RIFLING METHODS - A REVIEW AND ASSESSMENT OF THE INDIVIDUAL CHARACTERISTICS PRODUCED

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The arguments traditionally put forth to explain and justify why the toolmarks imparted by a specific gun barrel to fired bullets are, or are not unique can be divided into theoretical and practical arguments.

Comments on the discovery of striation matching by Thomas (1967) reveal that striation matching as applied to toolmark identification was introduced about 1900 by early European pioneers in the forensic sciences. The author's review and subsequent correspondence with Dr. Thomas relative to his article indicates that the arguments presented by these early pioneers were essentially theoretical (i.e., mathematical/statistical) rather than fundamental and practical proofs of identification. In most cases, exemplary and classical "identifications" were offered to demonstrate and support the validity of the purely mathematical/statistical proofs presented. This type of circuitous reasoning persists, and remains today the mainstay of proof applied by most examiners without addressing the fundamental issues of identification.

The few practical reported demonstrations of proof in striation matching have usually been limited to situations where individual examiners have fired tests from consecutively rifled pairs of barrels, and then intercompared the tests from the same and different barrels to determine whether or not bullets fired from consecutively produced barrels can be "subjectively" differentiated. (Austin, 1969; Lutz 1970; Haag, 1977; Freeman, 1978; and Murdock, 1981.) Unfortunately, such demonstrations are of real value only to the persons making the comparisons because of the subjective nature of conclusions reached. This approach has also served to delay the development of objective criteria of identification which could be used to communicate among examiners the qualitative or quantitative similarities or differences observed.

Short of developing objective criteria of identification for striation matching, there is an alternative approach that can provide a fundamental understanding of, and the basis for, objective criteria of identification. Experimental work started by the author about 1955 to deal with these fundamental issues has continued sporadically to the present time and now includes examples of all of the different rifling methods used since the introduction of rifled gun barrels.

METHODOLOGY

Basically, the approach has been to study the fundamental character of the surfaces produced by the various rifling tools and processes by means of a PLASTISOL replica technique previously reported by the author (Fig. 1, Biasotti, 1956). The rationale of this approach is that if it can be shown that a particular rifling method produces toolmarks that are unique to a single barrel, then it is a valid assumption that any markings transferred to bullets fired from such a barrel will likewise be unique. This approach is valid because the toolmarks produced by the rifling method used become the primary source of the individual characteristics that are imparted to fired bullets.

It is proposed therefore that different rifling methods can be evaluated as to their potential for individuality by examining how the various rifling tools are made and used together with a critical evaluation, of the actual toolmarks produced by these rifling tools and methods in the production of rifled barrels.

DISCUSSION

With this background, the following review and assessment of rifling methods and their inherent potential for producing unique individual toolmarkings is offered:

HOOK CUTTER METHOD: Consists of a single point (hook shaped) cutter that is pulled through a barrel, cutting one groove at a time. The hook is pulled through 10 to 20 or more times for each groove to produce the desired groove depth.

The potential for individuality in the groove engravings of barrels consecutively rifled by the hook cutter method is very high when barrels are rifled individually. If, however, a length of barrel is rifled and then cut into sections to form several barrels, a high degree of correspondence may occur in the groove engravings in each barrel part that is not subjected to further finishing, such as lapping. Another caution is that adjacent groove engravings in the same barrel can also display a high degree of similarity. This similarity from one barrel section to another section, or from groove to groove, may occur because the single hook cutter edge makes the final cut in each consecutive groove *on the final pull through the barrel for each groove* finished. See figure 2 and perform the suggested exercise as a demonstration of the similarity that can exist in adjacent grooves cut by the same hook cutter. Another example of this hook cutter "carryover" effect is illustrated and discussed in Gunther and Gunther (1935) pp. 70-72, where bullets fired from a SAVAGE, 32-20 rifle barrel rifled with a hook cutter, show a remarkable similarity between all six groove impressions of tests fired from the same barrel.

Barrels rifled individually by the hook cutter method would not be expected to produce similar individual characteristics in the grooves of consecutively rifled barrels. This is because of the relatively rapid wear, and therefore change, that occurs in the hook cutting edge as multiple cuts are made to complete the full groove depth in one barrel before starting to cut the next barrel.

If no finishing (i.e., lapping) has been done, the grooves formed by the hook cutter method can be recognized by the relatively obvious striations which generally appear to run the full length of each groove cut. Because of the similarity in the metal cutting processes, the striations made by a hook cutter cannot always be readily distinguished from those produced by a broach cutter. The individual characteristics of toolmarks made by a hook cutter tend to persist over a greater length of cut than those made by a broach cutter. This difference can be explained by evaluating the cutting action of the single point (hooker) cutter as opposed to the multi point (broach) cutter. The single point, hook cutter removes a *relatively large amount of* metal on each pass and the toolmarks of the final cut are not modified further. On the other hand each step of the multi point broach cutter removes a relatively small amount of metal, and the cut made by each multi point cutter is modified by the succeeding step point cutting edge.

It is important to note that only those toolmarks which appear to be continuous throughout the entire length of a single barrel could possibly be reproduced in consecutively rifled barrels and therefore be mistaken as unique individual characteristics.

This method of rifling is no longer used for mass produced rifling, because only about five to fifty barrels may be rifled by a hook cutter, and the cutter may require sharpening several times per each barrel and requires about 30 minutes to rifle one barrel.

SCRAPE CUTTER METHOD: Consists of single or multi-point cutters inset into the opposed sides (i.e., 180 degrees) of a carrier rod that is pushed and pulled to cut, or scrape, two opposed grooves simultaneously. The scrape cutter requires 20 to 80 passes through a barrel to complete the final groove depth, and cuts or scrapes in both directions to form an even number of grooves only.

The potential for individuality in the groove engravings of barrels rifled by the scrape method is very high. This is because the cutting edge actually scrapes in both directions and requires many passes through a barrel to complete the desired groove depths. Grooves cut by a scrape cutter generally produce less prominent striae than the hook cutter because of the very small amount of metal removed on each pass, and the burnishing effect of the push-pull action of the scrape cutter. This is perhaps the oldest known rifling method and is still used by some custom barrel makers who specialize in making muzzle-loading rifles. This method is capable of producing a very fine finish when properly applied. It is, however, too slow, and therefore, expensive for anything except occasional custom-barrel rifling.

BROACH METHOD: A rifling broach is a rod on which from 25 to 30 hardened steel rings are spaced. Each ring is slightly larger in diameter than the preceding ring and has the negative shape and pitch of the final rifling configuration. The lands on each ring bear a cutting edge (analogous to that on a hook cutter) which in a stepwise fashion, cut each groove to a finished depth as the broach is rotated while being pushed or pulled through a barrel blank of proper bore diameter.

Broaches are production tools adapted for a single pass operation. Broaching combines both rough and finish cuts in a single operation and removes stock to precision limits quickly and economically. Modern rifling broaches are formed by grinding from a single piece of tool steel. Each broach is capable of cutting several hundred barrels before the cutter teeth need to be resharpened (by grinding) and each broach can produce thousands of barrels before being replaced.

An exception to the single broach procedure is that used on Cooey rifle barrels of Canada where a total of six broaches are required to rifle a single barrel. Each of the first five broaches removes about .005", and the sixth and final broach, about .0025" of metal. This multibroach procedure, as reported by CHURMAN(1949) and SKOLROOD (1975), gives rise to a series of repeatable "B", or broach characteristics, can be mistaken as unique individual characteristics by the unwary and therefore must be recognized and evaluated with caution.

Using the PLASTISOL replica technique, the author has studied the toolmarks produced in consecutively broached (and unlapped) .38 caliber S&W, 4" barrels, and found the individual characteristics within each groove to be substantially different within the length of a single 4" barrel (see figures 4-18). The reason for this relatively rapid change within a single barrel is due to the nature of the metal cutting process, and the fact that multiple or "step" cuts are made in one operation to produce the finished groove depth. In broaching, the metal ahead of the cutting edges is compressed and then wedged apart along the slip planes of the molecular structure. This results, at the molecular level, in a "tearing" as illustrated by a close examination of the replica photomicrographs. The same admonitions noted for the hook cutter process, also applies to broach cut rifling; that is, only those toolmarks which appear to be continuous throughout the entire length of a single barrel could possibly be reproduced in consecutively rifled barrels, and therefore be mistaken as an unique individual characteristic. An excellent example of this situation is the case reported by

LOMORO (1972, 1974, 1977) of the remarkable similarity noted in several different 32 SWL caliber F.I.E. *TITANTIC, revolvers. The similarity of striae observed by* LOMORO occurred in the "groove" marks (which LOMORO refers to as "lands" on the bullet). Further correspondence with LOMORO in 1974 indicated that a "cutter type" rifling tool (i.e., BROACH) was used and that gross striae (responsible for the "pseudo" matches) can be seen to extend the entire length of the grooves in the barrel. Lomoro also noted that no comparable similarities were observed in the land marks.

BUTTON SWAGE: A swaging (cold forming) process in which an elliptical shaped, tungsten carbide steel plug, or button, bearing on its long axis the negative form of the finished lands and grooves is pushed or pulled through a smooth bore of slightly smaller diameter than the "lands" on the button. As the button is forced through the bore, at high pressures, the metal is compressed and displaced to take the negative shape of the finished rifling of the button.

Because no metal is removed in this process, the markings that result from drilling and reaming in the bore often are visible as concentric rings which run across the width of both the lands and the grooves of the finished rifling. Because of the tremendous compression forces involved, the resulting rifling surfaces are extremely smooth and "workhardened". The original surface markings formed by drilling and reaming will thus be compressed or "ironed out" onto both the lands and groove surfaces of the rifling. *These concentric bore markings can be seen with proper* cross lighting and with the aid of a sterobinocular microscope, or by way of plastic replicas. (See figure 19.)

There is little question about the individuality of button swaged barrels when the physical processes involved are analyzed. The button imparts few, if any, persistent markings parallel to the long axis of the barrel. The button only tends to compress the concentric toolmarks that may remain from drilling and reaming. A possible exception this generalization would be where "gross" defects, from a defective button resulting from metal build-up (galling) or chipping are impressed into the full length of a barrel and therefore could possibly be duplicated in a series of consecutively rifled barrels. The magnitude of such "gross" defects would be such that they would appear as relatively broad and well defined striae as opposed to the usual striae (a few thousands or less of an inch wide) generally used to affect an identification. Whether such an exception may apply can be ascertained by an inspection of the rifling to determine if there are any gross characteristics which appear to extend the entire length of the rifling as was noted under the various cut rifling processes.

HAMMER SWAGE (FORGE) METHOD: A cold forming (swaging) process where a drilled and reamed barrel *blank is compressed, under great pressure, onto a mandrel* which bears the negative shape of the finished rifling. As with the button swage, the great pressures required to cold swage the rifling produces a very hard, mirror-like surface. For a typical application and a further explanation of this process, refer to the article on Weatherby's Hammer-Forged rifling. (Weatherby Guide, 1975).

Because of the similar physical principles involved, it is very unlikely that unique individual characteristics would be reproduced in consecutively hammer swaged barrels for the reasons as given under the button swage processes. See figure 20 for an example of typical surfaces resulting from this rifling method. Both the BUTTON and HAMMER swage methods require a finished reamed barrel blank with heavy, uniform, wall thickness in order to achieve uniform rifling dimensions.

FINISHED APPLIED AFTER THE RIFLING IS FORMED:

Methods used to improve the finished appearance of the rifled barrels by smoothing residual drill or ream marks and rifling cutter toolmarks can modify or obliterate any toolmarks resulting from the rifling process, therefore the effects of finishing methods should also be evaluated.

A common method used in finishing rifled barrels is "lead lapping". A lead casting of the rifled barrel blank is used to work an oil slurry of abrasive (e.g., 300 to 400 Mesh Carborundum) back and forth through the barrel. This lapping process is typically used for broach cut rifling to remove or smooth out the relatively coarse ream marks on the lands and the broach cutter marks in the grooves. Figure 21 shows replica of an S&W, 38 SPL barrel that has been lead lapped. In comparing this lead lapped surface with the broach cut, and unlapped barrels, previously discussed, it can be seen that a new set of stria have been superimposed upon both the land and groove surfaces. The stria produced by lead lapping are similar in overall appearance although somewhat smoother in appearance than the stria made by the broach cutter. It should be apparent, however that the toolmarks produced by lapping are not uniformly spaced and change relatively rapidly over the length of a single barrel as shown by Figure 21.

BOOKER (1980) has expressed contrary opinions regarding the random and/or unique character of striaed toolmarks generated in the production of rifled gun barrels.

> To quote Booker: "The assumption that all striae are random is not one which can be made freely in the examination of bullets. Because most tools used to manufacture gun barrels are prepared by grinding with abrasive wheels which resemble close-packed spheres of uniform diameter, the spacing and depth of the primary marks on the tools are proportional to the size of the abrasive. The surface imperfections of the tools create flaws in the gun barrel which, in turn, cause striae on the bullets fired through it. In a simpler case, a lapped gun barrel must be considered to be a primary tool which causes striae. Explaining the striae on bullets as being directly influenced by the barrel maker's choice of abrasive may seem to be a theoretical exercise, but it merits consideration when evaluating a small number of striae, especially those which are uniform in contour and spacing. A simple experiment conducted by grinding a sharp edge with a 400 mesh abrasive, produced a tool from which two marks were made; these marks were noted to have a large number of striae uniformly spaced apart at approximately 40 um, the diameter of 400 mesh abrasive. The maximum number of consecutive striae in a mismatched configuration was sought by giving photographs of two marks to five examiners. All the examiners reported the finding of seven or more consecutive matching striae."

The unrealistic toolmark experiment used to support the hypothesis presented by Booker should be critically evaluated and compared with the actual examples of rifling toolmarks as demonstrated when determining which theory can be validated. Booker has hypothesized regarding the random and unique nature of toolmarks produced by rifling methods and has attempted to support his hypothesis with a less than realistic experiment. In contrast, I have proposed a different hypothesis which is supported and illustrated by a study of actual toolmarks in production barrels.

SUMMARY:

Two factors virtually assure that an unique set of individual characteristics will be reproduced in barrels rifled consecutively by the current rifling methods evaluated. The first is the random nature and rapidity with which the toolmarks produced by "cut" type rifling methods change within a single barrel, or consecutively rifled barrels. Secondly, the toolmarks remaining in "swage" type rifling are predominately perpendicular to the axis of bullet travel. A possible exception to this generalization is the rare case where barrel blanks, are cut into multiple barrels; or where a swage or broach rifling tool with gross defects is capable of producing axial toolmarks that can be seen to extend the entire length of the bore. This latter case should present a problem to the examiner only where the questioned barrel is not available for examination.

