A General discussion of Gun Barrel Individuality and an Empirical Assessment of The Individuality of Consecutively Button Rifled .22 Caliber Rifle Barrels.*

by John E. Murdock**

Section I - General Discussion

A. Introduction

The examination of firearms as practiced in forensic science laboratories encompasses a broad range of problems ranging from "is this weapon operable and if so, has it been fired recently to how far was the muzzle from the subject when it was fired assuming that the fatal bullet was fired from the weapon in question."

The article by Davis (1) is probably the most cogent presentation of the diversity of problems which can be encountered in firearms examinations. This same article is also highly recommended since, in the opinion of this writer, the basic approach advocated by Davis is the most sound to ever appear in print.

The firearms examination most often requested is a comparison of a fatal bullet(s) with test firings from a firearm having a rifled bore to determine if the questioned bullet(s) was fired through the barrel of the submitted firearm to the exclusion of all others.

The inner surface of the bores of modern handguns and rifle barrels are either cut or formed with spiral grooves so that fired bullets may be projected accurately. The raised areas left standing in between the grooves are called the lands. Most bullets fired through rifled bores, if collected undamaged, will thus exhibit land and groove impressions on their bearing surfaces. The examiner first compares the class characteristics of test and questioned bullets. He considers such features as caliber; and number, size, and angle of land and groove impressions. If agreement is found, he microscopically intercompares the striations on the test bullets and then with the

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* This research was submitted by the author in December 1977 as a portion of a Masters Thesis entitled: Toolmark and Firearm Individualization as Affected by Manufacturing Methods, in partial satisfaction for a Master of Criminology degree, University of California, Berkeley, California. It was also presented at the 51st semi-annual seminar of the California Association of Criminalists, Big Bear Lake, California, May 11-13, 1978.

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questioned bullets. If sufficient agreement is found, the examiner may conclude that both test and questioned bullets were fired through the same gun barrel to the exclusion of all other gun barrels.

Why is it possible for the firearms examiner to make such a definitive opinion? It is because of the existence of the concept of the individuality of rifled gun barrels.

The individuality of rifled gun barrels is based upon the precept that each barrel will produce upon the surface of bullets fired through it a pattern of microscopic striations which will be unique to that barrel alone.

The background research responsible for this concept of individuality was conducted at a time when the rifling of gun barrels was accomplished through the physical removal of metal by cutters or scrapers. Much of this early work was done by Goddard who drew upon the "nature never repeats" theory (2-4) going so far as to compare the individuality of gun barrels with that of fingerprints. (5-7)

Goddard credits Balthazard with making the contribution in 1912 upon which the whole modern science of bullet identification rests. (8) This contribution is the purported observation by Balthazard that the cutter used in rifling a firearm never leaves quite the same markings in its successive excursions through a barrel.

Arthur B. Reeve, a writer of mystery fiction, as early as 1914 also credits Balthazard with showing that " . . . every gun barrel leaves marks on a bullet and that the marks are always the same for the same barrel but never identical for two different barrels. (9)"

The concept of the individuality of rifled barrels being due to continually changing cutting tool surfaces appears again and again in both the scientific firearms literature (10-18) and in the popular general crime literature. (19-21) The 1933 edition of a well known "Forensic Ballistics" correspondence course echoes this same basis for rifled barrel individuality. (22) The 1971 edition of this same course published by the same company under a different name states that even if no rifling tool wear were to occur, the barrels would still be individual since true metal cutting does not take place but rather a tearing of metal. (23)

The purpose of my research was not to question the validity of this early work but rather to test the appropriatness of the gun barrel individuality concept in light of a new swaging method of rifling gun barrels in which carbide buttons are used.

B. Cut Rifling Techniques

Before discussing this new method of button rifling, a review of the older techniques of rifling is in order.

In the scrape-cutter method a tool is utilized which consists of a rod, slightly smaller than the bore of the gun, into which is set either one or two hardened steel scrapers the height of which can be adjusted by a wedge, situated beneath the cutters, between successive passages through the barrel. (24) Anywhere from one to four scrape-cutters may be set into a given rod, depending on the type of rifling desired. It has been reported that anywhere from 2 (25) to 20 (26) barrels may be rifled with a scraper-cutter prior to resharpening and that approximately 75 (27) to 440 (28) barrels may be rifled before the cutter must be discarded. During the rifling process the scrape-cutter is rotated taking about 0.0001 inch of metal with each pass through the barrel. (29) This often necessitates many passages of the rifling head through the barrel. For example, in Colt .45 caliber automatic pistol barrels, which have six grooves, the rifling head moves through the barrel and back again approximately 420 times. (30) Scrape-cutters cut on both the forward and return strokes.

In the "hook-cutter" method, a cutter with the general shape of a crochet hook is set into a recess or slot in a rod which is a bit smaller than the bore of the barrel. (31) The height of the cutting edge of the "hook" can be adjusted by turning an adjusting screw at the end of the rod. The tool cuts only one groove at a time, removing about 0.0001 inch of metal with each pass. In the cheaper guns, only 20 or so passes are used for making each groove, whereas on finely made firearms as many as 80 or more passes might be used. (32) Anywhere from 5 to 50 barrels may be rifled per hook-cutter. The cutter is generally sharpened several times during the rifling of a single barrel. The tool life and sharpening frequency would, of course, depend upon the type of steel being rifled.

In the gang broach method of rifling, a tool is used which is composed of a rod upon which there are 25 to 30 hardened steel rings. Each ring is slightly greater in diameter than the preceding one and has slots of the proper size cut into it at equal intervals. The broach thus formed has a series (or "gang") of cutters, each of which has the same number of lands and grooves. (33) The lands on the cutters produce grooves in the barrel which are cut to the desired depth during a single passage of the broach through the barrel.

Each of the three methods of rifling described above have certain features in common. The bore is formed by drilling a hole in a length of bar stock. The hole margins are smoothed somewhat by a cut-reaming operation. This cut-reaming operation was the rule some years ago but has undergone modification in recent years. This modification has been the replacement of the cut-reaming step by a process known as swaging. This process will be discussed presently. After reaming, the grooves are formed by a process which involves the physical removal of metal by a scraping or cutting

edge. It wasn't long before firearms examiners discovered that "Family" resemblences were sometimes present on the groove impressions (raised lands on fired bullets) of bullets fired from consecutively rifled gun barrels which had been scrape or hook (34-36) rifled and barrels that had been broached. (37, 38)

The same type of carry-over of "Family" resemblences has been observed in firings from .32 S&WL caliber F.I.E. Corporation, Titanic revolvers. (39-41) The specific method of rifling for the Titanics was not reported but almost certainly some type of cutting edge was employed. The carry-over of family resemblences in these Titanic barrels was observed only in the bullet groove impressions. The land impression striations did not match. From the coarse nature of the tool marks in the Titanic barrel grooves, there does not appear to have been any lapping or honing used to smooth the bore.

The possibility of finding matching striae in bullet grove impressions between bullets not fired through the same barrel has caused much emphasis to be placed upon matching striae found in land impressions. This is, of course, because the scrape or hook cutting edges do not cause any appreciable tool marks on the barrel lands. The broach technique is, however, purported to cause definite scoring of the barrel lands as the grooves are cut. (42, 43) This scoring by the broach bearing surfaces would probably not result in a carry-over of family resemblences since it is not a cutting edge which makes the tool marks on the surface of the barrel lands. This observation has been confirmed somewhat by the study performed by Lutz (44) where he test-fired both plain lead and fully jacketed .38 Special bullets through two *consecutively broach rifled and honed (45) Smith and Wesson revolver barrels.* The testfirings were easily associated with the correct barrels. An inter-comparison revealed very little agreement or carry-over of striations in corresponding land impressions. The groove impressions were not compared. This would have been interesting since most carry-over of "family" striations, if present, should have been found there in the groove impressions.

