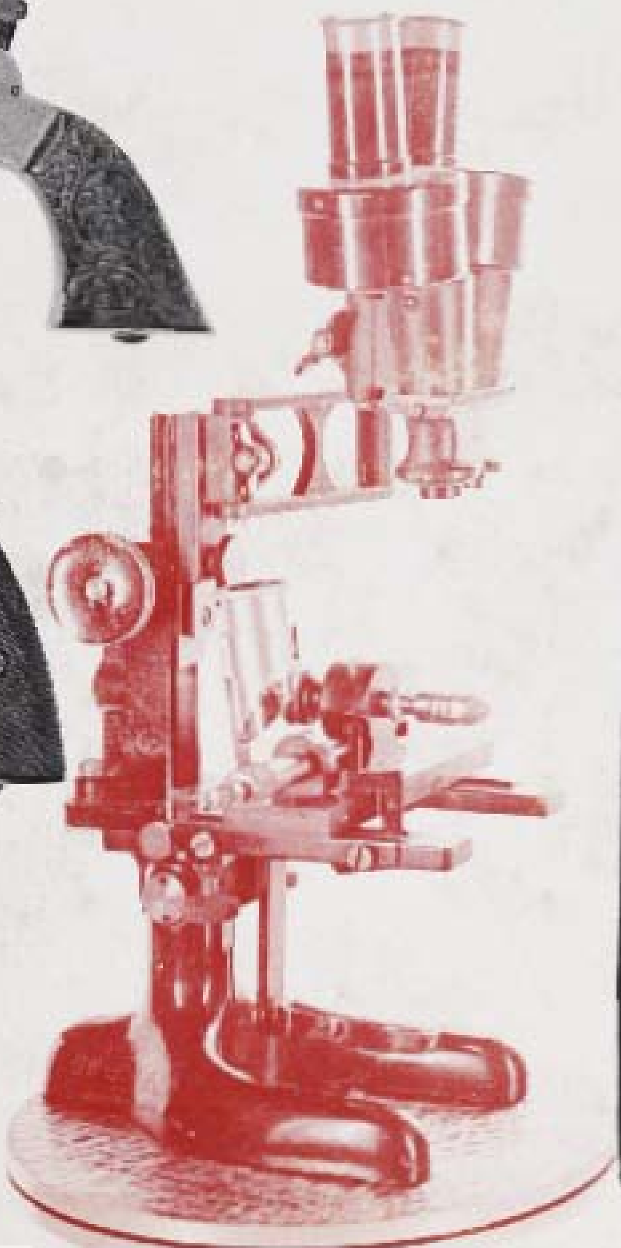
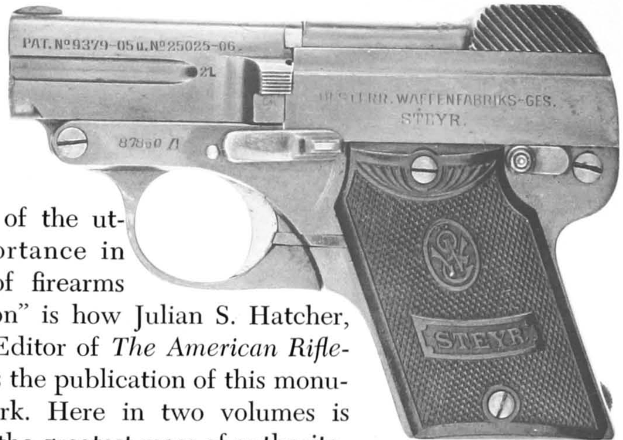
J. Howard Mathews

Firearms Identification

VOLUME I The laboratory examination of small arms, rifling characteristics in hand guns, and notes on automatic pistols

Volume I of Three Volumes





"An event of the utmost importance in the field of firearms investigation" is how Julian S. Hatcher, Technical Editor of *The American Rifleman,* greets the publication of this monumental work. Here in two volumes is assembled the greatest mass of authoritative information on weapons investigation and identification ever brought together in one place.

PART I consists of a comprehensive discussion of the principles involved and the laboratory procedures used in the identification of guns from fired bullets and fired cartridges, including descriptions of methods of rifling, instrumentation (both conventional and the newer instruments devised by the author), firearms photography, methods of restoration of serial numbers, and a chapter on "Pitfalls for the Unwary."

PART II is a very extensive research report which gives the results of measurements of rifling characteristics of over 2300 guns originating in 23 countries, a task that took twenty years.

PART III is devoted to "Miscellaneous Notes on Automatic Pistols," including much previously unpublished information.

PARTS IV and V contain nearly 3000 photographs of hand guns representing arms made in 23 countries and numerous makes and models, many of them uncommon.

PART VI consists of trade marks and other identification marks photographed from the guns examined. Very few have ever been published before.

In addition, eight appendices give other tabulations of data, techniques, lists, including photographs of firing pin impressions and a translation of the most important part of a German article on class characteristics of shell markings, by Mezger, Hees, and Hasslacher.

This storehouse of dependable and authoritative information is indispensable to police departments, firearms investigators, crime detection laboratories, lawyers, gun dealers and collectors, museums, and libraries. Fred R. Rymer of the Texas Department of Public Safety has summed up the book as "the result of exhaustive research, and excellent presentation, but of greatest importance, a non-prejudicial and scientific appraisal of the use of this material."

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With a Foreword by Julian S. Hatcher, Maj. Gen., U.S. Army, Retired

THOMAS BOOKS
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Foreword

Dr. J. H. Mathews, a 1903 graduate of the University of Wisconsin, with later Master's and Doctor's degrees from Harvard, is one of the real pioneers in criminal investigation work involving firearms identification. His first criminal case was in 1923 and involved the metallographic analysis of certain parts of a bomb which had killed one person and badly injured another. As a result of his success in this case, other cases, including firearms examinations and identifications, soon came to his laboratory and, as his well-deserved reputation in this work spread, the demand for his services rose until he now has a record of several hundred important cases successfully completed and can be considered one of the world's outstanding experts in this field. For 16 years he was a member of the Madison, Wisconsin, Police and Fire Commission, and for a time he was president of that body.

During World War I, Professor Mathews served 18 months in the Ordnance Department of the U.S. Army, and from 1919 until his retirement in 1952 he was a Professor in the University of Wisconsin, with the duties of Chairman of the Department of Chemistry and Director of the Course in Chemistry. Besides being a Past-President of the Madison Rotary Club, the Madison Professional Men's Club, and of the Madison University Club, he is also a founder of the professional chemical fraternity Alpha Chi Sigma, a Fellow of the A.A.A.S., and a long time member of the American Chemical Society as well as the organizer of the first Annual Colloid Symposium.

Dr. Mathews is the possessor of a superbly equipped laboratory devoted to firearms identification work containing many instruments designed by him and employing techniques which he developed or discovered in nearly 40 years of work in this field. Several of his cases have attracted international as well as national attention, and his work has been highly commended by the Chief Justice of the Supreme Court of Wisconsin in a Supreme Court decision, by the Wisconsin Bar Association, and by international experts. He has lectured widely on scientific criminal identification and has given a course of lectures on this subject each year for 15 years at the University of Wisconsin. Since his "retirement" on July 1, 1952, he has been putting in full time working at his hobby of improving the methods of criminal identification by scientific methods.

Early in his work along this line, he found that the data on the characteristics of various makes of hand firearms were unsatisfactory in quantity, woefully incomplete in many instances, incorrect in others, and not only inadequate but scattered and hard to refer to.

In an attempt to remedy this condition and obtain some of the data which he urgently needed in his own investigations, he began to collect and tabulate such information as width of lands, width and number of grooves of rifling, twist of rifling, diameter of bore and grooves, and various other important dimensions which the criminal investigator would be likely to need to know.

The task turned out to be colossal, for he soon found that many makers of pistols and revolvers had no fixed specifications for these things, and that the dimensions varied from gun to gun and from year to year. Others had specifications which might or might not be adhered to. In other words, he found that rather than to depend on published tabulations he had to obtain actual samples of every pistol and revolver available, make his own measurements, and construct his own tabulations.

This monumental task proved to be most difficult of accomplishment, involving as it did the collecting of information from all over the world and then the checking and verifying of this information by actual measurements made on sample guns which were often extremely difficult to obtain. The instruments used are described in detail in this book.

During the course of this part of the work, Dr. Mathews managed to obtain the loan of over 2100 different pistols or revolvers originating in 23 countries. His new book gives the rifling data taken by him in his own laboratory for all these guns, plus photographs of both sides of over 1100 different guns taken by him and some 900 gun photos from other sources. He has also included well over 100 photographs of rim fire firing pin impressions.

Besides all this tabular and illustrative matter, the book contains a meticulously complete text on the techniques and instrumentation of criminal firearms identification, all of which is copiously illustrated.

This treatise should also be of great interest and value to gun collectors, present and future. The number of photographs of hand guns far exceeds that to be found in any book heretofore published and many arms are shown here for the first time in any book of reference. Supplementing these numerous and unusual photographs, the section entitled "Miscellaneous Notes on Automatic Pistols," containing a large amount of hitherto unpublished information, will be of particular interest to collectors of such arms.

The publication of this splendid reference work will be an event of the utmost importance in the field of firearms identification.

Julian S. Hatcher, Maj. Gen., U. S. Army, Retired
Technical Editor, *The American Rifleman*
Washington, D. C. April 21, 1960

Acknowledgment

To give credit to all the individuals and organizations that have been of assistance in furnishing information, firearms, and counsel during the several years in which material for this publication has been accumulating would be quite impossible.

