TECHNICAL NOTE

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Machine Washing or Brushing of Clothing and Its Influence on Shooting Distance Estimation

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ABSTRACT: Experiments were conducted to assess the effect of machine washing or brushing of clothing items on Gunshot Residue (GSR) patterns (gunpowder residues, lead, and copper deposits) around bullet entrance holes. Results show that those treatments decrease considerably the amount and density of GSR. However, for close shooting distances not all of the GSR deposits are removed. Remaining patterns may be visualized by specific color reactions and used for shooting distance estimation.

KEYWORDS: shooting distance, gunshot residues, machine washing, brushing

Shooting distance estimation is based on the examination of gunshot residue (GSR) patterns around bullet entrance holes (1). Several studies dealt with possible effects of various factors on clothing items after shooting with regards to the shooting distance estimation (2–5). Most of these found that mechanical handling of clothing or soaking them in blood, in still or running water, considerably decreases the amount of GSR around the bullet entrance holes. Bergman et al. (3), on the other hand, did not find a significant effect of soaking in still water on the obtained GSR patterns. Sometimes in casework requests are received to estimate shooting distance on clothing items that underwent machine washing. The authors are not aware of any study that tested this effect.

The purpose of this work is to examine the influence on shooting distance estimation of very vigorous treatments that clothing may undergo after shooting. In this study the treatments were machine washing and brushing of the area around the bullet entrance holes. The tested GSR patterns were: total nitrite, lead, and copper deposits.

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Experimental

Experiments of Machine Washing

White cotton cloth was chosen as a model target material in this part of the study. The ammunition and weapons were: a 0.22 in. LR Remington brass washed, Beretta semiautomatic pistol; a 9 mm parabellum GFL FMJ, Glock semiautomatic pistol; and 0.38 in. Geco Special lead bullets, Colt Detective Spec. revolver. Shooting distances for all the ammunitions were: contact range, 10, 25, and 50 cm. Two shots were fired for each distance. The machine washing was carried out at 40°C. Twelve targets were washed together with other clothing to fill the machine.

The visualization procedures for total nitrite, lead, and copper are described elsewhere (1). A press was specially designed and built for this purpose. This press is operated by compressed air with adjustable pressure and temperature and the compressed area is 30 $\times$ 30 cm^2. The procedures are as follows:

Total Nitrite Pattern Visualization

Materials:

1. A "peelable" (low adhesion) transparent adhesive lifter (25 $\times$ 25 cm) with a protective cover (supplied by ISA Ltd., Crasly Street, Bulwell, Nottingham, England).
2. Two percent KOH in ethanol.
3. Modified Griess Test (MGT) reagent: 3% Sulfanilamide and 0.3% N-(1-naphthyl)ethylenediamine dihydrochloride dissolved in 5% phosphoric acid (AR).
4. Fixed photographic paper.

Procedure

1. The adhesive lifter is placed over the exhibit and subjected to a pressure of about 1.3 atmosphere in the press for 5 s.
2. The adhesive lifter is removed from the exhibit, attached to a cardboard, and sprayed lightly with the KOH solution and placed in an oven at about 100°C for 1 h.
3. The photographic paper is sensitized by dipping in the MGT reagent solution for a few seconds.
4. The excess solution on the photographic paper is removed by wiping with a paper towel. It is important that the excess solution is completely removed. The sensitized paper is placed on

the adhesive lifter and subjected to pressure of 1.3 atm. in the press at about 70°C for about 1 min.

Lead Pattern Visualization

Materials:

1. Ten percent Acetic acid (AR) in distilled water.
2. Freshly prepared 0.2% (w/v) of Sodium Rhodizonate solution in distilled water.
3. Buffer solution of pH 2.8 (1.9 g Sodium bitartarate and 1.5 g of Tartaric acid in 100 mL of distilled water.
4. Benchkote (Whatman) filter paper (10 × 10 cm) stapled to a cardboard.

Procedure

1. The Benchkote filter paper is sprayed with the acetic acid solution.
2. The paper is laid gently on the exhibit and both of them are placed in the press subjected to a pressure of 1.3 atm. in the press for 2 min.
3. The paper is removed and sprayed with the Sodium Rhodizonate solution. Then it is sprayed with the buffer solution.

