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Effects of Modern Technology
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Terrance A. LaVoy

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EFFECTS OF MODERN TECHNOLOGY
ON FIREARMS IDENTIFICATION

By
Terrance A. LaVoy

A THESIS

Submitted to
Michigan State University
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ABSTRACT

EFFECTS OF MODERN TECHNOLOGY
ON FIREARMS IDENTIFICATION

By

Terrance A. LaVoy

With the advent of modern technical advances in manufacturing processes and techniques, the long held theory of individuality behind the scientific identification of firearms evidence is being examined in terms of its validity as it relates to the criminal justice system.

This research project involved the collection of twelve firearms barrels consecutively rifled with the same tool. Two bullets were test fired through each barrel and recovered for subsequent microscopic examination.

Results indicated that a positive identification could be made of the comparison between the two tests fired from the same barrel. Conversely, in none of the tests could an identification be confirmed of a comparison between two tests fired from consecutive barrels.

In light of these findings, one may conclude that the probability of an identification of two or more bullets fired from different firearms is as remote as it was fifty years ago.

ACKNOWLEDGEMENTS

The author would like to extend his appreciation to Professor Ralph Turner for his guidance, as well as both the professional and personal interest he has shown in this project during my tenure as a student in the criminal justice program.

Special acknowledgement is extended to John and Robert Bauer who are responsible for the manufacture of Bauer Firearms. The guidance and technical assistance provided by both of these gentlemen in this project, the tour of each of their facilities, and the cooperation they extended, was extremely gratifying and helpful. Without the assistance of Ronald Bauer and his staff in the procurement of sample barrels, this research would have been difficult.

Appreciation is also extended to my peers within the various firearms identification units of the Michigan Department of State Police Technical Services Division; most especially to Tpr. John Willmer for the generous time and expertise given in the photographic work necessary for the completion of this manuscript.

The author wishes to extend his deepest and most sincere gratitude to his family and friends for their encouragement and assistance throughout the duration of my

academic work as well as during the research and preparation of this thesis.

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Chapter 1

INTRODUCTION

Throughout the career of this author, who is a court accepted expert in the field of firearms identification, the question has arisen at all levels of court proceedings: "What kind of gun may have been involved in this incident," and/or, "Was this particular gun used in this incident?" Obviously, an opinion answer is given based on reasonable scientific knowledge. Where and how the expert gained his knowledge is subject to cross examination by the defense counsel as is his competence as an expert. Each of these questions involve the microscopic examination and comparison of markings left on bullets fired from a particular rifled barrel.

Two types of markings are possible to observe: individual and accidental. Accidental markings have little value in the identification of a particular firearm. However, individual matching characteristics are extremely useful because they indicate the uniqueness of a particular rifled barrel to the exclusion of all others.

Metals produced from like substances are not completely homogeneous. Therefore, they will react differently when machined with various tools used in the manufacturing process. To the naked eye, the finished rifled barrels may appear identical. Microscopically, many

differences are apparent. These microscopic imperfections, or dissimilarities, produced during the manufacturing process are the "individualities" which the firearms examiner relies upon for identification or elimination.

Firearms identification has been a part of the criminal justice system since the early 1900's when experiments were first conducted with consecutively rifled firearms barrels. In light of technical advances in manufacturing and in conjunction with new and more complex materials having been developed since that time, it was felt that a reevaluation of the scientific basis behind the theory of firearms identification was indeed warranted. This study was undertaken to examine the similarity of striated markings produced on bullets fired from consecutively manufactured firearms barrels utilizing modern manufacturing techniques and materials.

Experience has shown that no two firearms, even those of the same make and model and made consecutively by the same tools, will produce the same markings on a bullet or a cartridge. There will, of course, be a "family resemblance" e.g., the bullets will have (approximately) the same diameter, same number of widths of grooves, same pitch and direction of slant of rifling marks. Technically expressed, the guns have the same "rifling characteristics", but while the markings may be sufficiently alike to characterize the make (and even model) of the gun, they are not sufficiently alike as to be considered "identical" and are not likely to confuse an expert. On the other hand, bullets fired through the same rifled barrel and cartridge cases (usually called shells) fired in the same gun may be expected to show an "identity" of markings which is peculiar to this particular firearm and to no other.¹

¹Mathews, J. Howard. Firearms Identification. I. Madison: University of Wisconsin Press, 1962, p. 3.

This statement made years ago is the hypothetical base upon which forensic firearms identification is based. It has withstood the challenge in the courts without faltering since the original experiments which lead to the original observations.

The significance of this study is relatively apparent to students of firearms identification in terms of its scientific application to the criminal justice system as a whole.

The introduction of the theoretically based firearms identification testimony in courts has helped place many defendants in custody; and, conversely has cleared others named as suspects.

Should this theory be inconsistent with modern manufacturing techniques, the consequences could be quite significant and far reaching.

It is recognized that this project involved only one firearms manufacturer out of over one dozen companies in this country; however, their effort to produce a quality firearm including the rifling process which has had special care and engineering should not be overlooked. The finished rifled barrel, as observed by this author at the time of manufacture, was mirror smooth and not noticeably different upon a closer inspection from barrels manufactured by Colt, Smith and Wesson, and other well-known firearms manufacturers.

As recent as four years ago, this author had the privilege of touring nine of the firearms manufacturers

on the East Coast and was able to observe the processes used to produce complete firearms. At that time, sample barrels were obtained from Colt and Smith and Wesson and a similar, less-extensive study such as this was undertaken. Although rifling methods may differ between manufacturers, the theory of individuality remains the same and will be tested and closely evaluated in the text following.

Chapter 2

REVIEW OF LITERATURE

From the number of texts devoted exclusively to the subject of firearms identification, it might appear that this specialized area of physical comparison is a highly-developed science with well-defined criteria for evidence evaluation. However, a review of the literature reveals a very superficial treatment of the basic problem of comparative striae and the establishment of identity. Few references were found which have been concerned specifically with developing objective criteria for establishing identity in the field of firearms identification.

The forerunner of firearms identification as it exists today, may have had its origin in New York state as a gross miscarriage of justice. I believe it is worthy of mention, and as a starting point for this study.

On March 22, 1915, an illiterate tenant farmer by the name of Charlie Stielow became embroiled in a legal battle as the result of finding a woman in her nightdress dead on his doorstep. A series of incompetent steps by local investigators resulted in Stielow and his brother-in-law Nelson Green being arrested for the murder of the woman, and their employer Charles B. Phelps.

The shooting had been done with a .22 caliber

firearm and both Stielow and Green denied having such a weapon. Stielow, in fact, owned a cheap .22 caliber revolver. Stielow confessed to the shooting, but later repudiated his confession.

