BULLET MARKINGS FROM CONSECUTIVELY RIFLED SHILEN DGA BARRELS

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ABSTRACT:

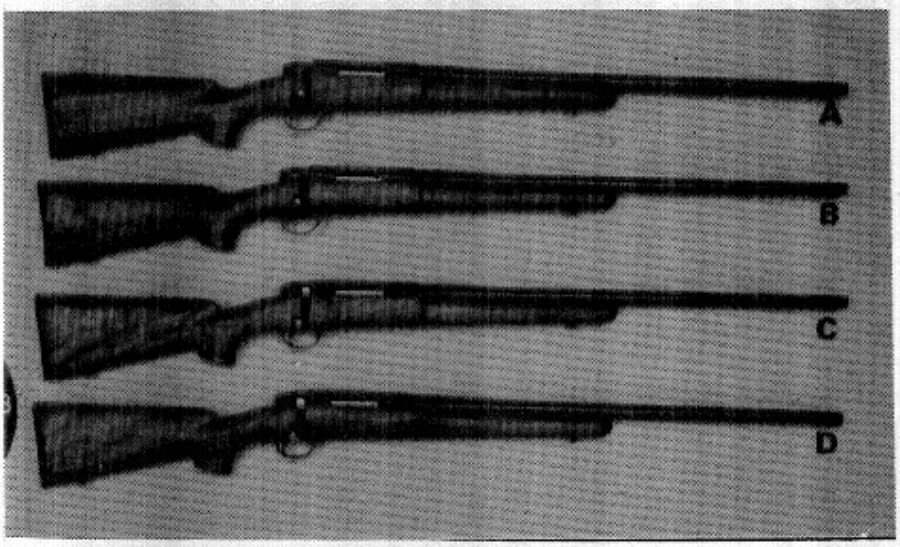
Bullets fired from four button-swaged Shilen rifle barrels with polygonal rifling were compared. Each land-land and groove-groove pair was assigned a coded rating and arbitrary criteria for three degrees of identification were devised. After the first five shots, bullets fired from the same barrel could be identified. No false identification could be made between bullets fired from consecutively rifled barrels. Consecutive reaming before rifling did not influence the significance of the bullet markings.

INTRODUCTION:

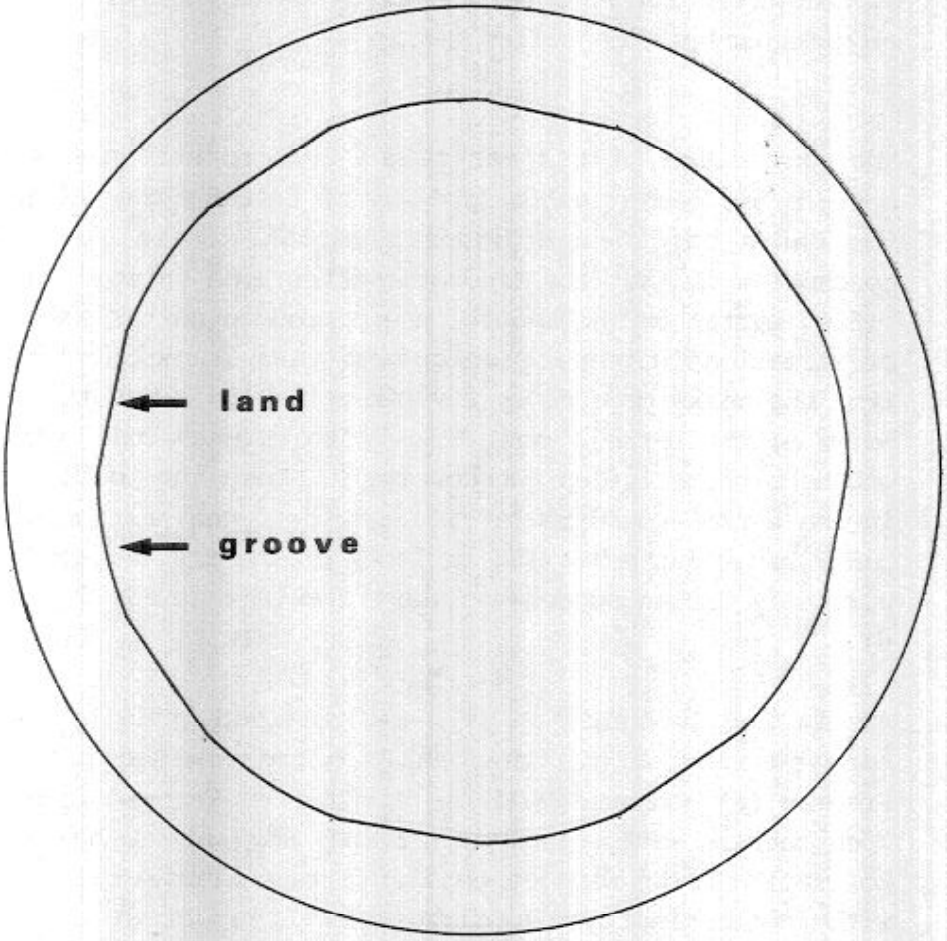
The comparison of bullets fired from consecutively rifled barrels has become a standard way of testing the validity of the basis of firearms identification. This fundamental assumption is that the random imperfections introduced into a rifled barrel during manufacture reproduce on bullets a series of striations which are unique to that barrel and distinct from the marks created by any other barrel. Were this not to be true, the barrels most likely to produce the same marks would be those rifled consecutively, where the toolmarks made in one barrel could be carried over into the next. This might occur because the working surfaces of the rifling tool remain virtually unchanged between these two barrels (1, 2, 3, 4, 5, 6).

Austin and Murdock (4, 5) have examined the marks made by consecutive barrels which have button-swaged rifling and Freeman (6) compared bullets from hammer-forged Heckler and Koch barrels with polygonal rifling. My intent however, was to examine marks made by consecutively manufactured barrels with the combination of polygonal rifling created using the button-swaging technique.

RCMP CRIME LAB - VANCOUVER, CANADA



Test Rifles



Cross Section of Shilen Barrel

So far as I am aware Shilen Rifles Inc. was the only company making this rifling type (DGA rifling) when this project began in January of 1979. Initially I spent time at the Shilen factory in Ennis, Texas viewing first-hand the consecutive rifling of the four DGA barrels for this experiment. Two of the .308 calibre barrels selected were consecutively reamed after deep hole drilling,while the other two were chosen at random from a pile of barrels already reamed. (The sequential relationship of the reaming operation on the latter two barrels, although unknown, is unlikely to be consecutive). The four barrels were marked and consecutively rifled by pulling a tungsten - carbide button through the bores smeared with a wax-based lubricant. The manufacturing operations necessary to complete the four rifles used in this project (including, heat treatment, lapping, chambering and crowning) were completed after my visit.

