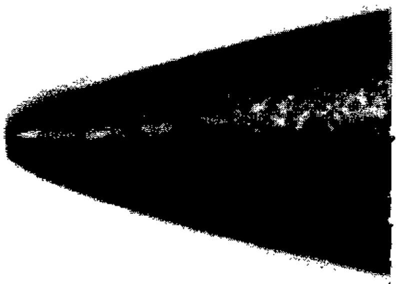
DAYTIME LASER PHOTOGRAPHY



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Investigators attempting to recreate the flight paths of fired projectiles or bullets have a number of options, including the utilization of trajectory rods, colored strings, and lasers.

Each of these reconstruction tools has their benefits and weaknesses, but lasers have always provided the straightest and sharpest representation of a fired bullet. Lasers have typically been limited to use in nighttime or low light conditions. However, by using high-powered lasers and a couple of photographic accessories, investigators are able to photograph laser trajectories at daytime crime scenes.

EQUIPMENT

The first necessity is a strong laser. A laser's strength can be identified by its milliwatt (mW) rating. A milliwatt is one-thousandth of a watt and a typical laser pointer has less than 5 milliwatts of energy. A laser with less than 5 milliwatts of power is classified as class IIIa laser and is typical of those lasers included in shooting reconstruction kits sold by crime scene supply companies. The lasers included in these kits are entirely inadequate for daytime reconstruction efforts and can even be problematic in illuminated nighttime environments. Class IIIb lasers have greater than 5 milliwatts of power and are necessary for daytime photography.

Lasers with enough power to complete a daytime laser trajectory photograph can be found on the Internet. These lasers are not sold as "laser pointers" because of the potential harm they can cause to the eye's retina. However, they can be found and purchased for purposes including research, pointing out stars in the night sky, and military applications. Class IIIb lasers are typically manufactured and sold through internet companies operating in China. The quality of individual lasers can differ significantly with regard to the beam's focus and intensity, even among lasers that are rated with the same number of milliwatts. Investigators can research lasers at a number of websites, including the following:

www.dragonlasers.com
www.dinodirect.com
www.wickedlasers.com
www.amazon.com
www.ebay.com

With regard to safety, when one makes a purchase for a high-powered laser, a pair of colored safety-goggles should also be purchased. The safety goggles will protect the retina from accidental exposures.

There are a few features possessed by lasers that can make one laser more desirable than another. Primarily, the amount of power a particular laser possesses is the most important factor in evaluating and choosing a laser. 20mW and 30mW lasers have significantly more power and visibility than the lasers commonly found in shooting reconstruction kits. These lasers create extraordinarily sharp and vivid recon-

structed flight paths in low-light conditions, but are not quite effective enough in daytime environments. Lasers with at least 80mW of power are required for daytime exposures. In addition to possessing at least 80mW of power, green lasers are more visible in daylight conditions than red lasers. Therefore, investigators should limit their options to green lasers having at least 80mW of power for daytime exposures. Figure 1 depicts different lasers.

Lasers with 80mW or more power can vary quite a bit in price and quality from one manufacturer to another. The differences between an inexpensive and a more costly laser having the same milliwatt rating will most likely reside in the laser's "beam divergence." A laser beam's divergence describes how much the laser beam expands as it travels further away from its source. As an example, a laser with a beam divergence of 1.0m Rad will have a beam that expands 1.0 mm per meter of light travel. Higher powered lasers may also overheat, especially in less expensive models. The overheating will diminish the light output over time, so that they are no longer useful for daytime exposures. Investigators should do their research and balance the cost-benefit

