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TECHNICAL NOTE

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Visualization of Gunshot Residue Patterns on Dark Clothing*

ABSTRACT: Determination of the muzzle-to-target distance is often a critical factor in criminal and civil investigations involving firearms. However, seeing and recording gunshot residue patterns can be difficult if the victim's clothing is dark and/or bloodstained. Trostle reported the use of infrared film for the detection of burn patterns. However, only after the film is developed are the results visible and multiple exposures at different settings may be needed. The Video Spectral Comparator™ 2000 (Foster & Freeman Ltd., Evesham, Worcestershire, U.K.) is an imaging instrument routinely used by forensic document examiners. Without use of specialized film could the VSC 2000 (at appropriate instrument settings) quickly, easily, and reliably provide instantaneous viewing, saving, and printing of gunshot residue patterns on dark and/or blood soaked clothing? At muzzle-to-target distances of 6, 12, and 18 in., test fires were made into five different types of dark clothing using eight different handguns of different calibers. Gunshot residues were detected for all eight calibers, and powder burn patterns were seen on dark clothing for all three target distances and calibers except 0.22 long rifle and 0.25 ACP. Bloodstains did not preclude the viewing of these patterns.

KEYWORDS: forensic science, gunshot residue patterns, GSR, video spectral comparator

Muzzle-to-target firing distance is often a crucial determination in the investigation of incidents involving gunshot wounds. When possible, firearm's examiners use the suspect firearm and the same type of ammunition to make test fires from different distances into targets. This enables them to compare the dimensions of the tests with the dimensions of the gunshot residue patterns on the clothing and/or body of the victim and thereby approximate the muzzle-to-victim distance. However, if the clothing worn by the victim is dark and/or bloody it may be difficult to see and record the gunshot residue pattern. One way around this problem is the modified Griess test (1–3). The modified Griess test detects the presence of nitrite residues. One of the many methods to perform this test is to treat a piece of desensitized photographic paper with a chemical mixture of sulfanilic acid in distilled water and α-napthol in methanol. The back of the item being examined is then steam ironed with a dilute acetic acid solution in the steam iron instead of water. The acetic acid vapors will penetrate the exhibit and a reaction takes place between any nitrite residues on the exhibit and the chemicals contained in the photographic paper. The resulting reaction will appear as orange specks on the piece of photographic paper. Although the modified Griess test works well, a method that would reveal the gunshot residue pattern on the item *in situ*, and without any added chemicals, would be an improvement. Trostle (4) found that there were components of gunshot powder burns that when excited by light energy in the blue and blue-green wavelengths of the visible spectrum (400–600 nm) would re-emit (luminesce) the absorbed energy at longer wavelengths towards the infrared spectrum (550–900 nm). Because these wavelengths are beyond the visible spectrum, Trostle had to use a special infrared-sensitive film in his camera, plus a barrier filter over the lens that blocked the excitation wavelengths (visible range) but permitted the longer infrared rays to pass through and expose the film. Although Trostle's method was successful in detecting gunshot powder burn patterns on dark clothing, its disadvantages were that photographers did not know if they had any results or the proper exposure settings until after they had developed the film.

Houde (personal communication, California Department of Justice, 1989) reported a gunshot case where a pullover shirt worn by a shooting victim was so heavily bloodstained that the shirt's pattern was obscured. Making things even worse, emergency staff at the hospital had cut right through the bullet hole. Using an infrared source in his crime lab's photo lab (the safety light) and a FIND-R-SCOPE® (FJW Industries, Mt. Prospect, IL) viewer worn on a headband, he was able to clearly see the shirt pattern through the blood, find the bullet hole, and properly match up the cut edges. However, the powder pattern was not apparent and he used a chemical mapping technique to make it visible.