PURPOSE:

The purpose of this experiment is to answer the following questions:

1. Does the theory that each rifled firearm produces bullet markings which are unique and reproducible,hold true for button swaged barrels with polygonal rifling produced consecutively?

2. Does consecutive reaming, prior to consecutive rifling of barrels, increase the possibility of a false match of bullets fired from them?

EXPERIMENTAL METHODS:

Before any shots were fired every barrel was lightly cleaned by pushing one patch soaked with WD40 lubricant, followed by one dry patch, through the bore. This was repeated for each barrel between firings up to the tenth shot as well as between shots 30 and 31. My intention was to carefully remove the bulk of the loose fouling without introducing any new imperfections into the barrel as a result of the cleaning operation.

SHOT SEQUENCE CHART

RIFLE	REAMED AT RANDOM				CONSECUTIVELY REAMED				
	A Ser. No. 1535		B Ser. No. 1536		C Ser. No. 1537		D Ser. No. 1538		
	CLEAN	FOULED	CLEAN	FOULED	CLEAN	FOULED	CLEAN	FOULED	
AMMO	1, 2, 3		1, 2, 3		1, 2, 3		1, 2, 3		TOTALS
REM. 180 gr P S P	10 31	20 30			10 31	20 30			20
I.V.I. 180 gr Sabre Tip	4, 5, 6		4, 5, 6 10 31	20 30	4, 5, 6		4, 5, 6		16
WIN. 200 gr Silvertip	7, 8, 9		7, 8, 9		7, 8, 9		7, 8, 9 10 31	20 30	16
I.V.I. BALL (discarded)		11 – 19 21 – 29		11 – 19 21 – 29		11 – 19 21 – 29		11 – 19 21 – 29	0
TOTALS FIRED	11	20	11	20	11	20	11	20	124 / 52

Both the bullet and cartridge case of each cartridge were marked on the same side as a reference point before firing. When the bolt was closed the cartridges tended to rotate in the chamber. The mark made by the ejector port on the head of the cartridge case was therefore used to determine the orientation of the cartridge in the chamber. This mark in conjunction with the previously mentioned marks on bullet and cartridge case established the same land as a starting point for comparison of bullets fired from the same barrel.

All bullet comparisons were made on Leitz comparison microscopes with Milar 10 cm. or Photar 80 mm. oculars in combination with 16x objectives to give a medium range magnification. Higher magnifications were used on occasion to check selected areas exhibiting very fine striae. Incandescent lights were used on a very oblique angle. Selected 35 mm photographs were made through the microscope.

Thirty-one bullets were fired from each rifle and thirteen of those were recovered in a horizontal water tank. Of that thirteen, eleven were fired through a clean barrel and two through the barrel while fouled. The recovered bullets were sporting types loaded in Remington, I.V.I. and Winchester cartridges (See shot sequence chart). Shots 11 to 19 and 21 to 29 inclusive were fired using military ball cartridges (I.V.I. 7.62 NATO) without retrieving the bullets. These military rounds were fired simply to introduce a wear factor, while the three ammunition brands served to provide an indication of the variation that might occur with differing combinations of bullet weight, hardness, diameter, bearing surface area and/or jacket construction.

The above factors enabled bullets fired from the same firearm to be compared in the following combinations:

(a) Same brands, weights and/or jacket material
(b) Different brands, weights and/or jacket material
(c) Near in the shot sequence order
(d) Distantly removed in the shot sequence order
(e) Same condition of bore cleanliness
(f) Different condition of bore cleanliness

Selections of bullet pairs were made as comparisons produced indications of trends to be checked and possibly investigated further.

One trend observed was a major reduction in agreement as the separation in the firing order of bullet pairs increased (e.g. less agreement A1 to A20 than A6 to A7). Hence, the pairs of bullets from different guns were all chosen on the basis of corresponding positions in the firing sequence. The possibility of a false indentification was expected to be greatest between corresponding shots, especially the first fired from every barrel.

For each of the bullet pairs, notes were made concerning the presence or absence of significant similarities on every land and every groove comparison and a code letter assigned to each as follows:

N - no significant agreement

P - enough agreement of individual characteristics to indicate a degree of probability

I - sufficient agreement of individual characteristics to constitute an identification if there is supporting agreement on other areas of the bullet.

Microscopic observations showed the reference marks put on before firing to be useful for indexing the phase relationship between bullets fired from the same gun. Also, after much preliminary viewing I became firmly convinced that one gross striation showing to some degree on all the bullets fired from every gun was produced by a single fault in the surface of the rifling button. This gross striation was used to index bullet pairs facilitating comparisons without incurring the lengthy examination involved in comparing each land of each bullet with all eight appearing on its counterpart.

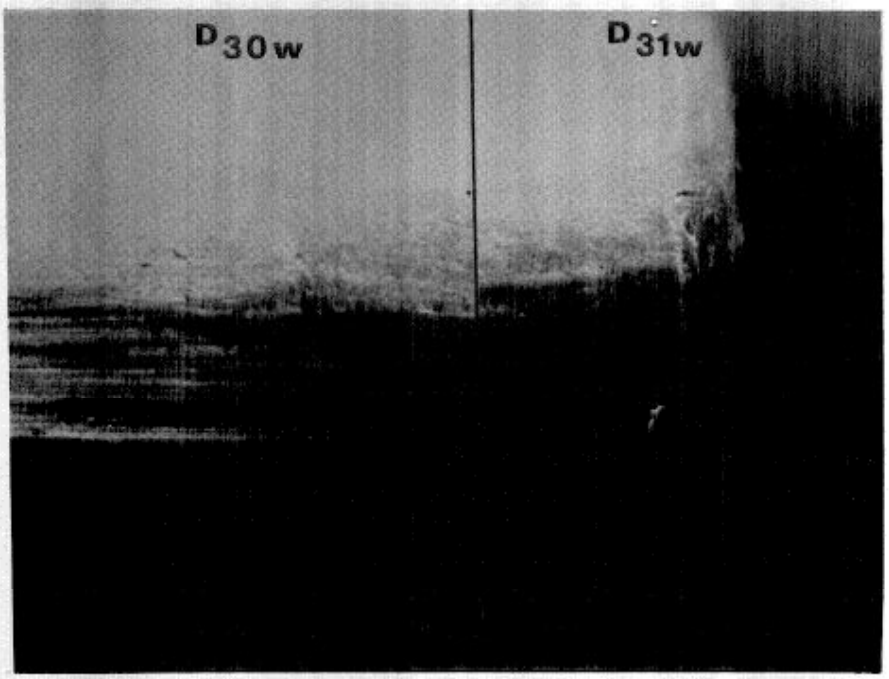
FINDINGS AND DISCUSSION:

The major difficulty encountered while comparing bullets with Shilen polygonal rifling is the lack of a distinct division or step (as in Enfield type rifling) between lands and grooves, as well as the variation in the widths of lands and groove engravings along their length. Hence there are no reference edges to use in determining whether or not an apparent match of scattered striae is a true match or a false one occuring because of a similar spacing of random striae which are not reproductions and are actually out of rotational phase. The problem is essentially the same as that encountered with a partial toolmark where the class characteristics of the tool are not revealed. An identification is possible but the examiner needs to be careful not to assign a higher value of significance to any apparent matching than is warranted by the other evidence seen.

