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Improved Method for Shooting Distance Determination. Part 2—Bullet Holes in Objects that Cannot be Processed in the Laboratory*

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ABSTRACT: An improved method for firing distance determination on exhibits that cannot be processed in the laboratory such as cars, doors, windows, or furniture is described. The novel part of the method includes transfer of total nitrite (nitrite ions and smokeless powder residues) from the target to an adhesive lifter. After the transfer, vaporous lead and copper deposits around the bullet entrance hole are visualized on the target by sodium rhodizonate and rubeanic acid, respectively. The Modified Griess Test is carried out after alkaline hydrolysis of the smokeless powder residues on the adhesive lifter.

KEYWORDS: forensic science, criminalistics, shooting distance, adhesive lifter, Griess reagent, sodium rhodizonate, rubeanic acid

In the first part of this series, we described an improved method for the determination of shooting distance on clothing (1). The method consists of the transfer of the gunpowder residues from the cloth target to an adhesive lifter. After the application of the adhesive lifter, vaporous deposits of lead and copper around the bullet hole are visualized on the target by sodium rhodizonate and rubeanic acid, respectively, using the Sheet Printing Method (SPM). The Modified Griess Test (MGT) is carried out after alkaline hydrolysis on the gunpowder residues transferred to the adhesive lifter to obtain total nitrite visualization.

It was shown that almost a complete transfer of gunpowder residue particles was obtained from the clothing to the lifter. No transfer of vaporous deposits of lead and copper was observed.

In our experience, most of the time, casework-examined exhibits, for shooting distance determination, are victim's clothing. Sometimes, however, we are asked to determine shooting distance on exhibits that cannot be processed in the laboratory such as cars, walls, doors, windows, furniture made of wood, plastic, leather, or fabric.

We are not aware of any reported chemical method for the determination of shooting distance determination on such exhibits aside from the visual examination of the discharge residue pattern around the entrance bullet hole. The only reported chemical type of examination that we are aware of is a bullet hole determination (2).

In this study we examined the feasibility of the method developed for clothing for additional materials: galvanized steel, glass, plywood, and high-pressure laminated plastic sheets of melamine and phenolic materials (Formica®).

Experimental

A Berreta semiautomatic pistol, 9 mm parabellum, and Geco 9 mm, full metal jacket (FMJ) ammunition, as well as a 0.22 in. Berreta LR pistol, and a 0.22 in. Win Super X, copper-washed ammunition were used in the shooting experiments.

The targets (30 × 30 cm) were as follows:

—Plywood.
—White Formica®.
—Galvanized steel plate (2 mm thickness).
—Nontoughened glass pane (4 mm thickness). An adhesive lifter was placed on the back side of the pane to prevent disintegration of the glass.
—White cotton cloth served as a reference for the other targets with regards to the obtained results.

The 0.22 in. caliber ammunition was fired at the following distances: contact, 5, 25, 40, and 65 cm. The 9 mm caliber ammunition was fired at the following distances: contact, 25, 75, and 130 cm.

In the case of targets shot from contact and 5 cm ranges, lead and copper were visualized consecutively on the targets after application of the lifter and on the lifters as well. Total nitrite visualization was carried out on the lifters applied on all targets except those that were shot from a contact, since at such distance gunpowder residues are not expected to be found.

Tests were carried out to examine a possible interference of carrying out rhodizonate and rubeanic reactions on the lifter prior to the hydrolysis and MGT. For this purpose targets shot (by 0.22 in. ammunition) from 5 and 40 cm distances were processed as follows: On half of the target a lifter was applied. It was subjected directly to the hydrolysis and MGT. On the other half, additional lifter was applied which was first subjected to the rhodizonate test, then to the rubeanic acid test, and finally to the hydrolysis and MGT. The visual patterns of the total nitrite were compared on both lifters.

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The patterns of lead, copper, and total nitrite from various targets were compared with the respective patterns obtained from the cotton cloth.

Total Nitrite Pattern Visualization

Materials

1. A peelable (low adhesion) transparent or nontransparent adhesive lifter ("JAC Vinyl," 25 cm × 25 cm × 80 μm) with a protective cover (supplied by ISA Ltd., Greasley Street, Bulwell, Nottingham, England).
2. 2% 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 applied with a roller over the exhibit.
2. The adhesive lifter is removed from the exhibit, attached to a cardboard, sprayed lightly with the KOH solution and placed in an oven at about 100°C for an hour.
3. The photographic paper is sensitized by dipping it into the MGT reagent solution for a few seconds. 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.
4. The sensitized paper is placed on the adhesive lifter and subjected to a pressure (1.3 atm) in the press at about 70°C for about one minute (1).

Lead Pattern Visualization

Materials

1. 10% 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 filter paper is applied with a roller over the exhibit.
3. The paper is removed and sprayed with the sodium rhodizonate solution.
4. Then it is sprayed with the buffer solution.

Copper Pattern Visualization

Materials

1. 10% 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 filter paper is applied with a roller over the exhibit.
3. The paper is removed and sprayed with the rubeanic acid solution.

Results and Discussion

For all tested target materials and shooting distances, the amounts and densities of the discharge residues detected visually were considerably smaller than those obtained after chemical treatments.

