Journal of Criminal Law and Criminology

Volume 44 | Issue 6 Article 13

1954

A Measurement of Land Impressions on Fired Bullets

J. H. Mathews

A MEASUREMENT OF LAND IMPRESSIONS ON FIRED BULLETS

J. H. Mathews

Professor J. H. Mathews, Ph.D., was a Professor of Chemistry and Chairman of the Department at the University of Wisconsin from 1919 until his retirement in 1952. Since 1923 he has also been engaged as an expert in crime detection and has testified in numerous cases particularly relating to fire-arms identification. In addition to his teaching of chemistry, he has given a course in criminal investigation by scientific methods for the last fifteen years. At the present time he is actively engaged in research in the field of fire-arms identification compiling information on the rifling characteristics of all known hand guns.—EDITOR.

PART I. A STUDY OF THE REPRODUCIBILITY OF MEASUREMENT

The data recorded in Part I of this paper resulted from a study of the widths of land impressions on a series of lead bullets fired from a group of seventeen .38 Spl. S and W revolvers, all of which had seen extensive use prior to and after their purchase by the Berkeley, California Police Department.[1]

The guns are listed as guns number 2 to 18 in the order in which they were fired. For the details concerning the guns and ammunition used and the conditions under which these tests were fired see Table I and supplementary notes. As was expected since all of these were used guns, some of the bullets were not in suitable condition for measurement. Some of these guns had evidently seen much use—and possibly abuse. Measurements were made on those bullets which had at least 4 measurable land impressions. Satisfactory measurements could not be made on bullets fired from guns number 13, 14, and 17, because the rifling did not leave sufficiently well defined land impressions.

Method of Measurement. A number of methods have been used by various investigators for the measurement of the width of land and groove impressions on fired bullets, such as the filar micrometer, measuring microscopes, traveling microscopes (comparators), tool makers microscopes, etc. (3, 4, 5). All of these have been tried out in this laboratory, and while satisfactory measurements can be made with any of these instruments on bullets fired from new guns, where the edges of the land impression will usually be cleanly cut clear to the bottom of the land impression (where the measurement should be made), they are not

1. These bullets were submitted by Mr. A. A. Biasotti, formerly with the Wisconsin State Crime Laboratory and now with the Pittsburgh and Allegheny County Crime Laboratory.

Table I

Gun No.	Serial No. Barrel	Serial No. Butt	No. Tests Fired	No. Lands/ No. Tests Measured	Land Impression Average	Land Impression Largest Deviation
2	V-521 282	V-79 702	12	60/12	0.0950″	+0.0006″ —0.0006
3	V-522 716	V-75 567	11	48/11	0.0972	+0.0006 —0.0002
4	V-519 202	V-73 721	12	20/4	0.0961	+0.0003 —0.0002
5	V-523 049	V-81 415	10	20/4	0.0952	+0.0004 —0.0004
6	V-521 028	V-75 014	12	20/4	0.0938	+0.0004 —0.0008
7	V-523 053	V-59 873	6	20/4	0.0959	+0.0006 —0.0006
8	V-525 224	V-81 640	6	19/4	0.0960	+0.0002 —0.0005
9	V-520 770	V-72 650	6	20/4	0.0957	+0.0005 —0.0008
		Average			0.0956″	
		Largest Deviation			+0.0016″	—0.0018″
10	V-524 213	V-81 832	12	20/4	0.0960″	+0.0004″ —0.0006
11	V-524 185	V-79 257	12	20/4	0.0963	+0.0006 —0.0007
12	V-520 829	V-79 094	12	20/4	0.0956	+0.0005 —0.0006
13*	V-520 062	V-78 327	12	0*	—	—
14*	V-527 190	V-82 697	12	0*	—	—
15	V-516 135	V-75 017	6	20/4	0.0976	+0.0006 —0.0006
16	V-526 624	V-71 565	6	20/4	0.0927	+0.0006 —0.0006
17*	V-518 596	V-74 798	6	0*	—	—
18	V-519 834	V-74 174	6	20/4	0.0966	+0.0011 —0.0009
		Average			0.0958″	
		Largest Deviation			+0.0018″	—0.0021″

* Bullets not suitable for measurement.

