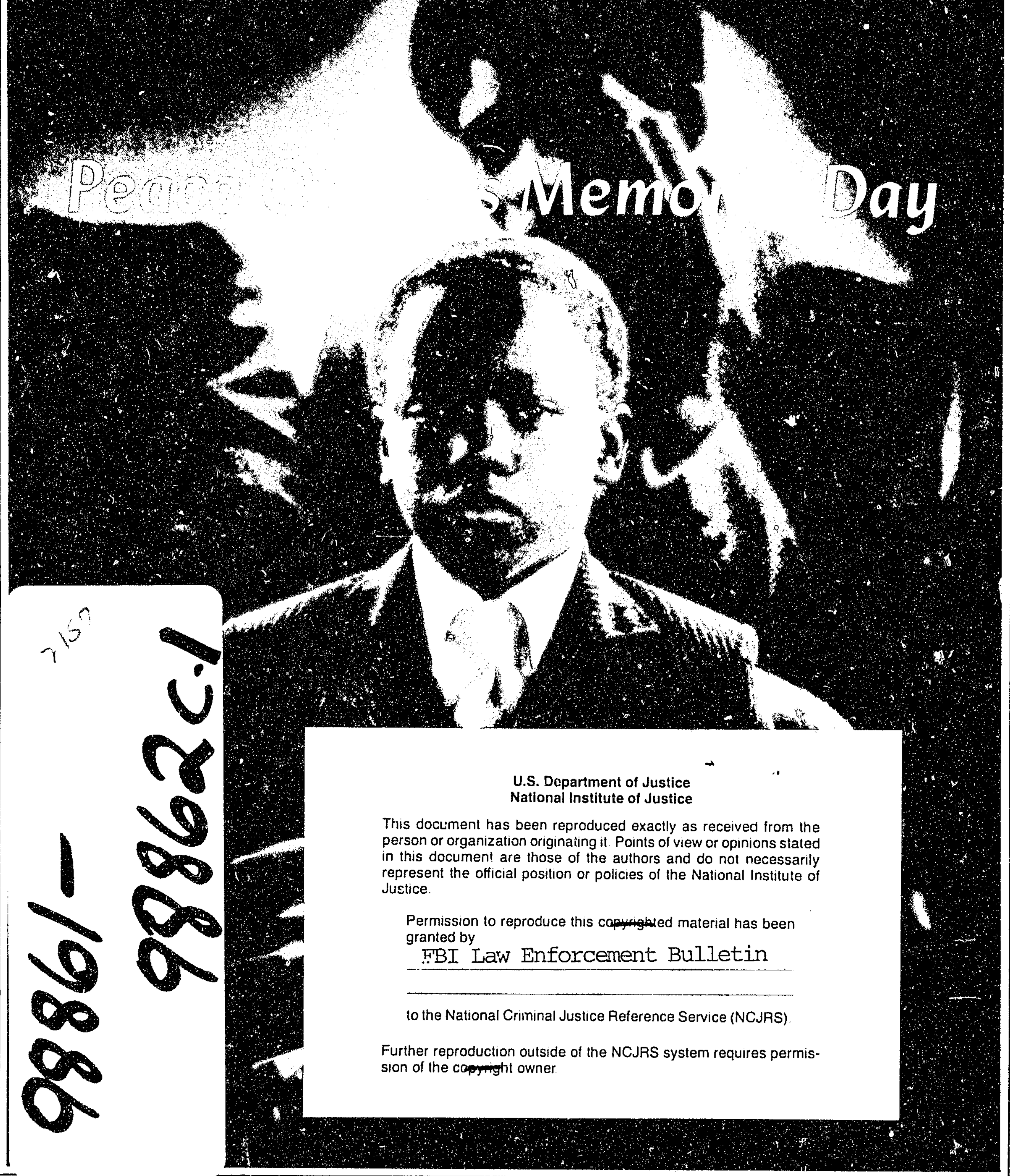
FBI LAW ENFORCEMENT BULLETIN

JUNE 1985



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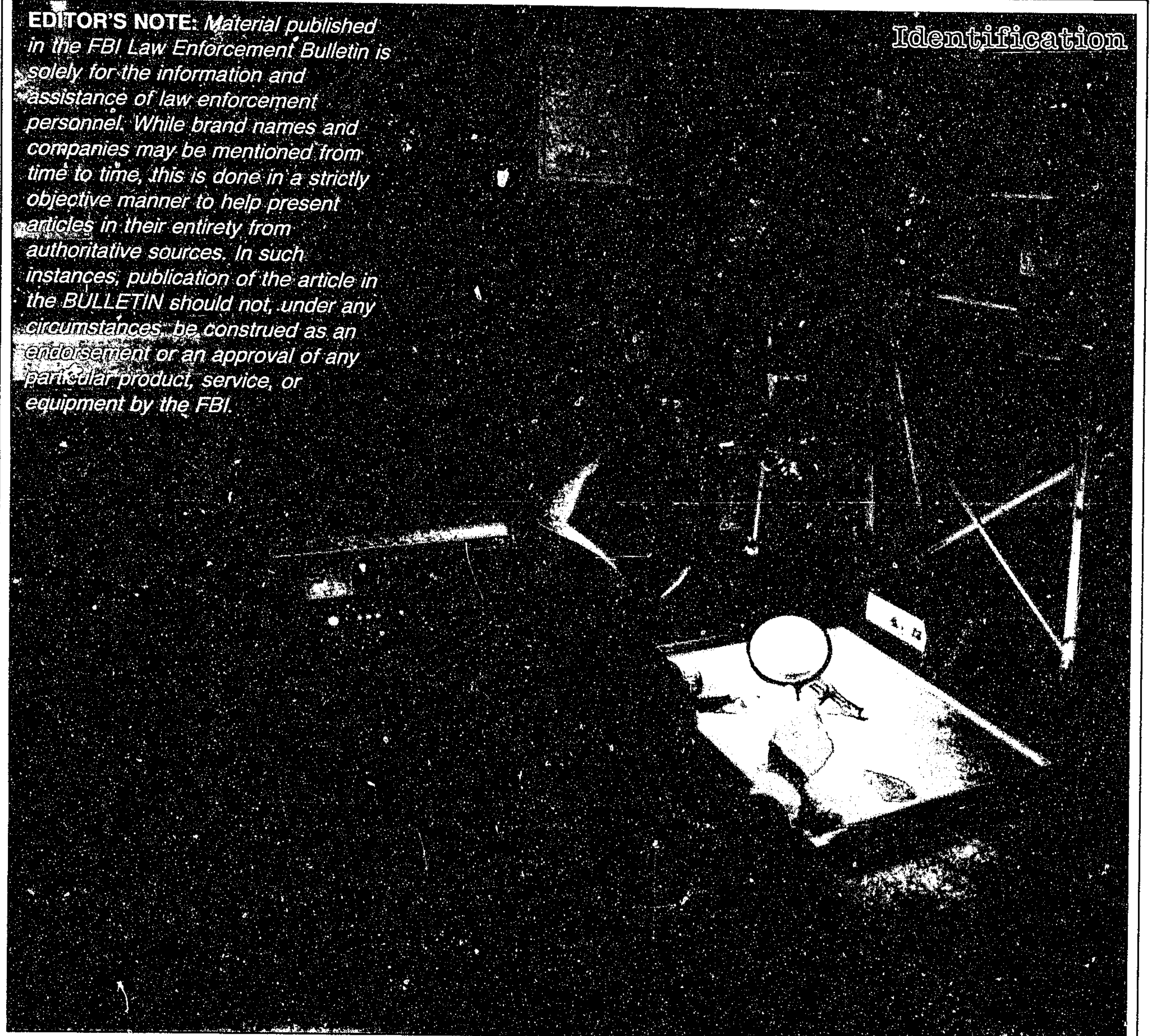

Identification

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Latent Print Detection by Laser

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The use of fingerprints as a means of identification has long been recognized by courts of law throughout the world as being infallible. This is because minute formations of the ridged skin areas of every finger and the relationship of these formations to one another are unique in every instance. The palms of the hands, toes, and soles of the feet are equally diverse and also are used as a positive means of identification.

Impressions obtained from the ridged skin areas of the body, namely, the palmar sides of the hands and soles of the feet, may be classified as

Mr. Ridgely

inked, latent, or patent prints. Inked prints are usually recorded for record purposes using a thin film of printer's ink as a transfer medium. Latent and patent prints may be left on an object when touched through perspiration, grease, oil, or foreign substance which may be present on the friction ridges at the time a surface is touched. If sufficiently pliable, the bearing surface itself may act as the transfer medium. Latent and patent prints differ only in that a latent print requires some type of treatment to be made visible, whereas the patent print can be readily seen. Location and preservation of latent prints left by the perpetrator of a crime is one problem encountered by the investigator. Traditional techniques usually call for application of powders or chemicals as latent print developers.

