NBSIR 74-627

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U. S. DEPARTMENT OF COMMERCE, Frederick B. Dent, Secretary

NATIONAL BUREAU OF STANDARDS, Richard W. Roberts, Director

ILLUSTRATIONS

THE INFLUENCE OF INK ON THE QUALITY OF FINGERPRINT IMPRESSIONS

ABSTRACT

Tests were conducted on several types of ink to determine their influence on the quality of fingerprint impressions which they could produce. The thickness and uniformity of the film used to ink the fingers were found to be the most significant factor in providing high quality impressions. A method is described for metering out printer's ink and estimating whether or not a uniform film of near optimum thickness has been rolled out on a glass inking plate.

Key Words: Film thickness; film uniformity; fingerprint impressions; fingerprint readers; image quality; ink films; lubricity.

INTRODUCTION

The performance of automatic fingerprint reading equipment, such as the FINDER developed by the Federal Bureau of Investigation, is strongly dependent upon the quality of inked fingerprint impressions. Blurs, smudges, over-inked or badly under-inked impressions degrade the output data from the reader, even though sophisticated calibration and digital filtering techniques are employed to compensate for variations in image quality. This degradation takes the form of missed true minutiae and increased numbers of false minutia detections, together with erroneous or missing ridge contour data. While matching minutia data can be successfully accomplished with moderate numbers of missing or false minutiae, inadequate ridge contour data severely impedes the automatic registration and classification processes. Any single finger which cannot be classified multiplies the number of file fingerprint reference classes which must be considered as match candidates. Faulty registration adversely affects the matching process and may, under certain circumstances, greatly increase the computation time that is required.

These considerations support the importance of high image quality in inked fingerprint impressions and have led to an investigation of the factors which influence image quality. The initial results of this investigation suggest that control of the thickness and uniformity of the ink film rolled on the glass plate for the purpose of inking the fingers is a major factor in producing impressions of high image quality.

DESCRIPTION OF TESTS

Current Federal Bureau of Investigation instructions for taking inked fingerprints stipulate the use of "heavy black printer's ink." No other physical attributes of the ink are specified. Contacts with suppliers of printing inks have revealed that there were many formulations of black inks with widely differing viscosities, and presumably differing in other characteristics. Three samples of these were obtained for testing, together with three samples of inks specially packaged as "fingerprint inks" and distributed by organizations specializing in law enforcement supplies.

The plan was to test the relative slipperiness or lubricity of these inks to see whether there were significant differences. If so, this factor would be expected to influence the likelihood of smudging an impression. This approach was suggested because of the empirical observation that some of the non-inked processes for recording fingerprints employ chemical agents which do not feel as slippery as conventional inks.

A simple instrument was constructed to test the relative slipperiness of the ink samples. As shown in figure 1, it consisted of a wheel with fixed loading established by weights which were mounted on a carriage that could be rolled along a surface in a straight line. Cam mechanisms permitted the wheel to be lowered to, or raised from, the rolling surface. A thin solid rubber tire with a large number of uniformly spaced transverse ridges was mounted on the wheel. The wheel was also equipped with a torsion spring and a locking dog mechanism. With the dog unlocked, the wheel could rotate freely on the pivot bearings supporting the needle point axle. Locked, the torsion spring was engaged and drag against the rolling surface increased in approximately linear proportion to forward motion. The wheel would begin to skid when the frictional forces at the rolling surface were exceeded by the force developed by winding up the torsion spring.

To operate the device, the wheel is cammed away from the rolling surface and unlocked. An inked glass plate is placed on the rolling surface and the wheel is lowered onto the plate, rolled across it once, and then raised. The glass plate is then replaced by a fingerprint card which is clamped in position. The wheel is then locked to its torsion spring and cammed down to a fixed starting point at the right-hand edge of the fingerprint card and rolled across the card past the point at which continuous skidding occurs. Five such tracks are shown in figure 2. All were made using one of the sample printer's inks. For the top, middle, and bottom track, the wheel was cleaned and re-inked. For the second and fourth track, the card was repositioned vertically, and the wheel was not unlocked or re-inked so that these tracks were produced by ink left on the wheel after making the previous track.

