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A Rapid, Inexpensive Method of Obtaining Infrared Images

Special photographic techniques have long been used to examine evidence for identification and comparison. Ultraviolet, infrared, and X-ray are the most notable [*1,2*]. In particular, the visualization of charred writing, obliterated writing, and gunpowder residues and the comparison of inks have been successfully made with the aid of infrared-sensitive films and electronic video techniques [*3*]. Success with this technique depends on the existence of differences in the tendencies (that is, extinction coefficients) of the components of the materials being studied to absorb radiation in the infrared band. If the ink added to alter a check shows no difference in absorption from the original ink then no distinction between the two can be made with infrared photography.

A specimen that has been overwritten with another substance cannot always be made visible with infrared reflectance photography. The method will only be successful if the material used in the original writing is a stronger infrared absorber than the material used in the overwriting.

In general, when presented with this type of evidence one does not have the information to readily decide whether or not infrared photography will be successful. Because the technique is not destructive, test photographs are usually made. This process involves making trial exposures. Infrared-sensitive film and an infrared pass filter (for example, Tiffen 87 or 87C) are used. Some source of infrared radiation such as a photoflood or flash lamp is needed. Because infrared-sensitive light meters are not available a series of exposures is tried to establish correct exposure conditions. Finally the film must be developed to determine whether or not (1) the correct exposure was used and (2) the material is suitable for examination with infrared radiation.

It may be that an exposure that is suitable for one part of a document must be altered for the successful examination of another portion of the document. More photographs must then be made until the desired results are obtained. While the entire process is not particularly difficult to master it does require a camera and ancillary equipment, some skill in darkroom techniques, and darkroom facilities. These requirements can discourage the routine application of the technique.

Many of the materials that are susceptible to treatment with infrared photography can also be successfully analyzed much more rapidly with a Thermo-fax® office copying machine. An earlier study [*4*] illustrated the examination of obliterated writings. To make a copy one must first place a special blank sheet on top of the document and then both are simultaneously inserted into the machine. In a few seconds the original document with its copy is ejected from the machine.

The blanks are made of heat-sensitive materials. They darken when exposed to heat, the degree of darkening depending on the intensity of the exposure. When the material

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passes through the copier it is exposed to infrared radiation. If the substances in the writing material absorb infrared radiation they become hot and because they are pressed against the blank it darkens and a copy results. Obviously not all writings can be successfully copied with this machine. Materials that are strong infrared absorbers, such as inks containing graphite or carbon black, will appear dark on the blank while materials that do not absorb infrared radiation will not appear on the blank. Substances that fall between these two extremes will appear as various shades of gray. It can be inferred that the same materials that can be successfully analyzed with infrared photography should also be successfully analyzed with a Thermo-fax copier. The degree of exposure in the Thermo-fax instrument can be adjusted by means of a control dial on the instrument which is provided with a scale ranging continuously from 1 through 10. A setting of 1 results in the material passing through the copier at the slowest speed (and therefore longest exposure to radiation) while a setting of 10 causes the material to pass through at the most rapid rate (and therefore shortest exposure to radiation). Therefore, by using a Thermo-fax copying machine, some of the analyses done with traditional infrared photography can be accomplished in a much shorter time with no special skills needed. The technique is limited by the size of the document that can be passed through (approximately 216 by 279 mm or 8½ by 11 in.) and by the thickness of the document (roughly index-card thickness). The material must also be flexible because it is rolled while being pressed against the blank.

Experimental Procedure

Materials

Four 350-W photofloods for infrared photographs, a Tiffen 87C filter, a Graflex 102- by 127-mm (4- by 5-in.) format camera, Kodak high-speed infrared film (Type 4143 Estar thick base), Kodak Tri-X Pan Professional film (Type 4164 Estar thick base, American Standards Association rating of 320), and standard photographic developing and processing materials were used.

A Thermo-fax office copying machine, Model 22, "The Secretary," was obtained from 3M Corp. A more recent version, Model 45EGA, permits a document of virtually any length to be continuously fed into the machine. Two types of Thermo-fax blanks were used in this study:

(1) Thermo-fax transparency film, infrared, Type 588, black image on a clear background (a clear, transparent sheet costing $0.20 to $0.40 per sheet) and

(2) Thermo-fax copy paper, a standard buff, Type I, costing $0.05 per sheet, a thinner, nontransparent, beige, and much less expensive item than the transparency film.

