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Calibrating your shutters

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Coincidentally to the proposal for this presentation (as well as many times earlier) there appeared in the popular literature a general description of the two tests I'll be describing related to shutter speed testing with a TV set and a turntable. A bonus bit of information for those in attendance will be the description of a high speed sequence camera made from a standard SLR.

SHUTTER TESTING WITH A TV

To test the higher speeds of a camera a black and white TV set, a ruler and a slide projector are needed. The "time base" against which the shutter is compared is the (NTSC) industry standard of 15,750 horizontal lines scanned on a TV picture tube face each second by the cathode ray gun. These 15,750 lines make up 30 separate pictures but 60 total scans of the tube face. This means that the tube face is made up of 262 1/2 lines and that each total picture consists of 2 superimposed scans of the tube face each lasting 1/60 second. That is, to present one of the 30 different pictures shown on the TV tube each second the gun first scans 262 1/2 lines on the screen in 1/60 second and then scans another 262 1/2 lines between the first set of 262 1/2 lines in another 1/60 second! This is called interlacing.

To test the shutter with a TV screen set the camera up so that the back is paralell to the screen and the screen pretty much fills the viewfinder. It could actually even fill it completely with no major ill effects. Load the camera with high speed (400) film. Your pictures of the screen should be made with the TV set set to a non-picture channel.

Theoretically then, with an exposure time of 1/15,750th of a second we would only see one line on the screen. The line could extend from edge to edge on the screen or start halfway along one horizontal line and end halfway along the next lower horizontal line. This depends on the exact time at which the shutter in your camera opened. A consequence of this is that the more lines we see in a picture of the screen the longer the shutter remained open. These lines must be counted along the vertical direction with respect to direction of the TV screen. You should take a number of pictures to ensure that you count these scan lines always in about the same area on the frame.

The exposure time is given by number of lines counted divided by 15,750. This test is usable all the way to 1/125 easily. At 1/60 second there may be a slight offset or overlap between the first and second interlaced scan patterns. If there is a clearer or less dense space, count the number of lines missing and subtract from 262 to determine total lines; if

there is a region of overexposure or a dark band, count the extra lines in the dark area and add to 262. This eliminates concern over lines which may be "out of the picture." A similar situation exists at 1/30 of a second. If there is a "clear" area here you'll notice it has the same density as the predominantly "grey" area of the 1/60 second speed while the overall density will be similar to that of the "dark" area in the 1/60 second shot if your 1/60 of a second was on the long side. If there is a clear band between the overall density areas subtract the number of lines in this band from 525 and if there is an even darker band apparent, add the number of lines in this band to 525. Thus, the largest number of lines you'll need to count will be about 126 for the 1/125 second speed. While this test works best with FP shutters, leaf shutters can also be tested but the number of lines will be harder to count because of indistinct areas at top and bottom of the scan pattern.

By the way, you only need to take an exposure reading at 1/60 of a second and use the f number required for this speed for all your speeds. The slide projector is used to blow up your negatives to a convenient-for-counting size!

In addition, if you are testing a FP shutter, you can also determine the exposure time and slit width at various locations across your frame, and also curtain velocity and acceleration. Of paramount importance is that exposure should be even from one side of the frame to the other. To determine the degree of unevenness just count scan lines on the far left and right of your frame by making sure that the TV screen completely fills the field of view of your camera.

To roughly determine what the width of the slit is at any given speed simply measure the length on a contact print of any given line in the horizontal direction. You will notice that at one side of the frame the lines are shorter than at the other. This is due to the compensating action that the FP shutter introduces to automatically keepthe exposure time the same even though the curtain is accelerating as it moves across the frame. You may also notice that the width of the slit increases in direct proportion to the increase in exposure time such that doubling the exposure time doubles the slit width. You can only prove this for some of the shorter times because the width soon exceeds the width of the 35mm frame but if you want to see the principle at work there it will be at speeds of 1/250 and higher. The implication of this last item is that the curtain velocities remain the same (also evident from the fact the the slopes of the scan patterns remain constant) as the exposure time change definitely indicating that exposure time changes are due to slit-width changes and not to variations in spring tension.

Note: If you are blowing the image up with a projector then first determine how many times bigger the projected image is than your contact print and then divide the measure slit width by this factor to arrive at close to the real witdth of the slit during exposure.

Finally, make sure that a vertical FP shutter camera is turned on its side to take the TV screen pictures or the test will be slightly off due to the fact that the slit will be moving with or against the motion of the scanning beam.

With a digital camera that "shutters" its exposures electronically the only test one can perform is that of exposure time accuracy since the shuttering action is not performed mechanically with a scanning slit and so the results look similar to those one would achieve with a leaf shutter photographing a TV screen. Namely only horizontal "bands" containing more or fewer lines depending on exposure time delivered by the shutter. Here you can see the effect of a digital camera operating at a variety of speeds and the results that can be obtained.

TESTING WITH TURNTABLE

To test the slower speeds a turntable running at 33 1/3 RPM or 200 degrees/second, a protractor and a slide projector are needed. If you have a 78 RPM turntable your accuracy will increase by almost 100% at the shorter speeds.

Place the camera on a tripod and photograph the turntable placed on the floor from a vertical angle. On the edge of the record tape a narrow (about 1/8- to 1/4 inch) piece of white tape. On the edge of a 12-inch disc the 1/8 inch tape moving at 33 1/3 RPM will be giving an "exposure time" of about 1/100 second while the 1/4 inch tape will be twice that. At 78 RPM these figures will be cut in half. Since at the longer times the black surface of the disc may be reflecting enough light into the shadow areas to bring the density too high up onto the shoulder of the film's characteristic curve instead of assuming an exposure time of 1/100 second use a time of roughly 1/15 second. Adjust the aperture to give a proper exposure with the lighting available and with the film you'll be using and do not change the aperture as you make exposures from 1 second to 1/60 (or 1/125 if you have a 78 RPM turntable) second. Also make one exposure with the turntable stationary. Use an incident light meter to determine exposure since the record you'll be photographing is quite dark. Or substitute an 18% grey card for it to determine exposure.

To determine exposure times, first blow up and measure the arc covered by the white tape on the stationary mode. Then subtract this number from the number of degrees the white mark covered at the various exposure times and divide the figure by 200 if your turntable was a 33 1/3 or 468 if it was a 78 RPM one.

Correlate the 1/30, 1/60, and 1/125 speeds with the tests done with the TV set. At these speeds in particular some error will be introduced if you're testing a FP shutter if the white mark is moving with or against the shutter movement while the exposure is made. If testing an FP shutter try to make the exposure so that the mark is moving perpendicular to the shutter motion at the beginning (and end, if possible) of the exposure.

For further introductory material on these methods, consult the popular literature. The February and March issues of 1980 of POPULAR PHOTOGRAPHY recently referred to these tests. The description of how to use a FP shutter camera as a 1000 picture per second camera will be provided to participants attending the presentation, and anyone else may write to me at the Rochester Institute of Technology or call me at (716) 475-2592 for the details or send me e-mail at andpph@rit.edu.