This effect was in particular pronounced in the case of glass where blackening could hardly be observed even from contact shooting ranges. It was found that on all tested target materials visualized patterns of vaporous lead deposits were obtained (Fig. 1). On the lifter, the obtained lead patterns were similar to those obtained on the corresponding targets except for cotton, but their color intensity was considerably weaker. On the lifter from the cotton cloth only particulate lead could be visualized (1).

The vaporous copper deposit patterns visualized on plywood, Formica, and glass were considerably weaker than those obtained on the cotton cloth. The most similar was on the plywood. We do not have a reasonable explanation for this effect. Changing the sequence of the color reactions, namely visualization of copper before lead, did not affect the visualization results for either metal.

On the galvanized steel target, no copper pattern could be visualized. The plausible explanation for this result is the fact that a large excess of zinc interferes with the reaction between copper and rubeanic acid. Very faint or almost no copper deposit patterns could be visualized on the adhesive lifters applied on all the targets except cotton cloth, where only particulate copper could be visualized similar to the lead patterns (1).

Total nitrite patterns visualized on the lifters applied on the various targets were similar to those obtained on the lifters from the cotton cloth at relatively short shooting distances, i.e., up to about 25 cm. The patterns were similar in terms of the amount of particles and their density around the entrance bullet hole (Figs. 2 and 3). As shooting distances become greater, the number and density of nitrite spots on the lifters from all the tested materials' targets decrease considerably in comparison to the lifters from the cotton cloth, the wood target being the most similar (Fig. 4).

A possible reason for the difference in behavior between cotton cloth and the other target materials in this study is due to the differences in hardness and smoothness of the materials. Discharge residue particles impinging on a target may adhere to it, backscatter leaving contact traces if they have enough kinetic energy, or backscatter without leaving any detectable contact trace.

Cotton cloth was the softest and had the roughest surface among the tested target materials. Thus, it is reasonable to assume that gunpowder residue or metal particles impinging on a cotton cloth will adhere to it more efficiently than on the other tested target materials. This assumption is reflected in the results of the visualization by MGT. In short-enough shooting distances, the gunpowder residue particles have enough kinetic energy to adhere to or to leave contact traces on the hard material targets tested in this study. Thus in such distances, the density of nitrite spots on the lifters from all the hard material targets was similar to that obtained on the lifters from the cotton cloth.

At longer distances the gunpowder residue particles are not energetic enough to adhere to or to leave contact traces on hard surfaces. Therefore, at such distances the amount and density of the total nitrite particles on hard material targets was less than on the cotton cloth.

