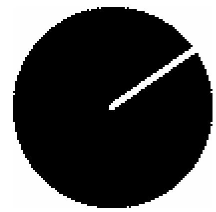
Section D. Measuring Short Time Intervals and High Speeds

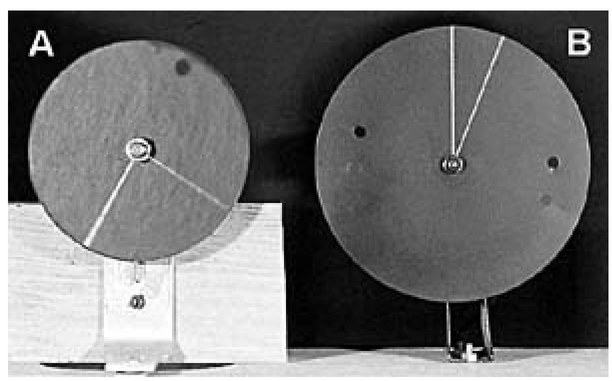
Introduction

A single flash unit can capture dramatic images of rapidly moving objects without giving much information about how fast the objects are moving. The only clue is usually some blurring of the object. This results from the fact that the image moves a perceptible distance along the film plane as the flash unit is discharging. Two or more flash units and a high-frequency clock are needed to measure speeds.

The clock may simply be a black cardboard disc being turned at high frequency by a motor. The motor can be a small, household fan with the blades removed. The disc, shown to the right, has a white, radial line painted on it to serve as a hand. If the disc is turning as two flash units are discharged in succession, an image of the line appears for each discharge. The angle between the two images is proportional to the time interval between flash discharges. Of course, one has to know how fast the disc is spinning in order to calculate a time interval. The disc frequency is usually measured with an electronic stroboscope.



The photograph below shows two high-frequency clocks of different frequencies. Two flash units were discharged toward the clocks as they were rotating. Since the time interval was the same for both clocks, the fact that Clock A rotated through a greater angle than Clock B shows that A was rotating faster. In fact, A was rotating about 4 times faster than B, as the angles are about 89° and 22°. If the period, the time for one complete rotation, is known, then the time interval between flashes is obtained through a proportion as follows:



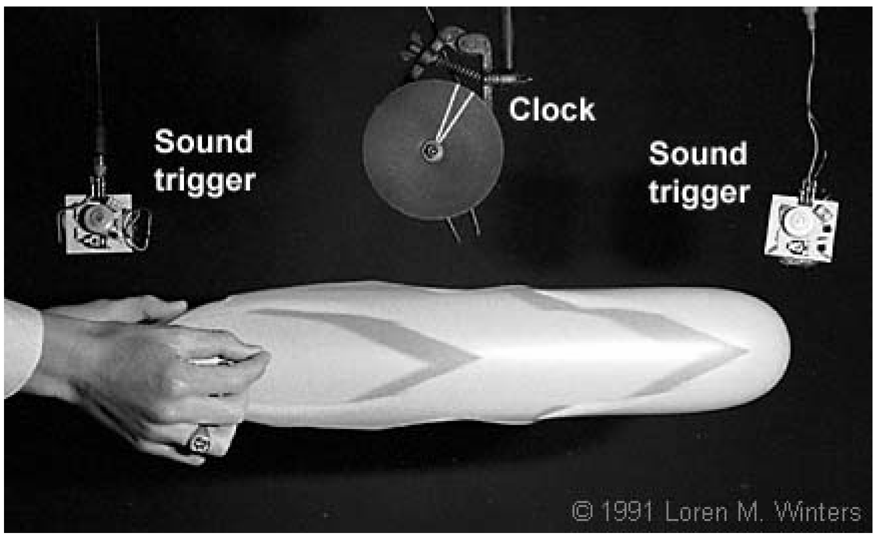
$$\frac{time}{period} = \frac{angle}{360°}.$$

Note that the period is simply the inverse of the frequency, which is measured with a stroboscope. In this particular case, the frequency of Clock B was 50 rps. Using the formula above, the time interval between flashes was about 0.0012 seconds. Since angles smaller than 22° are easily measurable, sub-millisecond time intervals can readily be measured with this technique.

With faster clocks, greater angles are swept out for the same time interval. A fast enough clock, therefore, can be used to estimate the brief duration of a flash burst. In this case, a single electronic flash illuminates the disc, and the hand sweeps out a blurred sector as the flash unit is discharging. The lines in Clock A show evidence of such blurring, but the angle is only a few degrees at the most. An angle of 2° would indicate a flash duration of about 30 millionths of a second. This is typical of shortest durations obtainable with consumer grade flash units. Of course, one would need a much faster motor to obtain an accurate measurement of flash duration using this technique.

Timing: Measuring High Speeds

With a high-speed clock such as the one described previously, one can measure very high speeds. The photo below shows the elements of a setup to measure the speed of a balloon rip. The clock is centered above the balloon. Two sound triggers placed at opposite ends of the balloon were used to trigger two flash units. The sound from the pop took longer to reach the trigger on the right, thus delaying the second flash discharge.



The time delay would approximately be the difference in time for sound to reach the two triggers from the puncture site. (The delay also depends on the response time of the sound trigger circuitry. This may not be the same for the two triggers.)

The two flash units captured two superimposed, V-shaped images of the moving rip. One could estimate the speed of the rip in relation to the speed of sound simply by comparing the distance traveled by the vertex of the rip to the difference in distances from the puncture site to each of the triggers. The result is about 5/7 of the speed of sound or 250 m/s.

A more accurate measurement can be obtained using the angle swept out by the hand of the clock. This method of measuring the time interval has been described previously. The distance traveled by the rip vertex can be measured in relation to a known distance. The diameter of the clock disc can serve this purpose as long as the disc is the same distance from the camera as the rip.