An expert for the prosecution testified that under the microscope he had found nine abnormal defects in the flare of the muzzle of Stielow's gun, and found nine corresponding peculiar scratches on the four bullets taken from the bodies. The scratches were not visible to the naked eye, he said, and were first detected under the lens. He gave as his opinion that all the bullets were fired from Stielow's gun and could have been fired from no other.

On cross examination it was brought out that the enlarged photograph of the bullets showed to the jury by the expert did not reproduce the nine marks. It was, for some unknown reason, a photograph of the opposite side of the bullet. Test bullets were obtained from Stielow's gun and taken to the Bausch and Lomb plant in Rochester for scientific examination by Dr. Max Poser, an expert in microscopic examination. Neither Dr. Poser nor anyone else could find a trace under high or low-powered magnification of the peculiar scratches which had doomed Stielow. Even more amazing was the fact that one of the lands on the murder bullet was abnormal and equaled the combined widths of two normal lands and one groove; there were five lands and grooves of normal width on the test bullets from Stielow's gun. The killing of Phelps and his housekeeper undoubtedly had been done with a defective

gun in which the rifling tool had presumably been broken, or the rifler had failed to complete his operation and the error had escaped the inspector's notice. The distinction between the two sets of bullets were glaring, and there was no possibility that the fatal bullet could have come from Stielow's gun. Stielow was given a full pardon.²

The next instance of incompetent firearms identification testimony occurred in the year 1921. Sacco, a shoe factory laborer, and Vanzetti, a fish peddler, found themselves charged with the murder of a paymaster and his guard in South Braintree, Massachusetts, in April of 1920.

On this occasion, defense expert witnesses displayed an ignorance of any reliable method of proof employed in the identification of firearms. They lacked any familiarity with the basic principles involved; and, in general, had unresponsive and vague explanations in an attempt to support their opinions. At the trial, they did not base their opinions on examinations made under a comparison microscope; they employed low-powered single microscopes and magnifying glasses. They had neither the knowledge nor equipment to arrive at reliable opinions.

Sacco and Vanzetti were found guilty of murder in the first degree on July 14, 1921.³

²Hatcher, Major General Julian S., Jury, Lt. Col. Frank J., Weller, Jack. Textbook of Firearms Identification, Harrisburg: Stackpole Company, 1935.

³Gunther, Jack Disbrow, and Gunther, Charles O. The Identification of Firearms. New York: John Wiley and Sons, Inc., 1935, pp. 103-245.

C. E. Waite, who worked with the Department of Justice during World War I and was instrumental in the Stielow case, gathered three associates: Phillip Gravelle, a microscopist and photographer; John Fisher, a tool design and machine maker; and Colonel Calvin Goddard of the United States Army Ordnance. They set up a laboratory in New York. In 1925, a comparison microscope for the identification of firearms was developed, and special bullet and shell mounts obtained from Remington. This modern science, utilizing the comparison microscopic technique, became famous through the St. Valentine Day Massacre in Chicago in 1929, where six men were shot down. Weapons used in this massacre were identified by Colonel Goddard.

The next important development came with the establishment of the crime laboratory at Northwestern University in April of 1930. Later, the staff and equipment became the original laboratory of the Chicago Police Department.

The Michigan State Police Crime Laboratory was established in 1932; primarily as a firearms identification laboratory. It later developed into other areas of criminal investigation. Today, firearms identification is still an important part of the Michigan Department of State Police Scientific Laboratory.

In 1926, at the Springfield Arsenal in Massachusetts, four barrels were rifled one after the other with the same 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.

Some time later, Col. Calvin Goddard fired 500 rounds through a machine gun and found that even bullet number 500 could be matched with bullet number 1 indicating that the individuality of a barrel persists.⁴

Lucas, as early as 1931, recorded the frequency of occurrence and attempted to describe the general character of the individual characteristics of some 200 fired bullets; however, the narrow scope and general nature of presentation makes this reference of little but historical interest. Lucas talks of the completeness of rifling grooves and the significance of recurrent secondary marks on several series of bullets fired from particular barrels. This study seems to have dealt more with the recurrence of marks within a barrel rather than the similarities of markings between different barrels.⁵

In 1942, Burd and Kirk made a statistical study of the frequency of matching striae in tool marks in which the results were presented in terms of percent "match".

⁴Mathews, J. Howard. Firearms Identification. I. Madison: University of Wisconsin Press, 1962, p. 3.

⁵Lucas, A. Forensic Chemistry and Scientific Criminal Investigation. London: Edward Arnold and Co., 1931, p. 324.

They felt that the proportion of matching lines was significant rather than the number of matching lines themselves.⁶

In 1957, Biasotti reported on a statistical study of the individual characteristics of fired bullets in which the results were presented in terms of consecutive matching lines. The dividing line by which data for bullets from the same gun can be distinguished from the data for bullets from different guns was found to be three consecutive matching lines for lead bullets and four consecutive matching lines for jacketed bullets. From this study it appears that an identity can be made with considerable confidence where only a few matching lines are associated by consecutiveness.⁷

In general, most experts on firearms identification take the position that each practitioner must develop his own intuitive criteria of identity gained through practical experience. Without a periodic reevaluation of the theoretical base upon which that practical experience is based, the subjective analyses should be considered suspect at the least.

Firearms examiners are drawing conclusions today on research data gathered some fifty years ago. This early

⁶Burd, D. G., and Kirk, P. L. "Tool Marks, Factors Involved in Their Comparison and Use as Evidence." Journal of Criminal Law and Criminology, (March-April, 1942), pp. 32-36, 679-686.

⁷Biasotti, A. A., "A Statistical Study of the Individual Characteristics of Fired Bullets." American Journal of Forensic Science, IV (January, 1959), pp. 34-50.

data may or may not be valid under the conditions of manufacturing operations as they exist today.

The most recent study of markings on fired bullets from consecutively rifled barrels was offered by Ray Freeman of the United States Army Crime Laboratory in Europe. Freeman studied the similarity of markings on bullets from consecutively rifled polygon barrels. This unique barrel is characteristic of barrels manufactured by Heckler and Koch of West Germany, and exhibits class rifling specifications of four lands and grooves with a right twist. As opposed to conventional rifled barrels, polygon rifled barrels have a highly rounded, rectangular profile and could easily confuse a less than knowledgeable examiner. Freeman's conclusions indicate that each of the three barrels he tested had a distinct individuality that was identifiable.

Fragmented studies are constantly being conducted by examiners all over the country to be sure; and hopefully, with the increased use and acceptance of the Association of Firearms and Toolmark Examiners (AFTE), some of those studies will be published and utilized by all of us in the field.

Chapter 3

RESEARCH DESIGN AND PROCEDURES

Sampling

The critical factor in the project was the proper collection of research samples, namely rifled firearm barrels. To be more specific, the collection of a sufficient number of consecutively rifled barrels to adequately test the theory of dissimilarity.