Examination of this figure reveals that full skidding occurs about twenty percent farther from the starting point on the tracks made when the wheel was not re-inked, compared with the tracks made by a cleaned and freshly re-inked wheel. In other words, with less ink the skid resistance was greater. In addition, these tracks show that partial skidding increases as the torsional force on the wheel increases. This is evidenced by an increase in both the width and the center-to-center spacing of the transverse tread lines as the track progresses from right to left. As each new tread ridge contacts the fingerprint card on the rolling surface, it appears to skid slightly. This removes some of the ink and causes the coefficient of friction to increase sufficiently to stop the skid. Ink removal becomes progressively greater until a full skid condition is developed at the point where the (nearly) dry frictional forces are less than the torsional forces.

Similar tests with the other ink samples yielded comparable results. On a cleaned and freshly re-inked wheel, the point at which a full skid condition was reached did not vary significantly with the different ink samples, and with all samples a higher skid resistance was developed when the wheel was used to lay down a second track without being re-inked.

Measurement of the incremental slippage that occurred prior to the point of full slippage of the wheel was accomplished with the aid of a very simple scheme. An inked track was laid down across the width of a fingerprint card with the wheel unlocked from the torsion spring. This produced a set of uniformly spaced tread marks showing no evidence of slippage. The card was then cut down the middle of this track so that it could be laid along other test tracks and used like a vernier. The right-hand tread marks of both the test track and the measurement track were aligned. The incremental slippage in the test track tread marks caused a progressive displacement of this alignment moving to the left, and alignment again occurred each time the cumulative slippage in the test track increased by one increment of tread-to-tread spacing in the measurement track. This is illustrated in figure 3 where the points of cumulative slippage of the first eight units have been marked.

Up to this point, the test results had suggested that a thinner film of ink on the glass inking plate might yield better results by more nearly approximating the residual film left on the wheel when it was not re-inked. If the right amount of ink could be metered out on the plate, a film of optimum thickness could be rolled out. Unfortunately, printer's ink is an especially difficult material to dispense in precisely measured volumes of the order of a few hundredths of a cubic centimeter without the use of special laboratory equipment, not normally available to persons taking fingerprints. Our solution to this problem was to use an approximation technique to measure out the ink. The ink samples were repackaged in collabsible metal tubes with eye tips having an orifice diameter of one millimeter (3/46 inch). This permitted laying a bead of ink for a measured length on the glass. An approximate volume could then be calculated as the product of the orifice area and the bead length. The accuracy of the volume is dependent upon the viscosity of a given ink sample. It is reasonably good with a stiff, highly viscous ink, whereas, with a more freely flowing ink, the calculated volume tends to be smaller than the true value.

The combined area of the glass plate and rubber roller used in these tests is 216 square centimeters. An ink volume of 0.0216 milliliter distributed evenly over this area would make a film one micrometer thick. A cylinder of ink the size of the eye tip orifice and 2.66 centimeters long would supply this volume. Thus, to a first approximation, each inch of ink bead laid out on the glass should make an ink film one mocrometer thick.

Figure 4 shows four tracks and four fingerprints prepared from ink films made from beads ranging from 19 to 38 millimeters (3/4 to 1-1/2 inches) in length. Figure 5 is a similar presentation using a different ink.

Further tests with the other ink samples showed that the eight unit cumulative slip (refer to fig. 3) point always fell between the range of values shown in figures 4 and 5 for ink film thicknesses of the order of one and one-half to two and one-half micrometers calculated thickness. These results are shown in figures 6 through 12, inclusive.

Figure 13 shows a sample track and fingerprint made from a newly ink-impregnated porous pad. The results indicate that the slipperiness of ink from this pad was comparable to that of about two micrometer thick films of the other inks tested. The inked ridge impressions of a fingerprint made from this pad were not quite as dark as some of the others, but still provided an adequate contrast ratio. No tests were made to determine the period of use necessary to deplete the ink supply to the point where impressions with insufficient contrast would be produced.

The percentage marks shown in several of these figures represent the typical values of absolute diffuse reflectance as measured with an eight mil spot size with the reflectometer spot centered over the inked ridge. Values of the order of 15 to 25 percent are representative of good quality prints and will usually be obtained from ink films about two micrometers thick.

A useful way of estimating whether or not an ink film is the proper thickness is to view a fluorescent lamp through the inked plate, un-ined side facing the observer, at a distance of about six feet, in a normally lighted room. The outline of the lamp should be just barely discernible. This procedure will also dramatically reveal any unevenness in the film thickness.

