AN EXAMINATION OF TWO CONSECUTIVELY RIFLED BARRELS AND A REVIEW OF THE LITERATURE

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ABSTRACT

Any possibility of a "carry-over", or reproduction of subclass characteristics is more likely to occur in consecutively manufactured barrels. Two barrels consecutively manufactured using the gang broach method are examined for subclass characteristics. Bullets are inter-compared and evaluated to determine the presence of subclass characteristics, and according to the conservative criteria for identification of striated toolmarks. A review of some previous articles discussing the examination of fired bullets from consecutively rifled barrels is included.

Introduction

When determining the potential for individuality of toolmarks observed on fired bullets, any striae observed are evaluated to determine if they are individual to the barrel through which the bullet was fired, or subclass characteristics belonging to a group of barrels. If subclass characteristics exist, they are most likely to be produced in barrels that are consecutively manufactured. This is because less of a change would be expected to occur to the working surfaces of the tools manufacturing the barrels consecutively, than the change exhibited on barrels made over a longer production period.

One of the earliest references found where in bullets fired from consecutively rifled barrels are examined is in Mathews (1). He states that at the Springfield Arsenal in 1926, "four barrels were rifled one after the other with the same rifling tools in an attempt to produce barrels as alike as possible. Bullets were fired through each barrel and compared. It was found that no two barrels matched completely; each had a distinct and separate individuality" (2).

Lutz examined bullets fired from two consecutively rifled .38 Special revolver barrels, firing twelve bullets from each barrel. A microscopic comparison of the bullets resulted in identifications to the barrels they were fired from. An inter-comparison of the bullets "revealed that each barrel had caused different markings to such an extent that each land and groove impression on each of the bullets had a great number of individual identifying striae" (3).

In an effort to examine crowning as a factor in the identification of bullets fired from consecutively rifled barrels, Murdock examined four barrels from different manufacturers. Each barrel was test fired three times, re-crowned, test fired again, and re-crowned (except one barrel). Bullets were microscopically compared before and after re-crowning from each barrel, and inter-comparisons of bullets fired from different barrels were made. Murdock noted that, "although some changes in striation pattern were observed on test bullets which were separated by a re-crown, sufficient agreement was noted to enable an identification to be affected" (4).

Skolrood used three consecutively rifled Cooey Barrels which were rifled using four separate broaches. Five bullets were fired through each rifle at the factory, and a series of bullets were fired for examination. Bullets fired from each barrel reproduced toolmarks sufficiently for the bullets to be identified to the barrel through which it was fired, and no "carry-over of pertinent characteristics was noted from one barrel to another". The article gives a detailed discussion on the observations of "broach characteristics" and points out that there is some "carry-over" of "broach characteristics" from one barrel to another, but that "there is no difficulty in differentiating between bullets fired from consecutively rifled barrels" (5).

Freeman examined three Heckler and Koch consecutively hammer forged rifled polygonal barrels. Five bullets were fired through each barrel, microscopically compared, and identified to the barrel which fired it. The third barrel required fifteen test bullets before toolmarks reproduced sufficiently for an identification. The barrels used for this study were fluted and resulted in reproducible toolmarks caused by the flutes. An inter-comparison of the bullets fired from these three barrels showed that "each barrel has a distinct and separate individuality" (6).

Murdock evaluated the concept of individuality of toolmarks on fired bullets from three consecutively button rifled barrels from three different manufacturers. Ten bullets were fired from each barrel. The initial bullets fired through each barrel failed to display sufficiently reproduced toolmarks for an identification. Subsequent test fired bullets could be identified to the barrel which fired it. Bullets fired from each of the barrels were then inter-

compared. The results as stated was, "there was absolutely no indication of a carry-over or family-type striations on bullets fired from consecutively button rifled .22 caliber barrels manufactured by Marlin, Mossberg, and Remington" (7).

Hall compared bullets fired from four button-swaged polygonal rifled Shilen rifle barrels. Thirty one bullets were fired from each barrel, with thirteen recovered for examination. An examination of bullets fired from the same barrel showed "a major reduction in agreement as the separation in the firing order of bullet pairs increased". An inter-comparison of bullets fired from different barrels showed, "one gross striation showing to some degree on all the bullets fired from every gun was produced by a single fault in the surface of the rifling button". Hall used this subclass characteristic to index the bullets. He noted that "there was never enough agreement seen in the marks on bullet pairs from two consecutively manufactured barrels to introduce the risk that a false identification might be made" (8).

In order to determine the possible carry-over of subclass characteristics in button rifled barrels, Matty obtained three .30 caliber barrels which were cut from the same section of rifled tube. He theorized that if any similarities could carry-over from one barrel to the next, it had it's best chance of occurring in barrels cut from the same rifled tube. Mikrosil™ casts of the barrels showed that "a few of the lines persisted through the length of all these barrels, but the majority of the groove striae changed along the length of the barrels". In firing test bullets, Matty noted that rapid change occurred to striae observed in the land impressions, from the first bullet fired in the new barrel to subsequent firings. Inter-comparisons of bullets fired from the three barrels "showed the same type of roughness and each barrel exhibited a settling-in period, it was not possible to find correspondence of individual characteristics; no match could be found when comparing bullets from different barrels" (9).