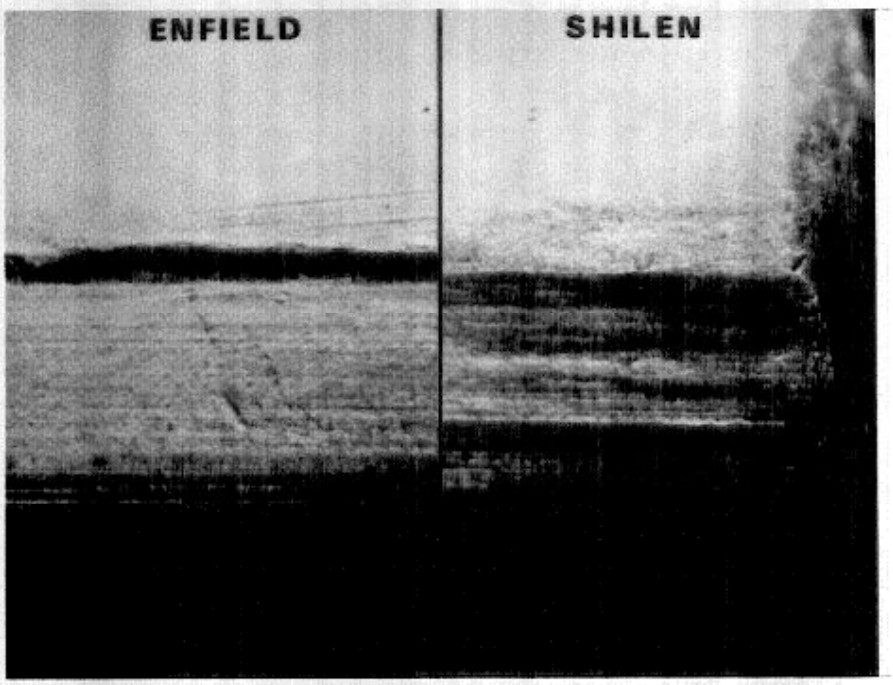
Polygonal rifling with this lack of a definite division between land and groove engravings makes measurement of class widths on the bullet virtually impossible. Presently, this style of rifling is a strong class feature in itself. However, should another manufacturer adopt this rifling type with the same number of grooves and direction of twist but a slightly different groove width, this problem could preclude a class elimination.

The second principal difficulty concerns the lack of easily viewed striae. The land engravings tend to be either very smooth with fine striae that are not continuous along the length of the bullet, or devoid of distinct striae, exhibiting only the irregular pattern of marks produced by the galling of the jacket material. Also the lack of marks on most groove engravings appears to result from a failure of the bullet to bottom in the grooves.

With few good striae resulting on land and groove engravings, some general similarities between bullets from different barrels, and the problems resulting from the lack of good



1. Engravings produced by the same land vary in width.



2. Enfield rifling compared with Shilen DGA rifling.

edges, I felt that any apparent matches of striae should be down-graded in the examiner's mind. This is of course, unless their position can be related to a larger group of matching striae or a common gross feature. In an attempt to take the above problems into consideration, as well as to offset any bias introduced by prior knowledge of the bullet sources, arbitrary criteria based on the code letters (previously described) earned by land-land or groove-groove pairs were adopted for assessing each bullet comparison. They may or may not be suitable for comparing a known bullet against an unknown but were useful for this project. The criteria for forming opinions on each bullet comparison were as follows:

(i) Positive Identification - To rate a positive, the bullets must show:

a) More than one land-land or groove-groove comparison rated a code "I"; or

b) One land-land or groove-groove pair assigned a code "I" plus one or more pairs of lands or grooves rated code "P"; or

c) Five or more comparisons of land or groove pairs assigned code "P"

(In each of the above cases there are to be no disagreements which cannot be resolved in the mind of the examiner).

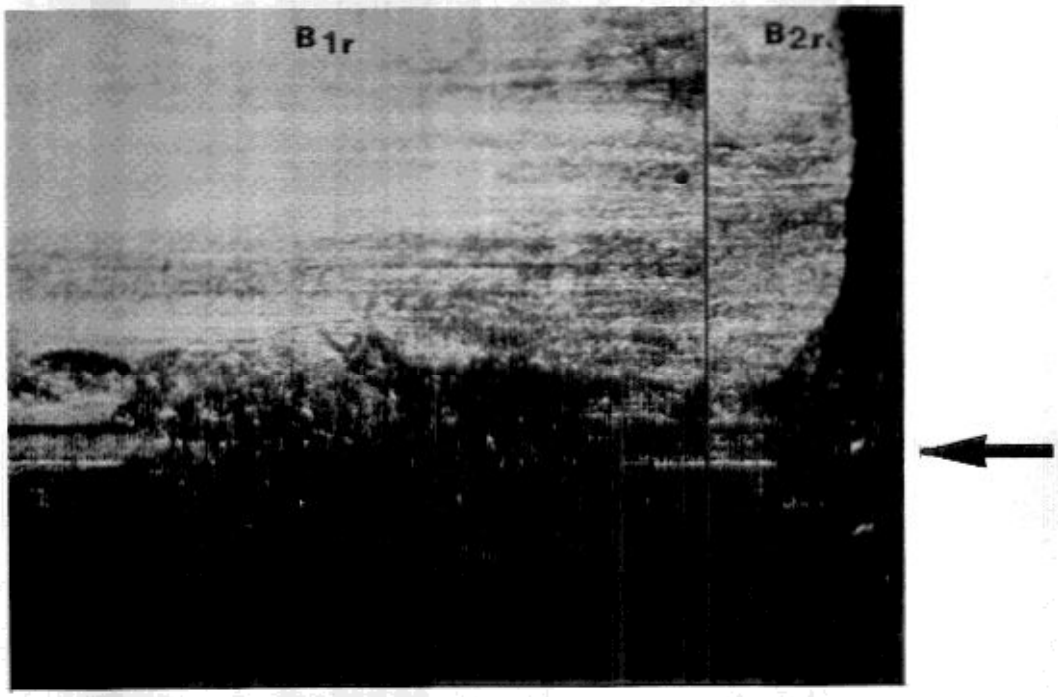
(ii) Probable - The bullets must show:

Three or four comparisons of land or groove pairs rated a code "P" (depending on the degree of probability for each pair)