Copper Pattern Visualization

Materials:

1. Ten percent Ammonium hydroxide (AR) in distilled water.
2. Saturated Rubeanic acid in ethanol.
3. Benchkote filter paper (10 × 10 cm) stapled to a cardboard.

Procedure

1. The Benchkote filter paper is sprayed with the ammonia solution.
2. The paper is laid gently on the exhibit, and both of them are placed in a press subjected to a pressure of 1.3 atm. for 2 min.
3. The paper is removed and sprayed with the rubeanic acid solution.

As to 0.22 in. and 9 mm caliber ammunition, on half of each target, between shooting and machine washing, the adhesive lifter was applied to lift the total nitrite for all shooting distances except contact range. After machine washing, the second halves were processed for comparison in the same manner. Regarding contact range, half of the target was visualized for lead and copper deposits before machine washing and the second half after washing. For this ammunition and for 10, 25, and 50 cm distances, lead and copper deposits were visualized on the whole targets after washing and lifting of the gunpowder residues. Regarding the 0.38 in. caliber ammunition only lead patterns were visualized: half of the target before washing and the second half after washing.

Experiments of Brushing

Smooth polyester cloth was chosen as a model target material in this part of the study. The reason for choosing smooth fabric was to simulate the worst possible scenario in casework regarding the mechanical removal of GSR. The ammunition and weapons were the same as in the previous part, except that a 0.38 in. caliber was not used and a 0.22 in. LR Winchester Super X copper washed ammunition replaced the Remington ammunition mentioned above. Shooting ranges were 10, 25, and 50 cm for 0.22 in. caliber and 10, 25, 50, and 75 cm for the 9 mm caliber. For each range two shots were fired. After shooting, the adhesive lifter was applied to half of every target to lift the total nitrite deposited after shooting. The second halves were brushed, followed by application of the lifters. A cloth brush (stiff hair) was used for brushing in the following manner: three repeated outward strokes starting in the bullet entrance hole. The total nitrite was visualized on the lifters using the procedure described above. Lead and copper deposits were visualized on the both halves by the procedures described above, after lifting the gunpowder residues from the both halves of a target.

Results

Effect of Machine Washing

Results show that machine washing of the cloth targets removes considerable amounts of GSR deposits around the entrance bullet holes. Nevertheless, for shorter shooting distances removal of all types of the examined GSR is not complete, and the remaining GSR patterns may serve for shooting range estimation. In general, the effect is a decrease of the maximum shooting range that may be estimated. Figures 1 and 2 show the effect of machine washing on the total nitrite visualization with regards to 9 mm caliber ammunition and shooting distances of 10 and 25 cm, respectively. It can be seen that most of the particles are removed, and the remaining residues are in the close vicinity of the entrance bullet holes. When shooting was done at a 50 cm range, hardly any gunpowder residues could be observed after washing. Similar results were obtained with 0.22 in. caliber ammunition.

Results show that machine washing did not significantly remove the vaporous lead and copper deposits at the contact range. For longer distances; in the case of the 9 mm caliber, lead and copper deposits (beyond the bullet wipe) could be visualized up to shooting ranges of 10 cm only, while in the case of 0.22 in. caliber, these deposits were observed even for 25 and 50 cm shooting distances (Figs. 3,4). Also, with regards to the 0.38 in. caliber ammunition, the vaporous lead deposit at the contact shooting range was not removed significantly by the machine washing. For longer distances the lead deposit (beyond the bullet wipe) could be visualized up to shooting distances of 10 cm only. Lead and copper deposits of the bullet wipe could be visualized for all the tested ammunitions (for the 0.38 in. caliber, only lead) and shooting distances.

Effect of Brushing

Results show that brushing removes considerable amounts of gunpowder residues, but to a smaller extent than in the case of machine washing. Figures 5 and 6 show the effect for 9 mm caliber ammunition and for shooting ranges of 10 and 25 cm. For 50 and 75 cm no gunpowder residues could be visualized after brushing. A similar influence was observed for 0.22 in. caliber ammunition. As to lead and copper deposits, no significant effect of brushing was observed for all the tested shooting distances.