The Video Spectral Comparator™ 2000 (Foster & Freeman Ltd., Evesham, Worcestershire, U.K.) is an imaging instrument routinely used by forensic document examiners. Mokrzycki (5) has written an excellent and well-illustrated review of the capabilities of the VSC 2000 for various questions related to questioned documents. The VSC™ 2000 (as well as previous and

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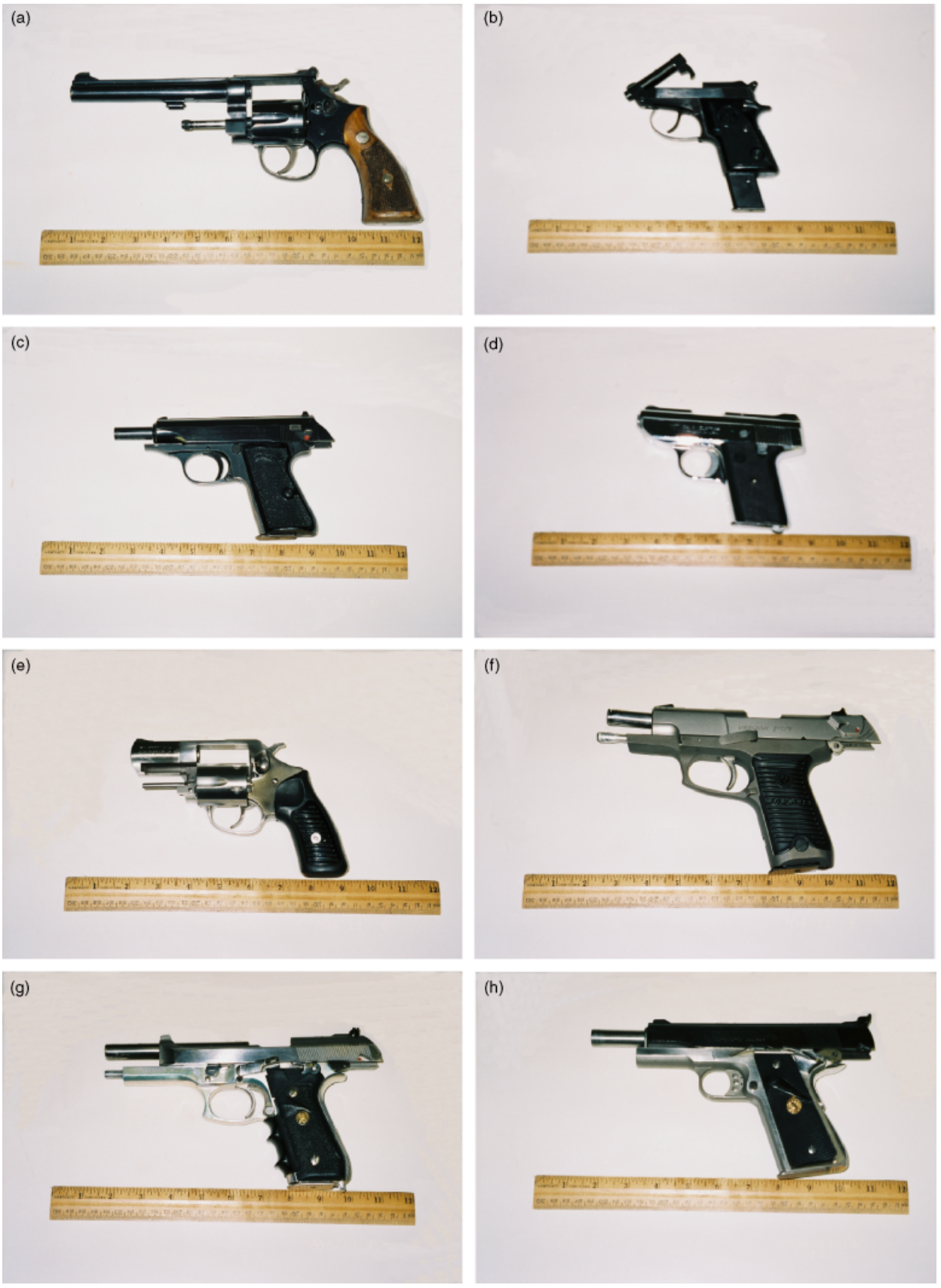

FIG. 1—*(a) 0.22 Long rifle revolver; (b) 0.25 ACP pistol; (c) 0.32 ACP pistol; (d) 0.380 ACP pistol; (e) 0.357 Magnum revolver; (f) 9 mm pistol; (g) 0.40 Smith and Wesson pistol; (h) 0.45 ACP pistol.*

current iterations of the VSC™) includes a color charge coupled device (CCD) video camera, a black-and-white CCD video camera, excitation/barrier filters, and various radiant energy sources (tungsten, halogen, and fluorescent lamps). Two important features of the VSC 2000 are the spot light source and signal integration. Together, they act much like a "time exposure" and permit the detection and capture of even weak luminescence within the infrared portion of the spectrum.