In those cases where the barrel is not available for examination, the examiner should use the toolmarks made by the lands or forcing cone to confirm an identification.

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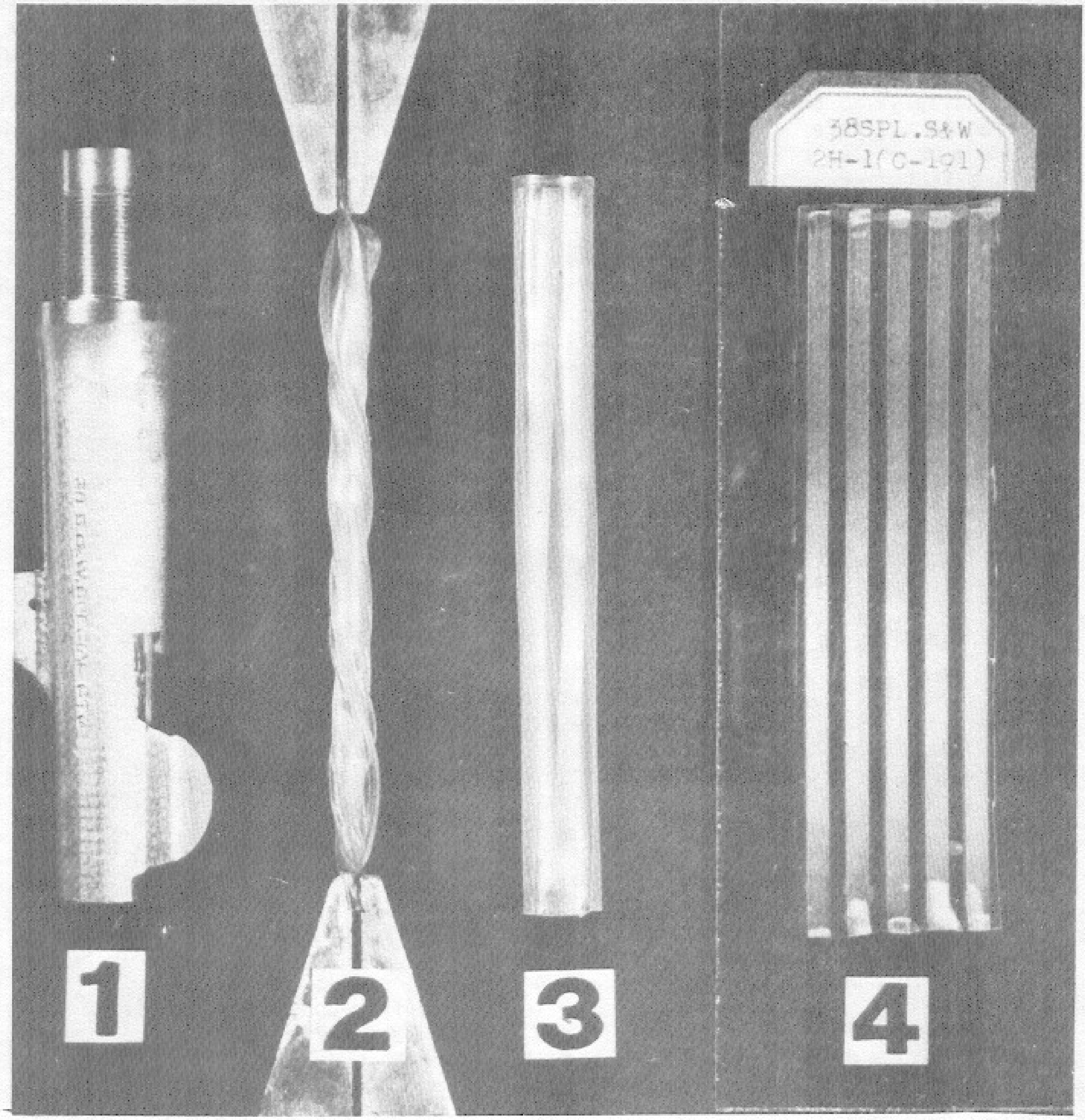


Fig 1. PLASTISOL as used to prepare replicas of the interior surfaces of gun barrels. Steps: (1) Barrel is removed to facilitate casting; (2) A heat cured cast, twisted to show flexibility needed for easy removal from barrel; (3) A whole replica before cutting; and (4) A replica cut along one land mark and laid flat on a glass plate for viewing. PLASTISOL is a thermosetting plastic (160° C oven for 10 to 15 min) with a formula of: VINYLITE QYNV resin 50%; dioctylphthalate plasticizer 49%; and epoxy heat stabilyzer 1%.

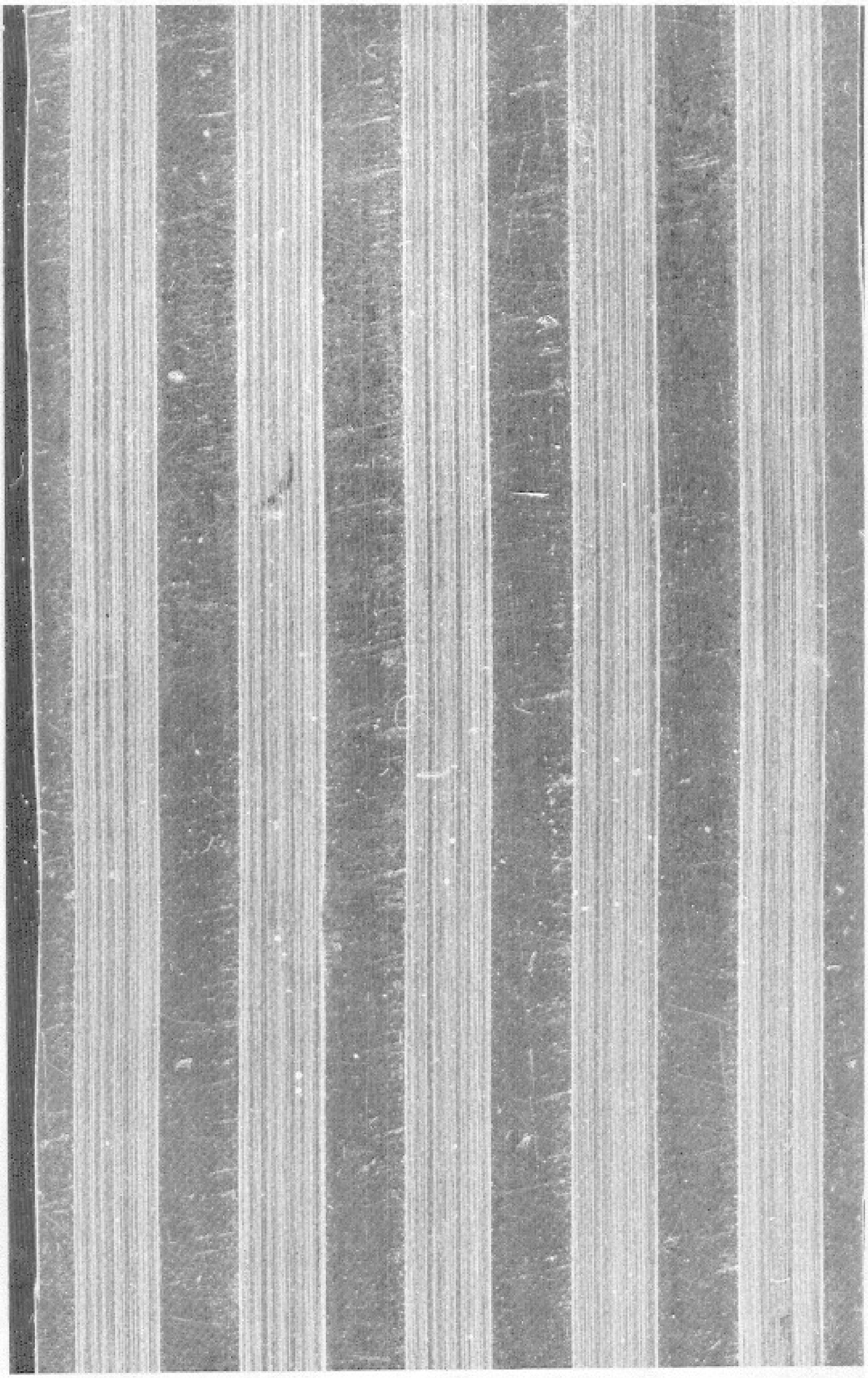


Fig 2. PLASTISOL replica of H&R 38 SW(5R) barrel rifled by a HOOK CUTTER and not lapped or fired. To compare the similarity of the HOOK CUTTER toolmarks from groove to groove, make 1:1 copy of this figure; cut copy in half across grooves; and then overlay cut edges to intercompare HOOK CUTTER marks in different grooves. This print was made using the replica as a transparency in a photographic enlarger to project an image onto high contrast enlarging paper.

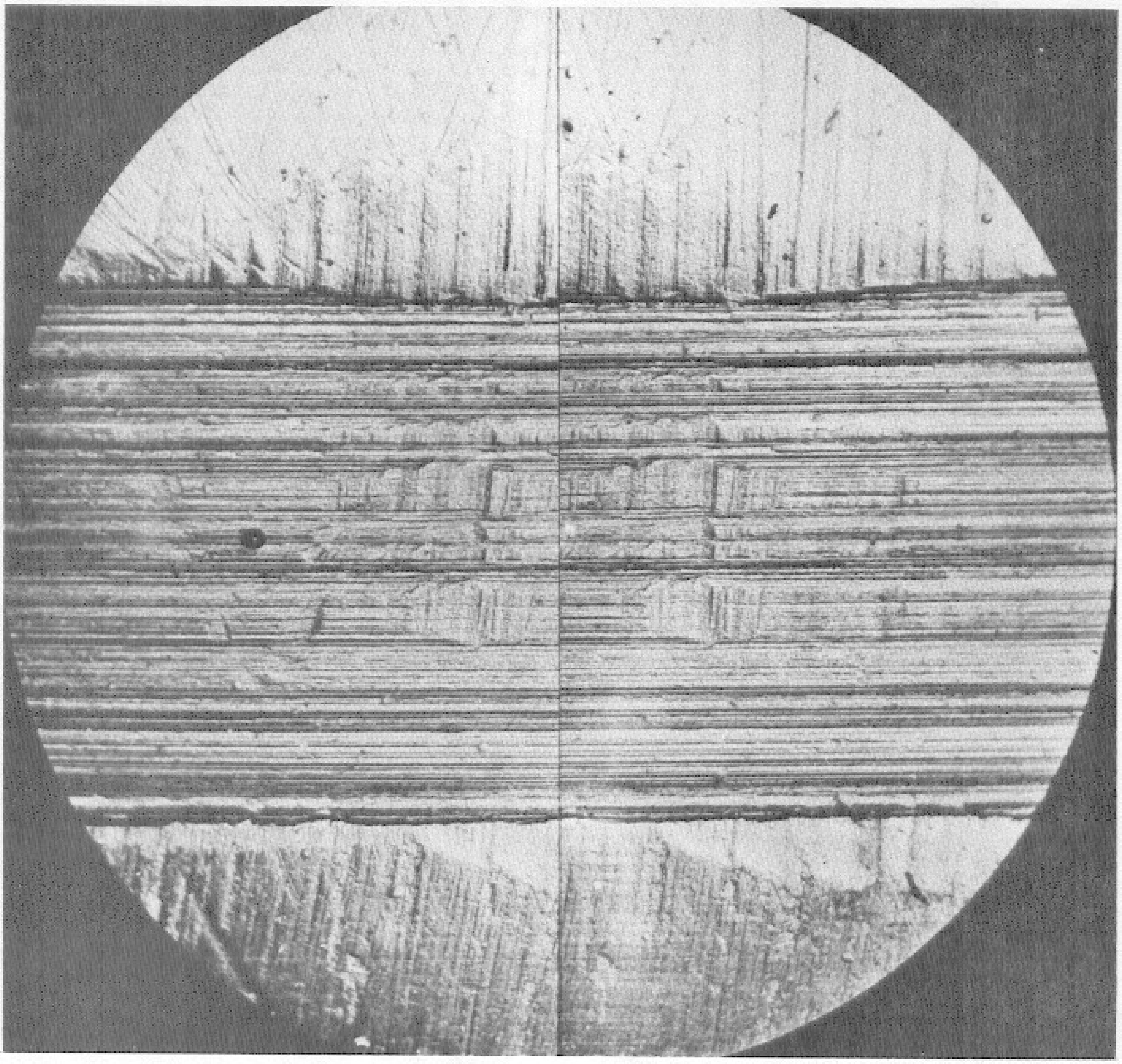


Fig 3. COMPARISON PHOTOMICROGRAPH (by oblique transillumination 23X) - Duplicate PLASTISOL replica of one groove cut from same H&R, 38 SW (5R) barrel shown in Fig. 2. Adjacent areas (i.e., not matched) are shown to allow comparison of same areas on duplicate replicas. The gross individual characteristics perpindicular to the HOOK CUTTER toolmarks indicates accidental damage which may or may not be associated with the rifling tool or process.

PREFACE to Figures 4 to 18:

COMPARISON PHOTOMICROGRAPHS (by oblique transillumination, 23 X) - PLASTISOL replicas of BROACH cut rifling, and not lapped, of S&W, 38SPL, 4" barrels, produced in 1955.

The subject of Figures 4 to 18 are three pairs of consecutively broached barrels:

The first pair ("start") were cut with a new broach. (Figs 4-8)

The second pair ("half") were cut with the same broach (without grinding) after 200 barrels had been rifled. (Figs 9-13)

The third pair ("final") were cut with the same broach (without grinding) after 900 barrels had been rifled. (Figs 14-18)

For each of the five grooves cut in each consecutively rifled pair of barrels, three different comparisons are shown on each page:

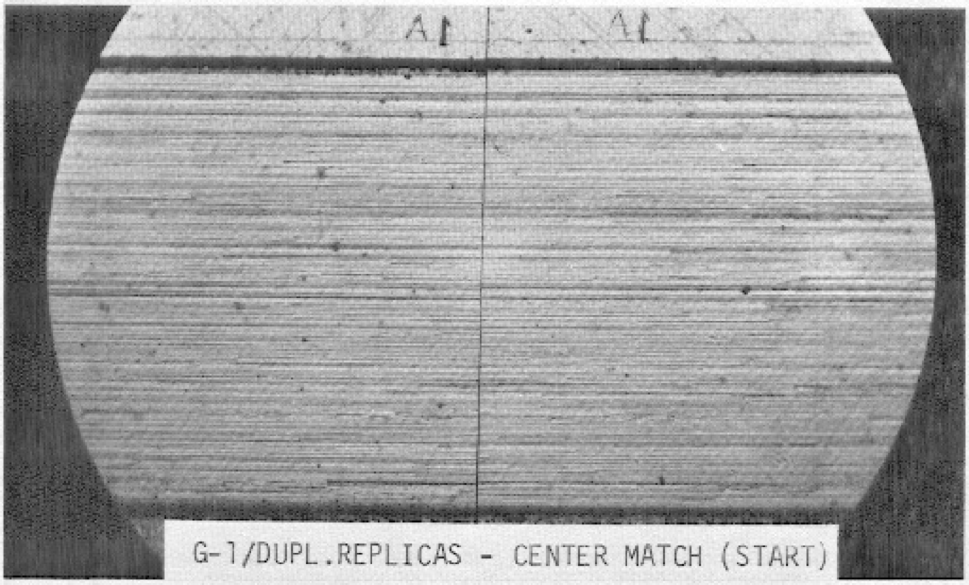
(a) Duplicate replicas, center match, to show the reproducability of the replica technique used.