No difference in the total nitrite pattern was found between the

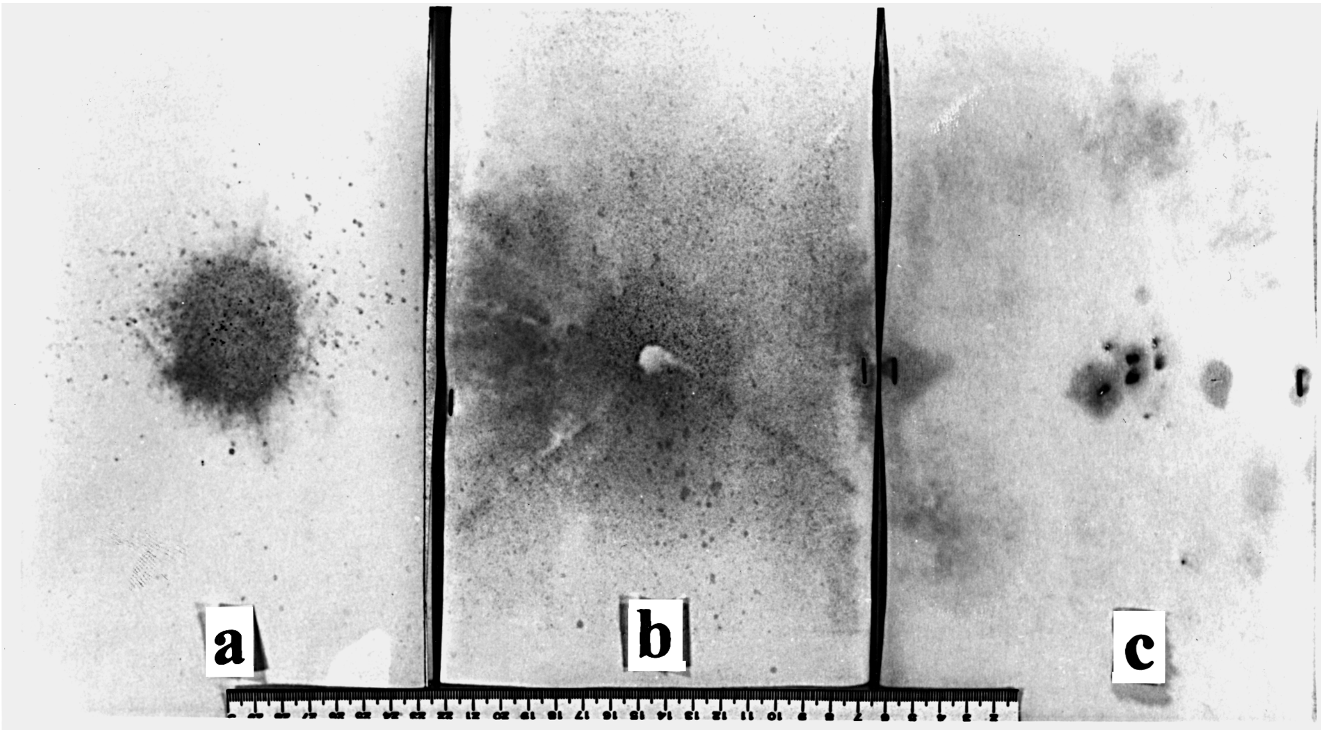


FIG. 1—*Visualized pattern of the vaporous lead fired with a Berreta LR pistol and a 0.22 in. Win Super X, copper-washed at contact range.* (a) *White cotton cloth.* (b) *Glass target after the application of the lifter.* (c) *Lifter applied on the glass target.*

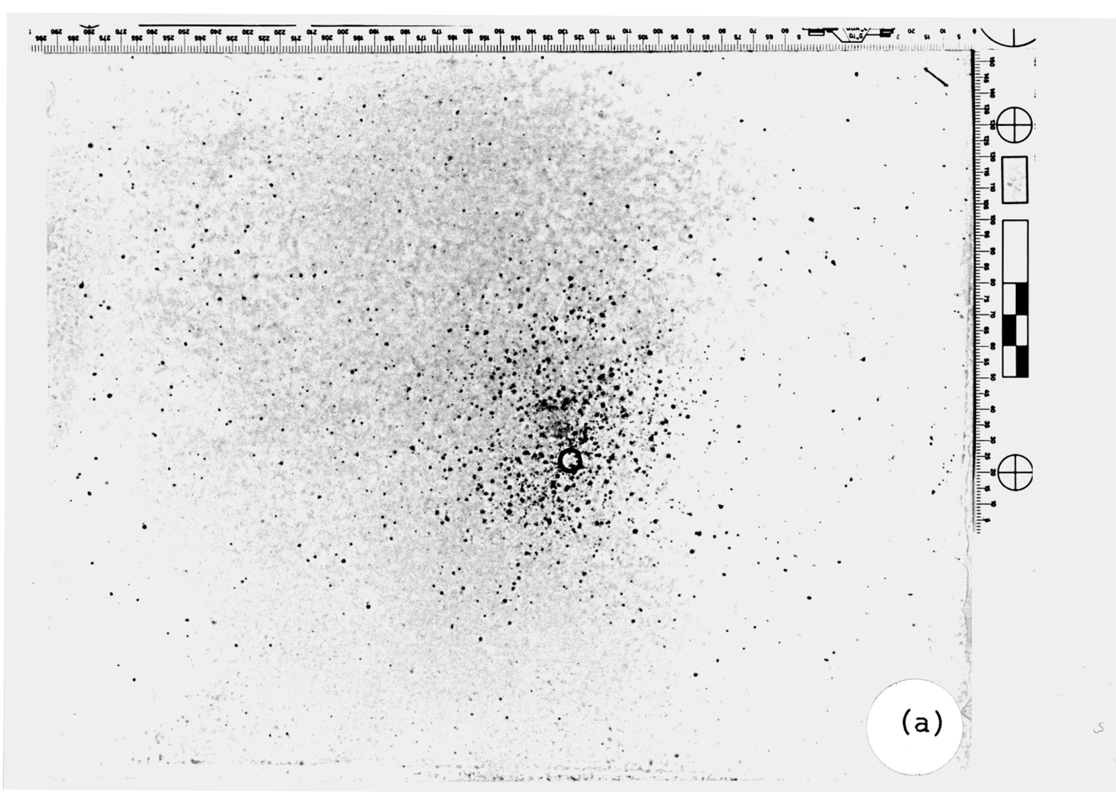


FIG. 2—*Visualized total nitrite patterns of the discharge residues of the test shots fired with a Berreta semiautomatic pistol, 9 mm parabellum, Geco FMJ ammunition at the range of 25 cm on the lifters from the following targets:* (a) *White cotton cloth.* (b) *Plywood.* (c) *Glass.* (d) *Formica.*

