

Variation of Markings on Primers of Expended Cartridge Cases: Analysis of Cartridge Cases Fired from Caliber .25 Semi-Automatic Pistols

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ABSTRACT

The relative positions of the extractor and ejector markings on cartridge cases are known as class characteristics of semi-automatic pistols and these have been used by some for listing the possible source firearm. However, the expended cartridge cases fired from pistols of small caliber such as 6.35mm or .25-caliber often exhibit no visible extractor or ejector markings. They will, however, possess a firing pin impression and often bear breech face markings. To evaluate the availability of markings on primers for the estimation of type and make of firearm, the author examined the markings on 323 expended cartridge cases fired from more than forty makes of .25-caliber semi-automatic pistols. The diameter and eccentricity of the firing pin impressions and firing pin aperture markings were measured. The degree of back flow of the primer around the margin of the firing pin impressions and the pattern of breech face markings were also noted and evaluated.

The author found great diversity among the markings on primers fired from the same make of firearm. It was difficult to estimate the make of firearm using the markings on primers.

Introduction

The relative positions of the extractor and the ejector markings are recognized as class characteristics of semi-automatic pistols. The early study by Metzger, et al. described the method used to predict the type and make of pistols using the relative positions of extractor and ejector markings on cartridge cases [1]. Gunther & Gunther defined the technique to determine the type and make of firearm in which a cartridge case was fired as second type of problem in firearm identification [2]. They indicated that the breechblock or recoil plate of the firearm could transfer its design features and machining operation onto the head or primer of the fired cartridge case. The size and shape of the nose of the firing pin are indicated by the impression on the head of the cartridge case in rimfire ammunition. Gunther & Gunther also indicated that the type, diameter, shape of the firing pin's nose, the angle of percussion and the nature of the machining operations are details that can be observed in centerfire ammunition. However, Gunther & Gunther pointed out that an extensive collection of comparison standards consisting of cartridge cases fired from known types and makes of firearms would be needed for the practical solution of this problem.

The .25 caliber semi-automatic pistols often produce shallow ejector markings or no ejector marks at all and it is often

difficult to use the relative positions of the extractor and the ejector marking for possible source estimation.

In this present study, the author studied the potential availability of size and position of firing pin indentation and firing pin aperture markings for a prediction of the make and model of firearm from which the cartridge cases were fired.

Materials and Methods

Test fired cartridge cases fired from various makes of .25-caliber semi-automatic pistols were used for this study. Remington R25AP cartridges were used to produce test-fired specimens in this study. Digital photographs were taken of 323 expended cartridge cases fired from 42 known makes and 2 unknown makes of 6.35mm/.25 Automatic pistols using a Fuji HC-2500 3CCD digital camera mounted on a Leica M420 microscope. The magnification of the zoom objective lens was set to 12.5X.

The following quantifiable parameters were selected: the diameter of firing pin impression, the diameter of firing pin aperture marking, the eccentricity of firing pin impression and eccentricity of firing pin aperture marking. These parameters were measured on a computer display. Both the firing pin impression and the firing pin aperture markings were assumed to be circular and their diameters measured using a three-point method. Neither the firing pin impression nor the firing pin aperture markings were exact circles in many cases. When possible, the diameters of circles circumscribing the firing

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pin impression and aperture mark were measured (Figure 1). Then the eccentricity was calculated using the centers of the firing pin impression and firing pin aperture marking versus the center of the primer pocket.

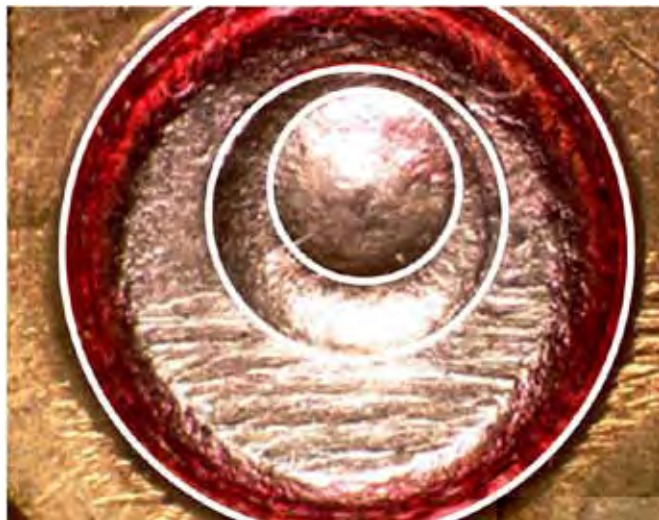


Figure 1: Measuring method for the diameter of firing pin impressions and firing pin aperture markings. The diameter of the circle circumscribed the firing pin impression or firing pin aperture marking was measured using the three points method.

The average resolution of the image used in this study was 280 pixels per primer pocket diameter. With a primer pocket diameter of a 25ACP cartridge of 0.175" (4.445mm), one pixel of the image is equal to 0.0159mm. For convenience in calculation, the diameter of firing pin indentations and firing pin aperture markings were expressed as a percentage of the diameter of the primer pocket. Eccentricity of a firing pin impression and a firing pin aperture marking were calculated as a percentage of the radius of the primer pocket.

The degree of backflow of primer around the firing pin indentation and the pattern of breech face markings were also observed and recorded.

Results

Diameter of Firing Pin Impression

The diameter of the firing pin impressions of all 323 expended cartridge cases from the various 25 caliber semi-automatics used in this study were widely distributed from 22% to 53% of the diameter of primer pocket of the cartridges and corresponded to diameters of 0.98mm to 2.36mm. The average value of the diameter was 35.5% of the diameter of the primer pocket and corresponded to 1.58mm (Figure 2). The average

diameter of the firing pin impression within each make of pistol was distributed from 24.5% to 45.0% of the diameter of the primer pocket of the cartridges and corresponded to values of 1.09mm to 2.00mm. On average, the firing pin impressions of Taurus and Beretta pistols were relatively small and those of Browning pistols were large. However, the range of values for firing pin impression diameters within the same make of pistol was very wide. These results indicated that it would be difficult to predict the make of gun based on the diameter of firing pin impressions (Figure 3). In Figure 2, the number of each gun is indicated by bar graph and the average diameter is indicated by horizontal lines. The range of diameters for each make is indicated by vertical lines.

