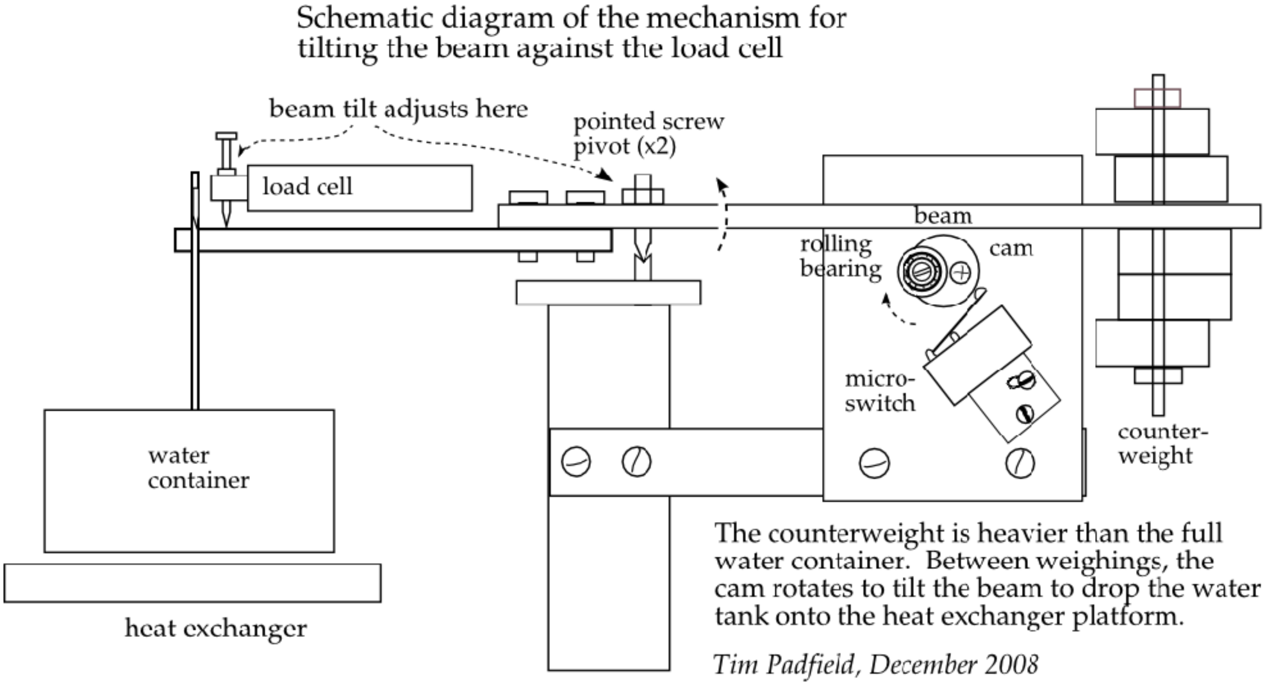
The new weighing device in the climate chamber

Tim Padfield, December 2008

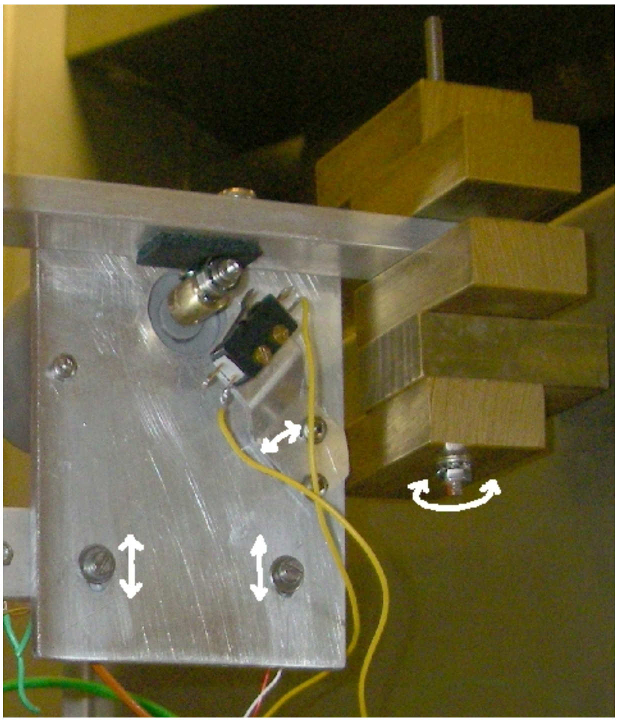


The original bending beam strain gauge has been replaced by a pivoted beam with a load cell registering the out of balance load on the beam.

