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THE DEVELOPMENT OF LATENT FINGER-PRINTS ON PAPER

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Latent impressions of friction skin left on hard, smooth objects such as metal, glass or polished wood usually present little difficulty from the standpoint of development. The secretion from the pores of the friction ridges, representing the pattern and details of the papillary lines, slowly dries on a hard surface and may remain for several years. Moreover, the development or intensification of such an impression usually requires little more than the careful brushing of a finely divided dry powder of suitable contrast over the surface, with the powder adhering to the secretion and causing it to stand out more or less sharply against its background. The development of latent fingerprints on paper, however, usually presents a problem of greater difficulty. Due to the absorbent nature of most papers, which results in the penetration of the watery secretion into the paper and the migration of at least some of its components (e. g., chlorides or sulphates) laterally within the paper, the simple mechanical process of development used on hard non-porous objects is inadequate in practical investigations where several days or even months have elapsed since a document or other paper article received the fingerprint impressions. Therefore, so far as paper objects are concerned,[1] developing agents are required which have some penetrating power in paper and also which react chemically with one or more components of the secretion from the fingers. All this, of course, is further complicated by the fact that many of the common paper objects submitted to the fingerprint expert for examination, such as letters, labels on bottles, cigarette packages, etc., are usually subject to more handling than metallic or other hard objects, and consequently the developed prints in such cases may be superimposed, blurred, or otherwise unsuitable for identification purposes. For these reasons the degree of success achieved in the examination of paper articles for latent fingerprints as compared with hard-surfaced objects is likely to be very slight.

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[1] Paper objects frequently met with in the course of investigations include letters, post cards, books, magazines, newspapers, wrapping papers, labels, envelopes, cardboard boxes, cigarette packages, numerous kinds of documents, photographs, identification cards and various personal papers.

Since the possibility of obtaining one or more fingerprints on paper objects in actual case work is conditioned by many factors (such as porosity of the paper, amount and kind of sizing, atmospheric and climatic conditions, the condition of the suspect's fingers, and the manner in which the impressions were made), it is always difficult to determine accurately the length of time after handling that identifiable fingerprints may be secured. It is probable that under ideal conditions sufficiently clear impressions may be found after several months.[2] However, under ordinary circumstances successful development cannot be effected after a few weeks, and in some cases the impressions may be lost after a few days.

Occasionally on questioned documents or other paper materials fingerprints are left which are clearly visible and require no treatment preparatory to analytical study. Such prints may be produced when the fingers become smeared with ink, blood, dust or dirt, paint, grease, etc. In the majority of cases, however, the fingerprint is formed only by the secretory matter derived from the skin. Since this matter is usually colorless, the *latent* image is invisible and requires some form of intensification or "development" in order that it may be clearly seen and studied. The perspiratory secretion, arising from the sweat glands of the skin and continuously deposited through the pores onto the friction ridges of the hands, is composed of 98% or more water with minute quantities or traces of sodium and potassium chlorides, lactic acid, albumin, glucose, urea, fatty acids, phosphates, carbonates, sulphates and perhaps creatine and creatinine.[3] This secretion, together with a small quantity of sebum which is picked up by contact of the hands with hair-producing skin, constitutes the somewhat evanescent, latent image from which a clearly visible pattern is to be derived. Its composition varies from time to time and probably differs slightly in different individuals, but this aspect of the problem and its possible influence on successful development seems to have received but little attention.

From the standpoint of the action of the agents employed, developing processes are of two types: (1) *physical,* wherein powders are passed over the surface of an object in some manner, the adhesive nature of the secretion causing the finely divided powder to adhere and thus rendering the latent impression visible, or, in

[2] Several investigators have reported instances in which fingerprints were revealed three or more years after being made. Such instances, however, are extremely rare in actual practice.

[3] McSwiney, B. A., The Analyst, 59:496 (1934); Locard, E., Traité de Criminalistique, (1931) Vol. 2, p. 37.

which an agent is employed that is absorbed by the deposit but does not react with it chemically in any way, and (2) *chemical,* in which a definite chemical reaction occurs between some substance in the latent print and the developing agent (as in the action of silver nitrate upon chlorides in the fingerprint).