The data resulting from measurements and photographs of firearms (both made by me could not have been obtained without the cooperation of a great many persons too numerous to mention individually. Such a list would include literally scores of my former students as well as many other friends who learned of my work. Special mention, however, should be made of some, including the following: General Julian S. Hatcher, Technical Editor of The American Rifleman, who made available his own private collection and that of the National Rifle Association; Clark E. Kauffman, a private collector of Leesburg, Florida, who furnished well over three hundred specimens; Col. G. B. Jarrett of the Ordnance Corps at Aberdeen, who, with the permission of the Chief of Ordnance, sent me every item requested from the Aberdeen Museum; B. D. Munhall and the H. P. White Laboratory of Bel Air, Md., who also sent me every specimen asked for from their extensive collection; Dr. W. C. McKern, Director, and Eldon G. Wolff, Curator, of the Milwaukee Public Museum who made available all items desired from the famous Nunnemacher Collection; the Wisconsin State Historical Society Museum, which contains the Rosebush Collection of firearms; Sidney Aberman, a private collector in Pittsburgh; Sam Smith, a private collector of Markesan, Wis.; H. C. Harrison, Assistant Director of the Laboratories for Scientific Criminal Investigation of the University of Rhode Island; the Police Departments of Milwaukee, Madison, and La Crosse in Wisconsin, and those of Cincinnati, Minneapolis, and St. Paul; the Laboratory of Criminal Investigation, U.S. Army, Fort Gordon, Ga.; and the Pittsburgh and Allegheny County Crime Laboratory. I am especially indebted to the Wisconsin State Crime Laboratory, as all guns acquired by this laboratory are made available to me. Charles W. Wilson, Superintendent, Joseph C. Wilimovsky, Jr., Associate Superintendent, and Allan Wilimovsky, Firearms Examiner, have all been most coöperative.

I also wish to express appreciation for the assistance given me by Jack Krema, Firearms Examiner in the Attorney General's Laboratory for the Province of Ontario, Toronto, Canada. Through him certain valuable material and a number of photographs have been made available. His assistance with the Czech guns has been particularly helpful.

For much of the technical and historical material in Part III I am particularly indebted to Donald Bady of Forest Hills, N. Y., a well known authority on firearms, whose assistance has been invaluable. I am also deeply indebted to Burt D. Munhall and the H. P. White Laboratory, and to Joseph C. Wilimovsky, Jr., for valuable historical information.

Mention should be made of the coöperation of many manufacturers and dealers, too numerous to mention individually, who have furnished catalogs, circulars, and information by correspondence. Firms such as Webley and Scott, Ltd., Smith and Wesson, the Bausch and Lomb Optical Co., and the American Optical Co. deserve special mention for the excellent photographs they have furnished, as does also A. W. Sijthoff of Leiden for permission to use several illustrations taken from Kersten's *Munitie en Wapens*. Acknowledgment is also made to Verlag J. Neumann-Neudamm, Melsungen, Germany, for illustrations taken from Bock's *Moderne Faustfeuerwaffen*.

Valuable information concerning arms formerly made in Spain was furnished by the Banco Oficiel de Pruebas de Armas de Fuego, in Eibar, and by the late José Maria Fernandez Ladreda, Director General de Industria y Material, of the Ministerio del Ejército, in Madrid, and by his successor, Joaquin Gomez-Pantoja.

J. H. M.

Contents

Volume I of Three Volumes

Introduction

Firearms identifications are of interest to those engaged in law enforcement and to gun collectors, but from quite different points of view. The law enforcement officer is chiefly concerned with bringing to justice persons who have committed crimes, while the collector is interested in guns because of a fascination that only a gun collector can fully understand. Both need to know all that they can learn about firearms and it is hoped that the material here presented will be useful to both groups. The work makes no pretense of being a complete treatise on firearms investigations or a manual of identification procedures, nor does it pretend to be complete as to measurements and photographs that might have been made. It does attempt to set forth the principles of firearms identification from the standpoint of the markings which may be found on fired bullets and shells. Large areas of the general subject were intentionally omitted. In addition to the very considerable amount of material presented here, the author knows of many hand guns of which he could not obtain specimens, and no doubt there are many makes and models of guns of which he has never heard. It is believed, however, that the types likely to be encountered are fairly well covered.

The justification for the publication of this work, if one is needed, is that it contains much material that is unavailable elsewhere and it presents a more nearly complete account of rifling characteristics *as they actually exist* than has ever before been compiled. The data here presented represent actual performance rather than manufacturers' specifications. The book also represents, to a certain extent at least, the fulfillment of a desire to pass on to others some of the basic information accumulated over a considerable number of years, in the hope that they will find it useful.

For over thirty years the author has devoted considerable time to the making of firearms identifications and to other applications of scientific methods of crime investigations for the law enforcement agencies of the State of Wisconsin. As his position was that of Professor of Chemistry and Director of the Course in Chemistry at the State University this work constituted an "extracurricular" activity, but one which seemed important because no one else in his state was doing it, it needed to be done, and the law enforcement agencies, from the police officer on the beat to the State Supreme Court, appreciated the service. This activity arose from the fact that the state, at that time, had made no provision for scientific investigations of crimes other than the employment of a State Toxicologist (for a few years), and there were urgent demands for such work.

The author's work along these lines began in 1923 when he assisted in the solution of the Magnuson bomb case, in which metallographic evidence was used for the first time in a murder case. Soon thereafter he was importuned to study the evidence in a homicide involving the use of a rifle. At this time Calvin Goddard was the only man in the country really qualified to make such investigations on a truly scientific basis, but the local authorities felt that they could not afford to pay his fees particularly, it is presumed, if they could get a professor from the state university to do it for next to nothing! The work was undertaken, with no other equipment than that to be found in a well-equipped laboratory of physical chemistry (cameras, microscopes, measuring devices, etc.), and it resulted in securing a confession of the murder during the course of the trial. The publicity resulting from these two cases brought others and it was soon realized that special equipment must be purchased and built to handle cases properly.

As the comparison microscope had just been introduced by Goddard for work in the firearms field, for which (unfortunately, as he and others later agreed he coined the name "forensic ballistics," an attempt was made through him to acquire one of these instruments, but one of his associates (Waite) objected to his giving out any information. An appeal to the Bausch and Lomb Optical Company, however, brought results and the author's laboratory soon received the first instrument that they made for firearms identifications. As time went on, more and more equipment was added until a fairly well-equipped laboratory, containing some instruments that were unique, was available.

It was realized very early, however, that the state should have a State Crime Laboratory, well equipped and adequately staffed, to handle the many types of work that come up in criminal cases and a recommendation to this effect was made to the Wisconsin State Bar Association at their annual meeting in 1925. A resolution was adopted unanimously directing that a bill be introduced in the next session of the Legislature calling for the establishment of a State Crime Laboratory. The bill was introduced, but because of inadequate support it did not receive favorable action. This process was repeated at each session of the Legislature until favorable action was taken, and in 1947 the laboratory became an actuality with Charles M. Wilson, formerly an associate of Goddard at the Northwestern University Crime Laboratory and later Director of the Chicago Police Laboratory, as Superintendent. Since the establishment of this laboratory the author has done little work in the way of investigations but has had an opportunity, especially since his official retirement from his professorship at the university in 1952, to devote himself to research in the field of firearms investigations.

Much has been said and written about the identification of the type, make, and model of a firearm from "class characteristics," which involves a knowledge of the rifling specifications (and practices used by different manufacturers, and of special features of construction which affect the markings to be found on fired shells. Because of differences of opinion and because of the unavailability of exact data concerning rifling characteristics as they actually exist, it seemed to the author that someone should make a comprehensive set of measurements on hand arms, covering all of the many makes, types, and models as far as the availability of specimens permitted. This was found to be quite an undertaking because many of the guns made in the last 75 or 100 years are still in existence and still usable and because many hundreds of thousands of cheap foreign-made guns were imported into this country, particularly after World War I. Therefore, no pretense of completeness is made. No measurements were made on rifles, which would have been desirable, although they are not as frequently used in the commission of crimes. But this would have extended the study by several years.

To start the work, methods for making the desired measurements were developed and the necessary equipment was either purchased or constructed. Three things soon became apparent: (a) many manufacturers who have exact specifications do not follow them closely, (b) many manufacturers apparently had no specifications, and (c) the author had a big job on his hands! As the work proceeded it was realized that here was a golden opportunity to secure photographs and information on guns that would be useful to collectors as well as to firearms examiners, so from that point on photographs were made of all the different makes and models that came to the laboratory for measurement. Unfortunately this procedure was not used right from the start and some interesting guns were returned to their owners without being photographed.

The determination of the names of the actual manufacturers of many foreign guns has been a task of great difficulty, and in a number of cases it has been impossible. Often a foreign-made gun may carry only the name of a dealer or his trade mark, and sometimes it may bear no marking whatever. To complicate things further, different manufacturers have used the same name for guns that are quite unlike in construction as well as for some that appear to be copies of each other or of some other well-known firearm. Many of these guns, particularly those made in Belgium and Spain, were made in little shops, perhaps in the workmen's homes, and were sold to dealers who put their names on them. For example, a number of Spanish automatics have been encountered which bear the inscription on the slide: FABRIQUE D'ARMES DE GUERRE DE GRANDE PRECISION—EIBAR, SPAIN. As a matter of fact, no manufacturing company of that name ever existed. This was exclusively an exporting company and not a manufacturer. Many other cases might be cited for guns made in Spain and in Germany. Of course this practice is not limited to Europe. It is a common practice in this country and has been for a hundred years or more. Scores of examples might be cited not only of guns bearing names that give no clue as to their maker, but also of guns bearing names of "manufacturers" that never existed. Some Spanish manufacturers not only made guns but also sold guns made by others, and it is difficult to ascertain which guns they actually manufactured. It is clear that Garate, Anitua y Cia. in Eibar was one of these as they certainly did not make all the guns that bear their trade mark. In Belgium the same practice was followed. L. Ancion Marx is a good example of a firm (and there were many others) who not only made some revolvers but who marketed a good many that they did not make. These were made, wholly or sometimes in part, in little shops and even in private homes in the city of Liége and in the surrounding country, particularly the upland of Herve, northeast of Liége. In the early part of the century this part of Belgium was a "beehive of activity" for firearms manufacture.