It was felt that the manufacturer itself was not the crucial issue, but the effort and care that was expended to produce a quality barrel and firearm was of more importance. Having had the opportunity in the past to observe the manufacturing processes of several firearms companies, it was felt that an objective decision could be made as to which product would be used in this study. The manufacturer chosen for this project was the Bauer Firearm Corporation of Fraser, Michigan. They were chosen for basically two reasons.

First, Bauer's quality and finished product met the requirements which have been outlined earlier. Secondly, both of their facilities were located geographically so that extended communication, repeated visits, and closer relationships with the owners, and understandings of their product could be more easily maintained. John and

Ronald Bauer both displayed a genuine interest in the project and extended generous cooperation.

The Bauer Firearms Corporation is an established firm which manufactures firearms completely in the United States. All of the major components including the receiver, slide, barrel, trigger, sear, and firing pin are made of high-quality, heat-treated stainless steel. All parts are precision machined and meticulously fitted to assure smooth, dependable, and lasting performance. Trigger pull is sharp and crisp.

The firearm used in this project was the Bauer .25 caliber semiautomatic pistol. It is the only firearm in production at Bauer in 1979. Specifications for the firearm are as follows:

Magazine Capacity	6 cartridges
Overall Length.	4 inches
Barrel Length	2 1/4 inches
Width of Pistol	13/16 inches
Number of Rifling Grooves . . .	6 grooves
Twist of Rifling.	1-16
Weight of Pistol (empty). . . .	10 ounces
Sights.	Recessed Fixed
Weight of Bullet.	50 grains
Muzzle Velocity	820 feet per second
Muzzle Energy	75 feet/lbs.
Ammunition.	25 caliber auto.

John Bauer, Vice President of the firm, is responsible for many facets of production including the

manufacture of the frame utilizing a new and unique process devised by himself and his staff.

The barrels are supplied to the Fraser plant by Roberts Manufacturing Company, Incorporated, of Oakwood, Ohio, of which Ronald Bauer is the Vice President and General Manager. The plant is located in a rural setting in northern Ohio. Firearm barrels are but one of several products manufactured by Roberts. The barrels for this project were obtained by this author from Ronald Bauer while touring the facility. To insure the authentic consecutive-ness of the barrels, this writer procured 12 barrel blanks from the stock supply, metal punched them with the numbers 1 through 12, and supervised their production throughout the process. The barrel manufacturing process is quite involved and merits explanation.

The metal used is number 416 Stainless Steel and is heat treated in bar form to Rockwell C 28-32. The barrel is then blanked out of the bar stock, and during this process a pilot hole is put into it for the gun driller.

From that point the blanked barrel goes to the centerless grinder (Figure 1) to remove all excess burrs which may have been rolled up or created by the form tools on the exterior surface.

After it has been centerless ground and sized, it goes to the gun driller machine (Figure 2) where the hole, or bore, is first drilled. The gun driller is a unique machine fashioned by Roberts to produce a micro-smooth interior bore. In essence, it is a single-tip carbide

drill with a hole in it which delivers oil under high pressure to the tip of the gun drill forcing the shavings out through the pilot hole with the oil. This process is instrumental in achieving the 18-20 RMS micro-finish bore. The specification of 18-20 RMS is simply the technical designation assigned to a particular level of smoothness in terms of finished metal.

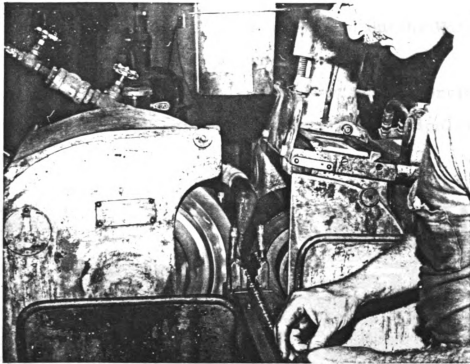


Figure 1. Burrs being removed on barrels as they are fed into the centerless grinder.

From the gun driller the barrels are rifled. The rifling specifications are, as indicated, six lands and grooves with a right-hand twist of one revolution in sixteen inches.

Rifling techniques and processes are a marketplace phenomenon and are not restricted to any one

manufacturer's repertoire in the manufacture of firearms. Rifling may take many forms; but in general, the diameter of the grooves at their deepest point is approximately equal to the diameter of the bullet to be used. The raised lands between the grooves actually cut into the bullet and force it to rotate as it passes down the barrel. Any number of grooves may be used. The fewest commonly encountered is the two-groove rifling of some replacement Springfield rifle barrels used during World War II. The most is twenty or more found in some forms of multigroove rifling. In conventional sporting guns over .22 caliber, grooves are generally nominally .004 inch deep.

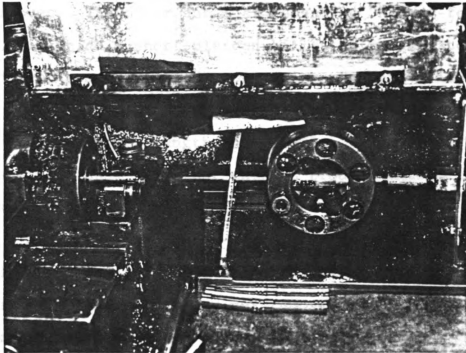


Figure 2. Gun Driller with barrel blank to be bored.

Rifling may be produced in several ways.

Traditionally, each groove is cut by a hook-type cutting tool carried through the bore on the end of a rod with numerous passes required to cut each groove to proper depth. A modern variation of this method uses a broach which contains a row of several successively higher cutting edges for each groove and which cuts all grooves to proper depth and twist in a single pass through the barrel.

Two other rifling methods do not require any metal being cut away. One is commonly called "button rifling" and is accomplished by forcing a very hard (usually tungsten carbide) "button" through the bore. The surface of the button contains a negative impression of the rifling and displaces rather than cuts metal to form the grooves. The other and most recent is "hammer-forged" rifling in which a short-pierced billet of barrel steel is placed over a mandrel (rod) containing a negative impression of the rifling and then forged down over the rifling and formed to proper length and profile. When properly and carefully done, all four methods produce extremely accurate bores.

Colt Firearms, among others, utilizes the broach method; whereas Bauer, High Standard and others use the burnishing method which does not remove metal but simply reforms it to the desired specifications.

Bauer utilizes a two-step burnishing process. A "rough" burnishing button with the negative rifling characteristics required is pushed through the barrel

hydraulically (Figure 3) to rough size the grooves to a depth of .001 to .002 inch deep. A second button is then pushed through the barrel to finish size the grooves depth from .0035 to .004 inch total depth per side.