(b) The same duplicate replicas with each replica displaced 2" from the center match shown in (a) to show the change in the individual characteristics of the broach toolmarks within the same groove of the same barrel.

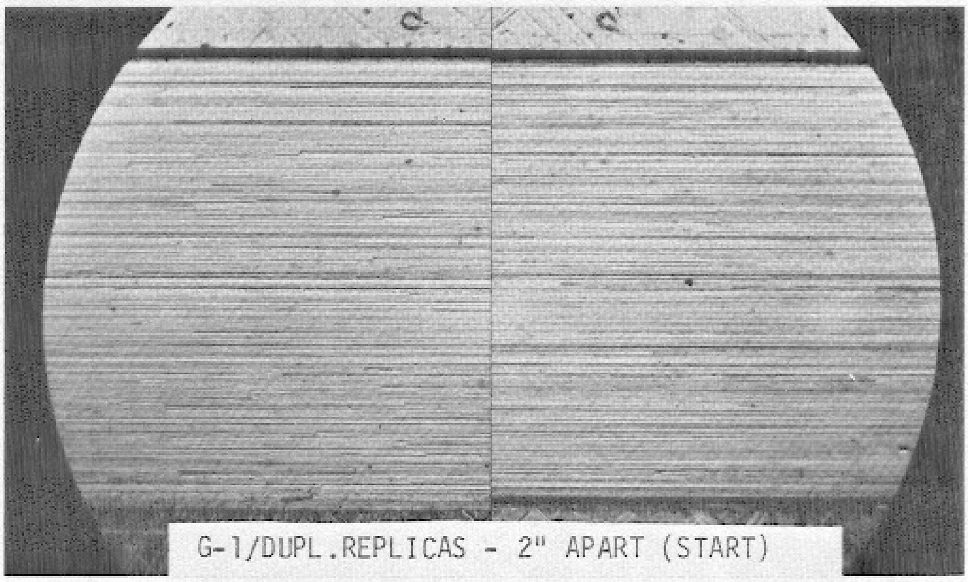
(c) Consecutively rifled pairs, center match, to show the non-reproducability of individual characteristics in the same groove of consecutively rifled barrels.

Note: This series of photomicrographs can be used as a striation matching exercise by making copies of the groove cuts shown. The photocopies can then be cut and overlayed to affect the intercomparison of any of the groove toolmarks shown.

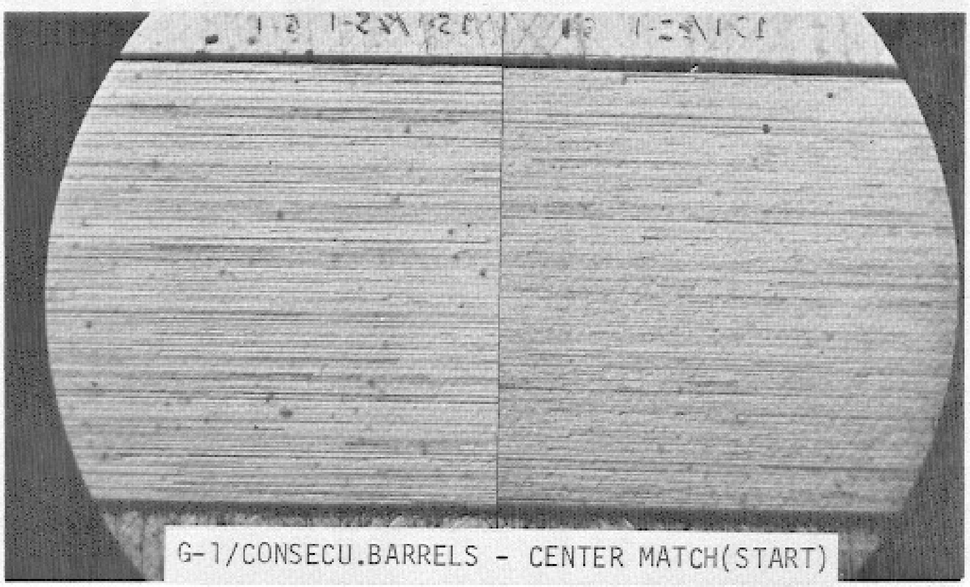
Fig 4 S&W, 38 SPL - NEW BROACH, FIRST PAIR (START), GROOVE 1



G-1/DUPL.REPLICAS - CENTER MATCH (START)

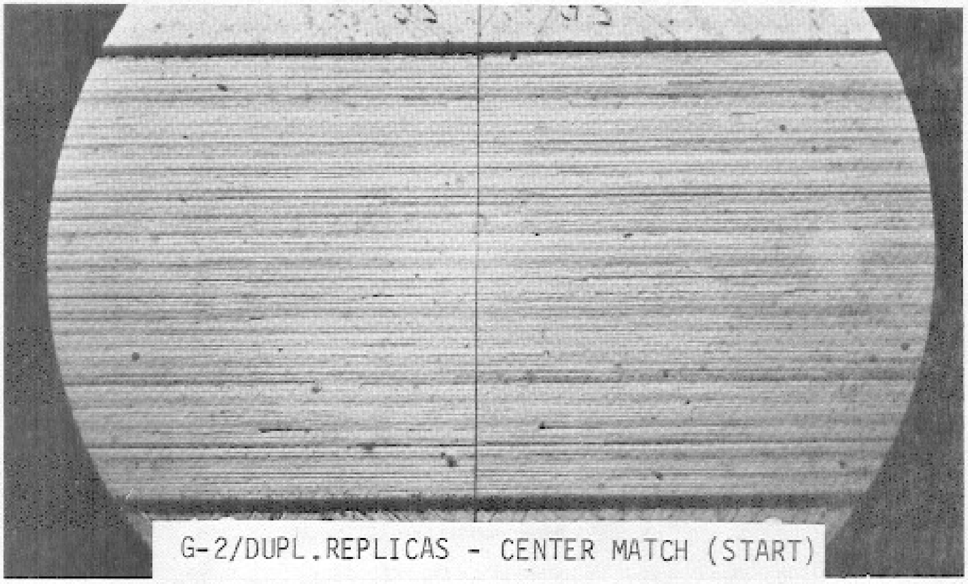


G-1/DUPL.REPLICAS - 2" APART (START)

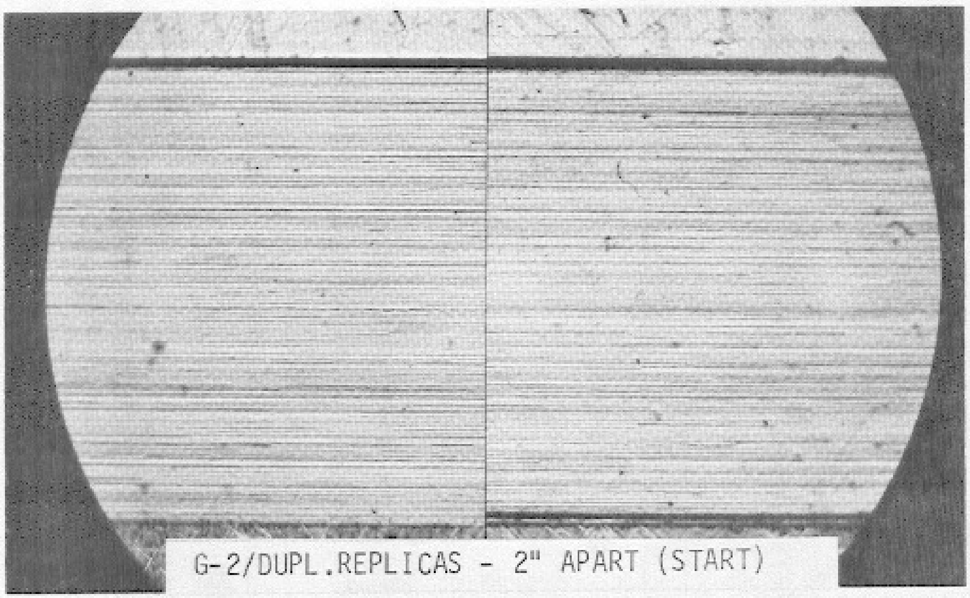


G-1/CONSECU.BARRELS - CENTER MATCH(START)

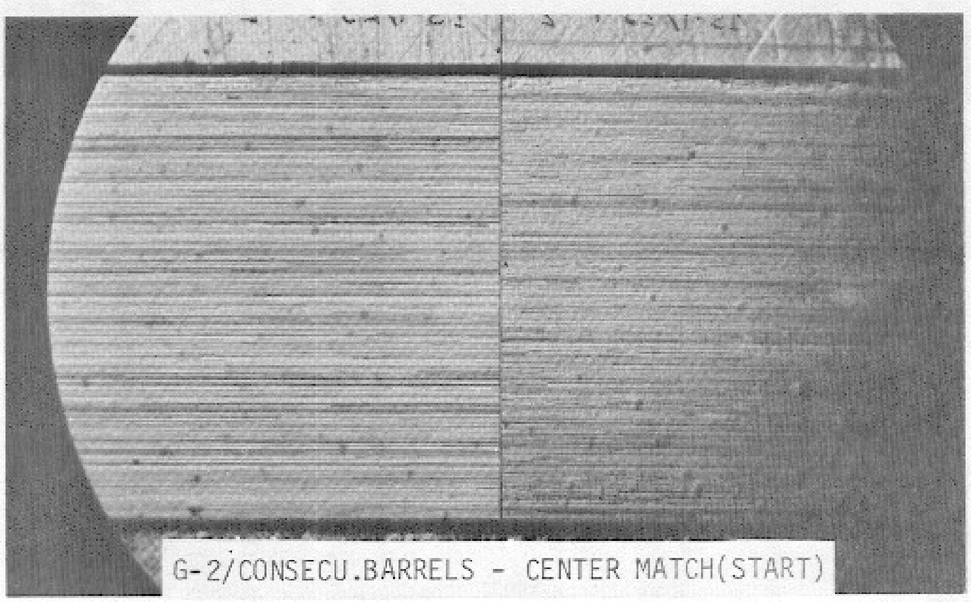
Fig 5 S&W, 38 SPL - NEW BROACH, FIRST PAIR (START), GROOVE 2



G-2/DUPL.REPLICAS - CENTER MATCH (START)

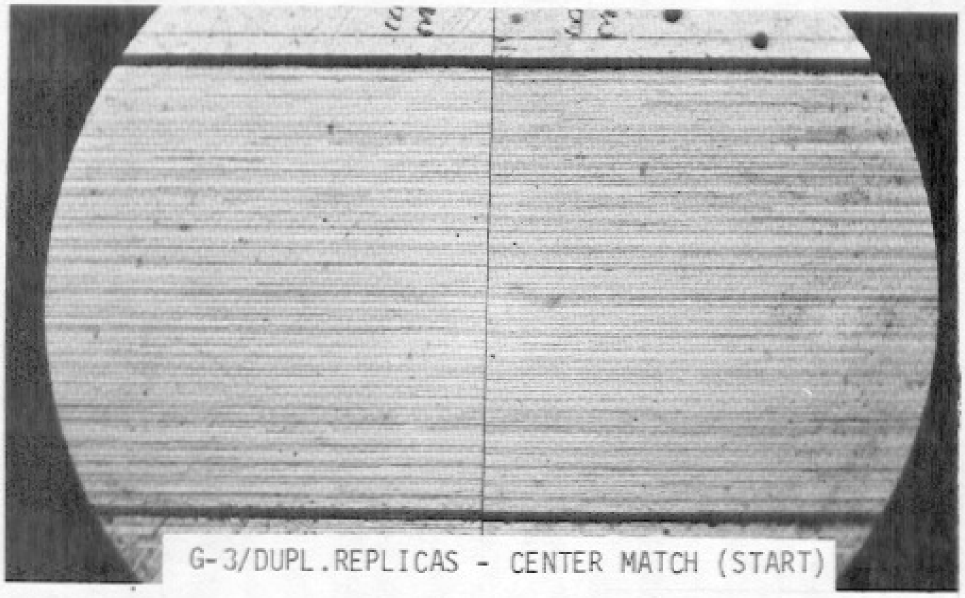


G-2/DUPL.REPLICAS - 2" APART (START)

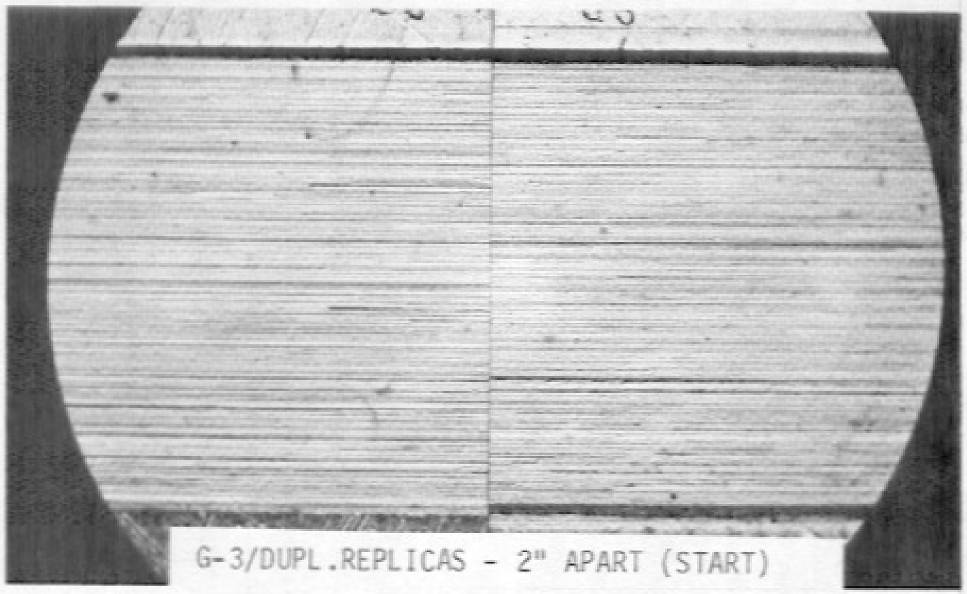


G-2/CONSECU.BARRELS - CENTER MATCH(START)