Diameter of Firing Pin Aperture Marking

Firing pin aperture markings were only confirmed on 307 cartridge cases out of 323 cases. The diameter of the firing pin aperture markings were distributed from 44% to 70% of the diameter of the primer pocket of the cartridges and corresponded to 1.96mm to 3.11mm. The average diameter for this parameter was 59% of the primer pocket's diameter and corresponded to 2.62mm (Figure 4). The average diameter of firing pin aperture markings within each make of pistols was distributed from 49% to 70% of the primer pocket's diameter and corresponded to 2.18mm to 3.11mm. The diameter of Raven pistols was rather small and that of Titan pistols was rather large. However, the range of values of those diameters became very wide as the number of exhibits increased. These results indicated that it would be difficult to estimate the make of gun based on the diameter of the firing pin aperture markings (Figure 5). Firing pin aperture markings were not always observed on the primer. The values measured and evaluated here were derived from 303 exhibits upon which marking were discernible. Although a Phoenix Arms HP-25 had a square firing pin aperture, this was enclosed by a circle resulting in the largest aperture 'diameter' for this make and model of pistol.

Eccentricity of Firing Pin Impression

The average eccentricity of the firing pin impressions fired from these pistols was distributed from 3.0% to 36.0% of the radius of the primer pocket corresponding to 0.067mm to 0.80mm (Figure 6). The average eccentricity of the firing pin impressions of major firearm makers, such as Colt, and Browning was small. To the contrary, the average eccentricity of the firing pin impression of inexpensive gun makers such as Lorcin, Jennings and FIE was large. However, the range of values of eccentricity was very wide even within the pistols from major makers such as Mauser, Browning, and Beretta. These results indicated that it would be difficult to predict the

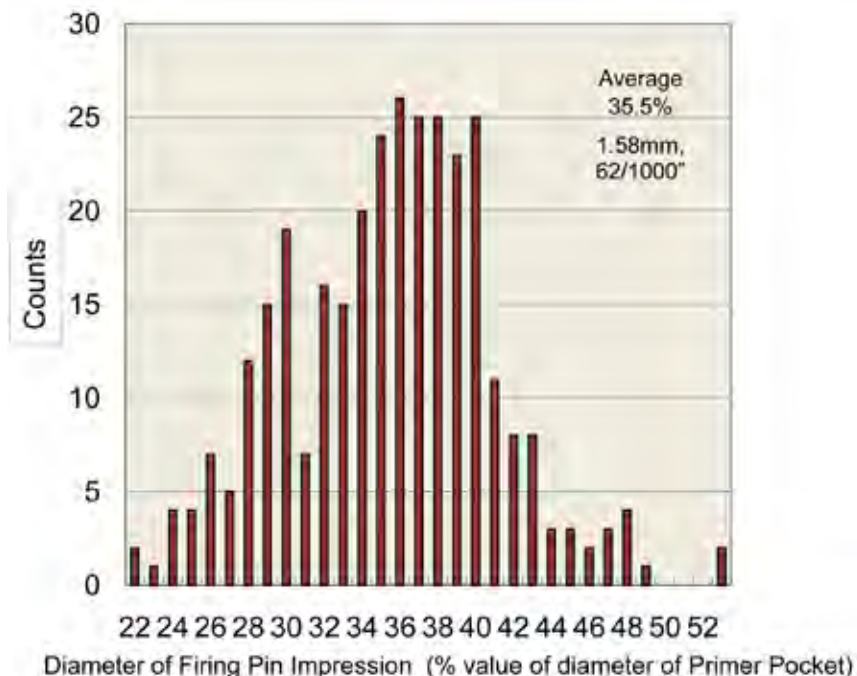


Figure 2: The distribution of diameter of firing pin impressions. The diameter is indicated as a percent value of the diameter of the primer pocket of the cartridge.

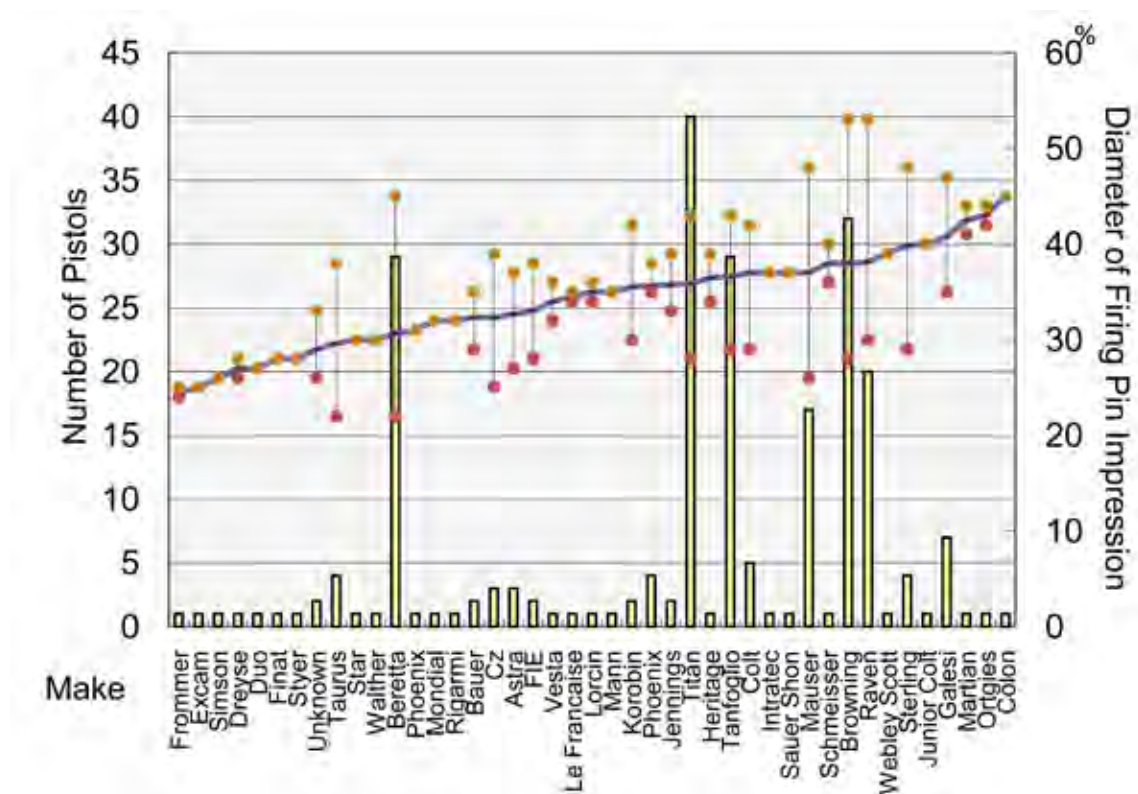


Figure 3: Diameter of firing pin impression of each make of pistol. The number of each gun is indicated by the bar graph and the average diameter is indicated by horizontal lines. The range of diameters of each make is indicated by vertical lines.