CONCLUSIONS

From these tests, we conclude that apparent slipperiness of an ink is more influenced by the thickness of the ink film that is rolled out on the plate than on the type of printer's ink that is employed. The heavy stiff inks are more difficult to roll out and distribute in a thin uniform film, but if this is done carefully, good quality fingerprints can be obtained. The inks that are commercially packaged as fingerprint inks have a viscosity that makes rolling a uniform film somewhat easier, but even with these, care is necessary. They are usually packaged in collapsible metal tubes, but the orifice is much too large to permit convenient metering of the ink. It is suggested that the distributors of these products could perform a valuable service by packaging their inks in tubes equipped with eye tips to facilitate metering the proper amount of ink onto the glass rolling plate. A film thickness of about two micrometers appears to be near optimum. This is obtained when 0.2 milliliter of ink is spread over each 1000 square centimeters of combined area of plate and roller.

High quality fingerprint impressions are characterized by crisp, clear ridge lines having few breaks and the absolute minimum of smudged areas. They should be well centered in the finger boxes and not overlay any of the finger box outline marks to avoid masking useful minutiae or distorting ridge contour information. Officials taking fingerprints are urged to make every effort to obtain the highest quality of impressions as the performance of an automated fingerprint identification system is strongly dependent upon the quality of the input data.