Fig 6 S&W, 38 SPL - NEW BROACH, FIRST PAIR (START), GROOVE 3



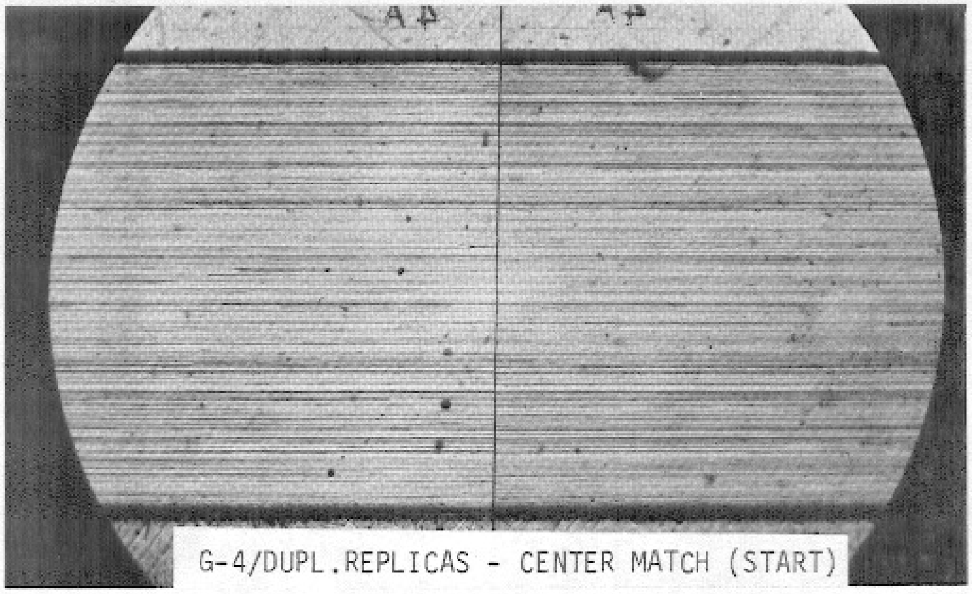
G-3/DUPL.REPLICAS - CENTER MATCH (START)



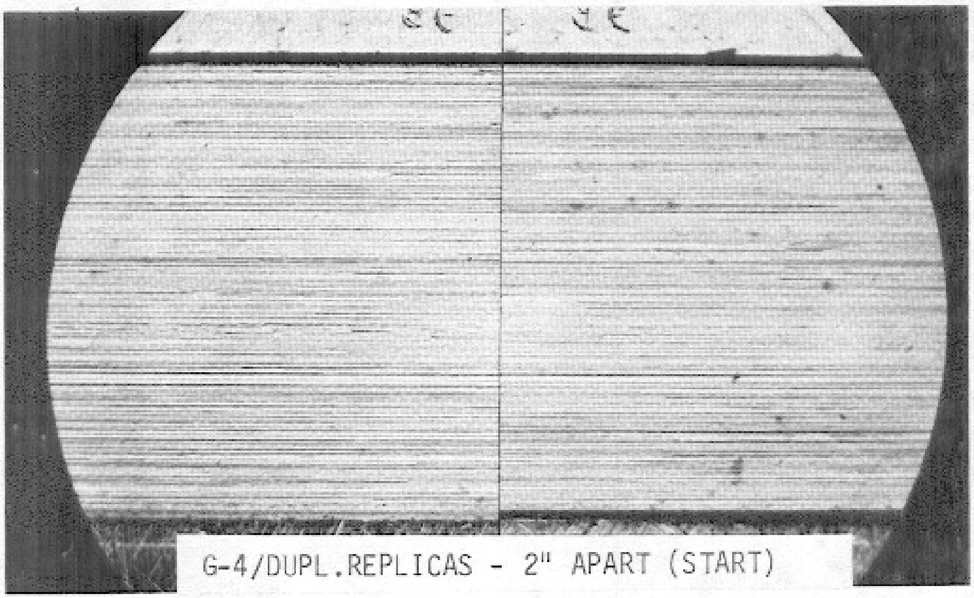
G-3/DUPL.REPLICAS - 2" APART (START)

G-3/CONSECU.BARRELS - CENTER MATCH(START)

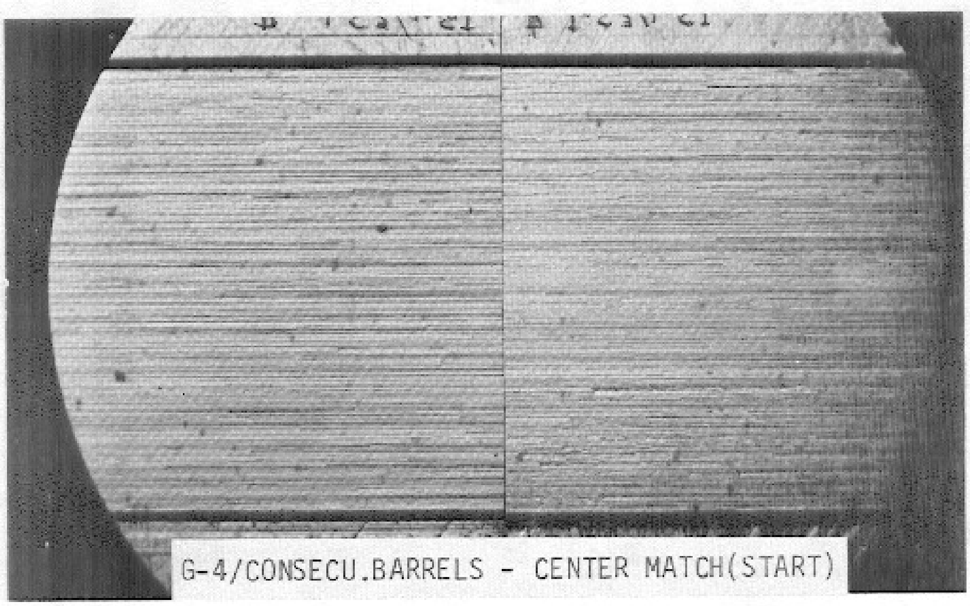
Fig 7 S&W, 38 SPL - NEW BROACH, FIRST PAIR (START), GROOVE 4



G-4/DUPL.REPLICAS - CENTER MATCH (START)

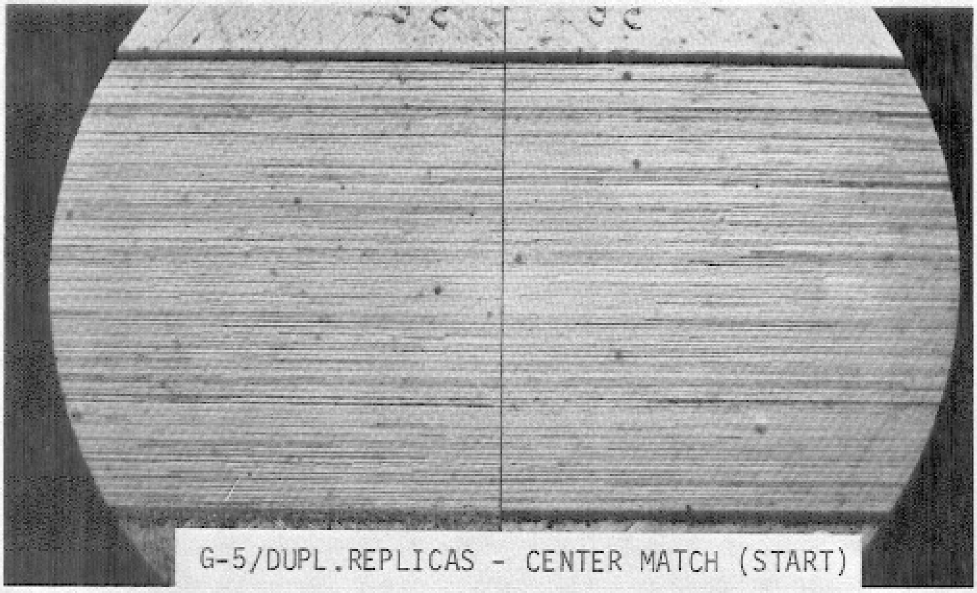


G-4/DUPL.REPLICAS - 2" APART (START)

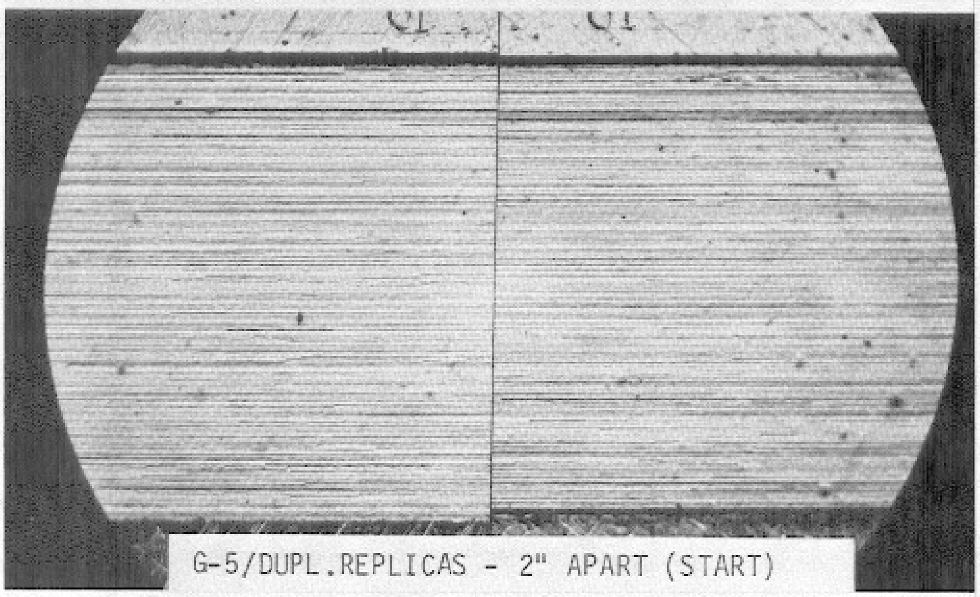


G-4/CONSECU.BARRELS - CENTER MATCH(START)

Fig 8 S&W, 38 SPL - NEW BROACH, FIRST PAIR (START), GROOVE 5



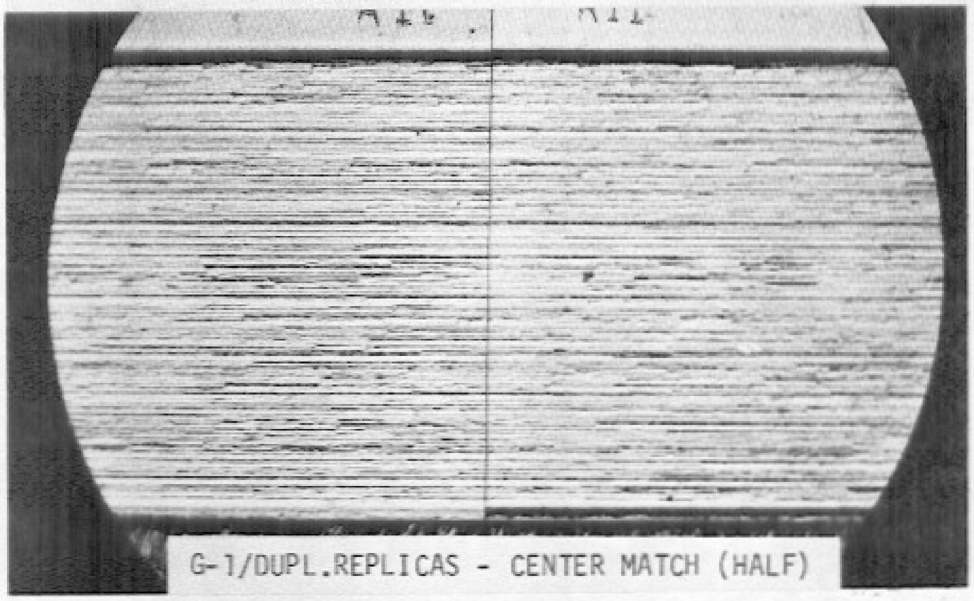
G-5/DUPL.REPLICAS - CENTER MATCH (START)



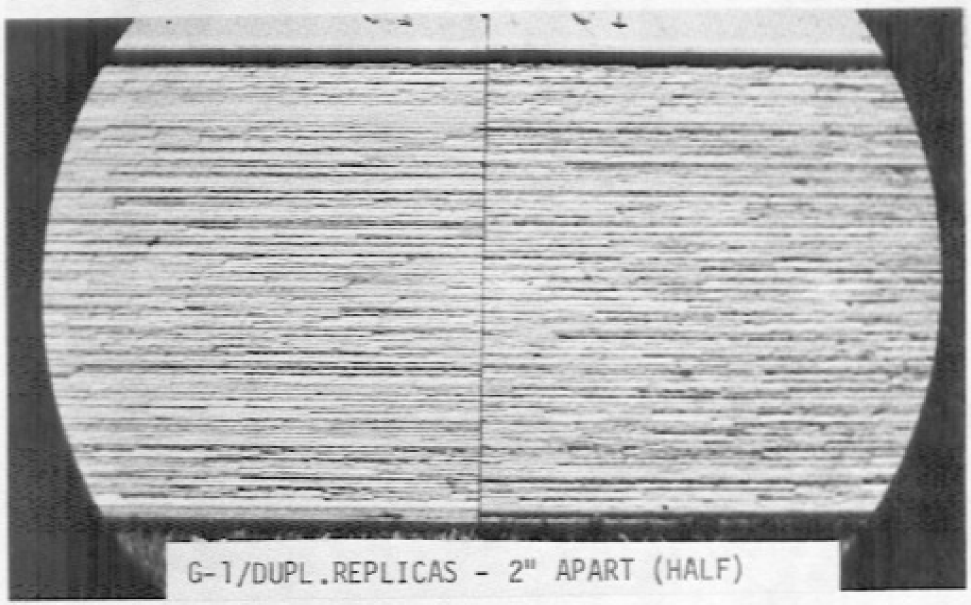
G-5/DUPL.REPLICAS - 2" APART (START)

G-5/CONSECU.BARRELS - CENTER MATCH(START)

