OPTICAL ENGINEERING NOTE #78
THE GUTS OF A 35mm SINGLE LENS REFLEX CAMERA

A hapless little **Vivitar 250/SL**, serial number 94400623 stopped working properly for its original owner, and got turned into a pinhole camera for an Optics class project. To add insult to injury, I further dissected it for your educational viewing enjoyment.

The camera can be broken down into four discrete components: the camera body/film transport; the reflex viewing system; the shutter assembly; and the metering system.

The camera body is an aluminum casting, and holds the film in an appropriately dark chamber. The other sub-assemblies attach to it. The cocking lever not only advances the film the appropriate distance, but tensions the springs in the shutter mechanism, and cocks the mirror assembly. Observe the action of the rack (a linear gear) on the bottom of the camera body as you move the lever.

The reflex viewing system consists of a box that holds the front surface mirror that intercepts the image coming out of the lens and reflects it up to a ground glass at the top of the box. This finely sand-blasted glass has some small micro-prisms etched into it as a focussing aid, but it does not have the split prisms that are much more popular.

If the image were to be viewed at this stage on the groundglass, the vertical inversion of the real image would be corrected by the mirror, but left and right would still be crossed. A pentaprism not only reflects the image on the horizontally oriented groundglass so that it exits the eyepiece in a conveniently ergonomic matter, but twists left and right around.

Even though the pentaprism works by **TIR**[*], it is protected from scratches and dirt by a plastic covering. The lateral inversion is accomplished by the 90 degree angle at the top of the prism,

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[*] **T**otal **I**nternal **R**eflection.

in the same way that you were treated to a view of yourself in the orientation that others see you when you looked at the pair of mirrors held in a right angle clamp in an earlier unit. These orthogonal sides reflect the light downward to the front of the prism, which sends the light back to the eyepiece.

The eyepiece is a 75mm positive lens used in the Case 5 conjugate distance[1]. The distance from the groundglass to the photographer's eye is only about 70mm, way closer than the normal person's near point. The eyepiece lens produces a magnified virtual image at a distance accessible to all.

Also on the mirror box assembly is a crescent-shaped metal piece that moves forward out of the camera body to push a pin on the lens mount that stops down the lens to its picture taking aperture. Normally the lens's aperture is kept wide open to provide the brightest image in the viewfinder; but to control the intensity of the light and the depth of field of the scene, the lens needs to be stopped down. This may dim the image in the viewfinder, making it hard to focus.

The light metering system looks at the image on the groundglass through two CdS cells on either side of the eyepiece. Since they are photo-resistors, the rest of the circuit is simply an Ohmmeter. Power was supplied by a 1.3 volt battery, and a small meter movement whose needle poked into the groundglass area measured the voltage after having passed through the CdS cells.

To activate the meter system, a sliding switch connected the battery compartment with the meter system and pushed the above-=mentioned crescent-shaped metal piece into the lens, stopping it down to the taking aperture. This made the viewfinder dim, but it enabled the light meter cells to see the intensity of light as the film would see it. Depth of field can also be previewed at this point.

The more light, the lower the resistance of the cells, and the meter would read more voltage by moving up to the + sign visible in the groundglass. To prevent overexposure of the film, the shutter speed would have to be shortened to compensate, and a string still tied to the meter movement would communicate these changes to the metering system, by physically moving the body of the meter mechanism. Alternatively the light could be too dim to center the meter needle in the viewfinder, and the shutter time could be lengthened. The film speed was also keyed into the shutter-f/stop equation on the shutter speed selector dial.

The shutter mechanism was timed by clockwork. The plastic gear on the front of the assembly selected various gear trains and spring tensions to regulate the time between the travel of the two focal plane shutter curtains.

There are two wires coming out of the shutter assembly, and they are used to synchronize the firing of the flash with the shutter. The brown wire would be used with the M socket on the camera to tell a flashbulb, which takes tens of milliseconds to burn, when to ignite. A simple mechanical switch on the timing gears closes the circuit.

The blue wire tells an electronic flash when to fire. This burst of light lasts only several milliseconds, so timing is more critical. On this camera, 1/125th of a second is the first speed that both shutter curtains are out of the way of the film during the exposure, so this is the preferred time for flash exposure. At shorter exposure times only a portion of the film may be uncovered when the flash goes off, so the picture may come back with only a slice exposed.

The taking of the picture required a Rube Goldberg type of cooperation between the shutter mechanism and the reflex mirror box. When the release button was pressed, it first activated the retraction of the mirror. When the mirror was up, and the crescent-shaped metal piece had stopped down the lens, a lever on the mirror box released the shutter. When the shutter was done exposing the film, a lever popped out of its mechanism and released a catch that let the mirror flip down. Advancing the film of the next shot also resets the shutter blades into the ready position, tensions the shutters clockwork timing mechanism, and cocks the mirror flipping action.

This mid-70's camera wasn't the state of the art when it was new, and pretty much obsolete now, but that didn't stop it from taking decent picturres. It does illustrate the basic principles of the ever-popular 35mm SLR format. Nowadays the shutters are timed electronically, thanks to meter systems use silicon cells and are so sophisticated that they can accurately, automatically expose the film. Tiny motors to advance the film are becoming standard, and DX coding on the film cassette tell the meter what you're using. Possibly the only refinement in the future that is possible is to replace the photo-chemical film with photo-electronics of the same resolution.

REFERENCES

1. See the **Handout, OPTICAL ENGINEERING NOTE #9: APPLICATIONS OF CONJUGATE RATIOS** IN uNIT 03.