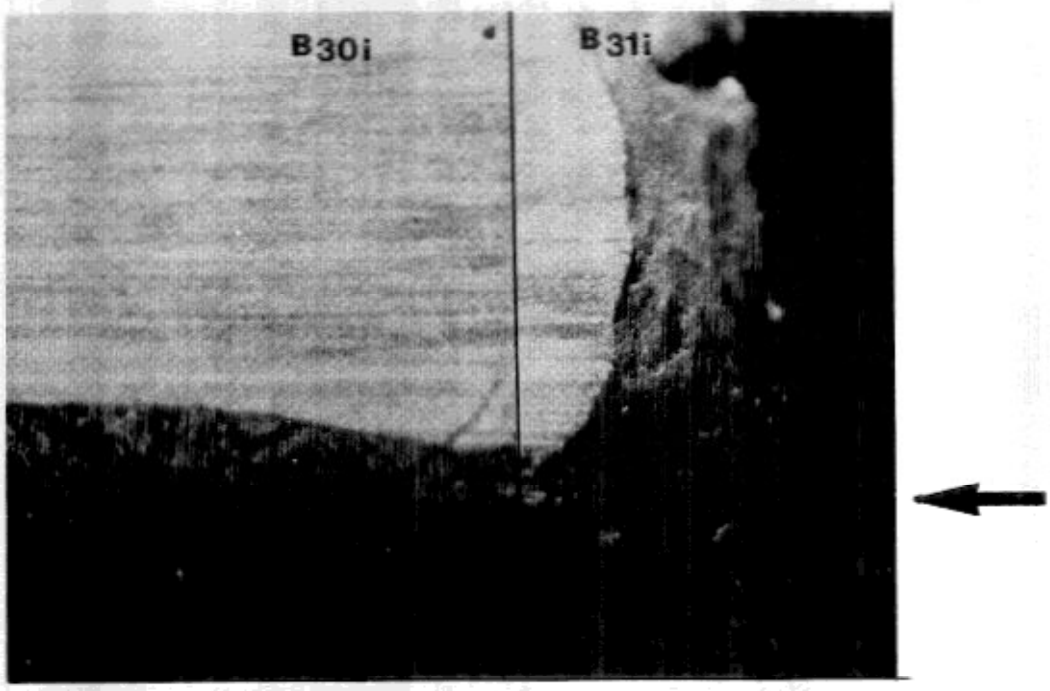
(iii) Neither identified nor eliminated - The bullets would show:

Two pairs rated code "P", or any lower degree of agreement.

Some insight into the interaction of bore and bullet surfaces was gained through general observations. On bullet pairs from the same barrel the accidental striae changed as the shot sequence progressed,with the changes less pronounced between the last shots than between the first (e.g. generally there was greater similarity of marks between bullets 20 and 30 than between bullets 1 and 2). One gross feature on bullets from rifle B disappeared almost entirely as the shooting progressed



1. Gross notch on bullets 1 and 2 made by rifle "B".



2. Same notch becomes indistinct because barrel is changing.

(see photos). This rapid change during the first few shots was seen as the reason for a lack of identifications where bullets from any of the first five shots were compared to any others. This finding generally corresponds to that of Murdock (5) in comparisons on rimfire bullets from barrels consecutively rifled using a button. As might be expected, bullets consecutively fired or at least close in the firing sequence generally showed the greatest similarities (with the exception of the first few shots as previously noted).

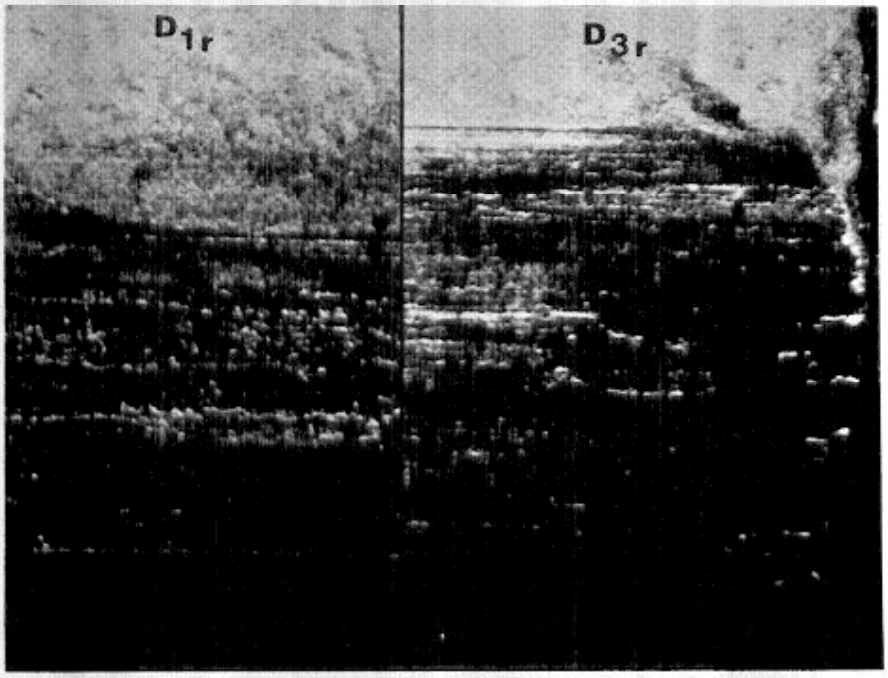
It is not surprising to note that out of a total of six bullet pairs identified, only one pair were bullets of different brands, considering that; 1. of twenty-two comparisons involving bullets of different brands only 5 were of bullets shot consecutively and

2. of the twenty-three comparisons which did not include any of the first five bullets from each barrel, only five comparisons were of different bullet makes.

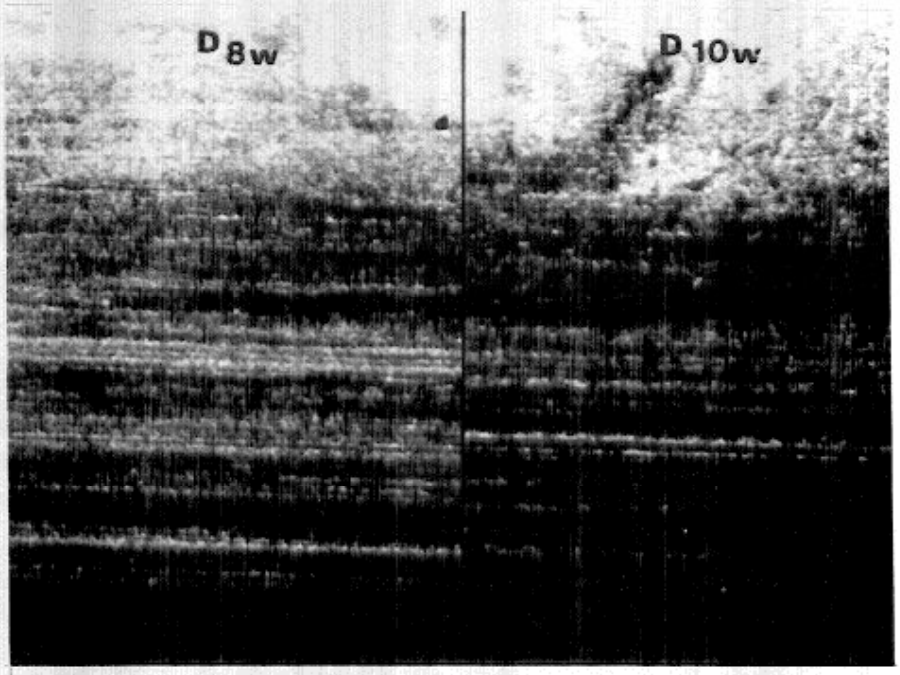
My general observations confirmed that there is no obvious variation in the marks made on different brands or weights of bullets with the exception of a slight variance in the degree to which they bottom in the grooves.