The developing agents employed for fingerprints on paper may be in the form of a solid, a liquid, or a vapor. Some developers may be used either in liquid form or as a vapor depending somewhat upon the particular conditions of a given problem. The developers which have been generally used by various experts are as follows:

Powders:

1. Graphite
2. Lampblack plus graphite
3. Wood charcoal
4. Carbon black
5. Animal charcoal
6. Metallic magnesium
7. Carmine
8. Indophenol
9. Copper (cuprous) oxide
10. Methylene blue
11. Manganese dioxide
12. Ferric oxide
13. Calomel
14. Red mercuric sulphide (vermilion)
15. Barium sulphate
16. Red lead oxide (Pb_3O_4)
17. Metallic iron
18. "Dragon's blood"
19. Anthracene
20. Uranyl phosphate
21. Basic lead carbonate
22. Metallic aluminum
23. Antimony sulphide or black metallic antimony
24. Various basic dyestuffs (e. g., Victoria Blue BS)

Liquids:

(Aqueous solutions of the following, except as noted)

1. Mercurous nitrate
2. Sodium thiosulphate
3. Eosin (alcoholic sol.)
4. Fuchsin (alcoholic sol.)
5. Sudan III (alcoholic sol.)
6. Lead acetate
7. Palladium chloride
8. Osmium tetroxide
9. Ruthenium tetroxide
10. Diluted ink
11. Osmic pyrogallate
12. Silver nitrate

Vapors:

1. Chlorine
2. Bromine
3. Iodine
4. Ruthenium tetroxide
5. Osmium tetroxide
6. Ammonium sulphide

Some of these materials have only a feeble developing action and a few have been found practically useless for routine work. Only a few of the more useful developing agents will be considered here.

Powders

Since the chemical methods of development are far superior to powders in most instances, the latter are seldom employed in the laboratory except in unusual cases. They are not effective except on hard surfaced papers, such as the better grades of writing and book papers, and then only when the latent prints are known to be very recent. If the impressions are more than two or three days old, or if it is even suspected that such is the fact, it is advisable to use some other type of development.

Powders are of value chiefly in the following ways:

(1) For the development of latent prints known to have been recently made.

(2) For the development of comparison prints obtained by allowing a suspect to handle a letter, wrap a parcel, etc.

(3) For the development of latent impressions on dark or multi-colored papers when the prints are comparatively recent (e. g., on magazine advertisements, book covers, etc.). Fluorescent compounds such as anthracene or uranyl phosphate are dusted on the paper and photographed in filtered ultra-violet light. In this way the effect of the multi-colored background is destroyed since only the fluorescent material in the latent print is recorded on the photograph.[4]

The black powders most commonly employed are lampblack, charcoal, and graphite, or a mixture of these. The light powders are usually "mercury and chalk" or aluminum powder. Although the aforementioned give satisfactory results, the writer has found that powdered black metallic antimony (for white papers) and "aluminum bronze" powder (for black or dark colored papers) are much more effective as developing agents. The antimony powder produces a sharper, more contrasty print, since it does not adhere to untouched portions of the paper and hence does not darken the interspaces of the latent impression. The "aluminum bronze" powder is extremely adhesive, and because of its light, fluffy character does not produce blurring of the latent print. However, it has

[4] Evans, A., Photography of Fingerprints on Multi-Colored Objects. (Pamphlet published by U. S. Department of Justice, October 16, 1933.)

one disadvantage, due to its lustre, in that it is difficult to photograph by ordinary means. Another white powder which is useful in dealing with certain classes of dark colored papers is basic lead carbonate ("Dutch process" white lead), but it does not adhere so tenaciously as the aluminum powder.

In treating papers with powder of any kind it is seldom good practice to apply it with a brush in the usual way. Instead, the powder is sprinkled lightly over the surface to be treated and the paper, while held by the ends between the hands, is agitated in such a manner as to cause the powder to be bounced slightly over the entire surface. When the optimum amount of powder has adhered to the developed impressions the excess powder is removed by tapping the reverse side of the paper with the fingernail, or by holding the sheet on edge and flipping it backward and forward. Using the powder as here described, very good results may be obtained with fresh latent impressions.[5]

Fingerprints developed with powders are easily smudged or destroyed unless carefully protected from contact with the fingers or other object. It is necessary, therefore, that they be photographed immediately following their development. If it is desirable to preserve the impressions in their original state, the paper may be floated for a few moments on a bath of diluted milk in a shallow dish or tray, after which it is hung up to dry.[6] An alternative method of fixation consists of spraying the paper with a clear varnish, or charcoal fixative, using an artist's sprayer to apply it in the form of a light mist.

Iodine

Iodine vapor is a rather sensitive developer and old prints can be develped by its use which could not be rendered visible with powders. The reaction is probably entirely physical, the vapors tending to adhere to the deposit of secretion more than to untouched portions of the object.[7] The coloration produced is light to dark brown and is usually extremely fugitive. Iodine sublimes readily at ordinary room temperature, hence the developed prints

[5] A fingerprint powder known as "Lightning Black," recently placed on the market, is extremely adhesive, and may be brushed on the paper with an ordinary camel's hair brush. It is supplied by the Finger Print Publishing Association, Chicago, Illinois.