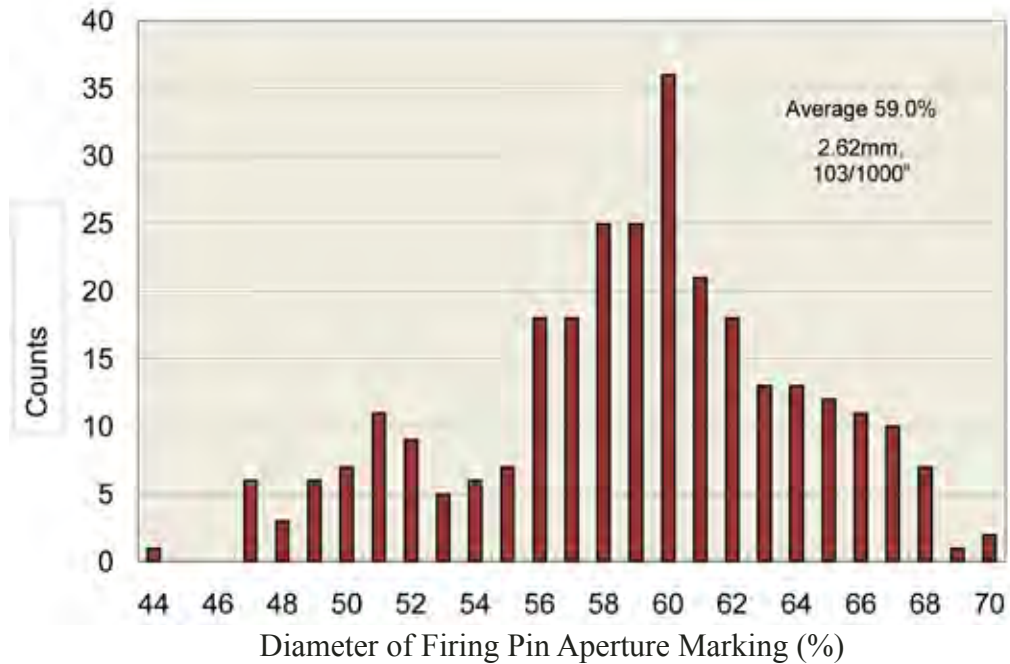


Figure 4: Distribution of diameter of firing pin aperture markings. The diameter is indicated as a percent value of the diameter of primer pocket of the cartridge.

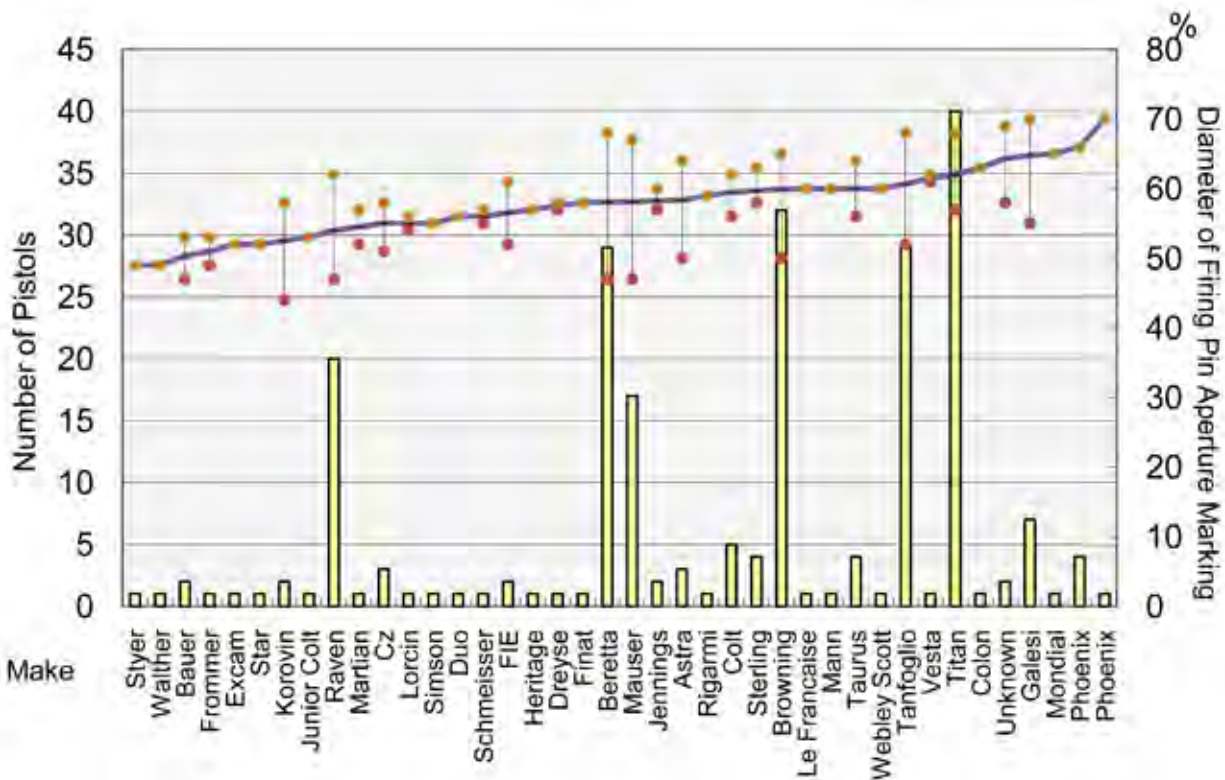


Figure 5: Diameter of firing pin aperture markings of each make of pistol. The number of each gun is indicated by a bar graph and the average diameter is indicated by horizontal lines. The range of diameters of each make is indicated by vertical lines.