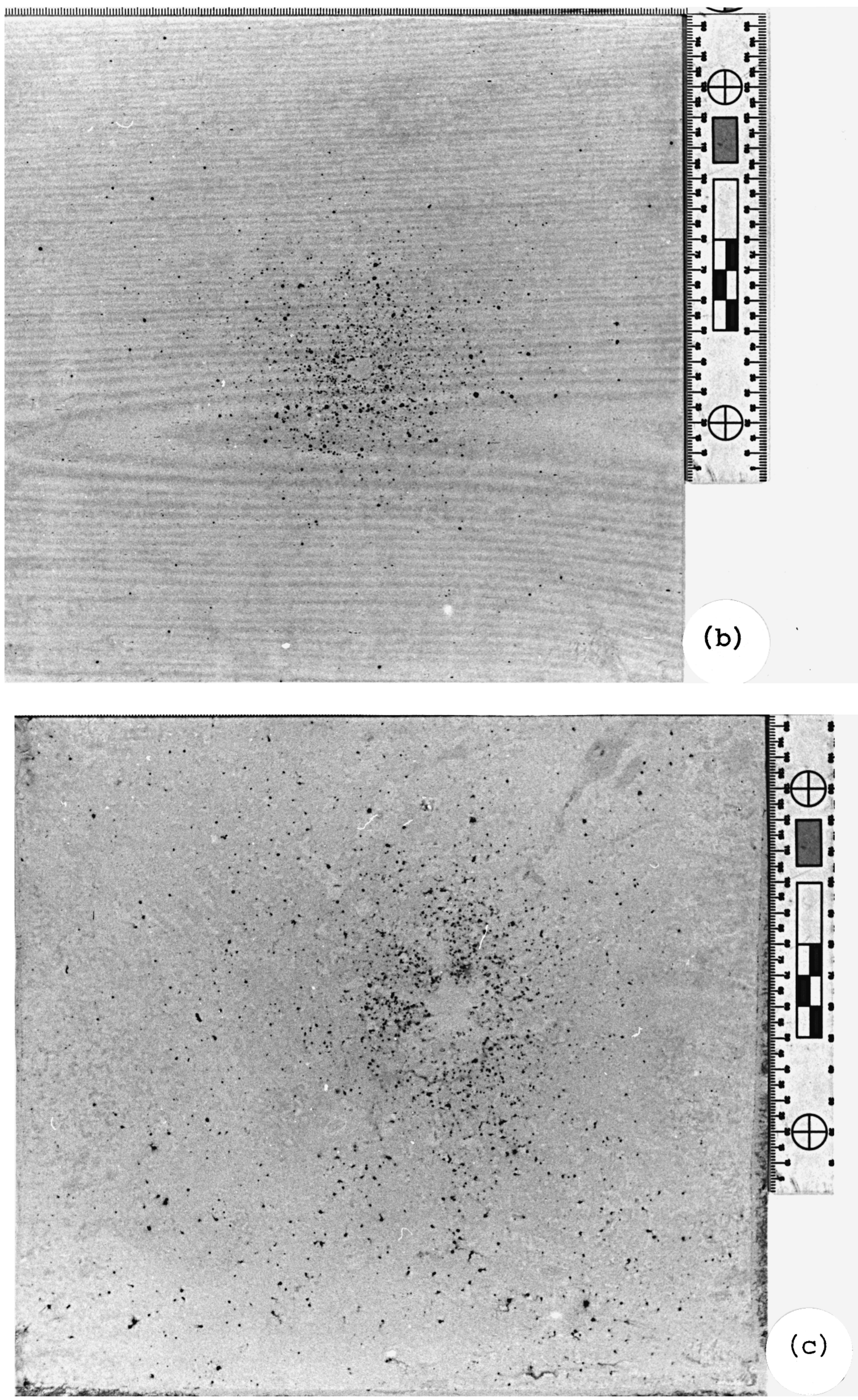
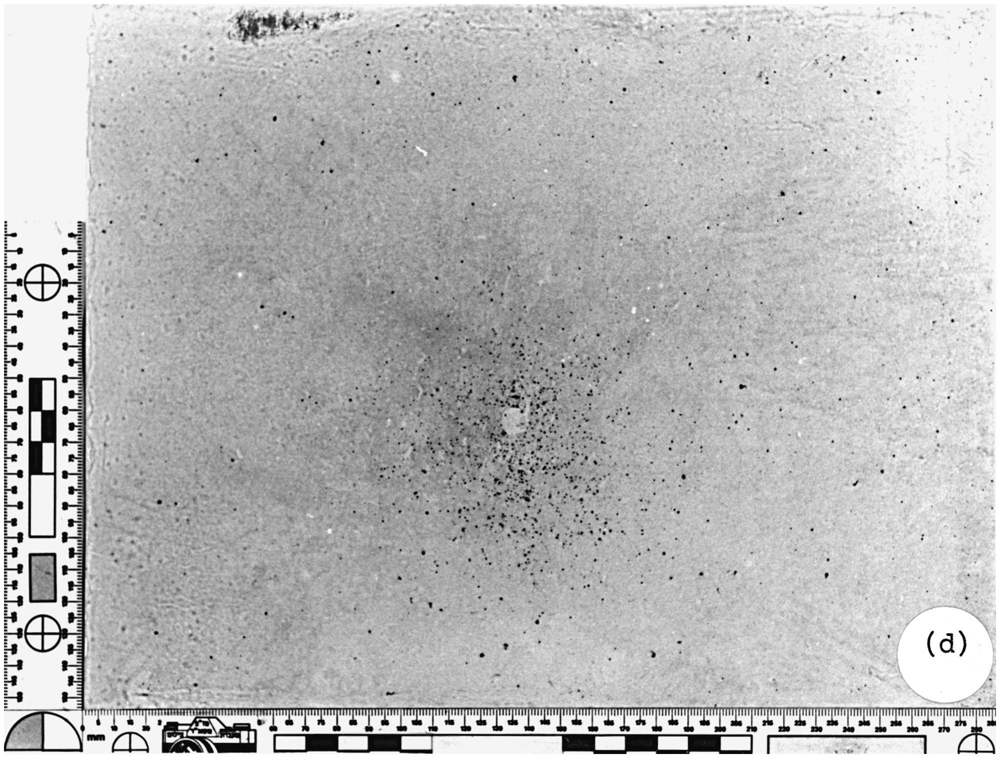