Conventional Detection Methods

Conventional latent print detection methods may be classified as either physical or chemical. Physical development depends on the adherence of powder to lipids, oils, and/or moisture contained in latent print residue. Chemicals most commonly used (iodine, ninhydrin, and silver nitrate) as developers are dependent on iodine fumes being absorbed by lipids and oils or an interaction between amino acids and ninhydrin or sodium chloride and silver nitrate. One or all of the aforementioned elements (lipids, oils, amino acids, and sodium chloride) may be present in one or more latent prints on a single specimen. Therefore, all three chemicals should be applied to a single specimen in an effort to develop as many latent prints as possible.

Although powders and chemicals develop a high percentage of the latent prints, their application, in some cases, produces undesirable effects, such as staining or discoloration. In addition, these processes do not develop all latent prints on a specimen in every instance. Therefore, law enforcement officials are constantly in search of new techniques and technology to aid in the location and preservation of elusive latent prints.

Laser Detection of Latent Prints

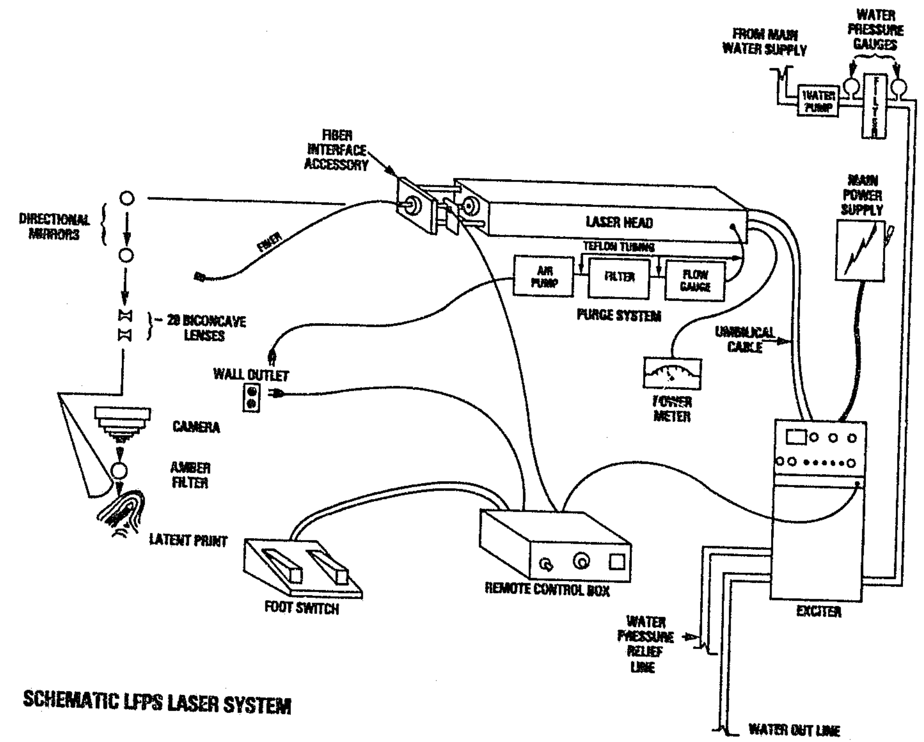
In the early part of 1977, a paper published in the *Journal of Forensic Science*[1] was brought to the attention of the FBI, Latent Fingerprint Section. The paper, in brief, reported that certain properties of perspiration and body oils contained in latent print residue will luminesce without pretreatment and to a degree that photographs could be taken when activated by a continuous wave argon-ion laser. In addition, this technique could detect latent prints not developed by conventional processes.

Preliminary tests conducted at various laboratories by FBI personnel resulted in the purchase of a laser for further research and evaluation. In April 1978, the FBI's Laser Latent Print Detection System was put into use.

Hardware

The nucleus of the FBI's Laser Latent Print Detection System is a Spectra Physics Model 171–19, continuous wave, 18-watt argon-ion laser with a Model 270 power supply. (See fig. 1.) This laser requires a three-phase with ground, 460-volt electrical line, 60 amps per phase, with a wattage rating of 38k. For cooling, a water flow rate of 3½ gpm (.22 liter/sec) at a minimum of 65 psi (4.6 kg cm ²) to

Figure 1—The FBI's Laser Latent Print Detection System.



operate. This unit has a spectral range of 457.9 nm to 514.5 nm. Optics provided with the laser allow single-line and multiline operation in the blue-green portion of the visible spectrum. With appropriate optics, the laser can produce approximately 3 watts of multiline UV, with a spectral range of 351.1 nm to 363.8 nm.