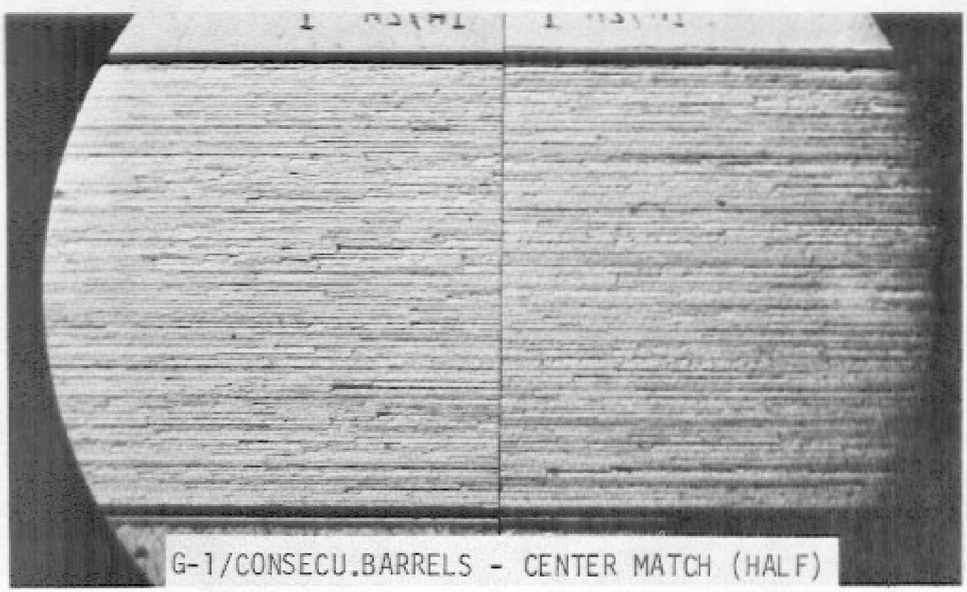
Fig 9 S&W, 38 SPL - BROACH AFTER 200 BARRELS (HALF), GROOVE 1



G-1/DUPL.REPLICAS - CENTER MATCH (HALF)

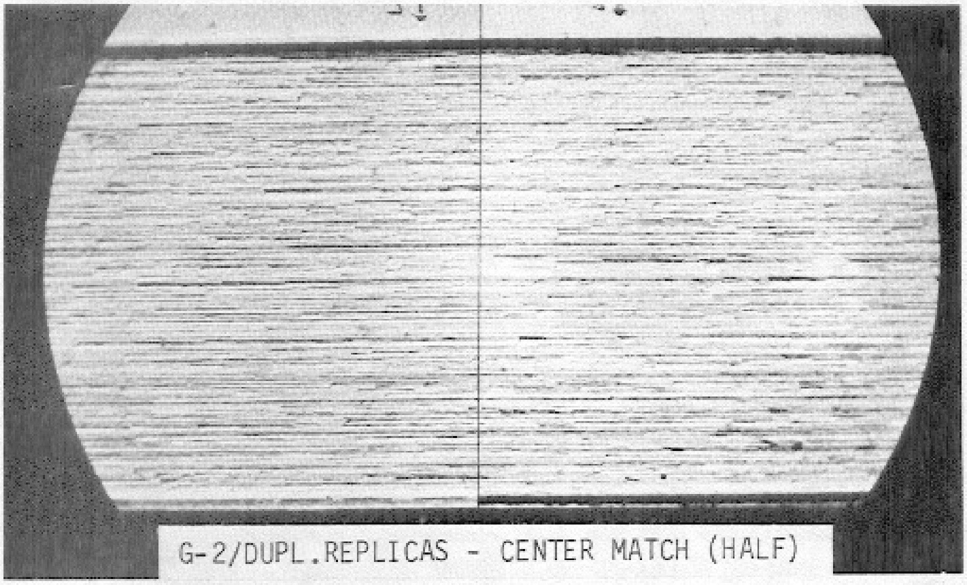


G-1/DUPL.REPLICAS - 2" APART (HALF)

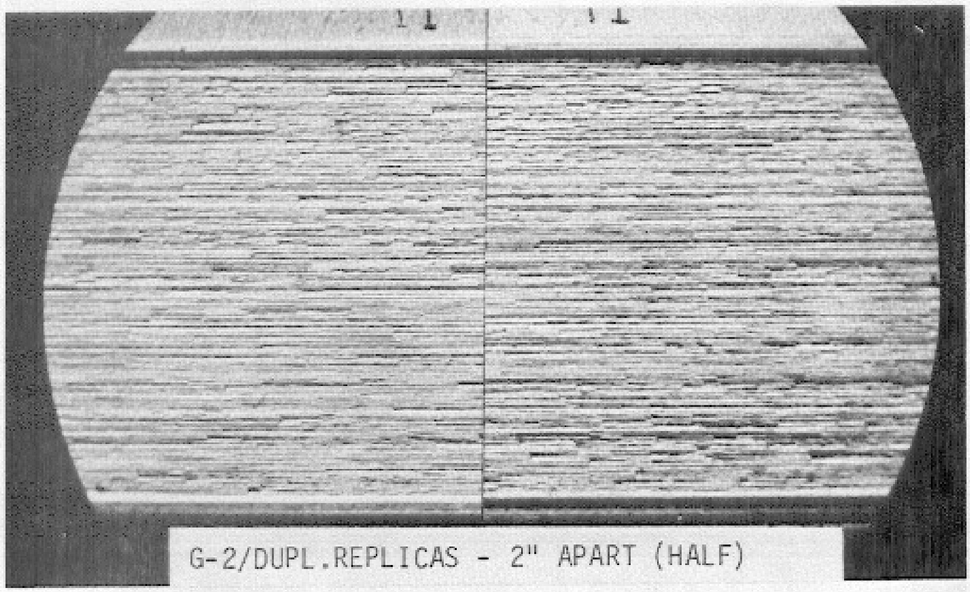


G-1/CONSECU.BARRELS - CENTER MATCH (HALF)

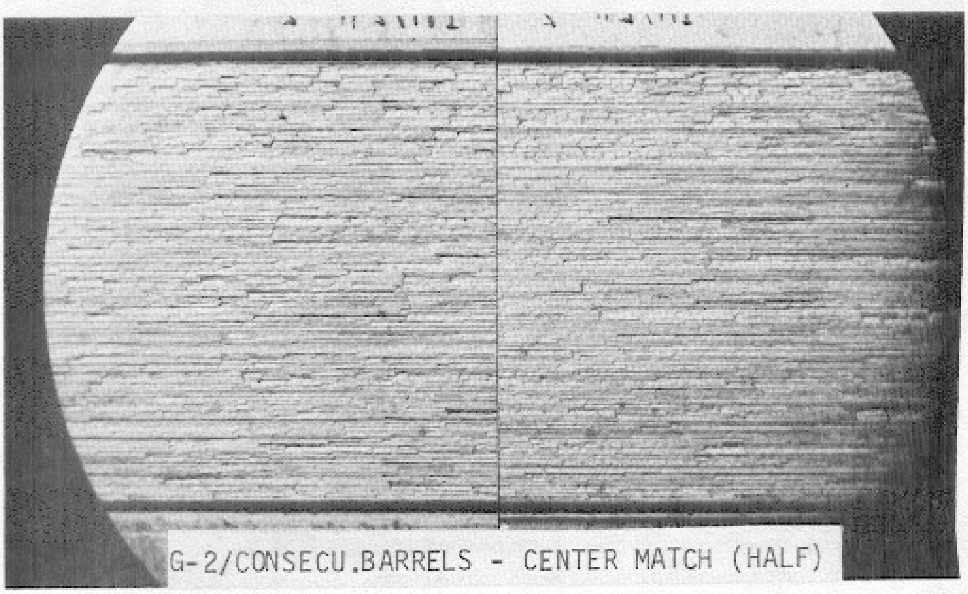
Fig 10 S&W, 38 SPL - BROACH AFTER 200 BARRELS (HALF), GROOVE 2



G-2/DUPL.REPLICAS - CENTER MATCH (HALF)

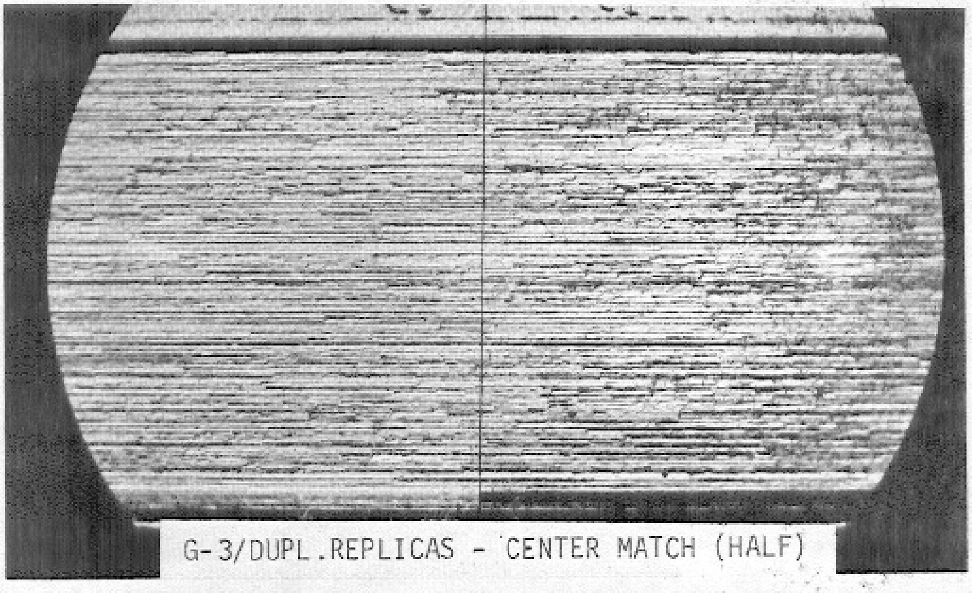


G-2/DUPL.REPLICAS - 2" APART (HALF)

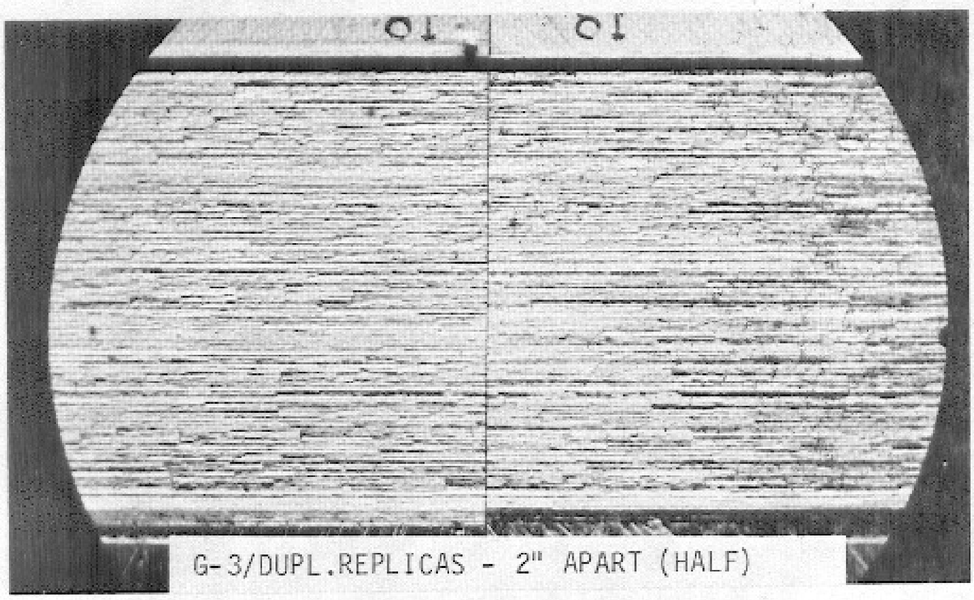


G-2/CONSECU.BARRELS - CENTER MATCH (HALF)

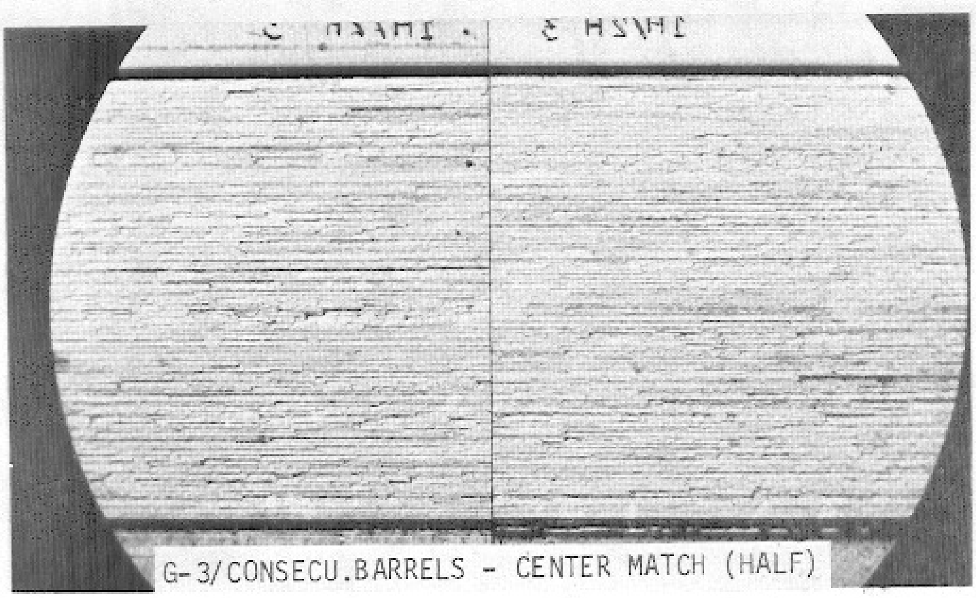
Fig 11 S&W, 38 SPL - BROACH AFTER 200 BARRELS (HALF), GROOVE 3



G-3/DUPL.REPLICAS - CENTER MATCH (HALF)

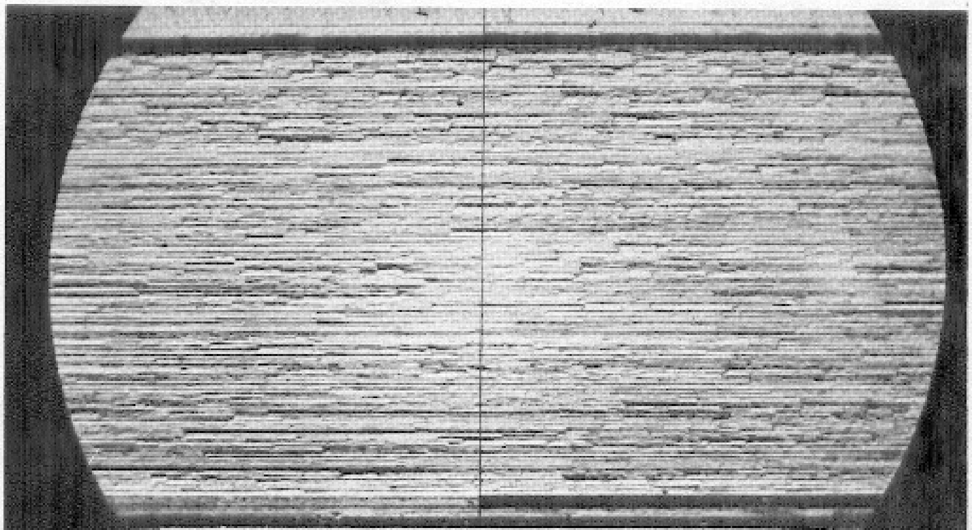


G-3/DUPL.REPLICAS - 2" APART (HALF)