FIG. 2—*(Continued.)*



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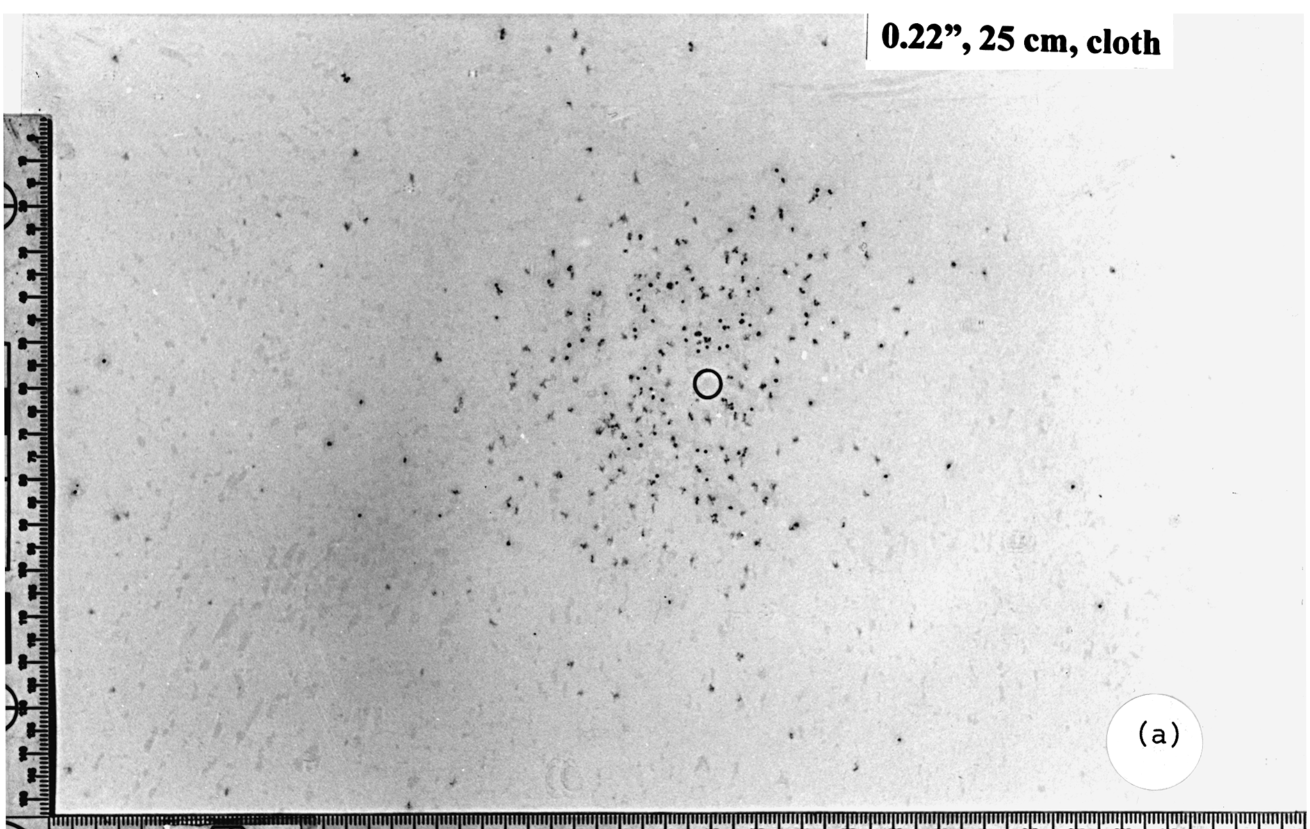

FIG. 3—*Visualized total nitrite pattern of the discharge residues of test shots fired with a Berreta LR pistol and 0.22 in. Win Super X, copper-washed at the range of 25 cm on the lifters from the following targets:* (a) *White cloth.* (b) *Plywood.* (c) *Glass.* (d) *Galvanized steel plate.*