We hypothesized that by proper selection of excitation wavelengths, bandpass filters, longpass filters, and integration times, the VSC-2000 would be able to detect and capture gunshot powder burn patterns on dark clothing. Additionally, the patterns could instantly be viewed, saved, and printed, and no interference would be encountered by bloodstains.

Methods

A VSC 2000 available in the Questioned Documents Section of the San Diego County Sheriff's Crime Laboratory was used to detect and capture all of the gunshot powder patterns in this study. Readers are directed to the Foster & Freeman website (www.fosterfreeman.com) and to the article by Mokrzycki (4) for instrument details.

Five different types of dark clothing material and one light control sample were used as targets. The clothing materials consisted of: one black and gray patterned jump suit (50% rayon, 50% polyester); one pair dark blue pants (100% polyester); one black pin striped dress (65% polyester, 35% rayon); one olive-green sweatshirt (100% cotton); one pair black pants (90% polyester, 10% spandex); and one white T-shirt (100% cotton). The clothing materials were all cut into approximately 12 × 12 in. squares producing eight targets for each.

Eight different calibers were used to shoot the clothing. The calibers and ammunition were comprised of: 0.22 long rifle S & W revolver (6 in.) with Remington Kleanbore (40 g); 0.25 ACP Beretta pistol Model 20 ($1\frac{1}{2}$ in.) with Fiocchi 0.25 ACP Auto (full metal jacket, 50 g); 0.32 ACP Walther pistol Model PP (4 in.) with PMC "Precision Made Cartridges" (full metal jacket, 71 g); 0.380 ACP Davis Industries pistol Model P-380 (3 in.) with Federal Hydra Shok (jacketed hollow point, 90 g); 0.357 Magnum Sturm Ruger revolver Model SP101 ($2\frac{1}{4}$ in.) with Winchester 38 Smith and Wesson special +P (jacketed hollow point, 110 g); 9 mm Luger Sturm Ruger pistol Model P89 Luger ($4\frac{1}{2}$ in.) with 9 mm Federal (jacketed hollow point, 147 g); 0.40 S & W pistol Model PT-101 (5 in.) with CCI Blazer (total metal jacket, 180 g); 0.45 ACP Colt pistol Model MK IV/Series 70 Gold Cup National Match (5 in.) with Winchester Black Talon 45 ACP (jacketed hollow point, 230 g) (Fig. 1).

The target materials were taken to the San Diego Police Department Crime Laboratory Firearms Unit for shooting. The San Diego Police Department Firearms Unit supplied all firearms and ammunition. Each target was labeled with the caliber of weapon and muzzle-to-target distance using a "white-out" pen. Each target was taped to a sheet of cardboard (Table 1).

The shot materials were taken to the San Diego Sheriff's Department Crime Laboratory Questioned Documents Section for examination with the VSC 2000. As control samples white T-shirts were examined first to determine the optimum settings for the VSC 2000 for the detection of gunshot residue patterns. Once the optimum settings had been determined, the dark clothing materials were placed under the VSC 2000, were put into focus, and a ruler was placed alongside the materials. The image on the computer screen was then printed for further examination.

TABLE 1—*Calibers used and muzzle-to-target distance (in.) of target material.*

Caliber	0.22	0.25	0.32	0.380	0.38	9 mm	0.40	0.45
White T-shirt	6	6	6	6	6	6	6	6
Black pin striped dress	6	6	6	6	6	6	6	6
Olive-green sweatshirt	6	6	6	6	6	6	6	6
Dark blue pants	12	12	12	12	12	12	12	12
Black pants	12	12	12	12	12	12	12	12
Black & gray jump suit	18	18	18	18	18	18	18	18

After the above portions of the examinations were complete, all of the 0.38 Special +P targets were separated to be stained with blood. Human blood obtained from the San Diego Sheriff's Department Crime Laboratory stocks (San Diego Blood Bank #3486) was applied to clothing materials in the Forensic Biology Section's exam room. Blood was applied to only the left half (front) of each fabric sample so that a side-by-side comparison could subsequently be made with the VSC 2000 of both bloodstained and nonbloodstained portions. The materials were air dried in the exam room for approximately 120 h before examination. The dried, bloodstained materials were viewed using the same previously determined optimum VSC 2000 settings.