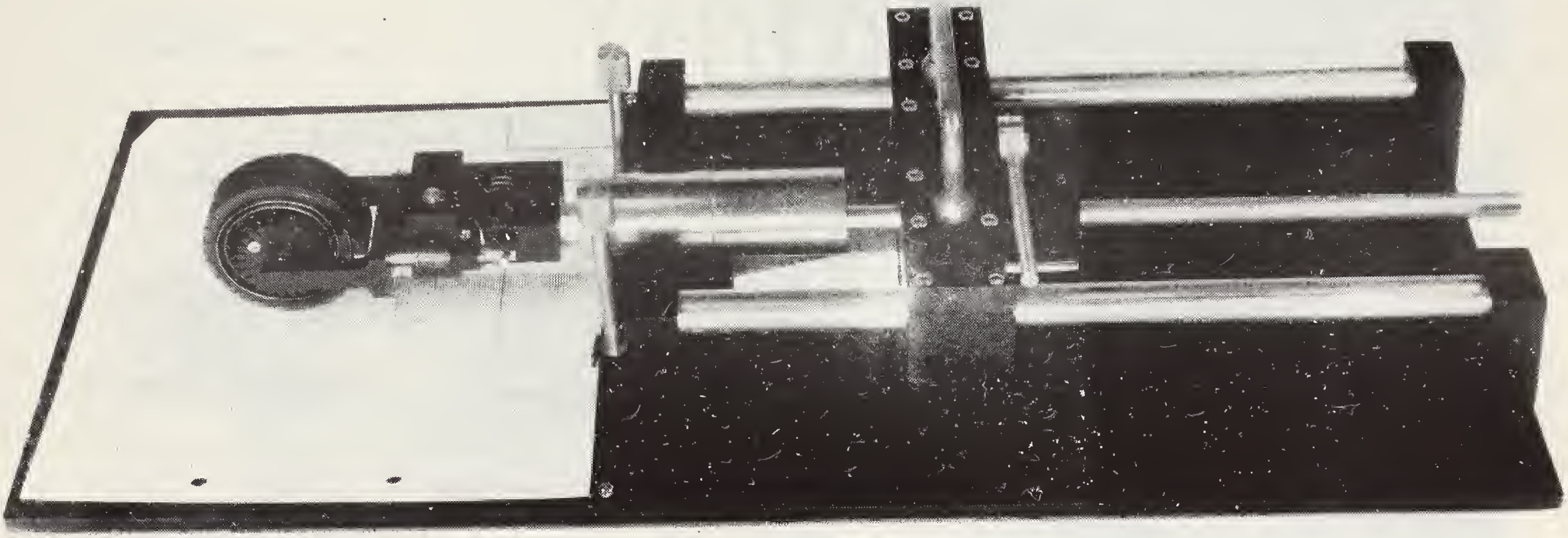

Figure 1. Ink testing machine

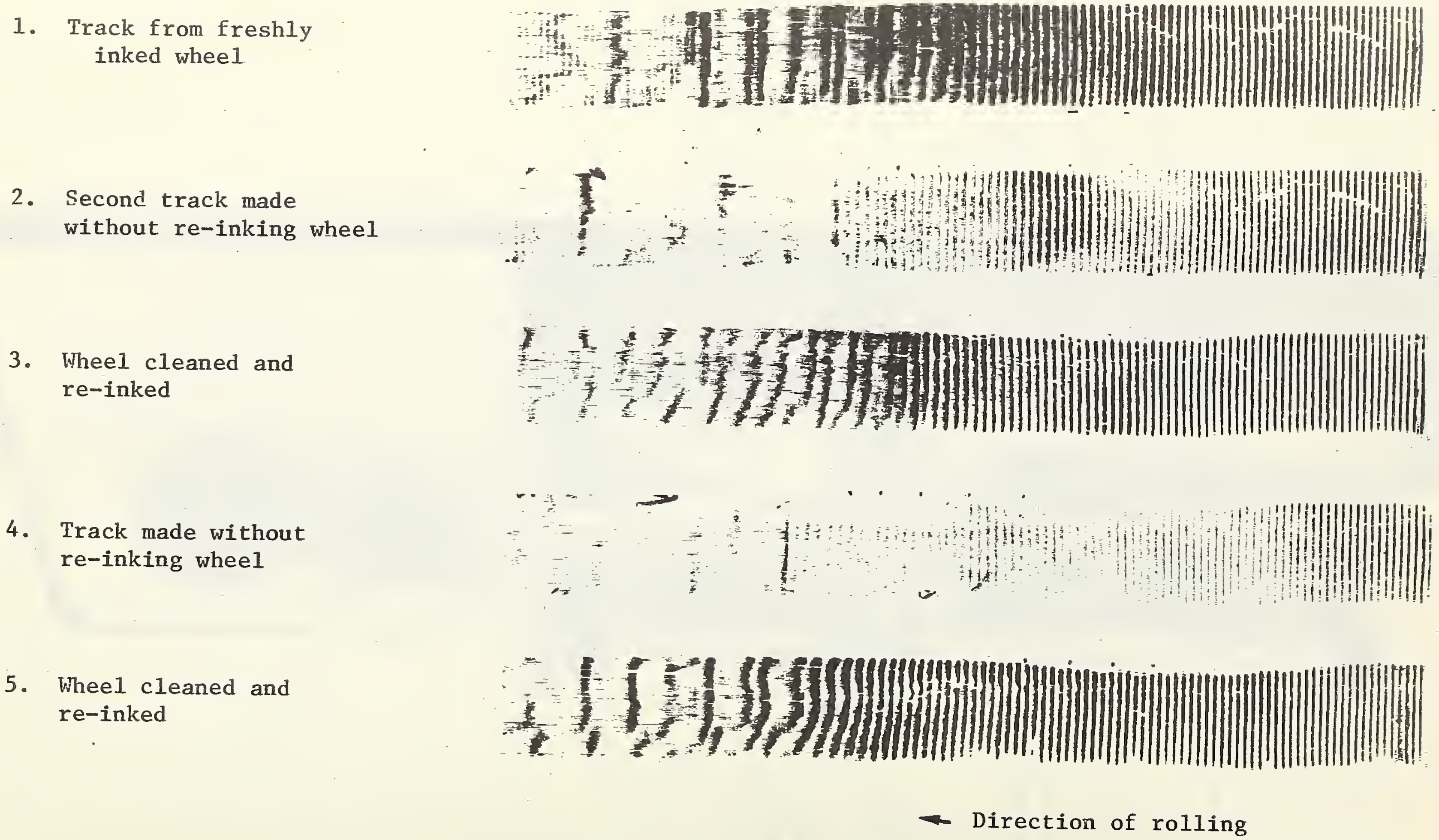

Figure 2. Typical test tracks

Test tracks made by inking wheel with
a 1 mm diameter 25.4 mm long bead of
10940 ink rolled on the glass inking plate