All infrared photographs were made with four 350-W photofloods at a distance of about 762 mm (30 in.) from the subject with the 87C filter held over the lens of the camera. The exposures were f/11 at 0.01 s. Examples of a number of applications are given in the following sections.

Example 1—Test Grid

Figure 1 shows a test grid prepared by using 13 different writing materials. A sheet of 216 by 279-mm (8½- by 11-in.) paper was divided into 13 columns and rows, making 169 boxes. A circle was drawn in each box in a column with the writing material corresponding to the number at the top of the column. (See Table 1 for the coding of these numbers and writing materials.) Then the material corresponding to the number on the left of each row was used to write over each of the circles in that row. The result of this procedure was a grid where every paired combination of the materials being tested was formed, once with

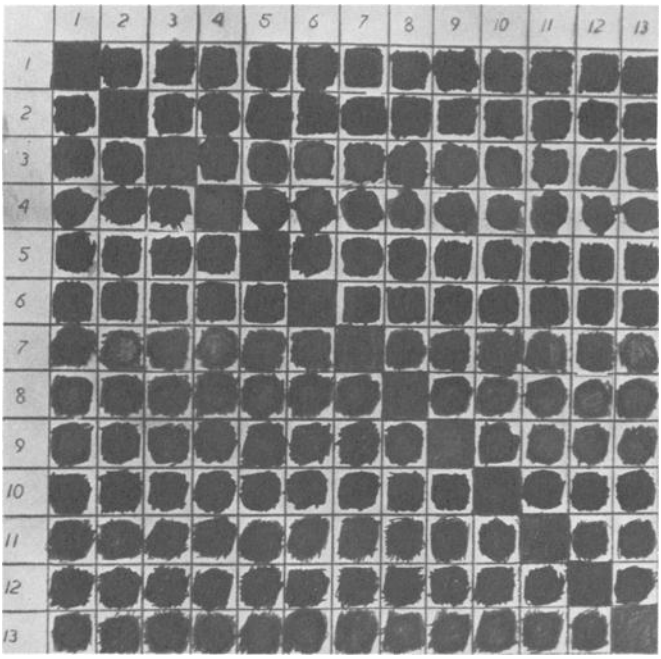

FIG. 1—*Test grid photographed with Tri-X film.*

one of the members of the pair as a circle on the bottom with the other member used to write over it, and once with the reverse situation. For example, in the square in Column 10, Row 6 there is a circle drawn with a Flair® black ink pen covered with Higgins American india ink, black No. 4415. In the square in Column 6, Row 10 the situation is reversed, with the india ink on the bottom being covered by the Flair black ink. In each of the squares along the diagonal only one ink is used. As can be seen in the photograph, because of the nature of the materials some of the circles are visible even to the naked eye.

Figure 2 shows the same grid photographed with infrared light. Some of the circles that were not visible have been made visible. Many of the materials that were visible are now

TABLE 1—*Coding of writing materials.*

Writing Material	Number
Sheaffer's Skrip, deluxe black #62, fountain pen ink	1
Sheaffer's Skrip, permanent jet black #32, fountain pen ink	2
Sheaffer's Skrip, deluxe blue #42, fountain pen ink	3
Sheaffer's cartridge, blue	4
Parker's Super Quink, permanent black, fountain pen ink	5
Higgins' American india ink, black #4415	6
National's Cedar King 223, #2 pencil	7
Flair, fiber tip, blue ink pen	8
Flair, fiber tip, red ink pen	9
Flair, fiber tip, black ink pen	10
Bic, AF-49 accountant fine point, blue ink, ball-point pen	11
Bic, black ink, ball-point pen	12
Papermate®, blue ink, ball-point pen	13