Results

The optimum settings for the VSC 2000 for imaging the gunshot powder burn patterns were determined to be: (a) lights/waveband filter 440–580 nm, (b) longpass filter 610 nm, (c) bandpass filter off, (d) magnification 1.61, (e) integration 0.2 sec, (f) gain auto, (g) brightness 40 h, (h) contrast 54.

The VSC 2000 detected some gunshot residue on dark clothing for all muzzle-to-target distances chosen in this study. Burn patterns were visualized on dark clothing for all calibers except 0.22 long rifle and 0.25 ACP. Although other ammunition brands were not tested, the lack of detection for the 0.22 long rifle and 0.25 ACP handguns may be due to the small amount of gunshot residue these weapons deposit after being fired, which is why only a few particles are visible on these printed images rather than a whole residue pattern. The targets shot at 6 in. produced a highly concentrated gunshot powder burn pattern around the entrance hole. The patterns became less concentrated on the targets shot at 12 in. and even less so at 18 in.

A few examples of the gunshot powder burn patterns visualized with the VSC 2000 are seen in Fig. 2(*a–h*).

Dried bloodstains on the dark clothing items did not interfere with the detection of the gunshot powder burn patterns. Examples of the images obtained with the VSC 2000 with bloodstained items can be seen in Fig. 3(*a*) and (*b*).

Discussion

This study has demonstrated that gunshot powder burn patterns on dark and/or bloodstained clothing may be quickly and easily visualized and captured with the VSC 2000. This would greatly facilitate the approximation of muzzle-to-target distances in firearms-related investigations. Because of their great utility in different aspects of questioned documents examinations, some model of the VSC (or similar imaging instrument) can usually be found in the Questioned Documents Section of major crime laboratories, as well as the offices of many private forensic document examiners. Our results should equally apply to both previous and present iterations of the VSC. Additional advantages of the