Brundage used ten consecutively gang broach rifled 9mm Ruger barrels and assembled test shots of fired bullets from the barrels consisting of thirty-five bullets each. These were then submitted to various examiners for evaluation. The objective of this study was to determine if bullets fired from consecutively rifled barrels could be correctly identified. As a result, he demonstrated on a national level, that properly trained firearms examiners could accurately identify bullets fired from consecutively rifled barrels to the barrel which fired it (10).

If it is more likely that consecutively produced barrels would display subclass characteristics, then it should be even more likely to observe a carry-over of toolmarks within various sections of the same barrel. In an unusual study, Tulleners set out to determine the reproducibility of striae on fired bullets after removal of one-inch barrel sections. A Thompson Contender button swaged barrel was used for the study. Test bullets were fired, then a section of barrel was cut off using wire EDM to provide a burr free finish. Additional test bullets were fired, and the process repeated until six sections were removed. A comparison of bullets fired from the barrel of the same section were identifiable. An inter-comparison of bullets fired from adjacent barrel sections could not be identified. The comparisons of striae were then evaluated using the consecutive groups of matching lines criteria (11).

Tulleners also reported on the examination of subclass characteristics observed in the groove impressions of bullets fired from ten consecutively manufactured gang broach barrels. An inter-comparison of the bullets fired from the ten barrels shows a reproduction of subclass features in the groove impressions of fired bullets, "the extent of this agreement would be sufficient for an identification", had they not be determined to be subclass characteristics. No subclass features were observed in the land impressions (12).

Research Method

The purpose of this study was to evaluate bullets from two consecutively gang broach rifled barrels. The barrels used were .44 caliber. The barrels were obtained one after the other from the manufacturing line as soon as the broach completed the pass. In this condition, the chamber end has been threaded and the barrel crowned. No additional process is done to the interior of the barrel. Exterior finishing processes must be completed before the barrel is ready to be fitted to a frame.

Mikrosil™ casts were made of each barrel and inter-compared. Two jacketed and two lead test bullets each were pushed through the barrels from breech to muzzle, due to the unfinished exterior condition of the barrels and possible safety hazards. As discussed by Hornsby, pushed bullets may be identified to fired bullets, and for this study, it was only necessary that all of the bullets transverse the barrel using the same method (13). Bullets from each barrel were compared to each other, and then inter-compared. Any toolmarks present were evaluated according to the conservative criteria for identification of striated toolmarks as proposed by Murdock and Biasotti (14).

Biasotti and Murdock, in the "conservative criteria for identification", have suggested the following criteria for the identification of striated toolmarks (15):

A. In three dimensional toolmarks when at least two different groups of at least three consecutive matching striae appear in the same rela-

tive position, or one group of six consecutive matching striae are in agreement in an evidence toolmark compared to a test toolmark.

B. In two dimensional toolmarks when at least two groups of at least five consecutive matching striae appear in the same relative position, or one group of eight consecutive matching striae are in agreement in an evidence toolmark compared to a test toolmark.

Before this criteria can be applied, the possibility of subclass features must be eliminated. Three dimensional images are referred to as those having depth when viewed through a microscope, and two dimensional images are described as those appearing so shallow that they lacked apparent depth and, therefore, contour variation. For the purposes of this study, two dimensional images were used for the data collection, similar to previous studies (16).

Results

The Mikrosil™ casts recorded the striae from the inside of the barrel well enough for a microscopic examination (See Photo 1). Reamer toolmarks can be observed at the chamber end of the cast which are then obliterated by the parallel longitudinal striae produced by the gang broach. Since the last cutter in the series produces the final toolmarks, these would be expected to reproduce on a subsequently rifled barrel.

The striations observed on the land impressions and groove impressions run the entire length of the cast and are well defined and numerous. A microscopic comparison was made between the casts of both barrels, oriented so that land impression #1 was at the top of the barrel, and were kept in phase during the 360° comparison. There was random agreement between the two casts within the groove impressions, none of which was sufficient to establish an identification (See Photos 2-7).

Three of the land impressions #3,5, and 6 exhibit an insufficient correspondence of striae for a conclusion of an identification to be made, with only random agreement observed. Land impressions #1,#2, and #4, exhibited many subclass similarities and could be identified as having been produced using the same tool working surface (See Photos 8-13). Notice that the correspondence of the striae occurs with the land edges offset, indicating a slight shift of the broach when cutting the next barrel. Table 1 shows a comparison of each land impression and groove impression from both barrel casts inter-compared, recording the number of striae observed, the number of matching striae observed, and the number and type of consecutive groups of striae observed. It is important to note that the Biasotti and Murdock conservative consecutive groups of striae criteria cannot properly be applied to this data for identification purposes, because the striae observed are the result of subclass features. ***The data is presented in this way to illustrate the importance of eliminating subclass influence before applying any criteria to a toolmark identification.***

The lead and copper jacketed test bullets pushed through the same barrel were compared to each other. The lead bullets did not record the striae as well as the copper jacketed bullets, but a microscopic comparison could be done, resulting in a conclusion of an identification (See Photos 14-15). Table 2 illustrates a comparison of the land impressions of both test bullets pushed through barrel number one, and a comparison of the land impressions of both bullets pushed through barrel number two. The information recorded for two dimensional known matches includes the number of striae observed, the number of matching striae, and the number and types of consecutive groups of striae observed. A conclusion of an identification could be made. The two bullets pushed through barrel number one exhibited a consecutive group of 12, meeting the requirements of the conservative consecutive group criteria. The bullets pushed through barrel number two, exhibited one consecutive group of 5, failing to meet the criteria requirements.