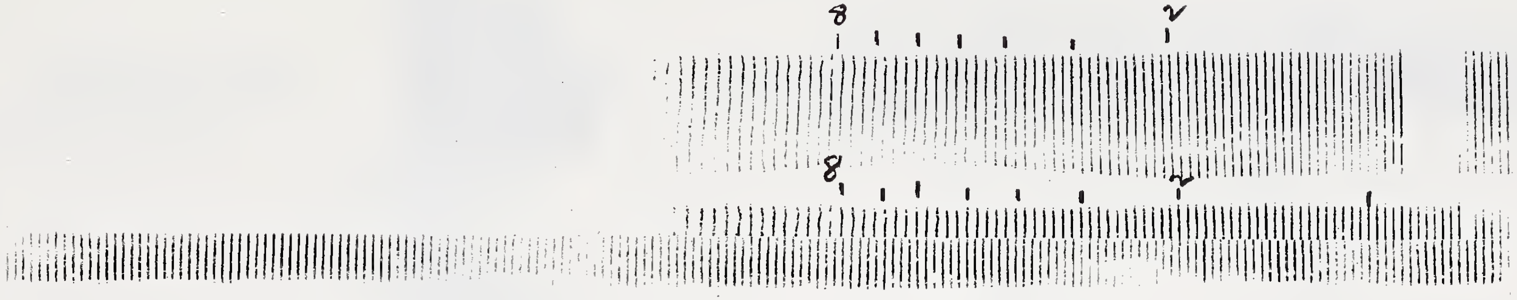

Figure 3. Vernier measurement of incremental slippage

Length of type S
ink bead 1 mm
in diameter

19 mm (3/4 in)

25.4 mm (1 in)

32 mm (1-1/4 in)

38 mm (1-1/2 in)