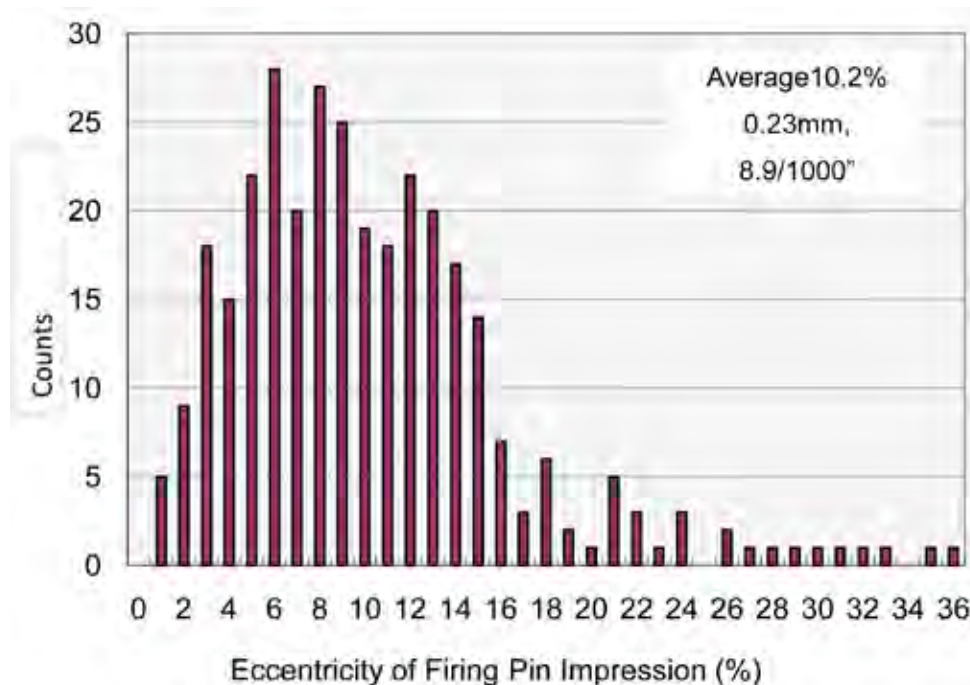


Figure 6: Distribution of eccentricity of firing pin impression. Eccentricity is shown as a percent value of radius of the primer pocket of the cartridge.

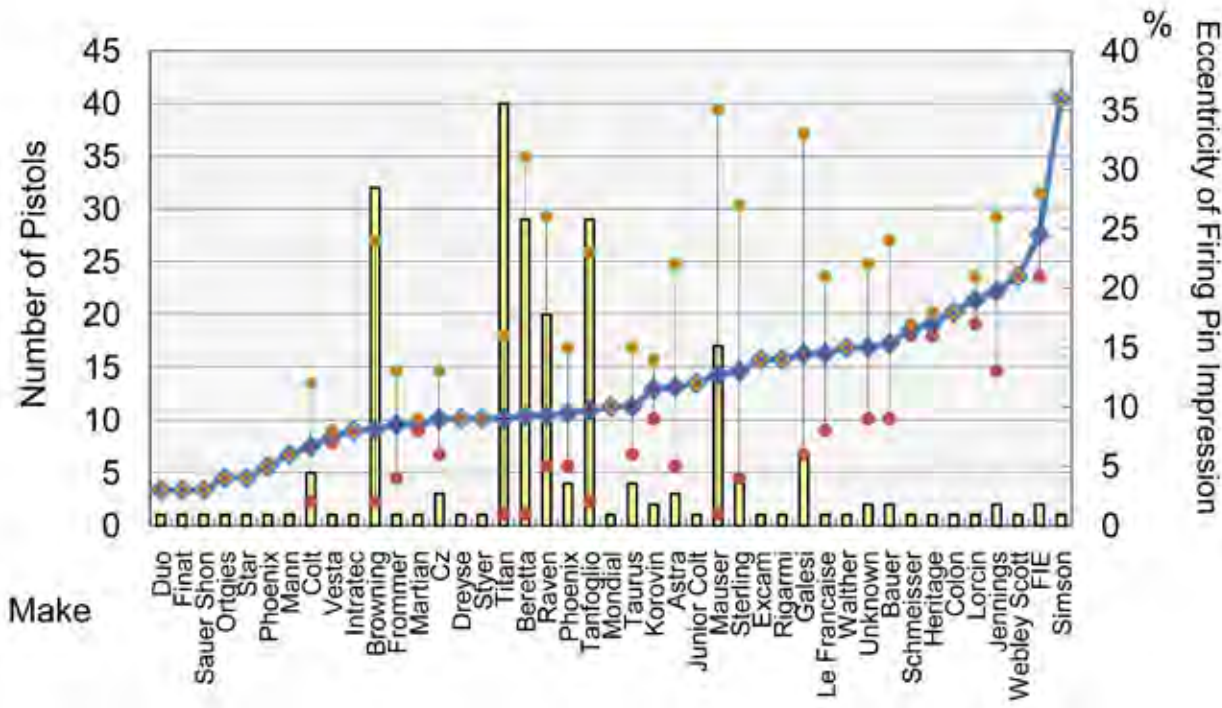


Figure 7: Eccentricity of firing pin impression of each make of pistol. The number of each gun is indicated by a bar graph and the average eccentricity is indicated by horizontal lines. The range of eccentricity of each make is indicated by vertical lines.

probable make of a gun based on the eccentricity of firing pin impressions (Figure 7). The average eccentricity of firing pin impression of all the exhibits was 10.2% of the radius of primer pocket corresponding to 0.227mm.

Eccentricity of Firing Pin Aperture Marking

The average eccentricity of the firing pin aperture markings fired from each make of pistol was distributed from 1.0% to 30.0% of the radius of primer pocket corresponding to 0.022mm to 0.67mm (Figure 8). As with firing pin impressions, the average eccentricity of firing pin aperture markings for major manufacturers such as Colt and Browning was small whereas those of inexpensive gun makers such as Jennings and Bauer were large. However, the range of eccentricity values was very wide, even within pistols from major manufacturers, such as Mauser, Browning, and Beretta. This was also true for Tanfoglio and Galesi pistols. These results indicated that it would be difficult to predict the probable make of a gun based on the eccentricity of firing pin aperture markings (Figure 9). The average eccentricity of firing pin impression of all the exhibits was 7.7% of the radius of primer pocket corresponding to 0.171mm. The average eccentricity of firing pin aperture markings was less than the average eccentricity of firing pin impressions.

Difference between Two Cartridge Cases Fired from the Same Pistol

Among the 323 test-fired cartridge cases, 182 cases were paired cases fired from the same pistol. Two cases were fired from each of 90 pistols and four cases were fired from one pistol. Differences in each parameter described above were analyzed between the two cartridge cases fired from the same pistol.

The distribution of diameter differences between two firing pin impressions fired from the same pistol is shown in Figure 10. The average difference was 2.68 points, which is 2.68 per cent of the diameter of the primer pocket corresponding to 0.043mm. Though the diameters of firing pin impressions measured within the same make of firearm were distributed over a wide range, the difference of diameter within the two firing pins fired from the same firearm was small in most cases.