NOTES:
1. GUNS: .38 Spl. S and W, Military and Police, Victory Mod.
2. AMMUNITION: 38 Spl. Remington KLEANBORE, Police Service, 158 gr. Lead (5138) Lot No. XO8H25.
3. COLLECTION MEDIA: Long staple cotton.
4. CHAMBERS USED: Guns No. 2 to 9 a random chamber was used for each test. Guns No. 10 to 18 a random chamber was chosen and held constant for each series of tests.
5. CLEANING: Guns cleaned before the first and after the last shot.
6. RIFLING: (Mfg. specifications) 5R, 1 turn in 18¾″, bore diam: 0.3555 to 0.3572, groove width 0.114, groove depth 0.005, land width 0.1034. Rifled with hook cutter and lead lapped.

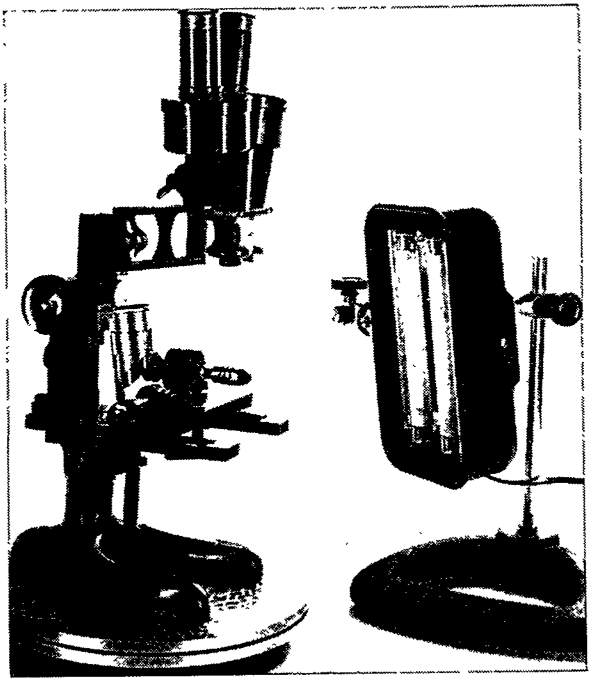

Figure 1

Complete assembly of apparatus for measuring groove widths on fired bullets. Greenough type binocular microscope on rotatable table, device for holding bullets and measuring groove widths, two tube fluorescent lamp (Burton).

entirely satisfactory for measurements made on bullets which have been fired from guns that have seen considerable use and which in consequence have lands whose edges are slightly rounded. The difficulty is of varying degrees, naturally, depending on the extent of wear on the lands and also on whether metal cased or plain lead bullets are being measured. Lead bullets cause more trouble. If the land impressions are not cleanly cut, it is of course difficult to see just where the cross-hair (reticle) should be set to coincide with the bottom edge of the land impression. This difficulty can be largely overcome by the use of a binocular microscope which gives a three dimensional view of the impressions and thereby reveals details which are not visible (or are confused) when an ordinary microscope is used as the observing instrument.

A method developed by the writer was used, and the apparatus is shown in figure 1. This method involves the use of a Greenough type binocular microscope (approximate magnification 20) in one eyepiece of which is a fine cross-hair (reticle—consisting of alternating narrow dashes and tiny circles), and a measuring device (figure 2) mounted