The counterweight always pulls the beam down, even when the tank is full of water. The load cell, with 400 g capacity, measures the net upward force. It replaces the strain gauge bridge of the earlier, bending beam. There is no change to the 5V excitation, but there are different multiplier and offset to convert the millivolt signal to grams. This conversion to weight is done in the data logger, using constants inserted from the instruction file *climch_rc.py.*

The right arm of the beam is raised by the ball bearing cam which is rotated to the up position by a brief pulse (0.25 s) of current through a relay to the geared motor (invisible behind the cam). In this position the water tank is lowered to touch the heat exchanger. To weigh, a 0.25 second pulse of current is applied, through a different relay, to the motor, which rotates the cam clockwise to the down position. The microswitch, operated by the same cam, interrupts the current before the end of the pulse, ensuring accurately repeating up and down stop positions. In the down position, the cam releases the beam to swing up against the pin of the load cell. Compared to the previous weighing device, the data logger relay functions are swapped, so the weighing phase is governed by the relay that previously lowered the beam onto the heat exchanger. This change is effected in the program; *there is no change to the chamber wiring.*

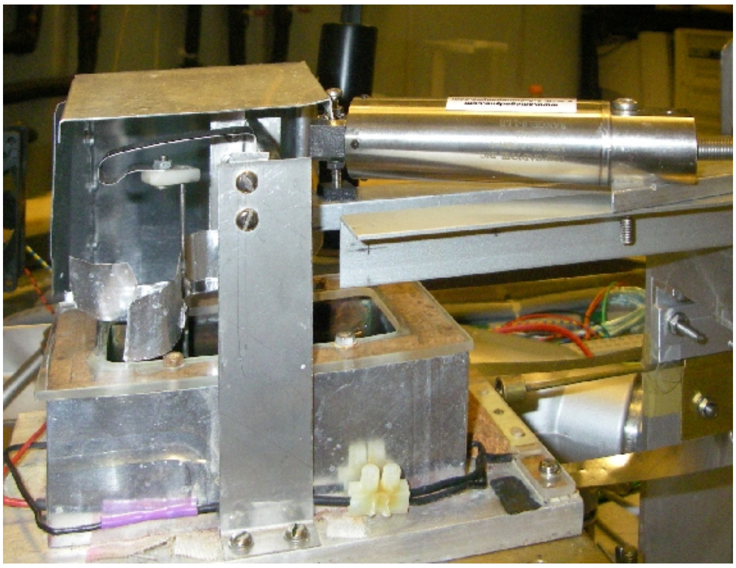
Mechanical adjustment



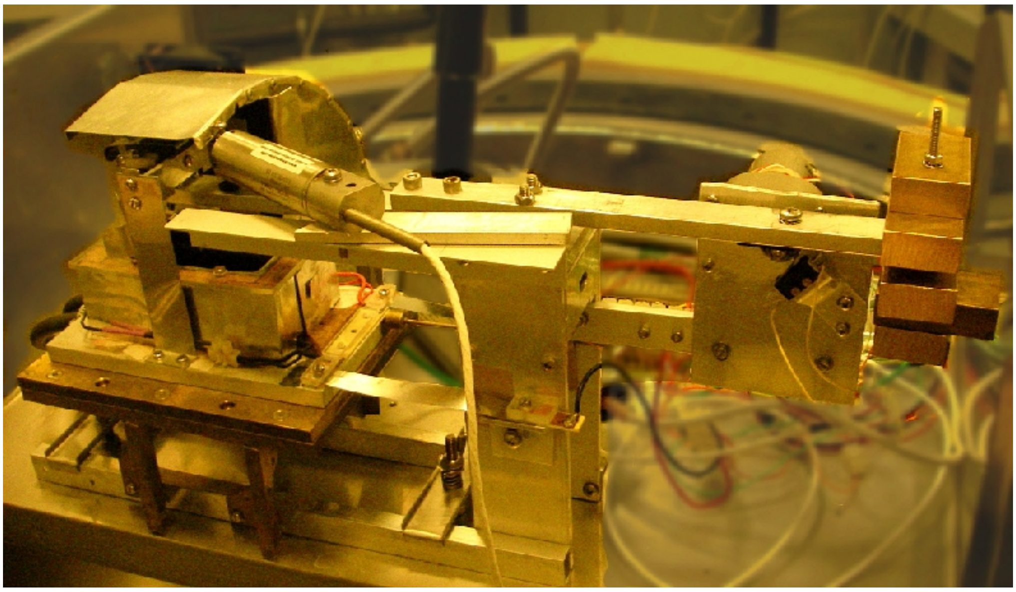
Counterweight: The counterweight is five rectangular brass blocks, each drilled off centre to receive the threaded rod which clamps them to the beam. The blocks are arranged both above and below the weighing beam to give a centre of mass approximately in line with the beam pivot point and the water tank pivot point. The exact counterweight moment is adjusted by rotating the individual blocks so their centre of mass is closer or further from the pivot. In this way, a continuous adjustment of the rotation moment is possible with just five brass blocks.

Cam adjustment: The entire assembly of motor and cam and microswitch can be moved vertically by loosening the two bottom screws, which slide in elongated holes. The microswitch is adjusted by loosening the upper screw of the bracket and rotating the bracket to bring the switch arm closer to the cam.

Vibration damping: The cam action is quite rapid, so the free beam bounces against the load cell. Small neoprene pads are glued to the beam, under the load cell pin and above the cam. These damp the vibrations so the beam comes to rest at about the same time as the air movement in the specimen chamber stops, ready for weighing. A seven second delay before measurement is written into the control program, though it could also be implemented in an instruction to the data logger.