The distribution of diameter differences between two firing pin apertures fired from the same pistol is shown in Figure 11. The value shown is the difference of diameter converted into a percent value of the diameter of the primer pocket. The average difference was 1.76 points corresponding to 0.028mm. Although the diameters of firing pin apertures measured within the same make of firearm were distributed

over a wide range, the difference of diameter within two firing pin aperture markings fired from the same firearm was small in most cases.

The distribution of eccentricity differences between two firing pin impressions fired from the same pistol is shown in Figure 12. The average difference was 3.40 points, which was 3.40 per cent of the primer pocket radius corresponding to 0.076mm. Although the eccentricity of firing pin impressions measured within the same make of firearm were distributed over a wide range, the difference of eccentricity within the two firing pin impressions fired from the same firearm was small in most cases. These values were large in some poorly made pistols. Values larger than 10 were observed in the exhibits fired from firearms by Sterling, old Le Francaise, Bauer and a poorly made pistol of unknown manufacture.

The distribution of the differences in the eccentricity of two firing pin aperture markings on cartridge cases fired from the same pistol is shown in Figure 13. The average difference was 2.24 points, which was 2.24 per cent of the primer pocket radius corresponding to 0.050mm. Although the eccentricity of firing pin aperture markings measured within the same make of firearm were distributed over a wide range, the difference of aperture eccentricity within the two firing pin aperture markings fired from the same pistol was small in most cases. These values were large in some poorly made pistols. Values larger than 5 were observed in the exhibits fired from firearms by Sterling, Bauer, a degraded Beretta, Browning and Titan. The Sterling and Bauer were the same guns previously mentioned with large firing pin eccentricity within the cartridges fired from the same pistol.

Degree of Backflow

The degree of backflow of the primer around firing pin impression was subjectively placed into one of four categories. These were ranked from 0 to 3, meaning no visible, low, medium and high backflow respectively (Figure 14). A distribution chart of backflow is shown in Figure 15. The distribution of the difference in degree of backflow between two cartridge cases fired from the same pistol is shown in Figure 16. Seventy-eight percent of all the pairs of test fired cartridge cases had the backflow in the same category. Figure 17 shows the relation between the degree of primer backflow and the diameter difference between firing pin aperture and firing pin impression. A weak correlation was observed between these values.

Discussion

Origin of Pistols of This Experiment

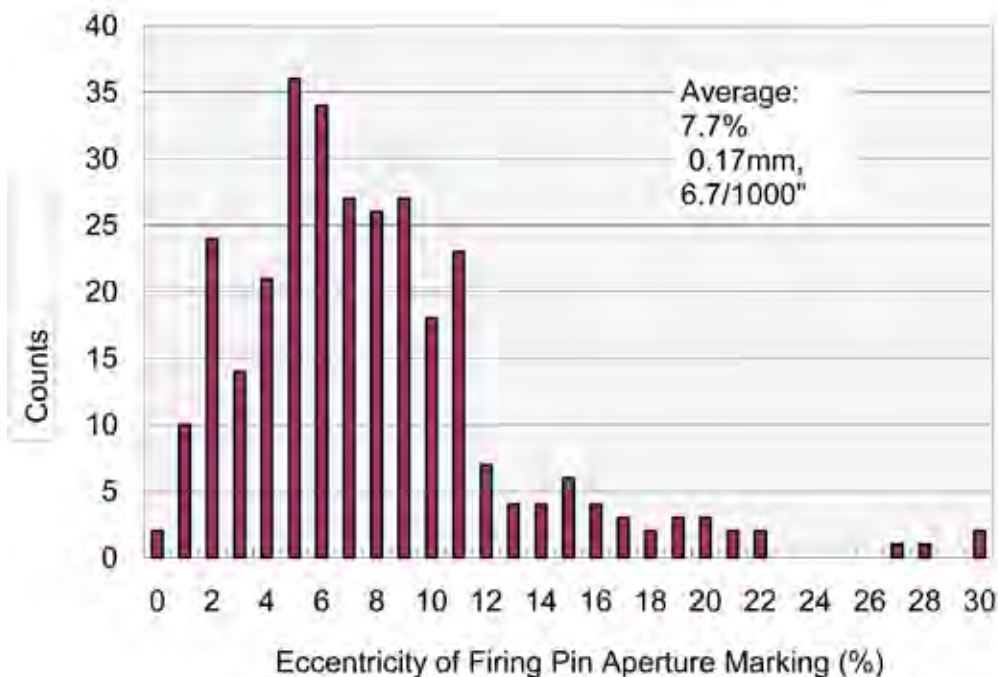


Figure 8: Distribution of eccentricity of firing pin aperture markings. Eccentricity is indicated as a percent value of the radius of primer pocket of the cartridge.