Since most carry-over type striae are quite coarse, reliance has been placed upon agreement between the finer type of striae whether they be found in bullet land or groove impressions.

It would appear that most authors subscribe to the individuality of gun barrels based upon the non-repeatable nature of man-made items.

They also believe that this individuality is a discernible feature and is manifested by changes that occur as a result of either tool edge break-down or the random formation of work hardened metal chips which act as secondary cutting edges as the rifling is being accomplished. A much more conservative view is offered by Camps who advises us when making identifications to be sure that matching striae are caused by " . . . specific identification characteristics of individual weapons" and are " . . . not the result of a general design, style, or class of material resulting from repetitive formation, as in a manufacturing process." (46)

C. New Methods of Rifling

Are the above reasons for gun barrel individuality valid in light of changes in rifling methods? It was with these questions in mind in 1968 that an inquiry, which may be seen as Appendix #1 (pages 13 and 14), was formulated and sent to over 80 rifle barrel makers, reboring and rerifling shops, and U.S. and foreign gun manufacturers listed in Gun Digest. (47) The responses received appear as Appendix #2 (pages 15 through 20). Although dated, the replies are included here for your general information. An analysis of these replies indicated that at that time to a large extent, especially on a volume basis, rifling was being accomplished using the button swage process.

The button swage process is a cold-forming process developed shortly after WWII (48) in which a small carbide plug (button) is forced through a softer steel small arms bore which has been formed by drilling and reaming. In some instances, the reaming process is supplanted by the passage of a bore button down the drilled barrel (ballizing). The rifling button is an extremely hard tungsten carbide torpedo shaped plug having a cross section of the desired rifled bore engraved on its surface in negative. This is forced through the inside diameter to form the rifling. (49, 50) This process is unique because no metal is removed during rifling formation. In fact, due to compression of the metal in the bore it becomes work hardened resulting in longer barrel life. Many thousands of barrels may be rifled quickly and less expensively using this method. Indeed it has been reported that in .22 caliber it is not uncommon to rifle between 40 thousand and 60 thousand barrels per button. (51) A rather thorough description of this process appears in Hatcher, Jury and Weller (52).

Another cold-forming process used is mandrel rifling. This process involves the insertion of a mandrel having a negative impression of the rifling into an oversized smooth-bore barrel. The barrel and mandrel are then passed through forming dies which compress the barrel to the mandrel form. The barrel and mandrel are then passed through straigtening rollers after which the mandrel can be removed by unscrewing it from the barrel. (53)

A third cold-forming process is called hammer-rifling. In this process, heavy automatic machinery is used to hammer, or knead, a piece of steel tubing over a mandrel having a negative profile of a section of the desired rifling. As the piece of tubing advances around the mandrel, the multiple hammers of the machine forge the interior of the tubing to the rifle form. (54)

Since these methods of cold-formed rifling are accomplished without the removal of metal, it was my opinion that the concept of the individuality of cut rifled barrels promoted by pioneers in the firearms identification field could not be transferred unilaterally to button rifled gun barrels. I chose, therefore, to empirically evaluate the individuality concept through an examination of plain lead bullets testfired through consecutively

button rifled .22 caliber rifle barrels. Austin did some research in this regard using .30-30 caliber 170 grain jacketed rifle bullets. (55) Austin obtained three Marlin lever action Model No. 336RC, .30-30 caliber carbine rifles with consecutively rifled 20-inch barrels. Ten bullets were fired through each barrel. He was able to identify consecutively fired bullets with other bullets from the same barrel. An intercomparison of bullets testfired from different barrels with one another revealed no agreement, thus, no carry-over of "bore-signature". Austin did find a marked reduction in the number of striations on fired bullets as compared to the number found on bullets fired through barrels which had been broach rifled.

The 1971 correspondence course entitled, "Firearms Identification" already mentioned in connection with cut rifling, treats the individuality of button rifled barrels very lightly stating only that imperfections will remain after the lapping and finishing operations are completed. (56) Before considering the effect of this type of rifling upon individuality, I investigated the possible effects of crowning. (57) This question came to mind while reviewing Austin's work. The effect of crowning on gun barrel individuality was evaluated by comparing testfirings from four button rifled .22 caliber rifle barrels. All barrels were testfired, recrowned and testfired again. Three of the four barrels were recrowned a second time and testfired. A comparison of test bullets from each barrel with bullets from the same barrel following recrown revealed that although some changes in striae pattern were observed, sufficient agreement was noted to enable identifications to be effected. A property performed crowning operation has, therefore, minimal effect on gun barrel individuality.

Section II - Comparison of Testfirings from Consecutively Rifled .22 Caliber Rifle Barrels.

A. Introduction and Preparation of Barrels

The firms of Marlin, Mossberg, and Remington each provided three consecutively rifled .22 caliber rifle barrels. The method of manufacture of these rifle barrels is described in figure No. 1. Each series of three consecutively button rifled barrels was numbered 1, 2, and 3 by the manufacturer.

The breech end of each barrel was machined to fit into a Mossberg bolt action. (Figs. No. 2 - 5). Each barrel was then chambered for the .22 LR cartridge (Figs. No. 6,7). A standard crown was machined at the muzzle end of each barrel (Figs. No. 8,9). Each finished crown was examined microscopically to insure that no flaws were present which could cause markings on testfired bullets. A representative example of the appearance of the rifling at the muzzle has been included as Figures No. 10 - 13. The Ithaca barrel was used in the recrown research.

B. Method of Testfiring

An untreated dry cotton mop was passed through each barrel prior to testfiring. Each barrel was indexed to the Mossberg bolt action by lining up marks scribed onto each. A series of ten plain lead standard velocity Remington .22 LR caliber bullets was fired through each barrel. Each bullet was indexed by placing a scribed line on its

nose. Each series of ten testfirings through each barrel was accomplished without any additional cleaning of the bore. All test bullets were collected in a vertical water recovery tank. Prior to firing, the nose of each bullet was marked with identifying data so that it would not be confused with any other test bullet. Thirty bullets were fired through each barrel.

C. The Examination - Technique and Results

The comparison of the testfired bullets was accomplished on a Leitz bullet comparison microscope using the 50 mm objectives and 10X eyepieces. A pair of Bausch & Lomb 120V, 9.5 watt fluorescent lamps were found to provide the best illumination. (Fiber optics were found to put the examiner at a definite disadvantage).

In general, the comparison between the first, second, and third firing from any one barrel failed to result in an identification. Some good agreement was present, however. The third, fourth, and fifth testfirings from any one barrel could, however, generally be identified as having been fired through the same barrel. It became obvious that each barrel needed to have a few bullets fired through it before it began marking in a reproduceable, identifiable manner.

The first bullet testfired from each barrel was intercompared with other first test bullets from the same series of three barrels. In addition, bullets testfired number four, five, etc., after the barrels had settled into producing a fairly reproduceable, identifiable striae pattern were intercompared. All of these bullets were compared near the base and near the front portion of the rifling since the striae patterns were found to change to a considerable extent from nose to base.