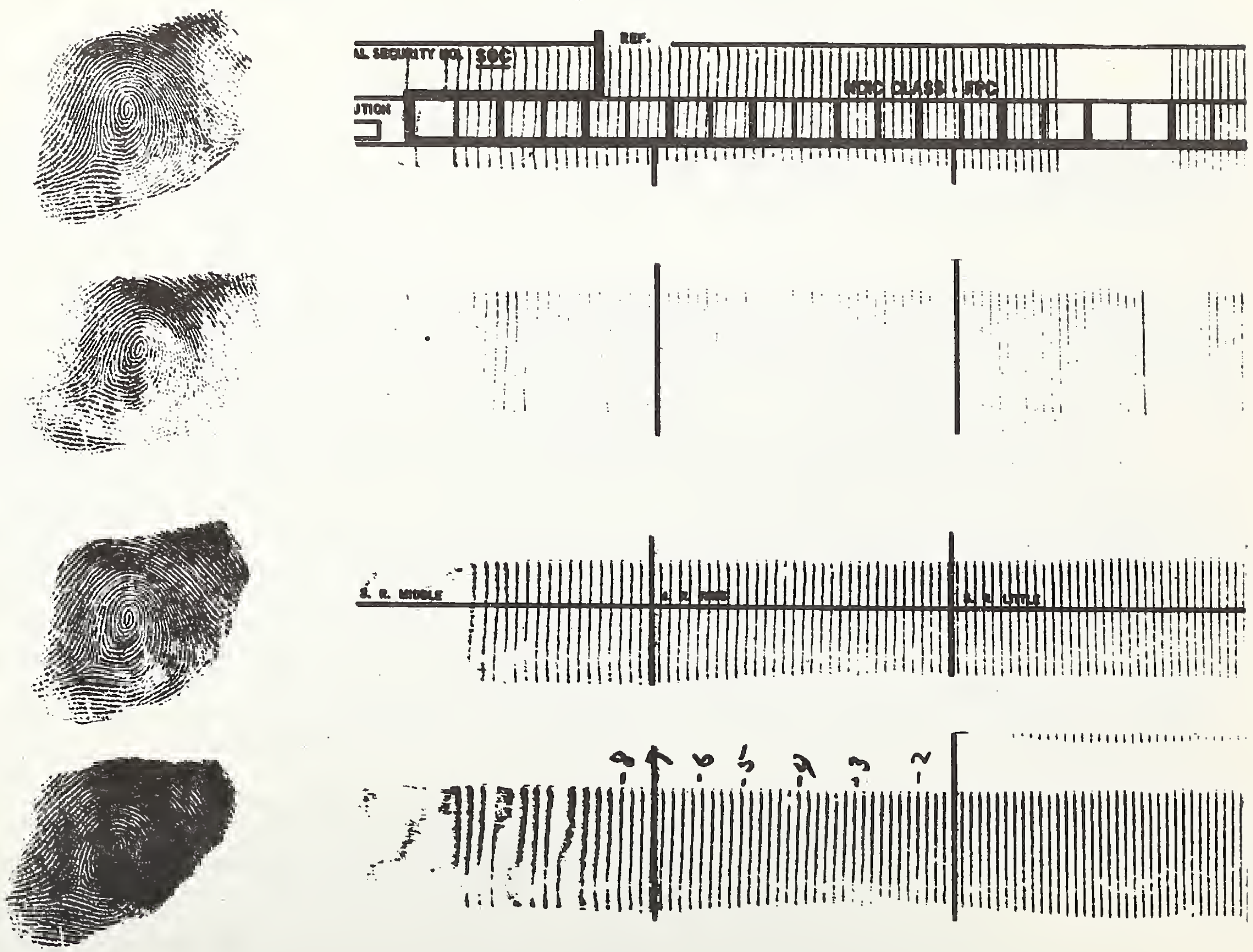

Figure 4. Four ink film thicknesses

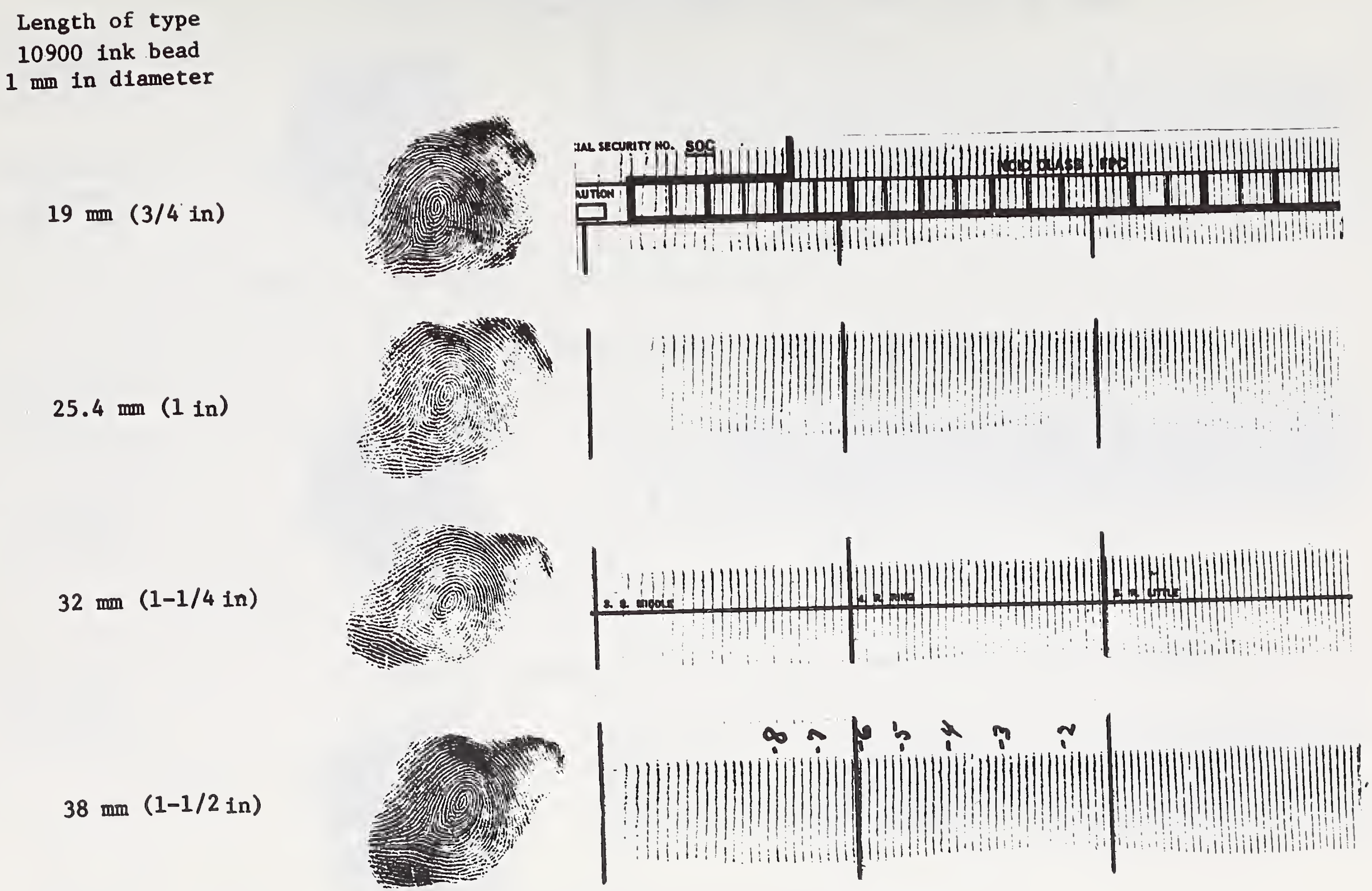

Figure 5. Four ink film thicknesses with a different ink

15% - 20%
diffuse
reflectance

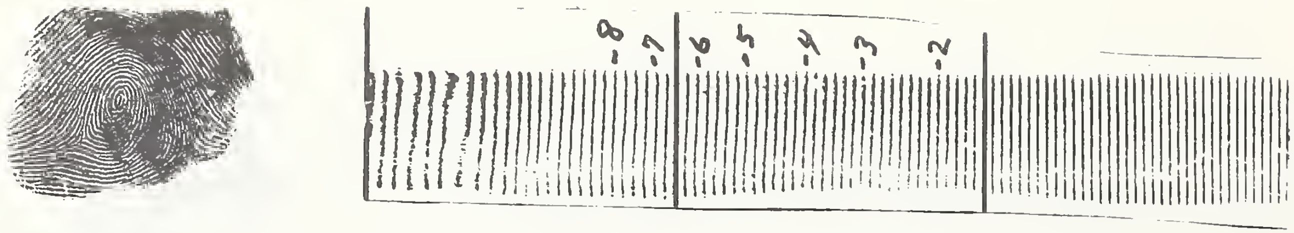

Figure 6. 38 mm (1-1/2 inch) bead of moderately stiff ink 10900

16% - 20%
diffuse
reflectance

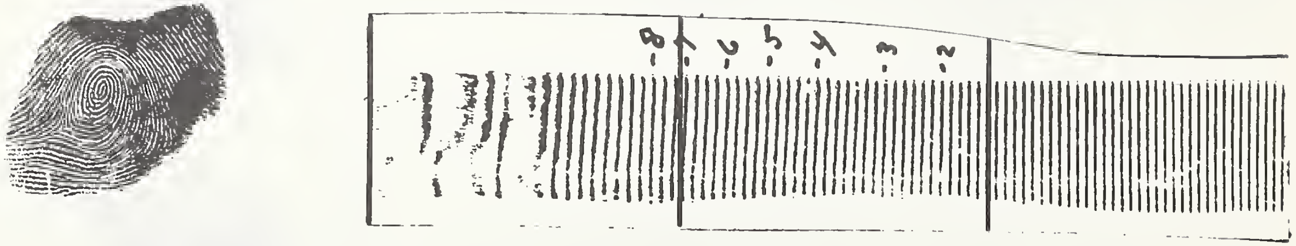

Figure 7. 38 mm (1-1/2 inch) bead of fairly free flowing ink S

48% - 55%
diffuse
reflectance

Figure 8. 38 mm (1-1/2 inch) bead of very stiff ink 10880

13% - 20%
diffuse
reflectance

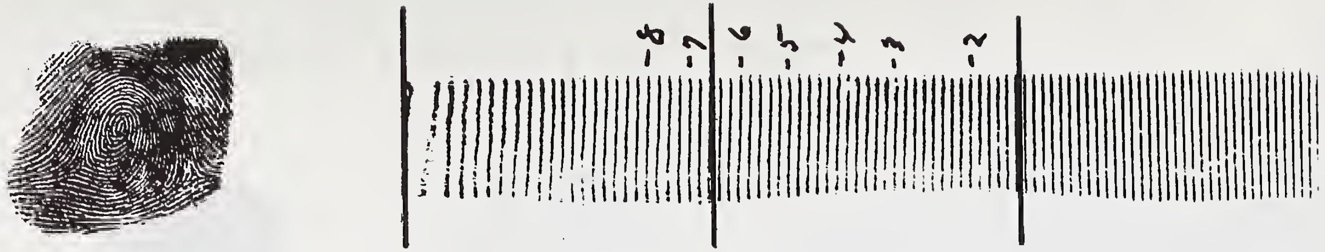

Figure 9. 63 mm (2-1/2 inch) bead of 10880 ink

23% - 25%
diffuse
reflectance

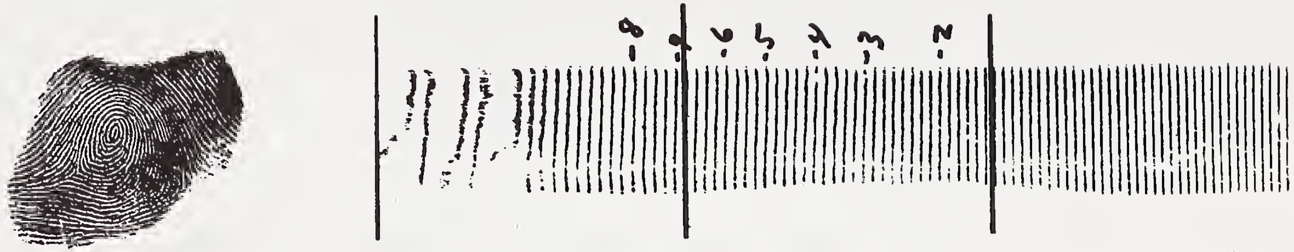

Figure10. 38 mm (1-1/2 inch) bead of moderately stiff 10940 ink

40% - 50%
diffuse
reflectance