A copper jacketed test bullet from barrel one was microscopically compared with a jacketed test bullet from barrel two. The three land impressions that displayed the most agreement of striae were number 1, 2, and 4 (See Photos 16-18). None of the agreement observed was sufficient to establish an identification, and the bullets could be eliminated as having been through the same barrel. These were also evaluated according to the total striae observed, total number of striae, and the number and types of consecutive groups of striae observed. The largest consecutive group observed in any of these two dimensional known non-matches was 3X, and adheres to the Biasotti and Murdock criteria (See Table 3).

The copper jacketed bullets pushed through barrel one and barrel two were microscopically compared with the casts from barrel one and barrel two (See Photos 19-24). Tables 4 and 5 show the results of the total striae observed, total number of striae, and the number and types of consecutive groups of striae observed, on the three land impressions which displayed the best agreement. No conclusion of identification could be made. These are included to illustrate casts compared with a copper jacketed bullet.

Table 6 shows the data for three dimensional known matches using the test bullets from barrel one, and Table 7 shows the data for three dimensional known

matches using the test bullets from barrel two. For barrel one, the highest consecutive group observed was 6X, and for barrel two, the highest consecutive group observed was 7X. Both sets of bullets from barrels one and two meet the conservative consecutive group criteria, and would result in an opinion of identification.

Table 8 shows the data for three dimensional known non-matches, comparing a test bullet from barrel one with a test bullet from barrel two. The lands chosen for comparison correspond with the top of the barrel which was designated as Land Impression #1, and continued clockwise. This corresponds with the barrel casts which show a high reproduction of subclass features, yet the highest consecutive group observed was 2X. Using the conservative consecutive group criteria, no erroneous identification would result.

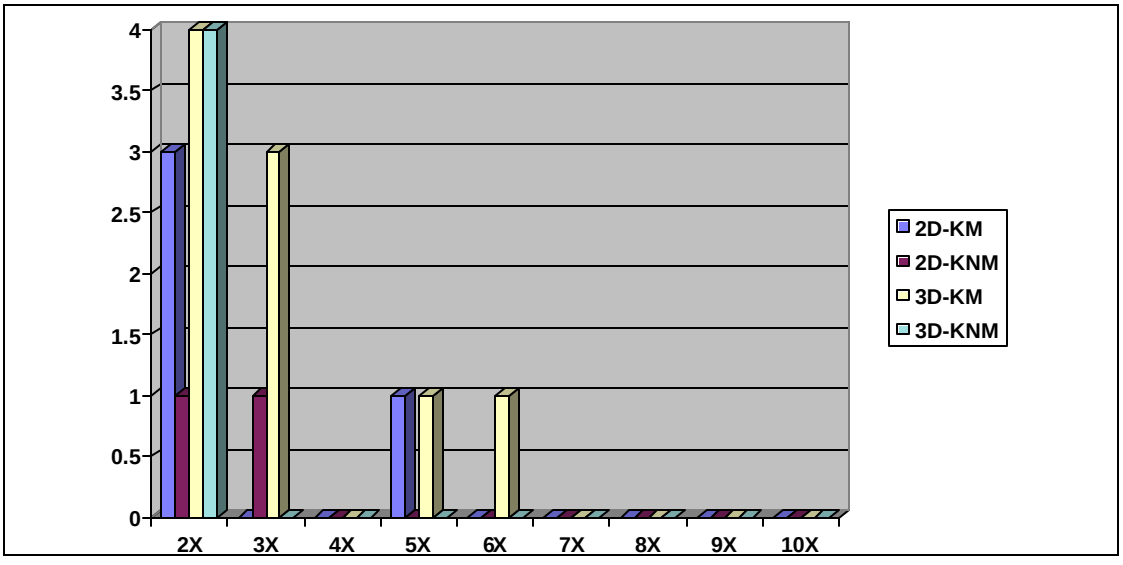
Conclusion

An examination of the casts from both barrels shows a significant reproduction of subclass characteristics within the land impressions more than the groove impressions. An examination of the bullets pushed through the barrels show that those subclass characteristics did not transfer sufficiently to the bullet surface to interfere with identification of striae on the bullets with the correct barrel.

Figure 1 shows the total number of consecutive groups of striae for the top two land impression comparisons for two dimensional and three dimensional known matches and known non-matches. It is clear that there is a significant occurrence of consecutive groups of 2X striae in all of the categories, with the larger groups appearing only in known matches. If only single land impressions are considered, with the conservative criteria for identification applied, then no erroneous identifications could be made. Some missed identifications could occur. If all of the available land impressions are considered when applying the conservative criteria for identification, then fewer missed identifications could occur, and no erroneous identifications will be made.

In theory, any similar characteristics which could be used as indices of identification between barrels would occur between sequentially rifled barrels. An examination of the barrels in this study shows a remarkable carryover of subclass characteristics from one barrel to the next. An examination of the bullets from these barrels shows that the subclass influence is not imparted to the surface of the bullet to the extent that it prevents an identification. Applying the "conservative criteria for identification" shows, after the elimination of subclass influence, that no erroneous identifications could be made between the bullets from two consecutively rifled barrels.