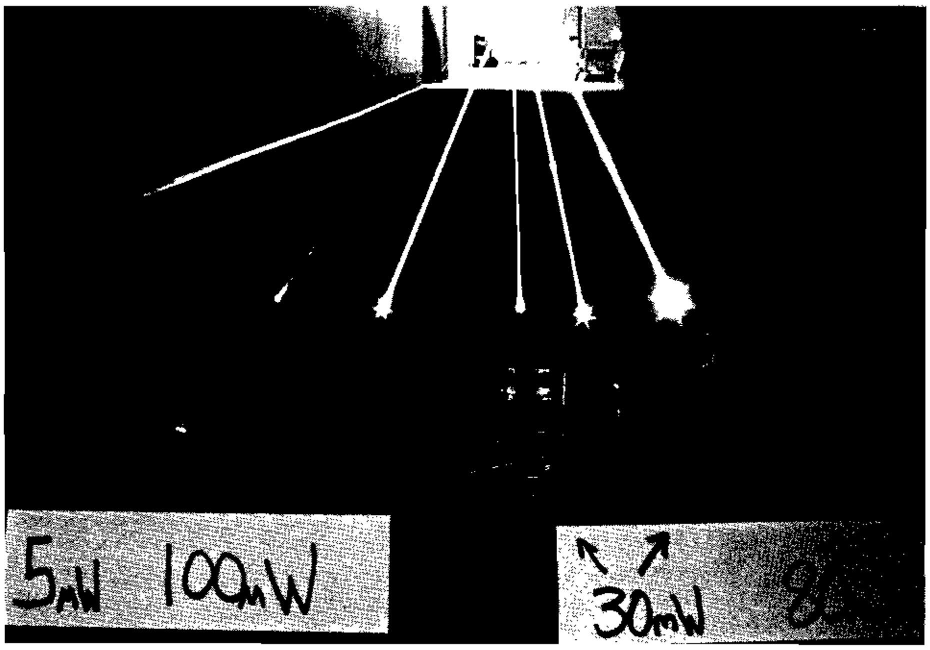

Figure 1


Figure 2


Figure 3

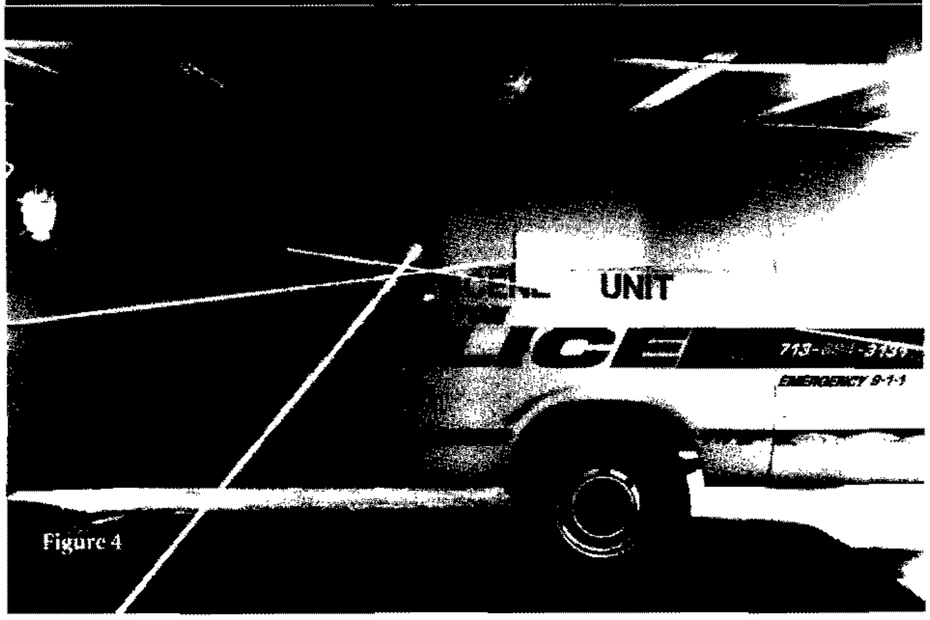

Figure 4

ratio prior to selecting an individual laser.

Laser trajectory photographs are easily recorded in low-light or nighttime conditions. However, daytime crime scenes pose a significant challenge. How does one limit the sunlight, yet still record a laser's beam? The answer is to use neutral density filters. Neutral density filters limit the amount of light recorded or seen by the camera. They are manufactured in a variety of densities, thereby reducing the amount of light by different levels or stops of light. A crime scene investigator would benefit by having several different neutral density filters, starting with a -10 stop, -3 stop, and a -1 stop assortment. These filters can be stacked to increase or fine-tune the total amount of light removed from a particular exposure. Neutral density filters have routinely been used by photographers to slow down their exposures in order to blur or remove moving subjects from their compositions. In comparing Figures 2 and 3, both figures were recorded in the daytime and show three busy freeways. Figure 2 was recorded at ISO 800, f/11, for 1/250th of a second. Figure 3 was recorded at ISO 100, f/11, for 30 seconds. Figure 3 was made possible by utilizing a -10 stop neutral density filter placed on the lens. Investigators "tracking" laser beams will become like the vehicles in Figure 3, disappearing from the image because they do not remain in any one place long enough to be recorded in the image.

