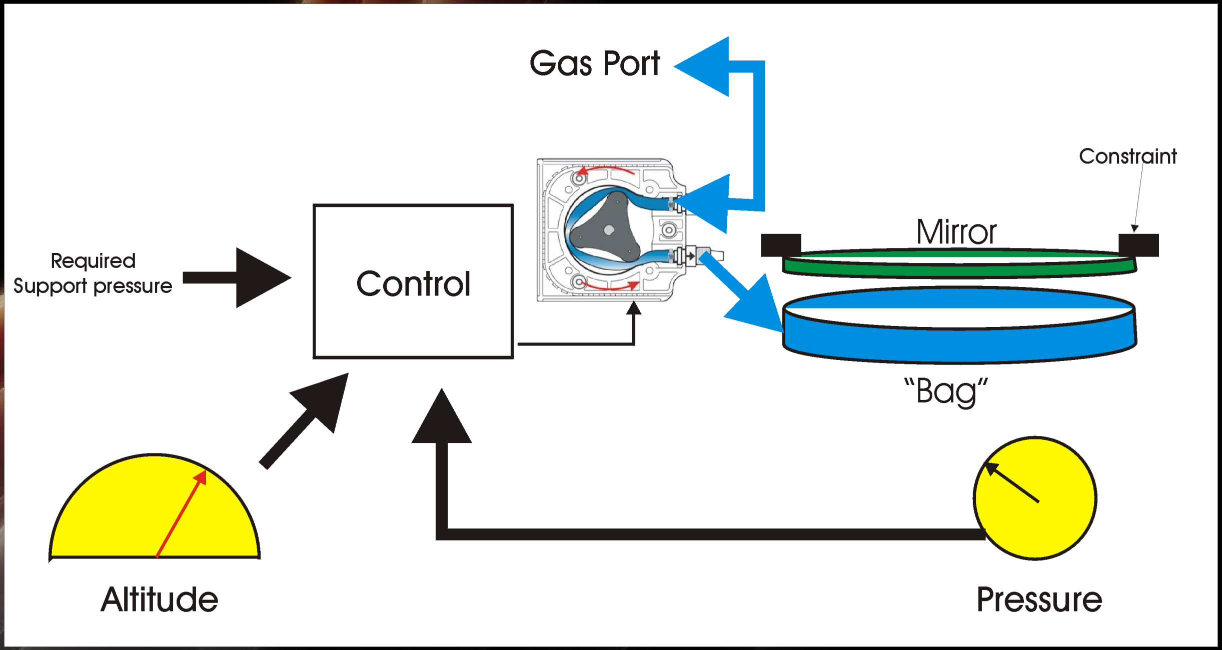
Pumped version

- Now the pump eliminates complexity, at the expense of speed.
- Pump goes one way, pressure goes up.
- Pump goes other way, pressure goes down
- Pump stopped, pressure stays fixed.



Control function

$$Axial\ Pressure = Axial\ design\ pressure \quad (1 - \cos(\theta))$$
$$Radial\ Pressure = Radial\ design\ pressure \quad (1 - \sin(\theta))$$

Where θ = angle of elevation 0° = Horizontal

Note NO dependency on temperature or atmospheric pressure, because controller is actively servo controlling the pressure with a digital PI loop.

User Interface

- Very little needed. Should be „Set and Forget”
- Calibrate Angle sensor
- Set Pmax at Zenith.

- Unit may have a display and small joystick button, or may be set over a virtual comm port on a USB connection. (that's almost old fashioned RS232)

Possibilities

By opening the back of the mirror, the addition of further active mirror control becomes possible AND such control will require less static supporting forces.

Clear space to circulate air within bag, metal backing creates lower thermal resistance from mirror to ambient

Project Progress

- Control system built, with peristaltic pressurisation
- Initial software ready.
- Waiting for candidate mirror to test.
- First testing ~1st quarter 2011

Acknowledgements

Russell Genet, for his infectious enthusiasm, and strong encouragement.

The members of the Alt-Az initiative, for their intelligent questions, and helpful suggestions.