[6] Battley, H., Single Finger Prints (1930) 74.

[7] Iodine vapor was used as early as 1876 by Pierre Aubert, and later by Coulier, Van Beneden, Stockis, Burnier and others.

will quickly fade out unless some method of preservation is used.

The iodine vapor used as a developer is usually obtained by vaporizing crystalline iodine, although some experts, notably in France, prefer using iodoform or potassium iodide as a source of iodine.[8]

The vapor may be applied in a number of different ways, as follows:

(1) Crystals of iodine are placed in an evaporating dish or crucible and heated gently by means of a Bunsen burner or alcohol lamp to hasten evolution of the vapor. The paper to be treated is held over the dish, a few inches above it, and moved slowly back and forth through the escaping fumes.

(2) A somewhat better procedure than the foregoing, and one commonly used by fingerprint experts, consists in placing the object and iodine together in a closed chamber and allowing the fumes to develop at room temperature and permeate the paper. Some experts use as a treatment chamber a specially constructed box through which fine threads are strung horizontally about two inches from the bottom. Iodine is spread out on the bottom of the box and the paper to be treated is laid out flat on the threads just above it. A glass window set in one side of the box permits the operator to watch the progress of development.

In place of the special fuming chamber the iodine treatment can be carried out effectively by using a bell jar, desiccator or similar vessel to enclose the object together with a small container of iodine crystals.

Wagenaar, of Rotterdam, uses a petri dish top with crystals of iodine fastened to the inside with an adhesive. The dish is then simply inverted over the area of the paper to be treated.[9] He also uses an ordinary glass atomizer for generating the vapor and applying it to a suspected area, but this method of producing the vapor is less efficient than the recently developed fuming tube described below.

(3) Instead of the customary procedure of treating a suspected object in some type of closed container, a special portable applicator, recently devised by McMorris,[10] constitutes perhaps the best

[8] Locard, E., Traité de Criminalistique, (1931) Vol. 2, pp. 134-135. From the standpoint of chemical theory it is difficult to understand the advantages of using such compounds. The writer has not found iodine vapor from such sources to have a greater developing power than that obtained from iodine crystals.

[9] Wagenaar, M., Pharm. Weekblad., 72:1265-1271 (1935).

[10] McMorris, J., "The Iodine-Silver-Transfer-Method for Recording Latent Finger Prints," Finger Print Magazine, *18* (9):6-10 (1937).

method of utilizing iodine vapor. The applicator, as described by the inventor, consists of two straight-form, single bulb, calcium chloride drying tubes joined together by means of a one-hole stopper; one tube contains anhydrous calcium chloride, the other a quantity of iodine crystals held in place with glass wool. In operation, the breath is blown through the instrument, passing first over the calcium chloride, which causes it to be heated and dehydrated, and then over the iodine, which is partially vaporized by the warm air. The iodine vapor thus formed is carried out of the mouth of the tube in the current of air onto the surface of the object treated, which is held about a half inch from the mouth of the tube. The advantages of this method of application are that the vapor is easily and quickly generated, and can be applied to selected small areas as well as over a large surface.

One disadvantage of the iodine process is that the developed impressions are not permanent, due to the fugitive nature of iodine. To overcome this tendency of the iodine prints to fade, some method must be used to prevent or retard evaporation, or to fix the prints by some chemical process.

Enclosing the iodine treated paper in a photographic printing frame, or between plates of glass of the same size and sealing the edges with gummed tape will help to prevent evaporation, at least for a sufficient length of time to permit photographs to be taken; however, by this method one has only a photographic reproduction and not an original print. McMorris advocates the use of a silver plate for the preservation of iodine prints. A plate of pure silver prepared with a "satin" finish is placed over the print immediately after development, allowed to remain approximately one second, then lifted off and exposed to direct sunlight or light from a photoflood bulb which results in the formation of a permanent black image on the silver surface. This procedure may be repeated a number of times without destroying the latent print.

The early methods of chemical fixation were generally unsatisfactory and are no longer in use. These included the addition of such agents as calomel and hydrogen sulphide, gallic acid and silver acetate, or 10% tannic acid.

One of the most satisfactory methods for chemical fixation of iodine prints is that devised by Popp.[11] This consists of the application of a 1% aqueous solution of palladium chloride containing

[11] "Chemische Hervorrufung und Fixierung latenter Fingerspuren," Krim. Monatshefte, 5:4-6 (1931).

a small amount of alum and tannin, until the color is developed to the proper shade, rinsing with distilled water, and allowing the paper to dry spontaneously.