The intercomparisons between bullets testfired from barrels 1, 2 and 3 of each set were carried out in the following way: One bullet was lined up at its phase mark and kept stationary while the bullet being compared with it was rotated 360 degrees. With the 50X objectives, it was possible with the Marlin firings (rifled 16 right) to view and compare one land and adjacent groove impression at one fixed position of the stationary bullet. The Marlin bullet being rotated 360 degrees was thus stopped at 16 positions and microscopically compared for significant agreement at each. This procedure was continued until every land and groove impression on one bullet was compared with every land and groove impression on the other.

Since the Mossberg (8 right) and Remington (6 right) rifling left wider land and groove impressions, it was possible to view only one land or groove impression at a time.

In order to determine if the writer could recognize significant agreement when it should be present, testfirings from one barrel from each set were compared without reference to phase marks. In each case where the writer recognized what was considred subjectively to be significant agreement, the phase marks were found to line up correctly thus validating the comparison techniques.

The result of this extensive amount of intercomparison was that there was absolutely no indication of a carry-over of Family-type striations on bullets fired from consecutively button rifled .22 caliber rifle barrels manufactured by Marlin, Mossberg, and Remington. In fact, none of these nine barrels would even reproduce striae patterns on the first few bullets fired through them well enough for identifications to be effected. However, some coarse (Fig. No. 14) and some fine striae were found to agree (Fig. No. 15). I also observed the usual type of agreement normally found when bullets known to have been fired through different rifled gun barrels are compared with one another. It is, of course, only by making comparisons of known "mismatches" that the examiner can gain the ability to appreciate the significance of matching striae observed when comparing questioned and testfired bullets.

These results also clearly demonstrate the individuality that can exist in button rifled gun barrels. It is hoped that this research has contributed a little more science to the art of firearms identification.

Acknowledgements

The author wishes to thank the four firearms manufacturers who provided the rifle barrels, and Forest Motter, the gunsmith who performed the mechanical operations on them.

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OFFICE OF THE SHERIFF

CONTRA COSTA COUNTY

WALTER F. YOUNG
SHERIFF
MARTINEZ, CALIFORNIA

April 19, 1968

Gentlemen:

There is currently an increased emphasis being placed on the utilization of physical evidence in the United States initiated by various levels of government and agencies involved in the judicial processes. It is essential in order to implement such increased usage of evidence that adequate background data be available to permit the correct interpretations of laboratory observations. There is currently some evidence that such basic data may well be currently outdated as a result of improved technology.

In an endeavor to up-date such data, as well as to re-examine previously accepted hypothesis, the staff of this laboratory in connection with the graduate division of the School of Criminology of the University of California at Berkeley, is currently engaged in a research project regarding the interpretation of observations of firearm evidence. This research project is specifically directed towards those manufacturing procedures which may directly influence the manner and types of markings which occur on projectiles fired in small arms. Accordingly, we would appreciate information from your company relating to present and past manufacturing procedures as they relate to this project. We would therefore appreciate information which you may be able to forward us regarding the below listed subject matters:

(1) What techniques are currently being used by your company to rifle and finish the interior of various caliber gun barrels.

(2) What techniques, if any, have your current methods of rifling replaced and when did these changes occur.

(3) A description of the various rifling techniques used in the past and those currently being used, including such information as:

   a) The number of barrels rifled per tool prior to the tool being resharpened or discarded (tool - broach, button swage, hook or scrape cutter, etc.)

b) Tool life (number of resharpenings, etc.)

c) The number of barrels made from the same length of rifled stock.

Be assured that any information furnished by your company will be properly acknowledged in any publication resulting from this project.

We would appreciate information also as to the availability of internally finished barrels for small caliber weapons which have been consecutively finished by the same tool. Should such items be available, we would appreciate a quotation regarding their cost.

Any assistance which you may be able to render in this area of research will be greatly appreciated. Hoping to hear from you soon.

Very truly yours,

JOHN E. MURDOCK
Criminalist

JEM/vw

Appendix #2

Responses to Questionaire

These replies were received by December, 1968 and are included here simply to give the reader an appreciation of the "state of the art" at that time.

1. A & M Rifle Co., Box 1713, Prescott, Ariz. 86301

   Their barrels are rifled with a hook cutter, the cutter being sharpened in every barrel. Tool life for a hook cutter is about 30 to 50 barrels. One barrel is made per length of rifled stock.

2. Colt's, 150 Huyshope Ave., Hartford, Conn. 06102

   The following summary defines the present and past methods employed by Colt in the manufacture of small arm bores.

   1940 to 1948: Gun Drill - Ream - Hook - Lead Lap

   1948 to 1956: Gun Drill - Ream - Broach - Lead Lap

   1956 to 1966: Gun Drill - Ream - Broach - Wire Brush

   1966 to date: Gun Drill - Hone - Ballize - Broach - Wire Brush

   The average broach life is 8 to 10 regrinds. Colt does not manufacture small arm barrels from rifled stock, and all barrels are made from individual blanks and or forgings.

3. Fuller Gun Shop, Cooper Landing, Alaska 99572

   This craftsman employs methods used by "old time mountain gunsmiths" to rerifle the bores of muzzle loading rifles and reports that bullets which have passed through these barrels show "very little of the rifling on them when shot."

4. Hart Rifle Barrels, Inc., RD 2, Lafayette, N.Y. 13084

   This firm has been making stainless steel rifle barrels since about 1952 and has never used anything but the

button rifling system. Their barrels are lead lapped to produce a smooth inner surface and a uniform inside diameter. Estimates that, barring difficulty, one button may be used to rifle several thousand barrels. One barrel is made per length of rifled stock. The following caliber barrel blanks, made of stainless steel are currently being produced.

.22
.224 cal. in 14" twist
.25 cal. in 10" and 12" twists
.243 cal. in 10", 12" and 14" twists
.264 cal. in 8", 9" and 12" twists
.284 cal. in 9" and 10" twists
.30 cal. in 10", 12" and 14" twists

5. International Gunmakers, 12315 Newburgh Rd., Livonia, Michigan 48150

This firm produces percussion or flint ignition rifle and pistol barrels. Barrels are either cut reamed or reamed using a pull-type carbide button. Following the reaming operation, the rifling is accomplished using either a hook or scrape cutter or a carbide rifling button. Scrape cutters, which may be sharpened a dozen or more times, wear faster than hook cutters, which may be stoned or ground many dozens of times. About twenty barrels could be rifled using a scrape cutter before resharpening would be necessary. This firm normally makes one rifle barrel from each round bar stock length, but occasionally several 10" pistol barrels, are cut from one length of rifled round bar stock.

6. Ithaca Gun Co., Ithaca, N.Y.

This firm began, in the early 1950's, to produce .22 caliber rifle barrels for automatic rifles by means of broaching. In June, 1957, the buttoning method of rifling replaced the broaching process. All barrels produced since 1957 have been by the buttoning process. Blank barrels are cut from bar stock, drilled, reamed, ball sized, and buttoned individually. Although a good estimate of the number of barrels produced by a single button would be approximately one thousand, careful inquiry shows that these buttons do not wear out, but are generally broken due to accident, possibly due to the lack of care on the part of the operator or differences encountered in steel.

7. Ward Koozer, Box 18, Welterville, Ore. 97489

This firm engages in the reboring of old rifle and pistol barrels and reports that following reaming the rifling is accomplished with a scrape cutter. From two

to six barrels are rifled with one sharpening of the scrape cutter. The tool life of one scrape cutter is approximately 75 rifle barrels.