Discussion

This study showed that even very vigorous treatments, which shot cloth items may undergo, do not remove all the GSR type deposits around the bullet entrance holes for close shooting ranges.

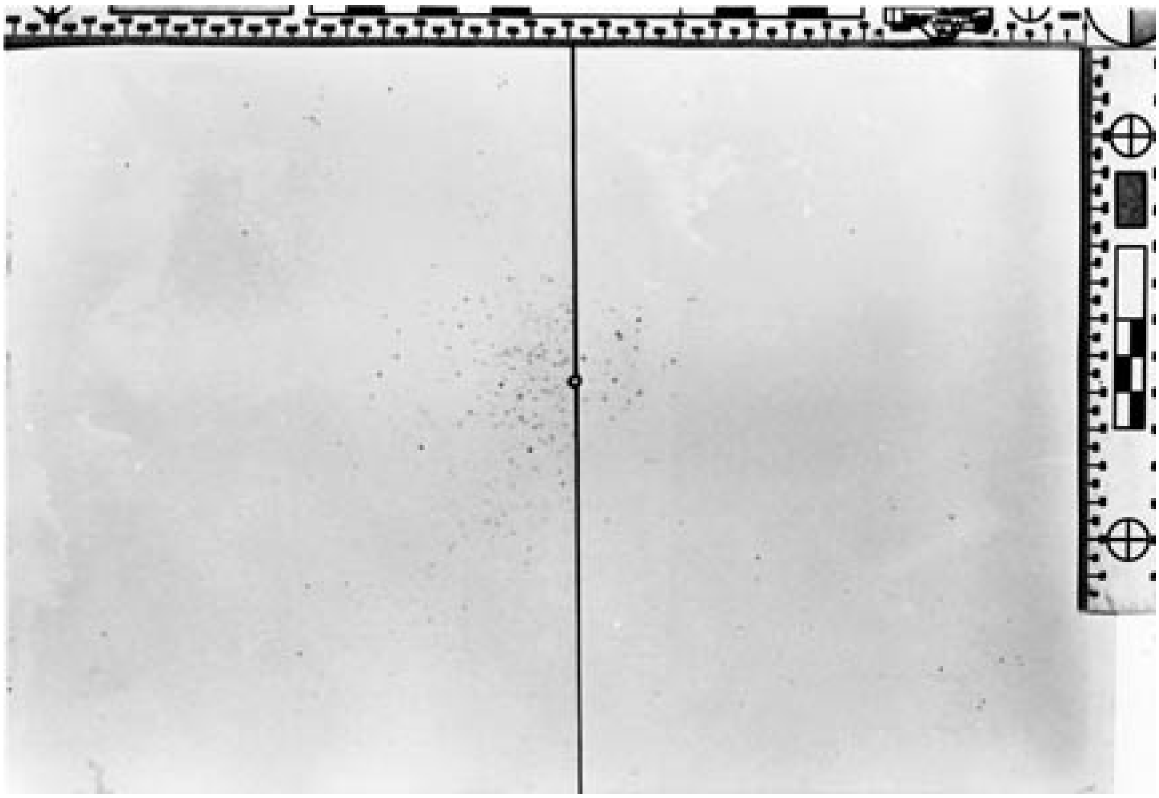

FIG. 1—*The effect of machine washing on the total nitrite visualization; 9 mm parabellum GFL FMJ, 10 cm shooting distance. Left half of the target without washing.*