In the few bullet comparisons made from the same barrel in clean versus fouled condition no observable differences were noted, in fact one identification was made despite this disparity.

Comparisons of the rifling marks from one gun to the next revealed only general similarities with very few combinations of more than two lines matching. In fact the hump used to establish a phase index was the only significant feature which showed any carry-over from one barrel to the next and even it quickly became more distinct as the firing progressed. One land-land pair did have enough matching fine striae to be assigned a code "P", however, the other areas on the bullets were woefully lacking in any agreement which might have



1. Galled land engravings have few good marks.



2. Identifications are not strong or easily seen.

supported the consideration that this congruence was meaningful.

CONCLUSIONS:

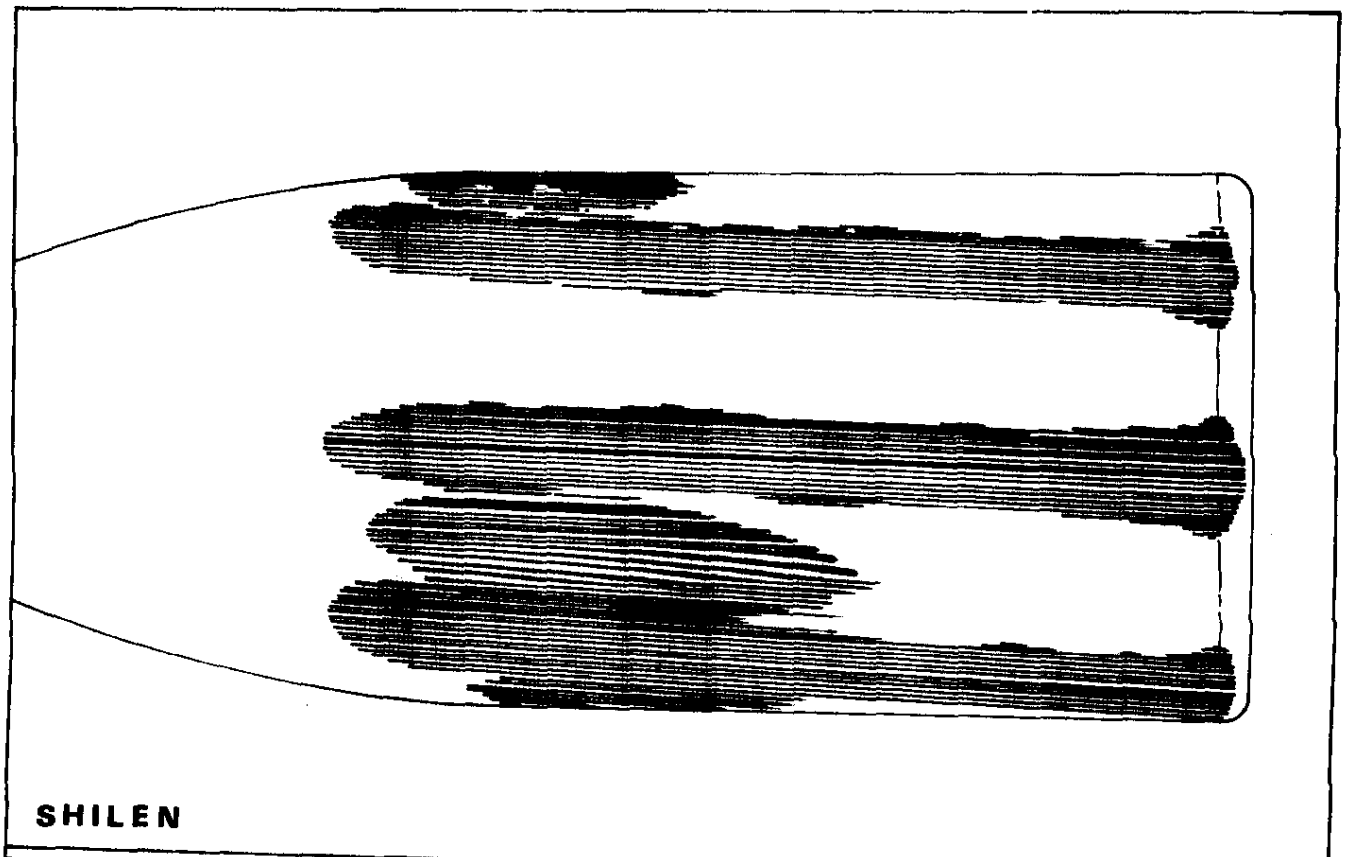
1. There was never enough agreement seen in the marks on bullet pairs from two consecutively manufactured barrels to introduce the risk that a false identification might be made. With bullets closely related in the firing sequence the dissimilarity of marks created by any two different barrels is significantly greater than the dissimilarity seen on bullet pairs that are from the same barrel.

2. The accidental striae on bullets fired from the same barrel are reproduced sufficiently to make an identification possible after the first five shots. The probability of an identification is enhanced when the bullets are consecutively fired or nearly so and increases as a greater number of shots have been fired (at least within the scope of this experiment).