Now practically all of this industry is gone. During World Wars I and II the Germans destroyed all of the firearms industry in Belgium that they did not need for their own use, and Franco wiped out the industry in Spain when he came into power and decreed that there should be only three manufacturers of automatic pistols and only one of revolvers. (Fortunately, he made good choices as to who should be allowed to make firearms.*) Thus the manufacture of revolvers in these countries has virtually ceased, but many hundreds of thousands of guns made earlier are probably still in existence. And as long as they exist, and they are rather "nonperishable," they will be a problem to firearms examiners, though perhaps a joy to collectors.

It might be thought that reliable information as to the names of firearms manufacturers could be obtained from the Government Proof Houses, but this is not the case because, in the course of war and revolution, their records have been destroyed. So they are of little help. The amount of reliable information from Government Ministries is also quite limited, perhaps for the same reason and because of changing personnel. Some of the manufacturers who are still in existence have been very helpful, but they too are often unable to give specific information that is desired concerning products made long ago. The Spanish and Belgian patents have been of some assistance, but they do not give much information as to the actual manufacturers.

The word "patent" as it relates to Spanish firearms is likely to be confusing. Unpatented arms may be marked "patent" or "patented." Where a patent number does appear it may refer to the general design of the arm, or to some design feature or to the trade mark or trade name. The legitimate design patents are usually prefaced by "Co." (for Concedido) and during the period 1915 to 1922, when there was a virtual epidemic of new Spanish pistols, these patent numbers ranged from 60,000 to 71,000. Trade mark patents usually bear the prefix "Mar." (for Marca) and in the same period they ran from 30,000 to 40,000. But these designating prefixes do not appear on the firearms, only in the patent literature. There is still another type of number that was applied to design models, roughly equivalent to the German D.R.G.M. (Deutsche Reich Gebrauch Muster). These do not seem to have a pattern and all of them center in the range 2,000 to 4,000 for the period 1915 to 1922. Some of these apply to pistols.

As pointed out, the number appearing on a Spanish firearm may relate to one of several kinds of patents, and only a search of the Spanish patents will reveal which it is. Some examples are the following:

1. The number 39,391 is a patent number appearing on the slide of all Colonial pistols examined. A study of Spanish patents reveals that Pat. Mar. 39.391 was issued in November 1920 to Etxezarraga Abaitua y Cia. of Eibar.

2. The patent number appearing on the slides of some specimens of the Libia is 69.094. This turns out to be Pat. Co. 69.094, issued to Beistegui Hermanos of Eibar on Feb. 19, 1919, and is a design patent covering automatic pistols without respect to any trade name. A later patent, not appearing on the pistol, is Mar. 36.386, issued to Beistegui Hermanos on Oct. 1, 1919, and covers the trade name Libia for use on automatic pistols and revolvers.

3. The JO-LO-AR bears the numbers 68027 and 70235. Both turn out to be design patents. Pat. Co. 68.027 was issued to D. Toribio Arrizabalaga y Ibarzabal on Jan. 8, 1919. Pat. Co. 70.235 was issued to D. José de L. Arnaiz on September 12, 1919. According to the Eibar Proof House, and other sources, the pistol was actually produced by Hijos de Calixto Arrizabalaga in Eibar. The 6.35 mm. SHARP SHOOTER (some are marked SHARP SOOTER), made by the same firm, bears the patent number 68,027. This pistol bears a close resemblance to the JO-LO-AR. It is

*Bonifacio Echeverria, S.A., in Eibar, pistols only (Star); Unceta y Cia., in Guernica, pistols only (Astra); and Gabilondo y Cia., in Elgoibar, pistols (Llama) and revolvers (Ruby). In 1958 Astra-Unceta y Cia. announced the manufacture of a .22 caliber revolver, the Cadix, so the original edict of Franco must have been modified. The company states that they will "make them in larger bores sometime in the future."

probable (but not confirmed) that the name JO-LO-AR was derived from the name of D. José de L. Arnaiz, to whom the second patent (No. 70,235) was issued.

Trade marks are often very helpful in identifying guns. But here again we have the same problem, i.e., Is a particular trade mark on a gun that of a dealer or that of a manufacturer, or perhaps of both? Garate, Anitua y Cia., already mentioned, is a good example. Although they made guns, their trade mark is found on guns that they definitely did not make. In spite of these uncertainties we believe that trade marks and other identification marks do have some value and we have taken the opportunities presented to accumulate a large number of them and to reproduce them here. There are some which we have not been able to identify, but perhaps someone else may be able to. No doubt we have identified some dealers' marks as those of manufacturers, and vice versa.

Despite these and other difficulties, considerable information has been accumulated, enough to warrant publication, we believe. Certainly there are many omissions, due to lack of information, and no doubt there are errors. In a number of cases our sources of information disagree.

Since quite a number of makes and many models of hand guns have not been available for measurement and photographing, there are important gaps in our information. To fill these gaps, in part at least, a collection of photographs from other sources has been made and many of these photographs are here reproduced. While it cannot be expected that all of the makes and models of hand guns that have been made in the past century can be photographed and published in a single volume, it is hoped that the information presented here is sufficient to be useful to both law enforcement agencies and collectors. It will be noted that very few of the revolvers made in the U.S. in the last quarter century are shown. This omission was deliberate because these firearms are so well known, or the information is so easily obtainable elsewhere.

Part IV of Volume II contains the photographs taken by the author. Chapter 1, Volume II, is devoted to automatic pistols and Chapter 2, Volume II, to revolvers and nonautomatic pistols. These are, in each case, arranged by caliber and alphabetized according to name and model of the arm. The name and location of the manufacturer (or source) are also given, where known. Serial numbers are also given as they help to date an arm or model. Both sides of each arm are shown, together with a scale.

Part V of Volume II consists of reproductions of photographs and illustrations of hand guns, most of which have been unavailable to the author, and are arranged alphabetically. These were obtained from various sources: donated or purchased photographs, loaned photographs or negatives, catalog and circular illustrations issued by manufacturers, etc.

The work of measuring and photographing hand guns is continuing and considerable new material has accumulated since this book went to press. Of necessity it has been omitted.

PART I

Laboratory identification of a firearm

Part I, *Chapter* 1

Principles involved

While there are many questions that come up in firearms investigations, the two that come up most frequently are: (1) What kind of a gun was used, and (2) was this particular gun used? Both of these questions involve a study of the markings which are left on the fired bullet or cartridge, or both. On each there will be two types of markings: *repetitive* and *accidental.* The accidental markings may have some relation to the investigation (instances of which will be mentioned later) but are of no value in identifying a particular weapon or make and model, since they are not formed regularly in the operation of the gun. Repetitive marks, on the other hand, are very useful because they show identity of performance. 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 and 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. These "Class Characteristics" have now been measured for a very large number of guns and the results are set forth later.

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.

These markings serve then to identify a particular rifled barrel because that barrel has an individuality possessed by no other barrel. In 1926 at Springfield Arsenal a very interesting and conclusive experiment was made. 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. Some time later Goddard fired 500 rounds through a machine gun and found that even bullet No. 500 could be matched with bullet No. 1, indicating that the individuality of a barrel persists. The results of these two early experiments have been confirmed over and over again in identification practice and are now generally accepted. Similarly, the markings produced on the head of a fired cartridge (shell) often can give valuable information as to the type and make of gun used and often can identify the particular gun when located.

Rifling methods

Modern rifles, revolvers, and pistols have barrels

*The words identity and identical as used in firearms investigations do not mean that the markings on two bullets two objects are ever identical in the absolute sense. Just as no or on two shells are absolutely alike in every particular. No two persons are alike, no two objects made by man or by nature are absolutely alike. So the term "identity" is a relative one.

which are "rifled," i.e., they have spiral grooves in the inner surface, the purpose of which is to cause the bullet to acquire a rapid spin on its longitudinal axis, the gyroscopic effect of which keeps the bullet from "yawing" or "tumbling" in flight. This method of improving the accuracy of the flight of a bullet has been used for hundreds of years and no one knows just when the principle was first discovered. These grooves in the bore of the barrel and the lands (ridges) between them constitute the rifling. In present-day hand guns the pitch (or twist, as it is called) of the rifling is uniform from one end of the barrel to the other. Many years ago certain manufacturers used a "gain twist" in which the angle of twist increased from breech to muzzle. This will be discussed in a later section.

While the method whereby the grooves were first produced seems not to be definitely known, it can be said that until fairly recently there have been two methods in general use for producing rifling. These methods are the "scrape cutter" method and the "hook cutter" method. Most of the weapons the firearms examiner will encounter have been rifled by one of these two methods, and mostly by the second. However, this situation will change as many firearms now being made are being rifled by newer methods which have the advantage of being more rapid.

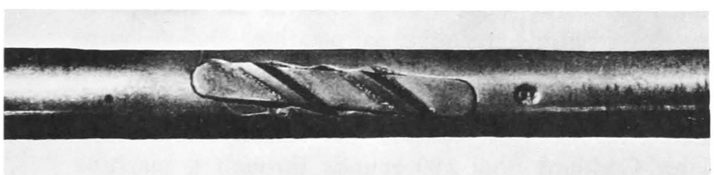


Fig. 1. Section of a "scrape" cutter. For rifling barrels with an even number of grooves, two (opposite) scrapers were used.

A typical scraping device is shown in Figure 1. It consists of a rod, slightly smaller than the bore of the gun, into which is set either one or two curved, hardened steel scrapers the height of which can be adjusted between successive passages through the barrel. If an odd number of grooves is to be cut, a single scraper is used. If an even number, two scrapers placed opposite each other may be used. Of course an even number can be cut with a single scraper, one at a time. The operation is a very slow one, particularly if five or six grooves are to be formed by a single cutter. Some of the finest rifling ever done has been done by the scrape-cutter method.