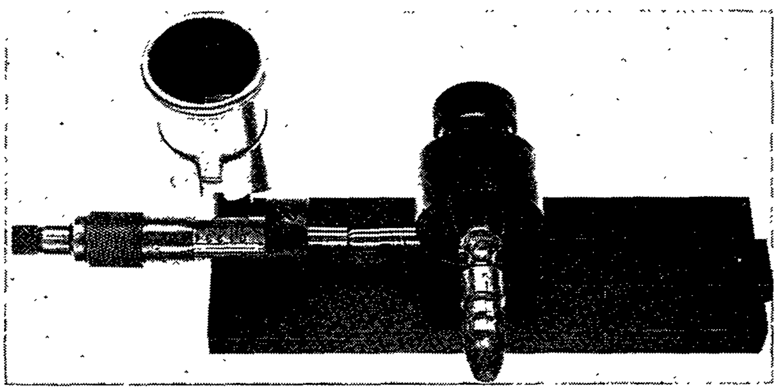

Figure 2

Device for holding bullet and for measuring width of grooves on fired bullet. Slide carrying bullet mount moves to right or left as Starrett micrometer spindle is rotated. The lens enables the operator to make accurate readings from microscope eye-piece level.

firmly on the stage of the microscope. The bullet is caused to move to the right or the left by turning the Starrett micrometer spindle. Rotating it clockwise causes the bullet to move to the left. When rotated to the left a coil spring in the base of the device (which at all times presses the bullet mount against the end of the spindle) causes the bullet to move to the right, thus permitting exact settings of the bullet such that the reticle will coincide with the bottom edges of the land impression. Several settings on each edge (driving and trailing edges) are made, and these are averaged and recorded as the proper setting for that edge. The difference between the *averaged* right hand and left hand settings represents the width of the land impression.

Before any settings are made the bullet must be carefully positioned (rotated) until each edge of the land impression being measured is in perfect focus at the time the setting is made (otherwise the two edges will not be in the same horizontal plane), and the eyepiece is rotated to line up the reticle with the edges of the land impression. Each land impression on the bullet is measured in this manner, and the average of all of these measurements represents the average width of the lands in the gun from which the bullet was fired. If one needs to know the width of the grooves in the gun, it can be calculated (approximately) from the measured land widths, diameter measurements, and a knowledge of the number of grooves.

In the case of plain lead bullets, and to a lesser extent with metal cased bullets, there is slippage when the bullet strikes the rifled part of the barrel and starts to rotate, if the bullet is fired from a revolver where the bullet acquires a relatively high velocity before engaging the rifling.

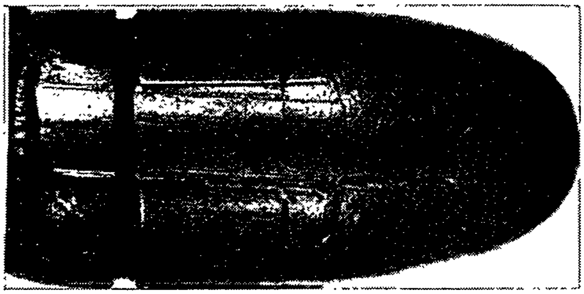

Figure 3

A test bullet fired from S & W Revolver No. C-173209. The arrow indicates the land width.

This does not occur in the case of pistols and automatic pistols where the end of the bullet is practically in contact with the rifling, in which case the bullet does not acquire any appreciable velocity before starting to turn with the rifling. When slippage does occur one has to be very careful in selecting the markings on the bullet which truly represent the width of the land. When slippage occurs the overall width of the land impression will be different at the two ends, being wider at the nose end of the bullet (see figure 3.) One side of the land impression (driving edge) will usually show a clear, distinct edge upon which the reticle is lined up. Then the bullet is moved across the field until the reticle coincides with the other edge of the land impression at the last point of contact of the bullet with the rifling (i.e. at the base end of the bullet). One will then usually observe an impression of the edge of the land which runs toward the nose end of the bullet and which will be *parallel* with the other edge of the groove upon which the reticle had been set. This impression is often faint (though not necessarily so) and requires proper illumination to bring it out in proper perspective, but with the binocular microscope it can be located and used for a proper setting of the micrometer. Micrometer settings made on land impression edges that are not parallel have no value.

The advantage of using a truly binocular microscope over a microscope with a single optical system is most striking, as it permits one to see the true shape of the edge of the land impression on the bullet. This third dimensional view is very important as it enables one to see exactly where the reticle should be, provided proper illumination is used. A two tube fluorescent lamp (Burton—see figure 1) gives very satisfactory illumination and is recommended over the customary small spot lights.