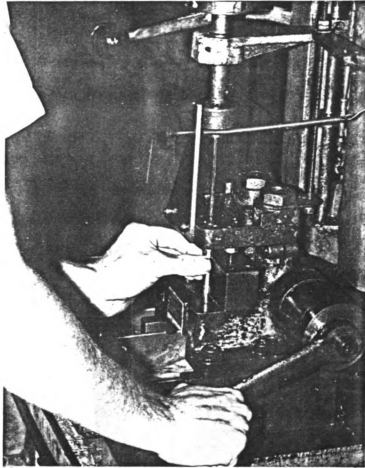


Figure 3. Rifling button being pushed through barrel.

These burnishing buttons are aided in their task by the use of a special wax lubricant devised by Roberts to achieve a better finish through decreased friction between the button and the barrel. Approximately 20,000 barrels can be produced before the burnishing button must be replaced.

The barrels are then crowned using a piloted spot

facing operation that requires a guide to extend approximately .125 inch into the muzzle of the barrel.

The barrels are once again centerless ground to achieve proper sizing of the locking lugs which lock the barrel into the receiver. Any swelling of the barrel due to the burnishing operation is also corrected at this time. From this point on, subsequent operations do not affect the rifling or come in contact with the interior surface of the barrel.

To complete the barrel, the next step is the rotary table which is to be credited to the ingenuity of Ronald Bauer and his staff.

The rotary table (Figure 4) is a six-station machine that performs four operations simultaneously and indexes itself after each operation.

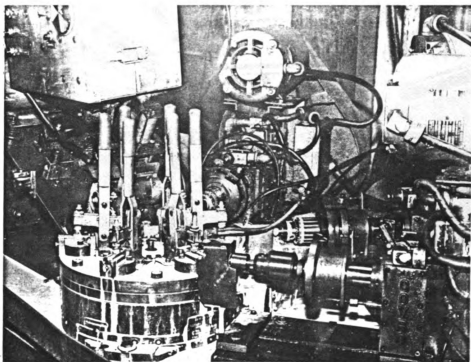


Figure 4. Six-Station Rotary Table

The barrels are placed into the table and at station #1 the ejector slot is machined; the table indexes and rotates to a point where station #2 rough chambers the barrel while station #1 is repeating its operation. Station #3 finish reams the chamber cavity and station #4 forms the ramp. At station #5 the completed barrel can be removed and a new barrel inserted into the last remaining open station.

All that remains is the milling of excess material from the barrel, hand polish, and roto-finishing the barrel with granulated corn cobs to its satin smooth finish.



Figure 5. Bauer's .25 caliber pistol with twelve test barrels.

All twelve barrels used in this project were produced by subjecting them to the process described above

in numerical sequence.

Once the barrels were satisfactorily secured, it became necessary to purchase a Bauer .25 caliber pistol for testing purposes. Such a firearm was obtained from Bauer with the serial number 105763 along with the twelve test barrels. (Figure 5)

Instrumentation

Before the development of the comparison microscope as a useful tool in firearms identification, there were two other methods of matching bullets and shells that are now obsolete.

The measurement and comparison of the widths of grooves on an evidence bullet in sequence and also on a test bullet could sometimes result in the identification of a particular firearm. This technique involved the use of a filar micrometer which is a special instrument placed on a compound microscope which allows the measurement of groove width of a bullet mounted on the microscope stage. The sequential measurement of each groove of the evidence and test bullets and the subsequent comparison of the figures noted sometimes provided an identification.

The other method utilized in early scientific endeavors was a technique originated in France and known as the interchange method. This involved the tedious and time-consuming task of taking a series of photographs of the test and evidence bullet with a specially equipped camera and critical illumination. After photographic

prints were made, sections of the test pictures were cut out and physically superimposed over the evidence pictures. When placed in juxtaposition, if the two photographs had a sufficient number of lines continuing across the divided photographs they were said to be matched and an identification was made.

In 1922, the Bureau of Forensic Ballistics was formed. One of the original members, Philip O. Gravelle, had used a comparison microscope in his work as a pattern designer at a textile factory and suggested in 1925 that such an instrument might be useful in the comparison of firearms evidence. As a result of Gravelle's suggestion and with the aid of the Remington Arms Company, such a microscope was designed and built. Colonel Calvin Goddard, another of the founding members of the "Bureau", was credited for the advance in firearms identification through the utilization of the comparison microscope.

Basically, a comparison microscope is simply two compound microscopes mounted side by side and joined at the top by an optical bridge upon which rests a monocular or binocular eyepiece. By looking through the eyepiece, the examiner is able to observe portions of each of two bullets placed onto the stage of each microscope. Markings on each bullet may be compared by bringing them in juxtaposition. A fine black dividing line separates the "evidence" bullet on the stage of the left microscope from the "test" bullet on the right microscope.

Once the two bullets to be compared are placed in juxtaposition, or phase, both may be rotated simultaneously 360 degrees so that matching striae may be observed around the entire circumference of the bullets along their complete axes.

In the past fifty years, there have been no appreciable changes in the instruments or methods of examination employed in this field. The most obvious change was made by the updating of the examiner's major piece of equipment, the comparison microscope.⁸

The comparison microscope remains the most reliable method the examiner has to analyze the data he has gathered. The instrumentation that was used to observe and analyze the data gathered for this project was an American Optical comparison microscope having a total magnification variation of 12x, 20x, and 40x, using the 10x ocular lens. (Figure 6)

Photomicrographs of the appropriate areas of each bullet comparison as shown herein were taken with a Nikon 35mm model M35S single-lens reflex camera body, and a Nikon PFM reflex-type photomicrographic attachment. Macroscopic photographs were also taken with the 35mm Nikon camera. Kodak 35mm Panatomic X film with an ASA rating of 32 was used for maximum effectiveness. The film was developed in a 3:1 solution of Microdol X developer and fixed with Kodafix.

⁸Johnson, Al. The Journal of Forensic Science. IV (January, 1959) p. 34.

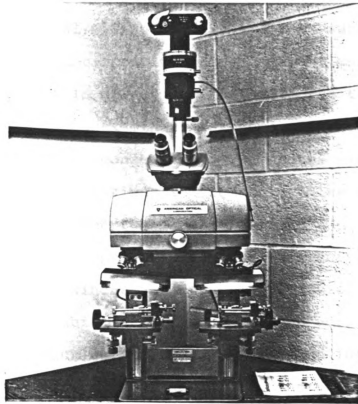


Figure 6. The A-O comparison microscope with photomicrographic attachments.

Methodology

Twelve barrels were obtained from Roberts Manufacturing Company that had been produced for the purpose of this research project alone. Barrel blanks were taken from a stock supply, stamped numerically one through twelve, and followed through the production procedure by this author to their ultimate finished state.