External optics consist of two all-band dielectrically coated multilayer mirrors (beam directors) and two crown glass negative 20 biconcave dispersal lenses. The first mirror is set in a mount with horizontal and vertical micrometer adjustments. This allows limited positioning of the expanded beam on the staging area for ease of specimen examination and photography. The second mirror is held in a fixed mount and is positioned at an angle to the reflected laser beam, downward and through the two dispersal lenses. The laser beam is expanded to approximately 8 inches (20 cm) on a staging area located 18 inches (45 cm) below the dispersal lenses. The purpose of the expanded beam is twofold—to allow a large area of a specimen to be examined at once and to protect flammable items from overheating, which could lead to partial or complete destruction of a specimen.

The laser head is equipped with an optional fiber interface which permits limited portability of the laser beam. A single 600-micron optical fiber cable transports the beam and is used in the FBI's system for examination of items too large or of a shape which prohibits the use of the staging area. Aberrations encountered when using the optical fiber cable may be alleviated through manual or mechanical vibration of the fiber. This vibration of the cable may only be necessary while photographing a latent print.

The optical arrangement may vary in other systems. The number, type, and positioning of mirrors and lenses may be dictated by the size and configuration of the housing room and the relationship of the staging area to the laser head. In fact, some systems employ a fiber-optic cable as the primary means to transport the laser beam.

Purified air is used to purge the bellows housing the Brewster windows of ozone and remove or prevent the entry of minute amounts of organic contaminants. These elements scatter laser light and coat optical surfaces, resulting in a drop in output power. This increases maintenance and operating costs and causes unnecessary wear on delicate optical surfaces due to repeated cleaning. By comparison, the purified air purge system is relatively simple and inexpensive. The system consists of a small air pump, microfilter with activated charcoal, and an air flow gauge. Tubing used in the purge system should be Teflon or polypropylene.

The laser head, optics, and purge system are mounted on a table 42 inches (105 cm) high, 24 inches (60

". . . time is no factor in the detection of latent prints by laser."

cm) wide, and 144 inches (360 cm) long. The staging area is a table 24 inches (60 cm) high, 30 inches (75 cm) wide, and 96 inches (140 cm) long. The two tables are positioned at a right angle to one another. Here again, the arrangement of optical benches, tables, or other support equipment may be dictated by the size and shape of the housing facility.

An air purification system and dehumidification system in the laser room, although not necessary, may prove beneficial to create a proper environment for laser operation. Closed loop cooling using deionized water or ethylene glycol is highly recommended in areas where the water supply is heavily ionized or mineralized. Unconditioned water of this type may lead to electrolysis and/or formations of scale on vital cooling surfaces, thereby causing reduced cooling efficiency and possible premature failure of major components. Additionally, a booster pump may be needed to acquire the necessary water flow rate and water pressure.

Methodology

The procedure used to detect latent prints with a laser is clean and relatively easy. No pretreatment of the specimen is required initially, and therefore, no alteration to the specimen occurs. The expanded laser beam is used to fluoresce certain properties of perspiration, body oils, and/or foreign substances contained in latent print residue. The laser output power is usually set at 15 watts with all lines emitting. Examination of a specimen is accomplished by passing small items under the expanded laser beam at the staging area. Large items are examined through the use of the optical fiber cable. In either mode of operation, the visual examination should be thorough, inasmuch as some latent prints exhibit only faint fluorescence.

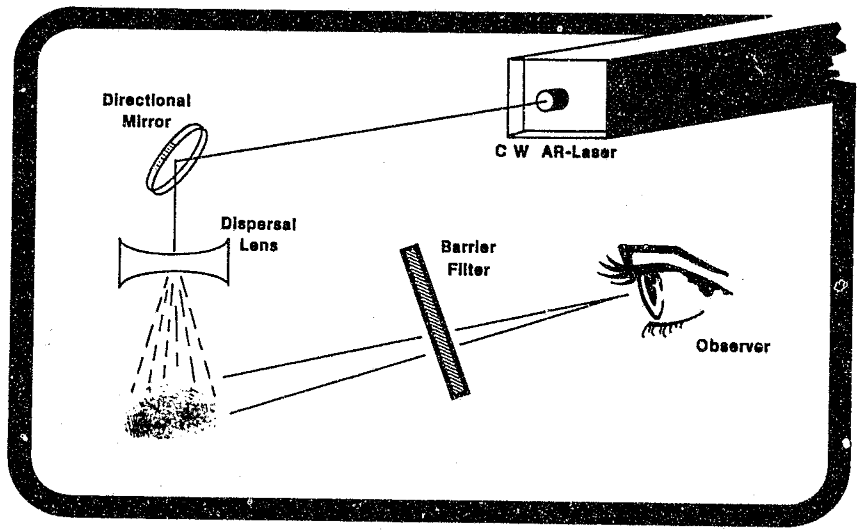


Figure 2—Schematic depicting basic laser latent print detection.