To facilitate what is at best a tedious operation of making a very great number of readings whose accuracy depends so much on getting exactly the right illumination in order to make certain the proper setting of the bullet with respect to the eyepiece reticle, the writer has devised a simple rotatable table upon which the microscope is placed. In front of this is the two tube fluorescent lamp, with the tubes set nearly vertically. The table consists of two 8″ circular plates of aluminum, each ¼″ thick, between which are ball bearings. The upper plate of the table rotates with a touch of the finger and is quickly turned and adjusted to the position where the light is at the proper angle to reveal clearly the shape of the edge of the groove on the bullet. One who has used this simple device would never return to the practice of trying to get proper illumination by moving the light source about.

Conclusions. With reference to the summary of the average measurements of land widths given in Table I, it is clear that accurate measurements of the widths of land impressions on a fired bullet can be made by the procedure developed in this laboratory, provided the bullets have been fired from guns that are in reasonably good condition and have not been damaged in the process of collecting them. It seems fair to conclude that the variation in reproducibility of a series of measurements is not greater than ±0.001″, and usually it is less.

Part II. A Study of the Variation of Land Widths in New Guns of Same Make and Model

It has long seemed desirable to the writer to make a study of the land impressions made on (A) plain lead bullets and on (B) metal cased bullets which had been fired from the *same* guns. It also seemed desirable to make a study of the variations in land widths which occur in the same make and model of guns made by a reputable manufacturer. The writer was furnished sets of bullets, both plain lead and metal cased, which had been fired from the same guns. These guns were the .38 Spl. Smith and Wesson, Military and Police Model, and had never been fired since leaving the factory.[2] They were the property of the Berkeley Police Department. For the details concerning the guns and ammunition used and the conditions under which these tests were fired see Table II and supplementary notes.

Because a new gun has rifling which is not worn, it is to be expected that the imprints of the lands on the fired bullets should be wider and that they should be more cleanly cut than would be the case for a much used gun. It also is to be expected that a metal cased bullet should show more cleanly cut land impressions than those made on a lead bullet,

2. See note 1.

Table II

Gun No.	Serial No. (Barrel)	No. Tests		No. Lands/ No. Tests Measured		Land Impressions: Average Width		Land Impressions: Largest Deviation		Difference In Average Width (M.C.-Lead)
		Lead	M.C.	Lead	M.C.	Lead Bullets	M.C. Bullets	Lead Bullets	M.C. Bullets	
40	C-176 498	6	6	20/4	20/4	0.0987″	0.0991″	+0.0005″ —0.0005	+0.0002″ —0.0001	—0.0004″
41	C-173 209	6	6	20/4	20/4	0.0983	0.0985	+0.0004 —0.0003	+0.0008 —0.0005	—0.0002
42	C-172 131	6	6	20/4	20/4	0.0995	0.0995	+0.0003 —0.0005	+0.0001 —0.0001	±0.0000
43	C-176 826	6	6	20/4	20/4	0.0981	0.0933	+0.0002 —0.0002	+0.0001 —0.0003	—0.0012
44	C-178 156	6	6	20/4	20/4	0.0984	0.0991	+0.0004 —0.0004	+0.0003 —0.0002	—0.0007
45	C-174 010	6	6	20/4	20/4	0.0979	0.0988	+0.0000 —0.0001	+0.0003 —0.0002	—0.0009
46	C-175 000	6	6	20/4	20/4	0.0981	0.0988	+0.0005 —0.0007	+0.0002 —0.0001	—0.0007
47	C-170 859	6	6	20/4	20/4	0.0999	0.1000	+0.0002 —0.0002	+0.0005 —0.0006	—0.0001
	Averages					0.0986″	0.0991″			
	Largest Deviation					+0.0013″ —0.0007″	+0.0009″ —0.0006″	+0.0003″ —0.0003″	+0.0003″ —0.0003″	—0.0005″