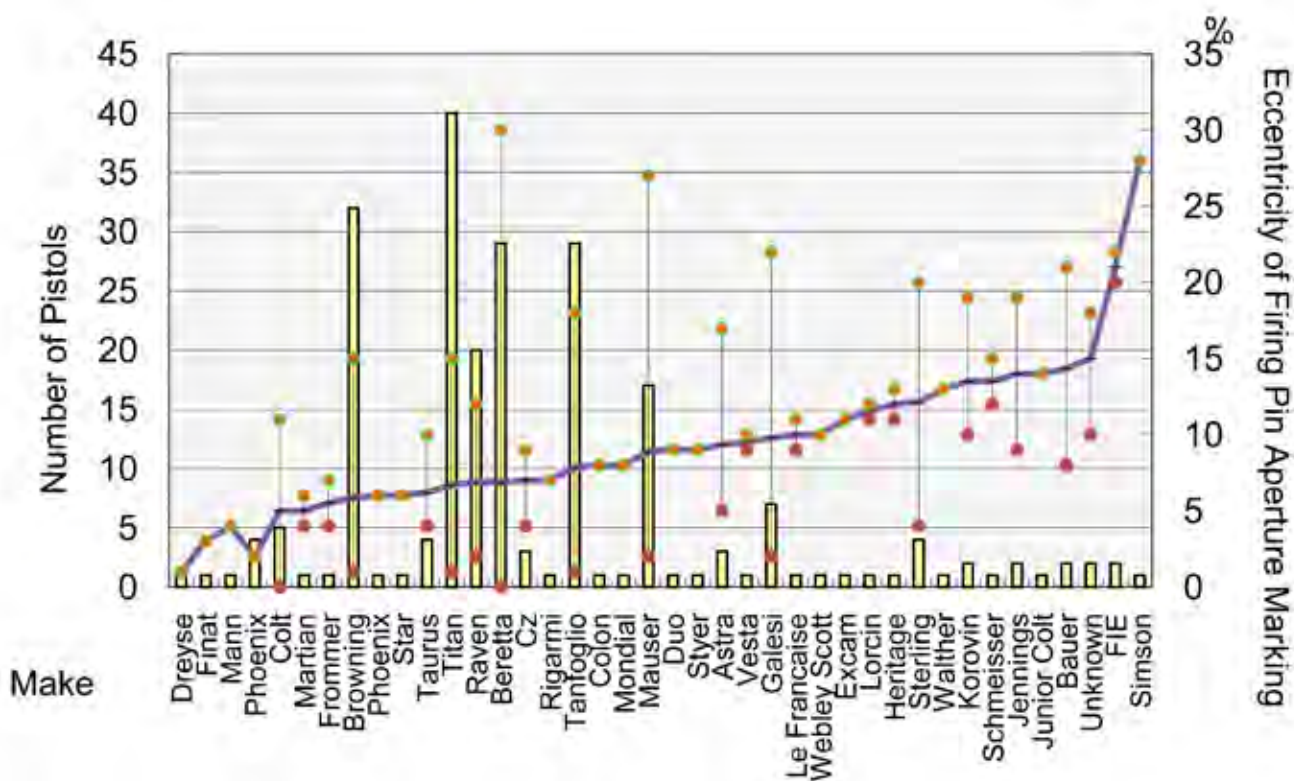


Figure 9: Eccentricity of firing pin aperture marking of each make of pistol. The number of each gun is indicated by bar graph and the average eccentricity is indicated by horizontal lines. The range of eccentricity of each make is indicated by vertical lines.

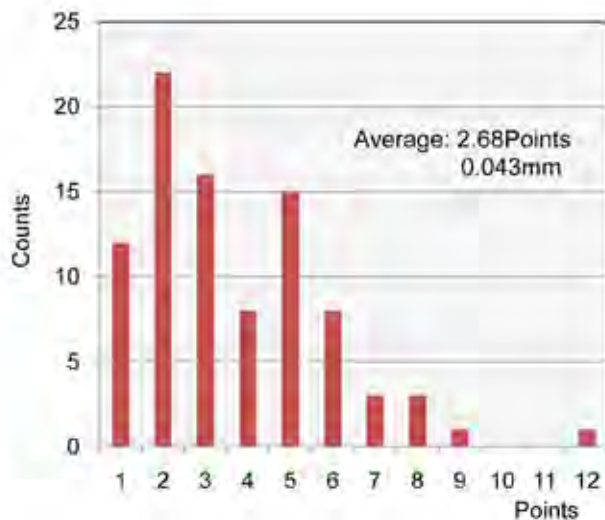


Figure 10: Diameter difference between two firing pin impressions fired from the same pistol.

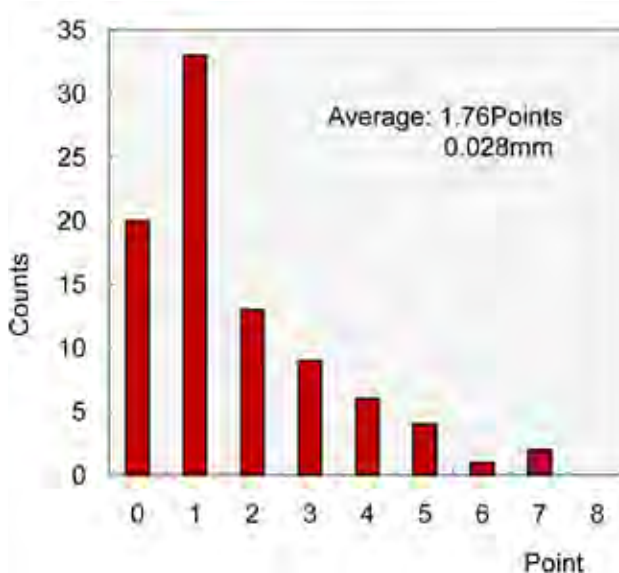


Figure 11: Distribution of the diameter difference between two firing pin apertures fired from the same pistol.

The makes and models of guns from which the test fired cartridge cases were taken in this experiment are shown in Table 1. All of these guns were confiscated by police for illegal possession. The number of cartridges fired from well-known makes such as Titan, Browning, Beretta, and Tanfoglio was more than 30. Those from Ravens and Mausers were more than 20. There were many of less common makes of which the sample number was only one or two. Although these pistols were samples from seized guns in Japan, there may be a strong relationship between the number of seized guns and number of that make produced.

Range of Measured Value

There appears to be a strong relationship between the range of data for diameter and eccentricity of firing pin impressions and the quality control of production of the various firearms examined. One would reasonably expect that guns from a major manufacturer would be produced under high quality control standards. In this study, the range of measured values was wide when the number of samples was large and the range was narrow when the number of samples was small.

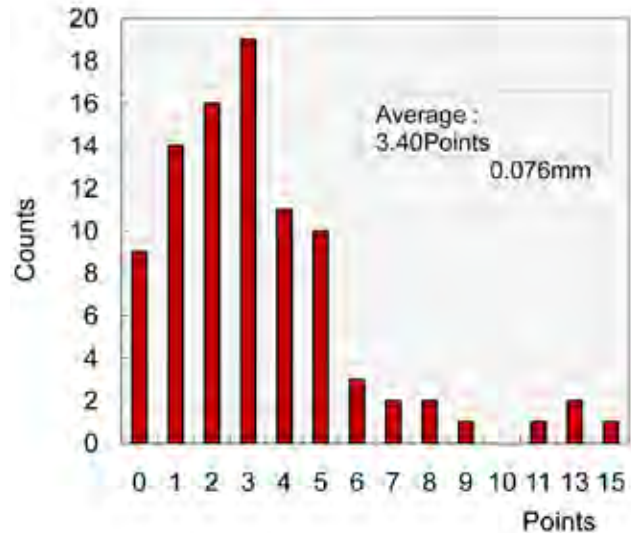


Figure 12: Difference in eccentricity of firing pin impression between two cases fired from the same pistol

The evidence guns examined in this experiment were often degraded by misuse while others were very old models. It is also quite possible that some manufacturers' specifications could change over long production periods. This may explain the substantial range of data for guns of major manufacturers with large production numbers and the narrow distribution of the measurements for small manufacturers that produce fewer firearms.

The variety of markings on primers encountered in real cases was wide even if the cartridge cases were fired from the same make of firearm. This implies that the chances of encountering similar markings in cartridge case identifications would be remote in real cases.