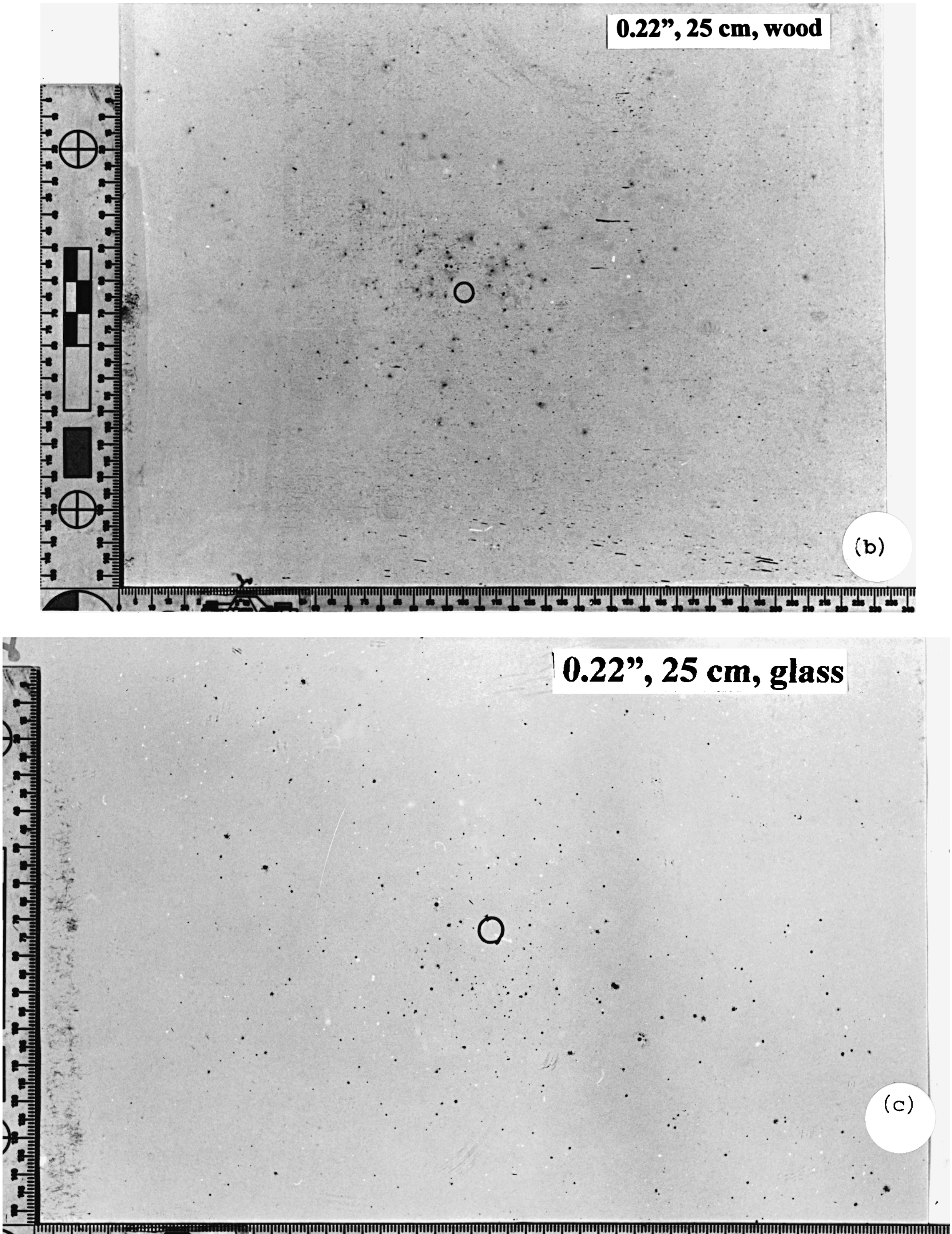

FIG. 3—*(Continued.)*

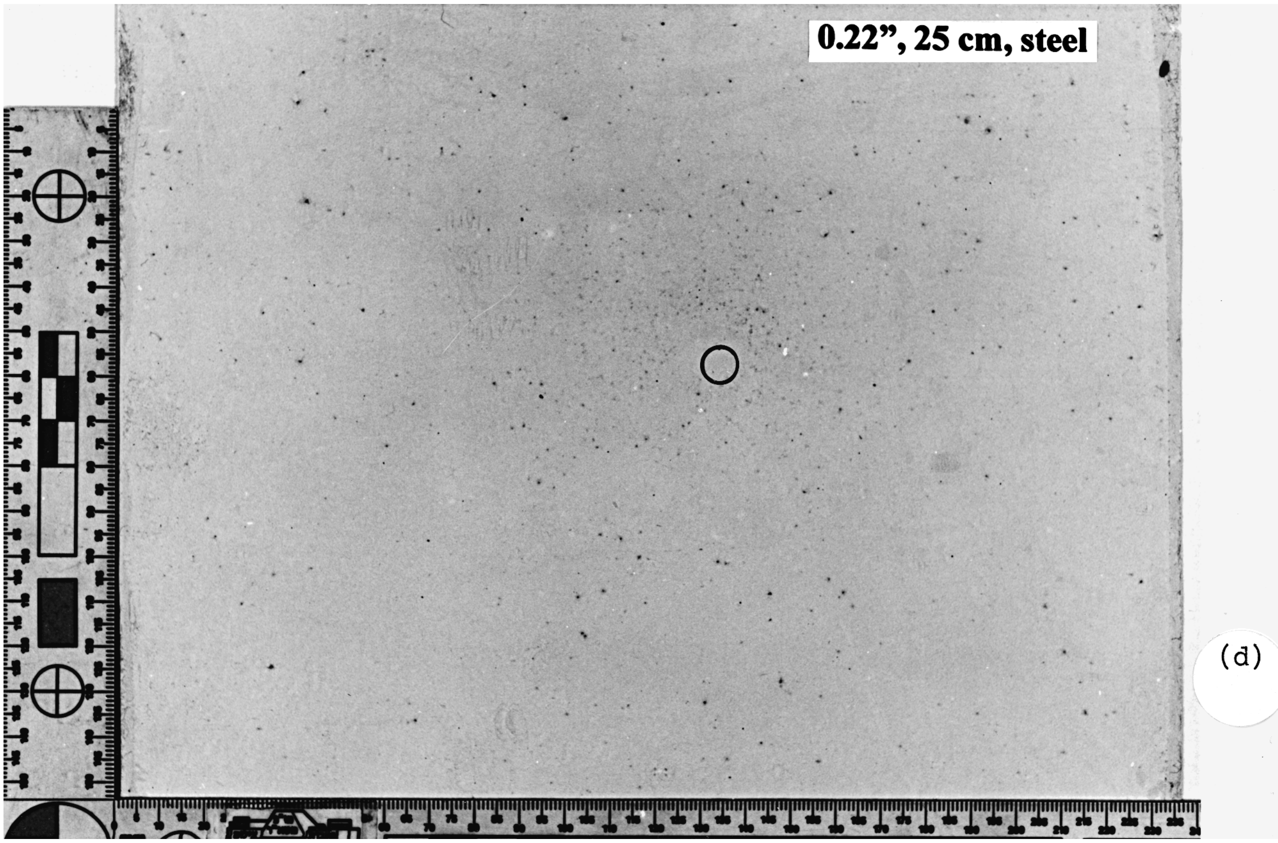

FIG. 3—*(Continued.)*

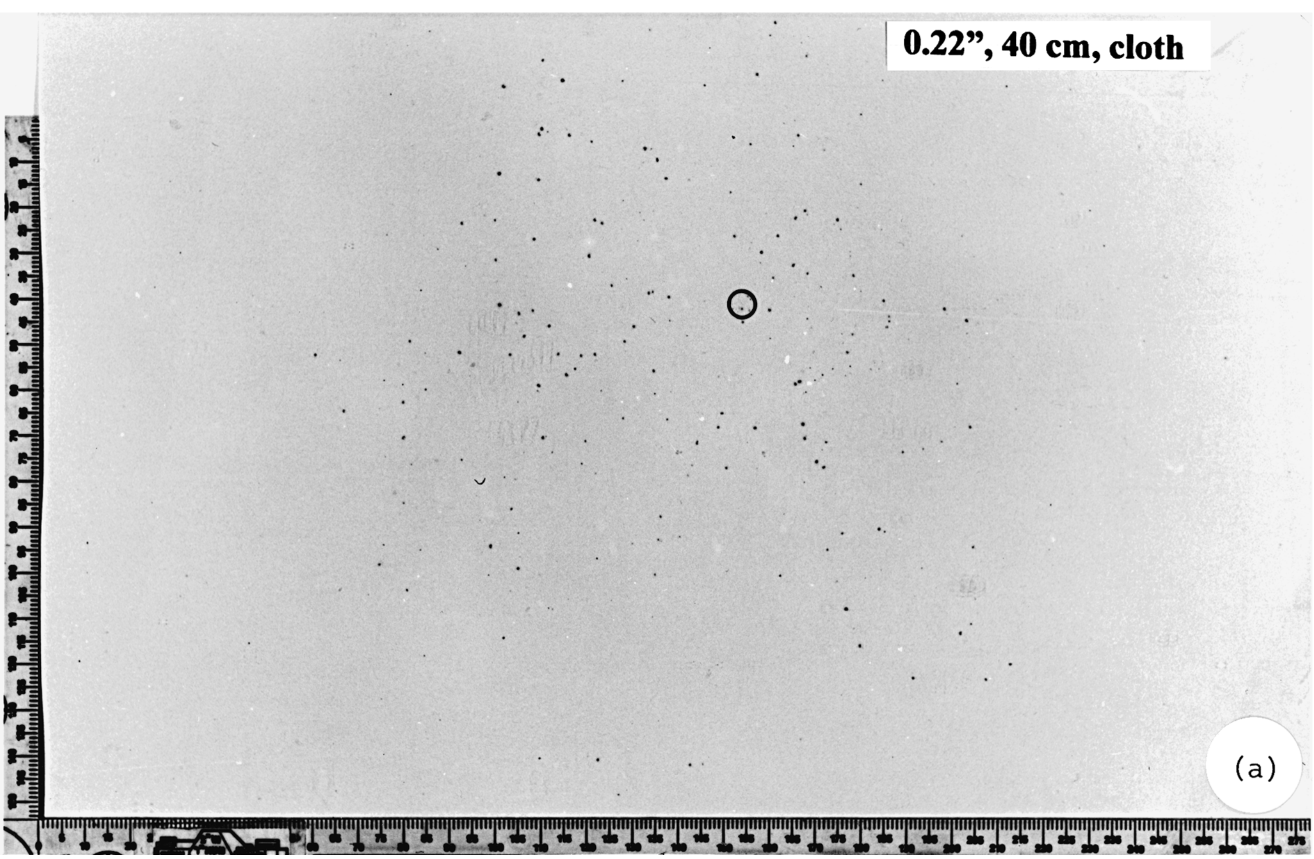

FIG. 4—*Visualized total nitrite pattern of the discharge residues of test shots fired with a Berreta LR pistol and Win Super X, copper-washed at the range of 40 cm on the lifters from the following targets: (a) White cloth. (b) Plywood. (c) Glass.*