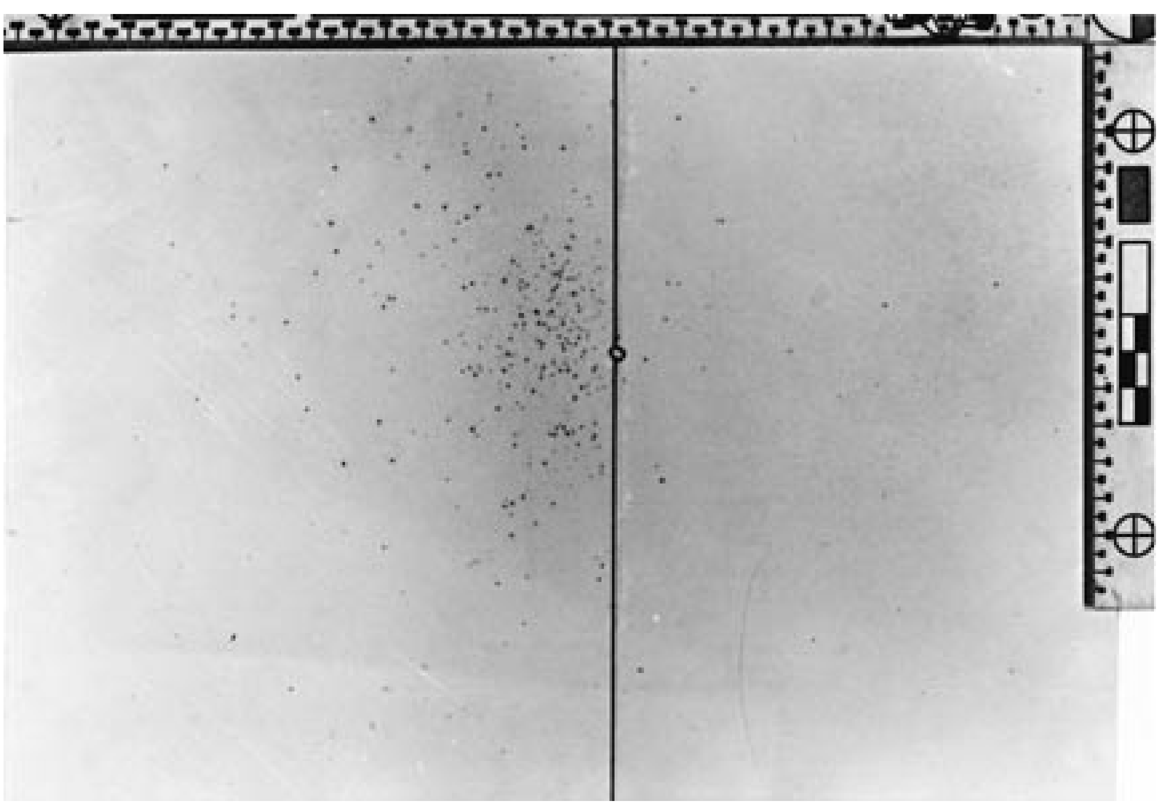

FIG. 2—*Same as Fig. 1 for 25 cm shooting distance.*

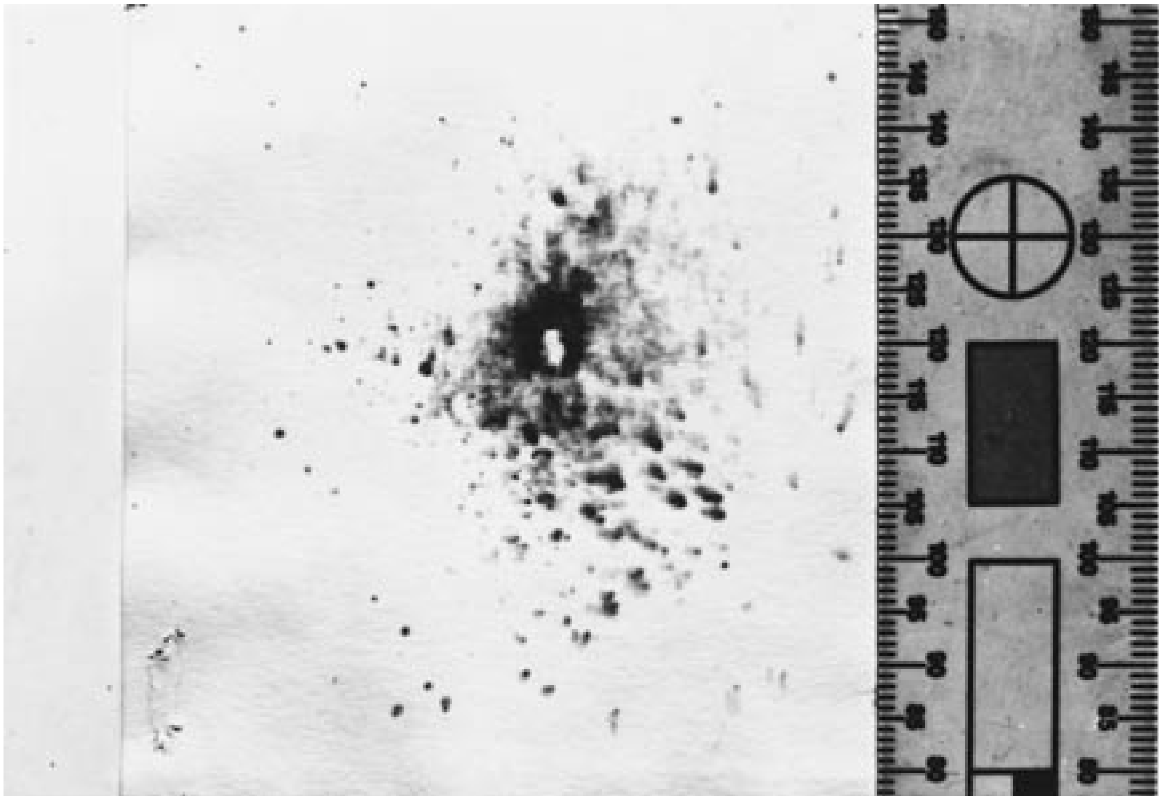

FIG. 3—*The effect of machine washing on the lead deposit visualization; 0.22 in. LR Remington brass washed, 25 cm shooting distance. The whole target was machine washed.*