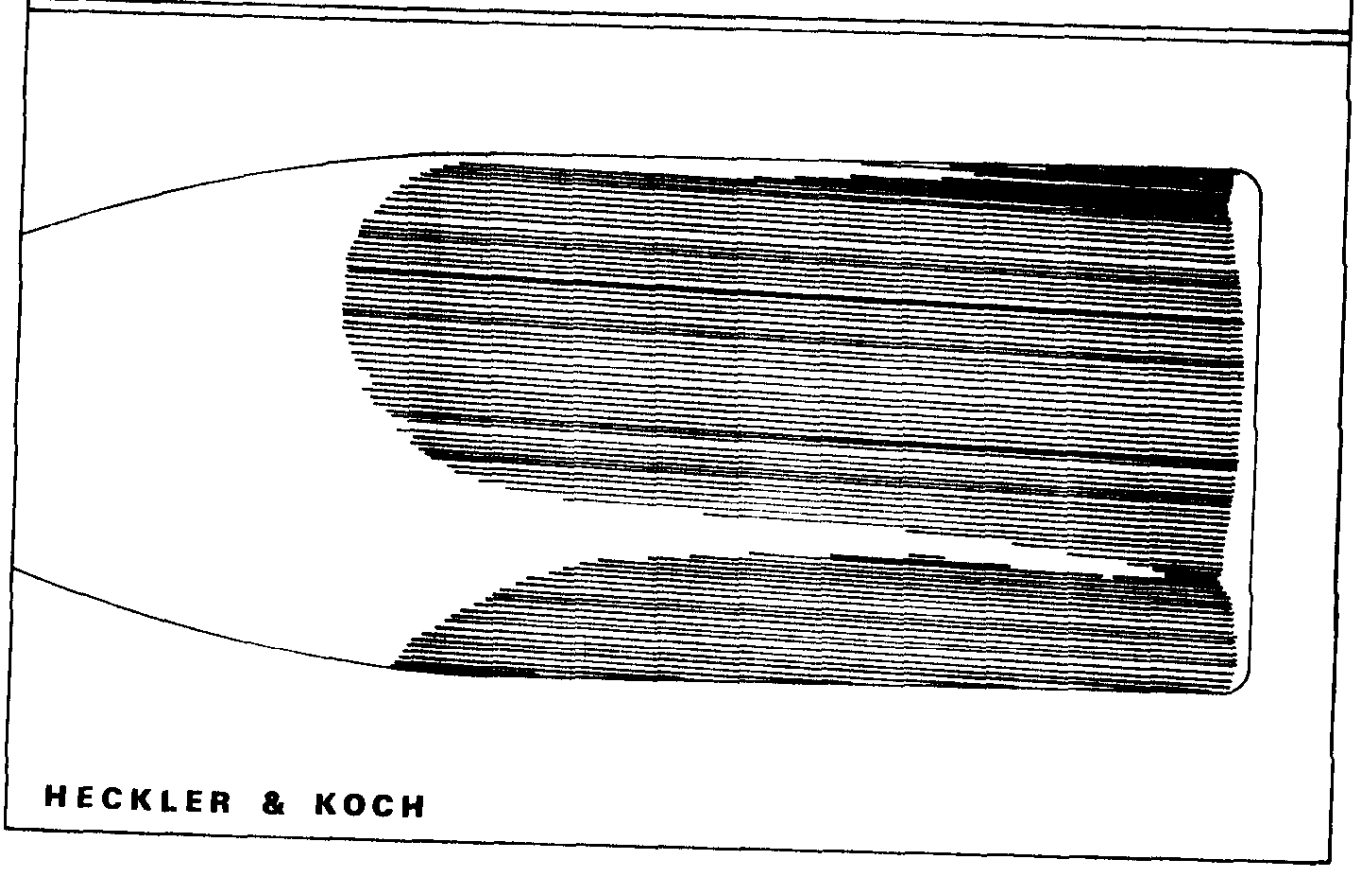
3. General observations indicated that there is no observable increase in agreement in barrels consecutively reamed before rifling. As a matter of interest, the single comparison from different barrels which had the greatest degree of agreement for any land-land pair (rated code "P") was a comparison from barrels selected at random and not from the pair known to be consecutively reamed (A31r vs B31i).

REMARKS:

The fact that these four rifles underwent lapping, chambering and crowning assures that they are representative of completed firearms sold on the market. However, the effects of these operations on the bullet markings probably do not cause enough modification to completely mask the results of consecutive rifling. The chambering operation may be responsible for a few imperfections creating the very occasional axial striae on groove engravings near the bullet base. As Murdock has stated (7), crowning, when done cleanly, has little effect on rifling marks. The hand lapping procedure while undoubtedly removing



SHILEN



HECKLER & KOCH

or modifying some of the imperfections is designed only to polish the bore surfaces without introducing any new marks of the magnitude of those created by the rifling button.

Although Shilen discontinued its DGA (polygonal) rifling about the time this project commenced, the problems of this rifling style, in particular the very smooth bore and the lack of a distinct land-groove edge are increasingly more common as polygonal rifling is being widely marketed by Heckler and Koch as well as other present day manufacturers such as L.E.S. and Harrington & Richardson. (Of historical interest Shilen DGA rifling is virtually the same as the octagonal Whitworth rifling used by Westley Richards circa 1860 (8) while Heckler & Koch's polygonal rifling echos Newton's Segmented rifling concept which in turn is only a variation on the rifling pattern Metford introduced about 1865 (8, 9).)

The risk in examing polygonal rifling marks concerns the possibility of aligning unrelated striae because the reference of a clear land-groove edge is lacking. However, the shortage of supporting evidence on the other areas of the bullets should serve as an adequate warning and prevent the false identification of bullets from different guns.

ACKNOWLEDGEMENT:

Thanks go to Ed and Doug Shilen for their time and efforts spent in processing this special order and for their co-operation at each stage. Also thanks to my colleagues for assuming some additional case load while I spent many more hours than anticipated on the comparison microscope, and to S/Sgt. Peter Law for assistance with charts and diagrams.

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COMPARISONS	RATING DATA									OPINIONS
	Land Engravings			Groove Engravings			Totals			
	N	P	I	N	P	I	N	P	I	
Bullets from the Same Rifle										
RIFLE A										
A1r - A2r	7	1	0	8	0	0	15	1	0	-
A1r - A3r	8	0	0	8	0	0	16	0	0	-
A1r - A4i	8	0	0	8	0	0	16	0	0	-
A1r - A7w	7	1	0	8	0	0	15	1	0	-
A1r - A8w	7	1	0	8	0	0	15	1	0	-
A1r - A10r	7	1	0	8	0	0	15	1	0	-
A1r - A31r	7	1	0	8	0	0	15	1	0	-
A2r - A3r	8	0	0	8	0	0	16	0	0	-
A4i - A6i	6	2	0	8	0	0	14	2	0	-
A6i - A9w	6	2	0	7	1	0	13	3	0	Probable
A7w - A8w	7	1	0	8	0	0	15	1	0	-
A9w - A10r	6	2	0	6	2	0	12	4	0	Probable
A10r - A31r	6	2	0	8	0	0	14	2	0	-
A30r - A31r	7	1	0	8	0	0	15	1	0	-
RIFLE B										
B1r - B2r	8	0	0	8	0	0	16	0	0	-
B1r - B3r	8	0	0	8	0	0	16	0	0	-
B1r - B31i	8	0	0	8	0	0	16	0	0	-
B2r - B3r	8	0	0	8	0	0	16	0	0	-
B3r - B4i	8	0	0	8	0	0	16	0	0	-
B3r - B6i	7	1	0	8	0	0	15	1	0	-
B3r - B7w	7	1	0	8	0	0	15	1	0	-
B3r - B9w	7	1	0	8	0	0	15	1	0	-
B3r - B10i	4	4	0	8	0	0	12	4	0	Probable
B6i - B7w	3	5	0	8	0	0	11	5	0	Positive I.D.
B7w - B8w	6	2	0	8	0	0	14	2	0	-
B8w - B9w	6	1	1	8	0	0	14	1	1	Positive I.D.
B9w - B10i	7	1	0	8	0	0	15	1	0	-
B10i - B31i	6	2	0	8	0	0	14	2	0	-
B30i - B31i	5	3	0	8	0	0	13	3	0	Probable
RIFLE C										
C1r - C2r	8	0	0	8	0	0	16	0	0	-
C1r - C3r	8	0	0	8	0	0	16	0	0	-
C1r - C31r	8	0	0	8	0	0	16	0	0	-
C2r - C3r	6	2	0	8	0	0	14	2	0	-
C3r - C4i	8	0	0	8	0	0	16	0	0	-
C3r - C8w	8	0	0	8	0	0	16	0	0	-
C3r - C10r	8	0	0	8	0	0	16	0	0	-
C3r - C31r	8	0	0	8	0	0	16	0	0	-
C4i - C7w	8	0	0	8	0	0	16	0	0	-

