The Basic Haig Mount

The Haig mount (sometimes called the Scottish or barn door mount) is a device that enables a camera to track stars as they move across the night sky, so that a long exposure will reveal the stars as points of light, rather than "star trails" across the film or camera sensor.

The basic design is simple (see Figure 1). Two flat boards A and B are joined along the edge by a hinge H which acts as a pivot. Board A is fixed on a wedge so that the axis of the hinge point to the pole star. The camera is mounted on the upper board B on top of a standard universal camera mount, which allows the orientation of the camera to be adjusted as desired. Board A is penetrated by a screw bolt S, so that by turning the screw the upper board B may be raised and so turn through the angle α about the hinge H. (In practice the screw bolt is not fixed into the bare wood of board A, but instead passed through a nut embedded in the board.) The rate of turn of board B is determined by the rate of turn of the screw and can, with care, track the stars as they turn in the sky overhead.

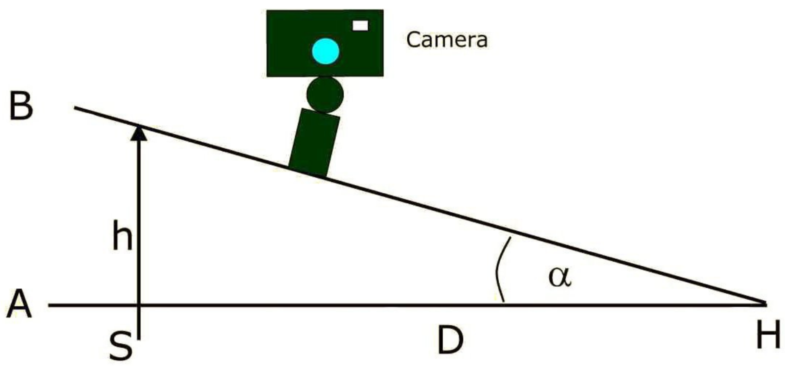

Figure 1

How can we determine the rate at which we should turn the screw to obtain the correct tracking rate? The Earth rotates through 360^{o} in 23 hours 56 minutes (sidereal revolution), which is equivalent to 0.25^{o} per minute, this is the rate of tracking we require. Ideally we should construct the mount so that an easily maintained rate of screw turn will produce the desired tracking rate. This rate is usually chosen to be one turn per minute, which is easy to maintain if a clock with a minute hand is close by. With this decision made, the maths is simple.

Let D be the distance from the hinge H to the screw S. The height of the screw above the board A is the distance $h.$ Then from simple trigonometry we can see that:

$$h = D \tan \alpha \tag{1}$$

From which we obtain by differentiation with respect to time:

$$\frac{dh}{dt} = D\, sec^2 \alpha \frac{d\alpha}{dt}, \tag{2}$$

or:

$$v = \omega D \sec^2 \alpha, \tag{3}$$

where ω is the rate of tracking across the sky and v is rate at which the screw bolt moves through board A. Now it can be shown that for $\alpha \leq 10^o$, $\cos^2 \alpha \approx 1$ with an error of ~ 3%. Hence for small α (in practice less than 10°):

$$v \approx \omega D = \frac{0.25\pi}{180} D. \tag{4}$$

In which we have used the fact that $\omega = 0.25^o$ per minute and then converted from degrees to radians. This formula shows that, provided α remains small, the speed of the screw through board A is directly proportional to the required (and known) rate of tracking and to the distance D of the screw from the hinge. This formula can be rearranged to:

$$D \approx \frac{720}{\pi} v \tag{5}$$

so if we knew what v was, we could calculate D, or where to position the screw bolt in the lower board.

The speed v is easy to obtain. Firstly we know that the screw turns once per minute, because that is what we decided above. We can also work out how far the screw progresses in each turn, by measuring how far it moves through its nut in (say) 10 complete turns of the screw. (This is easier to measure than the distance moved in just one turn, and is more accurate provided we count the number of turns correctly. We can obtain the required distance per turn by dividing the measured distance by 10.) Thus if we obtain Y centimetres per turn, then v will be simply Y centimetres per minute. Now we can calculate the length D.

Note that if we measure the screw rate in centimetres per minute, the formula gives D in centimetres, as you might expect!

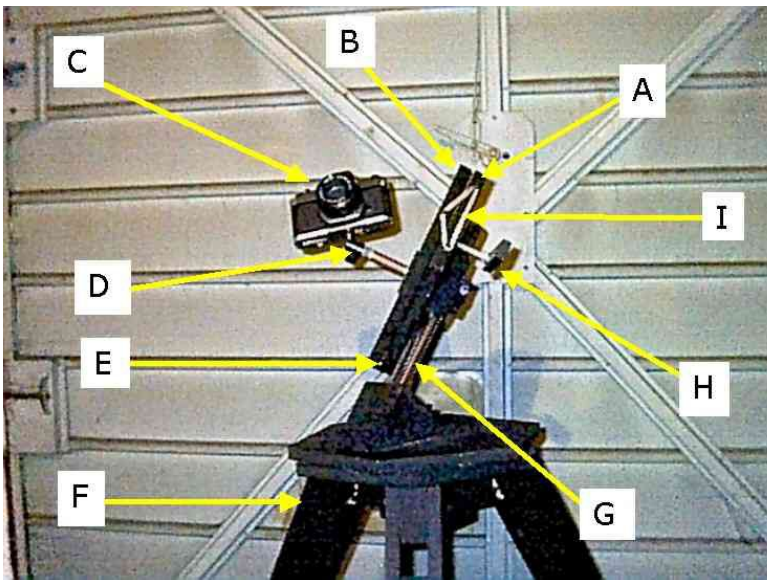

Figure 2: A practical Haig Mount

In Figure 2 above, an example Haig mount is shown. This has been used successfully by the author for a number of years to obtain quite acceptable pictures of the night sky with a SLR camera (Pentax K1000) and a 50 mm lens. Typically 1 minute exposures with ISO 400 film (I have used Kodak Elite Chrome and Fujichrome Sensia 2 with equal success). I have also used it with a DSLR and a 50 mm lens with ISO set at 800. Note however that such a device is not recommended for use with long focus lenses, as it is very difficult to maintain a precise enough driving speed, and much more care needs to be taken in aligning the hinge axis with respect to the celestial pole.

The parts list for Figure 2 is as follows:

- A - Lower board (A in text);
- B - Upper board (B in text);
- C - Camera;
- D - Universal camera mount (on pillar);
- E - Hinge (parallel to polar axis G below);
- F - Tripod stand (not essential);
- G - Polar axis (fixed to back of board A);
- H - Screw bolt with turning handle;
- I - Elastic bands to maintain hinge tension