An excellent fixative for iodine prints was devised by Wagenaar.[12] It is a thin paste made by mixing: Rice starch, 1 gram, water, 20 cc., potassium iodide, 2 grams, and thymol, 0.3 gram. The rice starch is made into a paste, then the potassium iodide is added in solution, as is the thymol, and the whole finely mixed together. The paste is applied directly where the fingerprint appeared as a result of the iodine vapor application. The imprint will be colored dark brown and can be preserved for at least several months. The fixed print can be made still more permanent by varnishing it with a 3% solution of gum dammar in benzol.

Osmium Tetroxide

If the latent fingerprints are not too old they may be developed by subjecting the paper to fumes of osmium tetroxide,[13] also known as "osmic acid." A characteristic property of this reagent is that it is easily reduced by fatty matter to a black compound with the formula: $Os\ O_2$. Since fats and other organic matter are nearly always present in the latent impression, osmium tetroxide constitutes an excellent developing agent, although it is somewhat slow in reaction. It is obtainable in solid form, in half-gram or one-gram quantities in sealed glass ampoules. Although the cost of the pure compound is unusually high (approximately six dollars per gram at the time of writing), the reagent is used in the form of a 1% or 2% solution and only a small quantity is required at one time.[14]

The reagent may be applied as a liquid but is usually used in the form of a vapor, because it is more penetrating in that state and in addition the developing action can be more easily controlled.

A few cc. of the 1% solution is placed in a small clean evaporating dish or crucible, heated gently over a Bunsen burner for a

[12] Wagenaar, M., "Vorschlag eines Verfahrens zur Fixierung der mit Jod sichtbar gemachten latenten Fingerabdrücke," Archiv f. Krim., 97:45-48 (1935).

[13] According to Locard, osmium tetroxide was first used by Charpy about 1877, and the method was revived by Forgeot in 1890. It has been used by numerous investigators since that time.

[14] The solution is stored in a dark bottle fitted with a ground glass stopper. A bottle with a grooved stopper is recommended for the reason that small quantities of the solution can be obtained without removing the stopper, thus preventing contamination which might affect the reagent.

few seconds[15] and then placed under a bell jar (or similar closed vessel) with the paper to be treated. The time required for development is usually about 30 minutes, although it may be as much as 12 hours, depending upon individual conditions. The fingerprint ridges developed by this procedure are gray or black, whereas the interspaces remain uncolored. The prints are permanent and require no fixation.

Silver Nitrate

The principle upon which silver nitrate as a fingerprint developer is based is that the reagent will unite with the chlorides of sodium and potassium present in the impression to form silver chloride, which, upon exposure to light, will be reduced with the formation of a dark purplish image corresponding to the pattern itself.[16]

The optimum concentration of silver nitrate for general work is a matter about which there is considerable disagreement among experts. Concentrations recommended by various authorities range from 0.5% to 15%. Perhaps the reagent most generally used is the 5% aqueous solution. Some experts recommend the addition of a small quantity of acetic or nitric acid; others use the solution without acidifying it.

The treatment of a suspected paper with the reagent is best carried out in a dark room. The silver nitrate solution is placed in a photographic developing tray or a shallow, enameled pan and the paper floated onto the bath for a few minutes. The paper is then hung up to dry in the dark, after which it is exposed to sunlight or to intense artificial light, such as that from a 500-watt photoflood lamp, until the latent image is clearly developed. Upon continued exposure to light the entire paper will gradually darken, so that it should be preserved in absolute darkness to retard further reduction of the silver compound.

Instead of using the reagent in the form of a bath, it may be applied with a roller or sprayed on with an atomizer or spray gun, but the method described seems superior to other methods of application.

The reduction of the silver chloride may be effected chemically as well as by actinic means. The paper, after being treated with

[15] Heat is applied to hasten the evolution of the vapor. The cold solution can be used with good results but it requires a much longer time for development.

[16] The silver nitrate method was first employed by Pierre Aubert about 1878.

silver nitrate, is rinsed in distilled water and then immersed in a bath of formaldehyde and sodium hydroxide,[17] which causes a reduction of the silver salt to metallic silver, revealing the impressions as black images on a light background.

Soon after development, and while the fingerprints are still sharp and contrasty, the paper should be photographed. Various methods of fixation have been employed, such as immersion in ammonium sulphide or sodium thiosulphate, but the fixing processes tend to reduce the sharpness of the print.

The silver nitrate process is perhaps the best method available at the present time for the development of latent fingerprints on paper. Through its use latent impressions several months old have been clearly revealed, whereas other processes of development usually are not applicable to fingerprints more than two or three weeks old.

[17] One part formalin (40% formaldehyde) to ten parts dilute (1-5%) sodium hydroxide.