Rifle C Continued.

C7w - C8w	7	1	0	8	0	0	15	1	0	-
C8w - C10r	7	1	0	8	0	0	15	1	0	-
C10r - C31r	5	3	0	8	0	0	13	3	0	Probable
C10r - C20r	6	1	1	8	0	0	14	1	1	Positive I.D.
C10r - C30r	5	3	0	8	0	0	13	3	0	Probable
C20r - C30r	5	2	1	8	0	0	13	2	1	Positive I.D.
C30r 0 C31r	7	1	0	6	2	0	13	3	0	Probable

RIFLE D

D1r - D2r*	4	0	0	4	0	0	8	0	0	-
D1r - D3r	7	1	0	8	0	0	15	1	0	-
D1r - D31w	8	0	0	8	0	0	16	0	0	-
D2r* - D3r	2	2	0	3	1	0	5	3	0	Probable
D3r - D4i	7	1	0	8	0	0	15	1	0	-
D3r - D8w	7	1	0	8	0	0	15	1	0	-
D3r - D10w	7	1	0	8	0	0	15	1	0	-
D3r - D31w	8	0	0	8	0	0	16	0	0	-
D4i - D7w	5	3	0	8	0	0	13	3	0	Probable
D7w - D8w	4	3	1	7	1	0	11	4	1	Positive I.D.
D8w - D10w	6	1	1	7	0	1	13	1	2	Positive I.D.
D10w - D20w	8	0	0	8	0	0	16	0	0	-
D10w - D30w	6	2	0	8	0	0	14	2	0	-
D10w - D31w	6	2	0	8	0	0	14	2	0	-
D20w - D30w	6	2	0	8	0	0	14	2	0	-
D30w - D31w	6	2	0	7	1	0	13	3	0	Probable

Bullets from Different Rifles

A1r - B1r	8	0	0	8	0	0	16	0	0	-
A1r - C1r	8	0	0	8	0	0	16	0	0	-
A1r - D1r	8	0	0	8	0	0	16	0	0	-
B1r - C1r	8	0	0	8	0	0	16	0	0	-
B1r - D1r	8	0	0	8	0	0	16	0	0	-
C1r - D1r	8	0	0	8	0	0	16	0	0	-
A3r - B3r	8	0	0	8	0	0	16	0	0	-
A3r - C3r	8	0	0	8	0	0	16	0	0	-
A3r - D3r	8	0	0	8	0	0	16	0	0	-
B3r - C3r	8	0	0	8	0	0	16	0	0	-
B3r - D3r	8	0	0	8	0	0	16	0	0	-
C3r - D3r	8	0	0	8	0	0	16	0	0	-
A10r - B10i	8	0	0	8	0	0	16	0	0	-
A10r - C10r	8	0	0	8	0	0	16	0	0	-
A10r - D10w	8	0	0	8	0	0	16	0	0	-
B10i - C10r	8	0	0	8	0	0	16	0	0	-
B10i - D10w	8	0	0	8	0	0	16	0	0	-
C10r - D10w	8	0	0	8	0	0	16	0	0	-

A30r -	B30i	8	0	0	8	0	0	16	0	0	-
A30r -	C30r	8	0	0	8	0	0	16	0	0	-
A30r -	D30w	8	0	0	8	0	0	16	0	0	-
B30i -	C30r	8	0	0	8	0	0	16	0	0	-
B30i -	D30w	8	0	0	8	0	0	16	0	0	-
C30r -	D30w	8	0	0	8	0	0	16	0	0	-
A31r -	B31i	7	1	0	8	0	0	15	1	0	-
A31r -	C31r	8	0	0	8	0	0	16	0	0	-
A31r -	D31w	8	0	0	8	0	0	16	0	0	-
B31i -	C31r	8	0	0	8	0	0	16	0	0	-
B31i -	D31w	8	0	0	8	0	0	16	0	0	-
C31r -	D31w	8	0	0	8	0	0	16	0	0	-

* Bullet D2r damaged with only four land engravings and four groove engravings remaining.

Key for Comparison Rating Data

Bullet designations e.g. A31r

A - rifle from which the bullet was fired (A, B, C, D)

31 - position in shot sequence for that particular rifle (1 to 31)

r - bullet brand (r - Rem., i - I.V.I., w - Win.)