NOTES:
1. GUNS: .38 Spl. S and W, Military and Police (New)
2. AMMUNITION: a) Lead: 38 Spl. Remington KLEANBORE, Police Service, 158 gr. Lead (5138) Lot No. X08H25
   b) Metal case: 38 Spl. Peters, 158 gr., M.C.
3. COLLECTING MEDIA: Long staple cotton
4. CHAMBER USED: Chamber picked at random and held constant for each series of 6 lead tests followed by 6 M.C. tests.
5. CLEANING: Guns were cleaned before first and after last shot of each series of lead and M.C. tests.
6. RIFLING SPECIFICATIONS: (Mfg. specifications) 5R, 1 turn in 18¾″ bore diam: 0.3555 to 0.3572, groove width 0.114, groove depth 0.005, land width 0.1034. Rifled with a *broach cutter* and lead lapped.

because of the softness of lead in comparison to metal cased bullets. In the case of a new gun, or one having undamaged rifling, it would be expected that the width of the land impressions would be the same on lead and metal cased bullets if normal powder pressures were used. The first assumption is verified, but the second seems to be only approximately true.

Table II shows that usually the widths of land impressions on lead bullets are slightly narrower than those found on metal cased bullets fired from the same gun. In no case were they wider. Since the differences are all in the same direction, it is believed that they are real and are not the result of error in measuring.

Part III. Variation in Land Widths in D.W.M. Luger Automatics

A series of six bullets which had been fired from a D.W.M. Luger, Model of 1916, serial no. 3837, were measured to ascertain the reproducibility of land widths. The land impressions on the test bullets were very clean cut, and consequently very satisfactory measurements could be made. The average width of the four land impressions on each of the six test bullets was 0.1136″ with the largest deviations being +0.0002″ and —0.0003″. The ammunition used was 7.65 mm. Luger, Remington Kleanbore, 93 gr. M.C. (0730). The gun was cleaned before the first and after the last shot only.

The average land width for this gun had been determined in this laboratory about two years previous by measuring the widths of the land impressions on lead disks forced through the barrel during the process of measuring the degree of rifling twist by the use of the "rifling meter" (2). The gun had not been used in the meantime. The value obtained at that time for the average width of the four lands was 0.1133″—a difference of only 0.0003″ from the average value obtained two years later on six fired bullets.

The land widths for this gun are a little wider than usual for a 4 land Luger. Previous measurements on five other Lugers of this model gave 0.108″, 0.108", 0.107″, 0.102″, and 0.110″; and a Luger carbine was found to have an average land width of 0.110″.

Discussion

In a recent article Bradford and Brackett (1) have pointed out that when the distance between the two edges of a groove on a bullet is measured by the optical method one measures a distance on a plane surface and not actually the curved distance (following the contour of the bullet) which is the true width of the groove. They give a formula whereby the difference can be calculated, and a series of curves showing what the corrections amount to for various groove widths on bullets from .22 to .45 cal. In the case of the .38 cal. bullets used in this investigation, having a land width of about 0.10″, the correction amounts to +0.0014″. Surely no fault can be found with their statements—but actually in the practice of gun identification it does not matter because if one uses the same system of measurement on the evidence bullet and on the test bullet, he gets his answer as to identity or non-identity in either case, if a positive identification by such measurements is possible. As a matter of fact this method is rarely used nowadays to determine identity of a particular gun because the comparison microscope (or better, the comparison camera) enables one to establish identity or non-identity more quickly and more strikingly, and photographs of the matches between the evidence and the test bullets can be made and shown to the jury. Many years ago (1925), before he had a comparison microscope or comparison camera, the writer made a positive and most convincing identification of a revolver in a murder case by measuring the land impressions on the two evidence bullets and on three test bullets fired from the suspect gun. There happened to be considerable variation in the widths of the lands in the evidence gun. The suspect confessed and was sentenced to life imprisonment so the evidence was not used in court.