For those unfamiliar with the term, "tracking" refers to the process of tracking or tracing the laser's beam of light by reflecting the beam back towards the camera with a card or other reflective surface. The card replaces the once common use of photographic fog that does nothing more than create a murky image. Reflecting cards are typically black or white. However, daytime exposures can be greatly enhanced by using a black reflecting card with a white-circular center (Figure 4). The darker background will help prevent a ghosting presence of the card from developing in the photograph and the white-circular center will assist in creating a more intense beam of light, as well as a consistent and round beam of light. In daytime exposures, the white reflective surface creates a more vivid beam. Black reflective surfaces are beneficial when using high-powered lasers in low-light conditions.

In addition to the laser, neutral density filters, and tracking cards, investigators will need a camera capable of a bulb or time exposure and a cable release or remote shutter release. The length of the exposure is likely to extend past 30 seconds in length, therefore a bulb exposure will be necessary. At least two tripods are also required. One tripod will support the camera and one will support the laser. Investigators may find that a black cloth will also be helpful. The cloth can cover the lens when beginning an exposure or when adjusting the laser for second or third reconstructed flight paths. More importantly, the cloth should be used to cover the eye piece or eye viewer during the exposure. Light can leak through the eye piece on the back of the camera and destroy an image.

Figure 5

Figure 6

COMPLETING A DAYTIME LASER TRAJECTORY PHOTOGRAPH

Obviously, the first step in any laser reconstruction effort is to determine the points of origination and termination for the bullet's flight path. The termination point for a fired bullet is typically the easier of the two to establish, because it typically will be a bullet strike or bullet hole found in some targeted surface. The point of origination can be somewhat more of a challenge. However, the approximate position of the shooter can be determined through witness statements or examination of impact sites using forensic protractors, angle finders, or trajectory rods. Investigators can then mount their laser to a tripod, position it at the approximate position of the shooter, and aim the laser at the impact site.

The next step in capturing the photograph is to position the camera. Recording as much of the crime scene in the composition as possible, along with the bullet's flight path, is most desirable. Positioning the camera perpendicular to the laser's beam may provide an overall more-pleasing composition; however, photographing lasers from the side is more difficult. The laser's beam of light is spread out or more diffused from a perpendicular point of view. In contrast, when a camera is aligned parallel with the laser's beam, the laser's light is recorded more easily because the laser's beam is more compact and therefore more vivid or dense. In low-light environments, photographing lasers from the side is easier. One simply has to slow down while tracking the beam. However, in daylight environments, that is not always possible. For daylight exposures, investigators will have greater success if they align their cameras behind the laser's mounted position.

With the camera and laser positioned as desired, the next step is to determine the exposure values. Photographers need to slow everything down in order to complete the tracking of the laser's beam, therefore small apertures and ISO values of 100 or slower are recommended. With the ISO set to 100, the length of the exposure (shutter speed) can be determined by estimating the length of time that will be required to track the entire length of the laser from point of origination to the point of termination and back. With two factors of the exposure equation determined (ISO and shutter speed), the photographer can select the appropriate aperture to match the lighting conditions.

Photographers will have to select one of their neutral density filters and attach it to the camera in order to get the length of exposure necessary for a daytime laser photograph. Neutral density filters, especially those that remove 10 stops of light or more, can cause difficulties with some cameras with regard to focusing and metering light. Photographers can set the camera's focus, attach the neutral density filter, and then turn off the auto-focus feature. By so doing, the camera will not seek to refocus the camera when it comes time to actually record the image. As for metering light, some cameras may not be as accurate metering light through a neutral density filter as they are normally. If an investigator finds metering light difficult, simply meter the light without the neutral density filter and then add the appropriate number of stops of light to the exposure that equals the number of stops removed by the filter. As an example of an exposure problem, observe the following example using the "sunny f/16 rule" as a starting point:

- Normal daytime exposure metered at ISO 100, f/16, for 1/125th of a second

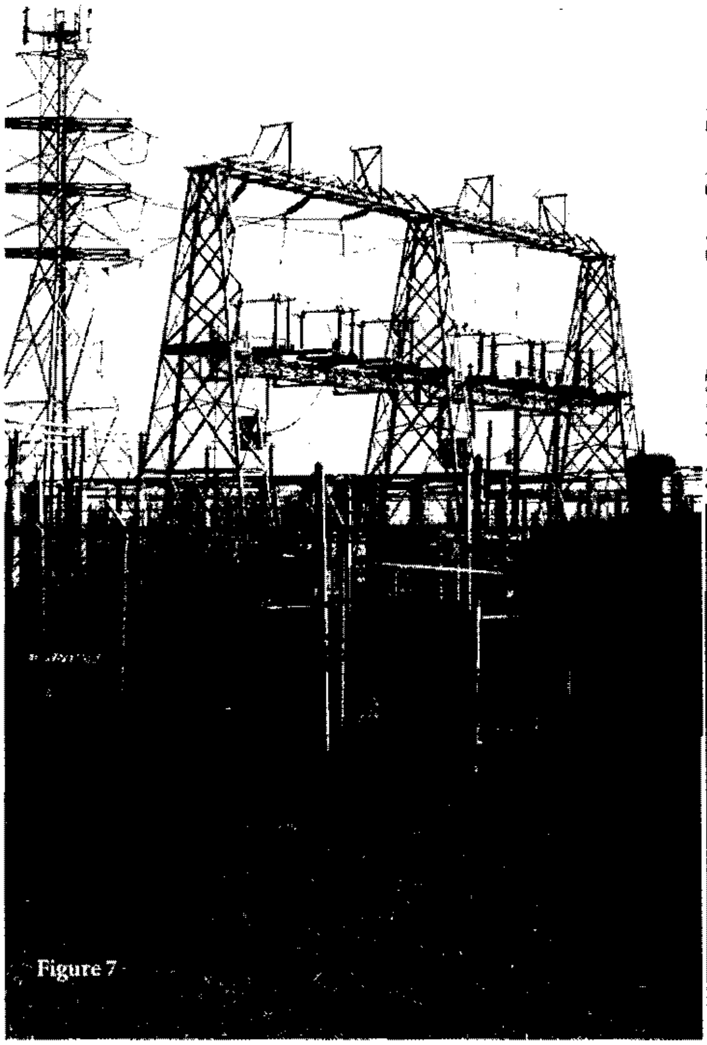

Figure 7

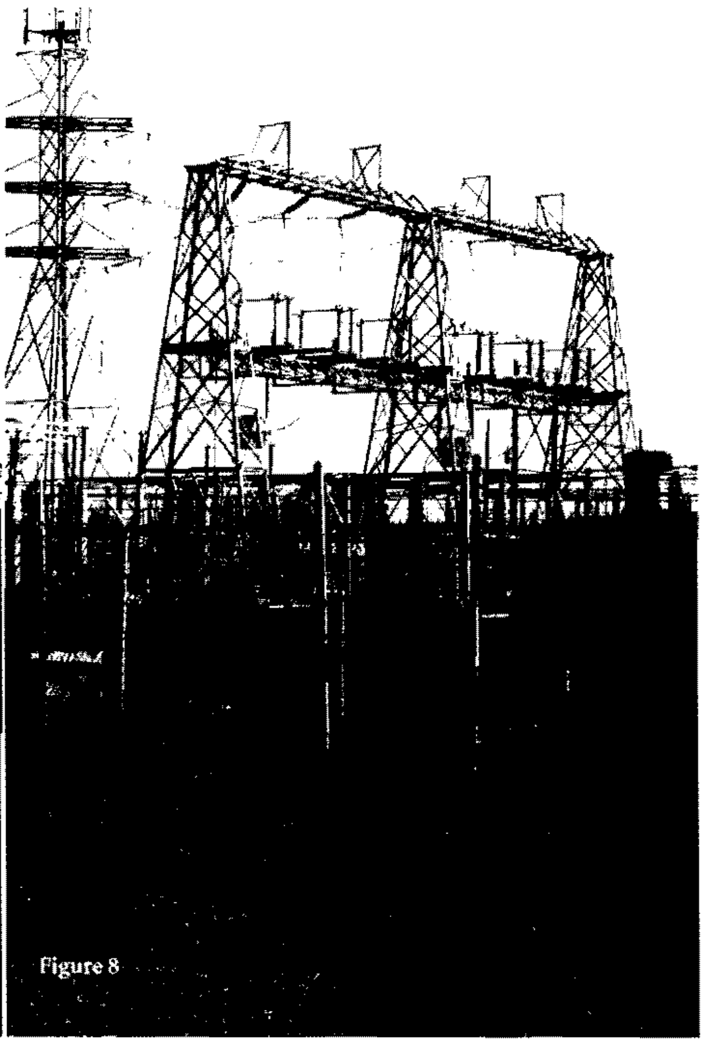

Figure 8

- Neutral density filter removes 10 stops of light from exposure, but the camera is unable to accurately meter through the filter
- Photographer required to manually calculate and remove 10 stops of light from normal exposure calculation
- Removing 10 stops of light:
    - Change in aperture: f/16 to f/22 to f/32 = minus 2 more stops of light, for a total of 12 stops of light needing to be added to the exposure
    - Change in shutter speed from 1/125th of a second to 30 seconds = 12 total stops of light added to the exposure
- New exposure of ISO 100, f/32, for 30 seconds with a −10 stop neutral density filter equals an unfiltered ISO 100, f/16, for 1/125th of a second exposure
- The photographer now has a starting point to begin a series of exposures and can record a set of bracketed exposures in order to ensure a quality image capture

Although the actual calculation of the exposure equals 30 seconds in length, if the exposure requires a little additional time, investigators should not fret. Extending the exposure from 30 seconds to 60 seconds is only equal to one stop of light and even digital cameras can produce excellent results with exposures that are as much as a stop off from an accurate exposure.

With the camera set and the laser positioned, the investigator is ready to begin capturing a valuable image. Turn on the laser, begin the time exposure, and begin tracking or tracing the laser's beam. Tracking the beam is a way to turn the laser's visible dot into a solid line representing the flight path of the fired bullet. By reflecting the dot throughout the course of the laser's path, a singular line will become visible in the final recorded image. The photographer simply holds the reflecting card with the laser's dot projected onto the card's white center. Next, walking at a consistent and slow pace, walk the card along the laser's beam, doing one's best to maintain the beam within the card's center. In order to prevent the reflecting card from creating a ghost appearance in the photograph, the card should be tilted slightly downward so that the light cast by the sun or sky does not strike directly onto the card.