The most critical aspect of this research was the necessity to verify that all twelve barrels had been rifled and produced consecutively using the same tools throughout the manufacturing process. This would be the condition under which the situation might exist that

firearms barrels which have been rifled consecutively using the same tool will produce striations sufficiently alike to allow identification between two or more barrels. This statement is in direct conflict with the theory utilized by firearms examiners for some fifty years. In fact, barrels rifled consecutively using the same tool will not produce striations sufficiently alike to permit identification between two or more barrels.

The methodology involved marking twenty-four .25 automatic caliber Winchester-Western full-metal jacketed cartridges by scribing a line at the ogive portion of the bullet so that each bullet could be inserted into the chamber of the pistol with the mark in the twelve o'clock position. This would later provide a starting point from which the examiner could determine the position of each bullet in relation to a constant groove or land within the twelve barrels. For example, assume that one of the six grooves in each barrel had its beginning from the breech end of the barrel at the twelve o'clock position. As each separate scribed cartridge was placed into the barrel and fired, there would appear at the ogive near the start of the land the previously scribed mark. It should be pointed out that what is referred to as the land in the barrel will create the groove on the fired bullet, and vice-versa. So, if the test bullets are so dissimilar that it becomes impossible to identify bullets from different barrels, we will at least be able to put one in juxtaposition with the other with some degree of

certainty through the use of the prescribed mark.

If different barrels mark their respective bullets similarly, then the scribed mark will serve to confirm our findings through the consistency of the groove in the twelve o'clock position.

Once this premarking process was accomplished, the barrels were cleaned with a soft cloth gun cleaning patch. After cleaning to remove any foreign material from the manufacturing or packaging process, barrel #1 was fitted into the frame assembly of the Bauer .25 caliber pistol. A cartridge was inserted into the chamber and the firearm was test fired through a one and one-half inch thick section of Dip-Pak and into a bullet recovery tank. (Figure 7)

The bullet was removed from the water tank and immediately marked as 1-1, indicating barrel #1, test #1. The test bullet was then placed into a similarly marked container for subsequent comparison. The barrel was removed from the frame assembly and once again carefully cleaned using only a soft cleaning patch. No gun oil or cleaning agent was introduced into the barrel as to create a possible cushion or provide unique results. The cleaning procedure only insured that the striae pattern which is inherent and peculiar to each barrel would be examined as it came from the manufacturer and would not include "accidental" striae due to fouling, leading, or powder particles adhering to the interior bearing surfaces of the barrel.



Figure 7. Author test firing the Bauer .25 caliber pistol into recovery tank.

Once cleaned, the barrel was reinserted into the frame assembly and the second test cartridge loaded into position and fired. When recovered, the second test bullet was marked for identification as being 1-2, indicating barrel #1 and test #2. All succeeding tests were similarly marked, i.e., 2-1 and 2-2 for barrel #2; 3-1 and 3-2 for barrel #3, etc. All succeeding barrels were cleaned and test fired in the same manner described for barrel #1.

This numbering technique provides a built-in control, or known group, in each and every sample barrel. For example, having fired two tests from barrel #1 and marked them as 1-1 and 1-2; under normal conditions it

would be expected to be able to effect a possible identification from these two tests. Therefore, our control group is the two tests fired from a single barrel when compared with each other. The questioned comparison is whether two tests from different barrels which have the greatest probability of similarity; namely, test #1 from barrel #1 compared to test #1 from barrel #2; test #1 from barrel #2 compared to test #1 from barrel #3, etc., are in fact identifiable with each other.

In addition, microscopic comparison of several randomly selected test fired bullets will be conducted to eliminate any possibility of a chance positive identification.

Chapter 4

ANALYSIS OF THE DATA

Comparative Analysis

In the comparative analysis of fired bullets, it is of most importance that the examiner be as objective as possible in what is a subjective art and science. As most things are not black or white, the basis for most conclusions is a combination of both subjective and objective information. There is both "science" and "art" in the performance of work such as firearms identification or criminalistics in general.

I consider examiners, such as myself, who practice a profession utilizing scientific methods and principles not necessarily scientists, but persons involved in a field which has a valid scientific base. I consider that firearms identification is an "art", and the accomplished firearms examiner will be skilled in that art as well as knowledgeable in the scientific principles underlying it.

It will be the "art" and not the "science" which directs the examiner in his quest for objectivity and reaching the valid and reliable conclusions of striae matches in bullet comparisons. Skill in the "art" is certainly as critical as significant "scientific" knowledge.

This project was approached with the same objectivity that is required in the examination of evidence, by this author, in criminal cases on a daily basis. The illustrations depicted throughout the text are characteristic of the markings on all comparisons made during the examinations. The results of the examinations and comparisons were arrived at solely by this author and consisted of one of two possible decisions.

An "identification" was the result of the comparison of two or more bullets which were identifiable with each other.

A second possible decision was "not identifiable". This decision indicates that the comparison of two or more bullets resulted in the conclusion that they could not be identified with each other.

A third possible conclusion that two or more of the research bullets were "probably" and/or "probably not" fired from the same barrel, was considered during the comparative analysis procedure. However, at no time during the microscopic comparisons did this probability, one way or the other become a serious issue. In all of the instances of comparison it was felt that the decision could be made with a high degree of certainty that the comparison in question was either "identifiable" or "not identifiable".

The theory--that no two firearms will produce the same markings on a bullet--was analyzed by the comparison of bullet #1 from barrel #1 with bullet #2

from barrel #1; bullet #1 from barrel #2 with bullet #2 from barrel #2, etc. This established the validity of the control sample. Figure 8 is a photomicrograph of the comparison of tests #1 and #2 from barrel #4. The striated markings shown are indicative of markings around the entire circumference of the fired bullet. The area shown is that of the groove (land in the barrel) near the nose or ogive of the fired bullet. As the photomicrograph illustrates, both the land and groove in the bullet were marked considerably well by the barrel imperfections.

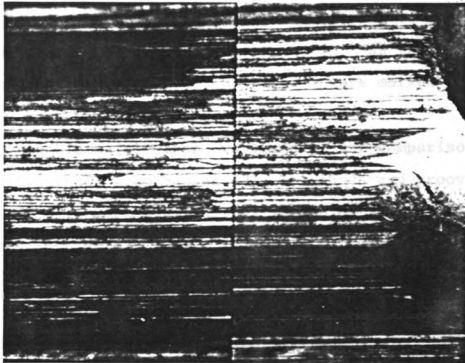


Figure 8. Photomicrograph of the comparison of test #1 & #2 from barrel #4.

Such is not always the case. Many times in the case of jacketed bullets, the bullet does not expand sufficiently, as a lead bullet does in a revolver, to

fill the entire groove diameter of the rifled barrel and mark the bullet equally on both its land and groove surfaces.