A more useful application of a knowledge of groove widths on fired bullets is to assist in the identification of the make (and sometime model) of gun that fired an evidence bullet when no suspect gun is yet at hand. If one knows the widths of the lands, the number of lands, the direction of the rifling twist, the pitch of the rifling and the caliber (actual, not nominal)—all of which can be obtained from the evidence bullet if it is in good condition—he is in a position to narrow down the search for the weapon very materially. If his information is sufficiently complete, he may be able to narrow the search down to a single make or at least to two, three, or four. This is possible only if one has extensive information concerning rifling characteristics as they actually exist in guns rather than in manufacturers' tables.[3] The "book-

3. Measurements of the rifling characteristics are constantly being made in this laboratory, and eventually the data are to be published so that they may be available to fire-arms examiners everywhere. Measurements on over 1400 guns are now in tabulated form, and data on any particular gun or guns will be furnished to anyone who desires such information. Measurements will gladly be made on any guns submitted, and the guns will be returned express prepaid and in good condition.

values" and the actual values are often quite different—and for many guns even book-values are not obtainable. Like typewriter fonts, rifling characteristics are subject to intentional change from time to time as well as to the unintentional errors made during the process of manufacture. Unfortunately in the case of many of the cheaper foreign guns, and particularly those made years ago, little if any attention was paid to the matter of rifling "specifications". This state of affairs is unfortunate for the fire-arms examiner as it naturally makes his task of identification of make and model of gun more difficult, and sometimes impossible. One American manufacturer (of a very popular gun) very frankly states that his company does not consider that any specification other than bore diameter is of any particular importance in the proper functioning of their guns. It is fortunate for the fire-arms examiner that all manufacturers are not of this opinion!

The manufacturer's specifications call for a land width of 0.1034″ for this particular model of gun from which the bullets described in Parts I and II were fired, but in the many measurements made in this laboratory no width as great as this has ever been found for this model of revolver—new or used. It is clear however that the lands become narrower as the gun is used. Of course, the edges become worn, and this makes a micrometer setting more difficult as the imprint of the land is not as clean cut. The difficulty is greatly reduced, however, by the use of the binocular microscope which reveals the true shape of the groove, when proper lighting is used. This method has been found to be superior to the filar micrometer, the tool makers microscope, the comparator, or the traveling stage microscope in all of which a single eye-piece is used in the observing instrument. A three dimensional view is necessary to see the true shape of the groove edge.

SUMMARY

1. While it is true that with the customary methods of measurement there is considerable difficulty in determining the exact positions for the cross-hair (or reticle) of the measuring device, this difficulty can be largely removed by the use of a Greenough type binocular microscope as the observing instrument. The three dimensional image afforded by such a procedure enables the operator to see more clearly where the edge of the impression of the land is located.

2. Using the technique here described it seems justifiable to conclude that measurements of land impressions on fired bullets can usually be made with a considerable degree of accuracy. Naturally, much depends

on the condition of the bullet. In a paper by Burton D. Munhall (4) he concludes that groove width measurements can not be made to a degree of accuracy greater than 0.01″. It would seem from the studies made in this laboratory that a higher order of accuracy is possible with the technique and apparatus here described.

3. The reproducibility of the average widths of land impressions on bullets fired from the same gun, as measured by the method used, seems to be of the order of ±0.0010″ when proper ammunition is used, even in guns that have seen much service. As is well recognized, it is abuse rather than use that is most harmful to the rifling of a gun.

References

1. Bradford, L. W., and Brackett, J. W. R., Identification News, March (1953).
2. Mathews, J. H. and Henke, Lee K., "The Rifling Meter", J. Crim. Law and Criminol., *35,* 134 (1944).
3. Mezger, Otto; Heese, Walter; and Hasslacher, Fritz (translation by A. O. Knoll), "Determination of the Pistol Employed from an Examination of Fired Bullets and Shells", Amer. J. of Police Sci., Part I, Vol. 2, pp. 473-99, Part II, Vol. 3, pp. 124-45 (1932).
4. Munhall, B. D., Proceedings of the I.A.I. (1950), pp. 166-171.
5. Wilson, Charles M., "Two New Instruments for the Measurements of 'Class' Characteristics of Fired Bullets", J. Crim. Law and Crimnol., *27,* 97 (1936).