Conclusions

1. The average diameter of firing pin impressions measured in 323 cartridge cases fired from 232 .25-caliber semi-automatic pistols was 1.58mm.

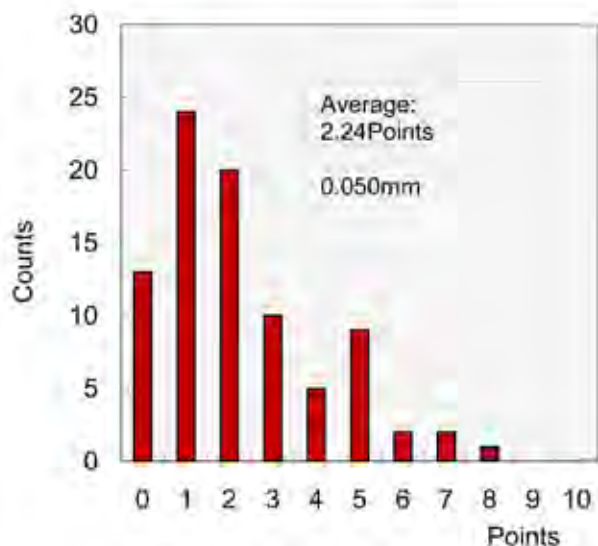


Fig. 13 Difference in eccentricity of firing pin aperture between two cases fired from the same pistol

2. The average diameter of firing pin impressions of Taurus and Beretta pistols was small, whereas that of Browning and Raven pistols was large. Since the range of data was very wide, it would be difficult to predict the make of a gun using the diameter of the firing pin impression.

3. The average diameter of firing pin aperture markings of 323 cartridge cases fired from 232 .25-caliber semi-automatic pistols was 2.62mm.

4. The average diameter of firing pin aperture markings of Raven pistols was small, whereas those of Tanfoglio and Titan pistols were large.

5. The average eccentricity of firing pin impressions of 323 cartridge cases fired from 232 .25-caliber semi-automatic pistols was 0.23mm.