In European practice there seems to have been more variation in the application of the scrape-cutter method. It seems that the following variations of rifling head construction have been used: (1) Two single curved cutting blades, each of which is an integral part of the surface of a plate that fits closely into slots that are placed opposite each other in the rifling head, so that two grooves are cut simultaneously. (2) Four cutting blades, two on each plate set "tandem" to each other so that the second cutter follows in the groove made by the first one, thus deepening the groove, the plates being set into slots opposite each other in the rifling head. Thus two opposite grooves are cut simultaneously but deeper than in (1). There is evidence that in some cases three cutters were set in tandem (in each of the two oppositely placed plates) so as to increase still more the speed of the rifling operation. (3) Two cutters

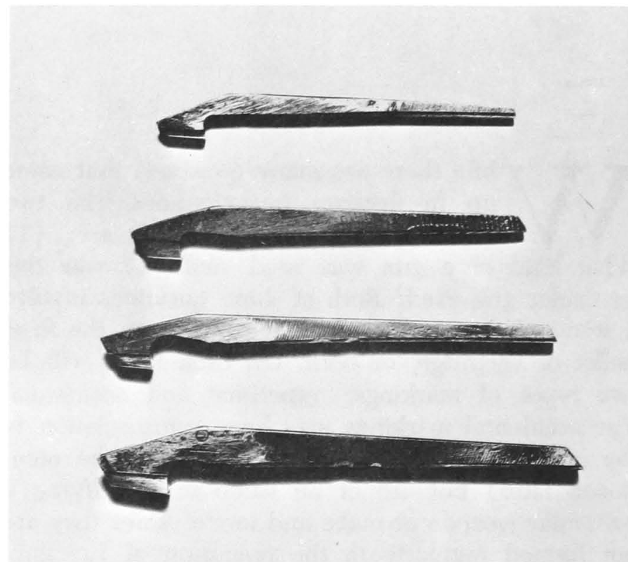


Fig. 2. Four "hooks" used in the hook cutter method of rifling a barrel.

The cutting edge of the hook, which has been filed to exact dimensions, projects through a slot in a rod whose diameter is slightly less than that of the bore to be rifled. The height to which the cutting edge protrudes is adjusted by a screw at the end of the rod.

The rod is pulled through the bore and on each pass a very small amount of metal is removed. Each groove is started with the same adjustment of the cutter. After all have been started the cutting edge is set up a bit and the process repeated on all grooves. This is done again and again until all the grooves are cut to the proper depth. This may take as many as 80 passes for each groove in the rifling of a first-class gun.

Since the hooks wear away during the cutting operation they have to be replaced frequently to keep within the tolerances that have been set in the specifications. Some manufacturers pay little attention to their "specifications," however.

The hooks shown are for .25, .32, .38, and .45 calibers.

on each of two plates set opposite to each other, but instead of being set in tandem they are set apart (with respect to the longitudinal axis of the rifling tool) a distance equal to the desired width of the land. Thus, when this assembly is pulled through the barrel four equally spaced grooves are cut simultaneously. (4) Three cutters arranged symmetrically in the rifling head so as to cut three equally spaced grooves simultaneously. To get the second set of three grooves the barrel or the rifling head is indexed into the proper position so that the completed job will have six equally spaced grooves.

In each of the above procedures a wedge-shaped rod (or shim) is pushed in a bit automatically at each rifling stroke so that for each passage the cutters are raised the desired amount, the process being repeated until the desired depth of groove is attained. The cutting edges in each case above are formed by milling away the steel of the plate so as to leave the curved cutter with the desired shape, height, and angle.

In the "hook cutter" method, a cutter with the general shape of a crochet hook (Fig. 2) is set into a recess or slot in a rod (Fig. 3) which is a bit smaller than the bore of the barrel. The height of the cutting edge of the "hook" can be adjusted by turning an adjusting screw at the end of the rod. On each pass through the barrel a fraction of a thousandth of an inch of steel is removed, and as the barrel is given a steady rotation at a predetermined rate a very shallow spiral groove is formed, having the width of the cutting edge. The barrel is then positioned so as to cut a second shallow groove parallel to the first one, and this process is repeated until all of the grooves have been started. Since they are not yet of the desired depth the cutting edge of the "hook" is now raised a bit and each groove is cut a bit deeper. The process is repeated again and again until all the grooves have been cut to the desired depth—amounting to a few thousandths of an inch. In the cheaper guns only 20 or so passes are used for making each groove, whereas on a finely made firearm as many as 80 or more might be used. Here again the process is exacting and time consuming, and for these reasons newer methods of rifling are coming into general use. In theory each groove is cut to very exact dimensions. All lands are supposed to be equal in width and all grooves are supposed to be of equal width and depth, but actually this perfection is never obtained and some manufacturers pay little attention to specifications.

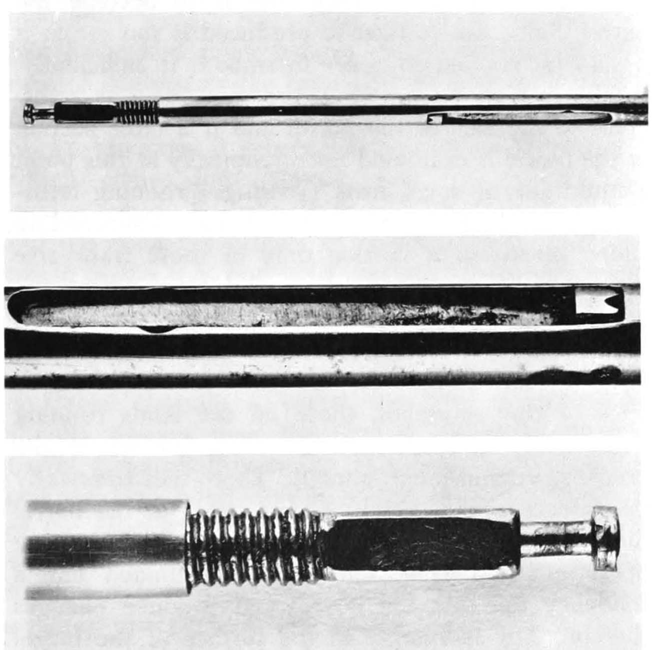


Fig. 3. The hook cutter. *Top:* Section of cutter for .22 caliber. *Middle:* Enlarged view of hook section. *Bottom:* Enlarged view of adjusting screw.

Whether a scrape cutter or a hook cutter is used, a microscopic examination with sufficient magnification of the cutting edge would reveal the fact that the edge is not truly smooth. It would have nicks in it, just as the blade of a dull knife has them, the only difference being that they are smaller. No matter how much care is used in the honing operation nicks will still be present and they result in serrations or ridges being formed in the bottom of the groove made by the cutter.

It must be remembered, also, that the steel used in barrels is not absolutely homogeneous and there will be some areas of the surface which are harder than others. The cutter will not act the same on these areas with different hardnesses and this will result in inequalities in the surface. Also, tiny chips of metal from the cutting operation may produce inequalities in the action of the cutter. No matter how these inequalities are produced, unless they are removed they will tend to make repetitive marks on bullets because the bullets are of softer material. Various methods are used to remove these inequalities.

Some manufacturers perform a "lapping" operation after all the grooves have been cut. A lead plug is cast on the end of a rod placed in the barrel. This, of course, insures a good fit. Then, with a mixture of oil and fine emery powder as a lubricant and polishing agent, the plug is pushed back and forth through the barrel. Finally a mirror-like surface is produced and most of the inequalities in the surface, produced in the boring, reaming, and rifling processes, are

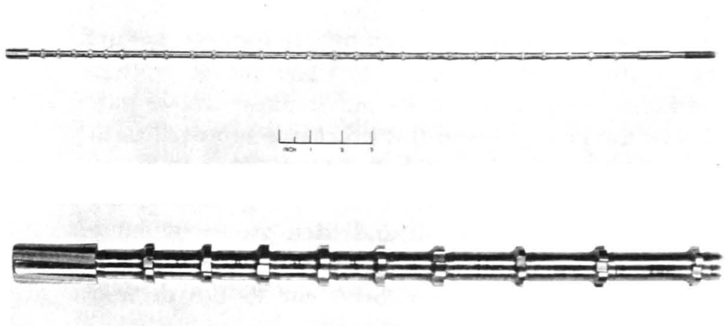


Fig. 4. Broach for cutting rifling. Upper view shows the entire tool, about 23″ in length, with 27 cutters. The lower view shows a section enlarged.

removed. A new, lapped barrel will leave fewer and smaller markings on a bullet fired through it than will an unlapped one, but marks will still be present and identification will normally be possible.

Next to be mentioned is the broaching process which is now used by several American firearms manufacturers and some in Europe as well. As somewhat of an oversimplification, a broach may be thought of as a rod upon which there are 25 to 30 hardened steel rings, each one being slightly greater in diameter than the preceding one and having slots of the proper size cut into it at equal intervals, thus forming a series (or "gang") of cutters, each of which has the same number of lands and grooves. (Figs. 4, 5) The lands on the cutters produce grooves in the barrel and all grooves are cut to the desired depth during a single passage of the series or gang of cutters through the barrel. Each successive cutter must be perfectly aligned so that its lands will follow the grooves made by the preceding (smaller) cutter. This is a simplified description of the process but will serve to illustrate the principle.

The broaches require much skill in their preparation but each broach is capable of rifling a large number of barrels and the operation time has been reduced to such an extent that one machine can rifle several hundred barrels in a working day. Also, many more can be rifled with a broach than with a single scrape cutter or hook cutter because the broach has many more cutting edges and the wear on each edge is consequently less than that on a single cutter.