After the photographer tracks the laser's beam from the point of origination to the point of termination, he or she should make a return trip back to the laser. Reflecting the laser's beam "coming and going" has several benefits. First, it insures that the most vivid and dense beam of light is recorded. Secondly, it is not uncommon for the laser's beam to fall away from the white center of the reflecting card and by retracing the laser one can help prevent gaps in the recorded beam of light. A third benefit created by retracing the laser's flight is the elimination of the starburst effect that can develop by leaving the laser projected onto a single point for too long. In comparing Figures 5 and 6, figure 5 shows a single pass along the length of the laser's beam and one can see how thin or light the laser's beam resulted. Figure 6 was created by walking up and back along the beam of light and has a denser appearance in the recorded image. In addition, by tracing back over the laser's beam, photographers can ensure that there are no breaks in the line created.

The two biggest obstacles to overcome in daytime laser trajectory photographs are obtaining a powerful enough laser that can be recorded in sunlight and preventing the development of ghosts in the image. Lighter colors are more likely to result in ghosting. Thus, investigators use black reflecting cards to prevent unwanted ghosts and white circular centers to reflect the brightest beam possible. In addition, the photographer tracking the laser should consider concealing any light colored portions of a uniform or skin with a jacket. Furthermore, when walking along the beam of light, investigators should walk up along one side of the beam and back along the other. By dividing in half the time the person reflecting the beam is present at any one spot in the composition will help eliminate ghosts. Observe the shadow of the photographer along the left side of the laser beam depicted in Figure 7 (ISO 100, f/20, for 72 seconds). However, by traveling along one side of the beam on the way out and returning along the other side of the beam, the photographer is no longer visible in Figure 8 (ISO 100, f/32, for 2 minutes).