8. O. F. Mossberg & Sons, Inc., 7 Grasso St., No. Haven, Conn. 06473

This firm reported the following pertaining to .22 cal. rifles released for sale 1938 - 1958.

4 cut grooves on all models to 1948

5 cut grooves on all models 1946 - 1947

6 cut grooves on all models 1948 - November 1952

6 swaged grooves on all models November 1951 - November 1952

8 swaged grooves on all models November 1952 - Present April 1968

"Cut" groove is made with cutting tool in rifling head indexed.

"Swaged" groove is made with a carbide button pulled through barrel.

The average life of the swaging buttons used to rifle .22 caliber barrels is about 50,000. The higher alloy steels used in their center fire rifles reduces tool life to approximately five to eight thousand barrels. Swage buttons are not sharpened or reground but are discarded when worn below minimum diameter. Each barrel is rifled individually.

9. Noble Mfg. Co. Inc., S. Main St., Haydenville, Mass. 01039

This company reports that since manufacturing .22 rifles was begun in 1949, the rifling has been accomplished using the button swedge method. Twenty two caliber is the largest size produced by this company. After rifling approximately 1500 barrels, the button swage is discarded. Each barrel is rifled individually.

10. Nu-line Guns., Inc., 5127 Natural Bridge, St. Louis, Mo. 63115

This company reports that they are currently using the hook cutter method of rifling barrels and that the cutter is sharpened after the rifling of each barrel. The tool life of each hook cutter is reported to be about five barrels.

11. Remington Arms Co., Bridgeport, Conn. 06602

This company, surprisingly enough, supplied rifle barrel dimensional data but informed the writer that specific data which I requested is not readily available for publication purposes.

12. Rohm Gesellschaft m.b.H., Sontheim/Brenz, Germany

This company, which markets large quantities of inexpensive, poorly made .22 cal. revolvers in the United States, informed this writer that barrels used in their weapon were made by other companies and supplied to them. The names of these suppliers were not provided.

13. Sears, Roebuck & Co. 825 S. St. Louis, Chicago, Ill. 60607

This company was unable to furnish the information requested as all firearms sold by them are manufactured under private label by Olin Mathieson Chemical Corporation, Winchester - Western Division; Savage Arms Corporation, Westfield, Massachusetts; etc.

14. Ed Shilen Rifles, 4510 Harrington Rd., Irving, Tex. 75060

This firm reports that they use the button method to rifle their barrels. Several thousand barrels may be rifled by one button. Although they obtain one barrel per length of rifled stock, they report that they supply barrel blanks to other gunsmiths and manufacturers who would quite possibly cut up a rifle barrel blank to make two or three pistol barrel blanks from it. The comment is made also that if a rifling button is kept in good shape, it leaves no tool marks of any kind inside the barrel.

15. Smith's Gun Shop, Box 486, East Tawas, Mich. 48730

This concern reports that they no longer manufacture barrels but are instead doing reboring and relining. Rifling is accomplished using a hook cutter. The cutter is sharpened while each barrel runs with a diamond hand stone. Approximately 50 barrels are rifled per tool before discarding. The only time that more than one rifled barrel would originate from the same length of rifled stock would be for a liner.

16. Snapp's Gunshop, 214 N. Washington, Royal Oak, Mich. 48067

This gunshop reports that its work is done on a custom basis. This involves, for the most part, the reboring of rifle barrels using the cut rifling method. Tooling

will last as long as 40-50 barrels on some of the older softer iron barrels, and on more difficult steel, it will take 2-3 cutters to get one barrel rifled. As a rule, the rifling cutter will be touched up with a stone after each barrel and sometimes maybe 2-3 times during the rifling of one barrel. For rebarreling, button rifled barrels are purchased from the G. R. Douglas Company, Charleston, West Virginia.

17. Weatherby's, 2781 E. Firestone Blvd., South Gate, Calif. 90280

This company reports that the method of rifling employed for their rifle barrels is the hammer-forged system. In this system, the caming surfaces of the hammers pass under the rollers and exact a powerful half-million pounds of squeezing action on the mandrel, thus producing a rifling completely free of any reaming or rifling marks. This method of rifling was initiated in 1959. Prior to this time, the horizontal broaching method was employed.

18. Marlin Firearms Co., 79 Willow, New Haven, Conn. 06502

This firm reports that through the late 40's the hook cutter method of rifling was employed. About 10 to 20 .22 caliber barrels were normally rifled per sharpening of the cutter. On these barrels the average cutter life was approximately 2 to 3 thousand barrels. In high power barrels of alloy steel, one might expect to go to 2 or 3 barrels per sharpening although sometimes a tool would require sharpening before it had completed a single barrel. The tool life in this case would be between 500 and 1,000 barrels. This firm now employs carbide rifling buttons to fabricate all of their rifle barrels. In .22 caliber, it is not at all uncommon to rifle between 40 and 60 thousand barrels per button. No sharpening or other maintenance is normally required. Although, very occasionally a button may pick up a little barrel steel on a land due to poor lubrication. This pick-up has to be polished off or it will tear the bottom of the groove it is making. In the case of high power buttons, the button life is usually between 5 and 10 thousand barrels. Each barrel is rifled individually.

19. Numrich Arms Corp., W. Hurley, N.Y. 12491

This firm advises that since they first started producing barrels that they have employed both the hook cutter and the button brooch. The hook cutter is used only on barrels for muzzle loader type weapons at present.

All hi-power - .22 RF and pistol caliber barrels are buttoned.

The hook cutter is employed to rifle 40-50 barrels before being resharpened with tool life (cutter) being 10-20 sharpenings. The button may rifle 500-1000 barrels before being repolished. They may be repolished several times and it is uncertain as to when they will be discarded.

Three to five revolver barrels are made from the same length of rifled stock while only one rifle barrel per length of rifled stock is fabricated.

Information received from Werner Vogel, General Manager.

Figure No. 1

Manufacturers	Method of Manufacture
Ithaca Gun Company, Inc. Ithaca, New York 14850	The barrel was drilled, reamed, ball sized* and button rifled. (6 right)
The Marlin Firearms Co. 79 Willow Street New Haven, Conn. 06502	The barrel was rifled with a carbide button. (16 right)
O. F. Mossberg & Sons 7 Grasso Avenue P. O. Box 497 North Haven, Conn. 06473	The barrel was rifled by pulling a carbide button through the barrel. (8 right)
Remington Arms Company Ilion, New York 13357	The Model 580 barrel was rifled using a swage process with no lapping. (6 right)

Method of rifling employed by those manufacturers who provided .22 caliber rifle barrel blanks.

* A procedure which involves pulling an oily carbide ball through the barrel after it is button rifled. This procedure sizes the lands. The ball may be attached to the rifling button or it may be a separate tool. (Information from Robert Johnson, Ithaca Gun Co., Customer Relations Dept., Ithaca, New York, Nov. 28, 1977)
"Ballizing" is a synonymous term and can also refer to the passage of a carbide ball through a barrel immediately following the drilling operation. This swaging procedure has, to a limited extent, replaced one of the cut reaming operations.