Figure 1: The two top scoring land impressions in each category of two and three dimensional known matches (KM) and known non-matches (KNM). (Groups of Consecutive Matching Stria)



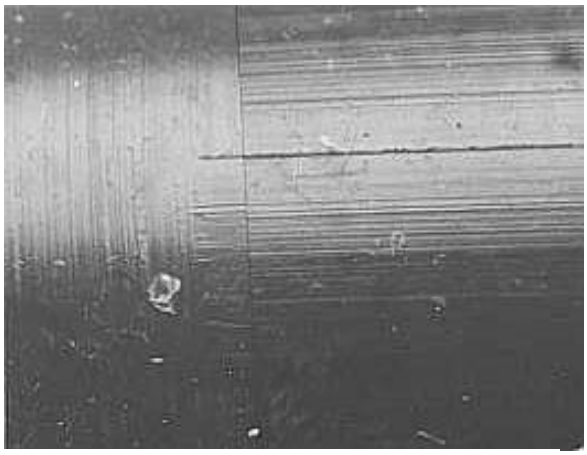


Photo 1: Parallel Striae on Cast at Land/Groove Impressions

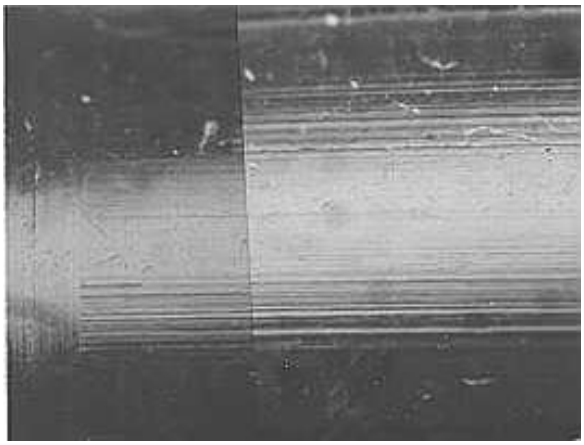


Photo 2: Groove Impression 1 (Barrel 2/Barrel 1)

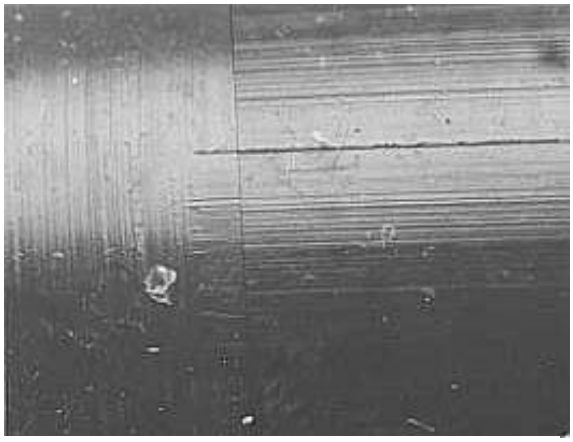


Photo 3: Groove Impression 2 (Barrel 2/Barrel 1)

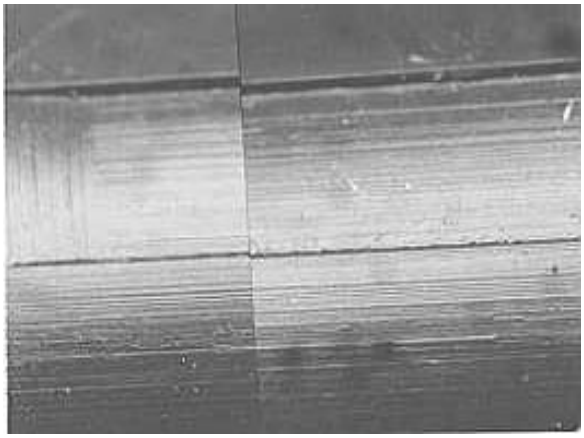


Photo 4: Groove Impression 3 (Barrel 2/Barrel 1)

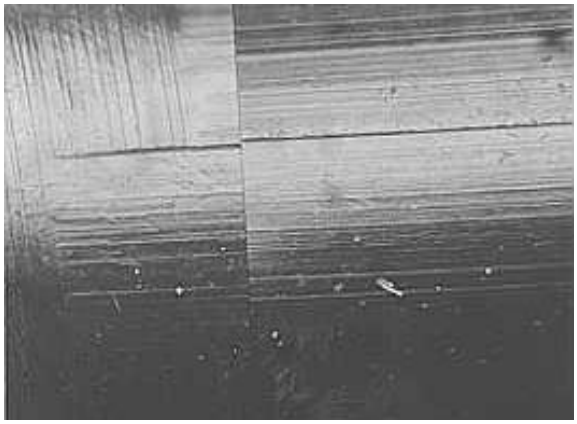


Photo 5: Groove Impression 4 (Barrel 2/Barrel 1)