Detection occurs when latent print residue absorbs the laser light and reemits it in longer wavelengths than the illuminating source. (See fig. 2.) The fingerprint specialist/operator, wearing laser safety goggles containing filters with an optical density of 7 at 515 nm, visually examines the specimen being exposed to the laser light. The filters absorb the laser wavelengths and permit wavelengths from approximately 540 nm and above to pass. Latent print residue fluoresces at approximately 550 nm and above. Thus, latent print residue producing sufficient fluorescence can be seen and photographed by placing this same filter across the lens of the camera. Additionally, the filters protect the operator against possible irreparable eye damage from scattered or reflected laser light. Examination of specimens and photography of the fluorescing latent prints are carried out in a darkened room.

Latent prints have been detected with the laser on a variety of surfaces. Some items, because of the material from which they are made and/or irregularity of surface, defy the use of powders or chemicals. Positive results have been obtained from glass, paper, cardboard, rubber, wood, plastics, leather, and metals, to mention a few.

Inasmuch as the first attempt at detecting latent prints with a laser is primarily by inherent fluorescence, the laser should be used prior to conventional methods. (See fig. 3.) Reexamination by laser after each conventional process is recommended, as there are occasions that the laser may enhance indiscernible latent prints or fluoresce latent prints resulting from a

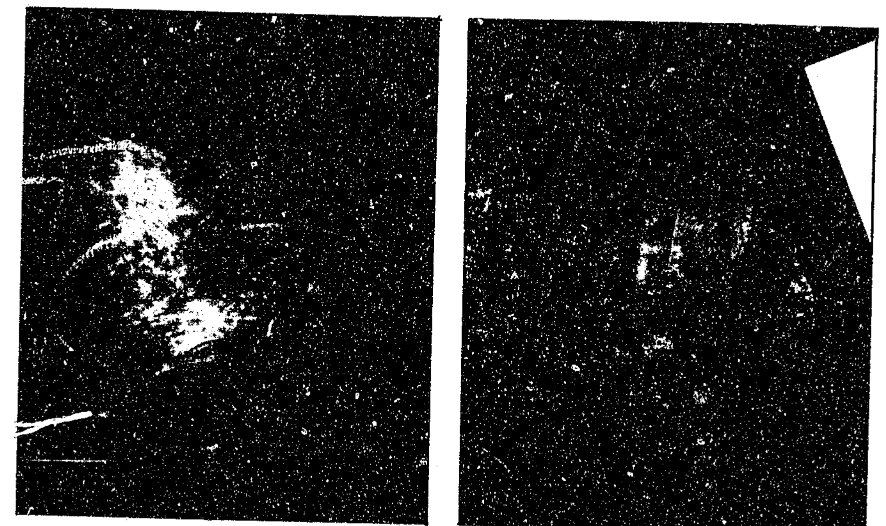


Figure 3—Latent prints detected through inherent fluorescence on black electrical tape and plastic bag.

combination of latent print residue and the added processes. In addition, the application of fluorescent products such as zinc chloride, after the ninhydrin process or rhodamine 6G following the use of cyanoacrylate or cyanoacrylate and fingerprint powder, may increase the quality of previously developed latent prints and/or make visible additional latent prints not seen before in room light. Fluorescent fingerprint powders have also been used successfully in some instances.

A working solution of zinc chloride may be made by dissolving 15 grams of zinc chloride in one liter of methanol. The ninhydrin-treated item is then lightly sprayed with the solution and allowed to dry for a short period (1 to 3 minutes). The application of the zinc chloride solution causes the ninhydrin print to change color from the usual purple to an orange, which is sensitive to the blue-green light of the argon-ion laser. In some cases, heating with an iron may enhance the color change.

Rhodamine 6G may be applied in solution or through evaporative dye staining. The strength of the solution may vary greatly; however, for a starting solution, dissolve 0.5 grams of rhodamine 6G powder in 500 milliliters of methanol. The solution may be applied as a first step after cyanoacrylate fuming or following the use of cyanoacrylate fumes and fingerprint powder. The solution may be applied by spraying, pouring, or dipping. The treated item is then left to dry. After drying, the specimen is examined under laser illumination in the usual manner. If solution dye staining has been effective, the latent prints will fluoresce. If a heavy concentration of dye has adhered, a wash of methanol is needed to remove the excess.

Solution dye staining is used primarily on relatively smooth nonporous surfaces. Direct application of the solution to untreated prints may cause the latent prints to be washed away.

Depositing rhodamine 6G through evaporative dye staining is relatively simple. Place a small amount of rhodamine 6G powder in a narrow-necked flask or breaker and heat it on a hot plate. Heating will cause vapor to form and rise in the container. Pass the item being examined over the container of dye vapor for a few seconds and examine the specimen under laser illumination. This procedure is most productive on relatively fresh latent prints on both porous and nonporous materials.