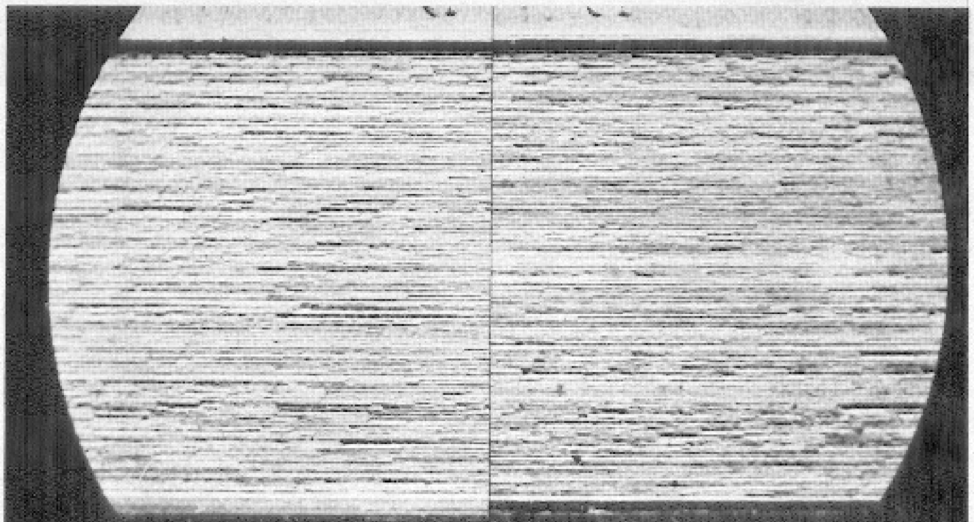


G-3/CONSECU.BARRELS - CENTER MATCH (HALF)

Fig 12 S&W, 38 SPL - BROACH AFTER 200 BARRELS (HALF), GROOVE 4



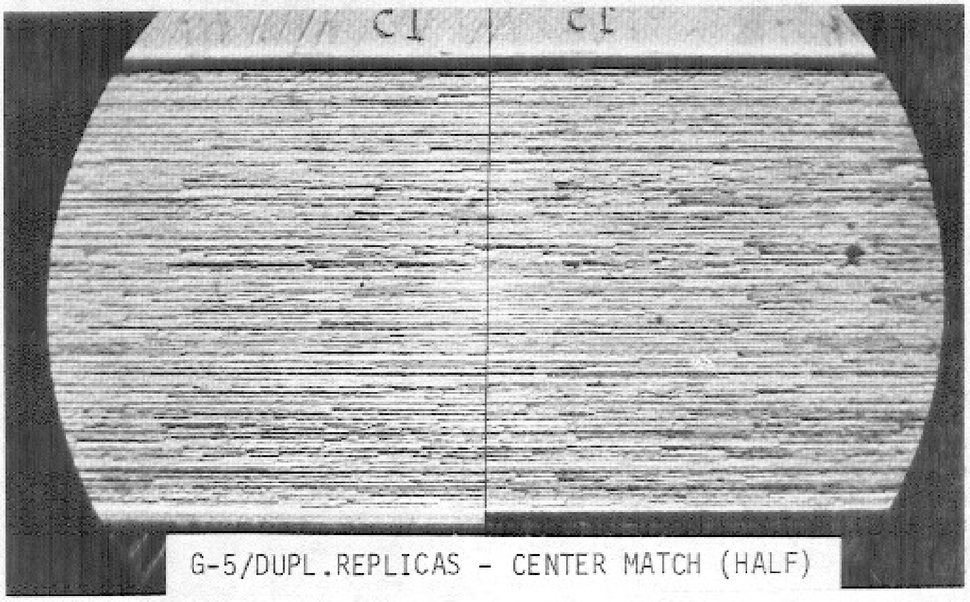
G-4/DUPL.REPLICAS - CENTER MATCH (HALF)



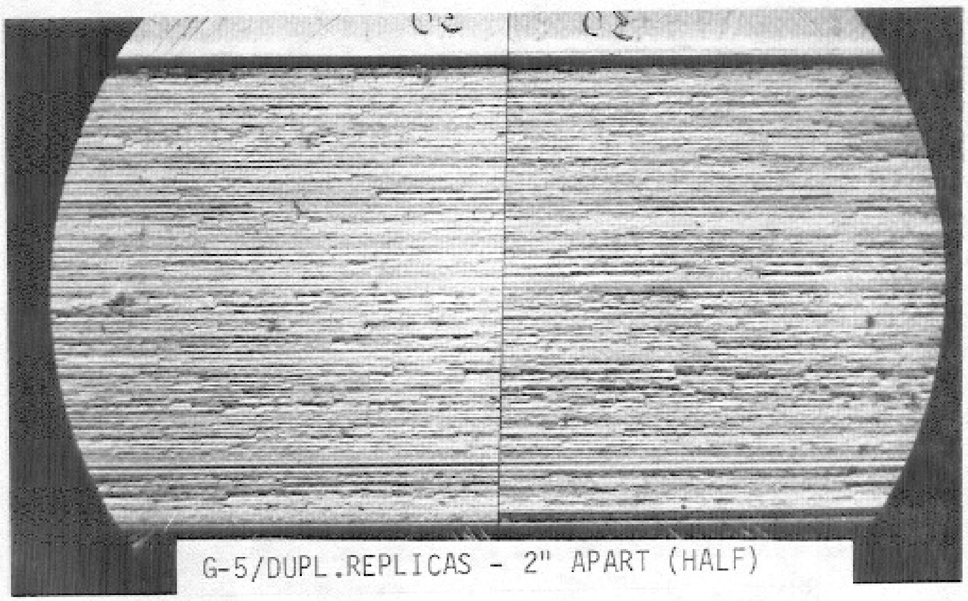
G-4/DUPL.REPLICAS - 2" APART (HALF)

G-4/CONSECU.BARRELS - CENTER MATCH (HALF)

Fig 13 S&W, 38 SPL - BROACH AFTER 200 BARRELS (HALF), GROOVE 5



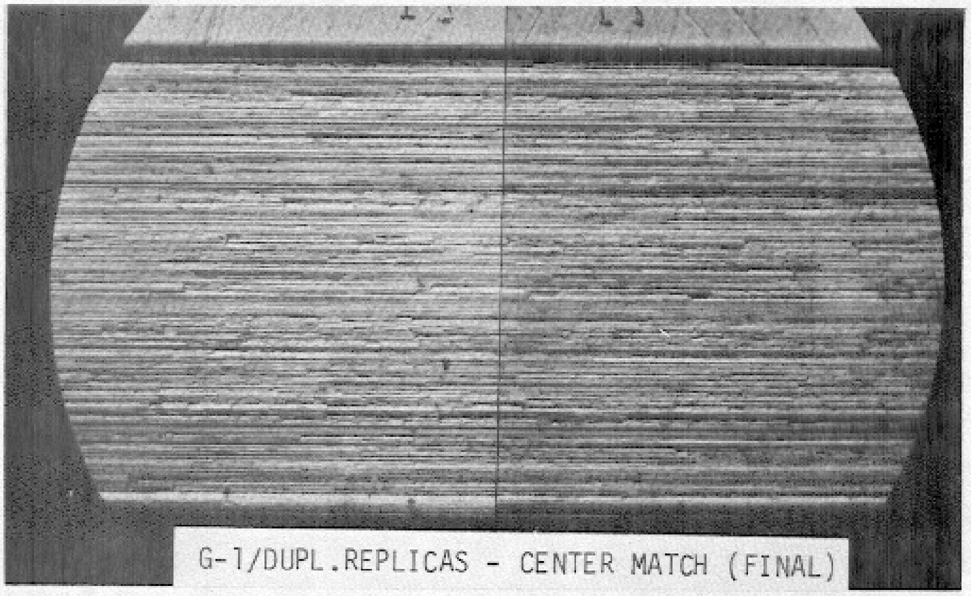
G-5/DUPL.REPLICAS - CENTER MATCH (HALF)



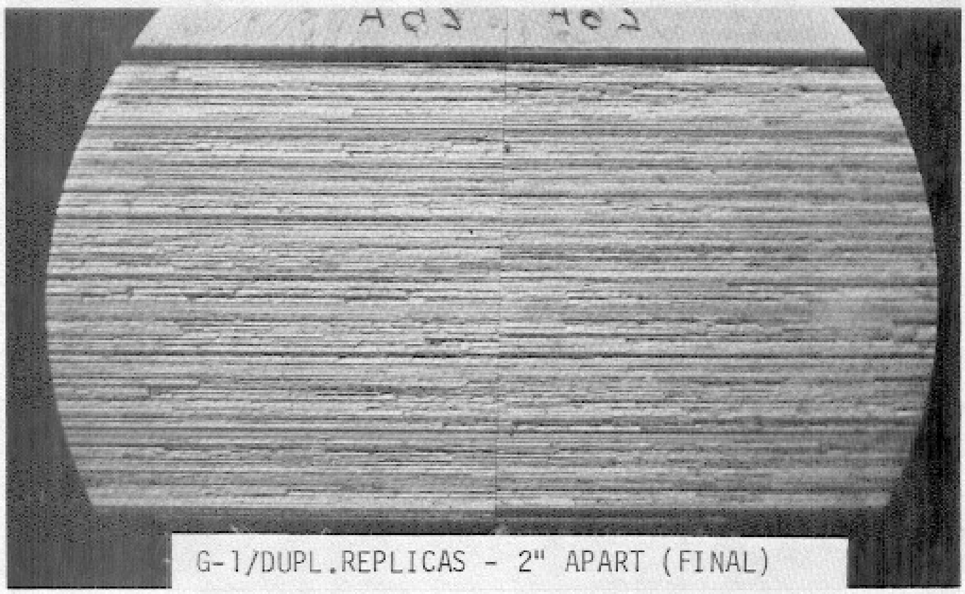
G-5/DUPL.REPLICAS - 2" APART (HALF)

G-5/CONSECU.BARRELS - CENTER MATCH (HALF)

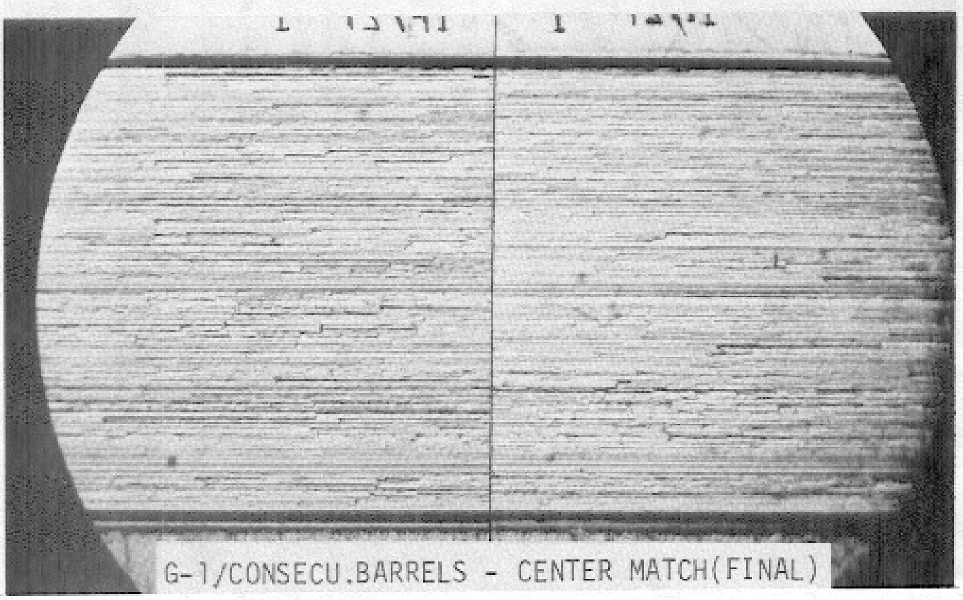
Fig 14 S&W, 38 SPL - BROACH AFTER 990 BARRELS (FINAL), GROOVE 1



G-1/DUPL.REPLICAS - CENTER MATCH (FINAL)

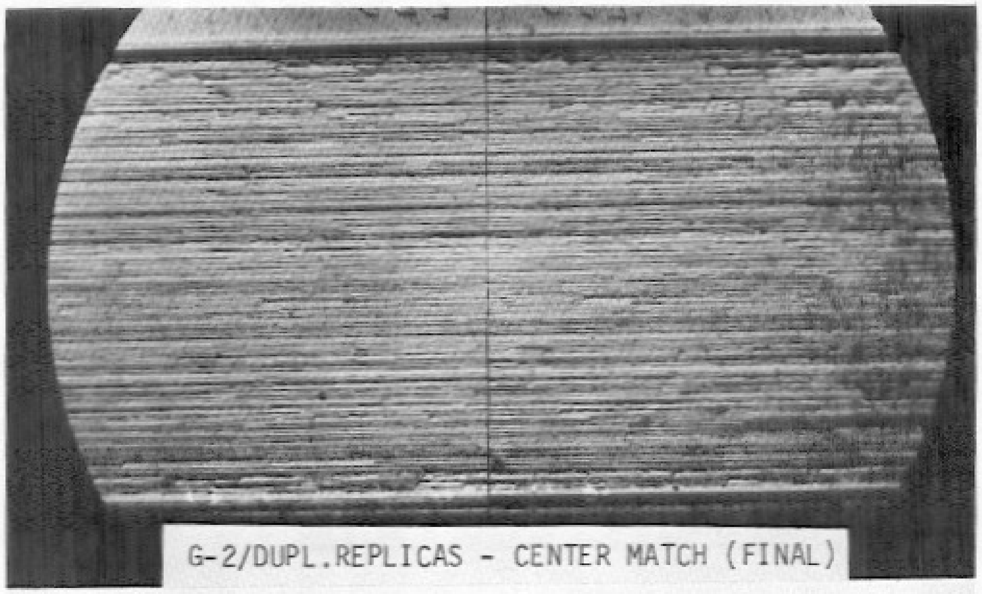


G-1/DUPL.REPLICAS - 2" APART (FINAL)