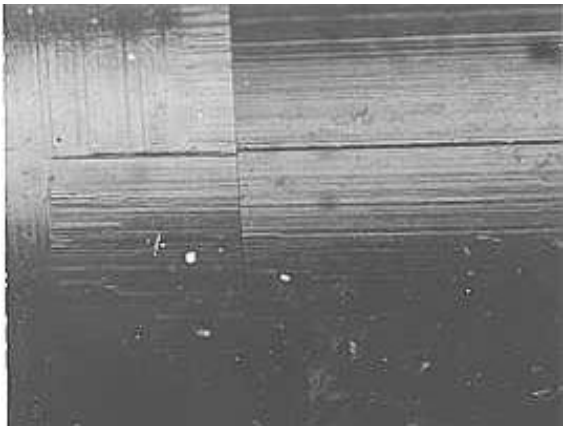


Photo 6: Groove Impression 5 (Barrel 2/Barrel 1)

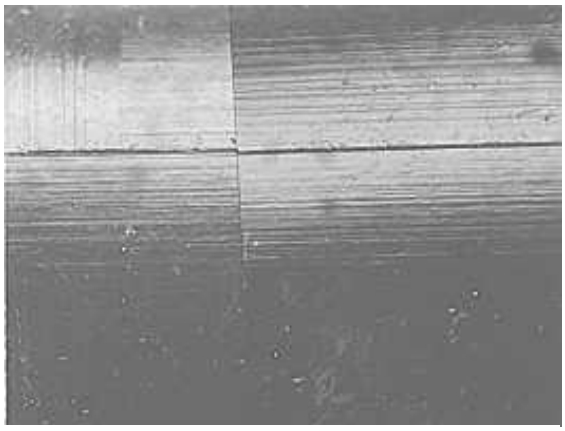


Photo 7: Groove Impression 6 (Barrel 2/Barrel 1)

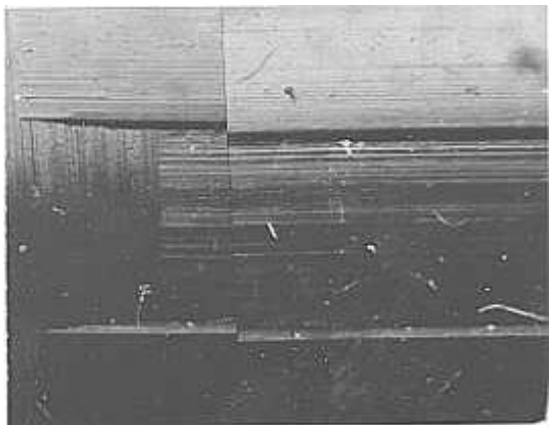


Photo 8: Land Impression 1 (Barrel 2/Barrel 1)

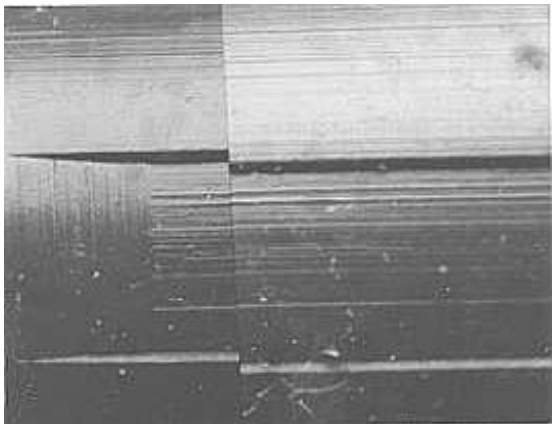


Photo 9: Land Impression 2 (Barrel 2/Barrel 1)

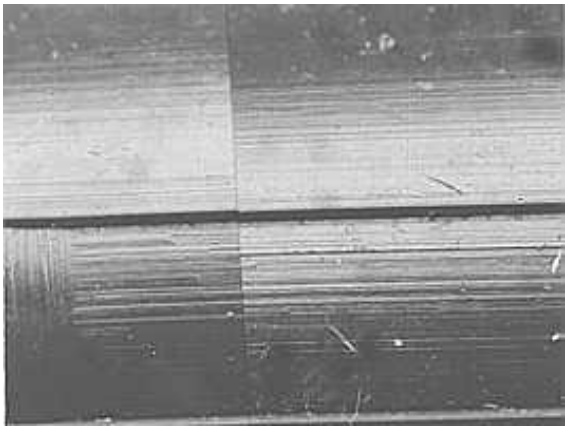


Photo 10: Land Impression 3 (Barrel 2/Barrel 1)

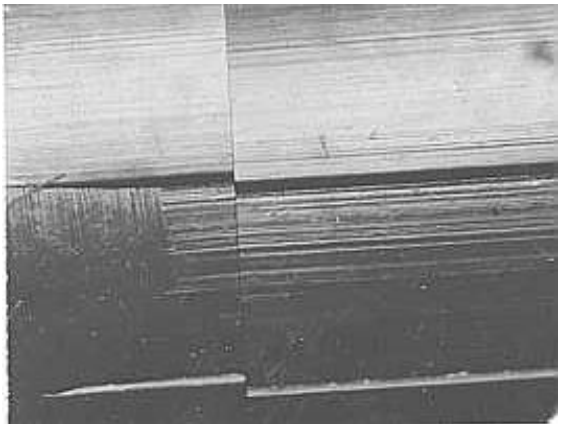


Photo 11: Land Impression 4 (Barrel 2/Barrel 1)