6. The average eccentricity of firing pin impressions of Colt and Browning pistols was small, whereas those of Lorcin,

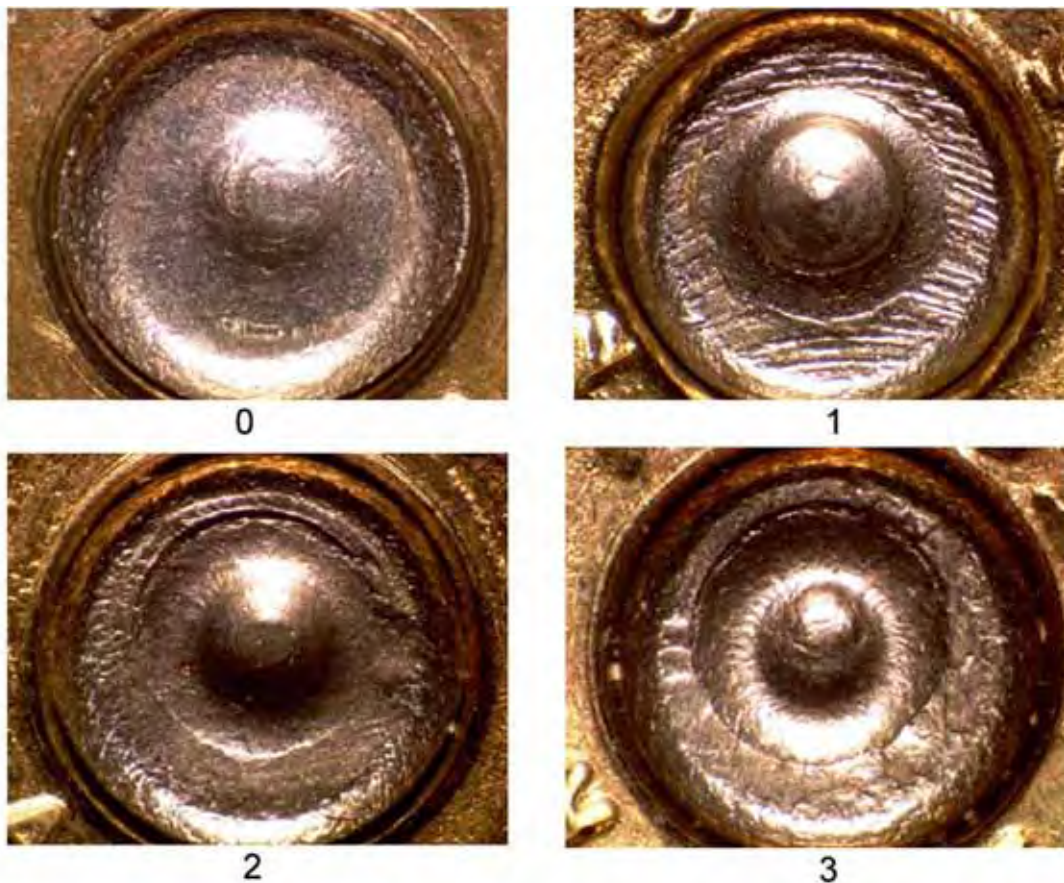


Figure 14: Sample images of each category of the degree of primer backflow

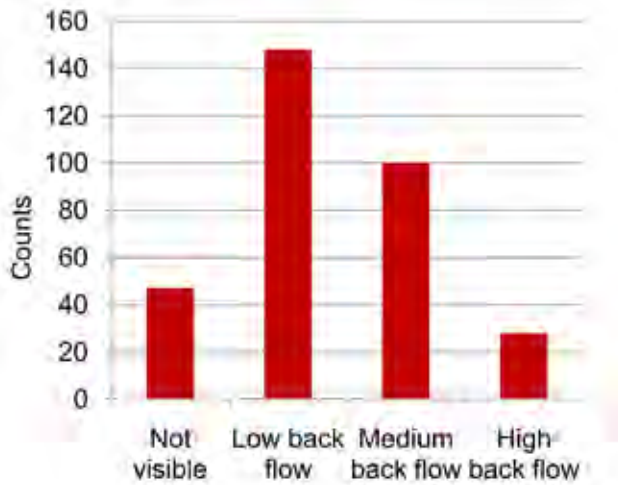


Figure 15: Distribution of the degree of primer back flow

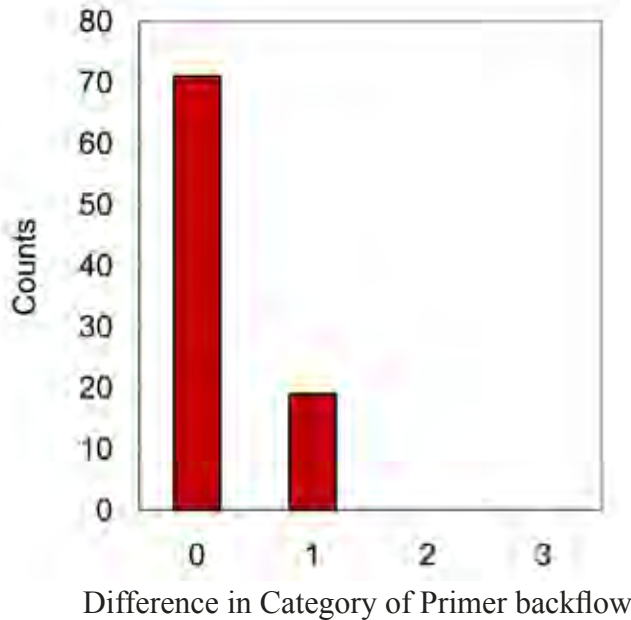


Figure 16: Distribution of the difference in degree of backflow between two cartridge cases fired from the same pistol.

Jennings and FIE pistols were large.

7. The average eccentricity of firing pin aperture markings of 323 cartridge cases fired from 232, .25-caliber semi-automatic pistols was 0.17mm.

8. The average eccentricity of firing pin aperture markings of Colt and Browning pistols was small whereas, those of Jennings, Bauer and FIE pistols were large.

9. When the average diameter and average eccentricity of firing pin impressions and firing pin aperture markings were ordered by each make of firearm, it was found that it would be difficult to predict the probable make of firearm from these data because the range of data within each make of firearm was very wide.

10. The difference in diameter and eccentricity of firing pin impressions and firing pin aperture markings between multiple cartridges fired from the same pistol was rather small.

References

[1] O. Mezger, "Determination of The Type of Pistol Employed from an Examination of Fired Bullets and Shells," *The American Journal of Police Science* Vol. 3, No.2 pp.124-145. 1932.

[2] J. D. Gunther, C. O. Gunther, *The Identification of Firearms*, John Wiley and Sons, New York, 1935.

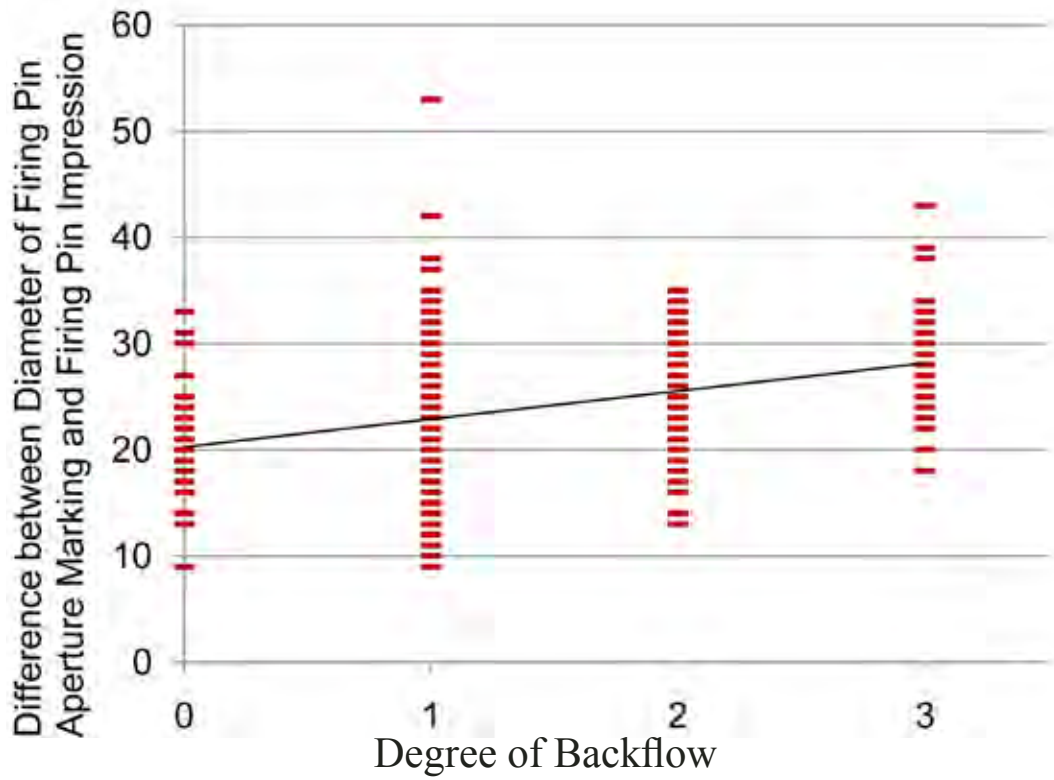


Figure 17: Relation between the degree of primer backflow and the diameter difference between firing pin aperture and firing pin impression.

	Make	Model	No. of Gun	No. of Ctg.		Make	Model	No. of Gun	No. of Ctg.
1	Titan		40	53	35	Mann		1	1
2	Browning		32	43	36	Mondial		1	1
3	Beretta		29	47	37	Phoenix	HP25	1	1
4	Tanfoglio	GT27	29	37	38	Rigarmi		1	1
5	Raven	P25, MP25	20	27	39	Sauer Shon		1	1
6	Mauser		17	24	40	Simson		1	1
7	Galesi	Model 9	7	9	41	Star		1	1
8	Colt	Pocket	5	6	42	Walther		1	1
9	Sterling		4	7	43	Webley Scott		1	1
10	Phoenix	Raven	4	5		Total		232	323
11	Taurus	PT51	4	5					
12	Astra		3	6					
13	Cz		3	3					
14	Jennings	M25	2	4					
15	Korovin		2	4					
16	Bauer		2	3					
17	Unknown		2	3					
18	FIE		2	2					
19	Dreyse		1	2					
20	Frommer	Lilliput	1	2					
21	Heritage		1	2					
22	Le Fran- caise		1	2					
23	Lorcin		1	2					
24	Martian		1	2					
25	Ortgies		1	2					
26	Schmeisser		1	2					
27	Styer		1	2					
28	Vesta		1	2					
29	Colon		1	1					
30	Duo		1	1					
31	Excam	GT28	1	1					
32	Finat		1	1					
33	Intratec	Protec-25	1	1					
34	Junior Colt		1	1					

Table 1