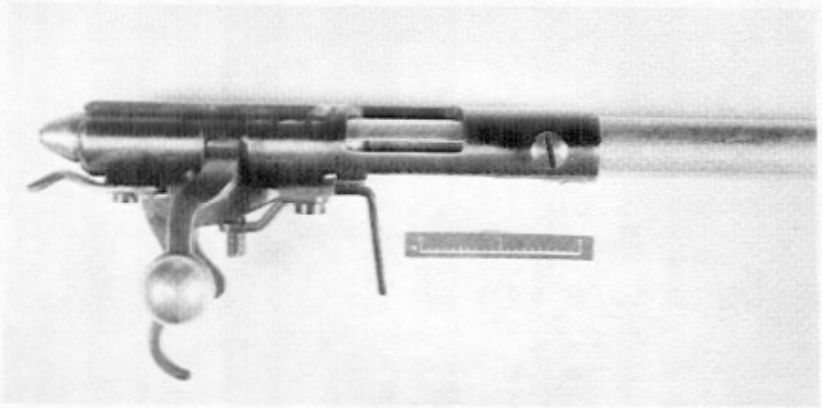

Figure No. 2

View of right side of Mossberg bolt action. Bolt is closed and a test barrel is being held in place by pressure from two screws (the head of one is illustrated).

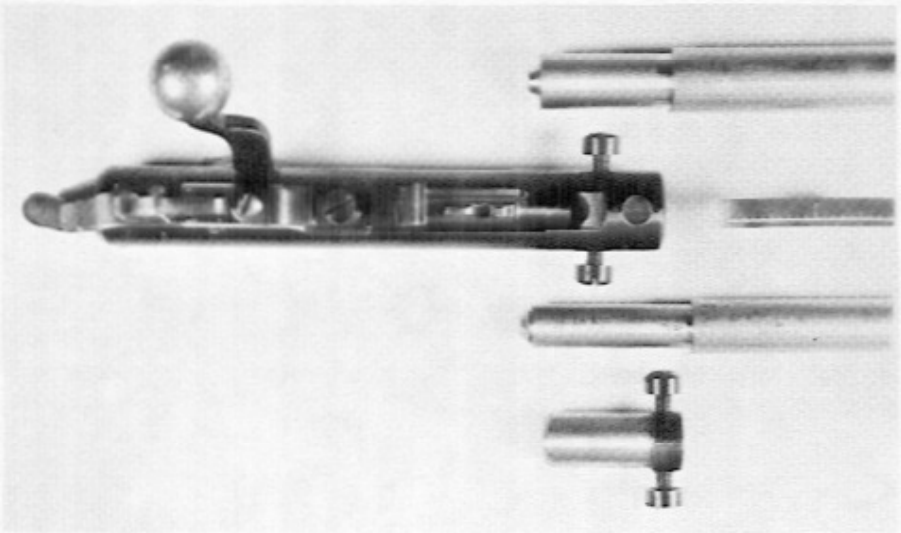

Figure No. 3

Underside view of Mossberg bolt action with a .22LR caliber cartridge case in firing position. The machined breech end of test barrels are held in place by screws.

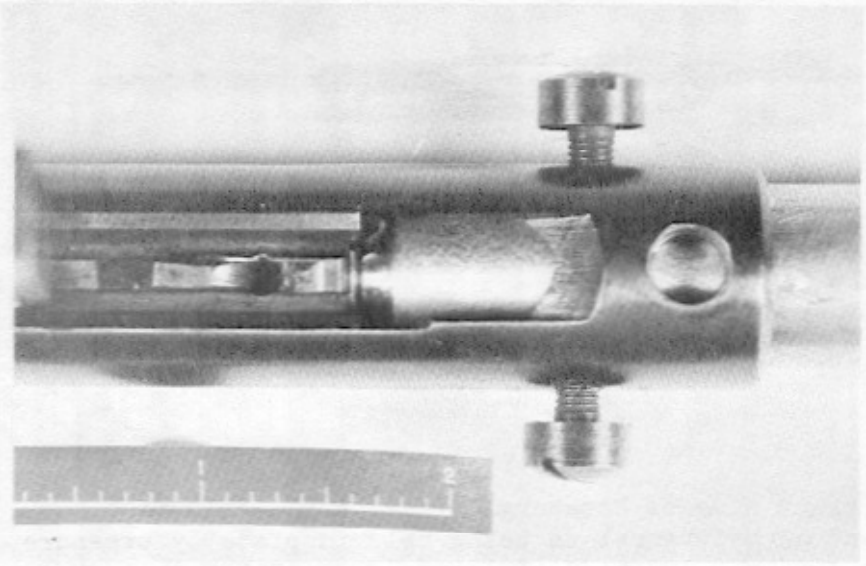

Figure No. 4

Two screws holding a barrel in place.
A .22 cal. cartridge case is chambered.

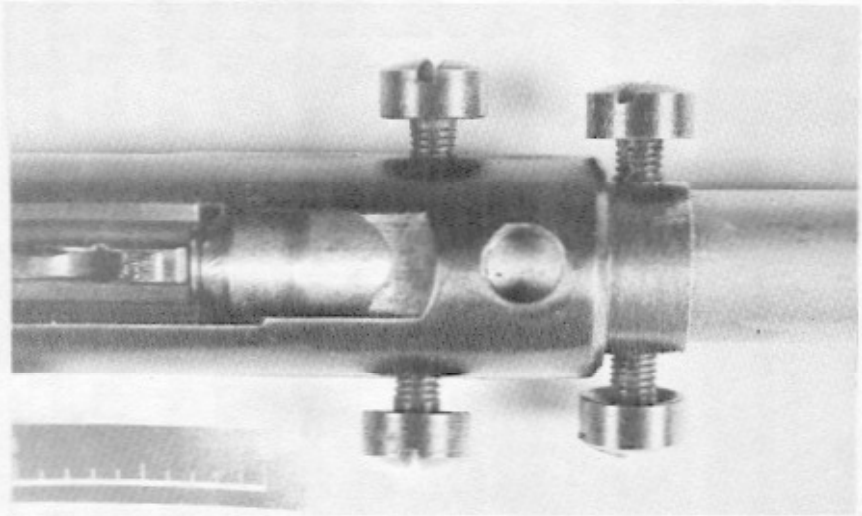

Figure No. 5

Four screws and adapter holding a barrel in place. A .22 cal. cartridge case is chambered.