Fluorescent fingerprint powders perform a dual role by acting as a conventional powder as well as a product amenable to laser excitation. These powders are applied in the usual manner. Fluorescent powder can be made by dissolving 0.1 gram of rhodamine 6G dye in 50 milliliters of methanol to which 10 grams of fingerprint powder are added. The mixture is heated and stirred until the solvent has evaporated. The powder is ground with a mortar, if necessary. In addition, commercially prepared powders are available.

Survey Results

A survey was taken by the FBI's Latent Fingerprint Section personnel involving the examination of actual crime scene evidence submitted in connection with 3,000 cases. This survey was based on inherent fluorescence, fingerprint powders, iodine fumes, ninhydrin, and silver nitrate solutions. Selection of the cases in most instances was based on the type of items received for examination. Primary interest was directed to cases containing specimens, which generally but not exclusively, presented some problems in developing latent prints through the use of powders or chemicals. The figures represent only cases in which identifiable latent prints were developed. Latent prints too fragmentary or indiscernible for identification purposes were not considered.

Latent prints were developed in 242 cases with fingerprint powders, 930 cases with ninhydrin, 1 case with silver nitrate, and 1 case with iodine fumes. The laser detected latent prints in 214 cases. Laser-detected latent prints in these cases were not developed in any instance by subsequent application of fingerprint powders or chemicals. However, there were occasions when latent prints, first detected by the laser, were developed by subsequent processing with fingerprint powders or chemicals, which produced the same latent print of as good or better quality.

Plastics and copy machine papers were observed as being the greatest producers of laser-detected latent prints. In fact, the laser detected latent prints on copy machine paper known not to have been touched by the subject in 5 years. The prints were subsequently identified as those of the subject. This leads to the belief that time is no factor in the detection of latent prints by laser. This fact was vividly illustrated when the laser detected a 40-year-old latent print on a document prepared during World War II, which resulted in the identification of a Nazi collaborator.

On August 13, 1984, Valerian Trifa, the former Archbishop of the Romanian Orthodox Church of America, departed the United States for Portugal. His departure culminated more than 9 years of litigation to strip Trifa of his U.S. citizenship and deport him from this country. Trifa's fate was brought about by sophisticated laser technology used by the FBI.

Trifa was born on June 28, 1914, in Campeni, Romania. He entered the United States on July 17, 1950, from Italy. In 1952, he was consecrated as a Bishop of the Romanian Orthodox Church of the United States, and in 1957, he was naturalized as a U.S. citizen.

In 1975, the U.S. Department of Justice instituted deportation proceedings against Trifa, alleging that he concealed material facts in obtaining his U.S. citizenship. It was alleged that in 1941, while in Romania, Trifa was a major figure in the violent Fascist and anti-Semitic Romanian Iron Guard and that he was responsible for the deaths of thousands of Jews in Romania. He reportedly received protection from the Nazis from 1941 to 1944.

In May 1982, at the request of the U.S. Government, the West German Government, through its embassy in Washington, DC, made available to the FBI's Identification Division certain documents for latent fingerprint examination. One such document was a postcard dated June 14, 1942, allegedly authored by Trifa and addressed to Heinrich Himmler, one of Hitler's close associates. Trifa emphatically denied authoring the document. The West German Government requested that the examination of the document not in any way deface or alter its condition. By using laser technology, a latent impression of a left thumbprint was developed on the postcard and subsequently identified as placed there by Trifa. (See fig. 4.)

Based on this information, Trifa was deported to Portugal on August 13, 1984. Thus, through the use of laser technology, FBI fingerprint experts were able to detect a latent fingerprint over 40 years old, a remarkable accomplishment in the pursuit of justice.

The Fluorescent Latent Print

Fluorescing latent prints appear in varied shades of red, orange, green, and yellow. No color can be associated with any particular substrate or age of a specimen. Latent prints which fluoresce in the lighter shades of yellow appear to be the most likely candidates for subsequent development with powders or chemicals. Background luminescence is clearly the greatest problem encountered and is considered to be the overriding factor in the lack of detection of latent prints by the laser. In this instance, the surface being examined fluoresces at the same wavelengths as the latent print substance and the latent print cannot be seen by the observer or photographed. However, on occasion, strong background fluorescence has worked in the examiner's favor by outlining a nonfluorescent latent print on a specimen.