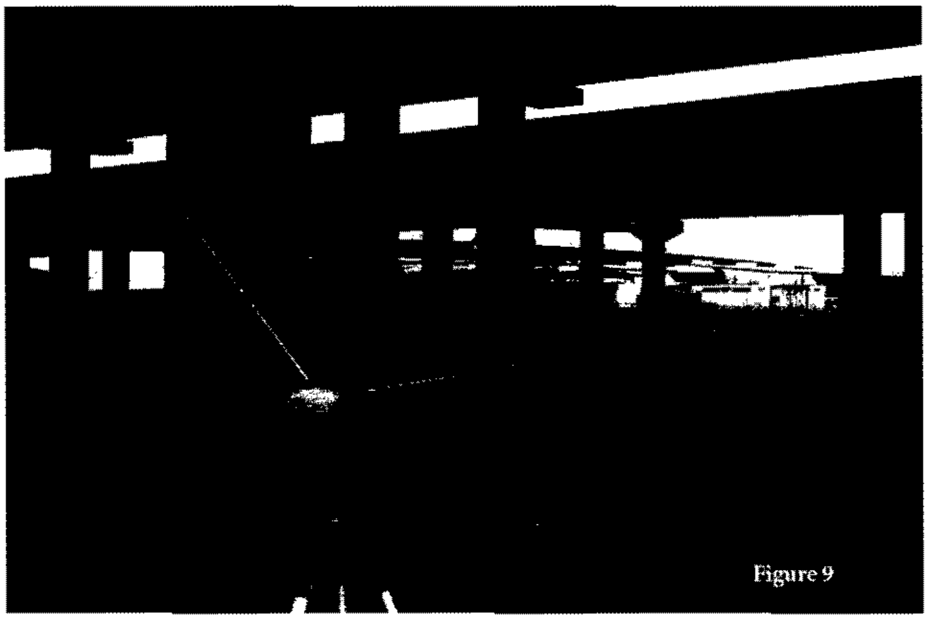

Figure 9

Figure 10

The greatest advantage of digital photography is the ability to have that immediate access to a photograph just recorded. Even viewing a small LCD screen on the back of a camera can provide valuable information to the photographer, such as the presence of ghosts, gaps in the laser's beam, or a lack of intensity in the beam. If a beam is not as dense as desired, one simply has to slow down the tracking of the laser. Another factor may be to position the camera more directly behind the laser and have the camera's lens pointed directly down the laser's beam of light. The appearance of ghosts can be caused by a number of factors, including light colored clothing or being in any one spot for too long. With all else being equal, photographers can decrease the size of their aperture, thereby lengthening the time of the exposure. By increasing the length of the exposure, the amount of time necessary to create a ghost will also be extended. Although the smaller aperture may cause a less dense laser beam to be recorded, the trade-off may be necessary.

It goes without saying that daytime laser trajectory photographs are much more difficult than nighttime exposures. Investigators using digital cameras have a tremendous advantage in that they can review their images and make corrections with regard to exposure evaluations and unintentional errors made in tracking the laser's beam. Investigators should review and evaluate their images, and determine a possible solution for any errors or problems observed in the recorded image. Film photographers can simply bracket their exposures to ensure a quality image capture. In addition, film photographers have the added advantages of reciprocity failure and greater exposure latitude than digital photographers. In the end, all photographers (digital and film users) can record quality laser trajectory photographs in the daytime.

Investigators must practice with their particular lasers and variety of neutral density filters in order to develop a starting point for