It might be thought that since many barrels are rifled with the same broach, all the barrels would have lands and grooves which are exactly alike and that it would be impossible for the firearms examiner to distinguish between bullets fired from them. This, however, is not the case. Each rifled barrel still possesses an individuality which is expressed in the markings made on bullets fired through it. This is due in considerable part to the fact that there is one thing in common in all three of the methods of rifling so far discussed. In all cases the preparation of the bore of the barrel to be rifled is essentially the same. A hole of suitable diameter is bored from end to end through the piece of stock that is to become the barrel. Since the surface so produced is too rough it has to be reamed in order to smooth it sufficiently. In this process of reaming, the movement is transverse to the axis of the barrel and if a cross section of the barrel is examined microscopically at this point a multitude of small lines (scorings) running crosswise of the bore will be observed. In the succeeding rifling operation a portion only of these transverse lines will be removed, i.e., in the areas where the grooves are cut. They will still be present on the lands. If a cross section of a rifled barrel is examined (Fig. 6) it will be seen that there are two sets of lines or tiny scratches, those on the lands running transversely and another set at the bottom of the grooves running longitudinally. There will frequently be defects in the surface of the lands in the barrel due to scoring by chips produced in the broaching operation, and it appears that the broach has a tendency to "ride the lands" and produce changes thereon. Any inequality in the surface of the barrel with which the bullet comes in contact may produce a scratch or serration on a bullet fired through it, and since the greater pressure against the bullet is produced by the lands on the barrel the most

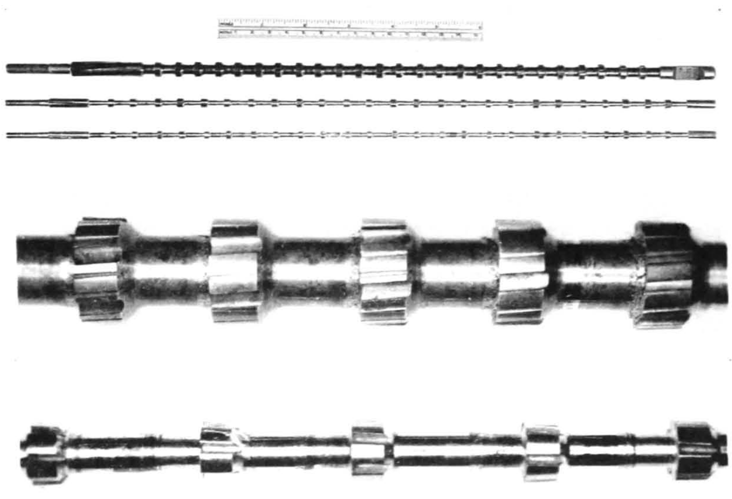


Fig. 5. Broaches for cutting rifling. Top views show three entire broaches: A .38 cal. Colt broach and two H & R broaches, all 16 inches long and having 25 cutters.

Enlarged views of short sections of the Colt broach and one of the H & R broaches are shown in the lower part of the figure.

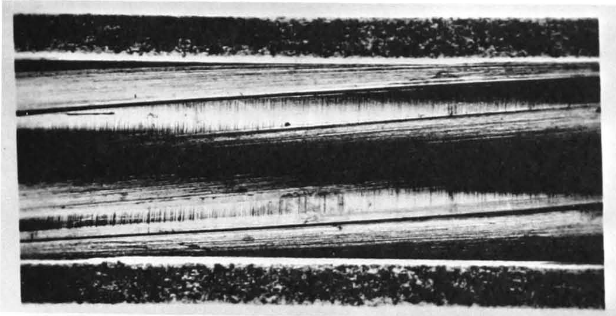


Fig. 6. Section of barrel rifled with a "hook" cutter. Longitudinal marks due to rifling tool. Transverse marks due to drill.

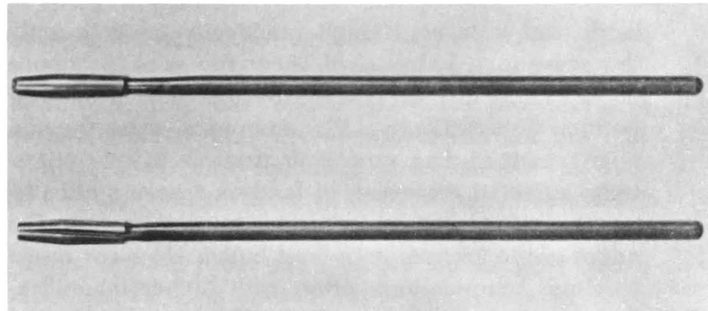


Fig. 7. Rifling buttons. *Upper:* Bore button swage. *Lower:* Groove button swage.

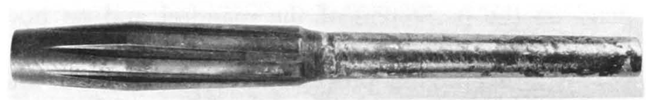
prominent markings are likely to be found at the bottom of the grooves on the bullet. However, if the bullet fits quite tightly longitudinal striations will be found on the lands of the bullet also, caused by the scraping of the bullet along the bottom of the grooves of the rifling. In many of the more cheaply made guns, particularly those made in the 1910–1935 period in Spain and Belgium, the reaming operation apparently was omitted, or was so poorly done that it might just as well have been omitted. Many of the cheaply made American guns also belong in this category. Since at one time an American revolver could be purchased for $1.50 one could not expect much! Unfortunately many of these are still in circulation.

Another system for rifling barrels is fast coming into favor and some believe that it may eventually replace completely the broaching process as it should produce a barrel in which the rifling will have a longer life since it causes a hardening of the surface which comes into contact with the bullet. The process seems to have been used first in Germany but has been the subject of considerable experimentation in the U.S. and is in use by at least two manufacturers. It is also being used in other countries.

This process is known as the swaging method. When a plug of extreme hardness (called a "button") is forced through a barrel the bore of which is slightly smaller than the button, the metal of the barrel flows slightly under this very high pressure and the bore is slightly increased (Fig. 7). Because of the elasticity of the metal of the barrel the bore will not be quite as great in diameter as the button itself, but it will be greater than it was before the swaging operation. If the button has a very smooth surface and is very hard, the newly produced bore will be very smooth, of very uniform diameter, and it will have a harder surface because of the increased density of the metal produced by the compression it has undergone. This is said to be superior to the reaming operation, particularly as the latter is usually performed. The grooves are formed in a similar operation, but with a torpedo-shaped button made of tungsten carbide, or other similar material of extreme hardness, which is provided with lands and grooves that are the negative of those to be produced in the barrel. As this passes through the barrel it causes a further compressing of the steel as well as producing rifling grooves. If both button reaming and button rifling procedures are used all of the interior surfaces of the barrel will be hardened and all will be exceptionally smooth. Any striations present, either on the lands or in the grooves, will run longitudinally through the barrel (Figs. 7, 8). Steels which are so hard that they give trouble when other rifling methods are used can be rifled by the swaging method. The making of a suitable button requires great skill because of the extreme hardness of the material and because it must have very precise dimensions to function properly; but once formed the same button may be used for the rifling of thousands of barrels. Because of the extreme hardness of the material, diamond-grinding processes must be used in forming them.

Because of less wear on the cutting edges in the broach and button methods, the lands and grooves in barrels rifled successively by one of these methods will be more alike than those in barrels rifled by the scrape-cutter or hook-cutter method. Indeed, many of the major markings (scorings, striations, etc.—particularly along the edges of the grooves) may be repeated from barrel to barrel, and the widths of the

Fig. 8. Rifling button used for .22 cal. rifles.



lands and grooves, though practically never exactly the same in a barrel, will show the same sequence of variations in barrels rifled by the same broach or button. Consequently, the examiner must be on guard, as it is then no longer possible to rely either upon agreeing sequences of land or groove widths or on the recurrence of striations or gouges on the edges of the grooves on a fired bullet. He must resort to closer examinations, often with higher magnifications than formerly necessary. Fortunately for the examiner, barrels rifled by these newer methods (and having nearly identical characteristics) still do have individuality, and as the gun is used (and abused) each barrel will develop more individuality.

Still another method of producing rifling, though it is doubtful whether it will come into general use for firearms of good quality, is also a swaging method, but a quite different one. In this method a tightly fitting mandrel of very hard steel, bearing a negative form of the rifling desired, is pushed into the bore of the barrel after the reaming operation and the barrel is then compressed onto the mandrel under very high pressure so that the steel flows into the grooves in the mandrel, filling them completely, thus forming a set of lands and grooves in the barrel. This method was used to some extent during World War II in the production of the M-3 submachine gun. Hard steel, such as is used in high powered rifles and good grades of hand guns, does not lend itself to this process, and the method has many difficulties.

The removal of the mandrel from the barrel appears to be a tricky job and during its removal the rifling is likely to be damaged somewhat. Here again experience has shown that every barrel produced has an individuality and bullets fired from different barrels can be easily distinguished.

To increase the rate of production of rifled barrels a cold forming process, known as the "hammer" process, was developed in Europe by a Dr. Appel, and this process has been introduced into the United States since World War II. It is being used by Appel Process, Inc., in Detroit, Michigan.

In this method a steel tube is passed over a short mandrel, composed of very hard steel, which bears a negative impression of the rifling desired. As the tube advances on the mandrel, multiple hammers pound the metal of the tube into the grooves of the mandrel. The degree of twist of the rifling so produced is determined by the pitch of the lands and grooves on the mandrel. The perfection of the rifling will depend on the perfection of the mandrel and on how perfectly the grooves in the mandrel are filled.

This is a swaging process but it differs from the one previously described in that the metal is caused to flow under the pressure produced by hammers, in an automatic machine, rather than by pressing a tube onto a mandrel by the application of a very high pressure, applied more uniformly. It would appear that the process would have some of the disadvantages experienced in the preceding process, notably the necessity of using a soft, malleable steel which would be quite unsuited for use in any but the cheaper, small-caliber arms. It doubtless has one decided advantage over the preceding process in that the mandrel used is relatively short and the difficulty of removing the long mandrel from the completed rifled tube would be eliminated.