Initially, several wavelengths at various power densities were tried to ascertain the most suitable argon-ion laser lines for exciting fingerprint fluorescence. Higher power densities within the operational wavelengths (visible spectrum) of the argon-ion laser proved very beneficial in latent print detection. Due to the output power limitations of single-line lasing (approximately 8 watts output power at 514.5 nm with an 18-watt argon-ion laser), the multiline mode appears to be most useful, due to its greater power range. After extensive testing using 10 to 20 watts of output power, 15 watts appear to be the best general setting for latent print detection through inherent fluorescence. This is because no appreciable number of additional latent prints were located above the 15-watt setting.

Latent prints can be detected with the laser on a variety of substrates; however, all individuals do not leave prints which exhibit strong fluorescence. In addition, some surfaces

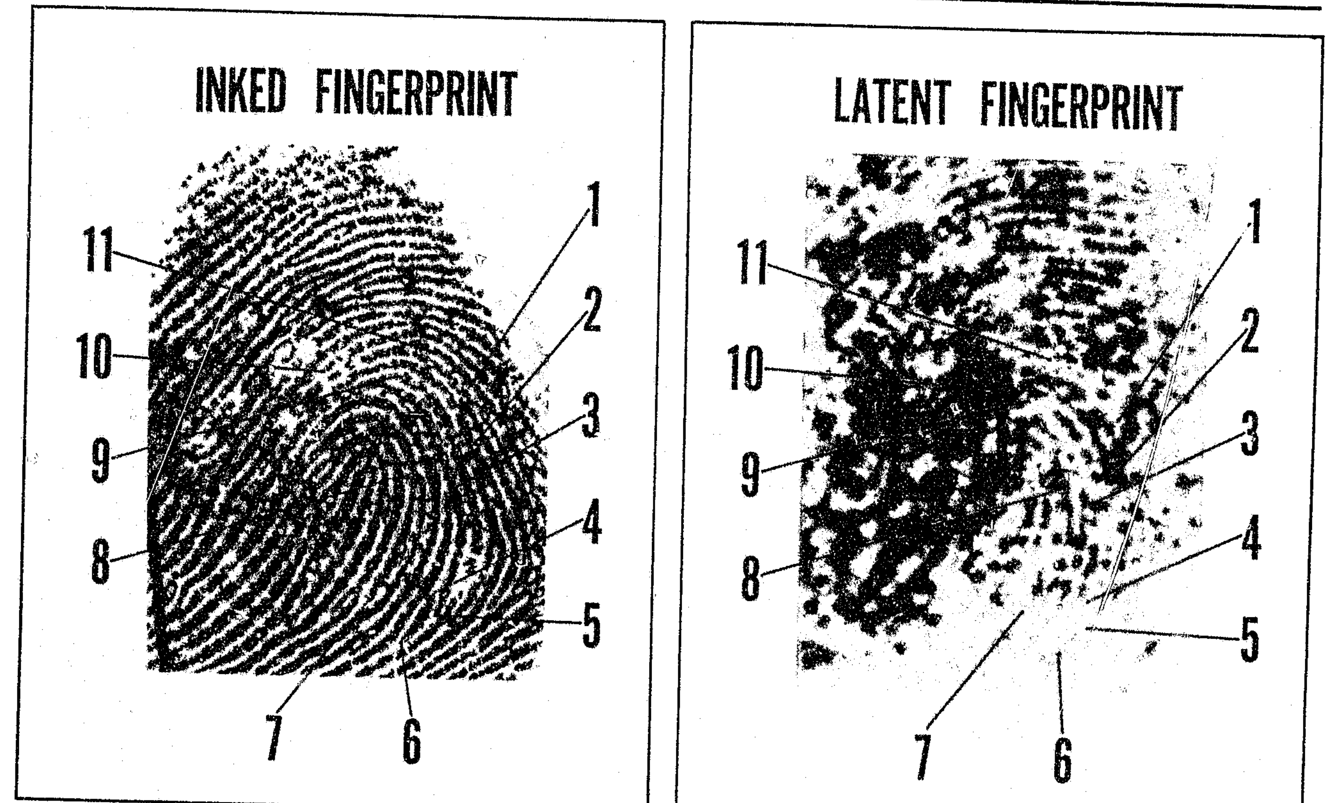


Figure 4—Charted enlargements illustrating the identification of a 40-year-old latent print.

do not transfer latent print residue as well as others. These facts, combined with the previously mentioned background fluorescence, lead to the inference that the laser detection method does not produce conclusive results in all cases. Therefore, from a practical standpoint in actual case specimen examination, this method, at the current state of the art, can only be considered a supplement to traditional processes.