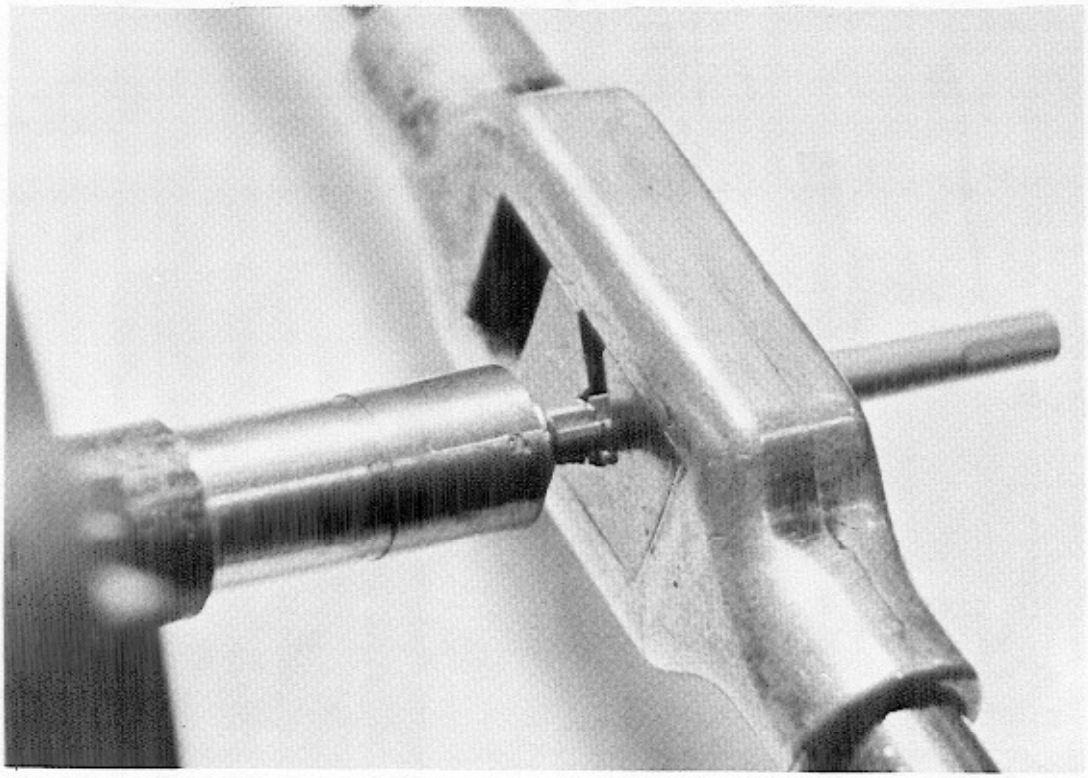

Figure No. 6

The Chambering Operation

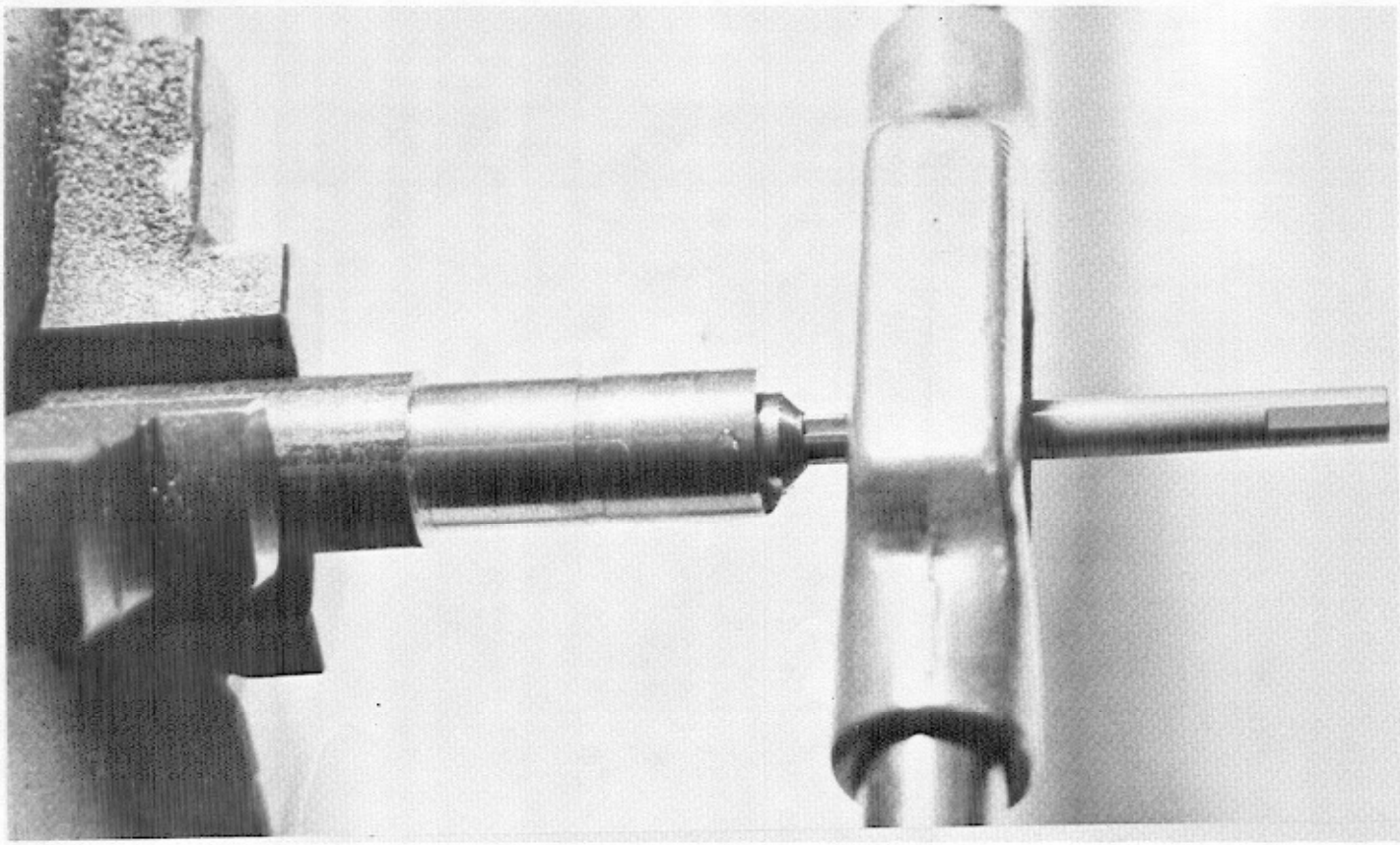

Figure No. 7

The Chambering Operation

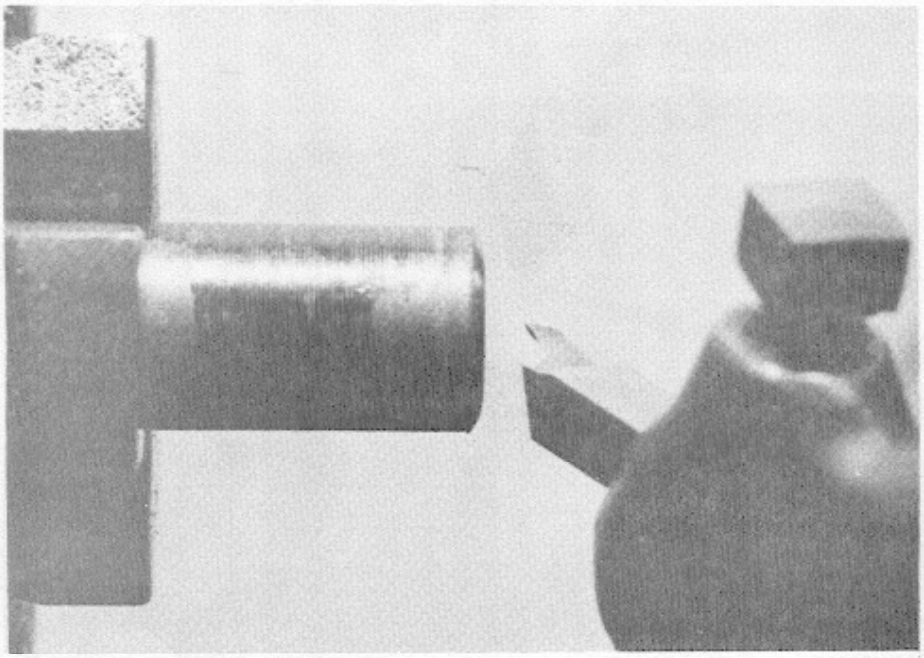

Figure No. 8

The Crowning Operation

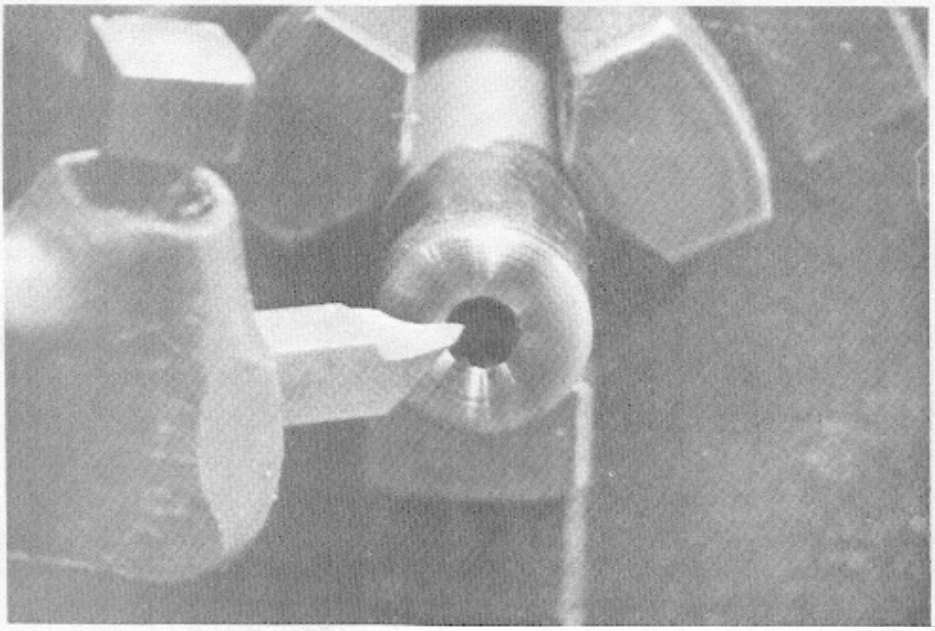

Figure No. 9