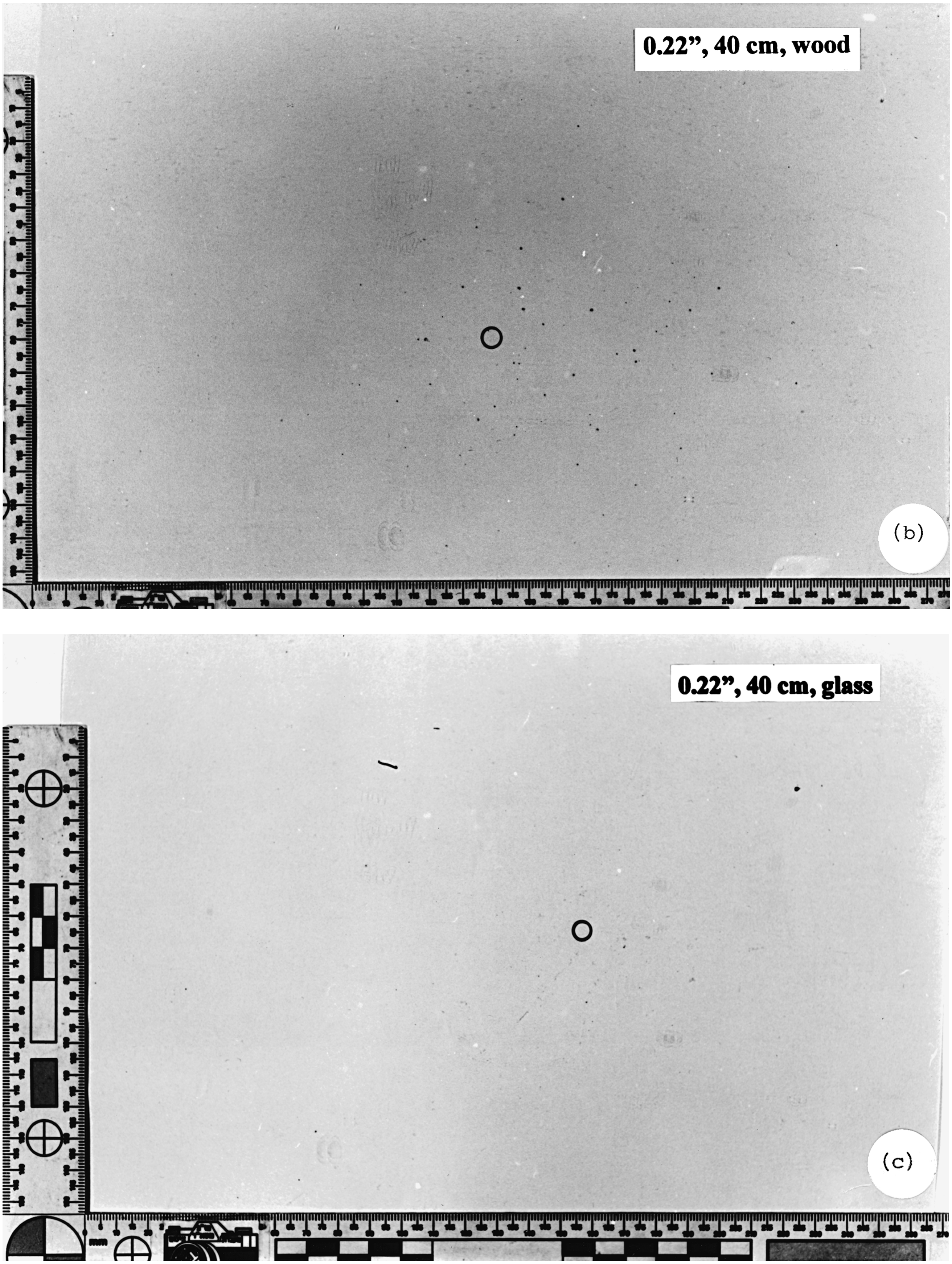

FIG. 4—*(Continued.)*

lifter processed first by the rhodizonate and rubeanic acid tests followed by the hydrolysis and MGT and those subjected directly to the hydrolysis and MGT.

Based on the obtained results in this study, the recommended method for shooting distance determination on the objects that cannot be processed in the laboratory is as follows:

1. Application of the adhesive lifter to the target.
2. Visualization of the lead deposits on the target by the rhodizonate test. It is recommended to photograph the lead pattern because of the instability of the color developed even after applying the tartarate buffer.
3. Visualization of the copper deposits on the target by the rubeanic test.
4. Visualization of the total nitrite on the lifter in the laboratory.

In cases in which there is a problem in carrying out rhodizonate and rubeanic tests for lead and copper, respectively, on the evidence at the scene of a shooting, these tests may be carried out on the lifters, before the total nitrite visualization, although, as was shown, the intensity of the vaporous lead pattern will be less than on the target itself and there is a small probability of visualizing copper.

To improve the accuracy of the shooting distance determination, test firings should be carried out at target materials as similar as possible to the materials of the examined evidence.

If there is no possibility of conducting a test firing with similar material to the evidence, then test firings may be carried out on cotton cloth. In such a case the visualized pattern of the total nitrite will be sufficient to state that the shooting distance on the evidence was equal to or below the shooting distance at which similar visualized patterns of the total nitrite are obtained on the cotton cloth.

The new method was already applied several times in casework.

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