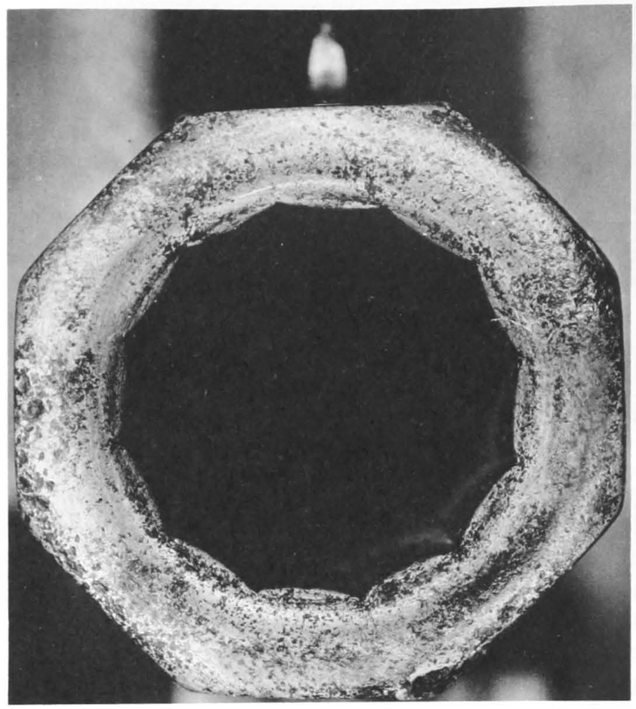


Fig. 9. An unusual type of rifling. 12 rounded lands. Galand revolver.

A very curious type of rifling, which has been encountered only in the Galand revolver, is that shown in Fig. 9. How this was produced is not known. The twelve convex lands would not seem to be as effective as the rifling generally used.

Another unusual type of rifling is that which was used in the .22 cal. single-shot Hamilton rifle, which was patented by Clarence J. Hamilton and Coelle Hamilton, U.S. Patent No. 600,725, dated October 30, 1900.

In the completed barrel the bore is a dodecagon, i.e., the rifling consists of twelve chords approximately equal in length, as shown in Fig. 10. Actually the chords vary in length (in one specimen at least) from 0.046 to 0.052 inch, though presumably they

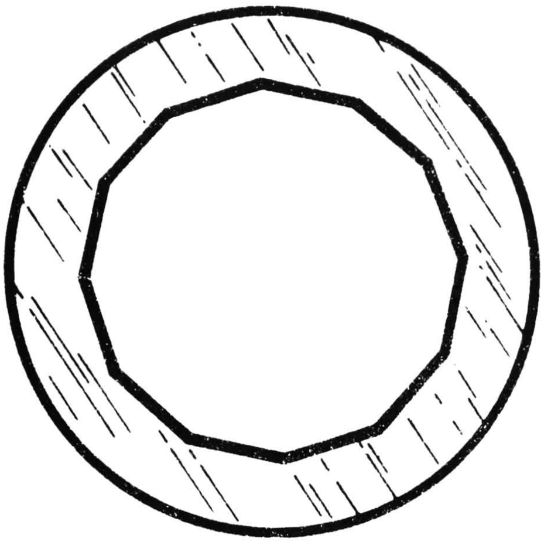


Fig. 10. Unusual type of rifling used in .22 cal. Hamilton rifle, Mod. 15. Bore is a dodecagon in cross section. Rifled sleeve is of bronze.

were intended to be equal. In the usual sense there are no lands and grooves.

This peculiar rifling was produced by slipping a seamless brass tube tightly over a steel mandrel which had the negative profile of the desired shape and subjecting the tube to powerful pressure in a suitable press. This compressed the brass into the desired shape and, according to the patent, "hardens the brass" due to the considerable pressure applied. After the brass tube had been pressed into its new shape a steel tube was sweated on to give added strength. In a variation of procedure, a heavier brass tube was taken and pressed into the desired shape, and no steel tube was used. The first procedure was preferred, however. Barrels longer than the mandrel were produced by taking a longer brass tube and pressing it in sections, being careful to have some overlap so that the bore would be uniform.

The gun was produced from about 1902 to 1908, and apparently in several different models. In Mod. 15 the barrel is but 8 inches in length although the over-all length is 27½ inches, the bolt being actually longer than the barrel. While the gun is only of historical interest, the manner of producing the rifling is of special interest as it seems to have been a forerunner of one of the modern procedures used in rifling gun barrels.

Part I, *Chapter* 2

Bullet identifications

Markings on the bullet

When a bullet, either plain lead or jacketed, passes through a rifled barrel under high pressure, the bullet tends to expand and fill the whole cross section of the barrel. The bullet should be of such size that it does this, in order to follow the rifling as it should, to prevent loss of pressure, and to prevent erosion of the inner surfaces of the barrel by escaping gases. The more completely the bullet fills the cross section of the barrel the more distinctive the markings will be and the better the matchings of rifling marks. Inequalities in the steel surfaces of both lands and grooves will then score the bullet as it passes through the barrel under pressure, and it will show useful markings not only in the grooves (made by the lands of the barrel) but also on the lands, where the pressure was less. The ideal case is that in which all grooves and lands on the fired bullet have markings which show an individuality which is repetitive, i.e., will be found on all bullets fired from this barrel, so that every groove and land can be "matched." Needless to say such perfection is rarely met! In some cases the examiner will be lucky, because of mutilation of the bullet, to get one match that is sufficiently convincing to enable him to express a positive opinion. In the case of jacketed bullets the situation where all lands and grooves can be matched is very rarely met because, the greater hardness of the jacketing material prevents the metal from being forced into the grooves sufficiently to fill the whole cross section. Indeed, it frequently happens that the lands of the bullet will show few if any markings of sufficiently repetitive character to enable one to get a matching that carries any conviction.

A good example of bullet markings (at least about as good an example as one can ordinarily hope to get) is shown in Fig. 11.* Such matchings of markings on both grooves and lands is not to be expected in the case of jacketed bullets, and rarely even on lead bullets. From what has been said, however, it must not be inferred that bullet matchings on lead bullets are superior in quality to those to be found on jacketed bullets. As a matter of fact the markings on jacketed bullets (generally in the grooves, however) are usually of better quality than those produced on lead bullets because the jacket is of harder metal.

Because of the greater hardness of the jacket, fine engravings produced in the passage of the bullet through the barrel are less likely to be wiped off. But, if the bullet is too small it may not follow the rifling sufficiently to produce repetitive markings. Obviously if the bullet slips there will be a confusion of markings, as two bullets are not likely to slip in the same manner. (A case in point is one where a man was killed by a .30-30 bullet fired in a .32 cal. rifle. Repetitive marks on test bullets could not be obtained. Fortunately, however, the case was solved by comparison of the markings on the head of the evidence shell with those made on test shells.) If a bullet is only slightly smaller than it should be, it may skid as it enters the rifled part of the bore of an automatic and then settle down and follow the rifling. In such a case the marks may be of the same character as the skid marks found on bullets fired from revolvers. Very frequently a bullet, particularly a jacketed one, while showing good markings in the

*Many other examples of bullet matchings will be shown later.

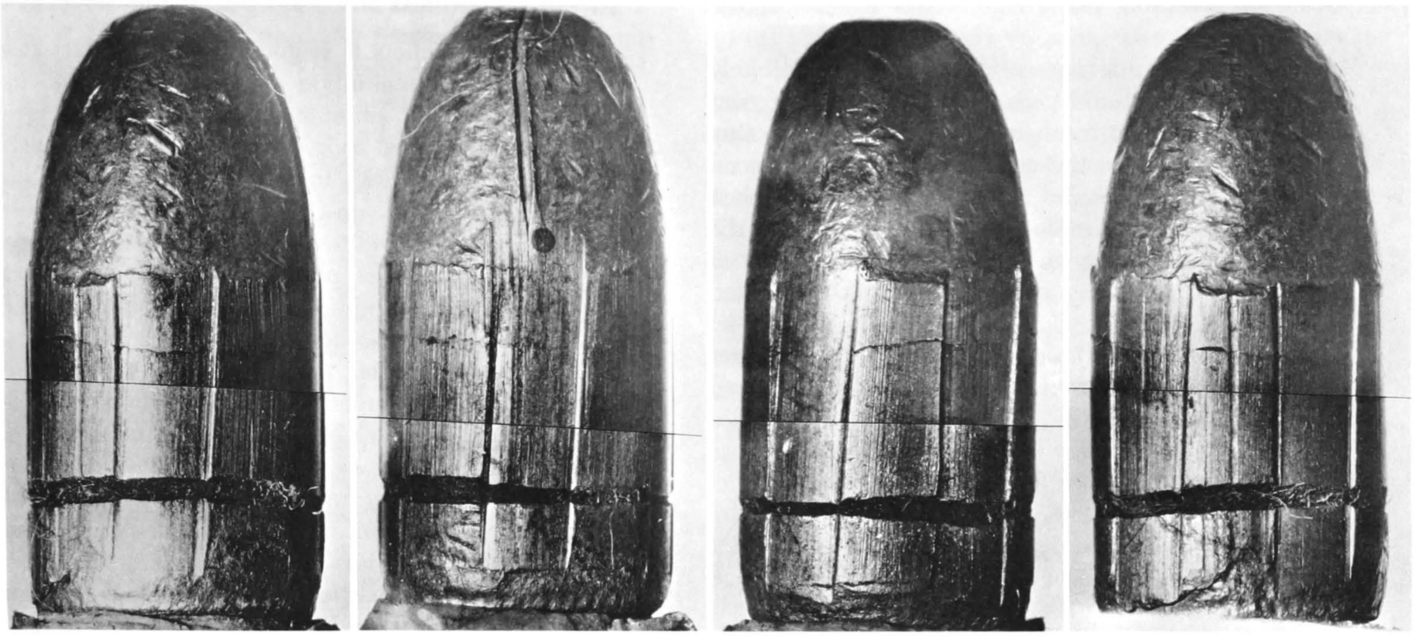


Fig. 11. Comparison camera photos showing four matchings found on a pair of bullets fired from a .38 cal. S & W revolver.

grooves will show little or no marking on the lands because the bullet did not expand sufficiently or was not of proper size in the first place.