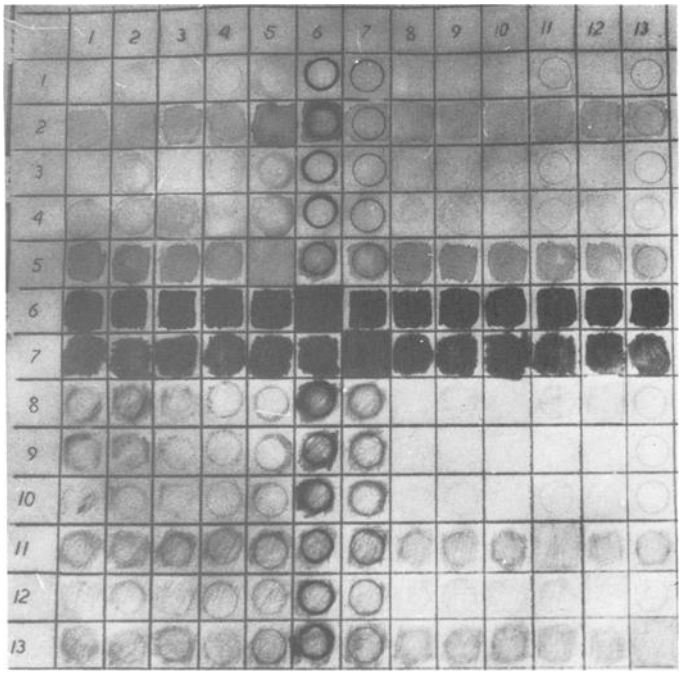

FIG. 2—*Infrared photograph of test grid.*

invisible with the infrared light. Figure 3 shows the same grid as copied onto a Thermo-fax transparency at a setting of 1, and Fig. 4 shows the grid as copied onto Thermo-fax copy paper at a setting of 3.

Example 2—Overwriting

Four phrases, each written with a different material, were written over so they could not be read. Table 2 lists the phrases and writing materials, and Fig. 5 is a photograph made with Tri-X film of the overwriting. Figure 6 shows the same sample photographed with infrared film. Figure 7 shows a Thermo-fax reproduction made at a setting of 7 on copy paper.

Example 3—Altered Check

A check was made out for four dollars with Sheaffer's Skrip® jet black #32 ink; two zeroes were added to the 4 and the word "hundred" was added with Esterbrook black ink (Fig. 8). The infrared photograph is shown in Fig. 9. Figure 10 shows two Thermo-fax copies made on copy paper, one at a setting of 4.5 and the other at a setting of 7. Figure 11 is a Thermo-fax copy made on a transparency at a setting of 1.

Example 4—Gunshot Powder Patterns

A number of powder patterns were prepared by firing a Smith & Wesson revolver at pieces of cloth from distances varying from contact to 305 mm (12 in.). The revolver had a 102-mm (4-in.) barrel and was chambered for .38 Special cartridges. Remington .38 Special