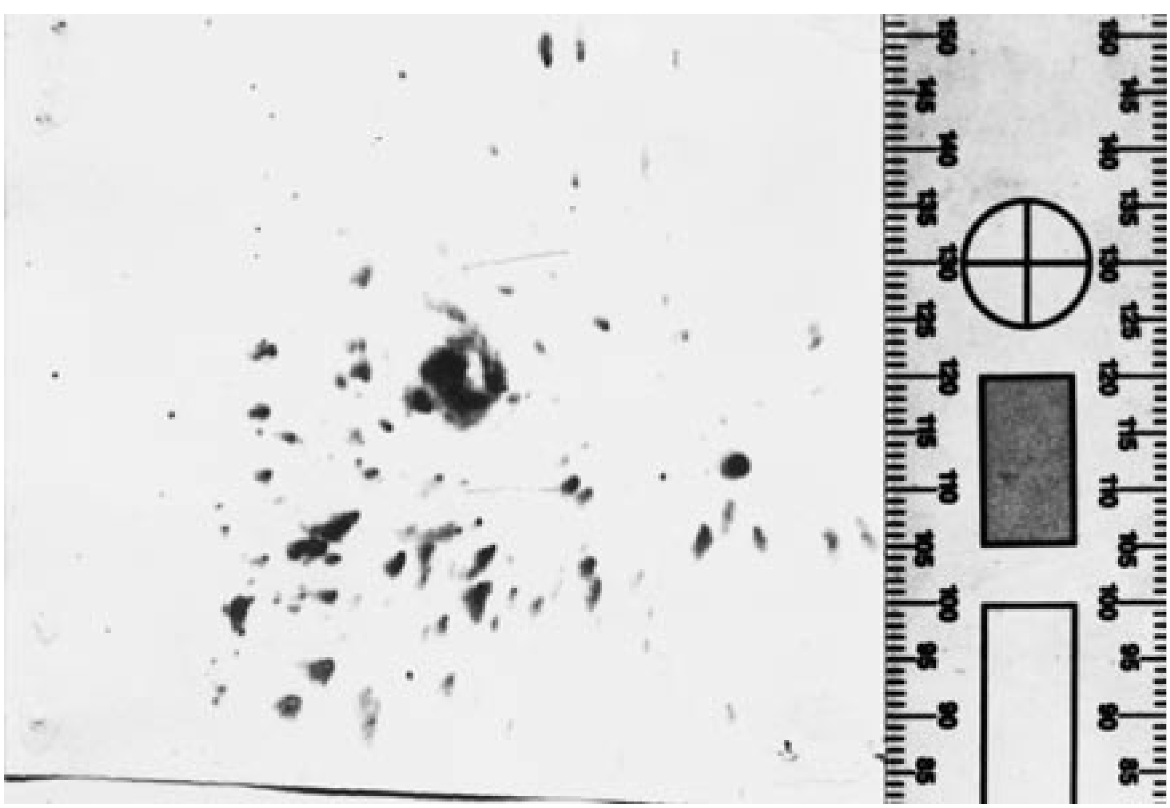

FIG. 4—*Same as Fig. 3 for 50 cm shooting distance.*

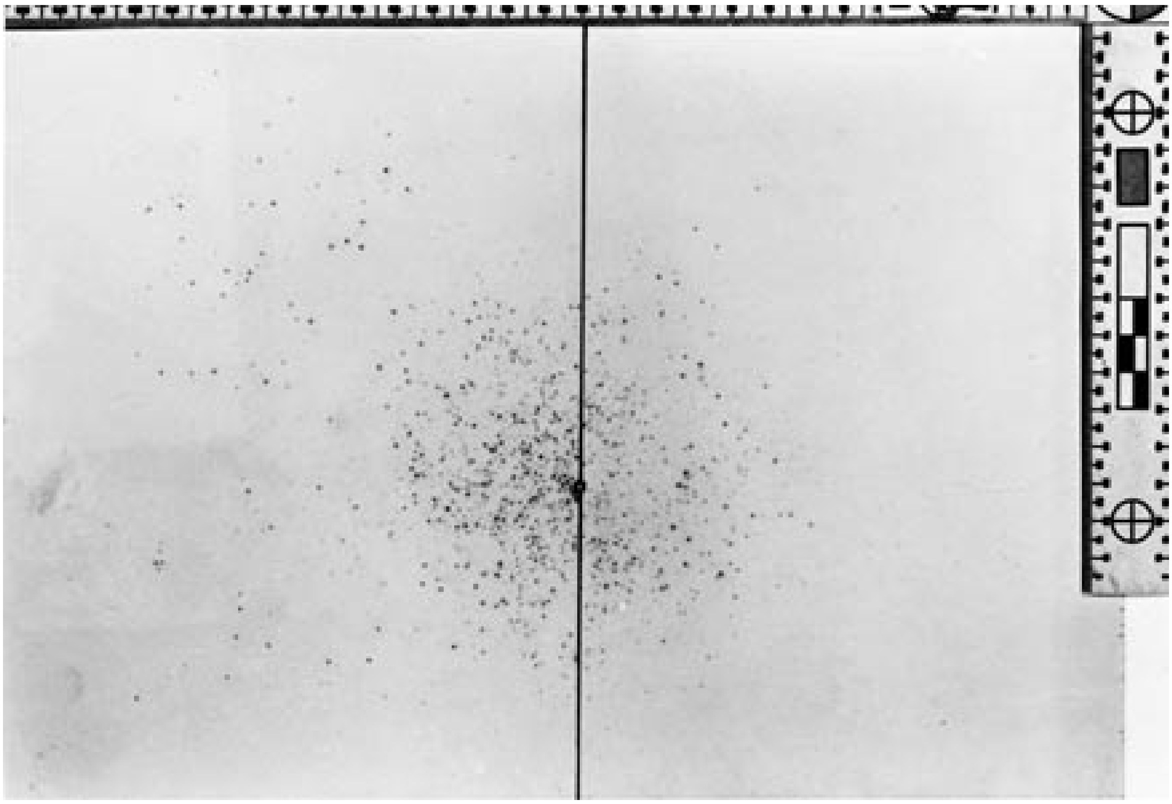

FIG. 5—*The effect of brushing on the total nitrite visualization; the ammunition and the shooting distance as in Fig. 1. The left half of the target was not brushed.*