In addition to the markings made by the rifling, marks may be made when the bullet strikes the forcing cone (if one is present) and by irregularities that exist at the muzzle. Some foreign-made guns have no chamfering of the rifling or forcing cone and the rifling begins abruptly. The diameter of the bore of the rifled section is less than that just preceding it. The ends of the lands, being sharp (not chamfered), dig into the bullet as it strikes them. In some makes of guns the barrel is constricted at the muzzle, probably caused in the operation of producing the crown. This constriction has an important bearing on the marks that have previously been put on the bullet as it passed through the major portion of the barrel. Previously made markings may be removed and new ones put on. Barrels are frequently found to be "burred" at the muzzle due to accident or some misuse and these burrs may dig into the bullet, producing distinctive marks in the form of longitudinal gouges. When such gouges are found one should examine the muzzle for the presence of burrs.

Frequently the examiner will find a gun that has a bulge in the barrel. These bulges are caused by firing a bullet through a barrel which has an obstruction in it—usually a bullet that has lodged. When a bullet is fired through a bulged barrel it will have two sets of rifling marks which, being out of phase because of failure to follow the rifling through the bulged zone, will be superimposed on each other to some extent and may cause considerable confusion.

When a bullet is fired from a revolver it usually will show slippage or "skid" marks, the grooves being wider at the nose end of the bullet than at the base end. This skidding of the bullet occurs when the bullet strikes the lands of the barrel after acquiring a high velocity during passage from the cartridge to the rifling. Because of the high inertia it has thus acquired, it resists the attempts of the lands to cause it to take a rotational motion; hence, it skids.

Skidding seldom is observed on bullets fired from automatic pistols. It naturally occurs most prominently where the bullet is traveling at a high velocity when it hits the lands. But this does not happen in an automatic, since the bullet, before firing, is practically in contact with the lands. Therefore, it starts into the rifling with comparatively little inertia and follows the lands from the start.

Revolvers which are poorly made or those which are very much worn may have cylinders which are not properly in alignment with the bore of the barrel and in such cases there will be "shaving of lead." An example of this is shown in Fig. 70. This shaving of lead may or may not cause difficulty in identification of a gun. If the performance is repetitive there will be no difficulty, but if it is not repetitive, of course, there will be. If the cylinder is very loose the alignment with the bore of the barrel will be capricious and trouble will be caused. Usually the difficulty is overcome by firing many test bullets instead of the customary three.

Nonrepetitive markings of another type are likely to be encountered and care must be taken that confusion is not caused by their presence. These are tiny scratches, parallel to the axis of the bullet, produced when the bullet is forced out of a shell into which it has been held by the crimping of the mouth of the shell into a cannelure on the bullet, or by points of the shell casing having been peened into the bullet, or even by a simple tight fit of the bullet in the mouth of the shell. These may exist in great number and occasionally some of them may not be removed by the passage of the bullet through the barrel. Since they are so short it may be difficult to determine the fact that they are parallel to the axis of the bullet rather than to the marks made by the rifling and, consequently, they can be mistaken for rifling marks. A bullet which has been forcibly pulled from a shell will, of course, show these marks.

In some of the cheap foreign guns, particularly those made in Spain and Belgium before the Spanish Revolution and World War II, the rifling was very poorly done. Not only were there transverse scrapings on the top of the lands but there were also deep scratches or gouges in the rifling grooves, caused by using cutters which had nicks in their cutting edges. If such gouges are present in a barrel they will produce markings on bullets fired through that barrel. If the nicks in the cutter are rather prominent, several almost identical gouges may be produced in each barrel groove, and a bullet fired through such a barrel might have several very similar markings on *each* land. When this occurs, pseudo or illusory matchings of one bullet against another could be obtained, i.e., one land might be matched with several others on the same bullet, provided *other* differentiating markings were absent. Fortunately each groove and land in a rifled barrel usually does have sufficient individuality to prevent an experienced examiner from going astray.

Short barrels can be, and sometimes are, made by cutting the required length from a longer rifled barrel, and the U.S. 45 once had barrels made in pairs which were then cut apart to form single barrels. In the former case the barrels will have the same class characteristics but each will have an individuality which expresses itself on bullets fired through it. In the case of the U.S. 45 the two barrels will have the same class characteristics, even though they are reversed when completed. Each will have a high individuality because the inequalities produced in the processes will also be reversed in order.

Firing test bullets

In firing test bullets it is good practice to use the same make of ammunition as that submitted as evidence, preferably ammunition taken from the gun itself when confiscated or in possession of the suspect. This will not only help to assure similarity, which often is important because of variations in the same brand as well as in different brands, but it will also meet the objections of opposing counsel who will very likely raise the question as to the similarity of test ammunition. If one does not obtain good matchings when using similar ammunition it is of course permissible to experiment with other makes of ammunition to see whether better matching of markings can be obtained. If they can be so obtained, they are good evidence because they could not be produced by any other gun, no matter what ammunition was used. Bullet markings are influenced not only by the presence of rust, particles of grit or other foreign matter, metal particles torn off bullets previously fired, etc., but also by the material of the bullet and coatings thereon. Bullets made from highly hardened lead will show markings somewhat different from those made from soft lead. Bullets made from zinc or solder would show little evidence of rifling marks. Lubaloy-coated bullets will show markings different from those on plain lead bullets.

Some investigators recommend that reduced powder charges be used to get test bullets, particularly when high powered cartridges are being fired, maintaining that the markings on bullets are not affected by the strength of the charge. Some have even resorted to pushing bullets through a barrel to get test bullets. Others view the matter very differently. Certainly wherever test bullets of suitable quality can be obtained by not reducing the charge the normal ammunition should be used. It is felt that a reduced charge should be used only in those cases where it is absolutely impossible to get a satisfactory test bullet otherwise, and one probably never should resort to pushing bullets through the bore for the purpose of getting a test bullet.

Collecting test bullets

Obviously it is important to collect test bullets in such a manner that additional marks will not be put on them after they leave the muzzle of the barrel. The most common procedure is to fire bullets from low powered guns into clean cotton waste, or into cotton batting. For high powered guns, such as many rifles, a better procedure is to fire them into oiled sawdust. The author uses a wooden box, 8 by 8 inches by 6 feet, set horizontally and open at the top. One end is also open and over this is placed a sheet of thin cardboard or heavy paper, through which the bullet is fired. Vertical sheets of cardboard or paper are placed as partitions across the box at intervals of 14 to 16 inches and the box is filled with sawdust which has been sifted to remove any pieces of wood or other undesirable material and then mixed with lubricating oil. The amount of oil used should be such that when a handful of the sawdust is squeezed tightly oil will exude. After the test bullet is fired, the paper partitions are removed one by one, from the firing end, until an unperforated one is found. The sawdust in the section in front of this is then scooped out and placed on a large (2- × 2-foot) sieve made of ¼-inch-mesh galvanized wire. The bullet is soon found.

A number of examiners use tanks filled with water, some being set horizontally and others vertically. Excellent results are reported. The vertical tank, with a cone-shaped bottom to direct the falling bullet into a wire basket which can be removed from the top of the tank or into a large gate valve at the bottom of the cone which, upon rotation, allows the bullet to fall out with a minimum loss of water, would seem preferable to the horizontal tank. The latter takes up much more floor space, the removal of the fired bullet is not so simple, and the firing must be through a self-sealing membrane of some kind to avoid a considerable loss of water. To prevent the growth of organisms in the water a small amount of bichloride of mercury or a little toluene may be added.

A rather unusual procedure for catching fired bullets is to fire them into a block of ice. Lead bullets of .22 cal. when fired into ice retain even the microscopic markings put on them by the gun and they show no perceptible deformation. The heat and pressure of the bullet cause the ice to melt, and the bullet decelerates without damage to its shape or to its surface markings. (Fig. 12) This is not a practical method for routine work but might be of use in special situations.

Methods of comparison

Before the advent of the comparison microscope in firearms identifications in the 1920's, and for some time thereafter, bullet matchings (and shell-matchings also) were sometimes made by other methods now seldom used. Sometimes a convincing identification of a bullet could be made by measuring in sequence the widths of the grooves on the evidence and test bullets and comparing them. These measurements were made with a filar micrometer (Fig. 13), an instrument readily obtainable. This is a special device placed at the top of a compound microscope. It has a scale and a cross hair which moves along this scale (or, as in the Spencer microscope, a scale which moves) as a calibrated drum is turned. One observes the bullet through the scale. The drum is rotated (clockwise, to avoid lost motion)

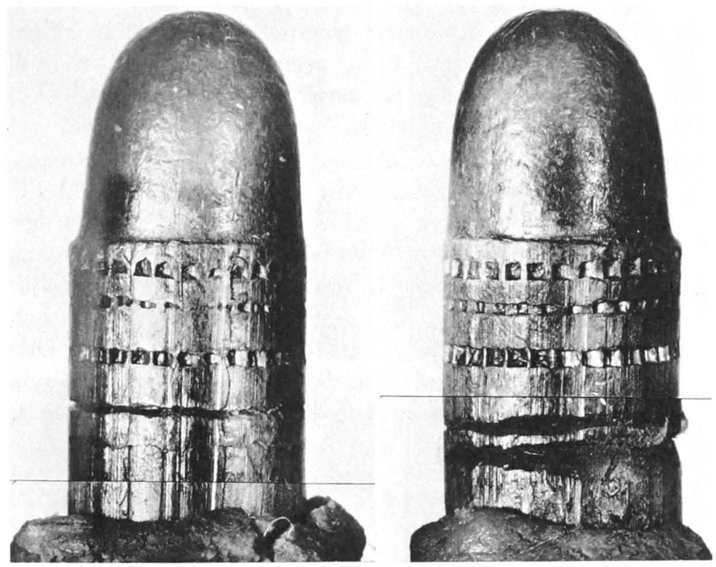
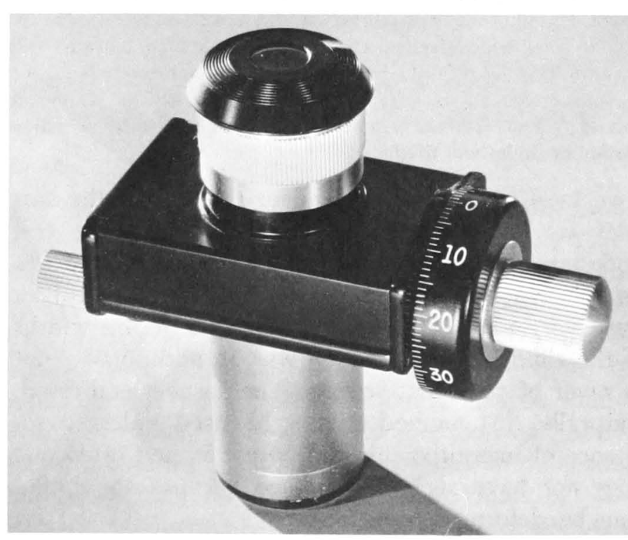


Fig. 12. Unusual bullet-collecting medium. Lead bullets of .22 cal. were fired into a block of ice. Heat and pressure caused the ice to melt and little if any deformation occurred. The matchings shown (comparison camera) are better than those ordinarily obtained for .22 cal. lead bullets collected in the usual manner.