In the tests conducted in this project, more often than not both surfaces were marked quite well. The groove portion of the rifling on the bullets were occasionally marked better than its land counterpart. In any event, barrel #4 was marked significantly around its circumference and along its entire axis to easily effect an "identification".

On barrel #5, we once again look at the surface near the nose of the bullet. Figure 9 shows the land portion of test #1 and #2 from barrel #5. As the photomicrograph indicates, the bullets were marked quite well on both the land and groove.

An "identification" was made on the comparison of the two tests from barrel #5. All lands and grooves on barrel #5 were marked vividly as is indicated by the area depicted in Figure 9.

The comparison of tests from barrel #6 are shown in Figure 10. In this illustration, a series of matching striations is visible on the land portion of the bullets along with other matching individual characteristics resulting in an "identification". Also noticeable at the right side of the photomicrograph is the line scribed on the ogive portion of the bullet prior to test firing.

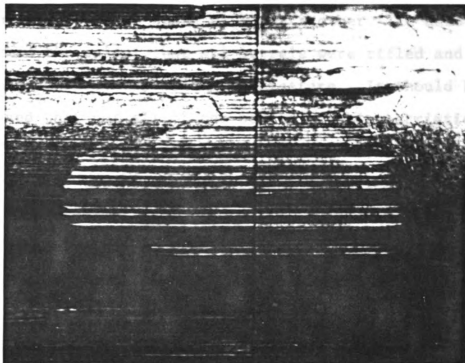


Figure 9. Land portion of test #1 and #2 from barrel #5.

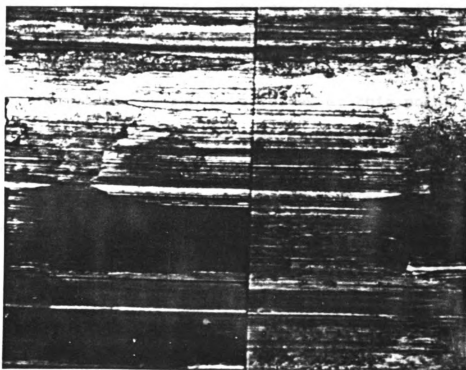


Figure 10. Comparison of tests from barrel #6.

The scribing procedure was of great value in placing all tests in phase with one another. It also confirmed the belief that all barrels were rifled and machined consistently during manufacture. It should be mentioned that not all of the better matching striations were found near the nose of the test bullet; many were observed near the base of the bullet as well as along its entire longitudinal axis.

Both tests from each barrel were compared and successfully identified with each other for all twelve barrels. After this was accomplished, microscopic comparison of test bullets was conducted on samples fired from consecutive barrels.

The photomicrograph in Figure 11 depicts the comparison of the area near the base of test #1 from barrel #4 on the left, to that of the same general area on test #1 of barrel #5 on the right. Some similarity and matching individuality can be observed at this point on both tests. This area is the most similarly marked portion on the entire surface of both bullets; and, obviously, based on the lack of more matching striae deserves the distinction of being "not identifiable". This is the best area on both bullets, and it may be possible to put the tests in phase, but even that is questionable. With the aid of the scribe mark at the bullet nose, they were able to be put in phase with some degree of certainty.

Figure 12 is an area quite similarly marked. The test on the left is test #1 from barrel #10 as compared to test #1 from barrel #11 on the right. At the base, a series of matching individual characteristics are observed on the land portion of the bullet. These were the only observable markings that could be detected on both tests, and with no other striae are not enough to allow even a significant degree of probability that they were fired from the same firearm barrel. Therefore, they are "not identifiable" with each other. However, in the absence of additional matching striae, these striae are not significant enough alone to warrant a "probable" decision.

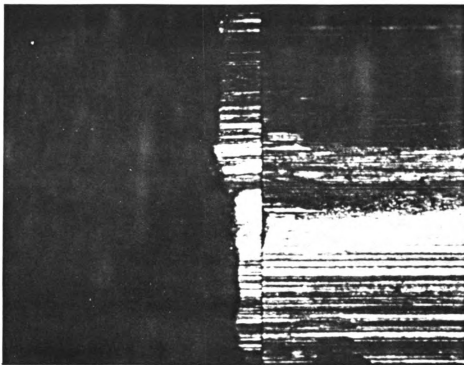


Figure 11. Comparison of test #1, barrel #4 on left to the same area on test #1, barrel #5 on right.

The markings on the land portion of tests in Figure 13 are considerably more infinite than those previously illustrated. The test on the left is from barrel #5 and the one on the right is test #1 from barrel #6. The area is obviously near the cannellure and gives some indication of matching individual markings. This "match" was also "not identifiable" and the photomicrograph shown depicts the most similarly marked area on both bullets.

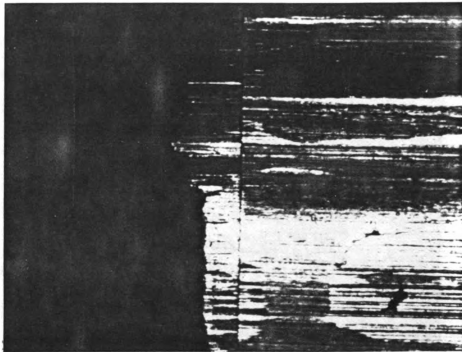


Figure 12. Comparison of test #1, barrel #10 on left to the same area on test #1, barrel #11 on right.

On all of the comparisons of "known" bullets, there were considerable areas of matching striae and dozens of photomicrographs were taken of those areas. A total of 108 photomicrographs were taken from some 34 comparisons.

made in this study. Table 1 indicates the comparison made and the results in terms of being "identifiable" or "not identifiable".

On all of the comparisons of "questioned" matches it was exceedingly difficult to locate areas of similarity sufficiently marked to present a meaningful example. The photomicrographs of comparisons of tests fired from consecutive barrels illustrated herein represent the best possible areas of similarity observed by this author, and indicates the heterogeneity of the rifling button.

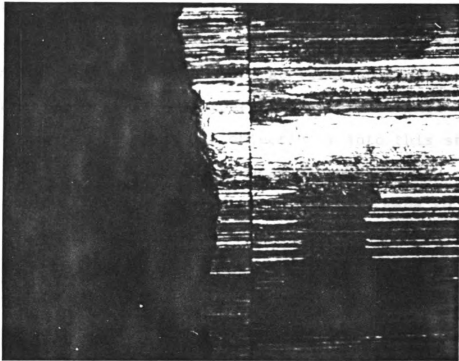


Figure 13. Comparison of test from barrel #5 on the left and test #1 from barrel #6 on the right.