Load cell: This is an Omega LC601-1. It has a maximum load of 400 g, suitable for the 20 - 160 g range between full and empty water tank. The load cell is protected by screws which limit its deflection in all directions. It is held fast by a screw at the right end of the cylinder. The active end is fitted with an adjustable bolt with rounded end which beds into a neoprene foam pad on the pivoted beam, close to the suspension point for the water container. The bolt is adjusted so that there is about one mm clear space between the heat sink and the heat exchanger in the weighing position of the beam.



The weighing beam: The water container and its heat sink and heat exchanger continue unchanged from the previous device, as does the frame with its central pillar. The new beam is stiff. It pivots about the points of the two screws in the centre of the beam, above the central pillar. These screws are threaded through the beam. Their vertical position is locked by nuts. The sharp screw tips bear on two grub screws with hollow tops set in the vertical column. The relative projection of the screw tips below the beam is set to ensure that the heat sink is exactly parallel to the heat exchanger, so the water tank sinks accurately down onto the heat exchanger. The water tank is suspended so it has a tendency to swing away and thus tension the retaining strips (which also serve as power leads to the Peltier devices), however much water is in the tank. The length of these strips is adjusted after loosening the screws clamping them to the heat sink.

The beam can be removed without disturbing the rest of the apparatus, though there is only just enough space for the manoeuvre. Take care not to disturb the delicate fan blades of the water stirrer.

Weighing precision: The precision is limited mainly by the beam pivot system. The beam is moved at each weighing, currently every minute. The four pivot points have to settle into a reproducible position. The standard deviation in a typical run was 0.08 g. This is about ten times better than the previous bending beam weighing system. In the earlier version, the beam had to have a stiffness to bear the approximately 1000 g load of the water tank and heat sink without exceeding its elastic limit, so the voltage change per gram from the strain gauge bridge was much smaller.

Overall precision: The improved weighing precision has moved the focus to sources of inaccuracy in other parts of the apparatus, notably the chamber temperature control. There is interaction between the Peltier activity and the chamber temperature control, because there is considerable heat exchange between the chamber air and the water surface and the heat sink. At the time of writing the proportional control of the temperature is being optimised, but ultimate stability may require changes to the program to make the temperature control algorithm incorporate heat transfer from the Peltier system.