Fig. 13. Filar micrometer eyepiece. (Photo by courtesy of Bausch & Lomb.)



until the cross hair is lined up with one edge of the groove and a reading of its position taken. Then a similar setting is made and reading taken on the opposite side of the groove. The difference is a measure of the width of the groove. The micrometer has to be calibrated before use, against an accurate scale placed on the stage of the microscope. Any change in the tube length (i.e., the distance between objective and eyepiece) destroys the calibration since it changes the magnification, so it is safest to recalibrate every time the micrometer is used. When properly used it is quite accurate. However, as will be discussed later, we now have better methods of measuring groove widths.

The width of each groove on the bullet is measured, proceeding clockwise, in sequence around the bullet, and the readings are then tabulated in order. If there is one groove on the evidence bullet and on the test bullet that is unusual in any way (as to width or marking) this may be called No. 1 for each bullet, and the readings then fall into order. One example of several identifications which were made by the author previous to 1925 is shown in Table 1.

TABLE 1

Widths of grooves

(Measurements made with the filar micrometer)

Grooves on fatal bullets		Grooves on test bullets		
Bullet X	Bullet Y	Bullet 1	Bullet 2	Bullet 3
.038 in.	.038 in.	.038 in.	.038 in.	.038 in.
.031 "	.031 "	.031 "	.031 "	.031 "
.034 "	.034 "	.033 "	.033 "	.033 "
.031 "	.031 "	.032 "	.031 "	.032 "
.032 "	.032 "	.032 "	.031 "	.032 "
.033 "	.033 "	.033 "	.033 "	.033 "

Note: The technique illustrated in this table is not only outmoded, because of the adoption of the comparison microscope which affords a much more positive means of identification, but would be inapplicable in these days when so many barrels are rifled by either the broaching or the button-swaging process. Barrels rifled successively with the same broach (or button) will have rifling grooves (and lands) which will show the same sequence of widths, thus making it impossible to say which of several barrels (rifled with the same tool) was the one from which a particular bullet was fired.

Two fatal bullets and a revolver taken from the suspect were submitted for examination. Three test bullets were fired into cotton waste, and the grooves on all five bullets were measured. All the bullets were very unusual as to the variation of the widths of the rifling grooves—which was an additional point in favor of the identification. The suspect confessed. Naturally this method cannot be used unless a sequence of measurements can be made, and often one does not have such a sequence because the bullet may be deformed too much.

Fig. 14. Method of interchange. (Applied to photos in Fig. 26.) *Left:* A portion of the photo of the Lowell Test Shell has been cut out and placed on the Evidence Shell. *Right:* A portion of the photo of the Evidence Shell has been placed on the upper part of the Lowell Test Shell.

Another method of identification used in the pre-comparison-microscope days was known as the method of interchange, which apparently originated in France—a method which required much skill, patience, and time. The evidence bullet was set up in front of a long-focus camera provided with a short-focus lens in order to get good magnification. Illumination was adjusted so as to bring out to best advantage the details of the markings on the bullet. If the bullet had six grooves, six pictures were taken, in sequence. The bullet was rotated and carefully positioned so that each succeeding groove occupied the same position on the ground glass as the preceding one. It is important that the angle of view be the same. Usually the groove, being the bearer of the best markings, occupied the exact center of the ground glass. Once established, the illumination was kept the same for all six exposures. Then the evidence bullet was replaced by a test bullet and a sequence of six pictures was made in the same manner, using the same illumination throughout. After prints were made from the properly numbered negatives, sections of the test pictures were cut out and placed on the appropriate evidence pictures to see if the markings matched. If portions of two photos (one of the evidence bullet, the other of a test bullet) when placed in juxtaposition were found to have a sufficient number of lines which were continuous across the boundary, the pictures were said to be matched.

In addition to being time consuming and tricky the method has the disadvantage that one never knows what degree of success he has had until all the pictures are taken and compared. Unless the bullets are placed in exactly the right position when photographed, the results will be disappointing. Figs. 14

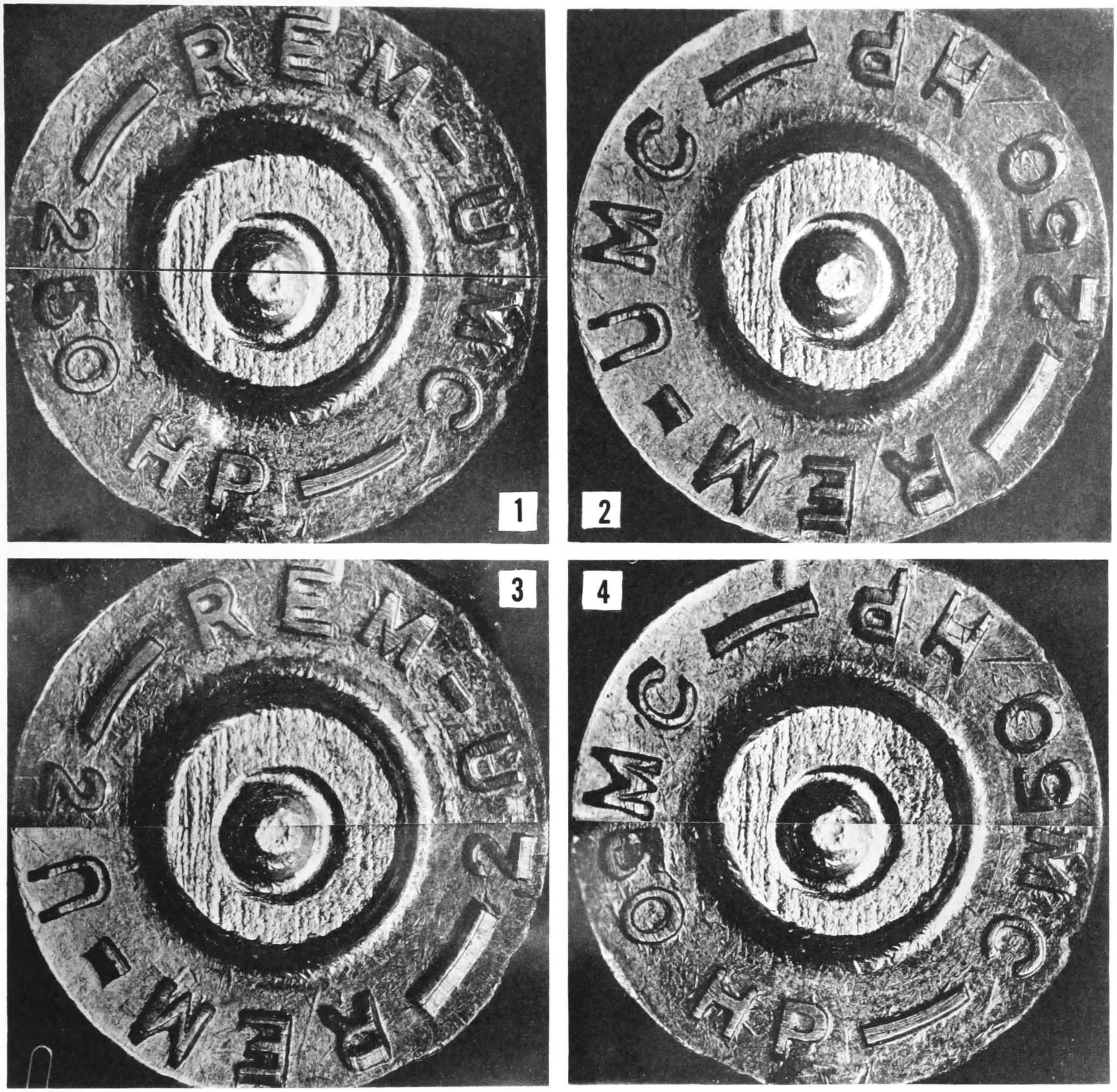


Fig. 15. Matching by method of interchange.

No. 1. Photo of head of fatal shell. (Cut in half for interchange.)

No. 2. Photo of head of test shell fired in suspect gun.

No. 3. Upper half of photo No. 1 superimposed on lower half of photo No. 2.

No. 4. Upper half of photo No. 2 superimposed on lower half of photo No. 1.

This method, now considered obsolete, originated with the noted French criminologist Balthazard in 1912 when he applied it to the identification of fired bullets.

and 15 show an application of this "method of interchange" as applied to the identification of shell heads through a comparison of breechblock markings. The method is much easier to apply in the case of shell heads because a whole series of pictures is not needed. It is of course necessary that the shells be placed in the same position and that they be illuminated the same, from the same direction and angle. Some experimentation will be necessary to determine the best angle for the illumination. Markings are made more distinct by using a low angle of illumina-