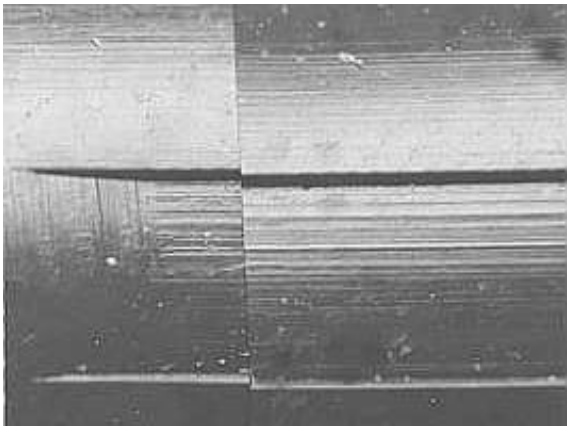


Photo 12: Land Impression 5 (Barrel 2/Barrel 1)

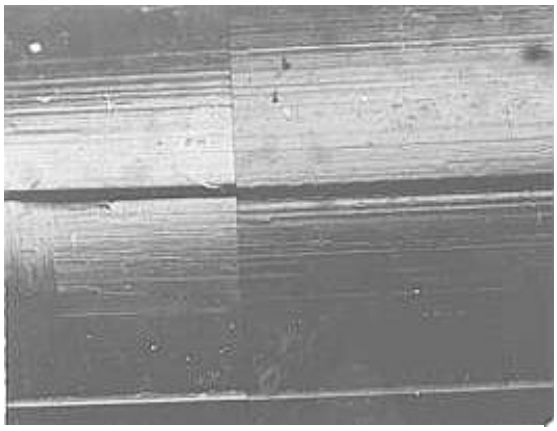


Photo 13: Land Impression 6 (Barrel 2/Barrel 1)

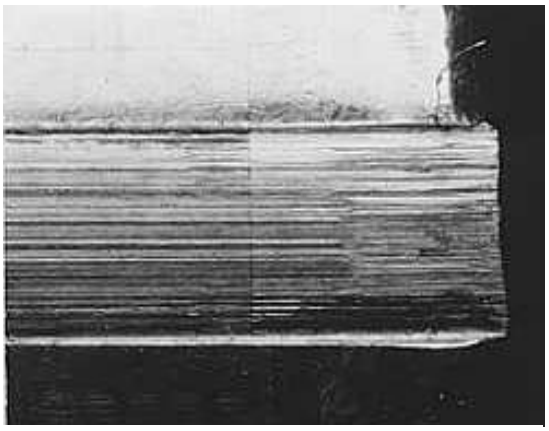


Photo 14: Barrel 1 Test Lead Bullets (Land 1)

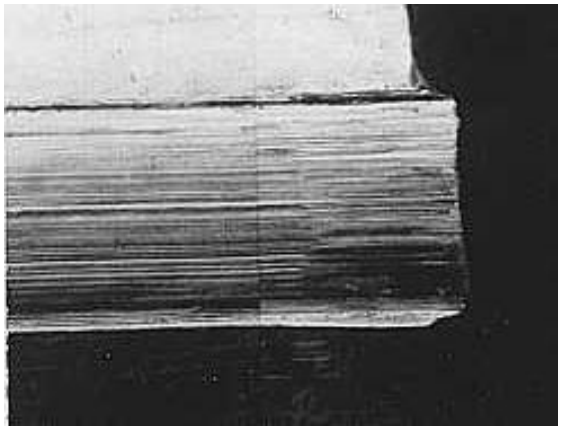


Photo 15: Barrel 2 Test Lead Bullets (Land 1)

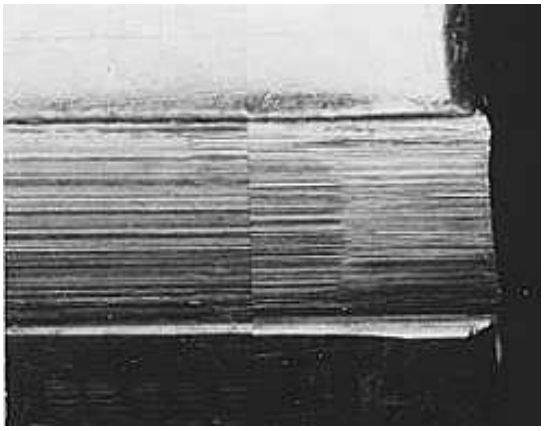


Photo 16: Barrel 1 and Barrel 2 Copper Jacketed Test Bullets (Land Impression 1)

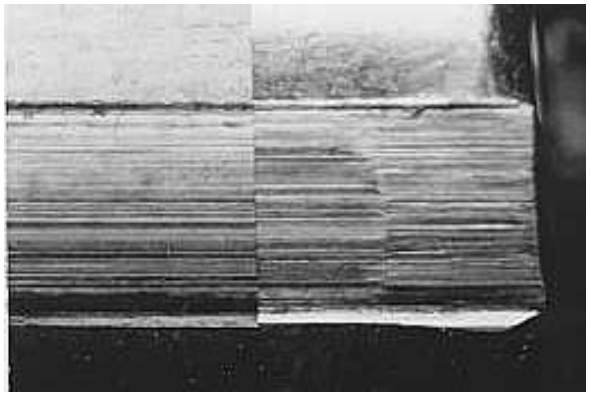


Photo 17: Barrel 1 and Barrel 2 Copper Jacketed Test Bullets (Land Impression 2)