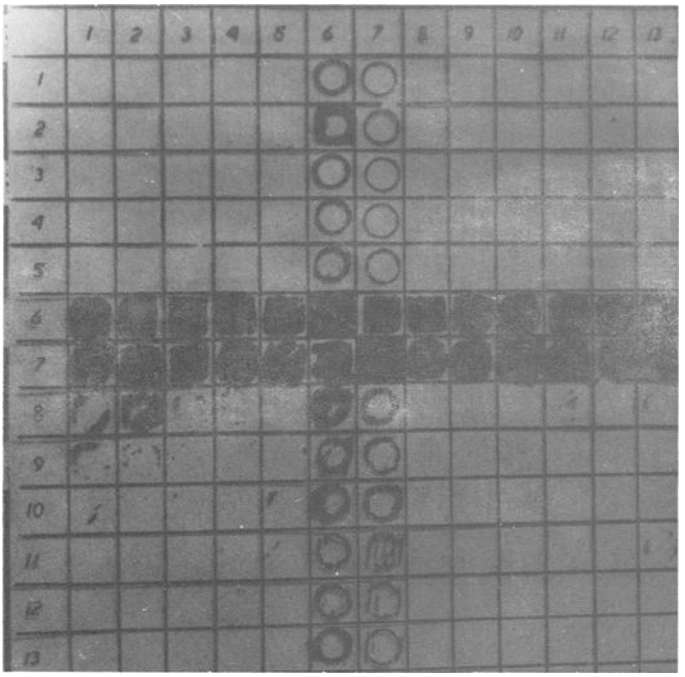

FIG. 3—*Test grid copied with Thermo-fax transparency at a setting of 1.*

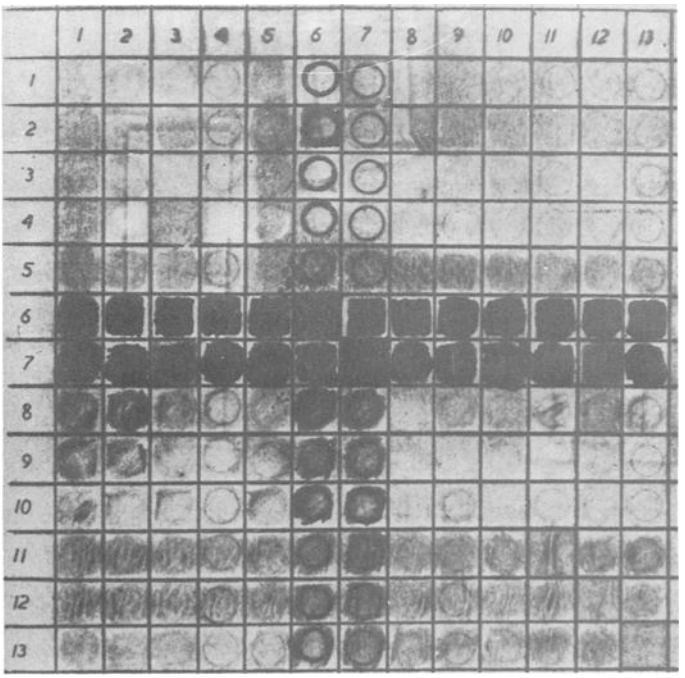

FIG. 4—*Test grid copied with Thermo-fax copy paper at a setting of 3.*

TABLE 2—*Phrases and writing materials for the overwriting sample.*

Number	Phrase	Material Used to Write Phrase	Overwriting Material
1	this is typewritten	typewriter	Parker's Super Quink, permanent black
2	india ink	india ink	Parker's Super Quink, permanent black
3	this is Xeroxed	Xerox photocopying	Shaeffer's Skrip, jet black #32
4	Esterbrook	Esterbrook ink	Parker's Super Quink, permanent black

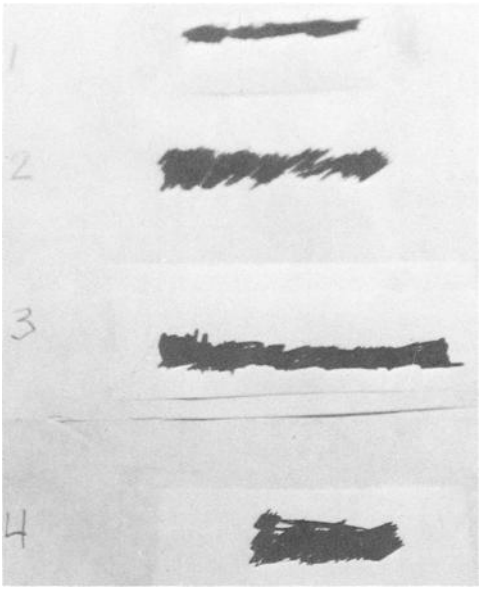

FIG. 5—*Photograph of overwritings with Tri-X film.*

lead cartridges were used. The cloth used was white, and thus the patterns were visible and could be compared with Thermo-fax copies.

Figure 12 (*left*) is a photograph made with Tri-X film of the contact pattern, and Fig. 12 (*right*) is a Thermo-fax transparency made at a setting of 1. It was found that the copy paper was unsuitable for the powder pattern examinations. Not only was the powder pattern reproduced but many spurious dark areas also appeared on the copy. These were greatly reduced although not entirely eliminated when transparency paper was used. This is shown in the test pattern made at 203 mm (8 in.). Figure 13 (*left*) is a photograph made with Tri-X film, and Fig. 13 (*right*) is the Thermo-fax transparency. For the most part the pattern seems to be reproduced very well. However, there is a vertical line of about eleven black dots appearing in the upper left-hand corner which does not correspond to any powder seen on the cloth. It does not appear in successive copies, although sometimes similar spurious patterns are produced in other locations. This artifact must be eliminated if powder patterns are to be compared. Also, if many copies are made in quick succession the machine tends to warm up, causing the darkening of successive copies. This darkening