Key for Comparison Rating Charts

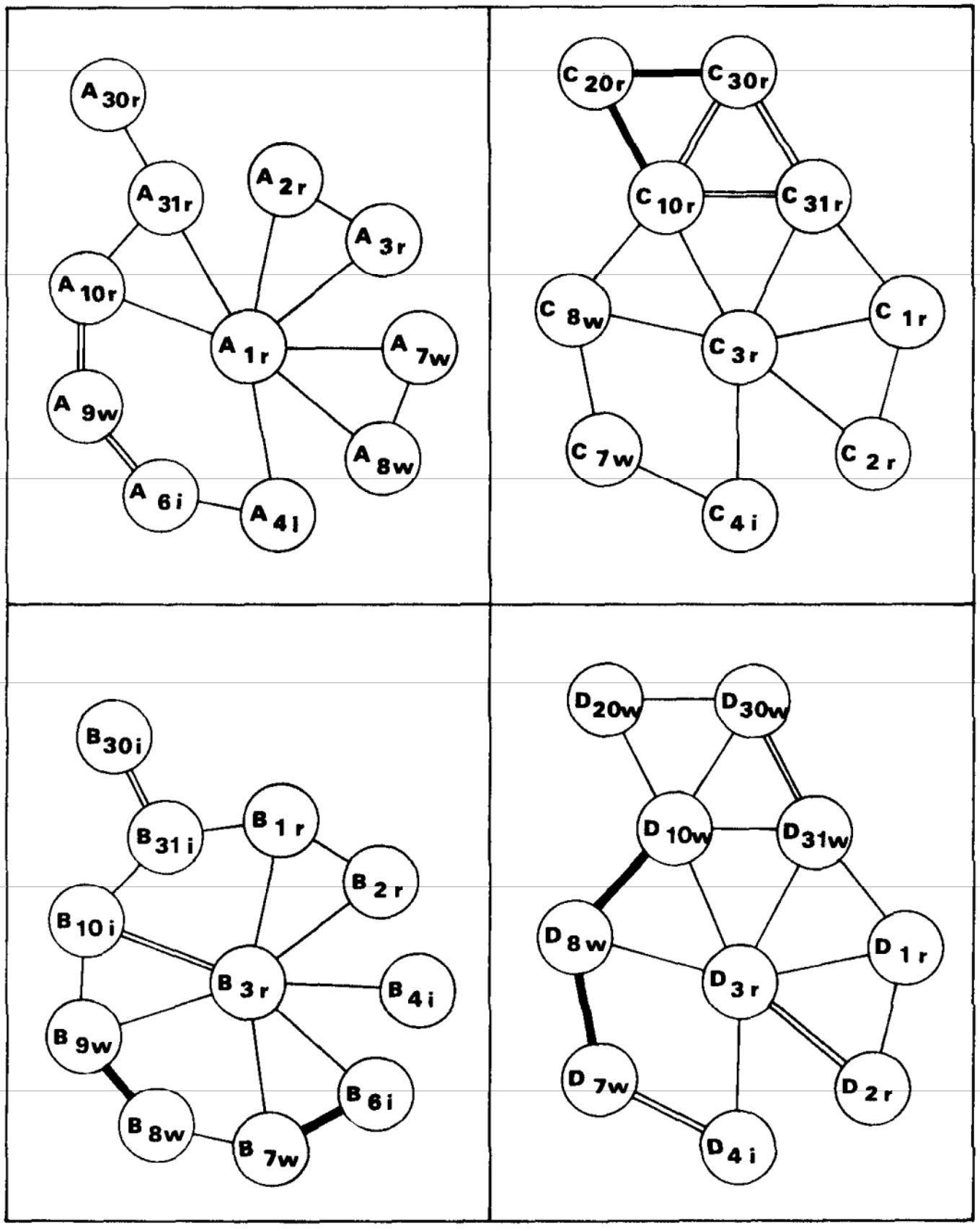
Bullet designations as shown for Rating Data

Comparisons as shown as joining lines

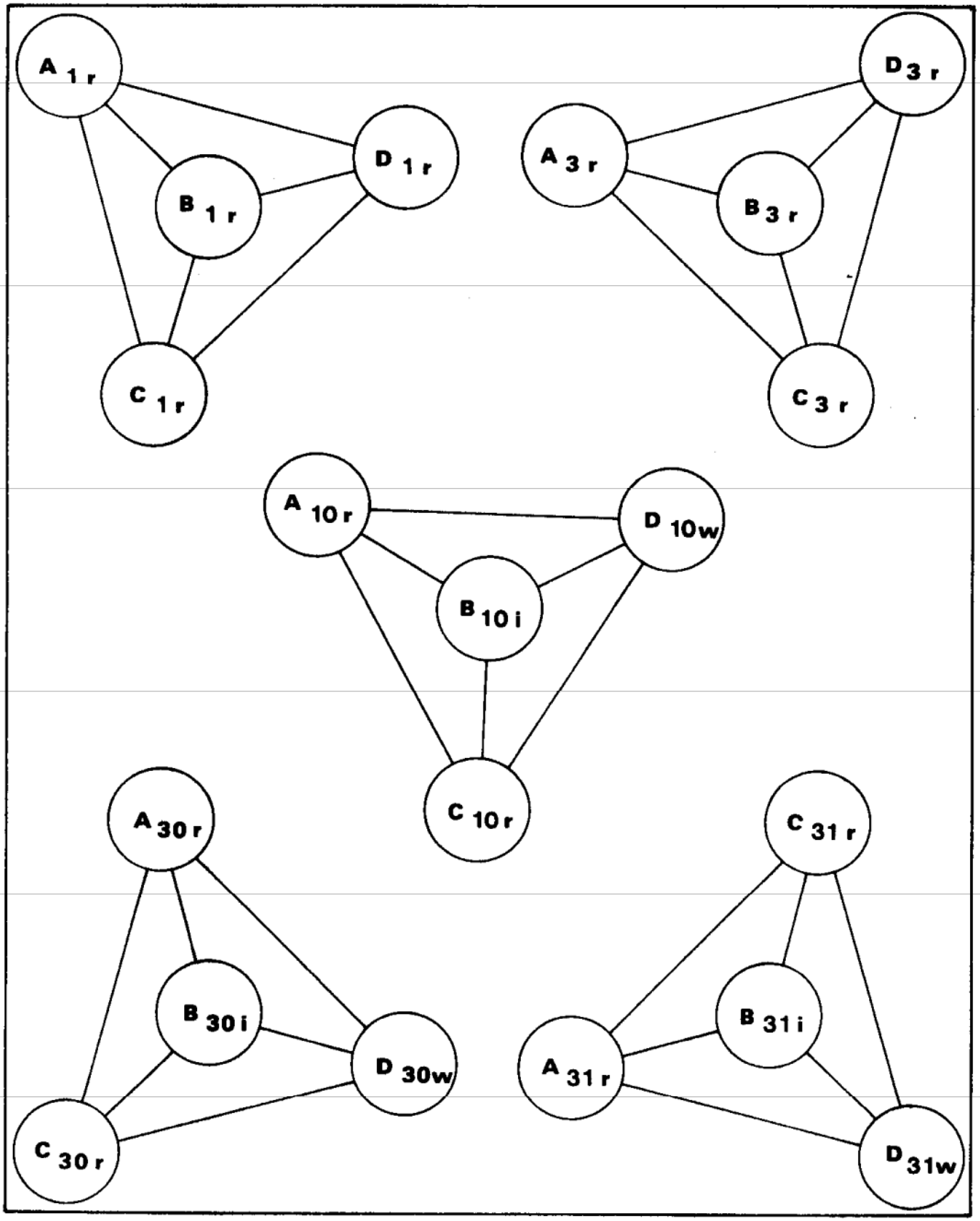
Positive Identification

Probable

Neither identified nor eliminated



COMPARISONS BETWEEN BULLETS FROM THE SAME BARREL



COMPARISONS BETWEEN BULLETS FROM DIFFERENT BARRELS