Photography

The camera used to photograph laser-detected latent prints is a 4 x 5 Polaroid MP-4, adjusted one to one, with a 135 mm lens, set at F:11. The filter is the same as the filter used in the laser safety goggles. On occasion, a #22 photographic filter has been used in lieu of the laser safety filter with good results. The laser is usually set at 15 watts output power, all lines emitting.

Two types of film used are Kodak Contrast Process Ortho and Kodak Royal X Pan. Contrast Process Ortho is used to photograph items with a strong fluorescent background and has an exposure time ranging from 15 to 60 seconds. Royal X Pan is used on items with little background fluorescence, with an exposure time of 1 to 2 minutes. However, regardless of the type of film used, the greater the fluorescence of the latent print, the less exposure needed. Proper exposure in some cases can be determined only through trial and error.

In order to place the print in the proper perspective (black ridges on a white background) for comparison purposes, reverse color is necessary. Negatives with strong detail are reversed on Kodak commercial film and negatives with weak detail are re-

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versed on Kodak Kodalith Ortho. Kodalith Ortho, a high contrast film, enhances the weak negative's images in the reversal stage and many times makes the difference between discernible and indiscernible ridge detail.

In addition to excitation of latent print residue, the unique coherent properties of the argon-ion laser proved to be of value for photographing visible, treated, and untreated latent prints, although the latent print itself is not fluorescent. Use of the expanded laser beam as a light source diminishes surface textures, fibrous backgrounds, reflection, and highlights encountered under incandescent lighting. Films used in this procedure are Contrast Process Ortho or Contrast Process Pan. The laser has increased the latitude of photographic procedures and provides a higher quality product, previously unobtainable, in instances where latent prints are developed on textured or fibrous surfaces.

Other Lasers Currently in Use

The copper vapor laser has also proved useful in the detection of latent prints. Several are currently in use by Federal, State, and local law enforcement agencies. While there has been no controlled study to determine whether the copper vapor laser is superior, inferior, or equal to the argon-ion laser, it is known that the cost factor involved in the procurement, operation, and maintenance of the copper vapor laser is considerably less than the argon-ion laser. This laser has an input power requirement of 208 volts and a cooling requirement of 1 gallon of unfiltered tap water per minute (.063 liter/sec) to operate. It produces 6 watts of power in green line operation at 510 nm and 2.5 watts of power in the yellow-orange line operation at 578 nm. With both lines emitting, the unit produces 10 watts of power. The copper vapor laser is a pulsed laser as opposed to the argon-ion which is a continuous wave laser.

As with many new applications of technology, the systems used initially are formed from equipment available at that time in the marketplace. In some instances, the use of such equipment leaves a void that must be filled by new technology or modification of available devices. Such was the case with laser latent print detection. It was apparent almost immediately that lasers being used to detect latent prints were confined to laboratory use due to size, weight, water, and electrical requirements. The void to be filled in this instance was laser latent print detection at crime scenes.

Portable and transportable laser latent print detection systems have been developed and are being used in actual case work in the laboratory and at scenes of crimes. The nucleus of the portable system is a Nd:YAG laser which produces up to 500,000+ watts/pulse at a rate of 10 to 20 pulses per second. Its operational wavelength is 532 nm—frequency doubled. The system is cooled with 1 quart of liquid coolant, which is self-contained, and may be operated with standard 110-volt wallpower or a 12-volt battery with converter. A fiber optic cable is the primary means of laser beam transport.

The nucleus of the transportable laser system is an argon-ion laser, which provides 4 watts of output power with all lines lasing. The system requires 3 gpm (.19 liter/sec) of water at 30 psi (2.1 kg/cm^2) and 220 volts of electricity to operate. This system would normally require some sort of support equipment for crime scene use. A fiber optic is also the primary means of laser beam transport in this system.

Both the portable and transportable systems use TV monitoring equipment to assist in locating latent prints. In addition, each manufacturer offers an optional video tape recorder to be used for later viewing of latent prints found.

Conclusion

As with traditional processes, the laser does not detect all latent prints and more than likely it never will have this capability. Also, it cannot even be said that it has replaced any of the conventional methods of latent print development. However, it represents a supplement to these methods, which has and will continue to provide a means to locate valuable latent print evidence that was unobtainable. The use of the laser in the forensic disciplines is only in its infancy. Further research in this field will spawn new ideas and techniques to further aid the forensic scientist and ultimately the investigator in their pursuit of trace evidence left at the scenes of crimes. It has already made a dramatic difference by providing an additional means to obtain the ultimate and most dynamic piece of physical evidence—the latent print. **FBI**

Footnote

B. E. Dalrymple, J.M. Duff, and E. R. Menzel, "Inherent Fingerprint Luminescence—Detection by Laser," *Journal of Forensic Science*, vol. 22, No. 1, 1977

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