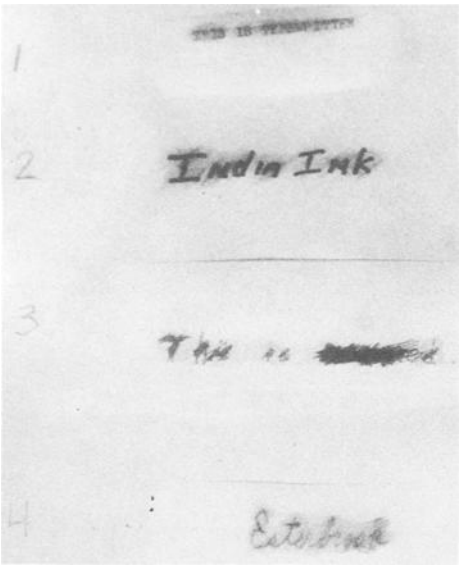

FIG. 6—*Infrared photograph of overwriting.*

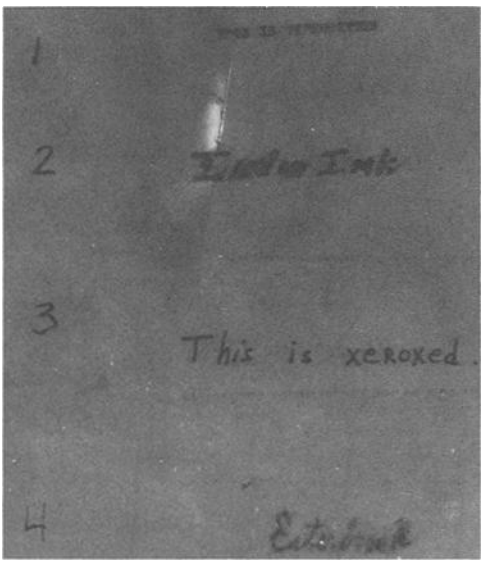

FIG. 7—*Overwriting copied with Thermo-fax copy paper at a setting of 7.*

is not critical in other applications but could affect the reproducibility of copies made of gunshot powder patterns. Normally the machine is switched on and allowed to warm up for 5 to 10 min before use. In this case it should be allowed to cool down for 1 to 2 min between copies. With this precaution, successive copies yielded fairly reproducible patterns. Another problem that might arise is the possible transfer of powder from the garment to the blank as a result of the garment being pressed against the blank as they are passed

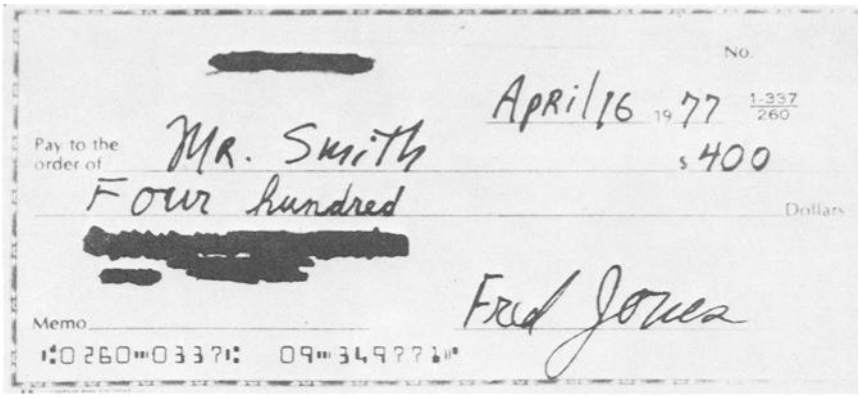

FIG. 8—*Altered check photographed with Tri-X film.*

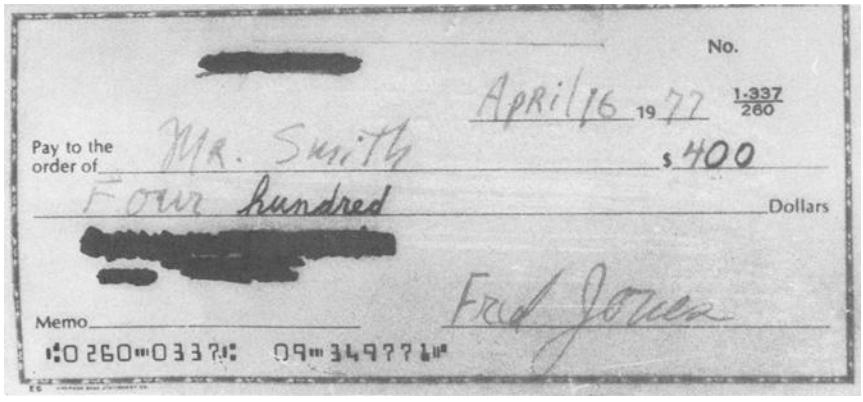

FIG. 9—*Infrared photograph of altered check.*

through the copier. Finally, one is limited to using only rather thin materials that will pass through the machine.