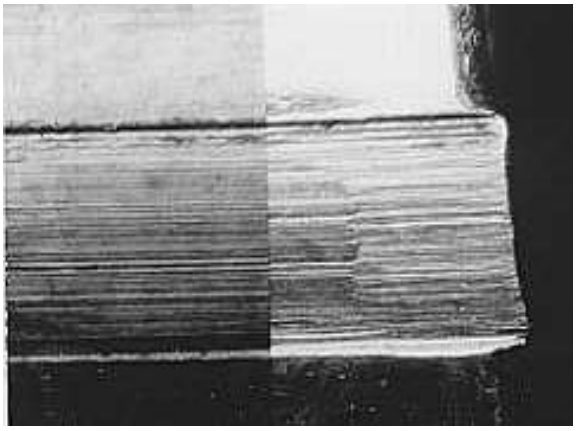


Photo 18: Barrel 1 and Barrel 2 Copper Jacketed Test Bullets (Land Impression 4)

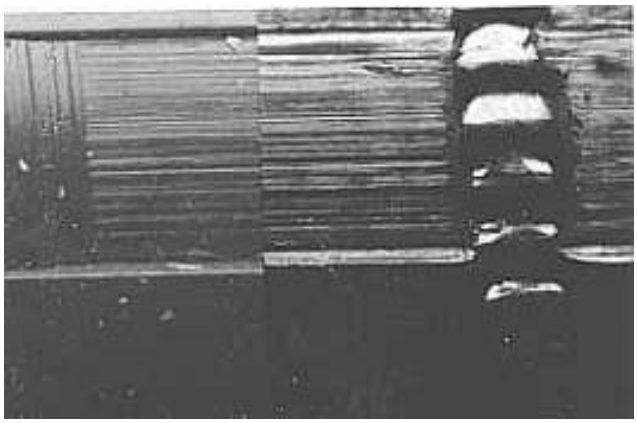


Photo 19: Barrel 1/Land Impression 1 Cast With Bullet

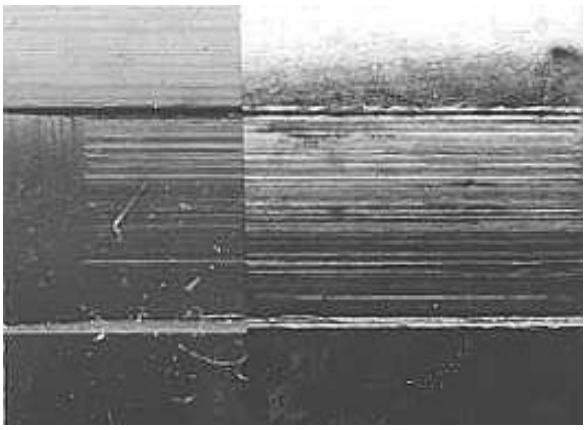


Photo 20: Barrel 1/Land Impression 2 Cast With Bullet

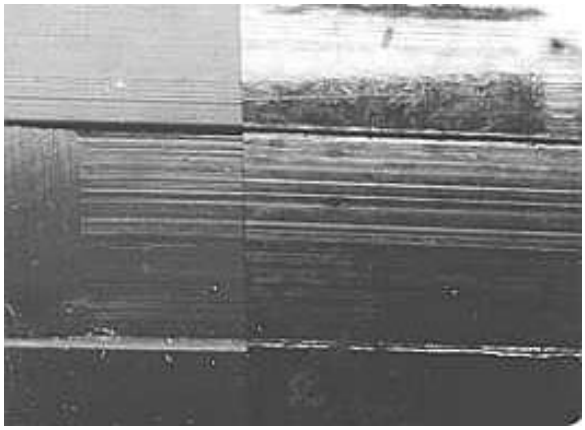


Photo 21: Barrel 1/Land Impression 4 Cast With Bullet

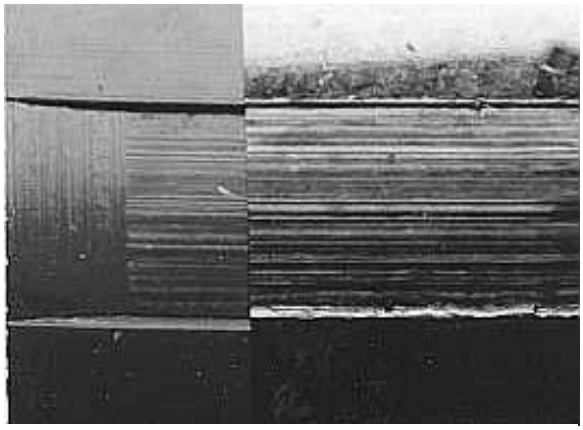


Photo 22: Barrel 2/Land Impression 1 Cast With Bullet

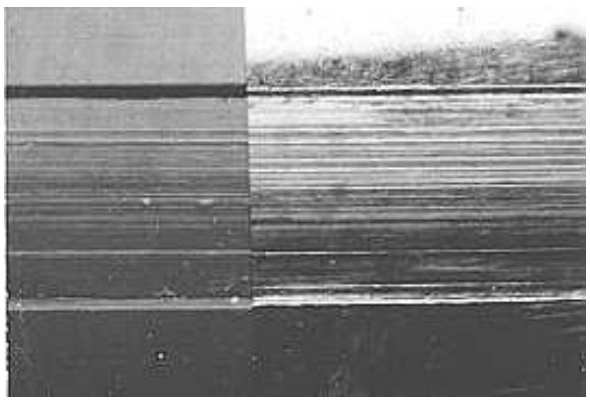


Photo 23: Barrel 2/Land Impression 2 Cast With Bullet

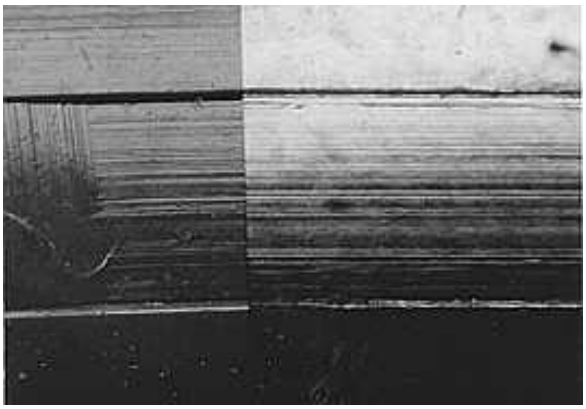


Photo 24: Barrel 2/Land Impression 4 Cast With Bullet

Table 1: Comparison of Casts of Land and Groove Impressions from Barrel 1 with Barrel 2 (2-Dimensional Observations)*

	Barrel 1	Barrel 2	Total Match	2X	3X	4X	5X	6X	7X	8X	9X	10X
Land 1 Imp.	30	26	17	2								1
Land 2 Imp.	18	22	9	1	1							
Land 3 Imp.	19	18	9	2								
Land 4 Imp.	14	16	12	1						1		
Land 5 Imp.	20	18	6									
Land 6 Imp.	10	11	6		1							
Groove Imp. 1	25	21	14	1	1		1					
Groove Imp. 2	21	20	8	2								
Groove Imp. 3	18	20	10	1	1	1						
Groove Imp. 4	18	17	5									
Groove Imp. 5	16	16	6	1								
Groove Imp. 6	17	17	5									

***These are subclass characteristics, and as such, cannot properly be evaluated using a criteria for toolmark identification.**

Table 2: Comparison of Land Impressions on Test Bullets from Barrel 1 and Barrel 2 (2-Dimensional Known Match)

	Test 1 Land Imp. 1	Test 1 Land Imp. 1	Total Match	2X	3X	4X	5X	6X	7X	8X	9X	10X
Barrel 1	34	36	24	2								1-12X
Barrel 2	26	25	13	1			1					

Table 3: Comparison of Land Impressions on Test Bullets from Barrel 1 with Barrel 2 (2-Dimensional Known Non-Match)

	Barrel 1	Barrel 2	Total Match	2X	3X	4X	5X	6X	7X	8X	9X	10X