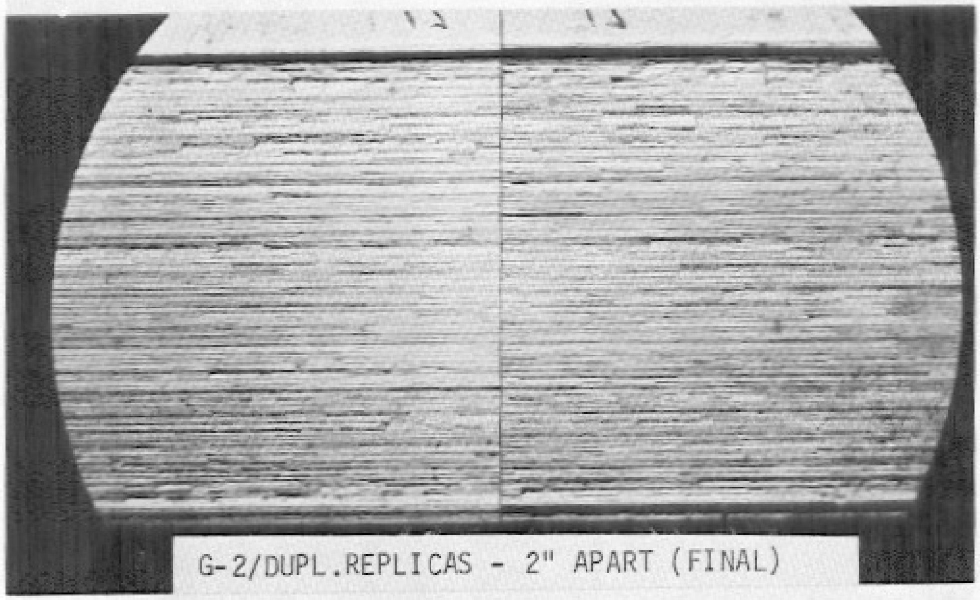


G-1/CONSECU.BARRELS - CENTER MATCH(FINAL)

Fig 15 S&W, 38 SPL - BROACH AFTER 990 BARRELS (FINAL), GROOVE 2



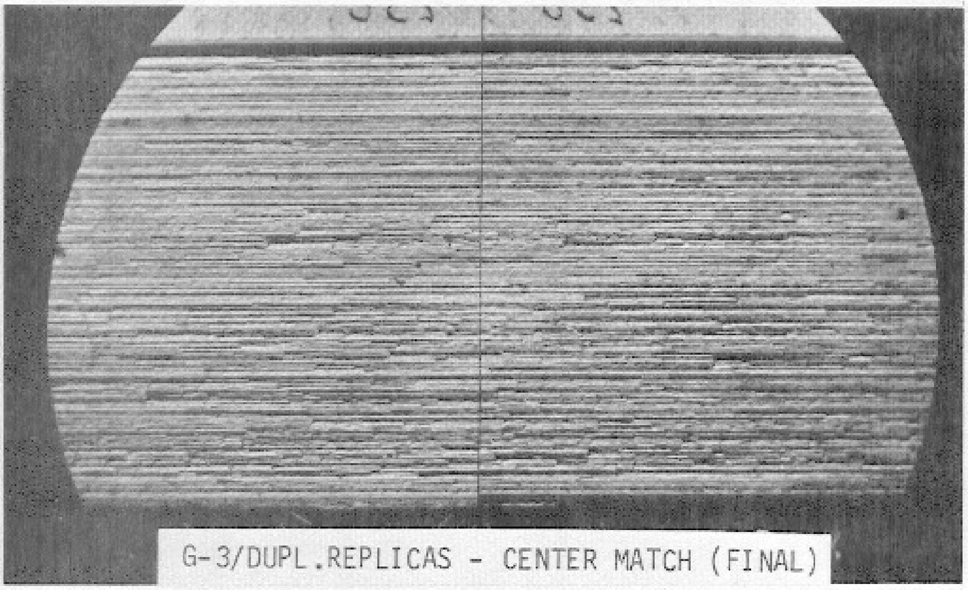
G-2/DUPL.REPLICAS - CENTER MATCH (FINAL)

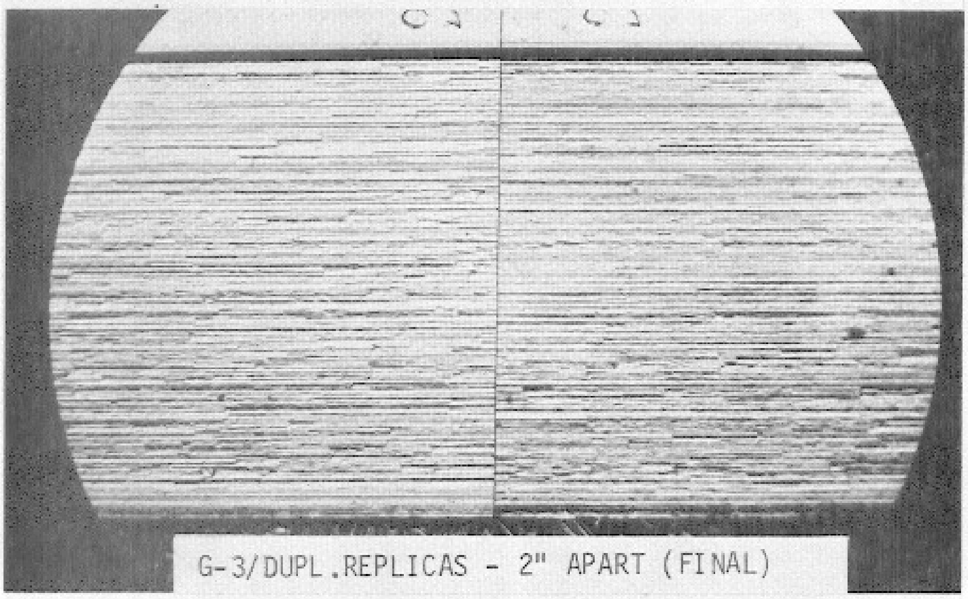


G-2/DUPL.REPLICAS - 2" APART (FINAL)

G-2/CONSECU.BARRELS - CENTER MARCH(FINAL)

Fig 16 S&W, 38 SPL - BROACH AFTER 990 BARRELS (FINAL), GROOVE 3


G-3/DUPL.REPLICAS - CENTER MATCH (FINAL)


G-3/DUPL.REPLICAS - 2" APART (FINAL)

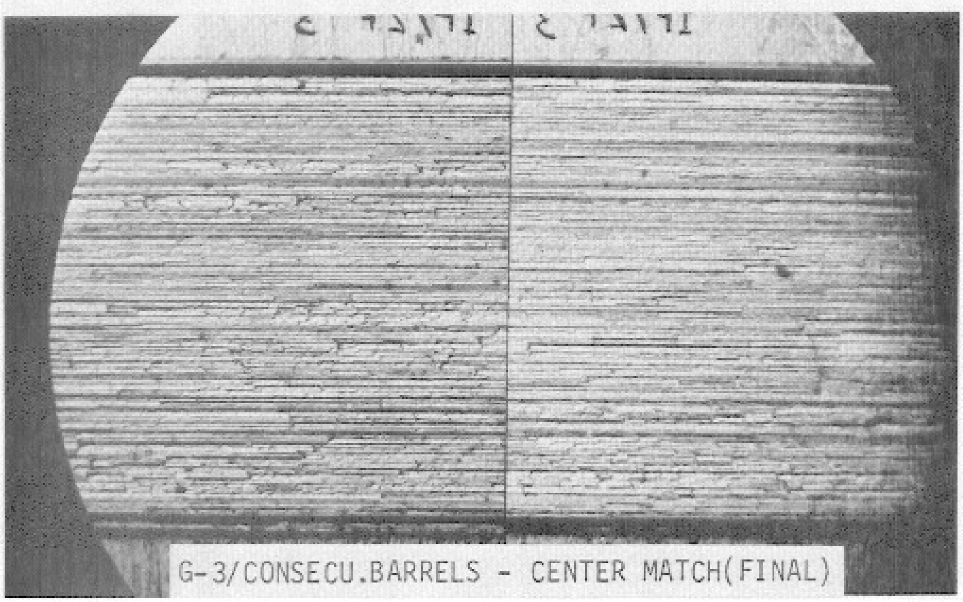
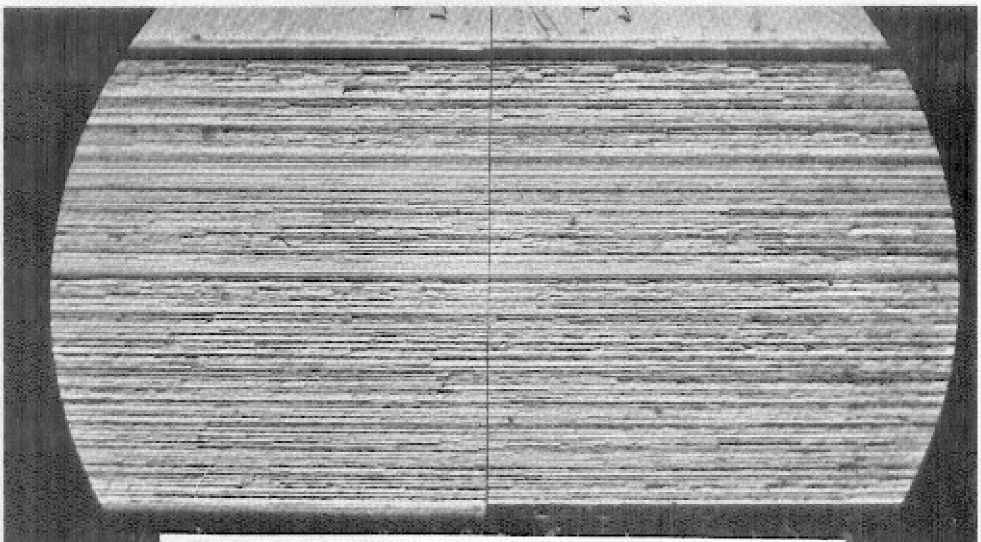
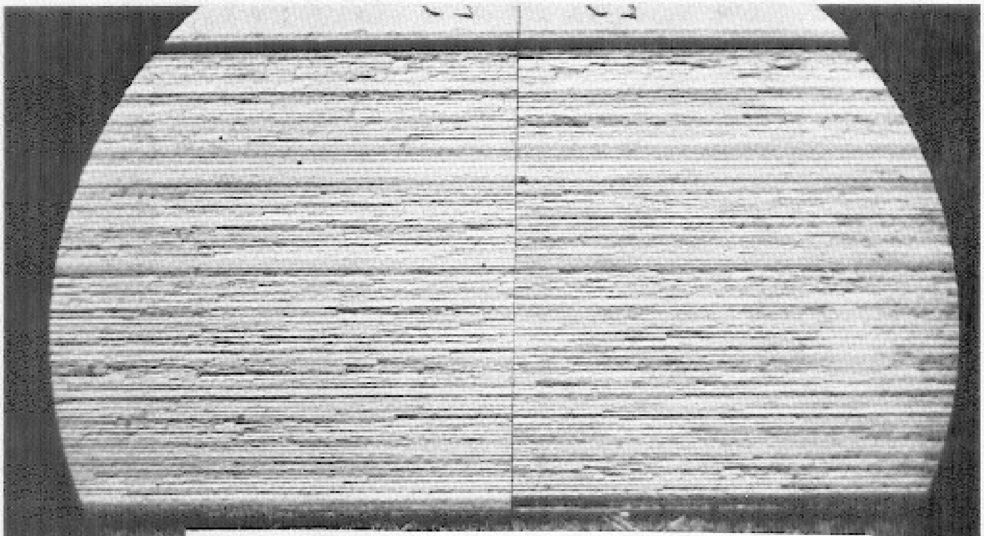

G-3/CONSECU.BARRELS - CENTER MATCH(FINAL)

Fig 17 S&W, 38 SPL - BROACH AFTER 990 BARRELS (FINAL), GROOVE 4



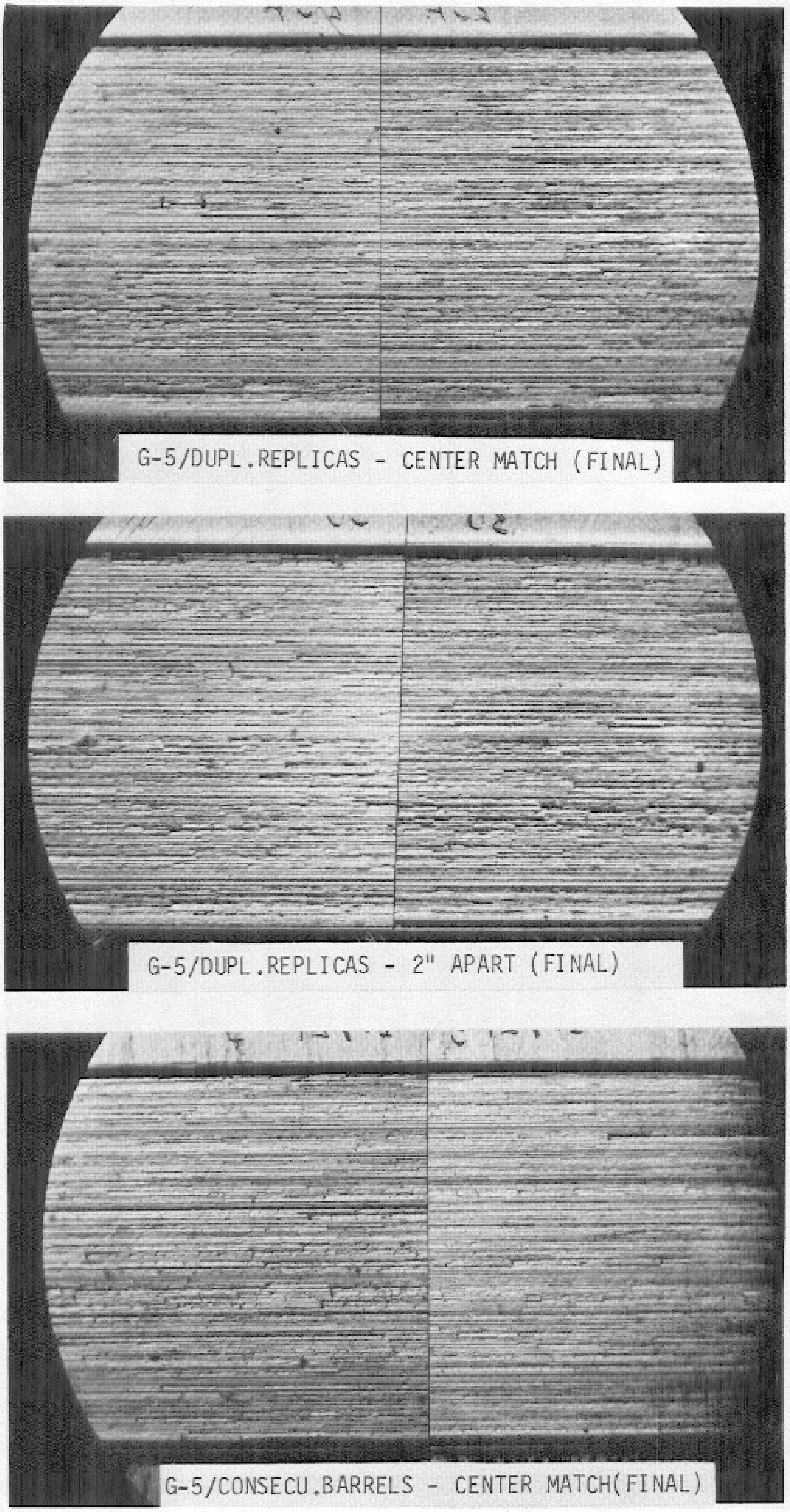
G-4/DUPL.REPLICAS - CENTER MATCH(FINAL)