For the purposes of this study (see Table 1) an "identification" shall be the result of a comparison between two bullets whose bearing surfaces exhibit sufficient

individual matching characteristics to allow this examiner to testify in a court of law that "in my opinion", the comparison is a positive identification. (See Figures 8 and 9)

The comparisons designated in the text and Table #1 as being "not identifiable" resulted from the lack of sufficient individual matching characteristics to allow this examiner to form any alternative opinion. (See Figures 11 and 12)

Because there is no model for objectivity in firearms identification, the opinions given will be dependent upon the examiner's experience, training, and education in his area of expertise. For approximately seven years, this writer has been accepted in courts throughout the state as an expert in firearms identification and has carried that objectivity into this study.

Many times during the course of comparisons, the situation arises where a decision must be made to the degree of probability of an identification. Without an objective model, it is necessary to rely on the past experience of thousands of observations of fired bullets. The laboratory system through policy or directive does not dictate to the examiner the level or degree of opinion he will render. Figures 11 and 12 are indicative of such a consideration. Both comparisons exhibit similarity of markings at the base of the bullets. Taken alone, this could be meaningful in the decision making process and could conceivably result in a probability statement such

as "could have been" or "probably was" fired from the same gun. However, the areas shown were the best and only areas of similarity of consequence on the entire bullets and resulted in the conclusion that they were "not identifiable."

This "grey area" is where all firearms identification problems originate. If the examiner had the bullet on the left in Figure 12 as his evidence bullet and it had been extensively mutilated except for the portion shown at the base, and compared it to his test which is shown on the right in Figure 12, conceivably he could render an erroneous decision causing considerable damage to the expert as well as the concept of firearms identification.

TABLE 1

COMPARISONS OF TEST FIRED BULLETS FROM
VARIOUS BARRELS AND RESULTS OBTAINED

IDENTIFICATIONS	NOT IDENTIFIABLE	NOT IDENTIFIABLE
B1T1 - B1T2	B1T1 - B2T1	B1T2 - B2T2
B2T1 - B2T2	B2T1 - B3T1	B2T2 - B3T2
B3T1 - B3T2	B3T1 - B4T1	B3T2 - B4T2
B4T1 - B4T2	B4T1 - B5T1	B4T2 - B5T2
B5T1 - B5T2	B5T1 - B6T1	B5T2 - B6T2
B6T1 - B6T2	B6T1 - B7T1	B6T2 - B7T2
B7T1 - B7T2	B7T1 - B8T1	B7T2 - B8T2
B8T1 - B8T2	B8T1 - B9T1	B8T2 - B9T2
B9T1 - B9T2	B9T1 - B10T1	B9T2 - B10T2
B10T1 - B10T2	B10T1 - B11T1	B10T2 - B11T2
B11T1 - B11T2	B11T1 - B12T1	B11T2 - B12T2
B12T1 - B12T2		
RANDOM COMPARISONS ALL RESULTING IN NO IDENTIFICATIONS		
B1T1 - B3T1	B7T1 - B1T1	B10T1 - B1T1
B1T1 - B6T1	B7T1 - B3T1	B10T1 - B3T1
B1T1 - B9T1	B7T1 - B5T1	B10T1 - B5T1
B1T1 - B12T1	B7T1 - B9T1	B10T1 - B8T1
B4T1 - B1T1	B7T1 - B11T1	B12T1 - B2T1
B4T1 - B7T1	B9T1 - B2T1	B12T1 - B4T1
B4T1 - B9T1	B9T1 - B5T1	B12T1 - B8T1
B4T1 - B11T1	B9T1 - B7T1	B12T1 - B10T1

NOTE: T denotes test. B denotes barrel.

SUMMARY AND DISCUSSION

This study involved the personal selection of twelve consecutively rifled firearm barrels from an established manufacturer to test the theory of firearm identification. It was felt that due to the lapse of time since the original experiments some fifty years ago, in addition to the newer manufacturing techniques and metals presently used, that a reevaluation of the theory was long overdue.

During the last fifty years, studies have been conducted by various members of the profession; however, published data and results are lacking in direct experimentation.

To continue to present expert testimony in courts throughout the state, it is necessary to have a strong foundation in the scientific principles underlying the "art" of firearms identification. Such a foundation can only be acquired through research and experimentation along with sound training and education in the field. A study of this type provides all of this criteria for not only the experienced examiner, but also for the person starting his career in firearm identification.

The statement that no two fingerprints have ever been found to be alike is an accepted theory. The theory of firearm identification is also an accepted

statement. However, backing that statement in court with experienced research conducted within our laboratory system makes the statement more meaningful in today's world.

From the results of this project, it is believed that one can go beyond Mathew's statement of two bullets fired from different weapons having only a "family resemblance".⁹ Analysis of the data has shown that in none of the comparisons of bullets fired from consecutively manufactured barrels was there a sufficient amount of individual matching characteristics to allow an identification between two or more barrels. They may exhibit sufficient similarity to be put in juxtaposition with each other (Figures 12 and 13); however, the similarity of markings fall far short of an identification and substantiates the theory of individuality between barrels.

This author has had the opportunity to visit ten firearm manufacturers in this country and personally observe the techniques and processes used by all to produce a firearm. Basically, they are alike except in the type of tools and methods used for rifling. Their collective goal is the manufacture of a rifled barrel that is micro-smooth. Tests have been conducted on bullets fired from consecutively manufactured barrels obtained from Colt, Smith and Wesson, Harrington and Richardson, Charter Arms, Ruger, and Bauer; the latter being the most extensive and meaningful in terms of its forensic application.

⁹Ibid.

The key to accurate work is the "examiner", supported by his experience, training, education, and personal objectivity. He must remain objective and not be swayed in his thinking. He must continue his experimentation and research as new methods, materials, and techniques become available. If newer, more sophisticated instrumentation becomes available, he must utilize that instrumentation. Only when the examiner has experienced all of these characteristics can he effectively and honestly communicate to the legal world his beliefs and opinions. Only then can he become a truly qualified firearm identification examiner.

Based on the research concluded in this text, the author is still confident of the testimony given by many as to the scientific probability of the theory of firearm identification.

It is recognized that there are limitations to this study also. Out of necessity, the procurement, marking, test firing, and subsequent comparisons were all conducted by the author.

A blind study would have been more meaningful, and is being planned for future students of firearms identification. The introduction of an in-house proficiency testing program is also being considered as a result of the work accomplished in this project; and, I am confident that the results are meaningful when taken in the context intended.