Land Imp. 1	34	25	7									
Land Imp. 2	24	21	6									
Land Imp. 4	27	28	9	1	1							

Table 4: Comparison of Land Impressions on Test Bullets from Barrel 1 with Barrel Casts (2-Dimensional Observation)

	Cast 1	Bullet 1	Total Match	2X	3X	4X	5X	6X	7X	8X	9X	10X
Land Imp. 1	30	36	13	4								
Land Imp. 2	18	24	8									
Land Imp. 4	14	27	6	2								

Table 5: Comparison of Land Impressions on Test Bullets from Barrel 2 with Barrel Casts (2-Dimensional Observation)

	Cast 2	Bullet 2	Total Match	2X	3X	4X	5X	6X	7X	8X	9X	10X
Land Imp. 1	26	25	7	1								
Land Imp. 2	22	21	8	2								
Land Imp. 4	16	28	5									

Table 6: Comparison of Land Impressions on Test Bullets from Barrel #1 (3-Dimensional Known Matches)

	Barrel 1 T-1	Barrel 1 T-2	Total Match	2X	3X	4X	5X	6X	7X	8X	9X	10X
Land 1 Imp.	58	48	18	1		1						
Land 2 Imp.	57	49	31	2	1	2		1				
Land 3 Imp.	43	43	14	3								
Land 4 Imp.	42	39	23	3	1							
Land 5 Imp.	45	42	32	1	1	1	1	2				
Land 6 Imp.	36	37	19	3	1	1						

Table 7: Comparison of Land Impressions on Test Bullets from Barrel #2 (3-Dimensional Known Matches)

	Barrel 2 T-1	Barrel 2 T-2	Total Match	2X	3X	4X	5X	6X	7X	8X	9X	10X
Land 1 Imp.	39	37	23	2	2	1						
Land 2 Imp.	38	41	28	2	1			1	1			
Land 3 Imp.	47	51	27	6	1	1						
Land 4 Imp.	41	33	22	2	1	1						
Land 5 Imp.	41	38	15	3								
Land 6 Imp.	34	39	12	2								

Table 8: Comparison of Land Impressions on Test Bullets from Barrel #1 with Barrel #2 (3-Dimensional Known Non- Matches)

	Barrel 1 T-1	Barrel 2 T-2	Total Match	2X	3X	4X	5X	6X	7X	8X	9X	10X
Land 1 Imp.	58	39	11	1								
Land 2 Imp.	57	38	15	3								
Land 3 Imp.	43	47	11	1								
Land 4 Imp.	42	41	12	3								
Land 5 Imp.	45	41	12	2								
Land 6 Imp.	36	34	15	2								

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