Conclusion

A technique has been presented which seems to be as useful for a number of forensic science applications as is infrared photography. Furthermore, it is faster and more sensitive and requires less skill and training to use. It cannot at present be used for large, bulky objects, and its use in establishing powder patterns is unsatisfactory. Additional applications such as making rapid comparisons between materials like paper, liquids, and paints may be possible. It should be possible to devise a technique that uses a heating lamp or an electric iron instead of a copying machine to supply the radiation. One should then be able to press the Thermo-fax blank against the object being investigated and obtain an image. This possibility is currently being investigated.

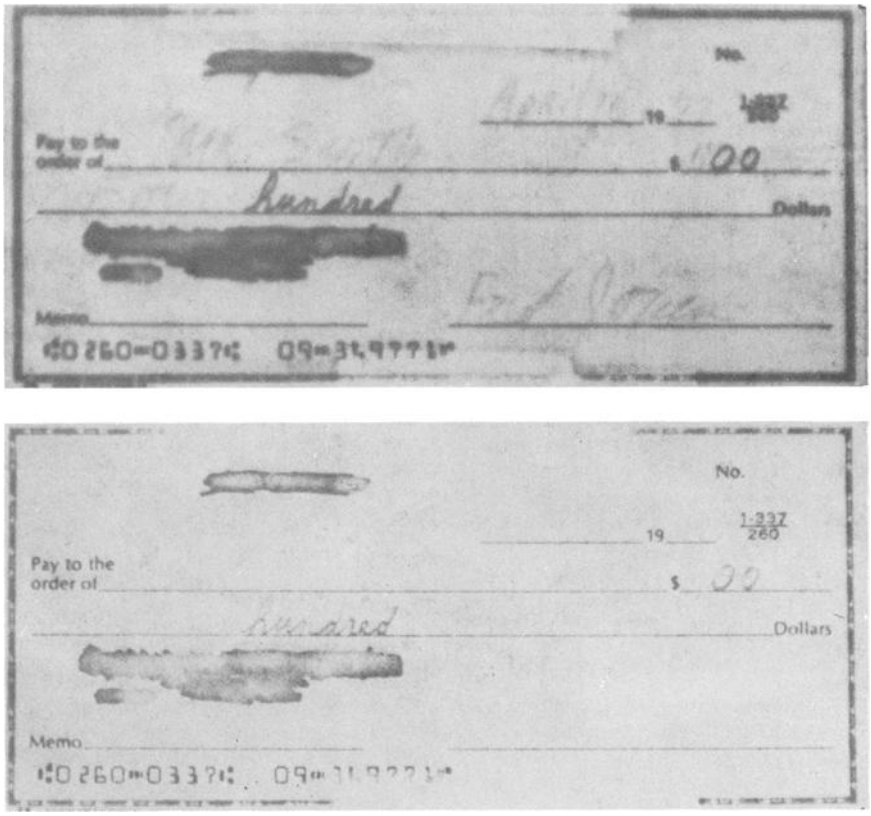

FIG. 10—*Thermo-fax of altered checks made on copy paper;* (top) *setting of 4.5 and* (bottom) *setting of 7.*