G-4/DUPL.REPLICAS - 2" APART (FINAL)

G-4/CONSECU.BARRELS - CENTER MATCH(FINAL)

Fig 18 S&W, 38 SPL - BROACH AFTER 990 BARRELS (FINAL), GROOVE 5



G-5/DUPL.REPLICAS - CENTER MATCH (FINAL)

G-5/DUPL.REPLICAS - 2" APART (FINAL)

G-5/CONSECU.BARRELS - CENTER MATCH(FINAL)

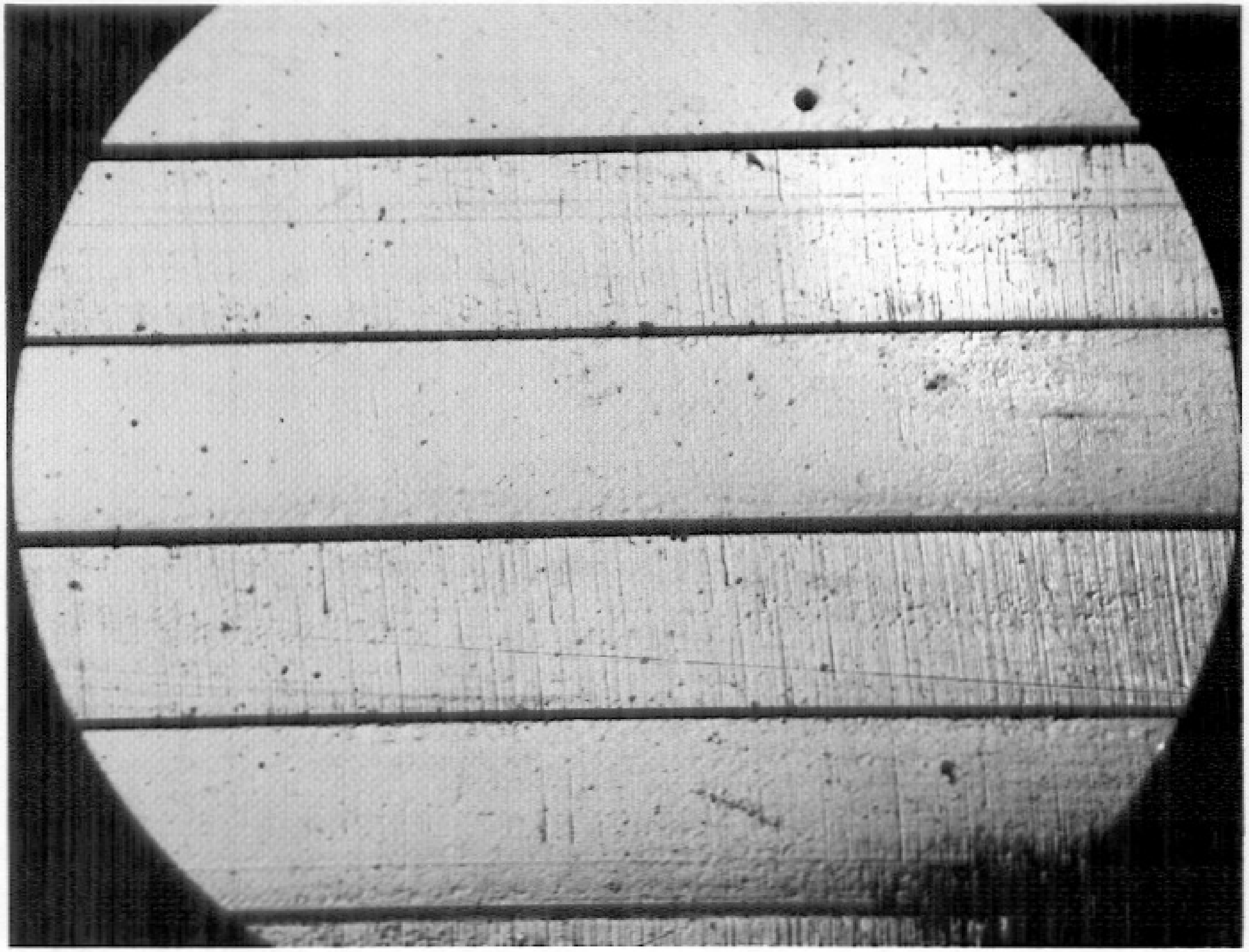


Fig. 19 PHOTOMICROGRAPH (by oblique transillumination, 23 X) - A PLASTISOL replica of Colt 22 (6L) barrel rifled by the button swage method without further finishing and not fired (COLT, 1955). Note the concentric ream marks on the lands which are less prominent on the groove surfaces. These differences result from the greater force exerted by the BUTTON in compressing and displacing the metal to form the grooves. Axial striae result from metal buildup ("galling") or imperfections on the BUTTON as it is pushed through the bore.

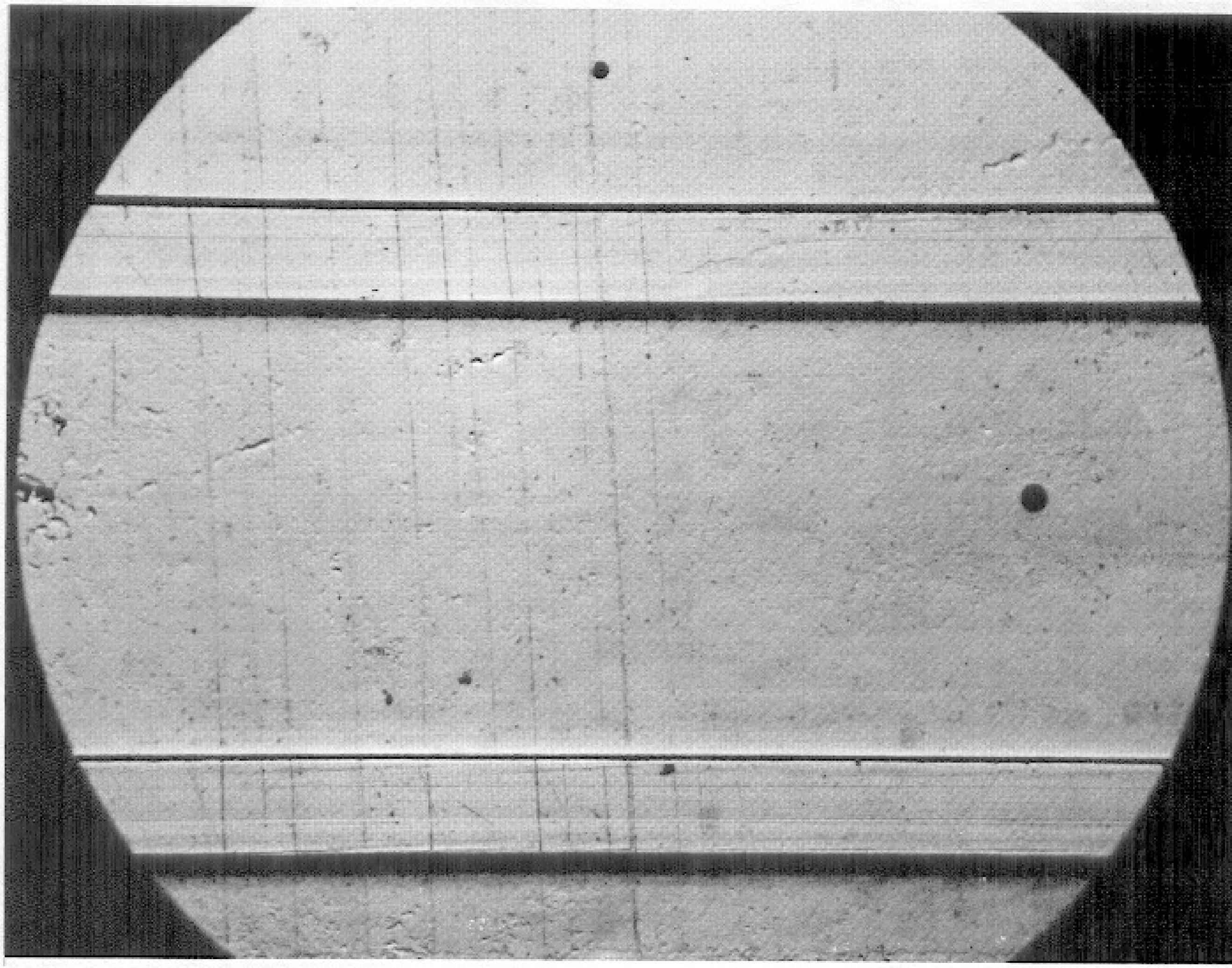


Fig. 20 PHOTOMICROGRAPH (by oblique transillumination 23 X) - PLASTISOL replica of a WEATHERBY 300 MAG (GR) barrel rifled by the HAMMER SWAGE method without further finishing and not fired (rifled in Germany for WEATHERBY, 1975). This rifling has a "mirror-like" appearance with little evidence of ream marks. The only notable toolmarks are a few, widely spaced, concentric lines and some axial striae on the lands which are probably the result of imperfections on the mandrel onto which the reamed barrel blank is "hammered" to form the lands and grooves.

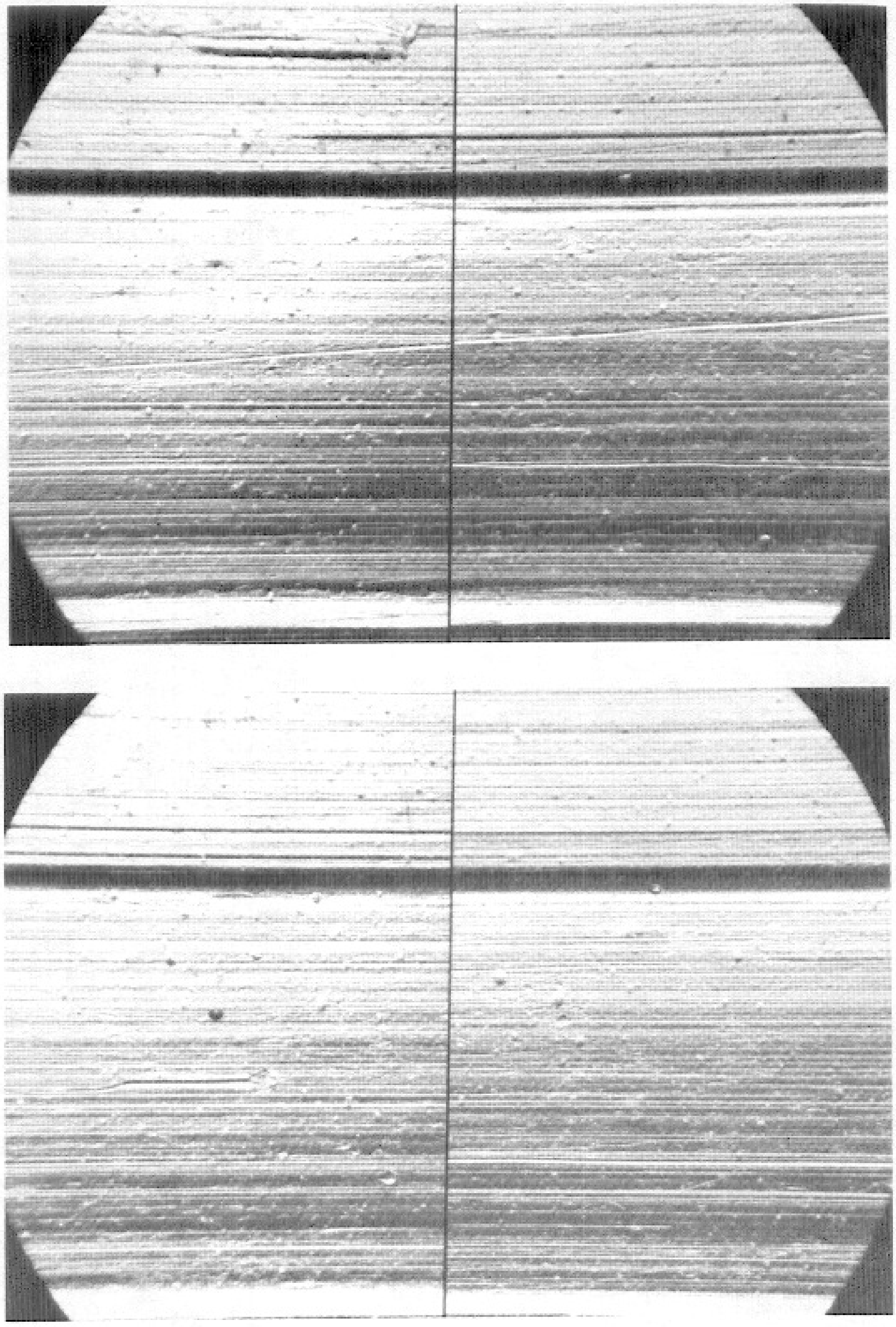


Fig. 21 - COMPARISON PHOTOMICROGRAPH (oblique transillumination, 23X) - PLASTISOL replicas of a S&W 38 SPL (5R)barrel rifled by the BROACH method, lead lapped, but not fired (S&W, 1955). The upper photo is two halves of the same replica shown in "match" position on the cut edges. The lower photo is the same two replica halves compared about 1" from each cut edge in the same groove cut. Note how the lapping process has formed similar axial striae on both the land and the groove surfaces which are not uniformly distributed, or of equal spacing, as hypothesized by BOOKER (1980). The gritty appearance is due to debris and air bubbles in the PLASTISOL replica and is not typical of lead lapped surfaces.