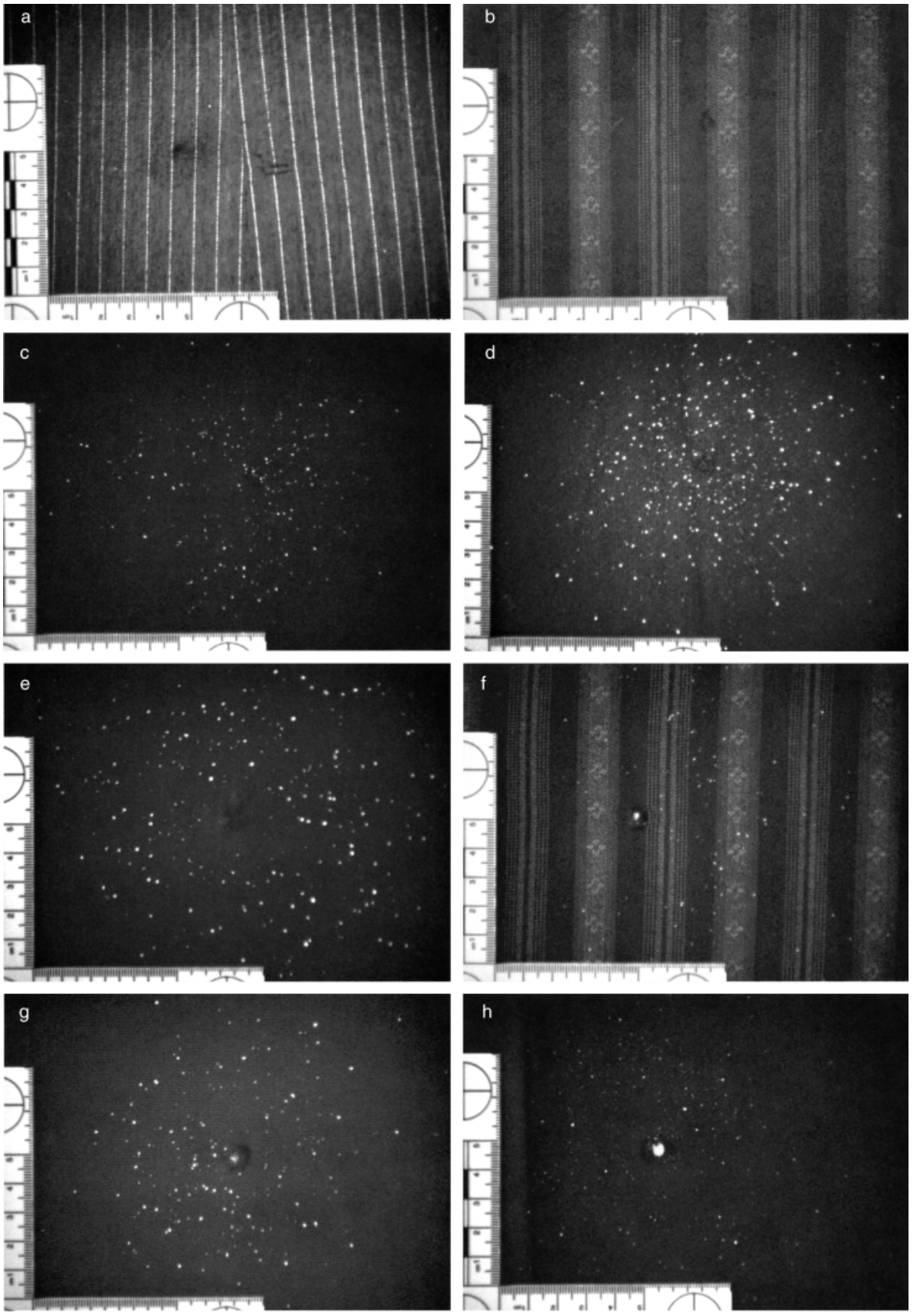

FIG. 2—*(a) 0.22 long rifle at 6 in.; (b) 0.25 ACP pistol at 18 in.; (c) 0.32 ACP pistol at 12 in.; (d) 0.380 ACP pistol at 6 in.; (e) 0.357 Magnum revolver at 12 in.; (f) 9 mm pistol at 18 in.; (g) 0.40 Smith and Wesson pistol at 12 in.; (h) 0.45 ACP pistol at 12 in.*

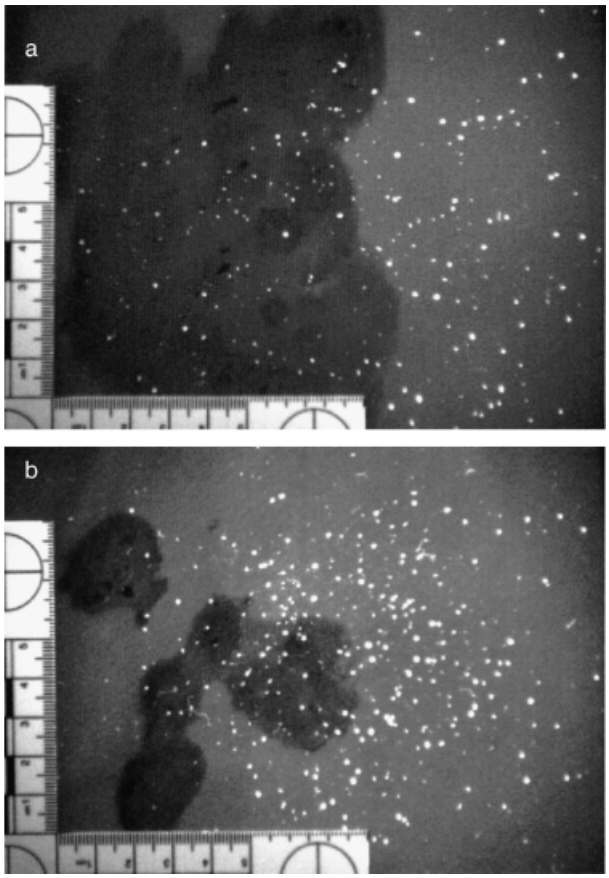

FIG. 3—*(a) 0.357 Magnum revolver at 12 in. with blood; (b) 0.357 Magnum revolver at 6 in. with blood.*

method are that it requires minimal handling of exhibit items (minimizes the possible loss of trace evidence or cross-contamination) and that the original state of the garments is not altered by the application of chemicals.

Areas for future study would be: (1) the determination of what chemical constituents in gunshot powder burn patterns account for the fluorescence in the infrared spectral region, and (2) additional test firings using unusual and newly introduced ammunition brands (example brands that because they do not contain lead, are intended for use in indoor ranges).

Acknowledgments

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