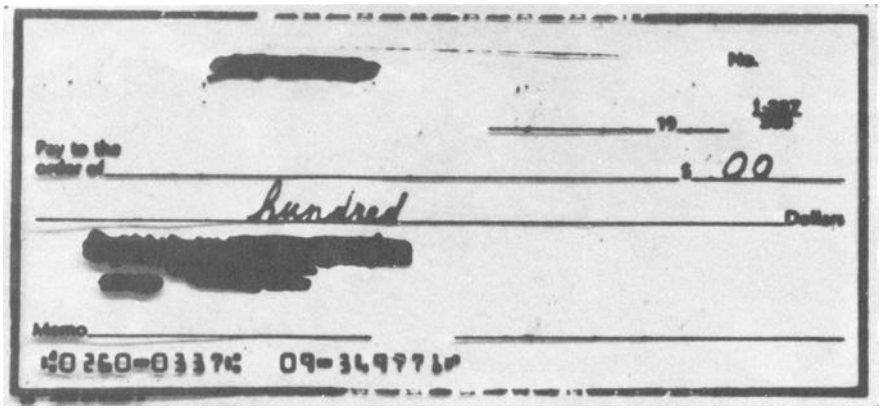

FIG. 11—*Thermo-fax of altered check made on transparency at a setting of 1.*

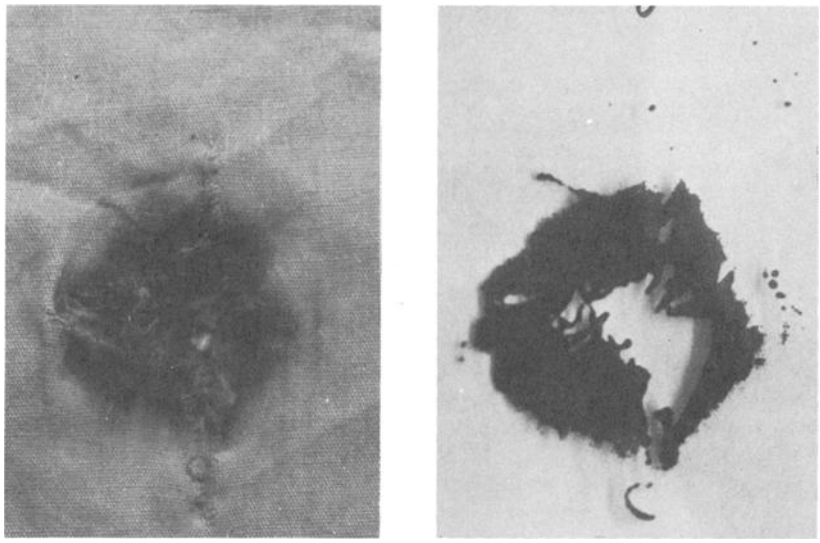

FIG. 12—*Gunshot powder pattern contact shot;* (left) *Tri-X film and* (right) *Thermo-fax transparency at a setting of 1.*

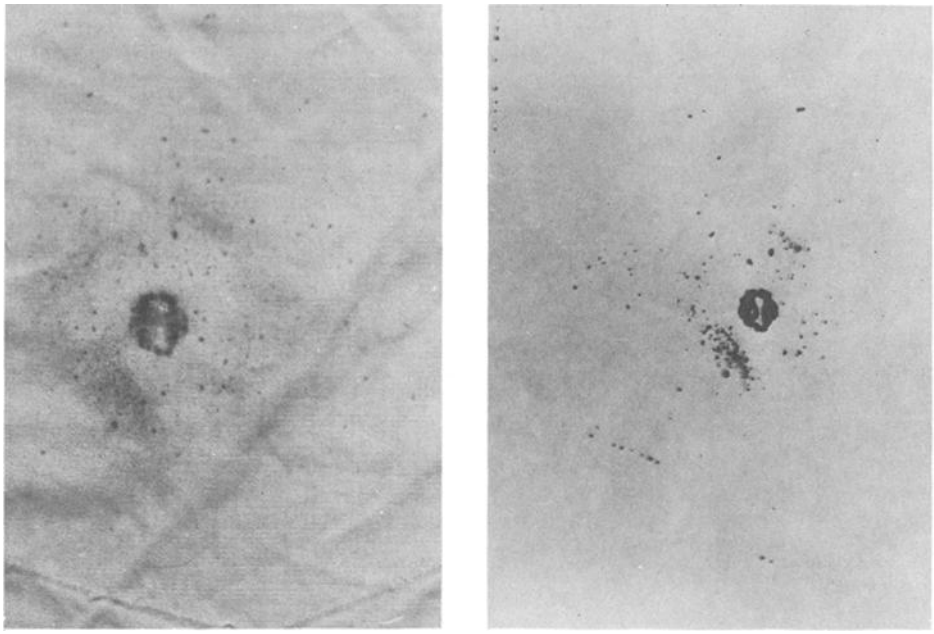

FIG. 13—*Gunshot powder pattern at 203 mm (8 in.);* (left) *Tri-X film and* (right) *Thermo-fax transparency at a setting of 1.*

Summary

A method of obtaining rapid infrared reproductions with a readily available Thermo-fax copier is described. Examples of a number of applications are given along with a discussion of the advantages and limitations of the technique.

Acknowledgment

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