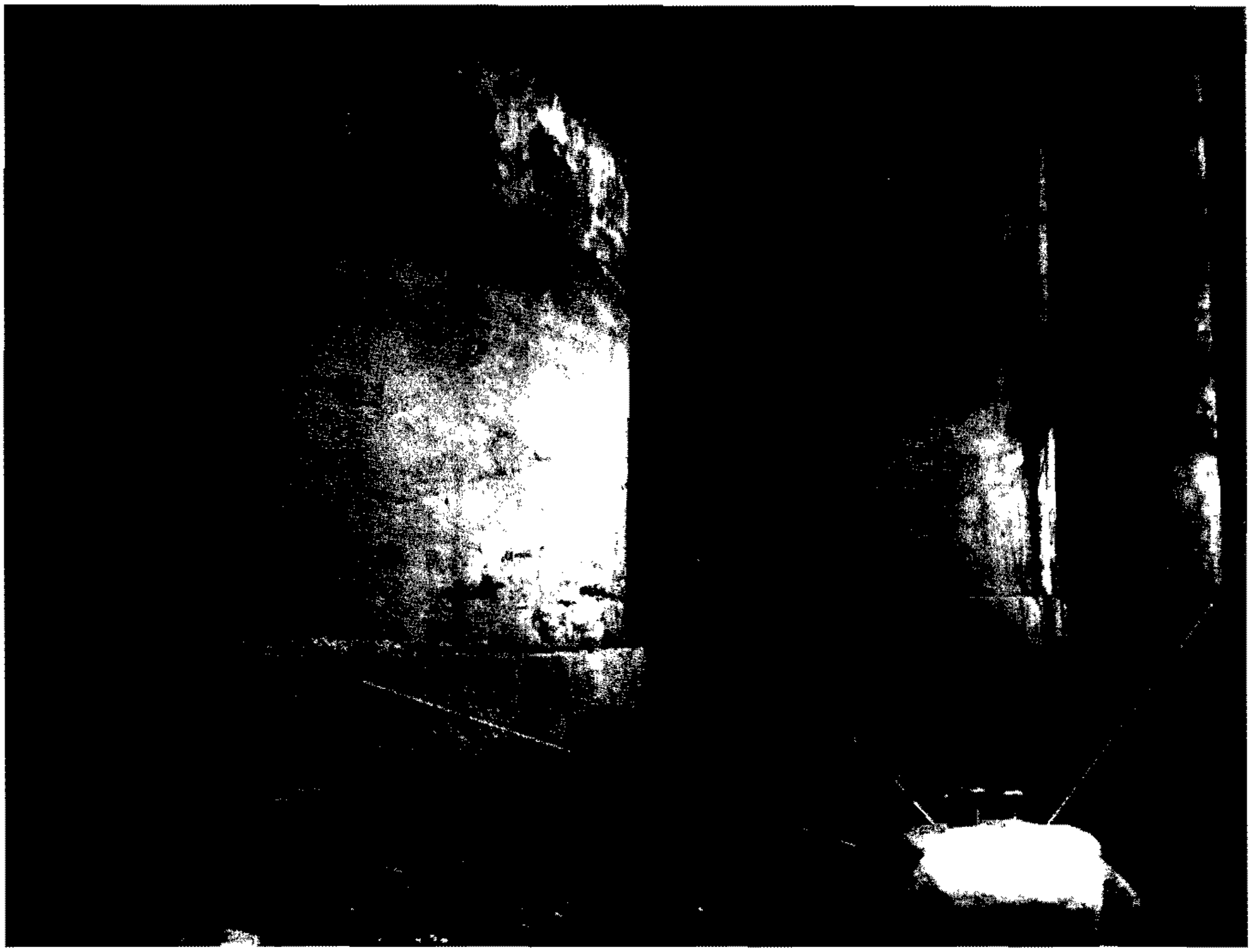

Figure 11

their exposures. Exposure determinations will vary significantly between cloudy days and sunny days and the amount of filtration needed under different conditions will vary accordingly. The power of individual lasers, the position of the camera in relation to the laser, and the environmental conditions will all affect the exposure evaluation and the pace of the photographer tracking the laser's beam. Investigators must be flexible and be able to identify solutions when results are not as originally desired.

Figures 9, 10, and 11 illustrate daytime laser photographs under different environmental conditions. Figure 9 was recorded on a cloudy day, using an 80 mW laser and a -10 stop neutral density filter. The exposure settings were ISO 100, f/14, for 3 minutes. Figure 10 was recorded on a sunny day, using an 80 mW laser and a -10 stop neutral density filter. The exposure settings were ISO 100, f/32, for 66 seconds. Figure 11 was recorded on a sunny day, but was recorded in the shade of the cement towers in the background. The exposure settings were ISO 100, f/25, for 130 seconds, and utilized a -10 stop neutral density filter. However, the length of the shutter speed includes the time for adjusting the laser between trackings. The camera's lens was covered with a black cloth so that it was not recording the scene when the laser was adjusted to the next impact site.

CONCLUSION

The value of quality daytime laser trajectory photographs cannot be underestimated. Not only can laser trajectory photographs provide valuable demonstrative evidence for courtroom presentations, but they can also offer explanations for transpired events that occurred during incidents involving gunfire. With a few additional tools and a little practice, any investigator can record daytime laser photographs. In addition to equipment, investigators need a little patience and basic photographic knowledge in order to make corrections or adjustments when recording a series of photographs. It has been said that daytime laser photography is impossible, but that simply is not accurate. Like any challenge in life, one must simply analyze the problem, brainstorm a set of solutions, and after experimenting or testing, select the best possible solution. Daytime laser trajectory photographs are just such an opportunity. By creating a lasting impression with one's photographic documentation of a crime scene, the photographer has the opportunity to show one's skill and dedication to crime scene investigation.★