The Crowning Operation

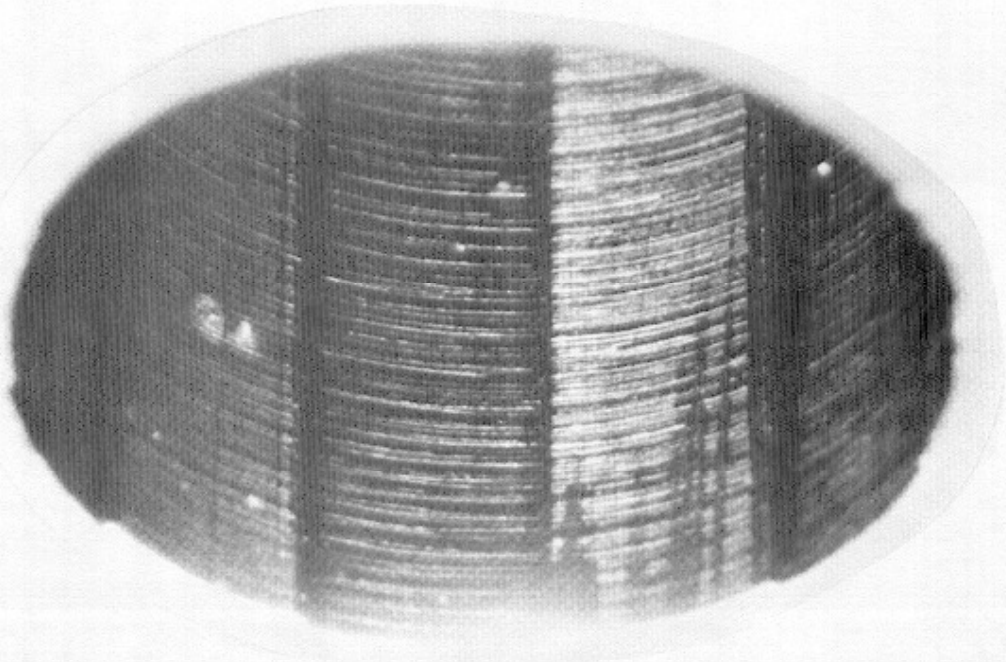

Figure No. 10

Ithaca Rifling

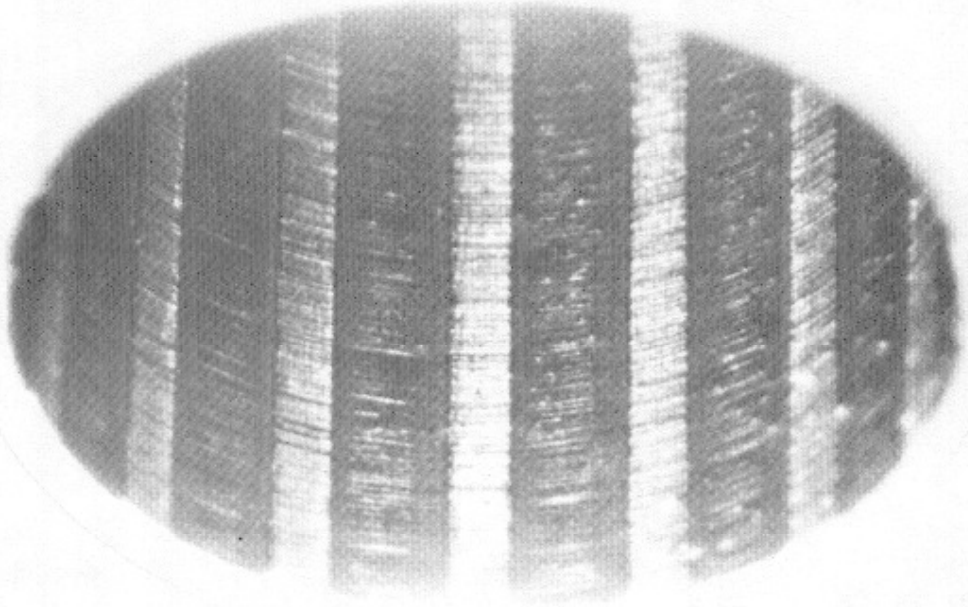

Figure No. 11

Marlin Rifling

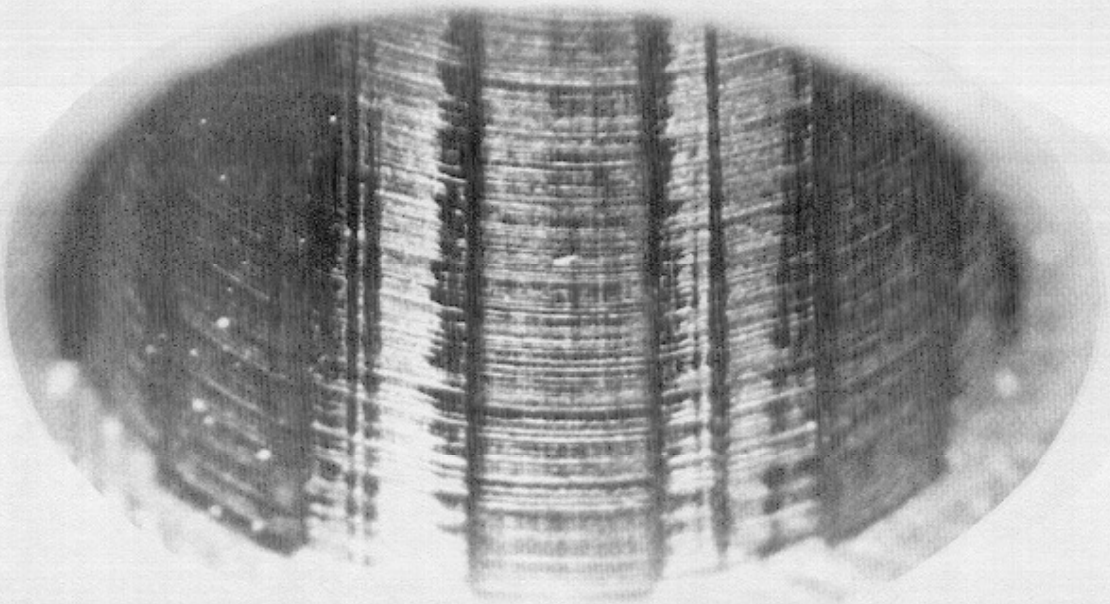

Figure No. 12

Mossberg Rifling

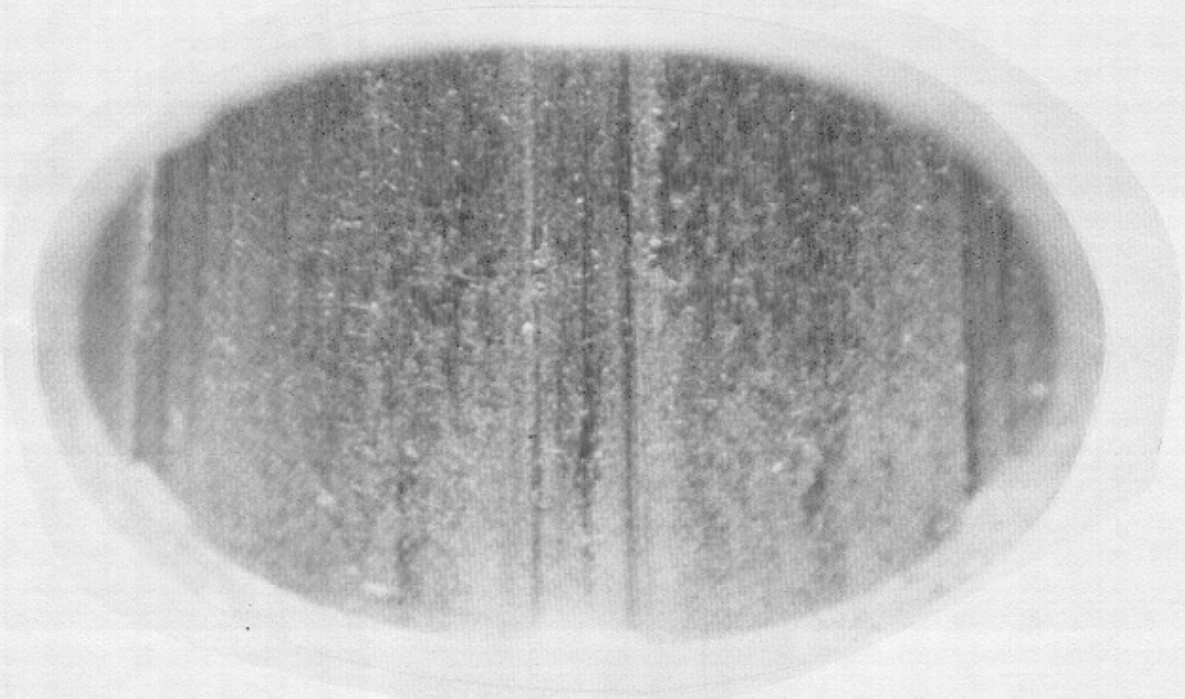