Figure 11. 38 mm (1-1/2 inch) bead of free flowing type U ink

17% - 20%
diffuse
reflectance

Figure 12. 63 mm (2-1/2 inch) bead of ink U

20% - 25%
diffuse
reflectance

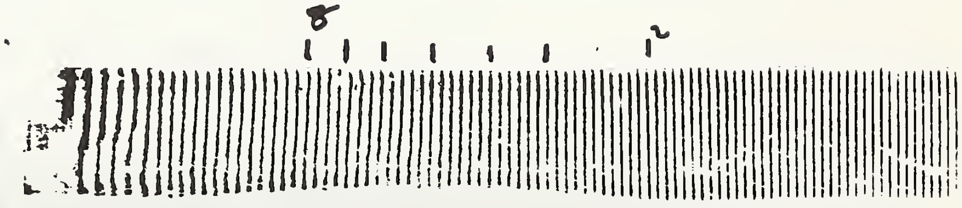

Figure 13. Tests from a porous inked pad

U.S. DEPT. OF COMM. **BIBLIOGRAPHIC DATA SHEET**	1. PUBLICATION OR REPORT NO. NBSIR 74-627	2. Gov't Accession No.	3. Recipient's Accession No.

4. TITLE AND SUBTITLE

The Influence of Ink on the
Quality of Fingerprint Impressions

5. Publication Date
December 12, 1974

6. Performing Organization Code
650.01

7. AUTHOR(S)
Raymond T. Moore

8. Performing Organ. Report No.
NBSIR 74-627

9. PERFORMING ORGANIZATION NAME AND ADDRESS

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234

10. Project/Task/Work Unit No.
6504400

11. Contract/Grant No.
FBI 34579

12. Sponsoring Organization Name and Complete Address *(Street, City, State, ZIP)*

Federal Bureau of Investigation
U. S. Department of Justice
Washington, D. C. 20537

13. Type of Report & Period Covered
Final

14. Sponsoring Agency Code
FBI

15. SUPPLEMENTARY NOTES

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

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17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Film thickness; film uniformity; fingerprint impressions; fingerprint readers; image quality; ink films; lubricity.

18. AVAILABILITY ☒ Unlimited

☐ For Official Distribution. Do Not Release to NTIS

☒ Order From Sup. of Doc., U.S. Government Printing Office
Washington, D.C. 20402, SD Cat. No. C13

☒ Order From National Technical Information Service (NTIS)
Springfield, Virginia 22151

19. SECURITY CLASS (THIS REPORT) X UNCLASSIFIED	21. NO. OF PAGES 15
20. SECURITY CLASS (THIS PAGE) UNCLASSIFIED	22. Price