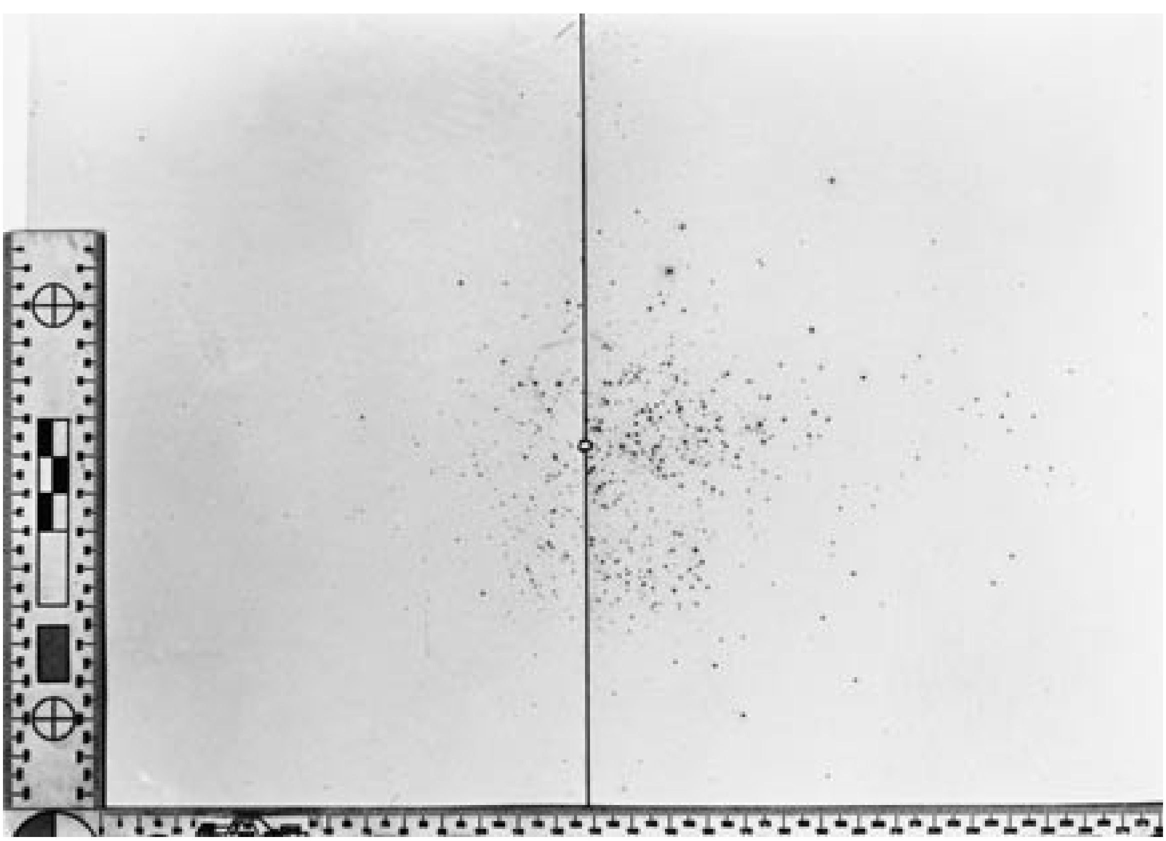

FIG. 6—*Same as Fig. 5 for 25 cm shooting distance.*

As could be anticipated, machine washing was considerably more effective in removing the GSR than brushing. As the shooting distance increases, the extent of removal is higher. This effect is obviously related to the kinetic energy of the GSR deposits impinging on the target. It may be assumed that discharge material having higher energy will adhere more efficiently to the fabric of the cloth target. A similar effect was demonstrated for hard material surfaces (6). As could be seen from the results, the practical consequence of any vigorous treatments of the cloth targets is a decrease in the maximum shooting distance that may be estimated. In casework, it is clearly recommended that after test firings, possible treatments undergone by shot clothing should be simulated to increase the accuracy of shooting distance estimation. If, for any reason, such a simulation is not possible, then any visualized pattern of GSR around the bullet entrance hole (beyond the bullet wipe) will indicate that the shooting distance was equal or below the shooting distance that provides a similar pattern without any treatment of the target after the firing. This study shows that the absence of GSR patterns around the bullet entrance hole is a clear indication that shooting was not at close range. In such a situation the authors cannot quite agree with the statement expressed by Dillon (4): "The *absence* of residues is *not* a basis for expressing a categorical and conclusive statement about a particular situation."

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