GLOSSARY

GLOSSARY

autoloading, autoloader: An autoloading gun fires, extracts, ejects and reloads once with each action of the firing mechanism. After each shot, pressure on the trigger must be released and reapplied before succeeding shot will fire.

automatic: Applied to small arms utilizing forces of gas pressure or recoil so after the first shot is fired the fired case is ejected and the next round is loaded, fired and ejected, and this cycle is repeated continuously until the ammunition is exhausted or the pressure on the trigger is released.

action: The combination of the receiver or frame and bolt together with other mechanism for functioning a firearm.

ballistics: The study of the natural laws governing the performance of propellants and projectiles, and the use of these laws to predict the performance of propellants and projectiles. Ballistics is divided into two branches: interior, which relates only to what occurs from the instant of cartridge ignition until the bullet leaves the bore; and exterior, which relates to the bullet's flight from the time it leaves the muzzle until it comes to rest. There is yet a third type of ballistics, which the layman seldom considers: terminal ballistics, or the bullet's effect and performance on striking or entering its target.

barrel: A metal tube which is that part of a gun designed to contain the exploding charge in the breech and concentrate the force of the gases generated in a manner that provides initial velocity and proper direction to the projectile being discharged.

barrel, test: A barrel bored and rifled under conditions approved by the author with normal minimal tolerance and chambered between normal minimal and mean chamber dimension.

bore diameter: In a rifled arm, diameter of bore before rifling, that is the diameter measured from the top of land to the top of opposite land.

broach rifling: The method of forming the spiral grooves in the bore of a rifle barrel by cutting the metal with a multiple tooth called a broach.

- bullet ball: Lead alloy or other metal projectile propelled by expanding gases formed by the combustion of the powder charge. Bullet must be of shape, dimension and composition required to engage the rifling and develop the specified velocity and accuracy.
- bullet jacket (metal case, metal patch): Covering over lead core. Usually gilding metal or steel. Nose is covered for metal case, open for expanding types with either lead exposed or protected or a separate tip inserted.
- bullet trap: A heavily constructed steel box built in such a shape that bullets entering its open side are decelerated and stopped without ricocheting or throwing fragments back toward the shooter. It usually has sloping sides and a series of deflector plates against which the bullet impacts successively until its velocity is reduced to zero. It normally has provisions for attaching a target over its working face, and is often moderately portable. Bullet traps are available to meet all requirements from .22 rimfire on up to the most powerful sporting rifle cartridges.
- caliber (bore): The diameter of the bore of a rifle, revolver or pistol, usually measured from land to land, which represents the diameter before the rifling grooves were cut, expressed in decimals as hundredths of an inch or millimeters. Ammunition designations are nominal and in several instances refer to groove diameter, e.g., 357 Magnum, 257 Remington, 308 Winchester, etc.
- cannelure: indentations or rings around the bearing surface of the bullet to hold surface lubricant. Also refers to indentation or ring around the cartridge case in certain rim fire cartridges either for identification or prevention of telescoping.
- carrier: Part of the mechanism of some repeating action firearms that helps to set the projectile in its proper firing position.
- cartridge (loaded round): Ammunition loaded. For use in center fire pistols, revolvers, rifles as indicated under adaptations. Complete round of fixed ammunition consisting of case, primer, powder, bullet and/or wad.
- cartridge guide: A repeating action firearm component which acts as a guide for the cartridge while it is being fed from the magazine to the chamber.
- cartridge ramp: An enclosed surface in the receiver of a repeating action firearm along which the cartridge rides in feeding from magazine to chamber.

- cartridge stop: A component of repeating action firearms which stops and holds a cartridge when feeding from the magazine.
- chamber: The enlarged and taper section at the breech end of a barrel bore in which the cartridge or shell is placed for firing.
- clip: A metal case designed to hold a number of cartridges or shells to facilitate leading into repeating small arms.
- consecutive: Proceeding from one part or idea to the next in logical order.
- crowning: The rounding or chambering normally done to a barrel muzzle to insure that the mouth of the bore is square with the bore axis and that the edge is counter-sunk below the surface to protect it from impact damage. Traditionally, crowning was accomplished by spinning an abrasive-coated brass ball against the muzzle while moving it in a figure-eight pattern until the abrasive had cut away any irregularities and produced a uniform and square mouth.
- chronograph: An instrument for recording short time intervals; used in determining velocities of projectile.
- Dip-Pak: A thermal plastic polymer through which the test bullets were fired to reduce their impact in the water recovery tank.
- feed: Act of transferring successive cartridges from the magazine to its chamber.
- follower: A shaped, usually metal, part to force the cartridges in the magazine successively into position to be fed into the chamber.
- forcing cone: Tapered area or change in diameter between the chamber and the bore diameter of a shotgun barrel.
- fouling: The deposit that remains in the bore after firing.
- groove: One of spiral cuts bore of firearm to impart rotary motion to projectile.
- groove-diameter: Inside diameter of barrel at base of groove.
- hammerless: Any firearm in which hammer or striker is concealed within mechanism.
- juxtaposition: The act of placing two or more objects side by side.

land: In a rifled barrel the raised spiral rib left standing between the grooves.

leade (lede): Also known as the "throat", the origin of the rifling in a rifled barrel. It is that portion of the bore immediately ahead of the case mouth in which the rifling lands have been cut away to allow entry of the bullet. Lands are normally cut away completely for a short distance, and then rise at a very shallow angle which permits the bullet to be more easily engaged by the rifling as it progresses from the case.

leading: The accumulation of lead in the bore of a firearm from the passage of shot or a projectile.

loading gate: Movable cover giving access to magazine.

loading port: Opening in receiver where cartridge may be placed in firearm, either directly in chamber or in magazine.

loading ramp: Device that aids in guiding cartridge into chamber.

locking lug: One of the projections on breech bolt engaging in corresponding recesses in receiver to secure breech during firing of firearm.

magazine: A separate or integral device wherein ammunition is held in position to be fed into the firing chamber of a firearm.

mouth: Open end of cartridge case of diameter and form suitable to receive and hold bullet.

ogive: The curved, rounded, or pointed forward portion of a bullet. All of the bullet forward of the bearing surface, regardless of shape.

pistol: Any firearm designed to be fired by one hand.

receiver (frame): The basic unit of a firearm to which the barrel and other components are attached.

rifling: Grooves cut into the bore to impart rotary motion to projectile.

rifling broach: A tool for cutting the rifling in barrels in one operation.

rifling pitch: The angle at which the rifling spiral is cut in relation to the axis of the bore. Usually expressed as one in --- inches.

self-loading: Term applied to semiautomatic firearms.

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semiautomatic: Firearm which fires, extracts, ejects and reloads once for each pull of the trigger.

shell (cartridge case): Brass, gilding metal, or other suitable material, drawn and shaped to chambers of firearms. Priming mixture is contained in the rim cavity to permit ignition at any point where the rim is struck by the blow of the firing pin.

swage rifle (button rifling): To form rifling in a barrel by displacing the metal with a hard die drawn through the bore. The metal is not removed.

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