Figure No. 13

Remington Rifling

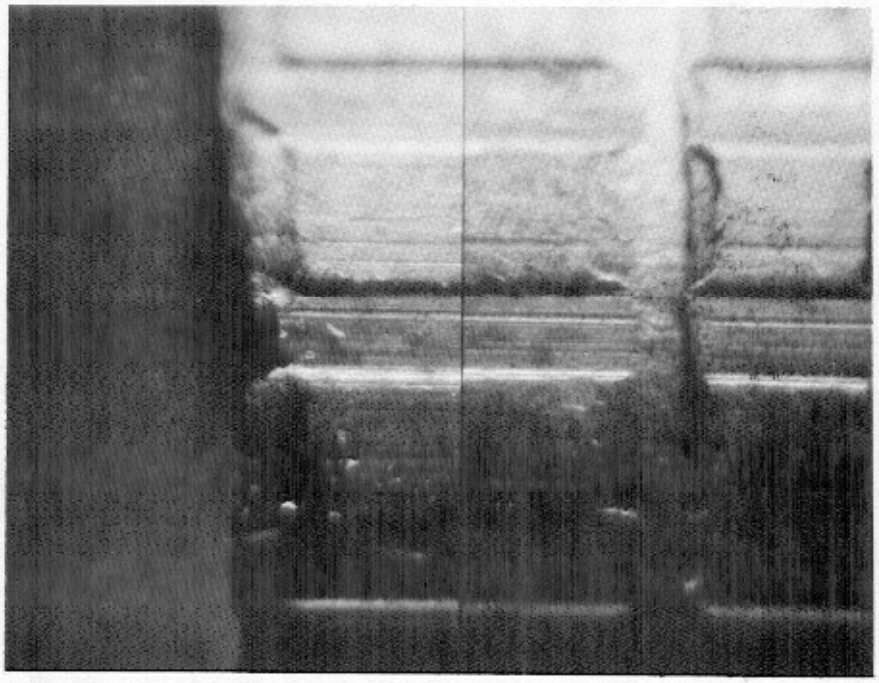

Figure No. 14

MARLIN
Barrel No. 1
Testfiring No. 1

MARLIN
Barrel No. 2
Testfiring No. 1

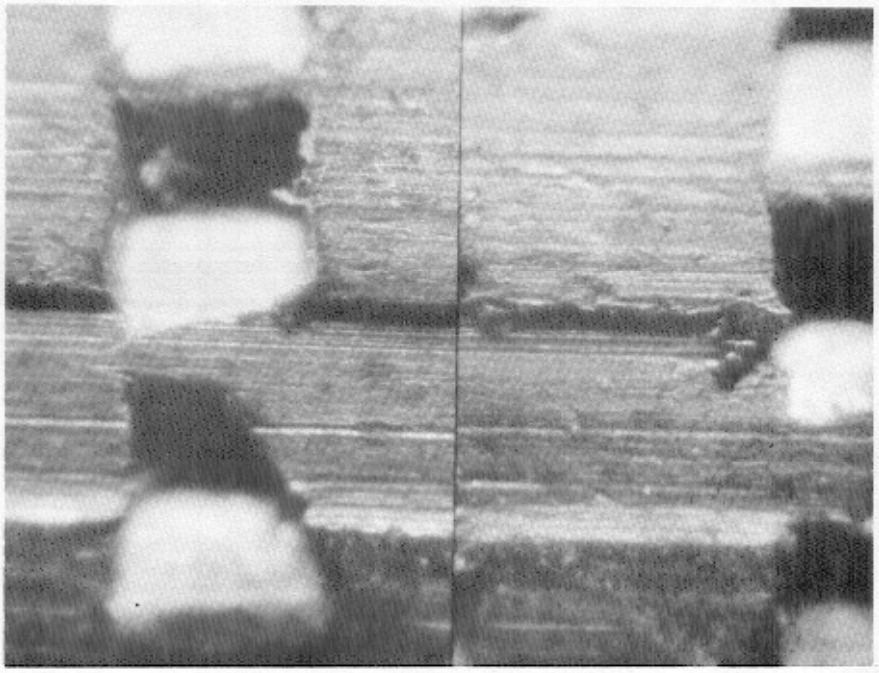

Figure No. 15

MARLIN
Barrel No. 2
Testfiring No. 1

MARLIN
Barrel No. 3
Testfiring No. 1